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RESPONSE OF SOYBEAN (*Glycine max,* L. Merrill) TO PLANT DISTRIBUTIONS AND MICROELEMENTS FOLIAR SPRAYING:
I. GROWTH CHARACTERS AND SEED OIL CONTENT.

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ABSTRACT

Two field experiments were carried out at a Private field in El-Mehala El-Kobra Center, Gharbia Governorate, Egypt during the two growing seasons of 2000 and 2001. This investigation aimed to study the effect of different plant distributions and microelements foliar application treatments on growth characters and seed oil content of soybean (Glycine max, L. Merrill) cv. Giza 35. The experiments included six plant distributions and seven treatments of microelements foliar application. A strip plot design with four replicates was used. The main findings could be summarized as follows:

1. Planting soybean in arrangements that approach uniform distribution on two sides of the ridge, 10 or 20 cm between hills and leaving one or two plants per hill produced the highest values of leaf area, leaf area index, oil % and number of branches per plant, however, the tallest plants were obtained from sown plants on one side of the ridge, 15 cm between hills and leaving three plants per hill.
2. Foliar application the combination of Mn + Mo at the concentrations of 100 and 50 ppm, respectively (F5) recorded highest values of leaf area, leaf area index and number of branches per plant and oil % in both seasons. However, foliar application of Zn at the concentration of 100 ppm (F2) and Mo at the concentration of 50 ppm (F3) produced the tallest plants in both seasons.
3. The interaction between plant distributions and microelements foliar application had significant effect on both leaf area index and number of branches per plant in both seasons. The highest values were produced from sowing on both ridge sides at 10 cm between hills and leaving one plant per hill with foliar application of combination of Mn +Mo at 100 and 50 ppm, respectively in both seasons.

INTRODUCTION

Soybean (Glycine max, L. Merrill) is one of the most important summer oil leguminous crops all over the world, due to the high nutritive value of its seed, which contain high amount of oil and protein. Increasing soybean production could be achieved as an urgent goal for meeting the continuous demands of this crop by enhancing soybean planting patterns by using plant distributions.

Planting soybean plants in arrangements on both ridge sides that approach uniformity and leaving 8.6 plants/m2 (Teigen, 1976); at 16 plants/m2 (Taylor *et al.*, 1983 and Nakano *et al.*, 2001); at 26 plants/m^2 (Picasso, 1986); at 31.0 plants/m^2 (Reis *et al.,* 1979 and Carangel, 1986); at 34.8 plants/m^2 (Parks *et al.*, 1983, Hassan and Abdalla, 1987 and Sharief, 1989) and at 44.4 plants/m2 (Safo-Kantanka and lawson, 1980 and Shahidullah and Hossain, 1987) resulting in significantly higher light intensities at the ground surface of hills and increased leaf area index and number of branches per plant. However, plant height and oil percentage were increased due to sowing plants on one side of the ridge, 5 cm between hills, one plant/hill (Sharief, 1989).

Foliar nutrients application is one of the most important factors which affect the productivity of soybean. Many investigators in different parts of the world studied the effect of this factor on growth of soybean and seed oil content. The micronutrients, in particular zinc, manganese and molybdenum found to be a yield limiting factors for many crops in Egypt including soybean.

Manganese foliar application on soybean may be improve soybean yields and its components as well as oil and protein content. Many investigators hoping to achieve the vital objectives to overcome the lake sufficient sources of cheep oils and protein. The most well known and extensively studied function of manganese in green plants is its involvement in photosynthetic O2-evolution (Marschner, 1986). In this respect, spraying Manganese alone significantly increased plant height and growth (Sakr *et al.*, 1988).

Zinc is required for the activity of various types of enzymes and zinc deficiency is associated with its impairment of carbohydrate metabolism and protein synthesis (Marschner, 1986). In this respect, increasing Zn concentrations up to 25 ppm as znso4 enhanced growth and dry weight (Al-Samerria *et al.*, 1988 and Abadi *et al.*, 1995 and Barman *et al.*, 1998) and leaf area (Sarker and Aery, 1990), leaf area index (Bisht and Candel, 1991) and oil content (Thalooth *et al.*, 1989 and Hugar and Kurdikeri, 2000) and increased plant height, number of branches per plant, leaf area index when it increased up to 90 ppm (Anton *et al.*, 2001).

With respect to, the function of the molybdenum as a plant enzymes, the molybdenum requirement for higher plants therefore depends on the mode of nitrogen supply. In this connection application of molybdenum at the concentration of 2.0 mg/l increased growth and oil content (Wahdan, 1991) and dry weight (Ali *et al.*, 1993), leaf area and number of branches/ plant (Aghatise and Tayo, 1994) and leaf area index (Dwivedi *et al.*, 1997, Mohan and Rao, 1997 and Anton *et al.*, 2001) and oil content (Sable *et al.*, 1998).

