Study of the Effects of Micronutrient Application on the absorption of macro- and micronutrients in the Soybean Cultivar Telar in the North of Iran

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Abstract: In order to study the effects of applying the micronutrients zinc, boron, and manganese (which are added to the soil and sprayed on the crop) on the absorption of the macro- and micronutrients in soybean seeds, an experiment was carried out using the factorial design with the two factors of adding the micronutrients zinc, manganese, and boron to the soil and spraying them on the crop, with 16 treatments and four replications (a total of 64 trials). On the basis of the soil test which had been conducted, the required amounts of the micronutrients (40, 30, and 10 Kg.h of zinc sulphate, manganese sulphate, and boric acid, respectively) were added to the soil before seeding. In the spray treatments, zinc and manganese (0.30 %) and boron (0.20 %) were sprayed on the crop at the start of stem elongation a d at flower bud formation. Results of the comparison of the means showed that the highest concentration of nitrogen (6.65 %) and phosphorous (0.18 %) in the seeds were obtained when zinc was sprayed on the crop, the highest potassium concentration in the seeds (0.92 %) was achieved when manganese was added to the soil, and the highest zinc concentration in the seeds (52.5 ppm) was observed when zinc was applied to the soil. These results also indicated that, among the treatments of spraying the micronutrients on the crop, the highest manganese concentration in the seeds (24.77 ppm) was obtained when manganese was sprayed on the crop, that the highest boron concentration in the seeds(46.58 ppm) was achieved when boron was added to the soil (and that this boron treatment had a statistically significant difference with the others). Comparison of the interaction effects of the data showed that the highest seed nitrogen concentration (6.72 %) was observed when zinc was sprayed on the crop, that the highest seed phosphorous concentration (0.22 %) was obtained when boron was added to the soil, that the highest seed potassium concentrations (0.93 % and 0.94 %) were achieved when zinc and manganese were sprayed on the crop, respectively, that the highest seed zinc concentrations were observed by adding manganese to the soil plus spraying zinc on the crop (55.33 ppm) and by adding zinc to the soil plus spraying zinc on the crop(55 ppm), that the highest seed manganese concentration (23.67 ppm) was obtained by adding zinc to the soil plus spraying manganese on the crop or by adding manganese to the soil plus spraying boron on the crop, and, finally, that the highest seed boron concentrations (44 and 41.67 ppm) were achieved by spraying boron on the crop and by adding manganese to the soil plus spraying boron on the crop, respectively

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1. Introduction

Oil crops are among the important crop plants and their products form a part of daily food for people and feed for stock. Considering our population of 70 million, we need more than 1.1 million tons of edible oil each year. However, less than 14% of our annual oil consumption is produced in the country, and the rest must be imported from abroad (Anonymous, 2006).

Soybean (*Glycine max* [Merrill]) is one of the most important oil crops, and it has played an undeniable role in the production of edible oil in our country, especially in the province of Mazandaran. Soybean is planted in rotation after canola, wheat, and other fall crops, and produces a considerable quantity of good quality oil (seed oil content of 18 to 25%) and protein (seed protein content of 30 to 50 pp%) (Khajeh Pour, 2006). Optimal application of plant nutrients has a considerable role in increasing the yield of soybean, and in improving its quality and the quality of its oil. Zinc deficiency is one of the most important and widespread micronutrient deficiencies in the world, and it causes a reduction in the yield of crop plants (Grewal et al., 1997; Cakmak, 2000). Soybean is also sensitive to boron deficiency (Victor et al., 1990), and this micronutrient plays a very important role in soybean seed formation and in increasing its oil content (Grant and Baily, 1992). Soybean is very sensitive to manganese deficiency as well, a condition common in neutral and alkali soils with high pH, and manganese deficiency causes soybean plants to be short and to have yellow leaves. Alley et al. (2008) reported that manganese absorption by soybean and soybean seed and oil yields increase when manganese is added to the soil and sprayed on the crop; and that manganese deficiency has a negative influence on soybean seed oil content. Undoubtedly, optimal application of plant nutrients has a significant role in improving the yield and quality of soybean and of its oil. Since Mazandaran is the center of soybean production in the north of the country, the study of the way the application of micronutrients (added to the soil or sprayed on the crop) influences the absorption of macronutrients, such as nitrogen and phosphorous and potassium, and micronutrients, such as zinc and manganese and boron, is very important. Therefore, this study was conducted in the region of Dasht-e-Naz in Sari (in the province of Mazandaran) to investigate the effects of the application of the micronutrients zinc, manganese, and boron (and to compare the effects of their mode of application – i.e., whether they are added to the soil or sprayed on the crop) on the way macro- and micronutrients are absorbed by soybean.

