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EFFECT OF SOME MICRONUTRIENT TREATMENTS ON VEGETATIVE GROWTH, ANATOMICAL CHARACTERS, YIELD AND YIELD COMPONENTS OF SOYBEAN PLANT (*Glycine max* (L.) Merrill)

BY

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ABSTRACT

A field trial was conducted at Agricultural Experimental Station, Faculty of Agriculture, Cairo University, Giza, during 2004 and 2005 seasons to study the effect of foliar spray with micronutrients (Zn, Mn, Fe and their mixture) on vegetative, yield and yield components and anatomical characters of soybean (*Glycine max* (L.) Merrill) cultivar Williams. These treatments were applied twice; after 45 and 75 days from sowing date using concentrations of 25, 50 and 100 ppm. The results showed that foliar spray with micronutrients (Zn, Mn, or Fe alone or in mixture) significantly increased most of the vegetative growth characters as well as yield and yield components over the control in both seasons. The best vegetative and yield characters were obtained by application of Zn (100 ppm), Mn (50 ppm) or Fe (100 ppm) alone or in mixture (100 ppm), respectively. These characters included; plant height (cm), main stem length (cm) and thickness (mm), No. of internodes, lateral branches, leaves, pods and seeds / plant as well as seed yield (g) / plant and 100- seed weight (g). The anatomical manifestations of stem, petiole and leaflet indicated that, spraying soybean plant with adopted concentrations of micronutrients alone or their mixture caused considerable increase of stem diameter due to the increase in thickness of epidermis and phloem as well as pith diameter. Moreover, dimensions of petiole were increased due to the increase in thickness of epidermis and cortex as well as pith diameter and dimensions of vascular bundles. Also, these treatments increased thickness of lamina and midrib comparing with the control, these may be due to the increase in thickness of lower epidermis and mesophyll tissue as a result to enlargement of lamina cells, and the increase in dimensions of midrib bundle as a result of the increase in numbers of xylem rows and vessels in such bundle.

INTRODUCTION

Soybean belongs to the family *Fabaceae* which cosists of about 440 genera and 12000 species, wide spread in tropical, subtropical and temperate regions (Cronquist, 1981).

Glycine is a well known genus of the family with ten species. *Glycine max* (L.) Merrill, soybean or soya is becoming the most important species of this genus (Jones and Luchsinger. 1987).

Soybean is an important crop as a source of oil and high-protein content. It has manifold uses: a source of numerous raw materials for use in industry such as meat-like substances, manufacture of candles, soap, varnishes, lacquers, paints, greases, linoleum, rubber substitutes, cleaning compounds, insecticides, disinfectants, and many other products and also a good feed for livestock (Caldwell *et al.*,1973).

Soybean is a rather new crop introduced to Egypt for cultivation in 1975. It is grown in summer, following early winter crops competing in crop rotation with other important summer crops such as cotton, rice and corn. Increase of soybean yield in Egypt is highly recommended to meet the demand of human needs and livestock.

Soybean area in Egypt has been dramatically decreased from about 150.000 faddans in 1982 to less than 10.000 faddans in 2002 as a result of severe competition from strategic summer crops. The attention has been focused on its intercropping with other summer crops, which led to removing huge amounts of nutrients from the Egyptian soils, so that application of micronutrients besides macronutrients fertilizers is promising for increasing seed yield under local conditions (Shuman *et al.*, 1979 on soybean, Saleh and Foda, 1980 and Nassar *et al.*, 1985 on bean).

In 2002, the corresponding values of imported soybean products were 350.000 tons of seeds and 200.000 tons of oil (Safina, 2003).

Supplying the plants with micronutrients is an efficient method for increasing their production, especially in Egypt because the soil is usually poor in its micronutrients content.

Many investigators demonstrated that the morphological characters and the yield and its components of legumes are influenced by Zn and Mn application. In this respect, Singh and Badhoria (1984) reported significant positive effect of Zn treatment (10 mg / kg soil) on seed yield of mungbean (56.5% over the control).

Nassar *et al.*, (1985) found that the micronutrients (Zn, Mn and Fe) in concentration of 100 ppm for each, significantly increased plant height (+16.9%), No. of internodes/main stem (+12.9%), No. of branches/plant (+90.0%), No. of pods/plant (+27.1%) and seed yield/plant (+32.1%) of the bean plant over the control.

Singh and Kumari (1990) found that mungbean yield increased from 445 to 535 kg/ha with 30 kg Mn/ha and was not further increased with 60 kg Mn/ha. Krishna (1995) stated that Zn up to 15 kg/ha significantly increased seed yield in mungbean.

Abd El-Lateef *et al.* (1998) studied the effect of foliar spray with 0.1% Zn, 0.2% Mn and 0.5% Fe alone or their combination on the growth of mungbean (variety Kawmy-1). They found that the combined treatments significantly increased plant height, number of branches and leaves, weight of 100 seed as well as seed yield. Zinc alone gave the tallest plant and increased the number of branches/plant.

Sarkar *et al.* (1998) reported that the application of micronutrients mixture (Zn, Mn, Cu, B, Mo & Fe) or Zn alone on mungbean resulted in better physiological parameters like dry matter production, leaf area index, crop growth rate, net assimilation rate and yield components leading to higher seed yield compared with individual application of Mn, Cu, B, Mo and Fe as well as the control plants. Multi – micronutrients and Zn resulted in 39 and 34% higher yield, respectively, over the control.

Sharief and El-Said (1998) mentioned that, foliar application with micronutrients (Zn, Mn and Fe) either separately or in a mixture significantly increased the number of branches per lentil plant.

Hessien (2000) mentioned that, VC-1000 variety of mungbean sprayed with Zn and Mn surpassed V-2010 variety in the number and weight of pods/plant and seed yield/plant, whereas, V-2010 variety was superior in 1000-seed weight.

Abdo(2001) stated that, foliar spray with micronutrients (Zn, Mn or their mixture) significantly increased most of the growth parameters of mungbean such as; stem length (cm), number of branches and leaves as well as anatomical characters of stem such as; stem diameter, xylem tissue thickness, vessel diameter and pith thickness and also leaf anatomical features such as; thickness of midvein, thickness of lamina, thickness of spongy tissue, dimensions of the main bundle of midvein, No. of vessels/midvein bundle and vessel diameter compared to the control.

Rizk and Abdo (2001) reported that, spraying Zn at 0.2 or 0.4 g/l, Mn at 1.5 or 2.0 g/l alone or in combinations on mungbean plants significantly increased yield and its components (especially Zn at 0.2 g/l) compared to the control.

The present investigation discloses the influence of micronutrients (Zn, Mn and Fe) and their combinations on vegetative, reproductive and anatomical characters of soybean during the two successive seasons of 2004 and 2005.

MATERIALS AND METHODS

This investigation was carried out at the Experimental Station, Faculty of Agriculture, Cairo University, Giza during the two successive seasons; 2004 and 2005.

Seeds of soybean (*Glycine max* (L.) Merrill) cultivar Williams used in this investigation were secured from Legume Research Division, Field Crop Research Institute, Agricultural Research Center, Giza.

The layout of the experiment was randomized complete block design with three replicates for each treatment. The experimental plot consisted of 5 ridges 3.5 meters in length and 60 cm in width. Seeds were inoculated with the specific Rhizobium strain at a rate of 500 g inoculant per 50 kg seeds using Arabic gum solution (16%) at a rate of 500 ml / 50 kg seeds and immediately sown in hills on one side of the ridge, 20 cm apart. The planting dates were on May 12th and 17th in the first and second seasons, respectively. Thirteen treatments were applied as foliar spray after 45 and 75 days from sowing, these treatments were as follows:

- Control (sprayed with tap water)
- Zinc at 25, 50 and 100 ppm
- Manganese at 25, 50 and 100 ppm
- Ferrum at 25, 50 and 100 ppm
- Mixtures of Zn,Mn and Fe using 3 concentrations for each; 25, 50 and 100 ppm.

Volume of spraying solution was 50 ml / plant. Tween 20 was added as a surfactant at the rate of 1 ml / litre. All common agronomic practices for soybean were followed.

The following measurements were recorded at 60 and 90 days from sowing date: plant height (cm); measured from the cotyledonary node up to the uppermost point of the plant, stem length (cm);measured from the cotyledonary node up to the shoot apex, number of main stem internodes, stem thickness (mm);measured with a vernier at the mid-point of the stem length, number of lateral branches/plant and number of leaves/plant. Likewise the following measurements were recorded at harvest: number of pods/plant, number of seeds/plant, seed yield/plant (g) and weight of 100 seeds (g). The harvest was after 145 days from sowing date.