The combination of microelements may affect growth, yield and its components as well as seed quality. In this respect, the combination of Zn + Mn spraying or Zn + Mn + B enhanced growth and plant height (*Sakr et al., 1988*) and the combination of Zn + B increased seed oil content (Chandel *et al.*, 1989), plant height and number of branches/plant were increased due to spraying Mn + Zn combination (*Sharief, 1993b*) and combination of Zn + Mo increased plant height, number of branches / plant and leaf area index (*Anton et al., 2001*).

The interaction between plant distribution and molybdenum soaking significantly affected growth of soybean (Kandil, 1985) and of field bean (Sharief, 1993a)

The objectives of this investigation were to study the effect of different plant distributions, the response of soybean to different single foliar application and combinations of micronutrients and their interaction effect on soybean growth and seed quality.

MATERIALS AND METHODS

Two field experiments were carried out at a private field in El-Mehala El-Kobra center, Gharbia Governorate, Egypt during the two growing seasons 2000 and 2001. This investigation aimed to study the effect of different plant distributions and microelements foliar application on growth characters and seed oil content of soybean (Glycine max, L. Merrill) cv. Giza 35. In each season, the field experiments were laid out in a strip-plot design with four replications. The horizontal plots were devoted to the six treatments of plant distributions as follows:

1. Planting on one side of the ridge, 5 cm between hills and leaving one plant in the hill (D1).
2. Planting on one side of the ridge, 10 cm between hills and leaving two plants in the hill (D2).
3. Planting on one side of the ridge, 15 cm between hills and leaving three plants in the hill (D3).
4. Planting on the two sides of the ridge, 10 cm between hills and leaving one plant in the hill (D4).
5. Planting on the two sides of the ridge, 20 cm between hills and leaving two plants in the hill (D5).
6. Planting on the two sides of the ridge, 30 cm between hills and leaving three plants in the hill (D6).

The vertical plots were allocated to the seven treatments of microelements foliar application as follows:

1. Foliar spraying of Mn at concentration of 100 ppm (F1).
2. Foliar spraying of Zn at concentration of 100 ppm (F2).
3. Foliar spraying of Mo at concentration of 50 ppm (F3).
4. Foliar spraying of Mn + Zn at concentrations of 100 ppm each (F4).
5. Foliar spraying of Mn + Mo at concentrations of 100 and 50 ppm, respectively (F5).
6. Foliar spraying of Zn + Mo at concentrations of 100 and 50 ppm, respectively (F6).
7. Foliar spraying of Mn + Zn + Mo at concentrations of 100, 100 and 50 ppm, respectively (F7).

Each plot area consists of 5 ridges 3.5 meters long and 60 cm in row width occupying an area of 10.5 m^2 (1/400 fed). In both seasons, soybean preceded by Egyptian clover (Trifolium alexandrinum, L). soybean seed of Giza 35 and its suitable peat inoculum Nitrogen were supplied by the Oil Crop Research Section, Agricultural Research Center, Ministry of Agriculture and Land Reclamation, Giza, Egypt. Just before planting, soybean seeds were inoculated with the peat inoculum Nitrogen by *Rhizobium japonicum*, L produced by Sakha Station Research, Egypt. Soybean seeds were hand sown with the usual wet method (Heraty planting) on 10^{th} May and 15^{th} May in 2000 and 2001 seasons, respectively. Three weeks after emergence plants were thinned to the suitable distribution.

Phosphorus was added in the form of calcium superphosphate (15.5% P2O5) at the rate of 30 kg P2O5/fed. Potassium was added in the form of potassium sulfate (48% K2O) at the rate of 24 Kg K2O/fed. Phosphorus and potassium were incorporated to the soil during seedbed preparation. Nitrogen fertilizer was applied as ammonium nitrate (33.5%N) at the rate of 50 Kg/fed in two equal doses (the half of the dose was added before the first irrigation and the other before the second irrigation). Soybean plants were hoed two times, the first was practiced before the second irrigation and the second one was performed before the third irrigation. Foliar spraying of micronutrients were added after 45 days from sowing. Normal agricultural practices as recommended by Ministry of Agriculture and Land Reclamation were followed.

