Bull. Fac. Agric. Cairo Univ.,52 (2001):445-466.

THE RESPONSE OF TWO MUNGBEAN CULTIVARS TO ZINC, MANGANESE AND BORON I. MORPHOLOGICAL, PHYSIOLOGICAL AND ANATOMICAL ASPECTS

(Received: 9.12.2000)

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ABSTRACT

Two field experiments were conducted at Giza Experimental Station, ARC, during 1998 and 1999 seasons to study the effect of foliar spray with micronutrients (Zn, Mn or B) on morphological, physiological and anatomical parameters of two mungbean (*Vigna radiata* (L.) Wilczek) cultivars V-2010 (Giza-1) and VC-1000. Zn (0.2 or 0.4 g/l), Mn (1.5 or 2.0 g/l), B (3.0 or 5.0 g/l) and a mixture of Zn, Mn and B (0.2, 1.5 and 3.0 g/l, respectively) in addition to distilled water as control were sprayed once at 35 days after sowing (DAS).

The results showed that foliar spray with the adopted concentrations of Zn, Mn or B alone or in a mixture, increased significantly most of the growth parameters over the control in both seasons. Application of Zn (0.2 g/l) alone followed by a mixture of micronutrients resulted in better morphological and physiological parameters [stem length (cm), No. of branches, No. of leaves, leaf area (LA) (cm^2), leaf area index (LAI) and shoot dry weight (g) per plant]. It was observed that mungbean cv. VC-1000 surpassed cv. V-2010 in all parameters under investigation in both seasons.

The effect of spraying with low level of Zn, Mn, B and their mixture on the internal structure of the vegetative growth of mungbean cv. VC-1000 was investigated.

Key words: *anatomy, foliar application, growth, micronutrients, mungbean.*

1. INTRODUCTION

The mungbean (*Vigna radiata* (L.) Wilczek) is a new summer pulse crop in Egypt. It is a rapid growth crop with short growing season ranging from 70 to 100 days. Mungbean is grown principally for its high protein seeds that are used as human food. It is utilized in making soups, curries, bread sweets, salads and many other culinary products (Poehlman 1991).

In the meantime, huge amounts of nutrients are continuously removed from the Egyptian soils due to increasing yearly cropping intensification. Although, micronutrients are successively removed from the soil in addition to macronutrient, yet application of macronutrient fertilizers only is still the prevailing field practice. Consequently, nutrient imbalance and deficiency of micronutrients, particularly B, Mn and Zn form one of the major yield limiting factors in Egypt.

Therefore, application of such micronutrients 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).

Many investigators demonstrated that morphological parameters of legumes especially mungbean are influenced by Zn, Mn and B application. In this respect, Singh and Badhoria (1984) stated that zinc application (5 and 10 mg Zn/kg soil as $ZnSo_4.7H_2O$) was significantly effective on dry matter accumulation at 50 days and at harvest. The dry matter yield increased with increasing levels of zinc at all growth stages, but the increase in the yield by Zn_2 was only marginally greater than Zn_1 on greengram plants.

Nassar *et al.,* (1985) found that the micronutrients (Zn, Mn and Fe) significantly increased plant height, number of branches/plant and plant dry weight of the bean plant.

Singh and Singh (1995) reported that the application of 20 kg/ha zinc oxide significantly increased leaf area (LA) and dry matter/plant.

Abd-El-Lateef *et al.,* (1998) studied the effect of foliar spray with some nutrients on the growth of mungbean (variety Kawmy-1). The foliar treatments were urea (1%) and four micronutrients [Fe (0.5%), Zn (0.1%), Mn (0.2%) and $CuSo_4$ (0.05%)], sprayed either alone or combined with urea at early pod-setting. They found that the effect of foliar spray treatments was significant on mungbean plant height, number of branches and leaves as well as total dry weight/plant. Zn alone gave the tallest plant and increased the number of branches/plant.

Sarkar *et.al.,* (1998) reported that the application of micronutrients mixture and Zn alone resulted in better physiological parameters like dry matter production and leaf area index (LAI) leading to higher growth.

Sharief and 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.

The present investigation is an attempt to bring to light more information about the effect of spraying micronutrients (Zn, Mn and B) alone or in combined mixture on morphological, physiological and anatomical characters of mungbean plants.

2. MATERIALS AND METHODS

Two field experiments were carried out at the Agricultural Experimental Station, Agricultural Research Center (ARC), Giza during the two growing seasons of 1998 and 1999. Two mungbean (*Vigna radiata* (L.) Wilczek) cultivars V-2010 (Giza-1) and VC-1000 were used in this investigation to study the effect of foliar spray treatments with some micronutrients on their growth and anatomy. Eight treatments were applied as foliar spray after 35 days from sowing and the treatments were as follows:

- Control (spray with water)
- Zinc sulphate 0.2 g/l (Zn_1)
- Zinc sulphate 0.4 g/l (Zn_2)
- Manganese (E.D.T.A) 1.5 g/l (Mn_1)
- Manganese (E.D.T.A) 2.0 g/l (Mn_2)
- Boric acid 3.0 g/l (B_1)
- Boric acid 5.0 g/l (B_2)
- Mixture (0.2 Zn, 1.5 Mn and 3.0 B g/l)

The experiment was laid out in a randomized complete block design with four replications. The experimental plot area was 12.6 m^2 consisted of 6 ridges 3 meters in length and 70 cm in width. Seeds were inoculated with the specific *Rhizobium* strain (*Bradyrhizobium Japonicum*) and immediately sown in hills on both sides of the ridge at 20 cm apart. Seeds were sown on May 31st (first season) and on May 12th (second season) and the harvest was after 90 days from sowing date; respectively. All agricultural practices were used as recommended.

The mechanical and chemical analyses for the experimental soil are shown in Table(1)and determined by using the method described by Chapman and Prait (1961)and Jachson (1958).The following measurements were recorded at three stages (50, 65 and 80 days after sowing date).

Stem length (cm), number of branches/plant, number of leaves/plant, leaf area (LA) in cm^2, leaf area index (LAI)=LA (cm^2)/ground area (cm^2) and shoot dry weight (g)/plant. The obtained data were statistically analyzed according to Snedecor and Cochran (1982).

