Comparison of the response of the Soybean to the method of micronutrients application

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Abstract: In this research, the effects of applying micronutrients, including zinc, boron and manganese, before seeding and as sprays on the crop, on the morphological features and seed yield of the Telar variety of soybean were studied. The experiment was conducted using the factorial design with 16 treatments and 4 replications during cropping seasons 2009-2011 in Dasht-e-Naz in Sari, Mazandaran, of northern Iran. 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. Results showed that, in the treatments of adding the micronutrients to the soil, manganese performed better than the other micronutrients, so that the tallest plants, the greatest mowing height, the biggest number of lateral shoots, the longest roots, the largest dry weight, and finally, the greatest seed yield, were observed in this treatment. In investigating the effect of spraying the nutrients also, it was seen that, although the tallest mowing height, the biggest number of lateral shoots, and the longest roots belonged to the spraying of manganese, yet the tallest plants, the largest dry weight, and finally, the greatest seed yield were obtained by spraying zinc on the crop. In the comparison of the mutual effects of the treatments also, it was found that the greatest mowing height (33 cm) belonged to adding manganese to the soil, but as for the other features (the tallest plants, 110.7 cm; the biggest number of lateral shoots, 4.18; the longest roots, 37.13 cm; the largest dry weight, 158 $g.m^{-2}$; and finally, the greatest seed yield, 170.7 $g.m^{-2}$) were observed in the treatment of the combination of adding manganese to the soil and spraying zinc on crop. Therefore, the superior treatment in the combined use of nutrients was that of adding manganese to the soil and spraying zinc on the crop.

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1. Introduction

The oil crop soybean (*Glycine max* (L) Merrill) is one of the important crop plants that, besides producing edible oil, yield a very good plant protein. Soybean has a very prominent position in the production of oil and protein in countries that produce edible plant oil. One of the most important factors in increasing the production of oil crops is the optimal and balanced use of plant nutrients, which has a very significant role in increasing the seed yield and the quality of the soybean crop and of its oil. The micronutrient zinc is one of the most important and necessary micronutrients, and its deficiency causes a reduction in the yield of crop plants (Malakouti and Mashayekhi, 1997). Boron is also a necessary micronutrient for plants and its deficiency rapidly results in a reduction in and a cessation of plant growth. Soybean is sensitive to boron deficiency (Victor et al., 1990), and boron is very effective in seed formation and in increasing oil yield (Grant and Bailey, 1990; Mekki et al., 2005). Soybean is also very sensitive to manganese deficiency, which frequently occurs in neutral soils or in alkali soils having high pH; and this deficiency causes soybean plants to become short and to have yellow leaves. Manganese deficiency negatively influences the oil content of soybean seeds. In Mazandaran, soybean is very important as the main crop, or as a second crop planted after harvesting wheat and other fall crops, but the importance of the use of micronutrients in increasing soybean yield has been ignored and no comprehensive and thorough information is available regarding the effects of using micronutrients on soybean seed and oil yield in the common soybean varieties grown in this province. Therefore, this research was conducted with the purpose of comparing the effects the micronutrients zinc, boron, and manganese (when added to the soil and/or sprayed on the crop) on soybean seed yield, its yield components, and its morphological features.

2. Material and Methods

This research was carried to investigate and compare the effects of the way the micronutrients zinc, boron, and manganese are applied (added to the soil and/or sprayed on the crop) on soybean seed

yield, its yield components, and its morphological features. An experiment was conducted using the factorial design, with the two factors of adding the micronutrients zinc, boron, and manganese to the soil and spraying them on the crop, in 16 treatments with 4 replications. 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; and T16 = Bs + Znf. To find out the required amounts of plant nutrients, a soil test was performed and, after the physicochemical features of the soil were determined, the nutrients were incorporated in the soil before seeding. On the basis of the soil test, the necessary quantities of the micronutrients zinc, manganese, and boron were tested by adding them to the soil before planting and by spraying them on the crop. In the spray treatments, the micronutrients were sprayed in two stages: at the start of stem elongation, and at flower bud formation.

3. Results

Plant Height:

Results of the comparison of the means showed that, among the treatments of adding the micronutrients to the soil, the tallest plants (101.1 cm) belonged to the treatment of adding manganese to the soil, with the second tallest plants (93.83 cm) in the treatment of adding zinc to the soil, while the shortest plants (70.42 cm) were observed in the control (Table 1). These results also indicated that, among the spray treatments, the tallest plants were in the treatments of spraying zinc and manganese on the crop, where the plant heights were 91.83 and 91.5 cm, respectively. In the treatment of spraying boron on the crop, the plant height was 81.58 cm, and, statistically, this treatment could be placed in one group with the control, in which the plant height was 79.33 cm (Table 2). Comparison of the mutual effects of the data also indicated that the tallest plants (110.7 cm) were obtained by adding manganese to the soil plus spraying zinc on the crop, that only in the treatments of adding zinc to the soil plus spraying manganese on the crop, and adding manganese to the soil plus spraying manganese on the crop, were the plants taller than 100 cm, and that the shortest plants were in the treatment of adding boron to the soil plus spraying it on the crop (60.33 cm) and in the control (59.33 cm) (Table 3).

