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SOYBEAN AS AFFECTED BY ZN, FE, AND MN FERTILIZATION (II): ECONOMIC YIELD, BIOLOGICAL YIELD AND HARVEST INDEX

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ABSTRACT

In order to investigate the effects of micronutrients on economic yield, biological yield and harvest index in soybean, an experiment was conducted in a factorial based on randomized complete block design with three replications in Kermanshah at 2010-2011. In this study, treatments includes: three level of Zn (0, 20, and 40 $kg.ha^{-1}$), Fe (0, 25, and 50 $kg.ha^{-1}$), and Mn (0, 20, and 40 $kg.ha^{-1}$). At harvesting time, in order to calculate final and biological 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. Harvest index was obtained by dividing economic yield by biological yield multiplied by 100. Based on results obtained zinc, iron and manganese had significantly effects on economic yield and biological yield ($P<0.01$). While, manganese had no significantly effect on harvest index. The results shown that Increase in grain yield up to 12.1, 10.3, and 36.4 percent were recorded by 40 kg Zn ha^{-1}, 25 kg Fe ha^{-1}, and 40kg Mn ha^{-1}. Zinc, iron and manganese interactions showed that, maximum grain yield and biological yield were obtained by using 40, 25 and 40 kg Zn, Fe, and Mn per hectare, respectively. Also, maximum harvest index was achieved with 20 kg zinc, 50 kg iron and 0 kg manganese.

Keywords: Iron, Manganese, Soybean, Yield Components, Zinc; Soybean as affected by Zn, Fe, and Mn fertilization; (II): Economic yield, Biological yield and Harvest index

INTRODUCTION

The shares of oilseeds as one of the most important agricultural products in order to suply human nutritional needs are increasing, and Soybean is a major source of vegetable oil and protein for human consumption. In the other side, plant nutrition is one of the most important factors in improving the quality and quantity of soybean product. For optimum soybean growth, all necessary elements must be adequately provided. Among the micronutrients, zinc, iron and manganese have a particular importance. Deficiencies of zinc [1 and 2], iron [3 and 4], and manganese [5 and 6] are major factors limiting crop yield in calcareous soils in the world. Application of micronutrients can be improved photochemical processes and increase chlorophyll concentration, which will be accompanied by increased quality and quantity of crop production [7]. [8] and [9] emphasized that harvest index improved by fertilization and there is positive correlation between harvest index and economic yield of dry bean. Based on [10] results, application of 20 mg Mn kg^{-1} soil are increased economic and biological yield in soybean. A similar results was obtained by [11]. [12] and [13] reported that using iron, zinc and manganese simultaneously is more effective in increasing grain yield than using them individually. Therefore, the objective of this study is to evaluation the effect of zinc, iron, and manganese (individually, and combination) on economic yield, biological yield and harvest index of soybean in western parts of Iran.

MATERIALS AND METHODS

Two field experiments were done at the research field of the Islamic Azad University of Kermanshah (34°23′ N, 47°8′ E; 1351 m elevation), Iran in years 2010 and 2011. Every year, Williams [*Glycine max* (maturity group III), supplied by the oilseed company of the Kermanshah Agricultural Administration, Iran], was selected as the experimental material. Soil samples were collected from experimental area at 0-30 cm depth. The results of soil analysis are shown in Table (1). The experimental design was a 3 × 3 × 3 factorial experiment based on randomized complete block (RCBD) with three replicates. Before planting of soybean, fertilizers were used as follows: 200 kg P2O5/ha and 50 kg N/ha and mixed with soil and land was ploughed once and harrowed twice.

Table 1: Soil characteristics of experimental location

Soil properties	2010	2011
Soil texture	Silty clay	Silty clay
Sand (%)	13	10
Clay (%)	41	41
Silt (%)	46	49
Organic matter (%)	2.3	2.1
pH	7.6	7.4
Electrical conductivity (dS/m)	0.61	0.52
N (%)	0.18	0.14
P (ppm)	9.9	10.1
K (ppm)	563	389
Zn (mg/kg)	0.71	0.83
Fe (mg/kg)	6.2	3.6
Mn (mg/kg)	4.3	4.0