It was intended to carry out a comparative microscopical examination on plant material, which showed the most prominent response of plant growth to investigated treatments.

Therefore, specimens of mungbean cv. VC-1000 were taken from the seventh internode of the main stem as well as, from the median leaflet of the corresponding compound leaf. Plants used for examination were taken throughout the second season (1999), at the age of 55 days (the stage of 50 % flowering) *i.e.*, three weeks after treatments.

Specimens were killed and fixed for at least 48 hr. in F. A. A. (10 ml formalin, 5 ml glacial acetic acid and 85 ml ethyl alcohol 70 %). The selected materials were washed in 50 % ethyl alcohol, dehydrated in a normal butyl alcohol series, embedded in paraffin wax of melting point 56°C, sectioned to a thickness of 20 microns, double stained with crystal violet-erythrosin, cleared in xylene and mounted in Canada balsam (Willey, 1971).Sections were read to detect histological manifestations of noticeable responses resulted from spraying with zinc (Zn), manganese (Mn), boron (B) or their mixture.

Table (1): Mechanical and chemical analyses of the experimental soil (means of 1998 and 1999 seasons).

Soil properties			
Mechanical analysis		**Chemical analysis**	
Coarse sand (%)	1.5	pH	7.5
Fine sand (%)	38.7	Organic matter (%)	1.73
Silt (%)	37.2	Available N (ppm)	42.0
Clay (%)	22.6	Available P (ppm)	7.2
Soil texture	Loam	Available K (ppm)	487.0
		Available Zn (ppm)	1.94
		Available Mn (ppm)	9.6
		Available B (ppm)	0.806

3. RESULTS AND DISCUSSION

3.1. Vegetative growth

3.1.1. Stem length

Data in Tables (2 and 3) show that stem length of the two mungbean cvs. V-2010 and VC-1000 was significantly increased by foliar spray treatments of micronutrients at 50, 65 and 80 days after sowing (DAS) in 1998 and 1999 seasons. Maximum increase was obtained at 80 DAS by using Zn_1 and the combined treatments of Zn_1+Mn_1+B_1 being 21.9 % over the control in the first season. The maximum increase in the second season was 50.13 % over the control for Zn_1 and it was 49.55 % over the control for combined treatment (Zn_1+Mn_1+B_1).

Similar results were reported by Singh and Badhoria (1984), Nassar *et al.*, (1985) on bean, Abd-El-Lateef *et al.*,(1998) and Sarkar *et al.*, (1998) on mungbean. The favorable effect of zinc may be due to its direct influence on auxin production which in turn enhanced the elongation processes of plant development (Skoog, 1940).

3.1.2. Number of branches/plant

Results in Tables (2 and 3) indicate that all adopted concentrations of micronutrients had no statistical effect on the number of branches/plant at 50 DAS in both seasons. On the other hand, Zn_1 alone or in combination with Mn_1 and B_1 gave a significant increase in the number of branches/plant at 80 DAS, being 35.78 and 43.77 % over the control in the first season; respectively and 73.61 and 78.13% over the control in the second season; respectively. These results are in agreement with those obtained by Nassar *et al.*, (1985) on bean, Abd-El-Lateef *et al.*, (1998) and Sharief and Said (1998) on lentil plants.

3.1.3. Number of leaves/plant

Number of leaves was increased linearly up to 65 and 80 DAS and was maximum at maturity (80 days). Application of Zn_1 and combined treatment (Zn_1+Mn_1+B_1) resulted in a higher number of leaves/plant at 80 DAS, being 34.03 and 28.62% over the control in the first season, respectively and 88.37 and 83.72% over the control in the second season; respectively. These results confirm those of Abd-El-Lateef *et al.*, (1998).

Table (2): Effect of micronutrients on means of different morphological and physiological parameters of two mungbean cultivars in 1998 season

Treatments	DAS			DAS			DAS		
	50	65	80	50	65	80	50	65	80
	Stem length (cm)			No. of branches/plant			No. of leaves/plant		
Control	33.63	38.75	46.25	2.11	2.50	3.13	9.38	15.13	23.13
Zn_1	41.38	48.75	56.38	2.25	3.15	4.25	13.13	16.75	31.00
Zn_2	43.00	47.13	54.13	2.37	3.34	3.93	13.38	21.75	28.63
Mn_1	50.38	54.00	54.50	2.21	3.31	3.93	14.25	18.88	27.00
Mn_2	44.18	44.38	54.38	2.22	3.11	3.38	12.38	25.25	29.00
B_1	46.38	47.00	55.25	2.24	2.91	3.50	14.00	20.13	26.50
B_2	49.00	50.63	54.13	2.20	3.01	4.00	14.63	22.63	28.50
$Zn_1+Mn_1+B_1$	46.25	55.38	56.38	2.51	3.35	4.50	14.75	27.00	29.75
L.S.D. (0.05)	7.49	7.83	5.45	N.S	0.19	0.19	N.S	7.44	4.66
V-2010	46.28	48.13	52.75	2.20	3.16	3.76	13.78	20.91	27.53
VC-1000	42.25	48.44	55.09	2.33	3.02	3.90	12.69	20.97	28.34
L.S.D. (0.05)	3.75	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
	LA (cm^2)			**LAI**			**Shoot dry weight (g)**		
Control	1220.28	1658.30	2414.95	3.49	4.73	7.03	11.14	24.75	36.25
Zn_1	1438.15	2763.55	4660.70	4.11	7.90	11.50	15.19	34.26	84.45
Zn_2	1742.31	3772.40	4145.40	4.48	10.78	13.09	15.98	50.97	64.20
Mn_1	1978.28	3205.95	3712.08	5.66	9.16	13.22	20.30	41.49	64.48
Mn_2	1636.87	3538.50	3560.56	4.68	10.11	12.09	16.75	40.01	55.77
B_1	2114.77	2804.25	3670.15	6.05	8.01	11.25	19.63	38.52	58.69
B_2	1845.67	4068.15	3435.45	5.28	11.63	15.14	17.18	41.41	53.10
$Zn_1+Mn_1+B_1$	1941.70	4297.90	4150.35	5.55	12.29	13.21	18.46	47.04	69.68
L.S.D. (0.05)	N.S	1451.69	682.20	N.S	4.15	3.44	N.S	11.86	15.50
V-2010	1785.94	3185.38	3528.24	5.11	9.10	11.05	16.70	37.14	58.07
VC-1000	1693.56	3341.83	3909.17	4.84	9.55	13.08	16.95	42.47	63.58
L.S.D. (0.05)	N.S	N.S	341.20	N.S	N.S	1.72	N.S	N.S	N.S