The obtained data were statistically analyzed according to Snedecor and Cochran (1982).

Anatomical studies:

A comparative microscopical examination was carried out on plant material which showed the most prominent response of plant growth to investigated treatments using individual elements; Zn 100, Mn 50, Fe 100, and a mixture of the 3 elements 100 ppm of each.

Specimens of *Glycine max* cv. Williams were taken from the seventh internode of the main stem, the median leaflet of the corresponding compound leaf as well as the petiole of the median leaflet. Plants used for anatomical study were taken through the second season (2005), at the age of 90 days (2 weeks after treatments).

All samples were killed and fixed in F.A.A. (Formalin-Acetic acid-Alcohol) solution for at least 48 hours, washed in 50% alcohol, dehydrated in normal butyl and embedded in paraffin wax (56-58° C mp.), (Sass, 1958). Cross sections, 20μ thick, were cut and stained by crystal violet/erythrosine combination, and mounted in Canada balsam (Jackson, 1926). Sections were examined and photomicrographed and the counts and measurements of different tissues were recorded using a micrometer eyepiece, and averages of 10 readings were calculated.

RESULTS AND DISCUSSION

1. Vegetative growth characters:

1.1. Plant height (cm):

Data in Table (1) clarified that spraying soybean plants cv, Williams with micronutrients at 60 and 90 days from sowing date significantly increased plant height in most treatments through 2004 and 2005 seasons. The maximum significant increase of stem length was 32.7% for both Zn 100 and Fe 100 ppm, followed by 31.6% for Mn 50 ppm and 30.9% for mix. 100 over the control treatment at the age of 60 days,and 46.3, 44.0 and 39.9% over the control, respectively, at 90 days in the first season, while the maximum increases in the second season were 36.1 and 29.6% for Zn 100 and Fe 100 ppm at 60 days, while were 38.1, 33.7 and 25.8% over the control for Zn 100,Fe 100 and Mn 50 ppm at 90 days, respectively.

Table (1): Effect of micronutrients on plant height (cm) of soybean after 60 and 90 days from sowing date during 2004 and 2005 seasons.

	Plant height (cm)							
	First season				Second season			
Ages / Treatments	60 days	+%to control	90 days	+%to control	60 days	+%to control	90 days	+%to control
Control	56.0	-	87.0	-	70.0	-	98.0	-
Zn25	62.0	9.6	116.0	33.3	82.3	17.6	112.0	14.3
Zn50	68.2	17.6	121.7	39.9	90.0	28.6	112.3	14.6
Zn100	74.3	23.1	127.3	46.3	95.3	36.1	135.3	38.1
Mn25	59.0	9.1	111.0	27.6	79.7	13.9	121.0	23.5
Mn50	73.7	12.7	120.0	37.9	82.3	17.6	123.3	25.8
Mn100	62.7	4.2	107.7	23.8	77.0	10.0	100.3	2.3
Fe25	57.7	6.0	100.0	14.9	73.7	5.3	101.7	3.8
Fe50	68.2	8.5	116.7	34.1	82.0	17.1	108.3	10.5
Fe100	74.3	17.6	125.3	44.0	90.7	29.6	131.0	33.7
Mix25	58.3	1.3	109.7	26.1	80.7	15.3	100.0	2.0
Mix50	65.0	3.1	112.7	29.5	81.0	15.7	101.3	3.4
Mix100	73.3	7.8	115.7	33.0	86.3	23.3	110.7	13.0
L.S.D.(0.05)	6.1		7.1		4.8		14.3	

The increases in plant height at the age of 90 days were significant in all treatments, in the first season, while in the second one were significant only with Zn 50 and 100, Mn 25 and 50; and Fe 100 ppm, respectively comparing with the control plants.

These results are in agreement with those obtained by Nassar *et al.*, 1985 on bean and Abd El- Lateef *et al.*, 1998 on mungbean.

1.2. Stem length (cm):

Data represented in Table (2) recorded the average main stem length of soybean cultivar Williams at 60 and 90 days after sowing as affected by spraying micronutrients in the seasons 2004 and 2005. In the season 2004, the maximum increases were obtained by using Zn 100, Fe 100 and Zn 50 ppm being 23.1, 17.6 and 17.6% over the control at 60 days, while the maximum increases at the age of 90 days were 36.5 and 29.0% over the control for Zn 100 and mix. 100 ppm, respectively.

Regarding stem length in season 2005, Zn 100 and mix. 100 ppm also recorded the maximum increments, being 37.8 and 29.2% over the control at 60 days whereas such ratio reached 61.7, 51.2, 49.8 and 47.9% over the control for Zn 100, mix. 100, Mn 50 and Fe 100 ppm, respectively, at 90 days. This effective role of Zn may be due to its direct effect on auxin production which in turn enhances cell elongation during plant growth (Skoog, 1940).

These findings are in harmony with those obtained by Abdo (2001) on mungbean.

Table (2): Effect of micronutrients on stem length (cm) of soybean after 60 and 90 days from sowing date during 2004 and 2005 seasons.

Stem length (cm)								
	First season				Second season			
Ages / Treatments	60 days	+%to control	90 days	+%to control	60 days	+%to control	90 days	+%to control
Control	55.0	-	72.3	-	50.3	-	70.3	-
Zn25	60.3	10.7	80.7	11.6	52.3	4.0	77.0	9.5
Zn50	64.7	21.8	89.0	23.1	61.0	21.3	91.7	30.4
Zn100	67.7	32.7	98.7	36.5	69.3	37.8	113.7	61.7
Mn25	60.0	5.4	75.7	4.7	52.7	4.8	96.1	36.7
Mn50	62.0	31.6	87.0	20.3	53.0	5.4	105.3	49.8
Mn100	57.3	12.0	79.7	10.2	51.0	1.4	82.3	17.1
Fe25	58.3	3.0	76.7	6.1	51.3	2.0	76.3	8.5
Fe50	59.7	21.8	80.0	10.7	64.0	27.2	89.7	27.6
Fe100	64.7	32.7	90.3	24.9	64.3	27.8	104.0	47.9
Mix25	55.7	4.1	80.3	11.1	53.7	6.8	80.3	14.2
Mix50	56.7	16.1	86.7	19.9	63.7	26.6	83.3	18.5
Mix100	59.3	30.9	93.3	29.0	65.0	29.2	106.3	51.2
L.S.D.(0.05)	4.6		5.9		4.7		17.6	

1.3. Number of internodes of main stem:

Results in Table (3) showed that there were significant increments for some sprayed micronutrients on No. of internodes of soybean plants related to the untreated plants in both seasons. Spraying plants with Zn at 100 ppm increased No. of internodes up to 36.1% over the control at 60 days in the first season, while the maximum ratio reached (26.5%) without any significant difference compared with Zn 50 (23.9%) and Fe 100 (21.2%) ppm at the same age in the second season.

On the other hand, using 100 ppm Zn increased No. of internodes up to 56.5% without any significant difference compared with Zn 50 ppm (47.6%), Fe 100 (38.1%) and mix. 100 (36.1%) at the age of 90 days in the first season, while this ratio reached 35.9% over the control by using Zn 100 ppm followed by 33.5, 29.9 and 25.7% for Fe 100, Fe 50 and Mn 50 ppm, respectively, in the second season. It is clear from Tables (2 & 3) that, increasing stem length is correlated with increasing No. of stem internodes.

Table (3): Effect of micronutrients on No. of main stem internodes of soybean after 60 and 90 days from sowing date during 2004 and 2005 seasons.

Number of main stem internodes								
	First season				Second season			
Ages / Treatments	60 days	+%to control	90 days	+%to control	60 days	+%to control	90 days	+%to control
Control	8.3	-	14.7	-	11.3	-	16.7	-
Zn25	9.3	12.0	19.7	34.0	13.3	17.7	18.0	7.8
Zn50	10.0	20.5	21.7	47.6	14.0	23.9	20.0	19.8
Zn100	11.3	36.1	23.0	56.5	14.3	26.5	22.7	35.9
Mn25	8.7	4.8	18.7	27.2	12.7	12.4	20.0	19.8
Mn50	9.7	16.9	19.7	34.0	13.0	15.0	21.0	25.7
Mn100	8.5	2.4	17.3	17.7	12.3	8.8	17.0	1.8
Fe25	8.7	4.8	18.0	22.4	12.3	8.8	19.0	13.8
Fe50	9.3	12.0	19.0	29.3	12.7	12.4	21.7	29.9
Fe100	9.7	16.9	20.3	38.1	13.7	21.2	22.3	33.5
Mix25	8.7	4.8	15.3	4.1	11.7	3.5	18.0	7.8
Mix50	8.7	4.8	18.3	24.5	12.7	12.4	18.7	12.0
Mix100	9.0	8.4	20.0	36.1	13.3	17.7	19.3	15.6
L.S.D.(0.05)	0.8		3.1		1.0		2.4	

1.4. Stem thickness (mm):

Data presented in Table (4) proved that, foliar application of micronutrients of soybean plants resulted in significant differences in stem thickness as compared with their respective control in both seasons except treatments of Zn 25 ppm at the age of 60 days in the first season and Mn 100 ppm at the age 90 days in the second season. At the first season, 60 days after sowing, Fe 100 ppm recorded the thickest stem without any significant difference with mix. 100 ppm being 109.4 and 93.8% over the control, respectively, while at 90 days after sowing, Fe 100 ppm treatment ranked the highest, followed by mix. 100, Zn 100 and Mn 50 ppm being 60.0, 48.9, 44.4 and 44.4 %, comparing with control plants, respectively.

