Journal of Phytology 2010, 2(11): 73-79
Phytophysiology

ISSN: 2075-6240
Available Online: www.journal-phytology.com

REGULAR ARTICLE

THE EFFECT OF IRON, ZINC AND MANGANESE ON QUALITY AND QUANTITY OF SOYBEAN SEED

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SUMMARY

In order to study the effects of iron, zinc and manganese on the yield of soybean an experiment was conducted in Miandoab agriculture research station. Treatments included iron (0, 25 and 50kg/ha), zinc (0, 25 and 40kg/ha) and manganese (0 and 40kg/ha) were arranged as factorial based on randomized complete block design with three replications. All of agronomic operation carried out based on research recommendations. Our results showed that 40kg/ha zinc and manganese led to the highest seed yield (3397 and 3367kg/ha), respectively. However zinc and manganese 40kg/ha produced the highest biological yield (7447 and 7387kg/ha), respectively. In general, the greatest grain number and seed weight per plant, pod number as well as biological and seed yield of soybean were obtained from 40kg/ha of zinc and manganese.

Key words: Biomass, *Glycine max*, Micronutrient, Seed yield

Vahid Ghasemian et al. The Effect of Iron, Zinc and Mangnese on Quality and Quantity of Soybean Seed. J Phytol 2/11 (2010) 73-79.
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1. Introduction

The soybean (*Glycine max*) is a species of Fabaceae native to East Asia. The plant is classed as an oilseed rather than a pulse. It is an annual plant that has been used in China for 5,000 years to primarily add nitrogen into the soil as part of crop rotation. Fat-free soybean meal is a primary, low-cost, source of protein for animal feeds and most prepackaged meals; vegetable oil is another valuable product of processing the soybean crop [1](Mian N. Riaz, 2006). Recent research has shown that a small amount of nutrients, particularly Zn, Fe and Mn applied by foliar spraying increases significantly the yield of crops [2,3](Sarkar et al., 2007; Wissuwa et al., 2008). Among the micronutrients, Zn and Fe nutrition can affect the susceptibility of plants to drought stress [4, 5, 6](Sultana et al., 2001; Khan et al., 2003, Cakmak, 2008). Iron (Fe) enters many plant enzymes that play dominant roles in oxidoredox reactions of photosynthesis and respiration. Iron participates in content of many enzymes: Cytochromes, ferredoxine, Superoxide Dismutase (SOD), Catalase (CAT), peroxidase and nitrate reductase. The deficiency of Fe in plants causes significant changes in the plant metabolism and induces chlorosis, especially in young leaves and leads to very low reutilization. Manganese (Mn), in turn, is regarded as an activator of many different enzymatic reactions and takes part in photosynthesis. Manganese activates decarboxylase and dehydrogenase and is a constituent of complex PSII-protein, SOD and phosphatase. Deficiency of Mn induces inhibition of growth, chlorosis and necrosis, early leaf fall and low reutilization. Zinc (Zn) is an essential trace element for every living organism. About 200 enzymes and transcription factors require Zn as a functional component [7](Kabata-Pendias and Pendias, 1999). Zinc is known to have an important role either as a metal component of enzymes or as a functional, structural or regulatory cofactor of a large number of enzymes [8] (Grotz and Guerinot, 2006). This element plays an important role in protein and carbohydrate synthesis and takes part in metabolism regulation of saccharides, nucleic acid and lipid metabolism. One of the first symptoms of Zn deficiency is an inhibition of cell growth and proliferation. Zinc affects growth of shoots and roots and growth symptoms of Zn toxicity in plants, generally, are similar to those of Zn deficiency. The toxic concentrations of Zn negatively affect photosynthetic electron transport and photophosphorylation and have an effect on the photosynthetic enzymes. One of the primary mechanisms of Zn toxicity may be an increased permeability of root membranes, which will cause nutrients to leak out from the roots [7](Kabata-Pendias and Pendias, 1999). Application of microelements fertilizers can enhance plants resistance to environmental stresses and caused in produced potential yield [6] (Cakmak, 2008**).** On the basis of our knowledge, information regarding application method efficiency of zinc, iron and manganese on the growth and development of soybean is scarce available. Therefore, the purpose of this study is to understand the effect of microelements on yield and yield components of soybean.