3.1.4. Leaf area (LA) and leaf area index (LAI)

Concerning LA and LAI (Tables 2 and 3), mungbean cv. VC-

1000 surpassed V-2010 at 80 DAS in the two seasons. The differences between the two cultivars at 50 and 65 DAS were not significant in the two seasons. At 80 DAS, Zn_1 alone recorded appreciably higher LA followed by $Zn_1 + Mn_1 + B_1$ being 92.99 and 71.86% more than the control; respectively in the first season and 115.46 and 88.00% more than the control; respectively in the second season. These results are in harmony with those obtained by Singh and Singh (1995) and Sarkar *et al.*, (1998).

Table (3): Effect of micronutrients on means of different morphological and physiological parameters of two mungbean cultivars in 1999 season

Treatments	DAS			DAS			DAS		
	50	65	80	50	65	80	50	65	80
	Stem length (cm)			No. of branches/plant			No. of leaves/plant		
Control	33.13	41.75	43.13	2.13	2.25	2.88	10.13	11.75	21.50
Zn_1	38.88	48.00	64.75	2.50	2.75	5.00	16.00	18.50	40.50
Zn_2	39.50	48.10	61.50	2.50	2.88	4.75	14.50	17.00	32.88
Mn_1	40.75	45.63	63.63	2.38	2.87	4.50	15.25	16.00	35.75
Mn_2	40.75	45.63	63.00	2.38	2.63	3.75	15.25	17.38	34.38
B_1	38.25	46.50	57.75	2.38	2.75	4.13	13.00	15.38	31.13
B_2	38.00	45.00	57.63	2.25	2.75	4.75	15.13	17.13	27.13
$Zn_1+Mn_1+B_1$	38.13	45.63	64.50	2.63	2.88	5.13	15.00	17.75	39.50
L.S.D. (0.05)	3.87	3.79	9.99	N.S	0.50	0.94	N.S	3.27	8.82
V-2010	37.47	44.88	52.22	2.22	2.53	4.28	13.81	15.88	30.31
VC-1000	39.38	46.68	66.75	2.56	2.91	4.44	14.75	16.84	35.38
L.S.D. (0.05)	N.S	N.S	4.99	0.31	0.25	N.S	N.S	N.S	4.42
	LA (cm²)			LAI			Shoot dry weight (g)		
Control	1148.60	1827.80	2458.00	3.29	5.23	6.91	19.97	32.51	53.55
Zn_1	2091.95	2892.40	5295.90	5.98	8.27	13.32	31.41	51.26	97.83
Zn_2	1847.15	2513.30	4434.60	5.28	7.18	10.61	26.76	43.01	77.82
Mn_1	1923.00	2367.90	4580.20	5.50	6.77	11.85	26.45	48.70	79.75
Mn_2	1717.60	2167.68	4421.30	4.91	6.20	9.82	28.20	43.20	79.27
B_1	2049.15	2605.40	4024.00	5.86	7.45	10.53	28.66	45.28	76.32
B_2	1811.45	2308.40	3936.60	5.18	6.60	10.49	26.79	43.45	75.06
$Zn_1+Mn_1+B_1$	1918.90	2353.10	4621.00	5.49	6.42	11.86	28.60	54.72	83.84
L.S.D. (0.05)	443.69	634.73	1202.39	1.24	1.89	2.30	7.88	10.41	17.33
V-2010	1743.51	2316.70	3866.06	4.98	5.38	10.08	25.33	43.11	72.66
VC-1000	1883.44	2442.30	4576.80	6.62	6.90	11.26	28.88	47.46	83.21
L.S.D. (0.05)	N.S	N.S	601.19	N.S	N.S	1.15	3.94	N.S	8.67

The good effects of Zn and combined of Zn, Mn and B are probably due to their potent role on increased cell division and elongation of leaves. Such a high LAI is indicative of high mobilizable protein pools available at the beginning of the reproductive phase (Boote *et al.,* 1986). Application of B_2 followed by control treatment resulted in considerably lower LA and LAI than all other treatments in the two seasons. Similar results were reported by Howeler *et al.*, (1978).

3.1.5. Dry matter production/plant (DM)

Regarding dry matter (Tables 2 and 3), DM was increased linearly up to 80 days and was maximum at maturity (80 DAS). Application of Zn and the composite form of micronutrients resulted in higher DM at all stages (except at 50 days in the first season), which was appreciably higher compared with other micronutrients.

From the same Tables it can be realized that foliar spray with Zn_1 alone or combined with Zn_1+Mn_1+B_1 gave higher DM, being 132.97 and 92.22% cver the control at 80 DAS in 1998 season; respectively. Zn_1 or Zn_1+Mn_1+B_1 significantly increased DM, being 82.69 and 56.56% over the control in 1999 season at 80 DAS; respectively.

Singh and Badhoria (1984) and Abd-El-Lateef *et al.*, (1998) reported the positive effects of Zn on the DM accumulation of mungbean plants, being in agreement with the present findings.

Higher dry matter might be due to conductive influence of combined micronutrients and Zn on crop growth. It was likely that improvement in metabolic processes by Zn (Price *et al.,* 1972) and promotion of synergistic interaction by micronutrients (Sarkar *et al.*, 1998), favorably induced crop growth and dry matter yield.

Results of interaction revealed that the response of the two cultivars to all spraying treatments showed the same trend.

3.2. Anatomical studies

It was aimed in this investigation to follow the internal structure of vegetative parts, which exhibited the most noticeable response to adopted treatments. The aforementioned findings concerning the morphological characters of mungbean proved that the low level of each of zinc, manganese or boron as well as, their mixture achieved the most remarkable effects among various tested treatments of micronutrients. This may justify a further study on the effect of spraying with low level of Zn, Mn, B and their mixture on the internal structure of mungbean.