2. Material and Methods

In order to investigate the effects of the application of zinc, boron, and manganese (added to the soil and sprayed on the crop) on the extent of absorption of macro- and micronutrients in soybean seeds, an experiment in the factorial design with the two factors of adding the micronutrients to the soil and of spraying them on the crop was conducted in 16 treatments with four replications (a total of 64 trials). The treatments were as follows: T1=control; T2= Zns; T3= Mns; T4= Bs; T5=Zns; T6=Zns+Bf; T7= Zns+Mnf; T8=Zns+Znf; T9=Mns; T10=Mns+Bf; T11=Mns+Mnf; T12=Mns+Znf; T13=Bs; T14+Bs+Bf ;T15= Bs+Mns ;T16=Bs+Znf. Based on the soil test carried out, the required amounts of the micronutrients (40, 30, and 10 Kg.h of zinc sulphate, manganese sulphate, and boric acid, respectively) were added to the soil before seeding. The spray treatments were carried out using zinc (0.3%), manganese (0.30%), and boron (0.20%) at the start of stem elongation and at flower bud formation. Leaf samples at flowering and seed samples at seed maturity were taken and sent to the laboratory for analysis and determination of the concentrations of the elements.

3. Results

Seed Nitrogen Concentration

Results of the analysis of the variance of the data showed that the effects of adding different levels of the micronutrients to the soil (Factor A), at five percent probability, and the effects of spraying different levels of the micronutrients on the crop (Factor B) and the interaction effects of adding the micronutrients to the soil and spraying them on the crop (AB), at one percent probability, on seed nitrogen percentage were significant (Table 1). Results of the comparison of the means indicated that, among the treatments of adding the micronutrients to the soil, the highest seed nitrogen concentration (6.57%) was achieved when manganese was added to the soil, and that this treatment had a statistically significant difference with the others. The treatment of adding boron to the soil came second with 6.33%, and the lowest seed oil concentration (6.29%) was that of the control. These results also showed that, among the treatments of spraying the micronutrients on the crop, the highest seed oil concentration (6.65%) was obtained when zinc was sprayed on the crop, and that this treatment was statistically different from the others. The lowest seed oil concentration (6.06%) was observed in the control (Table 3). Results of the interaction effects of the data indicated that the highest seed oil concentration (6.72%) was obtained by spraying zinc on the crop, and that the lowest seed oil concentration (5.65%) was observed in the control (Fig 1).

Seed Phosphorous Concentration

Results of the analysis of the variance of the data showed that the effects of adding the micronutrients to the soil (Factor A), the effects of spraying the micronutrients on the crop (Factor B), and the interaction effects of adding the micronutrients to the soil plus spraying them on the crop (AB) on the phosphorous concentration were not significant (Table 1). Results of the comparison of the means indicated that, among the treatments of adding the micronutrients to the soil, the highest seed phosphorous concentration (0.177%) was obtained when boron was applied to the soil, and that this treatment was not statistically different from the others. The treatments of adding zinc and manganese to the soil came second and third, respectively. The lowest seed phosphorous concentration (0.156%) was that of the control (Table 2). These results also showed that, among the treatments of spraying the micronutrients on the crop, the highest seed phosphorous concentration (0.183%) was achieved when zinc was sprayed on the crop, and that this treatment was not statistically different from the others. The lowest seed phosphorous concentration (0.175%) belonged to the control (Table 3). Results of the interaction effects of the data showed that the highest seed phosphorous concentration (0.225%) was observed when boron was added to the soil, ad that the lowest seed phosphorous concentration (0.139%) was that of the control (Fig 2).