At the second season, both Fe 100 and mix. 100 ppm treatments recorded the highest values of stem thickness for both ages being 95.0 and 87.5% (in the plants aged 60 days) and 93.8 and 93.8% (in the plants aged 90 days) as compared with the untreated plants, respectively.

1.5. Number of lateral branches/plant:

Table (5) represents No. of lateral branches per soybean plant cv. Williams sprayed with microelements;Zn, Mn or Fe or their mixture at 25, 50 or 100 ppm at 60 and 90 days from sowing date for 2004 and 2005 seasons. These treatments caused significant increases for No. of lateral branches at the age of 60 days as compared with control plants in both seasons. In the first season, Mn 50 ppm ranked the highest in increase of lateral branches/plant (1000.0%) followed by Mn 100 and mix. 100 ppm as both gave the same ratio (566.7%) over the control after 60 days from sowing. At the age of 90 days, Mn 50 ppm also achieved the highest ratio for No. of branches per plant with significant increases as compared with other treatments being 311.8% over its respective control.

Table (4): Effect of micronutrients on stem thickness (mm) of soybean after 60 and 90 days from sowing date during 2004 and 2005 seasons.

Stem thickness (mm)								
	First season				Second season			
Ages / Treatments	60 days	+%to control	90 days	+%to control	60 days	+%to control	90 days	+%to control
Control	3.2	-	4.5	-	4.0	-	4.8	-
Zn25	3.3	3.1	5.7	26.7	5.7	42.5	5.9	22.9
Zn50	4.0	25.0	6.2	37.8	6.0	50.0	6.2	29.2
Zn100	5.3	65.6	6.5	44.4	6.8	70.0	7.7	60.4
Mn25	4.8	50.0	5.7	26.7	6.3	57.5	6.8	41.7
Mn50	5.5	71.9	6.5	44.4	6.8	70.0	8.0	66.7
Mn100	4.5	40.6	5.8	28.9	5.3	32.5	5.7	18.8
Fe25	4.8	50.0	6.0	33.3	6.0	50.0	6.3	31.3
Fe50	5.3	65.6	6.2	37.8	6.7	67.5	6.9	43.8
Fe100	6.7	109.4	7.2	60.0	7.8	95.0	9.3	93.8
Mix25	3.5	9.4	5.3	17.8	5.0	25.0	7.0	45.8
Mix50	4.2	31.3	6.3	40.0	6.7	67.5	7.3	52.1
Mix100	6.2	93.8	6.7	48.9	7.5	87.5	9.3	93.8
L.S.D.(0.05)	0.7		0.7		0.6		1.1	

In the second season, both Mn 50 and Mn 100 ppm treatments achieved the maximum significant increase being 571.4% followed by mix. 100 ppm, being 514.3% over the control for the age of 60 days. The same trend occurred after 90 days from sowing as the maximum values were 173.9, 160.9 and 147.8% over the control value for Mn 50, Mn 100 and mix. 100 ppm, respectively. It is clarified from Tables (3 & 5) that, there were a positive correlation between No. of stem internodes and No. of lateral branches, specially in the second season.

The above mentioned results are in accordance with the findings previously reported by Nassar *et al.* (1985) on bean plant, Abd El- Lateef *et al.* (1998) on mungbean, Sharief and Said (1998) on lentil plant and Abdo (2001) on mungbean.

1.6. Number of leaves/plant:

Data tabulated in Table (6) clarified No. of leaves per soybean plant during the two seasons after 60 and 90 days from sowing date. In the first season, relative to the control, both treatments; Mn 50 and Mn 100 ppm showed the same maximum value (61.7%) after 60 days followed by 58.9% for Mix 100 ppm without significant differences between them, while spraying plants with Mn 50 ppm increased No. of leaves per plant after 90 days, being 151.3% over the control with significant differences for the other studied treatments.

Table (5): Effect of micronutrients on number of lateral branches/plant of soybean after 60 and 90 days from sowing date during 2004 and 2005 seasons.

Number of lateral branches/plant								
	First season				Second season			
Treatments \ Ages	60 days	+%to control	90 days	+%to control	60 days	+%to control	90 days	+%to control
Control	0.3	-	1.7	-	0.7	-	2.3	-
Zn25	0.3	0.0	2.7	58.8	1.3	85.7	4.0	73.9
Zn50	0.7	133.3	2.7	58.8	1.3	85.7	4.0	73.9
Zn100	1.0	233.3	3.0	76.5	1.7	142.9	4.7	104.3
Mn25	1.6	433.3	5.3	211.8	2.7	285.7	4.3	87.0
Mn50	3.3	1000.0	7.0	311.8	4.7	571.4	6.3	173.9
Mn100	2.0	566.7	5.7	235.3	4.7	571.4	6.0	160.9
Fe25	0.7	133.3	3.3	94.1	1.7	142.9	4.7	104.3
Fe50	1.0	233.3	4.3	152.9	2.7	285.7	5.0	117.4
Fe100	1.3	333.3	5.0	194.1	3.7	428.6	5.0	117.4
Mix25	0.7	133.3	3.7	117.6	2.7	285.7	3.7	60.9
Mix50	1.0	233.3	4.3	152.9	3.7	428.6	4.7	104.3
Mix100	2.0	566.7	5.0	194.1	4.3	514.3	5.7	147.8
L.S.D.(0.05)	1.6		1.0		0.9		1.2	

On the other hand, the maximal number of leaves per plant was achieved by using Mn 50 or Mn 100 ppm in both ages of the second season being 92.0 and 79.6% after 60 days and 85.7 and 70.9% after 90 days relative to the control, respectively. Generally, the higher No. of lateral branches, the higher No. of leaves / plant in most cases (Tables, 5 & 6).

The results previously mentioned are in agreement with the studies reported by Abd El-Lateef *et al.* (1998) and Abdo (2001) on mungbean.

2. Yield and yield components:

At maturity (145 days after sowing), data of yield and its components were recorded in both seasons and tabulated in Table (7).

2.1. Number of pods/plant:

Regarding to No. of pods per plant, it is evident that there were significant increases in No. of pods/plant between the plants treated with micronutrients and its respective control in both seasons, except treatments with Fe 25 and mix. 25 ppm at the first season. Zinc 100 ppm caused the highest increments in the average No. of pods per plant recording 262.6 and 168.4% over the control for the first and second seasons, respectively, Table (7).

This is in harmony with the findings obtained by Hessien (2000) and Rizk and Abdo (2001) on mungbean.

Table (6): Effect of micronutrients on number of leaves/plant of soybean after 60 and 90 days from sowing date during 2004 and 2005 seasons.

Treatments \ Ages	Number of leaves/plant							
	First season				Second season			
	60 days	+%to control	90 days	+%to control	60 days	+%to control	90 days	+%to control
Control	10.7	-	18.7	-	11.3	-	20.3	-
Zn25	10.9	1.9	22.3	19.3	12.3	8.8	24.3	19.7
Zn50	11.0	2.8	24.0	28.3	13.0	15.0	27.3	34.5
Zn100	13.3	24.3	34.0	81.8	15.0	32.7	27.3	34.5
Mn25	12.0	12.1	30.0	60.4	13.3	17.7	32.3	59.1
Mn50	17.3	61.7	47.0	151.3	21.7	92.0	37.7	85.7
Mn100	17.3	61.7	39.3	110.2	20.3	79.6	34.7	70.9
Fe25	12.3	15.0	30.0	60.4	14.0	23.9	22.3	9.9
Fe50	13.7	28.0	32.0	71.1	15.7	38.9	27.7	36.5
Fe100	15.0	40.2	34.3	83.4	16.7	47.8	33.0	62.6
Mix25	11.7	9.3	23.0	23.0	14.7	30.1	29.7	46.3
Mix50	13.7	28.0	33.7	80.2	17.7	56.6	32.3	59.1
Mix100	17.0	58.9	37.0	97.9	19.3	70.8	33.0	62.6
L.S.D.(0.05)	2.2		3.6		1.9		4.6	

2.2. Number of seeds/plant:

It is realized from Table (7) that, No. of seeds per plant was significantly increased due to micronutrients treatments in both seasons, except in treatments with Zn 25 and mix. 25 ppm in the first season.