Soybean seed was inoculated with *Bradyrhizobium japonicum*. This experiment included 27 treatments that were placed in 81 plots. The plots consisted of six rows, 5 m in length spacing 60 cm apart. The distance between plants within a row was 5 cm and plant density was 333000 plants/ha. The plant density was achieved by over planting and thinning at V3 stage. Usage amounts of fertilizers zinc (0, 20 and 40 kg/ha from ZnSO4 source), iron (0, 25 and 50 kg/ha from FeSO4 source) and manganese (0, 25 and 40 kg/ha from MnSO4 source) were calculated based on plots area surface; next, fertilizers were mixed with soft soil at the ratio of 1: 5 and placed on furrows made manually next to the stacks. The plots were irrigated when necessary to avoid water deficits. At the end of growing season (R8: harvested time) based on [14], in order to calculate final yield, a 1-m^2 area from each plot were completely harvested considering the sides. Weight 13% deduction of moisture, grain dry weight was calculated and considered as economic yield. To determine biological yield, total plant dry weight was employed as biological yield. Harvest index was obtained by dividing economic yield by biological yield multiplied by 100. MSTATC software was used for statistical analysis. Combined variance analysis was performed after Bartlet test for checking uniformity of data variance (*P=0.05*) on targeted traits. LSD (Least Significant Difference Test) was used to compare means and finally, Excel software was applied to construct diagrams.

RESULTS AND DISCUSSION

The results of analysis variance of economic yield, biological yield and harvest index of soybean at 2010 and 2011years was showed in Table (2). Based on results obtained zinc, iron and manganese had significantly effects on economic yield and biological yield (*P<0.01*). Also, manganese fertilization had significantly effects economic and biological yield (*P<0.01*), but in these conditions manganese had no significantly effect on harvest index in soybean. Economic yield *(P<0.05)*, biological yield *(P<0.01)*, and harvest index *(P<0.01)* affected by Zinc iron interaction effect (Zn×Fe). In our trial conditions all of evaluated traits affected by zinc and manganese interaction effects at 1% levels (Table 2). In addition, except for economic yield, other traits were affected by iron and manganese interaction effect (Fe×Mn). Triple interaction effects (Zn×Fe×Mn) had no effects on economic yield and harvest index and had significantly effect on biological yield at 1% levels (*P<0.01*). The effect of Zinc, iron and manganese (individually) on soybean economic yield were shown in Figure (1). The economic yields of soybean in different zinc levels application are varied by 3008 kg ha^{-1} in Zn_0 to 3372 kg ha^{-1} in Zn_{40} treatment (12.1%). The effect of zinc application on yield of cotton [15] and canola [16] were emphasized. While the highest economic yield in different levels of iron application was belonged to Fe_{25} treatment (3317 kg ha^{-1}) and in excess amount of iron (Fe_{50}), economic yield decreased (3263 kg ha^{-1}). Indeed, application of 25 kg Fe ha^{-1} economic yield increased by 10.3%. These results are in line with those of [17] and [18]. Manganese application had the most impact on economic yield of soybean and increased this trait up to 33.4% compared check treatment (Mn_0). Appling manganese caused increases economic yield from 2656 kg ha^{-1} to 3542 kg ha^{-1} (Mn_0 compared Mn_{40}). [19] and [20] reported that manganese application had significantly effect on sunflower economic yield. These results were shown that the response of economic yield of soybean to Fe used was different with Zn and Mn applications (Fig 1). The response of biological yield and harvest index to Zn, Fe, and Mn fertilization treatments were showed in Figure (2). The highest values of biological yield were recorded with Zn_{40}, Fe_{25}, and Mn_{40} treatments. Applying 40 kg Zn ha^{-1} increases biological yield up to 7635 kg ha^{-1} compared check treatment (7124 kg ha-1). Also, 40 kg Mn ha^{-1} was caused increases biological yield by 29.3% compared Mn0 treatment. Whereas, the highest biological yield was obtained in Fe_{25} and with excess amount of Fe (Fe_{50}) this trait reduced. In contrast, comparison of harvest index among different levels of Zn, Fe, and Mn showed that applying 20 kg zinc, 50 kg iron and 0 kg manganese reaches maximum harvest index (Fig 2). In this experiment, the effect of zinc fertilization on harvest index was more than the other evaluated micronutrients. The results of zinc used at different levels of iron on economic yield, biological yield and harvest index were shown in Figure (3). Based on results obtained, zinc applied up to 40 kg ha^{-1} in levels of 0 and 25 kg Fe ha^{-1} increases economic yield, but this increase for $Zn_{40}Fe_{50}$ treatment was slightly. Therefore, the highest economic yield of soybean was obtained by 40 and 25 kg ha^{-1} zinc and iron, respectively (3359 kg ha^{-1}). [21] Stated that simultaneous application of zinc and iron had the more impact on grain yield compared individually were used. Also, maximum biological yield was recorded in Zn_0Fe_{25} treatment by 7693 kg ha^{-1}. While, the highest harvest index was achieved in $Zn_{20}Fe_{25}$ treatment by 44.95% (Fig 3). Evaluation of interaction effect of zinc and manganese (Figure 4) indicated that application of 40 kg zinc and 40 kg manganese as combined resulted in the highest economic yield, whereas maximum biological yield was obtained in 20 kg Zn and 20 kg Mn treatment. In the other side, 20 kg zinc and 0 kg manganese per ha enhanced harvest index up to 44.61% (Fig 4). Results of interaction effects of iron and manganese on evaluated traits are presented in Figure (5). Results indicated that increasing the rates of Fe and Mn fertilizations from 0 to 25 kg Fe ha^{-1} and 0 to 20 kg Mn ha^{-1} has stimulated of additional economic yield of soybean and with excess amount of Fe applied the yield is reduced. Moreover, Mn fertilization of 40 kg Mn ha^{-1} in different levels of iron has decreased significantly economic yield. Many researchers in previous studies emphasized that application of excessive amounts of zinc, iron and manganese will be adversely effects on soybean yield [22 to 24]. Response of economic yield was more obvious at different levels of iron application than the manganese fertilizer treatments. The highest biological yield and harvest index were belonged to $Fe_{25}Mn_{20}$ and $Fe_{50}Mn_0$ treatments, respectively (Fig 5). Drastic decrease in biological yield was observed in Mn0 treatment, while the lowest harvest index was recorded with application of 40 kg Mn ha^{-1} in control treatment of iron (Fe_0).