Seed Potassium Concentration

Results of the analysis of the variance of the data showed that the effects of applying the different levels of the micronutrients to the soil (Factor A), and the effects of adding the micronutrients to the soil plus spraying them on the crop (AB) on the seed potassium concentration were significant at the five percent probability level, while the effects of spraying the different levels of the micronutrients on the crop (Factor B) on the seed potassium concentration were significant at the one percent probability level (Table 1). Results of the comparison of the means indicated that, among the treatments of applying the micronutrients to the soil, the highest seed potassium concentration (0.926%) was obtained when manganese was added to the soil, and that this treatment was not statistically different from the others. The lowest seed potassium concentration (0.839%) was that of the control (Table2). Among the treatments of spraying the micronutrients on the crop, the highest seed potassium concentration (0.915%) was observed when zinc was sprayed on the crop; and this treatment did not have a significant difference with any other treatment except the control, in which the seed potassium concentration was 0.843 percent. In the treatments of spraying manganese and boron on the crop also, the seed potassium concentration was higher than 0.9 percent (Table 3). Results of the comparison of the interaction effects of the data showed that the highest seed potassium concentrations (0.930 and 0.945%) were obtained when zinc and manganese were sprayed on the crop, respectively. The lowest seed potassium concentration (0.631%) was observed when manganese was added to the soil (Fig 3).

Seed Zinc Concentration

Results of the analysis of the variance of the data showed that the effects of adding the different levels of the micronutrients to the soil (Factor A) on the seed zinc concentration were significant at the level of one percent probability, while the effects of spraying the different levels of the micronutrients on the crop (Factor B), and adding the micronutrients to the soil plus spraying them on the crop (AB) on seed zinc concentration were significant at the level of five percent probability (Table 1). Results of the comparison of the means indicated that, among the treatments of applying the micronutrients to the soil, the highest seed zinc concentration (52.5ppm) was obtained when zinc was added to the soil, and that this treatment was statistically different from the others. The treatments of applying manganese and boron to the soil came second and third with 45.92 and 45.58 ppm, respectively. The lowest seed zinc concentration (42.5ppm) was that of the control (Table 2). These results also showed that, among the treatments of spraying the micronutrients on the crop, the highest seed zinc concentration (51ppm) was achieved when zinc was sprayed on the crop, and that this treatment had a statistically significant difference with the others. The lowest seed zinc concentration (44.42ppm) was also observed in the control (Table 3). Results of the comparison of the interaction effects of the data indicated that the highest seed zinc concentrations (55.33 and 55ppm) were obtained by adding manganese to the soil plus spraying it on the crop, and by adding zinc to the soil plus spraying it on the crop, respectively. The lowest seed zinc concentrations (29.33 and 30.1ppm) were observed in the treatment of adding manganese to the soil and in the control, respectively (Fig 4).

