Plant Archives Vol. 19, Supplement 2, 2019 pp.1896-1903 **e-ISSN:2581-6063 (online), ISSN:0972-5210**

RESPONSE OF GROWTH CHARACTERS, YIELD AND YIELD ATTRIBUTES OF GROUNDNUT (*ARACHIS HYPOGAEA* L.) CULTIVARS TO SOME MICRONUTRIENTS FOLIAR SPRAYING APPLICATION

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Abstract

Two field experiments were carried out during two successive summer seasons (2015 and 2016) at the Production and Research Station, National Research Centre, El- Nubaria Province, El-Beheira Governorate, Egypt to investigate the response of two groundnut (Giza 6 and Gregory) varieties to some micronutrients foliar application i.e. Zinc, Manganese and Boron and their interaction with different growth stages on yield, yield attributes and some chemical traits of groundnut seeds under reclaimed sandy soil condition.

Cultivar Giza 6 showed high value of growth characters compared with Gregory variety for all traits except plant height at 75 DAS. On the other hand, data illustrate that combination of Zn+ Mn+ B surpassed over all treatments and control. The interaction effect between groundnut varieties and micronutrient foliar application revealed a high significant difference for all studied traits.

Yield attributes (number of pods plant^{-1}, number of seed plant^{-1}, weight of pods plant^{-1} and seed weight plant^{-1} and 100 seed weight) were effected significantly due to foliar spraying with micronutrient treatments. The data recorded that Giza 6 show high performance for all studied traits comparing with Gregory. Mixture of (Zn+Mn+B) recorded high value comparing with dual effect of (Zn+Mn, Zn+B and Mn+B) also single effect (Zn, Mn and B) for yield components. Influence of interaction revealed that Giza 6 variety recorded high performance for all yield characters except harvest index and oil %. Therefore, Giza 6 variety responded positively to treatments with Zn 400 ppm +Mn 400 ppm+ B 0.06 as boric acid for pod, seed, straw, biological, oil and protein yield faddan^{-1}.

Key word: Groundnut, Micronutrients, Varieties, Zinc, Manganese, Boron

Introduction

Groundnut (*Arachis hypogaea* L.) is one of the world's fundamental sources of vegetable oil. United States Department of Agriculture (USDA) databases illustrated that, groundnut was ranked fifth worldwide in vegetable oil production among oilseed crops. Although groundnut is widely known as an oilseed crop, utilization of groundnut varies extremely from one country to another (Tillman and Stalker, 2009). The groundnut production are crushed for oil uses in some countries, while in others such as United States, groundnut are used mostly for food i.e., groundnut butter, confectioneries and some food industries. Cultivation and production of groundnut are concentrated in Asia continent especially in China and India where the two countries achieve almost 70% of the total annual groundnut world production (USDA, 2018). Comparing to soybean, the major oilseed crop in USA, idealistic groundnut oil has more oleic acid, less linoleic acid and no linolenic acid (White, 2000), so groundnut oil is considered to be premium oil and is desirable for cooking, salad oil and improved product storage life. Groundnut genotypes differ in the amount of each of these fatty acids, but most typical groundnut cultivars contain 45–50% oleic acid and 30–40% linoleic acid.

Micronutrients are essential for healthy growth and reproduction of plants i.e. boron, chlorine, copper, iron, manganese, molybdenum, nickel and zinc. Micronutrients deficiency are widely in humans, animal and plants, especially in many arid countries, due to high pH, low organic matter, salt stress, continual drought and imponderables application of fertilizers (Malakouti, 2008). Malnutrition accounts for more than 30 million deaths a year in mostly resource-poor families in the developing world. Much of this malnutrition is the result of insufficient intakes of available trace elements in the diets of the poor peoples. Through linking agricultural systems, human nutrition could be sustainable solutions for malnutrition on the future by changing agricultural systems in ways that will help supply enough essential trace elements to the poor to meet their needs for healthy and productive lives (Welch, 2002). Micronutrients are essential elements for plant growth and needed it in small quantities, higher yield and quality characters of agricultural products increased with micronutrients application (Tavakoli *et al.,* 2014). Whenever, the supply of one or more of these elements is insufficient, yields will be reduced and the quality of crop products impaired, but crop species and cultivars vary considerably in their susceptibility to deficiencies (Alloway, 2008).

Manganese plays an important function in many biological processes i.e., oxidation reactions, reduction, carboxylation, carbohydrates metabolism, phosphorus reactions and citric acid cycle as well as electron transport in photosynthesis, also, it acts as an activator for many enzymes i.e., protein-manganese in Photosystem II and superoxide dismutase.