Microscopical characters were examined through specimens of the seventh internode of the main stem of mungbean cv. VC-1000 as well as, of the median leaflet of the corresponding leaf. Sampling was carried out during the second season (1999) at the flowering stage, three weeks after spraying with micronutrients.

3.2.1. Anatomy of the main stem

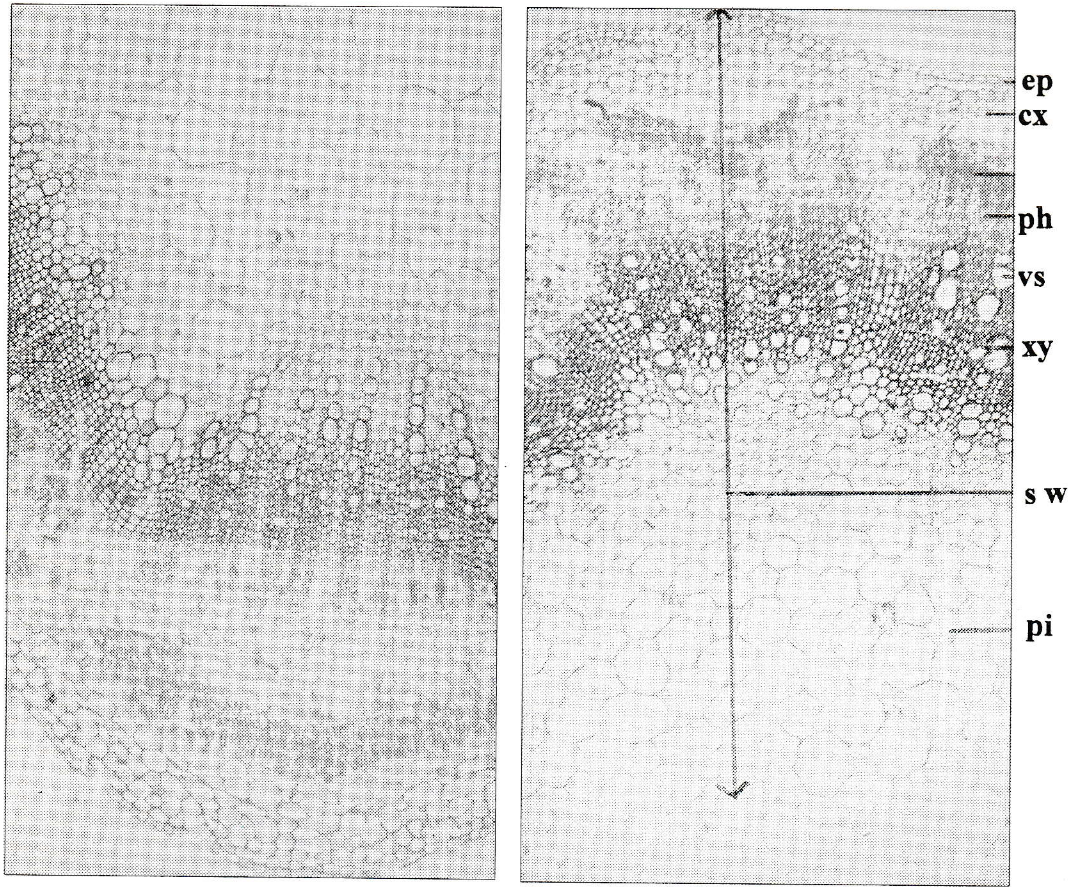
Microscopical measurements of certain characters of the seventh internode which resembled the median internode of the main stem of mungbean cv. VC-1000 sprayed with micronutrients are given in Table (4). Likewise, microphotographs depict these treatments are shown in Figure (1).

Table (4): Measurements in microns of certain histological features in transverse sections through the middle part of the seventh internode of the main stem of mungbean cv. VC-1000 as affected by Zn, Mn, B or their mixture (Means of three sections from three specimens).

Characters	control	Zn	± % to control	Mn	± % to control	B	± % to control	Mixture	± % to control
Stem diameter	5886	5545	- 5.8	7334	+24.6	6788	+ 15.3	6176	+ 4.9
Stem wall thick.	2230	2180	-2.2	2611	+17.1	3146	+ 41.1	2899	+ 30.0
Epidermis thick.	18	20	+ 11.1	15	-16.7	16	- 11.1	15	- 16.7
Cortex thick.	225	220	- 2.2	240	+6.7	230	+ 2.2	210	- 6.7
Fibre strands thick.	150	125	- 16.7	170	+13.3	165	+ 10.0	205	+ 36.7
Phloem tissue thick.	310	250	- 19.4	290	-6.5	330	+ 6.5	210	- 32.3
Xylem tissue thick.	525	430	+ 18.1	705	+34.3	650	+ 23.8	625	+ 19.1
Vessel diameter	39	43	+10.3	76	+94.9	42	+ 7.7	38	- 2.6
Parenchymatous pith thick.	1002	1135	+13.3	1191	+18.9	1755	+ 75.2	1634	+ 63.1
Hollow pith diameter	1425	1187	-16.7	2113	+48.3	496	- 65.2	381	- 73.3

3.2.1.1 The effect of zinc

It is clear from Table (4) and Figures (1 A and B) that the low used concentration of 0.2 g/l zinc sulphate slightly reduced the diameter of the main stem at the seventh internode due mainly to the decrease in the thickness of stem wall and in the diameter of hollow pith. The decre-