Seed Manganese Concentration

Results of the analysis of the variance of the data showed that the effects of the different levels of applying the micronutrients to the soil (Factor A) at the probability level of five percent, and the effects of spraying the different levels of the micronutrients on the crop (Factor B), and the interaction effects of adding the micronutrients to the soil plus spraying them on the crop (AB) at the probability level of one percent on the seed manganese concentration were significant (Table 1). Results of the comparison of the means indicated that, among the treatments of adding the micronutrients to the soil, the highest seed manganese concentration (23.08ppm) was obtained when manganese was applied to the soil, and that this treatment had a statistically significant difference with the others. The treatments of adding boron and zinc to the soil, with 22.5 and 21.75ppm, respectively, came second and third. The lowest seed manganese concentration (20.17ppm) belonged to the control (Table 2).These results also showed that, among the treatments of spraying the micronutrients on the crop, the highest seed manganese concentration (24.77ppm) was observed when manganese was sprayed on the crop, and that this treatment had a statistically significant difference with the others. The lowest seed manganese concentration (20.58ppm) was obtained in the control (Table 3). Results of the interaction effects of the data indicated that the highest seed manganese concentration (23.67ppm) was achieved by adding zinc to the soil plus spraying manganese on the crop, and by adding manganese to the soil plus spraying boron on the crop. These results also showed that the seed manganese concentration was observed to be 23ppm by applying boron to the soil plus spraying manganese on the crop, or by adding manganese to the soil plus spraying it on the crop. The lowest seed manganese concentration belonged to the treatment of adding boron to the soil (Fig 5).

Seed Boron Concentration

Results of the analysis of the variance of the data indicated that the effects of applying the different levels of the micronutrients to the soil (Factor A) at the probability level of five percent, and the effects of spraying the different levels of the micronutrients (Factor B) and the interaction effects of adding the micronutrients to the soil plus spraying them on the crop (AB) at the level of probability of one percent on seed boron concentration were significant (Table 1). Results of the comparison of the means showed that, among the treatments of applying the micronutrients to the soil, the highest seed boron concentration (46.58ppm) was achieved when boron was added to the soil, and that this treatment had a statistically significant difference with the others. The treatments of applying zinc and manganese to the soil, with seed boron concentrations of 36.67 and 36.83 ppm, respectively, came second and third. The lowest seed boron concentration (36.5ppm) belonged to the control (Table 2). These results also indicated that, among the treatments of spraying the micronutrients on the crop, the highest seed boron concentration (40.33ppm) was achieved when boron was sprayed on the crop, and that this treatment had a statistically significant difference with the others. The lowest seed boron concentration (34.92ppm) was observed in the control (Table 3). Results of the interaction effects of the data indicated that the highest seed boron concentrations (44 and 41.67 ppm) were obtained by spraying boron on the crop, and by adding manganese to the soil plus spraying boron on the crop, respectively. The lowest seed boron concentration (29.67ppm) was that of the control (Fig 6).

Table 1. Analysis of variation of the elements concentration

SOV	DOF	Mean Square					
		N	P	K	Zn	Mn	B
Replication	3	Ns	Ns	Ns	Ns	Ns	*
Basal Application (A)	3	*	Ns	*	**	*	*
Spray Application (B)	3	**	Ns	**	*	**	**
AXB	9	**	Ns	*	*	**	**
Error	30	0.004	0.001	0.001	0.326	0.178	0.151
CV (%)		0.96	1.95	0.095	1.23	1.93	1.02

* and ** show the least differences at 1 and 5 level of probability respectively and ns shows none significant difference

Table 2- Comparison of the means of the data related to the addition of zinc, manganese, and boron to the soil on nutrient concentration in seed.

Treatment	N (%)	P (%)	K (%)	Z (ppm)	Mn (ppm)	B (ppm)
Control	6.298 B	0.156 A	0.839 C	42.50 C	20.17 C	36.50 B
Zn to Soil	6.249 B	0.169 A	0.913 AB	52.50 A	21.75 B	36.67 B
Mn to Soil	6.574 A	0.170 A	0.926 A	45.92 B	23.08 A	36.83 B
B to Soil	6.331 B	0.177 A	0.901 B	45.58 B	22.50 B	46.58 A
LSD (0.05)	0.105	0.052	0.016	0.952	0.703	0.648

Numbers having common letters in each column are not significantly different at the probability level of 5 percent

Table 3- Comparison of the means of the data related to spraying the micronutrients zinc, manganese, and boron on nutrient concentration in seed.