Zinc is one of the most important essential nutrients required for plant growth. It acts as an activator of several enzymes in plants and is directly involved in the biosynthesis of growth substances such as auxin which is involved in plant growth and cell division. Foliar spraying with of 40 kg N/faddan + Zn foliar spraying (0.2 % $ZnSO_4$ $7H_2O$) either at flowering or seed filling stages significantly increased number of pods plant^{-1}, weight of pods plant^{-1}, number of seed plant^{-1}, weight of seeds plant^{-1}, 100-pod weight, 100-seed weight, pod, seed and straw yield faddan^{-1} (El-Habbasha *et al.* 2013). Singh and Chaudhari (2015) showed that zinc foliar application of 0.2% aqueous solution of zinc sulphate thrice at 40, 55 and 70 days at 500, 500 and 1000 L ha^{-1}, respectively, increased number of pods, pod yield, shelling and 100 seed weight. Bellaloui *et al.* (2013) indicated that foliar boron application in the form of boric acid was applied twice at flowering and seed-fill stage with a rate of 1.1 kg ha^{-1}. Seeds of (W+B) plants had higher protein (11% increases) comparing with (W–B) treatment. El-Haggan (2014) illustrated that significant effect of micronutrients foliar application on all studied characters. Fe+Zn+Mn+B combination as foliar application treatment produced the highest values of plant height at harvest, number of branches $plant^{-1}$, number of pods $plant^{-1}$, 100-seed weight, seed yield $plant^{-1}$, seed yield (kg ha^{-1}), oil content, oil yield , protein content and protein yield compared with control treatment.

This investigation was carried out to study the response of growth characters, yield and yield attributes of groundnut cultivars to zinc, manganese and boron foliar spraying application.

Materials and Methods

Two field experiments were carried out during two summer successive seasons 2015 and 2016 at the Production and Research Station, National Research Centre, El-Nubaria Province, El-Beheira Governorate, Egypt to investigate the response of two groundnut (Giza6 and Gregory) varieties to some micronutrients foliar application and its effect on growth characters, yield and yield attributes under reclaimed sandy soil condition. Soil samples were taken (0-30 cm depth) in the experimental site before sowing to determine the physical and chemical properties of soil site in Table (1).

Table 1 : Mechanical and chemical analysis of the field experiments soil on 2015 and 2016 seasons.

Mechanical analysis			**Chemical analysis**		
Prosperities	**2015**	**2016**	**Prosperities**	**2015**	**2016**
Sand (%)	92.30	90.10	PH (1:2.5)	7.64	7.50
Silt (%)	3.15	4.60	EC(dS/m^{-1})	0.36	0.31
Clay (%)	4.55	5.30	Organic matter (OM %)	0.35	0.40
Texture	Sandy	Sandy	Calcium carbonate (CaCo3%)	1.43	1.65
Macronutrients (mg/100g)			**Micronutrients (ppm)**		
Properties	**2015**	**2016**	**Properties**	**2015**	**2016**
Available N (ppm)	8.10	8.17	Fe	3.65	3.80
			Zn	0.37	0.41
Available P (ppm)	3.28	3.40	Mn	1.75	1.80
			B	0.23	0.28
Available K (ppm)	20.52	21.05	Cu	0.59	0.62

The experimental design was split-plots design with four replicates, where cultivars were assigned in the main plots and micronutrients foliar application with Zn, Mn, and B were randomly distributed in the sub-plots. The experimental unit area was 10.5 m^2 (3.5 m in length and 3 m in width), the plots contained five rows, 60 cm apart between rows. Seeds of two groundnut cultivars (Giza 6 and Gregory) are sown in hills 10 cm apart between plants at the rate of 40 Kg/faddan. Groundnut cultivars (Giza 6 and Gregory) were obtained by Oil Crop Research Department, Field crops Institute, Agriculture Research Center, Giza, Egypt. Seeds were sown on the mid of May in the two summer successive seasons. The seeds of two cultivars were coated just before sowing with the bacterial inoculants, Rhizobium *spp*, using Arabic gum (40%) as adhesive agent. The preceding crop was wheat in both seasons. Seeds of groundnut (3-4 seeds) were deposited in the hill, and then the plants were thinned to two plants after complete emergence (two weeks after sowing). Phosphorus and potassium fertilizers were added during seed bed preparation at the rate of 100 kg /faddan in the form of calcium superphosphate (15.5 % P_2O_5) and potassium sulfate (48% K_2O). Nitrogen fertilizer at the rate 40 kg N/faddan were added as ammonium sulfate (20.6 % N) in equal weekly doses from 15 to 60 days after sowing. Sprinkler irrigation was applied as plant needed. Micronutrients were applied twice at 45 and 60 days after sowing. Standard cultural practices of groundnut growing followed by the farmers of this district were adapted.