CONCLUSION

These results indicated that response of economic yield to zinc and manganese fertilizer applications were similar to biological yield. Indeed, increasing the rates of zinc and manganese fertilization from 0 to 20 and 40 kg ha^{-1} has stimulated the production of additional economic and biological yield. In contrast, responses of economic and biological to iron applications were varied. Excessive amount of iron from 25 to 50 kg Fe ha^{-1} were declined economic and biological yield. Furthermore, the highest harvest index was obtained with small amounts of zinc and iron application treatments. The economic yield was reduced severely when that 40 kg Zn ha^{-1} and 50 kg Fe ha^{-1} were applied, simultaneously. Therefore, in our experiment there are antagonistic effects between zinc and iron concerning economic yield.

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REFERENCES

[1] Erenoglu B, Nikolic M, Römheld V and Cakmak I, Uptake and transport of foliar applied zinc (65Zn) in bread and durum wheat cultivars differing in zinc efficiency. *Plant and Soil*., 241, 2002, 251–257.

[2] Rosolem CA, Sacramento LVS and Oliveira DMT, Kinetics of zinc uptake and anatomy of roots and leaves of coffee trees as affected by zinc nutrition. *J Plant Nutr*., 28, 2005, 2101– 2112.

[3] Lucena JJ and Chaney RL, Response of cucumber plants to low doses of different synthetic iron chelates in hydroponics. *J Plant Nutr*., 30, 2007, 795-809.

[4] Zocchi G, De Nisi P, Dell'Orto M, Espen L and Gallina PM, Iron deficiency differently affects metabolic responses in soybean roots. *J. Exp. Bot*., 58, 2007, 993–1000.

[5] Ducic T and dolle A, Transport and detoxification of manganese and copper in plants. *Brazilian J. Plant physiol*., 17, 2005, 103-112.

[6] Rosas A, Rengel Z and Mora ML, Manganese supply and pH influence growth, carboxylate exudation, and peroxidase activity of ryegrass and white clover. *J Plant Nutr*., 30, 2007, 253-270.

[7] Sverdlova EL and Markarov AM, Effect of foliar application on development of maize subject to soil moisture stress. Nokotorye Voprosy Sovremennogo Estettvonamixa (Abstract). 1971.

[8] Snyder FW and Carlson GE, Selecting for partitioning of photosynthetic products in crops, *Adv. Agron*., 37, 1984, 47-72.

[9] Fageria NK, Barbosa Filho MP and Da Costa JGC, Potassium use efficiency in common bean genotypes, *J. Plant. Nutri*., 24, 2001, 1937-1945.

[10] Shahnon DA, Kueneman EA, Wright MJ and Wood GW, Fertilization effects on soybean grown and yield in the southern Gainea Savanna of Nigeria. *J Plant Nutr*., 15, 1992, 639-658.

[11] Singh V, Effect of phosphorous and manganes on yield, concentration and uptake of nutrients by soybean. *Ann Agric Res*., 18, 1997, 254-257.

[12] Abdolsalam AA, Ibrahim A H and Elgarhi AH, Comparative of application or foliar spray or seed coating to maize on a sand soil. *Ann Agric Sci Moshthor*. 32, 1994, 660-673.

[13] Sankarnarayanan K, Spraharaj C, Nalayini P, Bandypadyay KK and Gopalakrishnan N, Effect of magnesium, zinc, iron and boron application on yield and quality of cotton (*Gossypium hirsutum*). *Indian J Agric Sci*., 80(8), 2010, 699–703.

[14] Fehr WR and Caviness CE, *Stages of soybean development*, Spec, Rep, 80, Iowa State Univ, Ames, 1977.