Number of Lateral Shoots:

Results of the comparison of the means of the data indicated that, among the treatments of adding the micronutrients to the soil, the highest number of lateral shoots (3.84) belonged to adding manganese to the soil, with the treatment of adding zinc to the soil coming second (3.75), and that the lowest number of lateral shoots was in the treatment of adding boron to the soil (3.34) (Table 1). Similarly, these results showed that, among the treatments of spraying the micronutrients on the crop, the highest number of lateral shoots was observed for manganese and zinc with 3.90 and 3.83, respectively, and that spraying boron came next with 3.43. The lowest number of lateral shoots was seen in the control with 3.35 (Table 2). Results of the comparison of the mutual effects of the data indicated that the highest number of lateral shoots belonged to the treatment of spraying manganese on the crop (4.27), and that this number was more than 4 in the treatment of adding manganese to the soil plus spraying zinc on the crop, and less than 4 in the other treatments. The lowest numbers of lateral shoots were seen in the treatment of adding boron to the soil plus spraying boron on the crop (2.83) and in the control (2.66) (Table 3).

Root Length:

Results of the comparison of the means of the data showed that, among the treatments of adding the micronutrients to the soil, the longest roots (34.48 cm) were obtained when manganese was added to the soil, the treatment of adding zinc to the soil came second with a root length of 30.14 cm, and the control had the shortest roots (23.43 cm) (Table 1). These results also indicated that, among the treatments of spraying the micronutrients to the soil, the longest roots (30.57 cm) were seen when manganese was sprayed on the crop, but, statistically speaking, this treatment could be placed in one group with the other treatments. The shortest roots were observed in the control (28.53 cm) (Table 2). Results of the comparison of the mutual effects of the data showed that the longest roots (37.13 cm) were obtained by adding manganese to the soil plus spraying zinc on the crop, and that the shortest roots were seen in the treatments of spraying the crop with manganese or zinc, and in the control, with root lengths of 23.97, 22.55, and 22.67 cm, respectively (Table 3).

Dry Matter:

Results of the comparison of the means of the data showed that, among the treatments of adding the micronutrients to the soil, the largest amount of dry matter belonged to adding manganese to the soil (140.3 $g.m^{-2}$), and that adding zinc to the soil came second with 127.3 $g.m^{-2}$. The smallest quantity of dry matter was seen in the control (102.5 $g.m^{-2}$) (Table 1). These results also indicated that, among the treatments of spraying the micronutrients on the crop, the largest amount of dry matter was obtained by spraying with

zinc (134.1 $g.m^{-2}$), and that this treatment was statistically different from all the other treatments.

The least quantity of dry matter belonged to the control with 106.7 $g.m^{-2}$ (Table 2). Results of the comparison of the mutual effects of the data showed that the largest amount of dry matter (158 $g.m^{-2}$) was obtained in the treatment of adding manganese to the soil plus spraying zinc on the crop, while the treatment of adding boron to the soil plus spraying it on the crop, with 80.88 g of dry matter per square meter, yielded the poorest quantity of dry matter among the treatments (Table 3).

Seed Yield:

Results of the comparison of the means indicated that, among the treatments of adding the micronutrients to the soil, the best seed yield (152.9 $g.m^{-2}$) was obtained by adding manganese to the soil, and adding zinc and boron to the soil came second and third with 141.6 and 122.3 $g.m^{-2}$, respectively. The control with 112.3 $g.m^{-2}$ had the poorest seed yield (Table 1). These results also showed that, among the treatments of spraying the micronutrients on the crop, the best seed yield (146.3 $g.m^{-2}$) was obtained by spraying zinc on the crop, and that spraying with manganese and boron yielded 138.5 and 126.5 $g.m^{-2}$, respectively. The poorest yield belonged to the control with 117.7 $g.m^{-2}$ (Table 2). Results of the comparison of the mutual effects of the data also showed that the highest seed yield (170.7 $g.m^{-2}$) among all the treatment was obtained in the treatment of adding manganese to the soil plus spraying zinc on the crop, and that, statistically, this treatment could not be placed with any of the other treatments in one group. Other researchers, including Darjeh et al., (1991), Maftoun and Karimian (1989), and Cakmak (1991), have reported similar results. The treatments of adding manganese to the soil plus spraying it on the crop, and adding manganese to the soil plus spraying boron on the crop, with 153 and 149 $g.m^{-2}$, respectively, came second and third. The worst seed yield was that of the control with 88 $g.m^{-2}$ (Table 3).