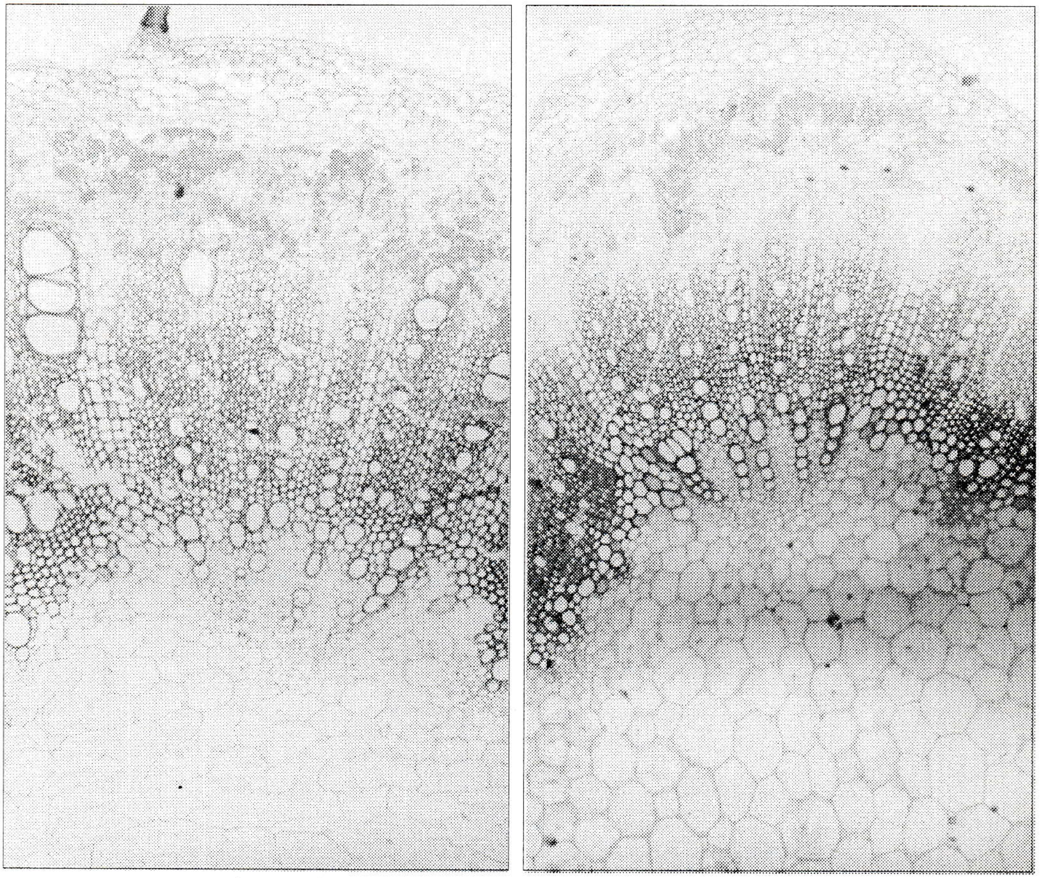


A B

Fig. (1): Transverse sections through the seventh internode of the main stem of mungbean cv. VC-1000 as affected by spraying with micronutrients. (X52)

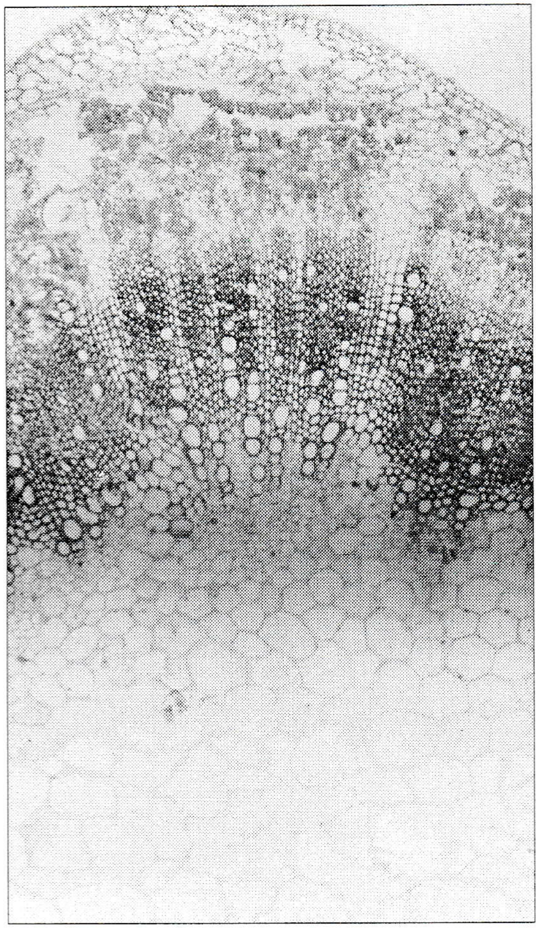
A- Untreated plant.
B- Plant treated with 0.2 g/l zinc sulphate.

(Cont.)



C D

Fig. (1): Cont.
C- Plant treated with 1.5 g/l manganese (E.D.T.A.).
D- Plant treated with 3.0 g/l boric acid.
(Cont.)



E

Fig. (1): Cont.

E- Plant treated with mixture of micronutrients (0.2 g/l zinc sulphate + 1.5 g/l manganese + 3.0 g/l boric acid).

Details: cx, cortex; ep, epidermis; fi, fibre; h pi, hollow pith; ph, phloem; pi, pith; s w, stem wall; vs, vessel and xy, xylem.

ment below the control amounted to 5.8, 2.2 and 16.7 % for internode diameter, stem wall thickness and hollow pith diameter; respectively. It is obvious that the decrease in stem wall thickness could be attributed to the decrease in cortex (by 2.2 %), fibre strands (by 16.7 %), phloem tissue (by 19.4 %) and xylem tissue (by 18.1 %) below the control. Nevertheless, the thickness of the epidermis was increased by 11.1 % and parenchymatous pith thickness was increased by 13.3 % over the control. It is worthy to note that the most beneficial effect of zinc on anatomical structure was observed in vessel diameter, which was increased by 10.3 % over the control. Also, such treatment induced more lignification in xylem tissue (Figures, 1 A and B).