[15] Liagat A, Mushtaq A and Qamar M, Effect of application of zinc and boron on seed cotton yield and economics in cotton-wheat cropping pattern. *J. Agric. Res*., 49(2), 2011, 173-180.

[16] Grant CA and Bailing LD, Fertility management in canola production. *Canadian J Plant Sci*., 73, 2000, 65-76.

[17] Sajedi NA, Ardakani MR, Naderi A, Madani H and Mashhadi ABM, Response of Maize to Nutrients Foliar Application Under Water Deficit Stress Conditions. *Am. J. Agric. Biol. Sci*. 4(3), 2009, 242-248.

[18] Heidari M, Galavi M and Hassani M, Effect of sulfur and iron fertilizers on yield, yield components and nutrient uptake in sesame (*Sesamum indicum* L.) under water stress. *African J Biotech*., 10(44), 2011, 8816-8822.

[19] Jabeen N and Ahmad R, Effect of foliar applied boron and manganese on growth and biochemical actives in sunflower under saline conditions. *Pak. J. Bot*., 43(2), 2011, 1271-1282.

[20] Ebrahimian E and Bybordi A, Effect of Iron Foliar Fertilization on Growth, Seed and Oil Yield of Sunflower Grown under Different Irrigation Regimes. *Middle-East J Sci Res*., 9(5), 2011, 621-627.

[21] Maralian H, Effect of foliar application of Zn and Fe on wheat yield and quality. *African J Biotech*., 8(24), 2009, 6795-6798.

[22] Roomizadeh S and Karimian N, Manganese–Iron.reationship in soybean grown in calcareous, soils. *J Plant Nutr*., 19, 1996, 397-406.

[23] Halvin JL, Beaton J D, Tisdale SL and Nelson WL, Soil Fertility and Fertilizers: An Introduction to Nutrient Management, 6th Ed.; Prentice Hall: Upper Saddle River, N. J. 1999.

[24] Khudsar T, Arshi A, Siddiqi TO, Mahmooduzzafar and Iqbal M, Zinc-Induced Changes in Growth Characters, Foliar Properties, and Zn-Accumulation Capacity of Pigeon Pea at Different Stages of Plant Growth. *J Plant Nutr.*, 31(2), 2008, 281–306. DOI: 10.1080/01904160701853894.

Table 2: Analysis of variance of economic yield, biological yield and harvest index of soybean at 2010 and 2011years

Source of variation	MS			
	df	Economic yield	Biological yield	Harvest index
Year (Y)	1	48540.00^{ns}	7971.65^{ns}	2.54^{ns}
Zn	2	1787978.39**	3716043.30**	97.05**
Y×Zn	2	293105.05*	163914.75^{ns}	1.22^{ns}
Fe	2	1491700.79**	8503370.15**	10.03**
Y×Fe	2	192771.66^{ns}	126049.68^{ns}	1.99^{ns}
Zn×Fe	4	241284.61*	1776616.21**	8.82**
Y×Zn×Fe	4	196598.67^{ns}	437720.08**	2.96^{ns}
Mn	2	12089860.73**	56410253.80**	5.01^{ns}
Y×Mn	2	84955.01^{ns}	110140.06^{ns}	1.52^{ns}
Zn×Mn	4	1050982.79**	5152661.19**	8.83**
Y×Zn×Mn	4	45643.82^{ns}	154380.21^{ns}	0.18^{ns}
Fe×Mn	4	87319.34^{ns}	448029.44**	10.52**
Y×Fe×Mn	4	50710.03^{ns}	100552.78^{ns}	0.94^{ns}
Zn×Fe×Mn	8	138106.13^{ns}	717170.42**	3.03^{ns}
Y×Zn×Fe×Mn	8	176650.64*	151274.92^{ns}	1.11^{ns}
Error	104	86818.68	123626.06	2.02
Coefficient of variation (%)	-	9.22	12.79	5.28

-ns, * and **: non-significant, significant at 5% and 1% levels of probability, respectively