With respect to No. of seeds/plant in the first season, the highest increase was recorded by treating the soybean plants with Zn at 100 ppm followed by Fe at 100 ppm and Mn at 50 ppm being 297.2, 255.9 and 238.8% over the control plants, respectively, while in the second season, the same treatment (Zn 100 ppm) ranged the highest, followed by mix. 100, Mn 50 and Mn 100 ppm being 198.5, 185.2, 158.4 and 157.0% higher than the control, respectively.

2.3. Seed yield/plant (g):

Seed yield per plant (g) of soybean plants treated with micronutrients for two seasons are presented in Table (7). It is clear that, in the first and second seasons, seed yield/plant was significantly increased comparing with the control plants. Plants treated with Zn 100 and Mn 50 ppm recorded the highest increments without significant differences between them being 607.4 and 501.5% more than the control, respectively, followed by mix. 100 ppm (486.8%) and Fe 100 (422.1%). While in the second season, these ratios were 308.0, 301.0 and 299.0% over the control for Zn 100, Mix 100 and Mn 50 ppm, respectively.

Similar results were also recorded by Shuman *et al.*, (1979) on soybean, Saleh and Foda (1980) on bean, Singh and Badhoria (1984) on mungbean, Nassar *et al.*, (1985) on bean, Singh and Kumari (1990), Abd El-Lateef *et al.*, (1998), Sarkar *et al.*, (1998), Hessien (2000) and Rizk and Abdo (2001) on mungbean.

2.4. Weight of 100 seeds (g):

As shown in Table (7), weight of 100 seeds in the first and second seasons was markably heavier by using microelements with significant increase than control plants, except with treatment of Mn 25 ppm at the first season. The lowest concentration of Zn (25 ppm) in the first season recorded the heaviest weight of 100 seeds between all the treatments followed by mix. 100 without significant differences between them being 102.8 and 92.5% over the control, respectively.

In the second season, spraying soybean plants with Mn at 50 ppm gave the heaviest weight of 100 seeds being 54.5% followed by Zn at 25 ppm being 48.0% more than the untreated control plants. From the results of yield components, it is clarified that there was a positive correlation between all yield components, except weight of 100 seeds (Table, 7).

Furthermore, there was a positive correlation between No. of lateral branches or No. of leaves / plant and all yield components, except weight of 100 seeds (Tables, 5, 6 & 7).

These results confirmed the previous ones on mungbean (Abd El-Lateef *et al.*, 1998; Hessien, 2000 and Rizk and Abdo, 2001).

3- Anatomical studies:

The anatomical features of different plant organs including main stem, median leaflet and petiole which showed the most prominent response of plant growth to investigated treatments were examined microscopically and recorded in Tables (8, 9 &10) and microphotographed in Figures (1,2 & 3).

3.1. Anatomy of the stem:

It is clear from Table (8) and Figure (1) that applying micronutrients to soybean plants increased stem diameters compared with those of control plants as the increment ratios ranged between 9.9% (Zn 100) and 20.5% (Fe 100). The stem of soybean is nearly octagonal-shaped and its epidermis uniseriate with multiseriate hairs. The epidermis of treated plants is thickened between 33.3% (Zn 100 & Mn 50) and 56.9% (Fe 100) than the control plants, due to epidermal cell enlargement.

Table (7): Effect of micronutrients on yield components of soybean plant after 145 days from sowing date during 2004 and 2005 seasons.

Characters / Treatments	No.of pods/plant	+%to control	No.of seeds/plant	+%to control	Seed yield/plant (g)	+%to control	Weight of 100 seeds (g)	+%to control
First season								
Control	34.0	-	64.1	-	6.8	-	10.6	-
Zn25	50.7	49.1	104.5	63.0	22.5	230.9	21.5	102.8
Zn50	76.7	125.6	161.3	151.6	32.3	375.0	20.0	88.7
Zn100	123.3	262.6	254.6	297.2	48.1	607.4	18.9	78.3
Mn25	50.3	47.9	144.3	125.1	15.9	133.8	11.0	3.8
Mn50	102.4	201.2	217.2	238.8	40.9	501.5	18.8	77.4
Mn100	52.0	52.9	179.2	179.6	28.1	313.2	15.7	48.1
Fe25	41.4	21.8	124.3	93.9	15.6	129.4	12.6	18.9
Fe50	65.0	91.2	154.6	141.2	31.1	357.4	20.1	89.6
Fe100	93.6	175.3	228.1	255.9	35.5	422.1	15.6	47.2
Mix25	37.7	10.9	113.3	76.8	21.7	219.1	19.2	81.1
Mix50	69.7	105.0	160.8	150.9	30.1	342.6	18.7	76.4
Mix100	86.4	154.1	195.6	205.1	39.9	486.8	20.4	92.5
L.S.D.(0.05)	8.6		50.6		7.3		1.2	
Second season								
Control	38.0	-	81.1	-	10.0	-	12.3	-
Zn25	50.3	32.4	100.5	23.9	18.3	83.0	18.2	48.0
Zn50	69.3	82.4	188.1	131.9	31.6	216.0	16.8	36.6
Zn100	102.0	168.4	242.1	198.5	40.8	308.0	16.9	37.4
Mn25	63.3	66.6	150.5	85.6	22.3	123.0	14.8	20.3
Mn50	88.3	132.4	209.6	158.4	39.9	299.0	19.0	54.5
Mn100	62.7	65.0	208.4	157.0	33.3	233.0	16.0	30.1
Fe25	46.7	22.9	124.7	53.8	19.8	98.0	15.9	29.3
Fe50	65.0	71.1	157.6	94.3	22.4	124.0	14.2	15.4
Fe100	74.7	96.6	198.9	145.3	34.0	240.0	17.1	39.0
Mix25	55.7	46.6	120.0	48.0	18.3	83.0	15.3	24.4
Mix50	69.6	83.2	158.2	95.1	27.5	175.0	17.4	41.5
Mix100	80.0	110.5	231.3	185.2	40.1	301.0	17.3	40.7
L.S.D.(0.05)	7.9		34.7		5.7		1.0	

On the other hand, cortex thickness was reduced in the treated plants ranging between 8.6% (Zn 100) up to 35.3% (Mix 100) below the control plants. This reduction may be due to the decrease in number of layers (-13.3% in Fe 100 & Mix 100 and –20.0% in Mn 50) except Zn 100 which increased number of layers by 6.7% over the control.

The vascular tissue generally constitutes a closed cylinder 1148.8 µ in thickness (in control plants). Such tissue slightly increased by 2.2 and 5.6% in Mn 50 and Fe 100 treatments, respectively, and decreased by 9.3 and 21.2% in Zn 100 and Mix 100 treatments, respectively, compared to the control. The increase in such treatments may be due to the increase in phloem tissue thickness by 8.0 & 50.1% other than the xylem tissue, while the decrease in the other treatments may be due to the decrease in xylem tissue thickness by 14.4 & 26.0% other than the phloem tissue.

The secondary xylem of the stem is storied in radial rows. Spraying soybean plants with microelements resulted in decreasing thickness of fiber caps above vascular bundles and its number of layers comparing with the control plants except bundle cap thickness of Fe 100 treatment which was equal to the control (82.2 μ). The reduction ratios of bundle cap thickness were 15.8, 15.8 and 26.3% for Zn 100, Mix 100 and Mn 50, respectively, as well as reduction in number of bundle cap layers were 16.7, 16.7, 25.0 and 25.0% lower than the control for Zn 100, Fe 100, Mn 50 and Mix 100, respectively.

The pith diameter was 1860.5 μ in the control plants which was increased between 37.9% in Zn 100 up to 64.7% in Mix 100 as a result for applying the micronutrients on soybean plants.

It may be concluded that, increasing stem diameters of treated plants may be due to the increase in thickness of epidermis, phloem tissue as well as pith diameter. These results are in agreement with those obtained by Abdo (2001) on mungbean.