Treatment	N (%)	P (%)	K (%)	Z (ppm)	Mn (ppm)	B (ppm)
Control	6.064 C	0.175 A	0.843 B	44.42 C	20.58 B	34.92 C
Zn Foliar	6.656 A	0.183 A	0.915 A	51.00 A	21.25 B	38.83 B
Mn Foliar	6.393 B	0.175 A	0.913 A	45.67 B	24.77 A	36.50 B
B Foliar	6.339 B	0.179 A	0.907 A	45.42 B	21.50 B	40.33 A
LSD (0.05)	0.105	0.052	0.016	0.952	0.703	0.648

Numbers having common letters in each column are not significantly different at the probability level of 5 percent.

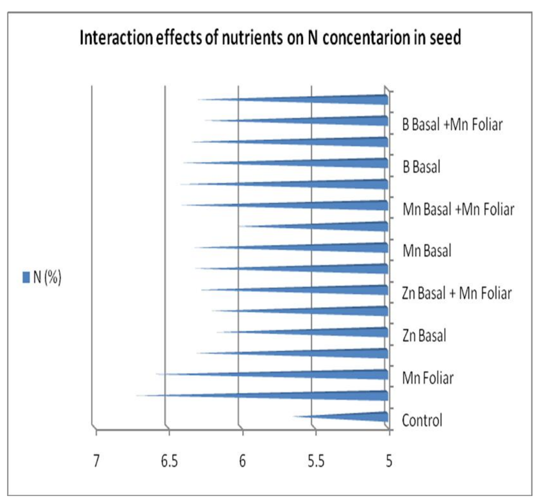

Fig 1. Interaction effects of nutrient application on N concentration in seed

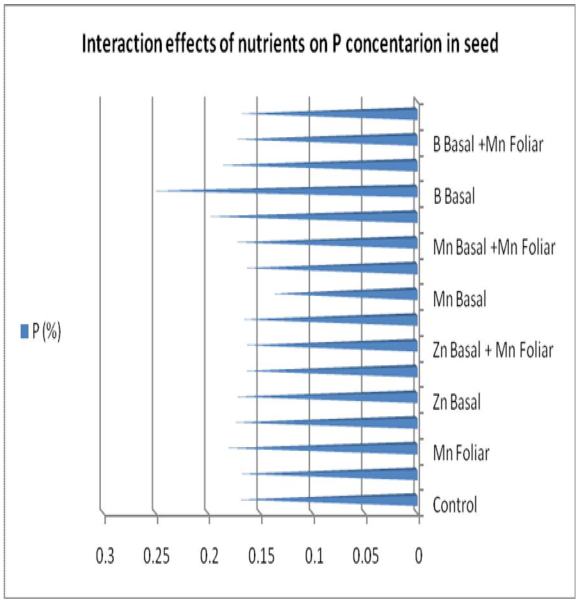