Micronutrients treatment:

1. Control (tap water).
2. Zinc 400 ppm (Zn chelates (EDTA, 20 % Zn)).
3. Mangaese 400 ppm (Mn chelates (EDTA, 17 % Mn).
4. Boron 0.06% as Boric acid (98%) .
5. Zinc 400 ppm + Mangaese 400 ppm .
6. Zinc 400 ppm + Boron 0.06% .
7. Mangaese 400 ppm + Boron 0.06% .
8. Zinc 400 ppm + Mangaese 400 ppm + Boron 0.06%

Data recorded:

1. Growth charachteres

At 75 and 90 days after sowing, five guarded plants were taken randomly from the 2^{nd} row of each plot in both seasons to determine the following growth characters:

Plant height (cm), number of branches $plant^{-1}$, fresh weight $plant^{-1}$ (g) and dry weight $plant^{-1}$ (g).

2.Yield and yield attributes.

A random sample of ten plants from each plot were taken at harvesting time (120 days after sowing) in both seasons 2015 and 2016 to determine the following characters: Number of pods $plant^{-1}$, number of seeds pod^{-1}, pod weight $plant^{-1}$ (g), seeds weight $plant^{-1}$ (g), 100 seed weight (g).

Plants of four square meters (2 m*2 m) from the middle part of each plot were harvested. These plants were dried under sunshine for one week and estimated pod, seeds, straw and biological yield fad^{-1} (kg $fad.^{-1}$).

3. Chemical analysis.

Protein content (%), was calculated by N% × 6.25 according to A.O.A.C. (2000). Oil content (%), was estimated using Soxhlet apparatus with petroleum ether (40-60 ºC).

Statistical analysis:

Data were statistically analyzed using analysis of variance (ANOVA) procedure according to Snedecor and Cochran (1990). The mean differences were compared using LSD at 5%.

Results and Discussions

Effect of groundnut varieties and micronutrients foliar application on growth characters.

The data presented in Table (2) illustrate the response of groundnut varieties i.e. Giza 6 and Gregory for some micronutrients foliar spraying application, Zn, Mn and B and its effect on growth characters i.e. plant height (cm), number of branches plant^{-1}, fresh weight plant^{-1} (g) and dry weight plant^{-1} (g) after 75 and 90 DAS, the data indicated that Giza 6 and Gregory varieties show highly significant differences at 75 and 90 DAS however, Giza 6 surpassed Gregory variety in all studied characters except plant height at two growth stages. These results are in harmony with Migawer and Soliman (2001) who studied the performance and responses of two groundnut cultivars (Giza 4 and Giza 5) to different micronutrient level, result revealed that significant differences between cultivars concerning the majority of growth characters,. The two tested cultivars showed different behavior during their vegetative and reproductive growth periods. Abd-Allah and Sorour (2004) showed that groundnut genotypes varied significantly concerning of growth traits such as plant height, number of branches plant^{-1} and dry matter accumulation. Gowthami and Ananda (2017) found that groundnut genotypes differed significantly at different growth stages.

Regarding the effect of micronutrient foliar spraying Zn, Mn and B and their combination, Zn+Mn+B treatment recorded highest value of all studied characters for plant height (58.92 cm), fresh weight plant^{-1} (163.93 g) and dry weight plant^{-1} (62.25 g) at 75 DAS as well as plant height (76.23 cm), fresh weight plant^{-1} (259.22 g) and dry weight plant^{-1} (129.00 g) after 90 DAS, except number of branches plant^{-1} after 75 and 90 DAS. These results were in agreement with those obtained by Ali and Mowafy 2003, Sonawane *et al.* 2010 and Helmy (2014). Aboelill *et al.* (2012) recorded that the growth parameters (plant height, number of branches plant^{-1}, number of leaves plant^{-1}, stem, root, leaves, and whole plant) were significantly influenced by different treatments of foliar spraying at 75 DAS for Giza 6 variety of groundnut plants.

El- Haggan (2014) showed that significant effect of micronutrients foliar application on all studied characters. Fe+Zn+Mn+B combination as foliar application treatment produced the highest values of plant height and number of branches plant^{-1}.

Table 2 : Effect of groundnut varieties and micronutrients foliar application on growth characters at 75 and 90 DAS (Combined data 2015 and 2016 seasons).