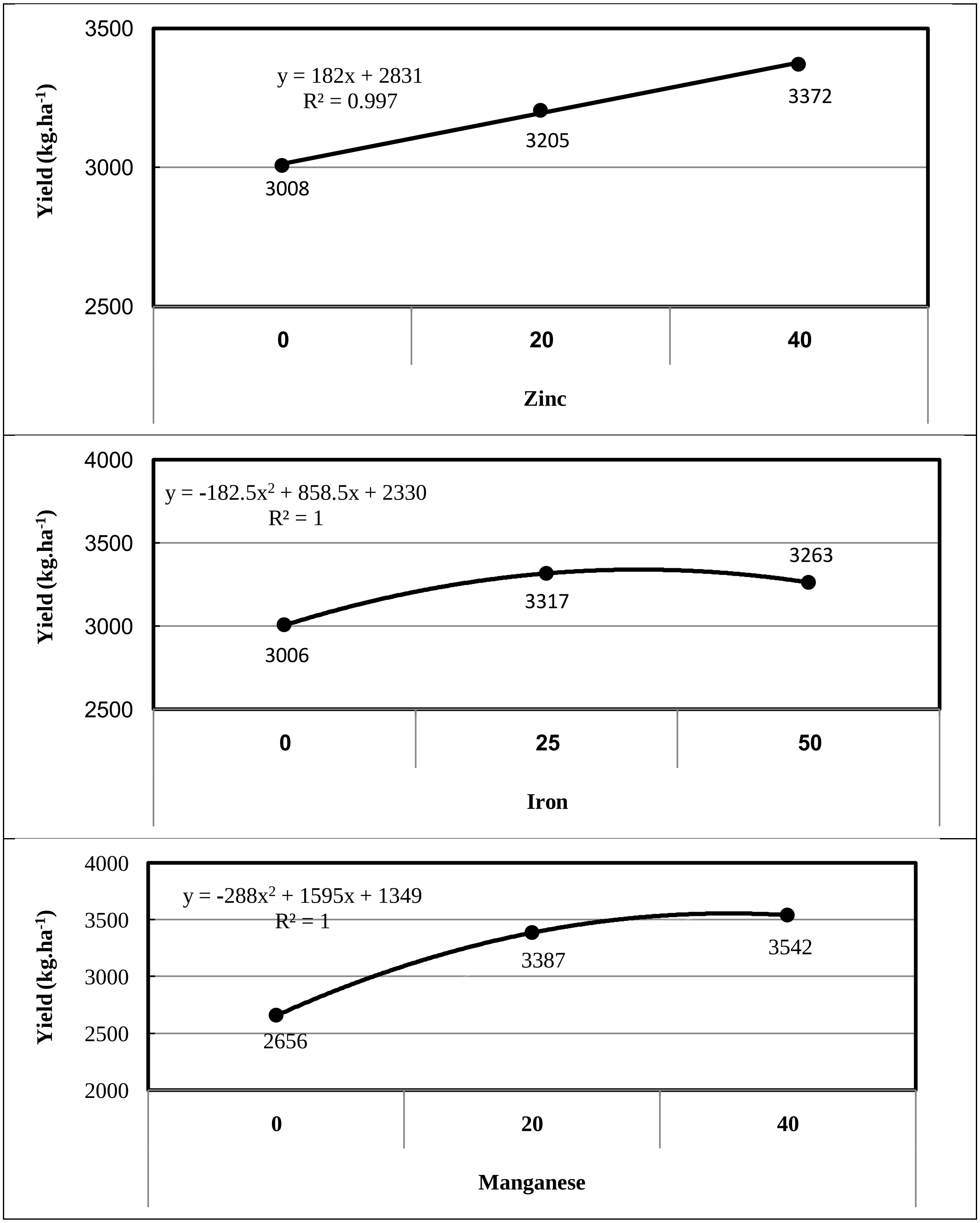

Figure 1: The effect of zinc, iron and manganese on soybean economic yield

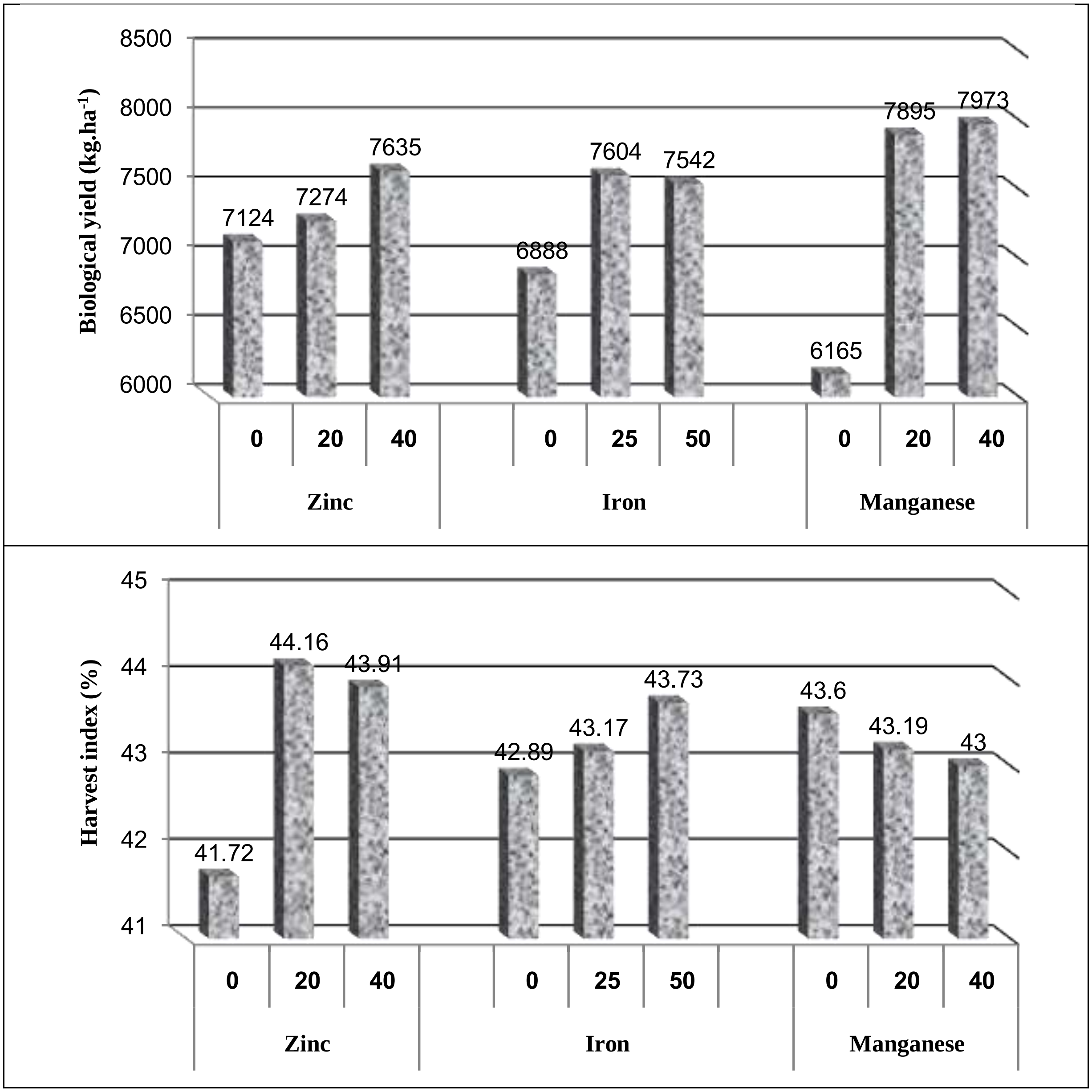

Figure 2: The effect of zinc, iron and manganese on Biological yield and harvest index