2. Material and Methods

This experiment was conducted in agricultural investigation center of Miandoab (1371m above sea level, longitude of 36° 9" East and latitude 36° 58" North). Annual rain average of experimental area is 298mm. The land was ploughed in autumn. After preparation of experimental unit, treatments, Zinc (0, 20 and 40kg/ha), Iron (0, 25 and 50kg/ha) and Manganese (0 and 40kg/ha) were arranged as factorial based on randomized complete block design with three replications. Plots were 12 meter squares include planting row in 60cm and 7.5cm intra row distance. The number of pods and nods per main and sub stems, seeds per pod, seed weight per plant, thousands seeds weight, were measured. To determine these characteristics, we have five plants in each plot. For measuring seed and biological yield we harvest 2 meter squares of experimental plots. Harvest index, the ratio of seed yield to biological yield was calculated, too. Data analysis of variance was done by MSTATC software based on randomized complete block design.

3. Results and Discussion

Results of analysis of variance showed that the effect of Mn and Zn on seed yield was significant (*P*<0.01) but effect of Fe on seed yield was non-significant (Table 1). The highest yield of seed (3398kg/ha) was obtained from 40kg/ha Zinc, that had no significant difference with 20kg/ha Zinc. The lowest seed yield (2957kg/ha) was obtained from control treatment (Fig. 1). However the highest (3367kg/ha) and lowest (3087kg/ha) seed yield were obtained from 40kg/ha Mn and control treatment, respectively (Fig. 1). Sharma and Misra [9] (1997) and [10]Graves and et al (1981) emphasized on the crescent effects of Mn and Zn elements on seed yield of soybean. [11] Bhanavase et al (1995) showed that consumption 25kg/ha $FeSO_4$, $ZnSO_4$ and $MnSO_4$ produced the highest biological yield, seed weight and seed yield because of increasing leaves chlorophyll content and increasing photosynthesis in plant. Shanon et al (1992) [12] found that using of different levels of phosphorus associated with a combination of macro and micronutrients including 25kg/ha Manganese, 33kg Solphour, 2,5kg Zinc, 2kg Berliuom, 2kg Manganese, 1kg Cupper, 0.2kg Boor, 0.2kg Iron in hectare with a significant effect on yield component causes the increasing of soybean seed yield.

Biological yield

Results showed that Iron, Manganese and Zinc had significant effects (*P*<0.01) on biological yield. Means comparison indicated that the greatest biomass (7447kg/ha) was obtained from 40kg/ha Zinc application. The biomass produced at 20kg/ha of Zinc (7170kg/ha) was same with the greatest amounts. Whereas the smallest biomass (6562kg/ha) was obtained from control treatment (0kg/ha zinc). However the greatest biomass (7359kg/ha) belonged to 50kg/ha of Iron, same with produced biomass (7183kg/ha) of 250kg/ha Iron. The smallest biomass yield (3047kg/ha) produced at control treatment (0kg/ha Iron). In Manganese application, the greatest (7387kg/ha) and the smallest (6732kg/ha) were obtained at 40 kg/ha of Mn and control treatment of manganese application, too. Singh et al (1993) [13] and Naik (1984) [14] confirmed these results. These results have conformity with the results obtained from Singh and Shah's study (1990) [15]. Khamparia (1996) [16]indicated that consuming 6kg/ha Zn caused in the higher plant, maximum number of pod and biological yield of soybean. Singh [17] (1997) reported that 0-20 mg/kg soil Mn consumption till 10 mg/kg soil lead to higher biomass of soybean (Fig. 1).

Yield components

The numbers and weight of pods per plant were affected by Iron, Zinc and Manganese, significantly (Table 1). The highest number of pods per plant (37.28) and pods weight per plant (24.24g) was obtained at 40kg/ha of Zinc, followed by 20kg/ha and control treatment of Zn. The lowest number of pods (33.57) and pods weight per plant (21.65g) belonged to control treatment (0kg/ha zinc). This reducing trend observed of Iron application, so that highest number (37.37), pods weight per plant (23.81g) and lowest number of pods per plant (33.61), pods weight per plant (21.93g) were obtained at 50 and 0kg/ha of Fe, respectively. In Manganese application the highest pods per plant (37.03) and pods weight per plant (24.203g) produced at 40kg/ha Mn compared with control treatment of Mn in values 34.68 and 22.073g, respectively (Fig. 1).