Treatment	75 DAS				90 DAS			
	Plant height (cm)	No. of branches plant^{-1}	Fresh weight plant^{-1} (g)	Dry weight plant^{-1} (g)	Plant height (cm)	No. of branches plant^{-1}	Fresh weight plant^{-1} (g)	Dry weight plant^{-1} (g)
Giza 6	54.97	8.72	148.06	47.57	70.91	11.06	235.18	106.52
Gregory	56.27	7.61	131.30	42.30	65.02	10.52	190.49	84.59
LSD 0.05	0.51	0.09	4.22	3.06	1.14	0.31	6.32	4.17
Control	54.87	8.00	137.24	38.88	66.32	10.81	173.79	72.81
Zn	54.82	8.56	131.13	36.02	67.93	10.81	211.29	86.20
Mn	52.06	7.69	105.94	29.84	62.19	9.88	187.64	79.89
B	53.37	7.75	143.91	44.55	66.28	11.06	203.55	89.50
Zn+Mn	58.45	9.50	159.43	54.90	69.50	11.75	240.87	103.23
Zn+B	56.02	7.38	118.93	38.33	68.61	10.63	226.93	109.16
Mn+B	56.48	8.13	156.93	54.71	66.68	10.13 c	199.36	94.67
Zn+Mn+B	58.92	8.31	163.93	62.25	76.23	11.25	259.22	129.00
LSD 0.05	1.92	0.78	7.68	5.57	2.32	0.73	14.68	8.92

The data presented in Table (3) shows the interaction between Giza 6 and Gregory varieties and micronutrient foliar application treatments Zn, Mn, B and their combinations at 75 and 90 DAS on plant height plant^{-1}, number of branches plant^{-1}, fresh weight plant^{-1} and dry weight plant^{-1}. Where, the different treatments show significant differences in both growth samples in all the studied characters.

According, single effect of micronutrient with Giza 6 variety, boron treatment recorded high value for all studied characters except number of branches/plant and dry weight/plant at 75 and 90 DAS, respectively. Boron effect on Metabolism Carbohydrate, Essential for germination and flowering, plays important role in physiological process of plant such as cell elongation, cell maturation. Due to defect in cell wall growth, leaves and stems of B deficient plants become friable and leaf tips tend to thicken. Affected plants grow slowly and appear feeble as a result of shortened internodes. Because B tends to accumulate in reproductive tissues, flower buds may fail and pollination and seed viability is usually poor in B deficient plants (Fageria *et al*., 1997).

On the other hand, Gregory variety were highly differences for all studied traits under micronutrient foliar application at two growth stages, individual effects of micronutrient (Zn, Mn and B) showed a high value of Zinc foliar application comparing the other treatment at 90 (DAS) for plant height plant^{-1}, number of branches plant^{-1} and fresh weight plant^{-1}. This effect due to the role of Zinc because is one of the most important elements in carbohydrates metabolism by activates this enzymes and deficiency of Zn due to these enzymes decreased in resulting carbohydrate accumulated in plant leaves and essential trace element for plant hormones such as auxin (IAA) and Tryptophan synthesis (Marschner, 1995 and Cakmak, 2008). El Habbasha *et al.* (2014) stated that, foliar zinc application from 1000 mg/L combined with 90 kg/ha (48% K_2O) show significant differences in most growth studied characters i.e., leaves dry wt. plant^{-1}, stems dry wt. plant^{-1}, total top dry wt. plant^{-1} and pods dry wt. plant^{-1} except dry weight pods plant^{-1} when applied at 90 days after sowing. However, the variety Gregory with the foliar application Zn+Mn+B records the highest values of plant height, number of branches plant^{-1} , fresh weight plant^{-1} and dry weight plant^{-1} at 75 DAS , followed by treatment Gregory + Zn+ Mn with no significant differences with the treatment Giza 6 + Zn+ Mn in all studied characters at 75 DAS. While, the treatment Giza 6 + Zn+Mn+B records the highest values for the studies characters with significant differences with other treatments at the second growth sample (90 DAS). No significant differences between the spraying foliar application Zn+B, Mn+B and Zn+Mn+B when applied with the cultivar Giza 6 for all the studied characters at 75 DAS. These findings were in harmony with Arunachalam *et al.* (2013), Shafarodi *et al.* (2013), and Irmak (2015).

Table 3 : Effect of interaction between groundnut varieties and micronutrients foliar application on growth characters at 75 and 90 DAS (Combined data 2015 and 2016 seasons).