3.2. Anatomy of leaflet petiole:

The anatomical features of leaflet petioles in treated and untreated soybean plants are presented in Table (9) and Figure (2). The leaflet petioles are pentagonal in shape and have two – well developed wings. The vascular tissue is composed of separate 5 large bundles and 6-7 small accessory bundles in between, in addition, a small bundle inside each wing. There is a fiber cap above all the vascular bundles.

Table (8): Effect of micronutrients on anatomical features of the seventh internode of soybean stem after 90 days from sowing date during the second season (Averages of 10 readings from 5 slides)

Character	Treatments								
	Control	Zn 100	± % to control	Mn 50	± % to control	Fe 100	± % to control	Mix 100	± % to control
Stem diameter (μ)	4641.6	5099.4	+ 9.9	5427.6	+ 16.9	5594.8	+ 20.5	5207.3	+ 12.2
Epidermis thickness (μ)	10.9	14.5	+ 33.0	14.5	+ 33.0	17.1	+ 56.9	15.5	+ 42.2
Cortex thickness (μ)	227.2	207.7	- 8.6	160.1	- 29.5	172.8	- 23.9	147.1	- 35.3
No. of cortex layers	6-9	7-9	+ 6.7	5-7	- 20.0	5-8	- 13.3	6-7	- 13.3
Fiber cap thickness (μ)	82.2	69.2	- 15.8	60.6	- 26.3	82.2	0.0	69.2	- 15.8
No. of fiber cap layers	5-7	4-6	- 16.7	4-5	- 25.0	4-6	- 16.7	4-5	- 25.0
Vascular cylinder thick. (μ)	1148.8	1041.5	- 9.3	1174.3	+ 2.2	1223.6	+ 5.6	905.7	- 21.2
Phloem thickness (μ)	242.8	260.4	+ 7.2	262.3	+ 8.0	364.4	+ 50.1	238.2	- 1.9
Xylem thickness (μ)	899.9	770.1	- 14.4	905.4	+ 0.6	856.7	- 4.8	666.3	- 26.0
Pith diameter (μ)	1860.5	2565.7	+ 37.9	2721.5	+ 46.3	2758.3	+ 48.3	3063.3	+ 64.7

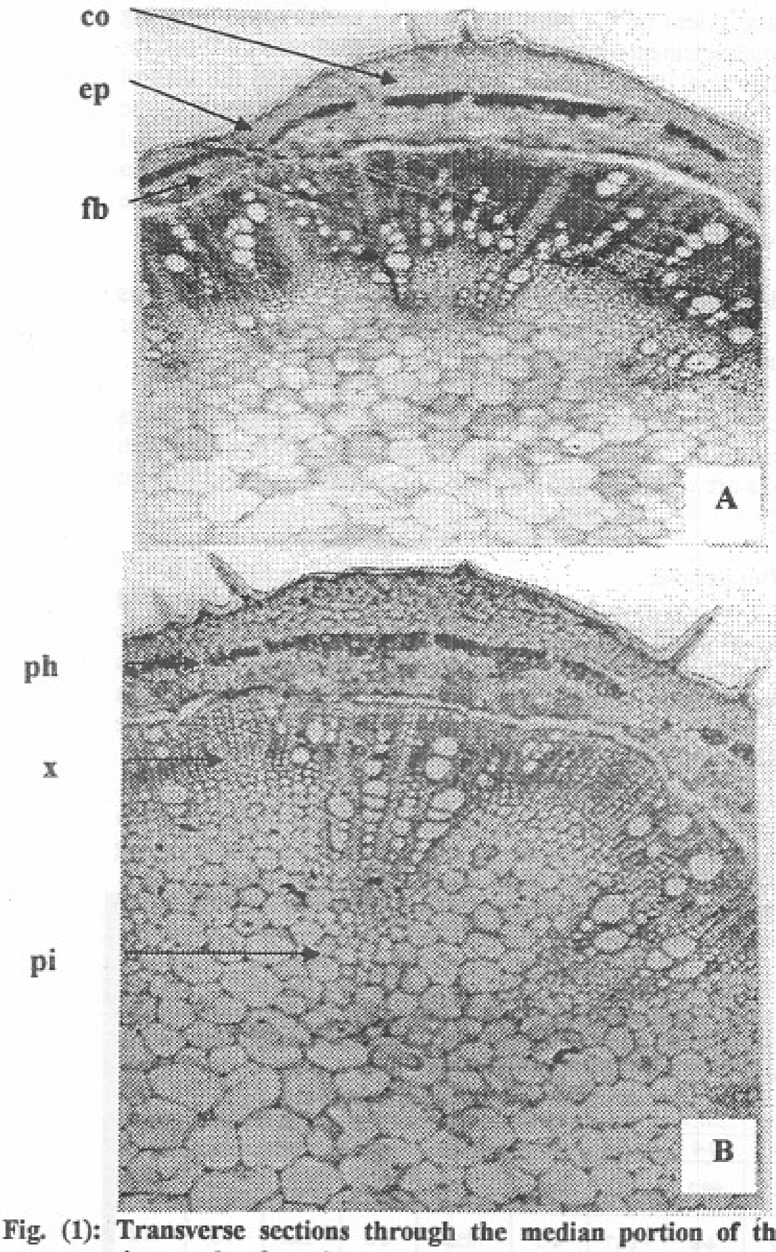

Fig. (1): Transverse sections through the median portion of the seventh internode of soybean stem sprayed with micronutrients after 90 days from sowing date during the second season.

A. Control plant

B. Plant sprayed with Zn at 100 ppm

Details: co, cortex; ep, epidermis; fb, fibers; ph, phloem;pi, pith; x, xylem (X 40).

Cont.

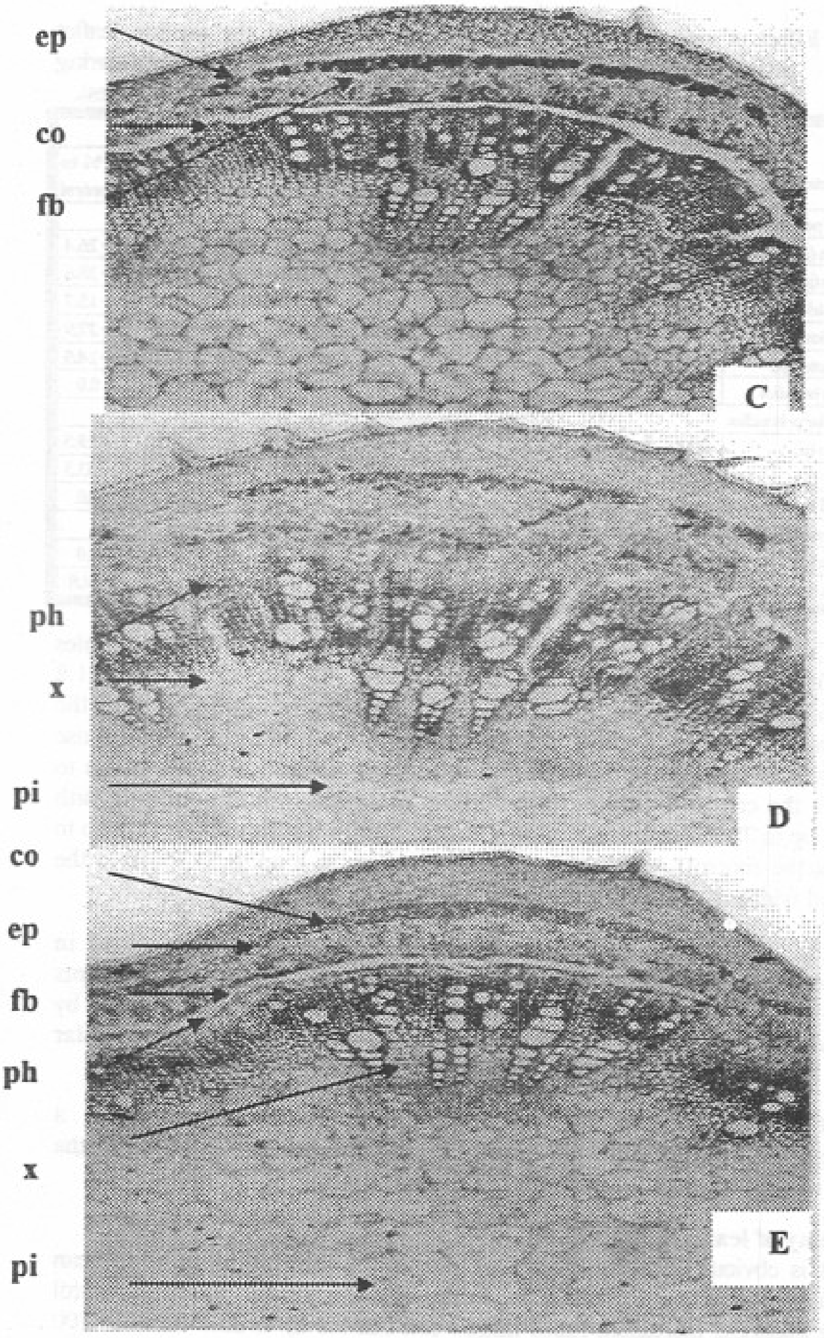

Fig. (1): Cont.
C. Plant sprayed with Mn at 50 ppm
D. Plant sprayed with Fe at 100 ppm (X 40)
E. Plant sprayed with Mix. at 100 ppm (X 40).