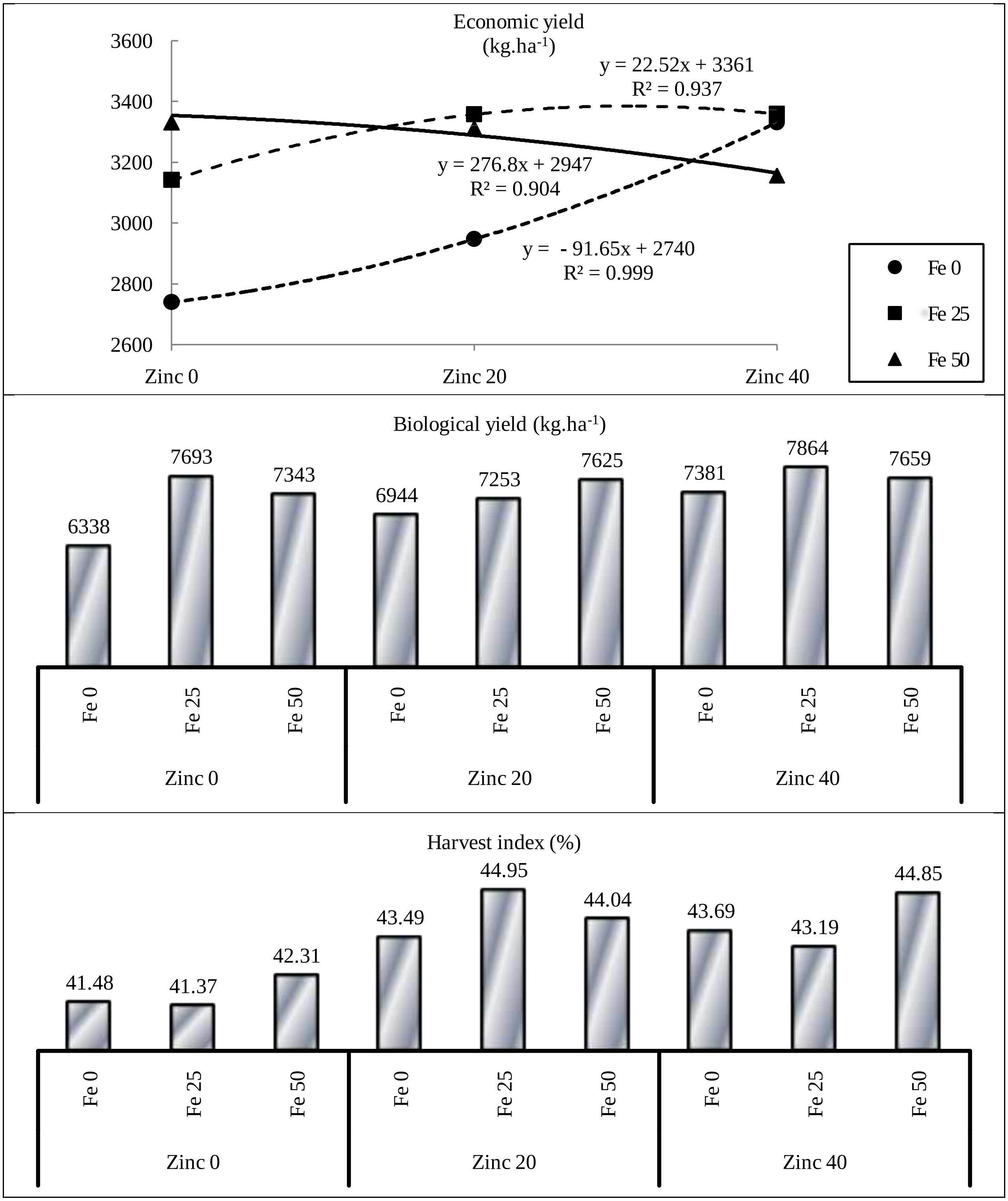

Figure 3: Economic yield, biological yield and harvest index of soybean affected by zinc and iron interaction