Var.	Micronutrient treatments	75 DAS				90 DAS			
		Plant height (cm)	No. of branches plant^{-1}	Fresh weight plant^{-1} (g)	Dry weight plant^{-1} (g)	Plant height (cm)	No. of branches plant^{-1}	Fresh weight plant^{-1} (g)	Dry weight plant^{-1} (g)
Giza 6	Control	54.94	8.13	138.86	40.97	64.83	11.50	179.57	69.36
	Zn	51.97	10.13	133.42	37.18	66.31	10.75	225.26	100.55
	Mn	53.81	7.88	130.51	37.64	65.13	10.00	199.06	83.14
	B	54.38	8.13	146.90	43.12	72.47	11.50	232.66	100.36
	Zn+Mn	58.42	9.38	158.98	51.78	76.37	12.25	274.79	124.23
	Zn+B	55.28	8.63	163.17	56.83	72.49	11.38	252.71	121.89
	Mn+B	55.77	9.25	160.25	58.66	67.56	10.13	240.29	107.92
	Zn+Mn+B	55.20	8.25	152.41	54.37	82.14	11.00	277.06	144.70
Gregory	Control	54.80	7.88	135.62	36.78	67.81	10.13	168.01	76.26
	Zn	57.66	7.00	128.85	34.87	69.55	10.88	197.33	71.85
	Mn	50.31	7.50	81.37	22.03	59.25	9.75	176.21	76.64
	B	52.36	7.38	140.93	45.98	60.09	10.63	174.45	78.63
	Zn+Mn	58.48	9.63	159.89	58.02	62.62	11.25	206.94	82.23
	Zn+B	56.76	6.13	74.69	19.84	64.73	9.88	201.15	96.44
	Mn+B	57.19	7.00	153.61	50.77	65.81	10.13	158.42	81.41
	Zn+Mn+B	62.63	8.38	175.45	70.12	70.32	11.50	241.38	113.30
LSD 0.05		**2.72**	**1.10**	**10.85**	**7.87**	**3.28**	**1.04**	**20.76**	**12.61**

2. Effect of groundnut varieties and micronutrients foliar application on yield attributes.

The data presented in Table (4) illustrate that the effect of groundnut varieties i.e. Giza 6 and Gregory as well as some micronutrients foliar spraying application, Zn, Mn, B and its combination on number of pods plant^{-1}, number of seed plant^{-1}, weight of pods plant^{-1}, weight of seed plant^{-1} and 100 seed weight where significantly differences were observed between the two varieties in the studied characters, however, Giza 6 surpassed significantly Gregory in all the studied characters. These results are in harmony with these obtained by El-Saady *et al.* (2014), Kamara *et al.* (2017). Abdel-Motagally *et al.* (2016) who showed that significant difference between both studied groundnut varieties (Giza-6 and Sohag-110) in all studied traits.

Concerning the single foliar spraying application, application of Zn, Mn and B significantly increased number of pods and seed plant^{-1}, weight of pods plant^{-1}, weight of seed plant^{-1} and 100-seed weight comparing with control treatment, however, number of pods plant^{-1} was increased by 19.3, 29.2 and 31.9%, weight of pods plant^{-1} was increased by 10.6, 20.2 and 33.3%, number of seeds plant^{-1} was increased by 19.0 , 23.5 and 33.5 %, weight of seeds plant^{-1} was increased by 17.7, 22.5 and 40.5, and 100-seed weight gave 11.2 , 10.2 and 21.0 %, by application of Zn, Mn and B comparing the control, respectively.

Regarding the dual foliar spraying application, spraying of Zn+Mn , Zn+ B and Mn+ B significantly increased the studied characters comparing with control treatment. However, number of pods plant^{-1} was increased by 31.9, 36.7 and 38.4 %, weight of pods plant^{-1} was increased by 36.0, 42.7 and 40.8 %, number of seeds plant^{-1} increased by 41.6, 43.3 and 42.6 %, weight of seeds plant^{-1} was increased by 39.5, 44.4 and 42.2 %, and 100-seed weight by 23.0, 27.3 and 27.0 %, by spraying of Zn+Mn, Zn+ B and Mn+ B, comparing the control, respectively.

Use mixture of the three micronutrients Zn+Mn+B as spraying foliar application tended to significantly increased in the studied characters where this treatment records the highest values for number of pods plant^{-1} (42.13), number of seed plant^{-1} (72.90), weight of pods plant^{-1} (58.92 g), weight of seeds plant^{-1} (50.50 g) and 100-seed weight (80.41 g). These increments might be achieved by the effect of micronutrient foliar application and the important role of zinc for activating many growth enzymes in plant and involving in the biosynthesis of growth matter such as auxin which produces more plant cells and more dry matter (Devlin and Withan, 1983). Manganese plays an important role in chlorophyll production and its presence is essential in Photo system II, also involved in cell division and plant growth (Mousavi, 2011 and Anderson, 1996). Increase in yield and its component by boron sprays might be due to its involvement of in the regulation of cell division and cell elongation, tissue and tissue differentiation, ion absorption, IAA and carbohydrate metabolism, and translocation of sugars (Marschner, 1995). These results in harmony with these obtained by Singh and Chaudhari (1997), Ali and Mowafy (2003), Gobarah, *et al*. (2006), Helmy and Shaban (2007), El-Habbasha *et al*. (2013), Abd EL-Kader and Mona (2013), Gowthami and Rao (2014) and Der *et al*. (2015). Mekki (2015) stated that increasing in pods and seeds weight and 100 seed weight for some groundnut cultivars by applying foliar application comparison to untreated plants.