The soil sample of the experimental site was collected from a surface layer (0 – 30 cm). Some chemical and mechanical properties of the used soil were estimated by the method described by Page *et al.* (1982) the soil was clay in texture and pH was 7.9 The available manganese was 46.0, 53.0 ppm, the available Zinc was 2.6,3.1 ppm and The available molybdenum was 0.50,0.54 ppm in the first and second seasons, respectively. The following growth traits were determined

1- plant height in cm.
2- Number of branches / plant
3- Leaf area index from the equation obtained by Radford (1967).
4- Seed oil percentage: Seeds were air dried, samples of 10 g were placed in a drying over at 50o C for 24 hours, until constant weight was achieved . The dried seeds were thoroughly ground to fine powder with an electric grinding mill. Aliquots of the dry powder were redried at 105o C until constant weight was reached to allow calculation on the basis of dry weight. Oil percentage was estimated in soybean seeds using Soxholet"s apparatus according to A.O.A.C. (1984).

In order to test the significance among treatments, all obtained data were subjected to the statistical analysis of the strip plot design as described by Gomez and Gomez (1984). Treatments were compared using the least significant differences values (L.S.D) at 5% and 1% levels of probability. Computations were made using computer software.

RESULTS AND DISCUSSION

The results obtained from this study for different soybean characteristics were determined during the two growing seasons of 2000 and 2001. It was divided into three following main topics:

1- Plant distributions effect:

The results in tables 1 and 2 clearly showed that plant height, number of branches per plant, leaf area index, oil percentage and oil yield/fed significantly differed by different plant distribution treatments in both seasons.

The tallest plants were obtained from sowing soybean at one side of the ridge, 15 cm between hills and leaving three plants per hill. However, the highest values of both number of branches per plant, leaf area index , oil percentage and oil yield/fed with sowing on both ridge sides, 10 cm or 20 cm between hills and leaving one or two plants per hill, respectively in both seasons. The increases in plant height due to sowing in D1 may be due to more competition between plants, However, The increases in leaf area and leaf area index values and number of branches per plant due to sown in D4 or D5 in arrangements that approach uniformity may be attributed to its increases in leaf area as well as less mutual shading between plants and thus achieve better light interception and lower competition for light. The increases in oil percentage due to sowing soybean plants in more uniform distributions (D4 and D5) may be due to increasing in translocation of assimilates which were converted to precursor of oil reflected increases in oil percentage. Similar results are in agreement with those reported by **Kandil** (1985), Sharief (1989), Ibrahim (1996), Sharief (1993a) and Nakano *et al.* (2001).

2- Micro-nutrient foliar application effects:

The results in tables 1 and 2 revealed significant effect on plant height, leaf area and leaf area values, number of branches per plant, oil percentage and oil yield/fed due to foliar application of microelements in both seasons. Spraying Zn or Mo alone at 100 and 50 ppm, respectively produced the tallest plants in both seasons. In addition, spraying the combination of Mn + Mo at concentrations of 100 and 50 ppm, respectively significantly produced the highest values of leaf area (cm2), leaf area index and number of branches per plant and oil yield/fed in both seasons. However, the highest seed oil percentages were recorded from spraying Zn, Mn and Mo in combination two of each in both seasons. The increases in growth due to foliar spraying of microelements in combinations may be due to their effects on different metabolic activities and growth such as chlorophyll resulting increases in leaf area and leaf area index reflected increases in net assimilation rate and accumulation of dry matter resulting increases in number of branches per plant (Anton *et al.*, 2001). These results confirm with those reported by Sakr *et al.* (1988), Chandel *et al.* (1989), Wahdan (1991), Dwivedi *et al.* (1997) and Sable *et al.* (1998).

3- Significant interaction effect:

The interaction between plant distributions and microelements foliar application significantly affected both leaf area index and number of branches per plant as presented in Tables 3 and 4 in both seasons. The results clearly showed that distribution soybean plants in uniform arrangement on two sides of the ridge, in 10 or 20 cm between hills and leaving one or two plants per hill (D4 or D5) with foliar spraying the combination of Zn +Mo at 100 and 50 ppm, respectively (F6) and or Mn + Mo at 100 and 50 ppm, respectively maximized both leaf area index values and recorded highest branches number per plant in both seasons. The interaction between plant distribution and molybdenum soaking significantly affected growth characters as reported by by Kandil, 1985.

Table 1: Means of plant height (cm), leaf area (cm³) and leaf area index (LAI) as affected by plant distributions and microelements foliar application during 2000 and 2001 seasons.