Table (9): Effect of micronutrients on anatomical features of the median leaflet petiole on the seventh node of soybean plant after 90 days from sowing date during the second season (Averages of 10 readings from 5 slides).

Characters	Treatments								
	Control	Zn 100	±% to control	Mn 50	±% to control	Fe 100	±% to control	Mix 100	±% to control
Dimensions of petiole:									
Length (μ)	934.6	1090.3	+16.7	1148.7	+22.9	1252.6	+34.0	1181.2	+26.4
Width (μ)	999.5	1213.6	+21.4	1211.0	+21.2	1272.0	+27.3	1285.0	+28.6
Epidermis thickness (μ)	13.4	14.5	+8.2	13.4	0.0	15.5	+15.7	15.5	+15.7
Cortex thickness (μ)	70.3	67.2	-4.4	65.1	-7.4	96.1	+36.7	89.9	+27.9
Pith diameter (μ)	584.1	726.9	+24.5	746.4	+27.8	811.3	+38.9	726.9	+24.5
No. of large bundles	5	5	0.0	5	0.0	5	0.0	5	0.0
Dimensions of large bundles:									
Length (μ)	233.6	259.6	+11.1	279.1	+19.5	265.6	+13.7	279.1	+19.5
Width (μ)	194.7	281.2	+44.4	266.1	+36.7	265.6	+36.4	298.5	+53.3
No. of small bundles	6-7	6-7	0.0	6-7	0.0	6-7	0.0	6-7	0.0
Dimensions of small bundles:									
Length (μ)	175.2	136.3	-22.2	162.3	-7.4	162.3	-7.4	175.2	0.0
Width (μ)	136.3	155.8	+14.3	149.3	+9.5	142.8	+4.8	142.8	+4.8

Treatment with micronutrients increased dimensions of leaflet petioles between 16.7 and 34.0% in length for Zn 100 and Fe 100, respectively, and 21.2 and 28.6% in width for Mn 50 and Mix 100, respectively, compared with the control. Such increment of leaflet petiole dimensions may be due to the increase in thickness and dimensions of most tissues such as; epidermis (from 8.2 up to 15.7% over the control), cortex (from 27.9 up to 36.7% over the control), pith (from 24.5 up to 38.9% over the control), length of large bundles (from 11.1 up to 19.5% over the control), width of large bundles (from 36.4 up to 53.3% over the control) and width of small bundles (from 4.8 up to 14.3% over the control).

On the contrary, treating the plants with microelements resulted in reducing cortex thickness of petiole by 4.4 and 7.4% less than the control plants for Zn 100 and Mn 50, respectively, as well as average length of small bundles by 7.4% (in Mn 50 and Fe 100) and 22.2% (in Zn 100). Number of small vascular bundles in the treated plants equaled the control (6-7 bundles).

It may be concluded that, the increase in dimensions of petioles as a result to spraying the soybean plants with micronutrients may be due to the increment of thickness and dimensions of different tissues.

3.3. Anatomy of leaflet blade:

It is obvious from Table (10) and Figure (3) that, treatment of soybean plants with microelements thickened the leaflet blades compared with the control plants. The thickness increasing ratios ranged between 9.8 up to 23.8% for Zn 100 and Mix 100, respectively, higher than the control. Most included tissues shared to different extents in increasing the thickness of leaflet lamina of the treated plants. The palisade tissue thickness increased between 15.5% (in Fe 100 & Mix 100) up to 46.3% (in Mn 50) more than the control plants without increasing the number of palisade tissue layers (two layers at all), may be due to enlargement of cells.

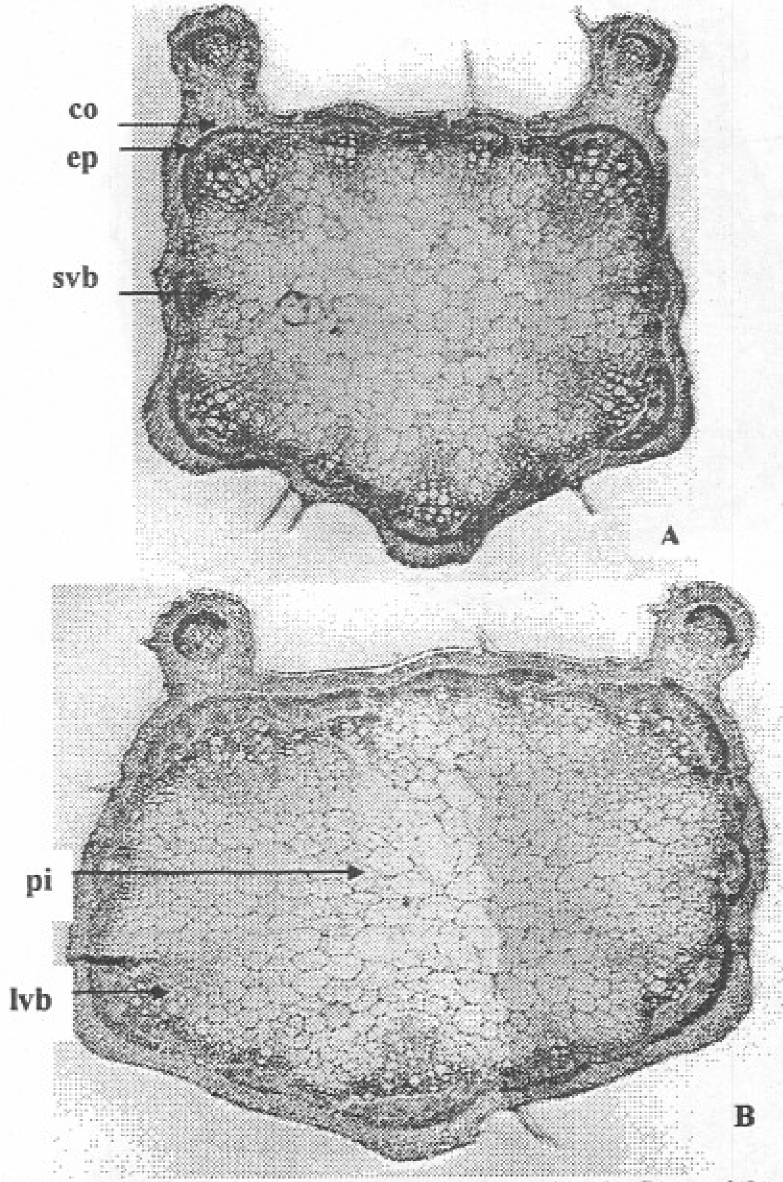

Fig. (2): Transverse sections through the median leaflet petiole on the seventh node of soybean plant sprayed with micronutrients after 90 days from sowing date during the second season.

A. Control plant

B. Plant sprayed with Zn at 100 ppm

Details: co, cortex; ep, epidermis; lvb, large vascular bundle; pi, pith; svb, small vascular bundle (X 40).