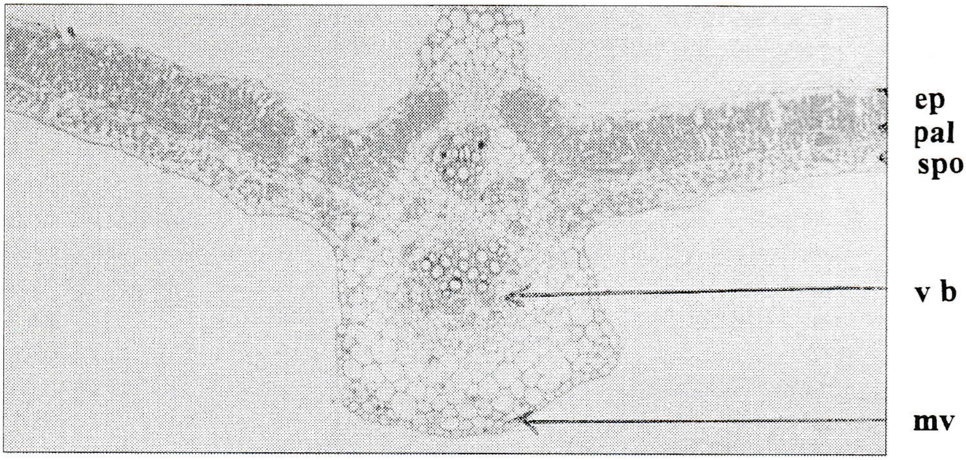
3.2.1.2 The effect of manganese

The main stem diameter at the seventh internode was wider in the treated plants by 24.6 % more than the control. This increment in internode diameter was due to the prominent increase in the thickness of stem wall and in the diameter of hollow pith, which was 17.1 and 48.3 % more than the control; respectively. Nevertheless, the thickness of epidermis and of phloem tissue was decreased by 16.7 and 6.5 % less than the control; respectively. Most of included tissues shared, to different extents, in increasing the thickness of stem wall as a result of spraying manganese. Thickness of cortex, fibre strands, xylem tissue and parenchymatous pith was increased by 6.7, 13.3, 34.3 and 18.9 % over the control; respectively. Moreover, xylem vessels had wider cavities (Figures, 1 A and C), being 94.9 % more than the control, which amounted to more total active conducting area to cope with vigorous growth resulting from the tested treatment.

3.2.1.3 The effect of boron

It is realized from Table (4) and Figures (1 A and D) that the concentration of 3 g/l boric acid increased the internode diameter by 15.3 % over the control. This increment in internode diameter was mainly due to the prominent increase in the thickness of stem wall, which was 41.1 % more than the control. However, the diameter of hollow pith was decreased by 65.2 % less than the control. At the same time, the thickness of parenchymatous pith area was increased by 75.2

A



B

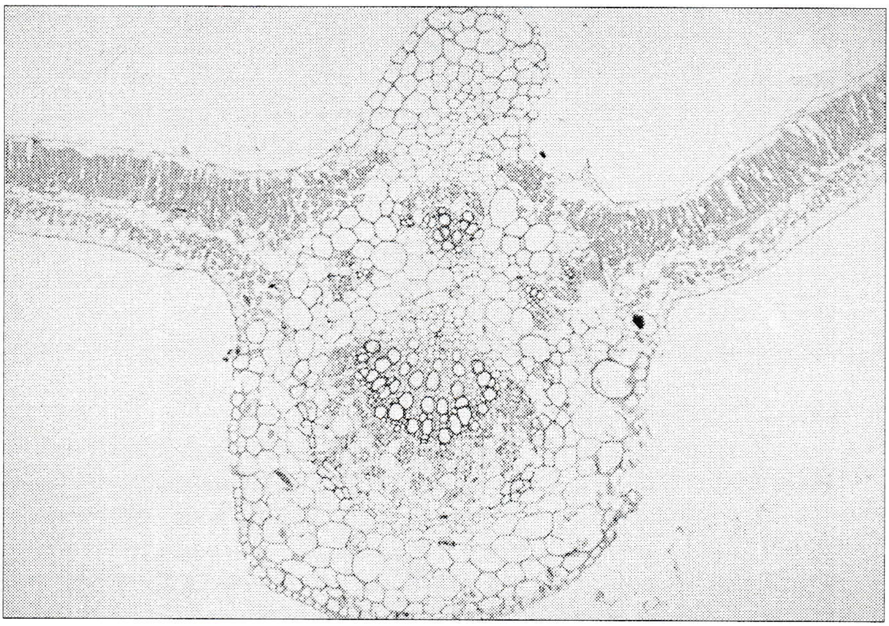


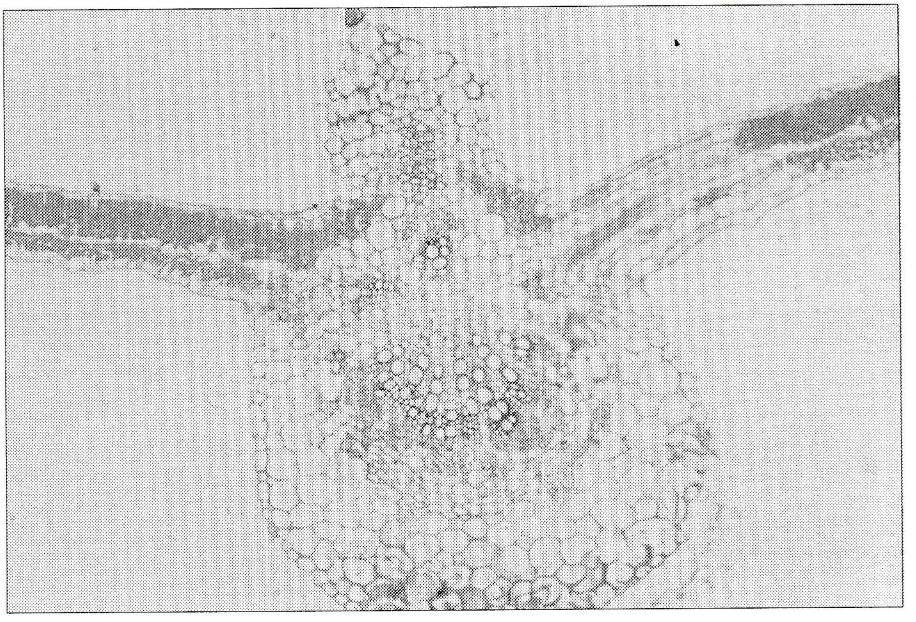
Fig. (2): Transverse sections through the blade of median leaflet from seventh leaf developed on the main stem of mung bean cv. VC-1000 as affected by spraying with micronutrients. (X52)

A- Untreated plant.