Characters Treatments	plant height (cm)		Leaf area (cm^3)		leaf area index (LAI)	
	2000	2001	20001	2001	2000	2001
1. Plant distributions						
D1	65.7	69.1	1410.9	1500.6	4.72	5.00
D2	66.8	74.1	1277.6	1361.4	4.26	4.54
D3	74.7	80.1	1548.3	16.52.9	5.16	5.51
D4	71.4	78.4	1775.7	1911.5	5.92	6.37
D5	68.8	71.7	1658.5	1780.6	5.53	5.93
D6	70.4	75.9	1463.2	1559.1	4.88	5.20
F. test	**	**	**	**	**	**
LSD 5%	2.1	1.7	34.2	53.3	0.11	0.18
LSD 1%	2.9	2.3	47.4	73.8	0.16	0.25
2. Microelements foliar application						
F1	69.7	69.7	1147.4	1198.8	3.83	4.00
F2	71.9	76.3	1362.5	1450.0	4.54	4.83
F3	72.8	74.7	1531.8	1643.2	5.11	5.48
F4	66.8	75.9	1395.5	1485.5	4.65	4.95
F5	68.3	77.1	1888.9	2058.8	6.31	6.86
F6	68.6	74.4	1607.3	1726.2	5.36	5.75
F7	69.2	76.1	1723.6	1831.4	5.74	6.11
F. test	*	**	**	**	**	**
LSD 5%	2.6	2.6	59.0	73.0	0.20	0.24
LSD 1%	-	3.6	80.9	100.1	0.27	0.33

*, ** Denote significant at 0.05 and 0.01 levels of probability, respectively.

Table 2: Means of number of branches/plant, oil percentage and oil yield (kg/fed) as affected by plant distributions and microelements foliar application during 2000 and 2001 seasons.

Characters Treatments	No. of branches/plant		oil %		Oil yield (kg/fed)	
	2000	2001	20001	2001	2000	2001
1. Plant distributions						
D1	3.4	4.0	20.4	20.1	375.4	414.8
D2	3.2	3.8	20.7	20.5	372.3	409.7
D3	3.7	4.5	21.0	20.6	440.7	491.2
D4	4.0	4.9	21.0	20.7	508.6	566.2
D5	3.7	4.5	21.0	20.8	475.3	524.6
D6	3.6	4.3	20.6	20.4	384.2	429.5
F. test	**	*	**	**	**	**
LSD 5%	0.3	0.4	0.1	0.1	53.0	58.6
LSD 1%	0.4	-	0.2	0.2	73.3	81.1
2. Microelements foliar application						
F1	3.2	3.9	20.3	20.1	377.3	409.0
F2	3.1	4.1	20.8	20.4	391.6	429.6
F3	3.8	4.3	21.0	20.7	443.5	493.3
F4	3.3	4.3	20.9	20.6	396.9	440.6
F5	4.2	5.0	20.9	20.5	472.7	524.4
F6	3.9	4.4	20.9	20.7	452.9	505.8
F7	3.6	4.3	20.7	20.5	447.8	506.0
F. test	**	**	**	**	**	**
LSD 5%	0.2	0.3	0.2	0.2	33.4	39.9
LSD 1%	0.3	0.4	0.3	0.3	45.8	54.7

*, ** Denote significant at 0.05 and 0.01 levels of probability, respectively.

Table 3: Means of leaf area index (LAI) as affected by the interaction between plant distributions and microelements foliar application in the two seasons of 2000 and 2001.

Season	2000						2001					
Treatment	D_1	D_2	D_3	D_4	D_5	D_6	D_1	D_2	D_3	D_4	D_5	D_6
F_1	2.91	3.03	4.01	5.53	4.64	2.83	2.88	3.11	4.22	5.95	4.93	2.88
F_2	3.95	2.89	4.31	5.09	6.01	4.99	4.15	2.95	4.56	5.45	6.49	5.38
F_3	4.67	4.31	5.33	6.35	5.29	4.68	4.97	4.56	5.72	6.88	5.72	4.99
F_4	6.09	4.67	3.83	4.63	4.57	4.11	6.59	4.97	4.02	4.93	4.86	4.34
F_5	5.49	5.54	6.20	7.28	6.77	6.59	5.96	6.06	6.70	7.94	7.36	7.15
F_6	4.11	3.95	6.37	6.99	5.99	4.73	4.34	4.15	6.90	7.61	6.47	5.04
F_7	5.79	5.41	6.07	5.55	5.43	6.21	6.12	5.95	6.43	5.84	5.70	6.59
F-test	**						**					
LSD 5%	0.50						0.54					
LSD 1%	0.66						0.72					

** Denote significant at 0.01 level of probability.

Table 4: Means number of branches per plant as affected by the interaction between plant distributions and microelements foliar application in the two seasons of 2000 and 2001.