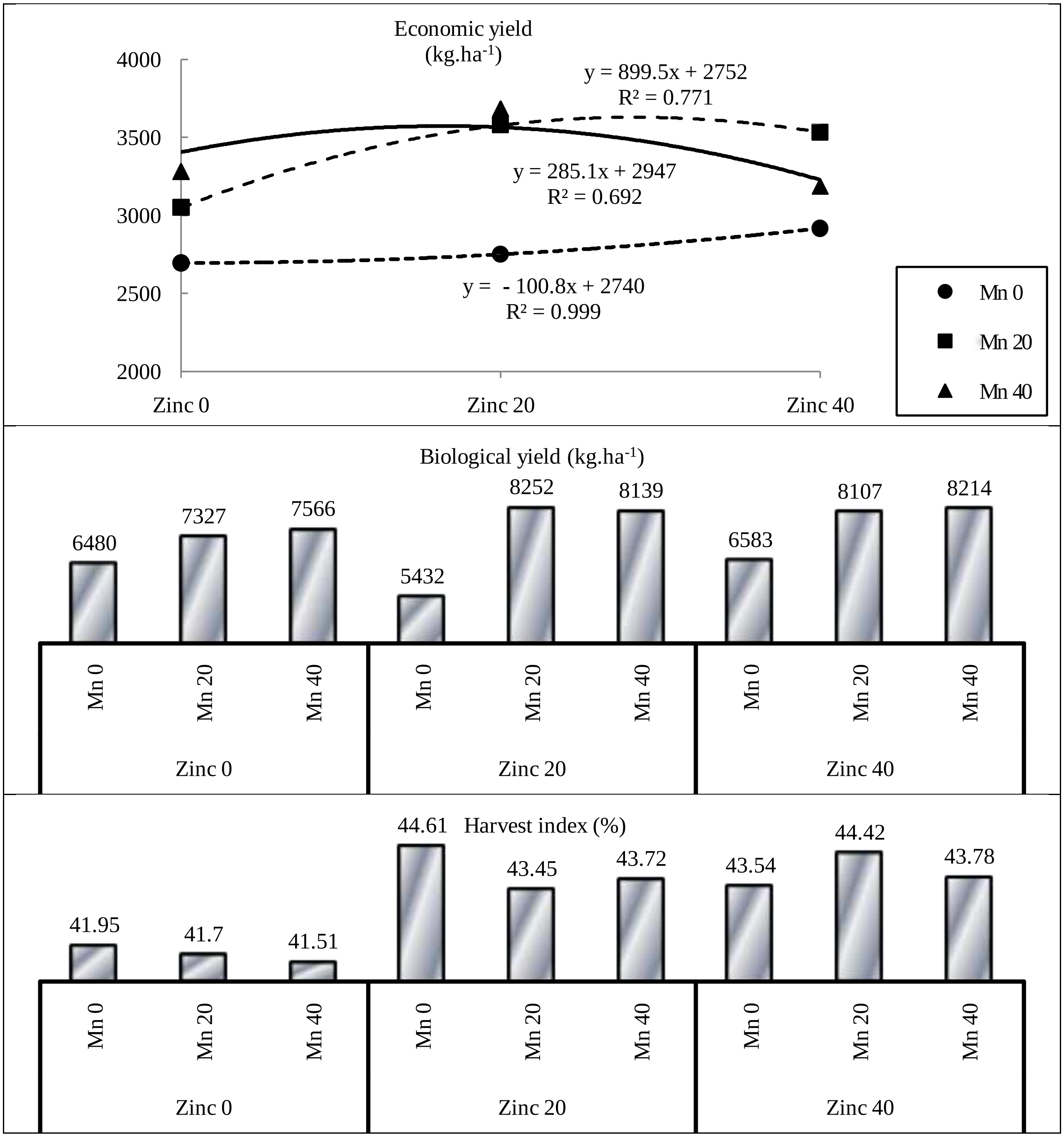

Figure 4: Economic yield, biological yield and harvest index of soybean affected by zinc and manganese interaction