B- Plant treated with 0.2 g/l zinc sulphate.

(Cont.)

C



D

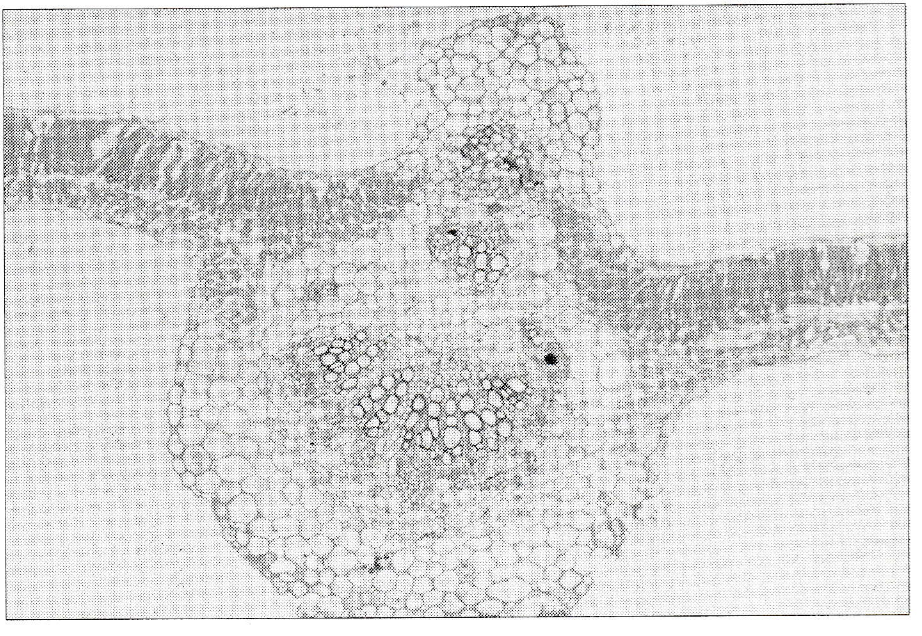


Fig. (2): Cont.

C- Plant treated with 1.5 g/l manganese (E.D.T.A.).

D- Plant treated with 3.0 g/l boric acid.

(Cont.)

E

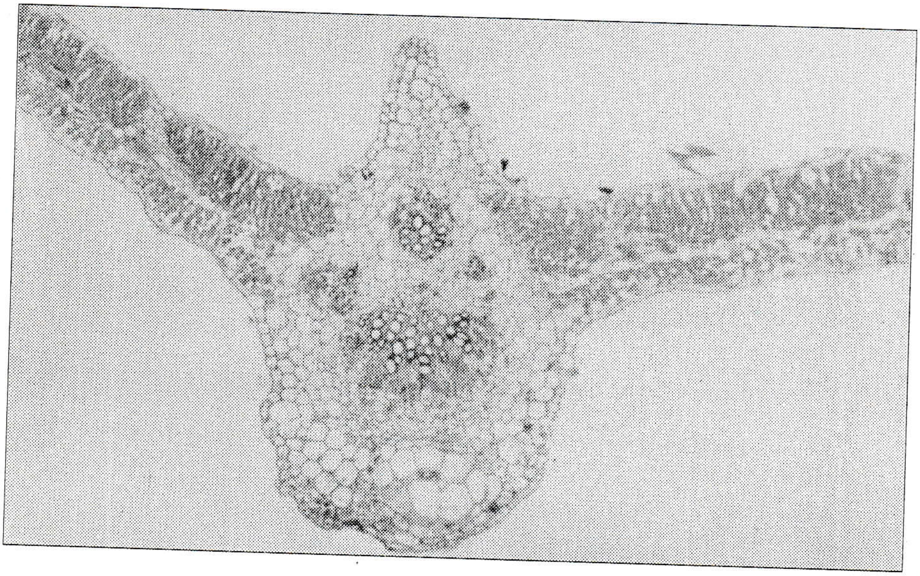


Fig. (2): Cont.

E- Plant treated with mixture of micronutrients (0.2 g/l zinc sulphate + 1.5 g/l manganese + 3.0 g/l boric acid).

Details: ep, epidermis; mv, midvein; pal, palisade tissue; spo, spongy tissue and v b, vascular bundle.

% more than the control and this compensate the reduction in the diameter of hollow pith. The increase in the transverse sectional area as a result of spraying boron could be attributed to the increase in the thickness of tissues outside the hollow pith; *i.e.*, stem wall components. The only exception was observed in the thickness of epidermis, which was reduced by 11.1 % less than the control. Cortex, fibre strands, phloem tissue, xylem tissue and parenchymatous area of the pith were 2.2, 10.0, 6.5, 23.8 and 75.2 % more than the control; respectively. Also, vessel diameter was increased by 7.7 % over the control.

3.2.1.4. The effect of micronutrients mixture

The application of micronutrients mixture (0.2 g/l zinc sulphate + 1.5 g/l manganese + 3.0 g/l boric acid) induced a little increase of 4.9 % in stem diameter compared with the control. This enhancement was mainly due to the increment in thickness of the stem wall, being 30.0 % over the control. Nevertheless, the thickness of epidermis, cortex and phloem tissue as well as, the diameter of hollow pith showed negative response. The increase of stem wall thickness of treated plants was attributed to the increase in the thickness of fibre strands by 36.7 %, xylem tissue by 19.1 % and parenchymatous area of the pith by 63.1 % more than the control.

3.2.2. Anatomy of the leaf

Results in Table (5) represent certain measurements of microscopical characters of the blade of the median leaflet of the seventh leaf developed on the main stem of mungbean cv. VC-1000 sprayed with micronutrients. Microphotographs depict these blades are given in Figure (2).

3.2.2.1. The effect of zinc

It is noted from Table (5) and Figures (2 A and B) that spraying zinc sulphate at a concentration of 0.2 g/l increased thickness of both midvein and lamina of leaflet blades of mungbean cv. VC-1000 by 40.0 and 3.6 % more than the control; respectively. It is clear that the increase in lamina thickness was accompanied with 17.5 % increment in thickness of the spongy tissue and 3.7 % reduction in thickness of the palisade tissue compared with the control.