Table 4 : Effect of groundnut varieties and micronutrients foliar application on yield attributes Combined data of 2015 and 2016 seasons)

Treatment	Number of		Weight of (g)		
	Pods plant^{-1}	Seed plant^{-1}	Pod plant^{-1}	Seed plant^{-1}	100 Seed
Giza 6 Variety	36.39	63.77	49.52	47.07	73.04
Gregory Variety	32.09	56.38	44.00	38.60	66.51
LSD 0.05	0.56	0.67	0.11	0.47	0.78
Control	24.41	39.72	31.94	25.37	55.86
Zn	28.71	49.02	35.72	30.84	62.94
Mn	30.25	51.93	40.02	32.77	62.22
B	34.39	59.71	47.92	42.45	70.70
Zn+Mn	35.86	68.05	49.88	41.96	72.58
Zn+B	38.54	70.06	55.71	45.67	76.87
Mn+B	39.62	69.22	53.99	43.91	76.62
Zn+Mn+B	42.13	72.90	58.92	50.50	80.41
LSD 0.05	0.69	1.07	0.66	0.92	0.84

The data presented in Table (5) show the effect of interaction between Giza 6 and Gregory varieties and micronutrient foliar application i.e., Zn, Mn, B and its combination on number of pods plant^{-1}, number of seed plant^{-1}, weight of pods plant^{-1}, weight of seed plant^{-1} and 100-seed weight. Data showed that the studied characters were significantly affected by micronutrient foliar application treatments.

Giza 6 variety revealed a high values comparing with Gregory variety in all studied traits. However, Giza 6 with the treatment Zn+Mn+B foliar sparing application records the highest values for the studied characters with significantly differences with the other treatments followed by the treatment Giza 6 with Mn+B foliar sparing application in all the studied characters except, number of pod plant^{-1} where the treatment Giza 6 with foliar spraying application Mn+B. While, the treatment Gregory variety with control treatment records the lowest values for the studied characters. The dual effect of micronutrient (Zn+Mn, Zn+B and Mn+B) with Giza 6 variety, Zn+ B treatment represented a high value of the studied characters except number of pods plant^{-1}.

These results are consistent with these obtained by Shams El-Din and Ali (1996), Helmy and Ramadan (2014). (Meena and Yadav 2015) found that significantly differences between two groundnut varieties on number of pods plant^{-1} and seed index (g).

Table 5 : Effect of interaction between groundnut varieties and micronutrients foliar application on yield attributes (Combined data 2015 and 2016 seasons).

Varieties	Micronutrient treatments	Number of		Weight of (g)		
		Pods plant^{-1}	Seeds plant^{-1}	Pod plant^{-1}	Seed plant^{-1}	100 Seed
Giza 6	Control	25.40	41.71	32.90	25.99	60.09
	Zn	30.26	52.44	37.17	33.76	64.87
	Mn	35.31	61.33	45.56	40.79	67.05
	B	36.78	63.10	51.38	47.58	75.67
	Zn+Mn	37.47	71.79	52.18	43.70	75.43
	Zn+B	40.26	72.74	60.10	49.15	79.44
	Mn+B	41.25	71.29	54.89	44.60	78.50
	Zn+Mn+B	44.40	75.73	62.00	53.32	83.31
Gregory	Control	23.43	37.74	30.98	24.75	51.64
	Zn	27.16	45.60	34.27	27.92	61.01
	Mn	25.18	42.52	34.48	24.75	57.40
	B	32.00	56.32	44.46	37.32	65.73
	Zn+Mn	34.24	64.31	47.58	40.22	69.73
	Zn+B	36.83	67.37	51.32	42.20	74.31
	Mn+B	37.99	67.14	53.09	43.22	74.75
	Zn+Mn+B	39.86	70.07	55.84	47.68	77.51
LSD 0.05		**0.98**	**1.31**	**0.93**	**1.30**	**1.18**

3. Effect of groundnut varieties and micronutrients foliar application on yield characters

The data presented in Table (6) show that the effect of groundnut varieties and micronutrients foliar spraying Zn, Mn and B as well as its combinations on pod yield faddan^{-1}, seed yield faddan^{-1}, straw yield faddan^{-1}, biological yield faddan^{-1}, harvest index, shelling %, oil %, oil yield faddan^{-1}, protein % and protein yield faddan^{-1} where significantly differences were observed between groundnut varieties in the studied characters. However, Giza 6 variety exceeds significantly Gregory in all studied traits except, harvest index and oil %. Gobarah *et al.* (2006) stated that Giza 6 variety was significant effect on protein percentage as well as oil%. El Habbasha *et al.* (2014) stated that significant differences in most studied characters i.e. protein content, pod, seed and straw yield ha^{-1} except seed oil content.