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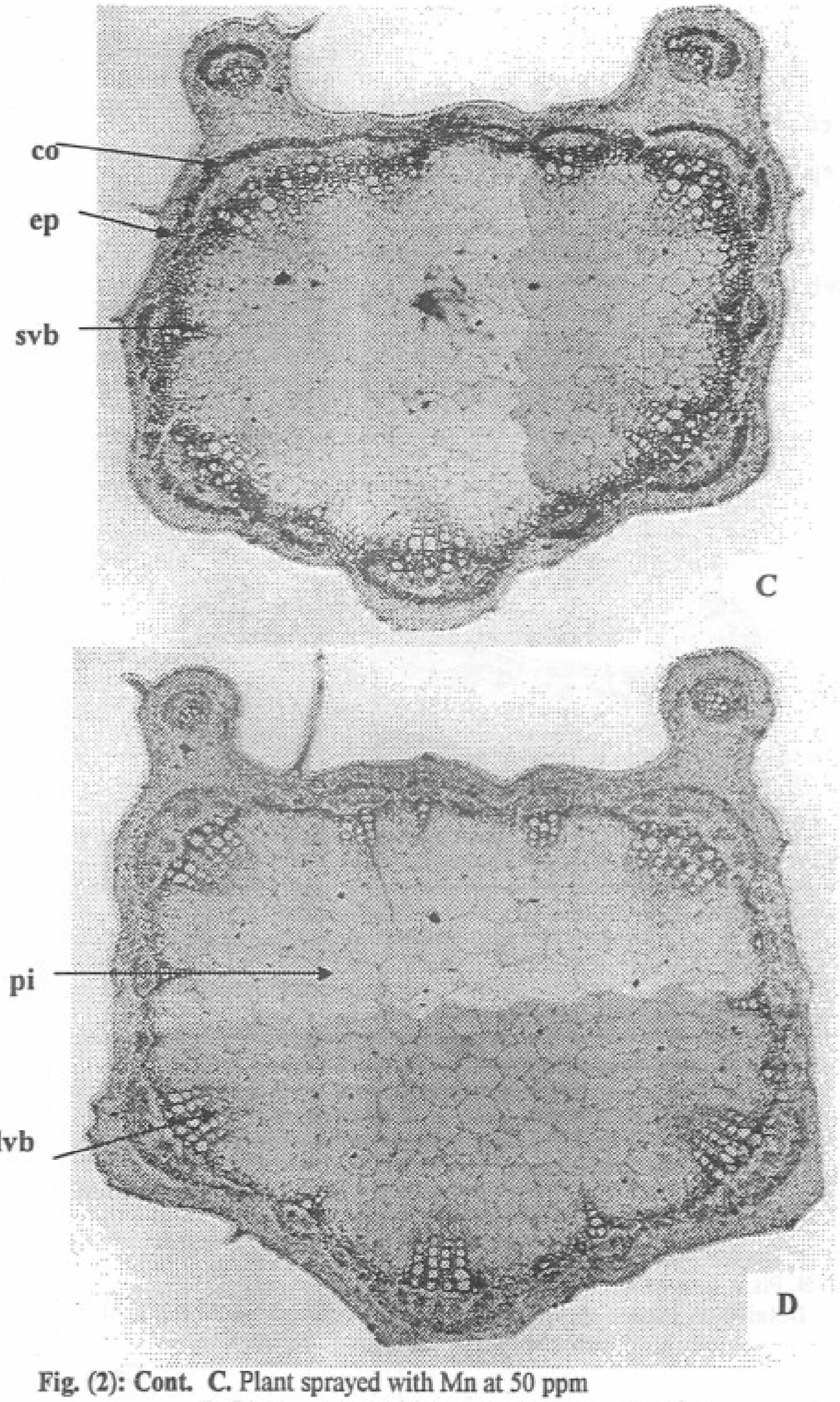

Fig. (2): Cont. C. Plant sprayed with Mn at 50 ppm
D. Plant sprayed with Fe at 100 ppm (X 40). Cont.

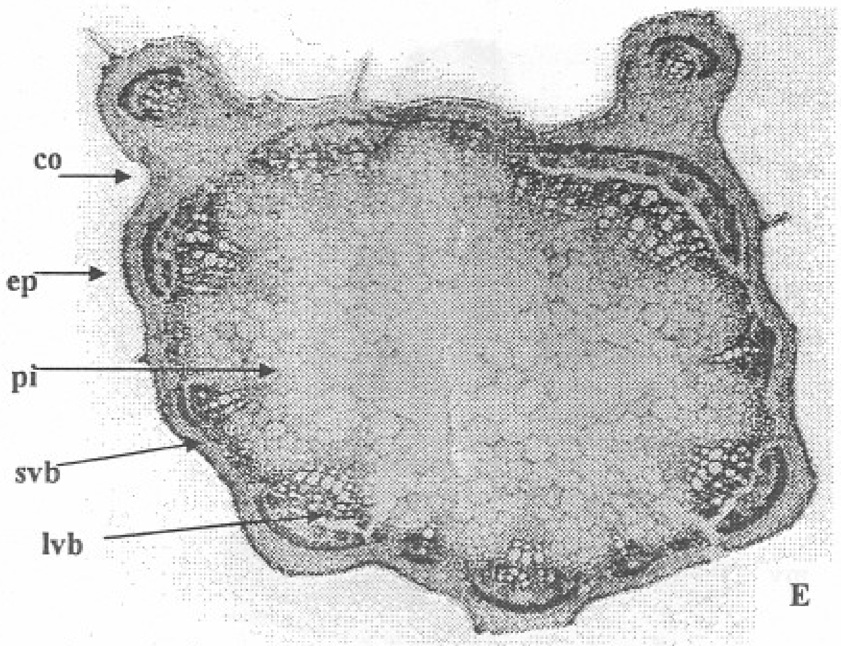

Fig. (2): Cont.
E. Leaflet petiole sprayed with Mix. at 100 ppm (X 40).

Table (10): Effect of micronutrients on anatomical features of the median leaflet of compound leaf on the seventh node of soybean plant after 90 days from sowing date during the second season (Averages of 10 readings from 5 slides).

Characters	Treatments								
	Control	Zn 100	± % to control	Mn 50	± % to control	Fe 100	± % to control	Mix 100	± % to control
Thickness of lamina (µ)	152.7	167.6	+ 9.8	183.1	+ 19.9	150.9	- 1.2	189.1	+ 23.8
Upper epidermi thick. (µ)	14.7	12.4	- 15.7	13.4	- 8.8	14.5	-1.4	13.4	- 8.8
Lower epidermis thick.(µ)	10.2	13.4	+ 31.4	11.4	+ 11.8	12.4	+ 21.6	10.2	0.0
Palisade tissue thick. (µ)	56.2	56.2	0.0	82.2	+ 46.3	64.9	+ 15.5	64.9	+ 15.5
No. of palisade tissue layers	2	2	0.0	2	0.0	2	0.0	2	0.0
Spongy tissue thick. (µ)	69.2	82.2	+ 18.8	73.6	+ 6.4	56.2	- 18.8	95.2	+ 37.6
Dimensions of midrib:									
Length (µ)	735.5	707.4	- 3.8	1440.8	+ 95.9	1107.6	+ 50.6	1016.3	+ 38.2
Width (µ)	540.8	636.0	+ 17.6	1311.0	+ 142.4	934.6	+ 72.8	649.0	+ 20.0
Dimensions of midrib bundle:									
Length (µ)	259.6	292.1	+ 12.5	514.9	+ 98.3	398.0	+ 53.3	307.2	+ 18.3
Width (µ)	279.1	346.1	+ 24.0	791.8	+ 183.7	544.7	+ 131.0	419.7	+ 50.4
No. of xylem rows of midrib bundle	6.7	9.7	+ 44.8	19.3	+ 188.1	13.3	+ 98.5	11.0	+ 64.2
No. of xylem vessels of midrib bundle	34.0	54.0	+ 58.8	148.0	+ 335.3	119.0	+ 250.0	70.0	+ 105.9

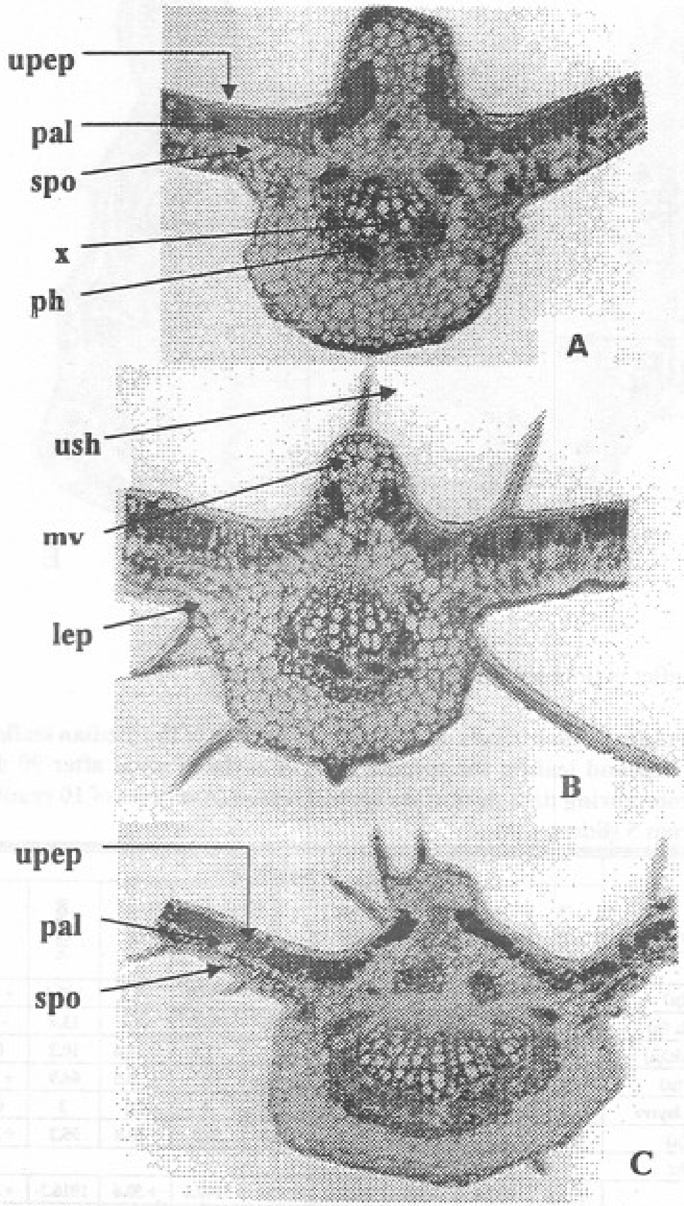

Fig. (3): Transverse sections through the median leaflet of the compound leaf on the seventh node of soybean plant sprayed with micronutrients after 90 days from sowing date during the second season.