Table (5): Counts and measurements in microns of certain histological features in transverse sections through the blade of the median leaflet of the seventh leaf on the main stem of mungbean cv. VC-1000 as affected by Zn, Mn, B or their mixture (Means of three sections from three specimens).

Characters	control	Zn	± % to control	Mn	± % to control	B	± % to control	Mixture	± % to control
Thickness of midvein	1153.8	1615.3	+40.0	1538.4	+33.3	1596.1	+38.3	1326.9	+15.0
Thickness of lamina	269.2	278.8	+3.6	249.9	-7.2	288.5	+7.2	289.4	+7.5
Thickness of palisade tissue	139.6	134.5	-3.7	122.8	-12.0	147.8	+5.9	141.2	+1.2
Thickness of spongy tissue	81.9	96.2	+17.5	78.4	-4.3	96.3	+17.6	105.4	+28.7
Dimensions of the main bundle of midvein:									
Length	288.5	499.8	+73.2	480.7	+66.6	461.5	+60.0	346.2	+20.0
Width	292.7	576.9	+97.1	615.4	+110.3	711.5	+143.1	384.6	+31.4
No. of vessels/midvein bundle	2.3	40.1	+79.8	44.8	+100.9	52.6	+135.9	31.2	+39.9
Vessel diameter	25.8	30.2	+17.1	38.1	+47.7	41.2	+59.7	22.4	-13.2

The main vascular bundle of the midvein increased in size as a result of spraying zinc. The increment was mainly due to the increase in length by 73.2 % and in width by 97.1 % over the control. Also, average number of vessels per midvein bundle increased by 79.8 % over the control. Moreover, xylem vessels had wider cavities, being 17.1 % more than the control.

3.2.2.2. The effect of manganese

It is realized that manganese at 1.5 g/l increased thickness of the leaflet at the portion of midvein by 33.3 % over the control. In contrast, thickness of the leaflet at its marginal portion was decreased by 7.2 % less than the control. It is obvious that the thinner lamina induced by spraying manganese was mainly due to decrease in thickness of both the palisade and the spongy tissues by 12.0 and 4.3 % below the control; respectively. At the same time, dimensions of the middle bundle increased by 66.6 % in length and 110.3 % in width in addition to an increase in its number of vessels by 100.9 % over the control. It is worthy to note that xylem vessels had wider cavities,being 47.7 % more than the control, which amounted to more total active conducting area to cope with vigorous growth resulting from treatment with manganese.

3.2.2.3. The effect of boron

It is clear from Table (5) and Figures (2 A and D) that spraying boron at the rate of 3.0 g/l boric acid on mungbean plants cv. VC-1000 resulted in thicker leaflets which had a relatively thick mesophyll, larger middle bundle and higher number of vessels per middle bundle. The obtained thicker leaflets could be attributed to an increase in thickness of midvein and of lamina by 38.3 and 7.2 % more than the control; respectively. The increase in lamina thickness was mainly due to the increase of both the palisade and the spongy tissues by 5.9 and 17.6 % over the control; respectively. Dimensions of the main vascular bundle of the midvein increased by 60.0 % in length and by 143.1 % in width in addition to an increase in its number of vessels by 135.9 % more than the control. Moreover, xylem vessels had wider cavities, being 59.7 % more than the control, which amounted to more total active conducting area to cope with vigorous growth resulting from spraying boric acid.

3.2.2.4. The effect of micronutrient mixture

Data presented in Table (5) and microphotographs shown in Figures (2 A and E) indicate that spraying a mixture of micronutrients containing zinc sulphate at a concentration of 0.2 g/l, manganese at a concentration of 1.5 g/l and boric acid at concentration of 3.0 g/l increased thickness of both midvein and lamina of leaflets blades of mungbean cv. VC-1000 by 15.0 and 7.5 % more than the control; respectively. The increase in lamina thickness was mainly due to a prominent increase of 28.7 % in spongy tissue more than the control. The main vascular bundle of the midvein increased in length by 20.0 % and in width by 31.4 % over the control. Also, average number of vessels per midvein bundle increased by 39.9 % more than the control. However, such treatment decreased vessel diameter by 13.2 % less than the control.

Such detailed information concerning the effect of micronutrients on stem and leaf anatomy of mungbean plants are not available in the literature.

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استجابة صنفين من فول المانج إلى كل من الزنك والمنجنيز والبورون
١- الصفات المورفولوجية والفسيولوجية والتشريحية

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ملخص

أقيمت تجربتان حقليتان بمزرعة مركز البحوث الزراعية بالجيزة خلال موسمي صيف ١٩٩٨, ١٩٩٩ لدراسة استجابة صنفين من فول المانج (VC-1000، V-2010) لبعض العناصر الصغرى (الزنك والمنجنيز والبورون) وتأثيرها على الصفات المورفولوجية والفسيولوجية والتشريحية.

* وتشير أهم النتائج إلى أن التسميد الورقي بأي تركيز من الزنك٢,. أو ٤,. جم/لتر والمنجنيز ١,٥ أو ٢ جم/لتر والبورون ٣ أو ٥ جم/لتر منفردة أو مخلوط من التركيز الأول لكل منها أدت إلى زيادة معنوية مقارنة بالكنترول في أغلب الصفات المدروسة.
* أدت المعاملة بالزنك (٢,. جم/لتر) منفردا وتليها معاملة الرش بمخلوط التركيز الأول للعناصر الثلاثة معا إلى أعلى نتائج مورفولوجية وفسيولوجية على صفات طول الساق الرئيسى ، عدد الأفرع ، عدد الأوراق ، مساحة الأوراق ، دليل مساحة الأوراق ، تراكم المادة الجافة.
* تفوق الصنفVC-1000 على الصنف V-2010 في كل الصفات تحت الدراسة خلال موسمي التجربة.
* كما تم دراسة تأثير الرش بالمستوى الأول لكل العناصر المستخدمة وهى الزنك والمنجنيز والبورون وكذلك الخليط بينهم على التركيب التشريحي لكل من الساق والأوراق لنبات فول المانج صنف VC-1000.

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