Concerning the single foliar application effect of Zn, Mn and B as well as its combinations significantly increased pod, seed, straw and biological yield faddan^{-1} as well as harvest index, shelling %, oil %, protein %, oil yield and protein yield comparing with control treatment. However, pod yield faddan^{-1} increased by 2.3, 3.0 and 4.1 %, seed yield faddan^{-1} was increased by 9.3 , 5.3 and 17.8%, straw yield faddan^{-1} was increased by 8.9 , 5.8 and 19.0 %, and biological yield faddan^{-1} increased by 9.0 %, 5.7 % and 18.7%, by foliar application effect of Zn, Mn and B, respectively comparing control treatment. Harvest index increased by 24.09, 24.26 and 24.08% and shelling percentage achieved 51.0, 55.0 and 52.25 %, for foliar application of Zn, Mn and B, respectively, comparing with control treatment.

Regarding the dual foliar application, spraying of Zn+Mn, Zn+B and Mn+B significantly increased the studied traits comparing with control treatment, yield of pods faddan^{-1} increased by 6.6, 12.5 and 12.4 % , seed yield faddan^{-1} was increased by 30.9, 35.4 and 34.1%, straw yield faddan^{-1} was increased by 31.6, 35.1 and 37.7 % and biological yield faddan^{-1} was increased by 31.4, 35.1 and 36.9 %, for foliar application of Zn+Mn, Zn+B and Mn+B, respectively. Oil % was increased by 45.7, 44.3 and 42.2 % , oil yield faddan^{-1} increased by 39.0, 41.2 and 37.1 % , protein % was increased by 25.9, 26.2 and 22.5 % and protein yield faddan^{-1} increased by 35.0, 40.1 and 29.0 %, for foliar application of Zn+Mn, Zn+B and Mn+B, respectively.

Using mixture of three micronutrients Zn+Mn+B foliar application revealed significant increase in the studied characters, where this treatment recorded the highest values for yield of pods faddan^{-1}, seed yield faddan^{-1}, straw yield faddan^{-1}, biological yield faddan^{-1}, harvest index, shelling %, oil %, oil yield faddan^{-1}, protein % and protein yield faddan^{-1} (Table 6). These results were obtained by application of micronutrient foliar application on yield characters may be due to the role of Zn that plays very essential role in plant metabolism by affecting the activities of hydrogenase and carbonic anhydrase. Plant enzymes activated by Zn are involved in carbohydrate metabolism, maintenance of the rectitude of cellular membranes, protein composition, regulation of auxin synthesis and pollen formation. Mousavi *et al*., (2011) stated that manganese (Mn) plays a substantial role in oxidation and reduction processes in plants. Manganese also has played a role in chlorophyll production, and its involvement is essential in Photosystem II process. Using fertilizers with manganese increases qualifications of photosynthesis and carbohydrates synthesis such as starch, thus photosynthesis efficiency decreases with manganese deficiency due to reduction on crop yield and quality. On the other hand, boron micronutrient plays important role in cell walls, cell division, sugar transport, flowering and fruiting and plant hormone regulation that lead to improve yield production. These results in harmony with these obtained by Bellaloui *et al.* (2013), Singh and Chaudhari (1997), Nassar and Osman (2008) and Singh and Chaudhari (2015).

Table 6: Effect of groundnut varieties and micronutrients foliar application on yield characters (Combined data of 2015 and 2016 seasons)