Table 1- Comparison of the means of the data related to the addition of zinc, manganese, and boron to the soil, and the effects of this addition on the morphological features of soybean and on its seed yield.

Trmt	A (cm)	B	C (cm)	D ($g.m^{-2}$)	E ($g.m^{-2}$)
Control	70.42	3.57	23.43	102.5	112.3
Zn Soil	93.83	3.75	30.14	127.3	141.6
MnSoil	101.1	3.84	34.48	140.3	152.9
B Soil	79.00	3.34	29.75	112.7	122.3
LSD	3.97	0.50	5.43	4.32	5.91

A: Plant Height, B: No. of Lateral Shoot, C: Root Length, D: Dry Matter, E: Seed Yield

Table 2- Table of comparison of the means of the data related to spraying the micronutrients zinc, manganese, and boron on the crop, and the effects of this spray on the morphological features of soybean and on its seed yield.

Trmt	A (cm)	B	C (cm)	D ($g.m^{-2}$)	E ($g.m^{-2}$)
Control	79.33	3.35	28.53	106.7	117.7
Zn F	91.83	3.83	29.84	134.1	146.3
MnF	91.58	3.90	30.57	127.4	138.5
B F	81.58	3.43	28.85	114.6	126.5
LSD	3.97	0.50	5.43	4.32	5.91

A: Plant Height, B: No. of Lateral Shoot, C: Root Length, D: Dry Matter, E: Seed Yield

Table 3- Comparison Interaction effects of the means of the data related to spraying the micronutrients zinc, manganese, and boron on the crop, and the effects of this spray on the morphological features of soybean and on its seed yield.

Trmt	A (cm)	B	C (cm)	D ($g.m^{-2}$)	E ($g.m^{-2}$)
Control	59.33	2.66	22.67	80.00	88.00
ZnF	75.67	3.81	22.55	113.3	126.3
MnF	70.00	4.27	23.97	107.7	116.3
BF	76.67	3.55	24.55	109.0	118.3
ZnS	90.00	3.71	28.00	118.0	133.7
ZnS,ZnF	90.67	3.85	29.81	131.0	142.3
ZnS,MnF	100.0	3.86	31.19	135.3	148.3
ZnS,BF	94.67	3.58	31.57	124.7	142.0
MnS	98.00	3.53	33.18	127.3	138.9

MnS,ZnF	110.7	4.18	37.13	158.0	170.7
MnS,MnF	101.0	3.88	35.60	139.3	153.0
MnS,BF	94.67	3.76	32.00	136.7	149.0
BS	70.00	3.49	30.28	101.3	110.3
BS,ZnF	90.33	3.48	29.88	134.0	145.7
Bs,MnF	95.33	3.58	31.53	127.3	136.3
BS,BF	60.33	2.83	27.30	88.00	96.67
LSD	3.97	0.50	5.43	4.32	5.91

A: Plant Height, B: No. of Lateral Shoot, C: Root Length, D: Dry Matter, E: Seed Yield

4. Discussion

As the results obtained in the experiment show, adding manganese to the soil yielded better results than the other micronutrients, because the tallest plants (110.1 cm), the biggest number of lateral shoots (3.84), the longest roots (34.48 cm), the largest quantity of dry matter (140.3 $g.m^{-2}$), and, finally, the best seed yield (152.9 $g.m^{-2}$) were obtained in this treatment. Therefore, adding manganese to the soil can be chosen as the superior treatment. As for the results of spraying micronutrients on the crop, although, the biggest number of lateral shoots, and the longest roots were observed in spraying manganese on the crop, the tallest plants (91.58 cm), the greatest amount of dry matter (134.1 $g.m^{-2}$), and, finally, the best yield (146.3 $g.m^{-2}$) were obtained by spraying the crop with zinc. Therefore, spraying zinc on the crop can be chosen as the superior treatment as far as spraying micronutrients on the crop is concerned. In comparing the results of the mutual effects of the treatments, it was also seen that the highest mowing height (33 cm) belonged to adding manganese to the soil, but, regarding other features, it was found that the treatment of adding manganese to the soil plus spraying zinc on the crop yielded the tallest plants (110.7 cm), the biggest number of lateral shoots (4.18), the longest roots (37.13 cm), the greatest quantity of dry matter (158 $g.m^{-2}$), and, finally, the best yield (170.7 $g.m^{-2}$). Therefore, as far as the combination of adding the micronutrients to the soil plus spraying them on the crop is concerned, adding manganese to the soil plus spraying zinc on the crop can be chosen as the superior treatment.

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