Fig 2. Interaction effects of nutrient application on P concentration in seed

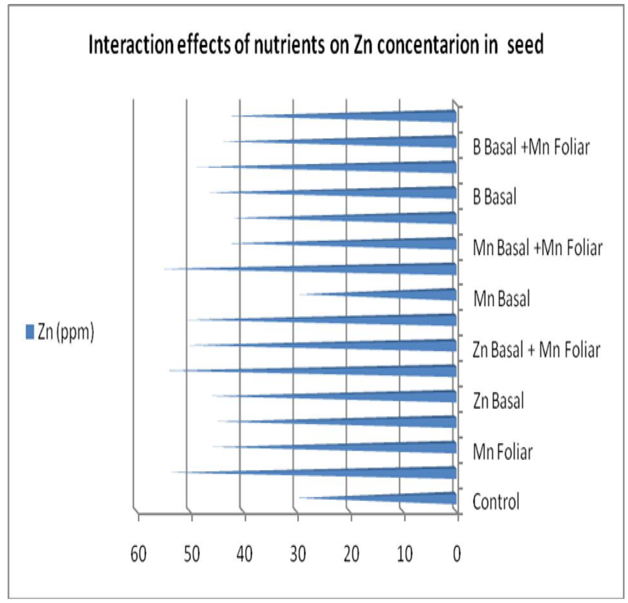

Fig 4. Interaction effects of nutrient application on Zn concentration in seed

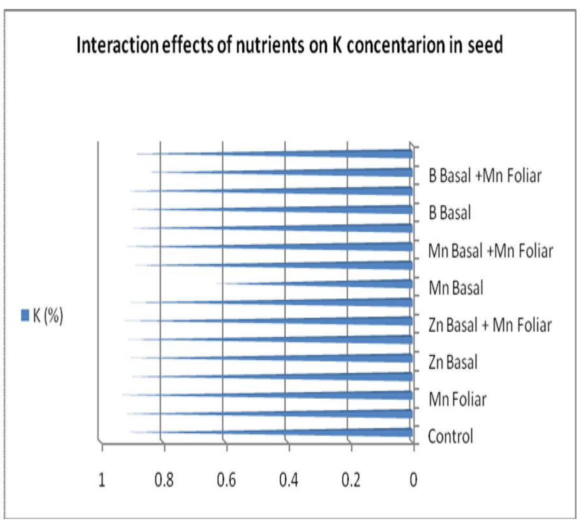

Fig 3. Interaction effects of nutrient application on K concentration in seed

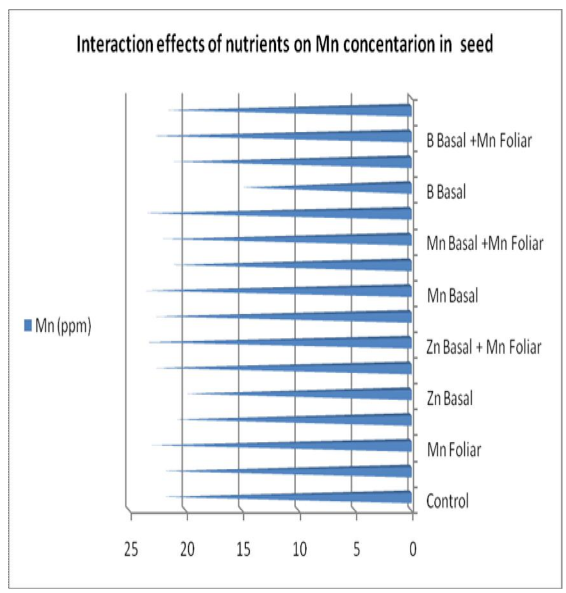

Fig 5. Interaction effects of nutrient application on Mn concentration in seed

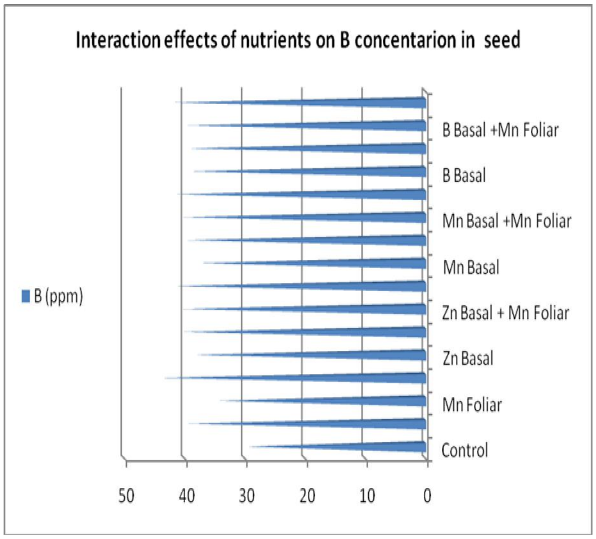

Fig 6. Interaction effects of nutrient application on B concentration in seed

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