Season	2000						2001					
Treatment	D_1	D_2	D_3	D_4	D_5	D_6	D_1	D_2	D_3	D_4	D_5	D_6
F_1	2.6	2.2	3.5	4.0	3.3	3.3	2.9	3.7	3.8	4.6	3.7	4.8
F_2	3.0	2.7	3.4	3.3	3.5	2.8	3.8	2.9	3.6	5.4	5.3	3.8
F_3	3.6	3.7	3.8	4.1	3.8	4.0	4.3	3.9	4.4	4.0	5.5	3.9
F_4	3.0	2.8	3.2	4.1	3.4	3.5	4.2	3.3	5.6	4.7	4.5	3.7
F_5	4.3	4.2	3.7	4.4	4.1	4.4	4.7	5.2	5.7	5.2	4.3	4.9
F_6	3.6	3.6	4.1	4.2	4.2	3.9	4.3	4.1	4.1	4.9	4.2	4.6
F_7	3.4	3.1	4.1	4.0	3.5	3.5	4.1	3.8	4.3	5.4	3.8	4.6
F-test	**						**					
LSD 5%	0.4						0.7					
LSD 1%	0.5						0.9					

** Denote significant at 0.01 level of probability.

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استجابة فول الصويا للتوزيعات النباتية و التسميد الورقى.
١- صفات النمو و نسبة الزيت بالبذور.

على السعيد شريف، محمود سليمان سلطان، محمد حسين غنيمه، سالى سيد الكمشيشى.
قسم المحاصيل – كلية الزراعة – جامعة المنصورة

أجريت تجربتان حقليتان بمزرعة خاصة بمركز المحلة الكبرى، محافظة الغربية خلال عامى ٢٠٠٠ ، ٢٠٠١ بهدف دراسة صفات النمو و نسبة الزيت بالبذور من خلال دراسة استجابة فول الصويا للتوزيعات النباتية المختلفة و كذلك دراسة استجابة فول الصويا للرش بالعناصر الصغرى منفردة أو مخلوطة و كذا التفاعل بينهما. تم تنفيذ التجارب فى تصميم الشرائح المتعامدة فى أربع مكررات حيث احتوت الشرائح الأفقية على ستة توزيعات نباتية و احتوت الشرائح الرأسية على سبع معاملات الرش بالعناصر الصغرى و يمكن تلخيص أهم النتائج كالآتى:

١- أشارت النتائج الى تأثير التوزيعات النباتية تاثيرا معنويا على جميع صفات النمو المدروسة فى كلا موسمى الزراعة. أدت زراعة نباتات فول الصويا فى توزيع نباتى أكثر انتظاما و ذلك بالزراعة عل الريشتين مع ترك مسافة ١٠ أو ٢٠ سم بين الجور مع ترك نبات واحد أو نباتين (D4 ، D5) على الترتيب الى زيادة معنوية فى صفات مساحة الأوراق/ نبات، دليل مساحة الأوراق، عدد الفروع/ نبات، نسبة الزيت بالبذور ومحصول الزيت/فدان و ذلك فى كلا موسمى الزراعة. بينما سجلت أعلى قيم لطول النبات فى حالة الزراعة على ريشة واحدة ، على مسافة ١٥ سم بين الجور و ترك ثلاث نباتات بالجورة فى كلا موسمى الزراعة.

٢- أوضحت النتائج أن الرش بمخلوط المنجنيز + الموليبدنيم بتركيز ١٠٠ و ٥٠ جزء فى المليون على الترتيب أدى للحصول على أعلى قيم لمساحة الأوراق/ نبات، دليل مساحة الأوراق، عدد الفروع/ نبات، نسبة الزيت بالبذور ومحصول الزيت/فدان فى كلا موسمى الزراعة. بينما أدى الرش بالمنجنيز منفردا بتركيز ١٠٠ جزء فى المليون أو الموليبدنيم بتركيز ٥٠ جزء فى المليون للحصول على أطول النباتات فى كلا موسمى الزراعة.

٣- لقد سجل التفاعل بين التوزيعات النباتية و الرش بالعناصر الصغرى تأثيرا معنويا على صفتى دليل مساحة الأوراق و عدد الفروع/ نبات فى كلا موسمى الزراعة حيث أدى الزراعة على الريشتين على مسافة ١٠ سم و ترك نبات واحد بالجورة و الرش بالعناصر الصغرى المنجنيز + الموليبدنيم بتركيز ١٠٠ و ٥٠ جزء فى المليون للحصول على أعلى القيم من كل من دليل مساحة الأوراق و عدد الفروع/ نبات فى كلا موسمى الزراعة.