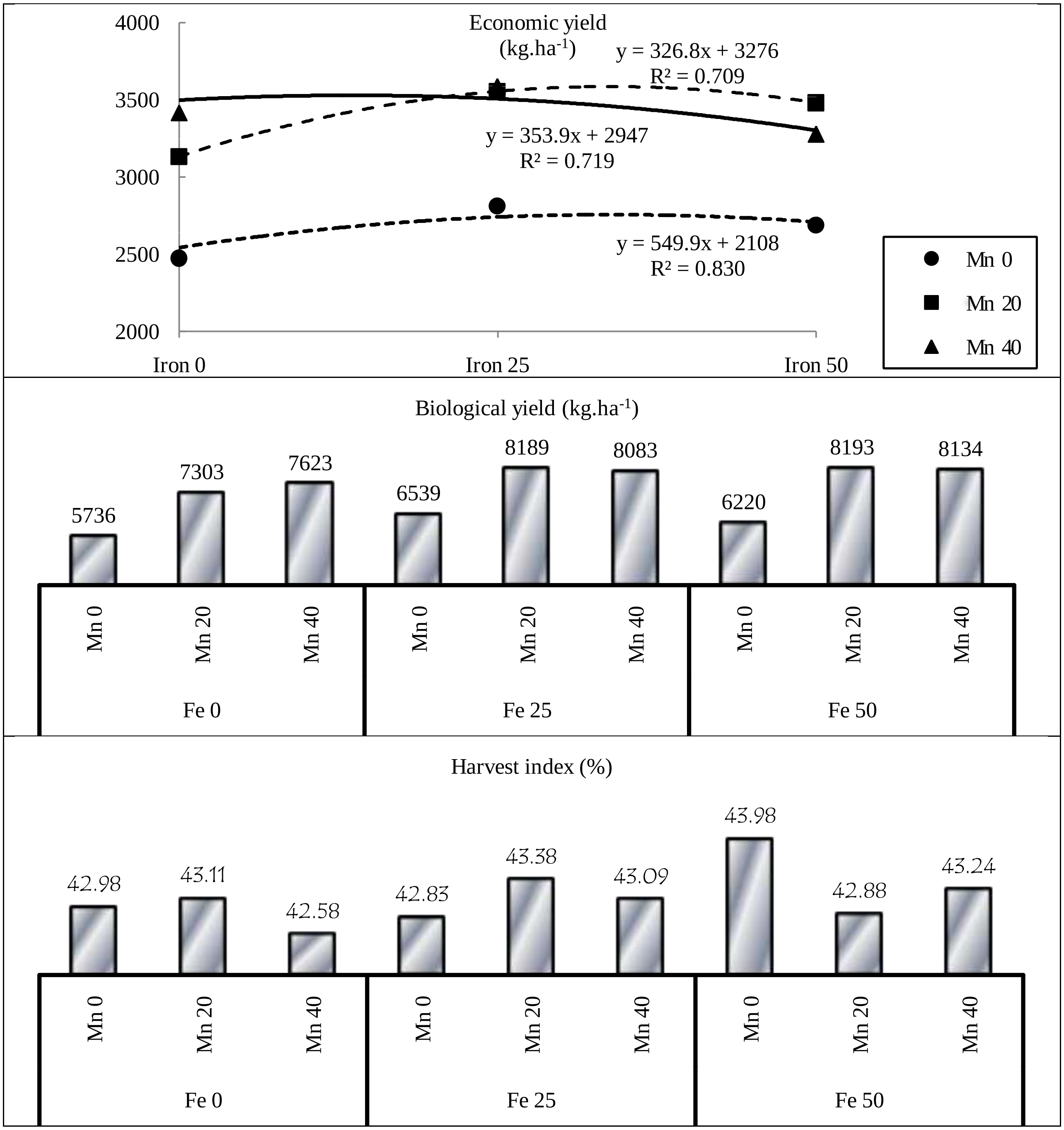

Figure 5: Economic yield, biological yield and harvest index of soybean affected by iron and manganese interaction