Seed weight per plant

Analysis of variance showed significant ($P<0.01$) effect of Iron, Zinc and Mn on seed weight per plant (table 1). The minimum seed weight per plant (21.65g) was obtained from control treatment (0kg/ha Zn). The seed yield had an increasing trend with Zinc application, so that 20 and 40kg/ha of Zn caused in higher amounts of seed weight (15.36 and 15.83g, respectively). This increasing trend in yield occurred at Iron applications and 50kg/ha produced the minimum (21.93g) and maximum (23.81gr) seed weight per plant, respectively (Fig. 1). However 40kg/ha of manganese produced the higher seed yield (24.203gr) compared with control treatment (0kg/ha Mn), (Fig. 1). Agraval et al (1996)[18] declared that consuming 0-20kg/ha Zn caused in highest number of nod, number and weight of seed per plant, seed yield and harvest index in soybean. Parker et al (1981) [19] reported that the 11.2- 22.4kg/ha Mn led to higher seed yield about 27% compared with control in soybean. Iron, Zinc and Mn increased seed yield of soybean (Hejazi et al 1990)[20]. Considering the results of this study 25kg/ha Fe, 40kg/ha Zn and 40kg/ha Mn produced the highest seed yield and biomass. These results were obtained because of the highest amount of yield components.

Zinc plays an important role in the production of biomass (Kaya and Higgs, 2002; Cakmak, 2008)[6,21]. Furthermore, zinc may be required for chlorophyll production, pollen function and fertilization (Kaya and Higgs, 2002; Pandey et al., 2006) [21,22]. Low solubility of Zn in soils rather than low total amount of Zn is the major reason for the widespread occurrence of Zn deficiency problem in crop plants. High seed-Zn has very important physiological roles during seed germination and early seedling growth (Cakmak, 2008)[6]. The review by Cakmak (2008)[6] provides further reasons and relevant research for benefits of high seed-Zn on plant growth. As an activator of Zn- or Mn-SOD, zinc or manganese is involved in membrane protection against oxidative damage through the detoxification of reactive oxygen species (Marschner, 1995) [23].