Treatment	Yield / fad (kg)				Harvest index %	Shelling Percentage %	Oil %	Oil yield fad^{-1}	Protein %	Protein yield fad^{-1}
	Pod	Seed	Straw	Bio						
Giza 6 Variety	2500.37	1600.78	5273.90	6874.68	23.24	63.61	42.63	684.56	26.15	418.75
Gregory Variety	2344.24	1382.76	4260.16	5642.92	24.65	58.69	45.92	637.37	23.00	317.34
LSD 0.05	0.874	0.422	4.367	4.395	0.019	0.072	1.03	15.59	0.094	1.192
Control	2198.63	1122.67	3555.13	4677.80	24.09	51.01	40.48	451.79	24.06	273.51
Zn	2249.38	1237.61	3900.44	5138.05	24.26	55.00	42.93	529.72	22.85	284.53
Mn	2265.48	1185.06	3775.99	4961.05	24.08	52.25	45.98	543.22	26.93	319.65
B	2292.69	1366.17	4390.59	5756.76	23.92	59.56	45.97	626.62	24.25	332.65
Zn+Mn	2354.47	1625.02	5197.97	6822.99	23.89	68.98	45.65	740.82	25.87	420.64
Zn+B	2514.01	1738.50	5474.39	7212.89	24.11	69.25	44.31	768.78	26.22	456.52
Mn+B	2511.01	1703.36	5709.28	7412.64	23.04	67.94	42.24	718.53	22.51	385.03
Zn+Mn+B	2992.79	1955.77	6132.48	8088.25	24.16	65.24	46.64	908.24	23.90	471.83
LSD 0.05	1.39	1.85	11.51	12.45	0.04	0.08	0.84	14.61	0.20	2.92

The data presented in table (7) illustrate the effect of interaction between Giza 6 and Gregory varieties and micronutrient spraying foliar application Zn, Mn, B and its combination on pod yield faddan^{-1}, seed yield faddan^{-1}, straw yield faddan^{-1}, biological yield faddan^{-1}, harvest index , shelling %, oil %, oil yield faddan^{-1}, protein %and protein yield faddan^{-1}. Data cleared that the studied characters were significantly affected by the applied treatments. Treatment Giza 6 with spraying foliar application Zn+Mn+B records the highest values of pod yield faddan^{-1}, seed yield faddan^{-1}, straw yield faddan^{-1}, biological yield faddan^{-1}, oil yield faddan^{-1} and protein yield faddan^{-1} followed by treatment Gregory with Zn+Mn+B in the characters pod yield faddan^{-1} and oil yield faddan^{-1}, the treatment Giza 6 with Zn+B in the characters seed yield faddan^{-1} and protein yield faddan^{-1} and the treatment Giza 6 with Mn+B in the characters straw yield faddan^{-1} and biological yield faddan^{-1}.

Table 7 : Effect of interaction between some groundnut varieties and micronutrients foliar application on yield characters (Combined data 2015 and 2016 seasons).

Varieties	Micronutrient treatments	Yield / fad (kg)				Harvest index	Shelling Percentage	Oil %	Oil yield fad^{-1}	Protein %	Protein yield fad^{-1}
		Pod	Seed	Straw	Biological						
Giza 6	Control	2215.01	1275.76	4145.09	5420.85	23.54	57.60	38.72	493.93	26.25	334.90
	Zn	2259.90	1318.21	4450.28	5768.49	22.85	58.33	40.96	539.96	25.07	330.42
	Mn	2289.08	1318.94	4446.73	5765.67	22.88	57.62	44.74	590.07	27.30	360.12
	B	2316.25	1443.65	5012.00	6455.65	22.36	62.33	44.18	637.85	26.00	375.35
	Zn+Mn	2420.50	1706.10	5695.49	7401.59	23.05	70.49	44.36	756.87	26.19	446.74
	Zn+B	2724.70	1855.62	5883.83	7739.46	23.98	68.10	43.01	798.23	26.81	497.50
	Mn+B	2667.31	1768.44	6017.87	7786.31	22.80	66.30	40.85	722.37	25.00	442.11
	Zn+Mn+B	3110.23	2119.53	6539.92	8659.45	24.48	68.15	44.22	937.18	26.56 b	562.87
Gregory	Control	2182.25	969.59	2965.16	3934.75	24.64	44.43	42.25	409.66	21.88	212.12
	Zn	2238.87	1157.00	3350.60	4507.60	25.67	51.68	44.90	519.48	20.63	238.65
	Mn	2241.87	1051.18	3105.24	4156.42	25.29	46.89	47.22	496.37	26.56	279.17
	B	2269.13	1288.69	3769.18	5057.86	25.48	56.79	47.75	615.39	22.50	289.94
	Zn+Mn	2288.44	1543.95	4700.45	6244.39	24.73	67.47	46.94	724.77	25.55	394.54
	Zn+B	2303.32	1621.38	5064.94	6686.33	24.25	70.39	45.60	739.33	25.63	415.53
	Mn+B	2354.72	1638.28	5400.68	7038.96	23.28	69.58	43.63	714.70	20.02	327.95
	Zn+Mn+B	2875.35	1792.02	5725.03	7517.05	23.84	62.32	49.07	879.30	21.25	380.80
LSD 0.05		**1.97**	**2.62**	**16.28**	**17.61**	**0.05**	**0.12**	**1.19**	**20.66**	**0.28**	**4.13**

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