A. Control plant

B. Plant sprayed with Zn at 100 ppm

C. Plant sprayed with Mn at 50 ppm

Details: lep, lower epidermis; mv, midvein; pal, palisade tissue; ph, Phloem; spo, spongy tissue; upep, upper epidermis; ush, Uniseriate hair; x, xylem (X 40).

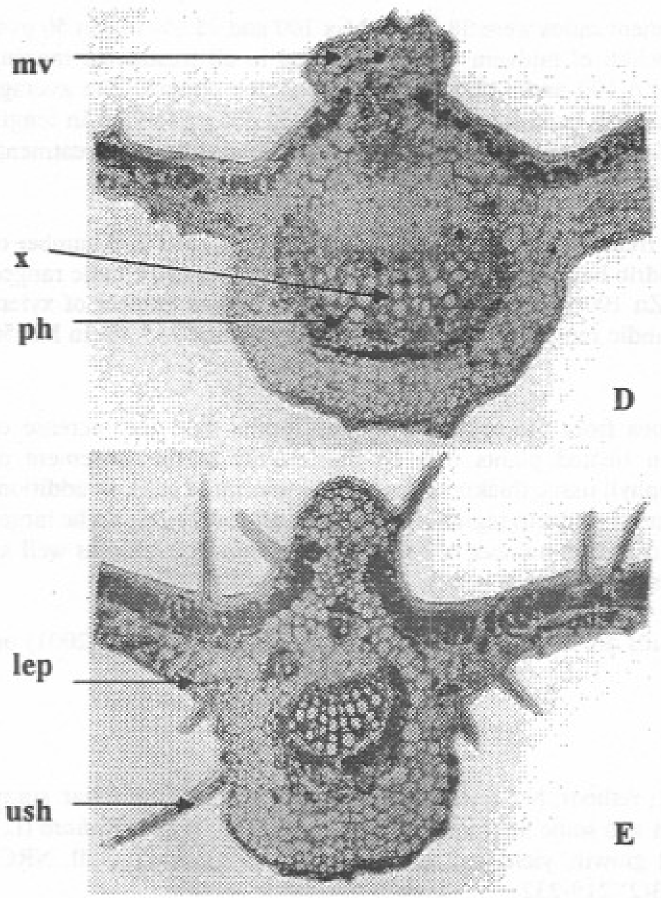

Fig. (3): Cont.
D. Plant sprayed with Fe at 100 ppm
E. Plant sprayed with Mix. at 100 ppm (X 40).

In addition, thickness of spongy tissue also increased in all treatments, except Fe 100 (18.8% lower than the control). The increment ratios were between 6.4% in Mn 50 up to 37.6% in Mix 100 compared to the control. The palisade tissue slightly extended inside the midvein region. The upper epidermis thickness decreased in all treated plants ranging between 1.4% in Fe 100 up to 15.7% in Zn 100 lower than the control due to narrowness of cells.

On the contrary, thickness of lower epidermis increased in all treated plants, except Mix 100 as equaled the control. The increment ratios were 11.8% in Mn 50 up to 31.4% in Zn 100 comparing with control plants. Both the upper and lower epidermis possess a uniseriate hairs in midvein region. The average dimensions of midvein region increased in length by using different treatments, except Zn 100 (3.8% lower than the control).

The increment ratios were 38.2% in Mix 100 and 95.9% in Mn 50 over the control. Also, width of midvein region increased in all treatments ranging between 17.6% in Zn 100 and 142.4 in Mn 50 over the control. The average dimensions of the midrib bundle increased between 12.5% up to 98.3 in length and between 24.0% up to 183.7% in width for Zn 100 and Mn 50 treatments higher than the control plants.

The same trend was observed in number of xylem rows and number of xylem vessels of midrib bundles. Number of xylem rows of midrib bundle ranged between 44.8% in Zn 100 up to 188.1% in Mn 50 as well as number of xylem vessels of midrib bundle ranged between 58.8% in Zn 100 and 335.3% in Mn 50 over the control.

It is obvious from the above mentioned results that, the increase of lamina thickness in treated plants may be due mainly to the increment of epidermis and mesophyll tissue thickness due to enlargement of cells. In addition, the larger dimensions of midvein region in treated plants may be due to the larger midrib bundle and the large number of xylem rows of midrib bundle as well as number of xylem vessels of midrib bundle.

These results are in agreement with those obtained by Abdo (2001) on mungbean.

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تأثير المعاملة ببعض العناصر الصغرى على الصفات الخضرية والتشريحية والمحصولية لنبات فول الصويا

مختار حسن عبد الرحمن أبو بكر ، عاطف زكريا السيد سبع
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أجريت دراسة حقلية فى محطة التجارب الزراعية التابعة لكلية الزراعة – جامعة القاهرة بالجيزة خلال الموسمين ٢٠٠٤– ٢٠٠٥ لدراسة تأثير الرش الورقى بالعناصر الصغرى (زنك– منجنيز– حديد) كل على حدة أو فى مخلوط على الصفات الخضرية والانتاجية والتشريحية لنبات فول الصويا (صنف ويليامز). وقد تم الرش بتلك العناصر مرتين الأولى بعد ٤٥ يوم ، والثانية بعد ٧٥ يوم من الزراعة بتركيزات ٢٥ ، ٥٠ ، ١٠٠ جزء فى المليون وقد أوضحت النتائج المتحصل عليهـا أن الرش بتلك العناصر كل على حدة أو فى مخلوط قد أدى الى زيادة معنوية لمعظم صفات النمو الخضرى و كذلك الصفات المحصولية بالمقارنة بنباتات الكنترول فى كلا الموسمين. وقد كانت أفضل النتائج المتحصل عليها بالنسبة للصفات السابقة عند رش النباتات بالزنك بتركيز ١٠٠ جزء فى المليون ، المنجنيز بتركيز ٥٠ جزء فى المليون، الحديد بتركيز ١٠٠ جزء فى المليون أو بمخلوط منهم بتركيز ١٠٠ جزء فى المليون. وقد أشتملت تلك الصفات على: ارتفاع النبات (سم) ، طول الساق الرئيسى (سم) ، عدد سلاميات الساق الرئيسى ، سمك الساق الرئيسى ، عدد الأفرع الجانبية ، عدد الأوراق للنبات ، عدد القرون للنبات ، عدد بذور النبات ، محصول البذور للنبات، وزن ١٠٠ بذرة. وقد أشارت المظاهر التشريحية لكل من الساق والعنق والوريقة الى أن رش نبات فول الصويا بالتركيزات السابقة من العناصر الصغرى قد أدى الى زيادة قطر الساق مقارنة بالكنترول والتى قد تعزو الى زيادة سمك البشرة ونسيج اللحاء وكذلك قطر النخاع كما أدت المعاملات الى زيادة أبعاد العنق والتى قد تعزو الى زيادة سمك كل من البشرة والقشرة وكذلك قطر النخاع وأبعاد الحزم الوعائية مقارنة بالكنترول. كما أدت تلك المعاملات أيضا الى زيادة سمك النصل والعرق الوسطى للوريقة مقارنة بالكنترول ، وقد يعزو زيادة سمك النصل الى زيادة سمك البشرة السفلى والنسيج الوسطى للوريقة بينما قد يعزو زيادة سمك العرق الوسطى للوريقة الى زيادة أبعاد الحزمة الوعائية الرئيسية نتيجة زيادة عدد صفوف الخشب وكذلك عدد الأوعية فى الحزمة.