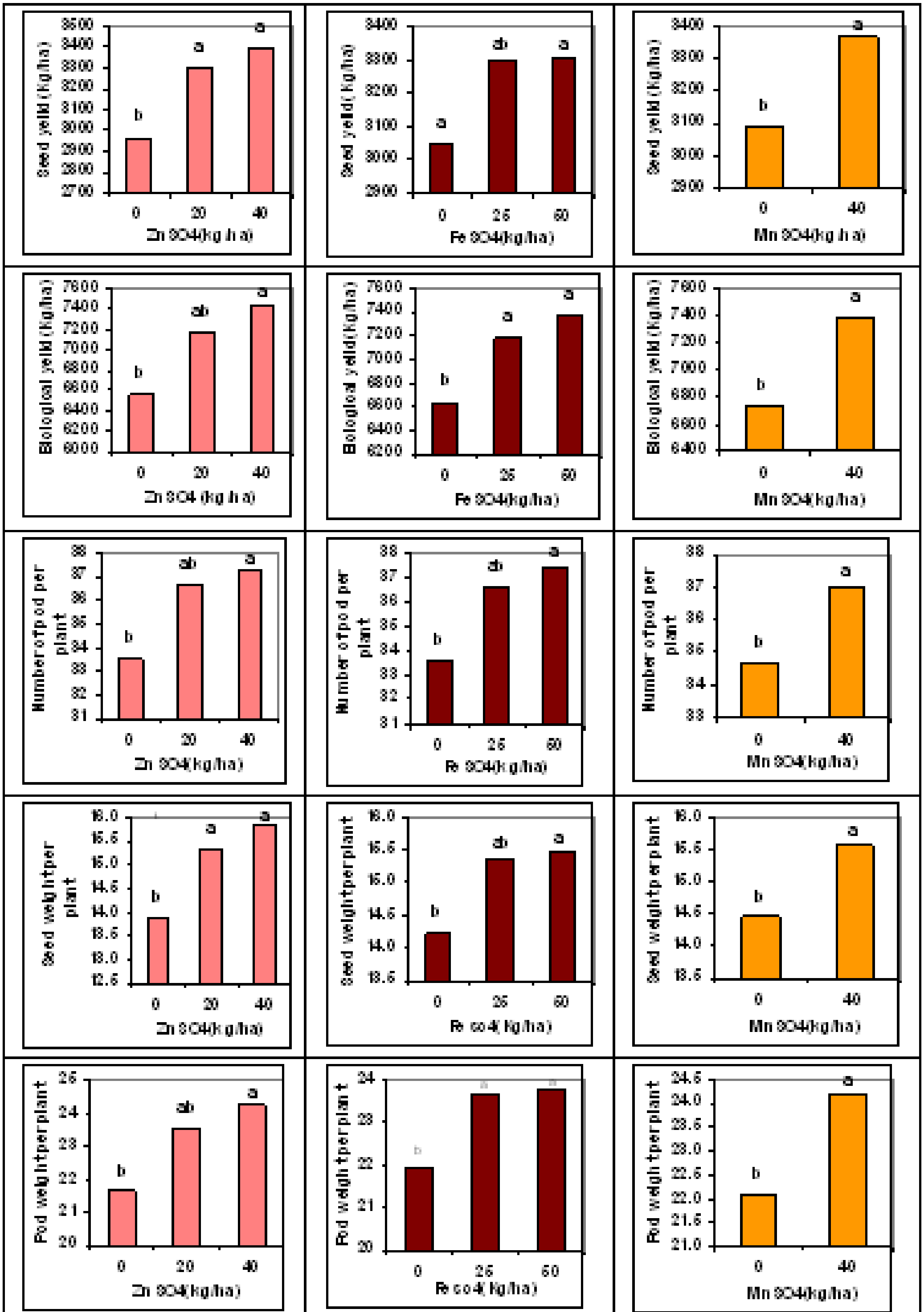

Fig. 1. Means of Seed yield, biological yield, numbers of pod per plants, seed and pod weight per plant affected by Zinc, Iron, and Manganese. The same letters showed non-significant differences.

Iron plays essential roles in the metabolism of chlorophylls. External application of Fe increased photosynthesis, net assimilation and relative growth in seawater-stressed rice (Sultana et al., 2001)[4]. This is especially true for soils of high pH where equilibrium conditions favor the oxidation of plant-available Fe^{+2} to unavailable Fe^{+3}. Plant yield on many soils is, therefore, limited by poor Fe availability, rather than a low Fe content in the soil. Also Fe leaching is the main pathway for Fe loss in coarse-textured soil with high pH, while excessive Fe uptake was the main pathway for Fe loss in clay-textured and acid soil. Application of Zn or Fe has been reported significant positive effects, in most cases, on growth measurements and chemical composition of safflower (Lewis and McFarlane, 1986)[24], lupine (Brennan, et al., 2001) [25], cumin (El-Sawi and Mohamed, 2002) [26], soybean (Gadallah, 2000; Heitholt et al., 2002) [27,28], barley (Genc et al., 2004; Hebbern et al., 2005) [29,30], wheat (Lu et al., 2004) [31], sunlower (Mirzapour and Khoshgotar, 2006) [32], mustard (Chatterjee and Khurana, 2007) [33], common bean (Fernandes et al., 2007) [34] and rice (Wissuwa et al., 2008) [3]. Even though iron is one of the most abundant elements in soils, the low solubility product of iron minerals makes the inorganic form of iron unavailable to plants and forms the most common widespread nutritional disorder world over (Welch et al., 1991) [35]. Plants subjected to iron deficiency excess respond in different ways (Abadia, 1992) [36]. It is believed that under conditions of iron stress, some plants can increase their absorption capacity for iron. The mechanism affecting the acquisition of this essential microelement is often present in aerobic soils in the form of Fe (Marschner, 1995)[23].

Table 1: Analysis of variance of yield and yield components affected by Iron, Zinc and Manganese in soybean

Treatments	df	yield		Number of pod per plant	Seed weight per plant	pod's weight per plant
		Seed	Biomass			
Replication	2	1375008.722**	9472377.732**	191.716*	19.069**	34..373*
Fe	2	390580..222	2551287.167*	70.729	8.698**	19.792
Zn	2	956444.677**	369206.056**	72.116	19.224**	32. 257*
Fe×Zn	4	21417.222	339052. 222**	2.298	0.332	2.675
Mn	1	907926.000**	579904.741	74.436	16.745**	61.269**
Fe×Mn	2	8518. 222	35999.796	1.407	0.131	0.337
Zn×Mn	2	122960. 677	25752052/643*	6. 972	0.198	10.793
Fe×Mn×Zn	4	128031.722	737453. 519	8.216	2. 254	9.433
Error	34	123730.742	605109. 095	23. 390	2. 002	6. 299

* and ** significant at 0.05 and 0.01 probability, respectively
df, degree of freedom

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