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EFFECT OF SOME MICRONUTRIENTS FOLIAR APPLICATION ON CHEMICAL CHARACTERS OF TWO GROUNDNUT CULTIVARS

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Abstract

Two filed experiments were carried out in two successive summer seasons (2016 and 2017) 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) cultivars to some micronutrients foliar application i.e. Zinc, Manganese and Boron and their interaction with different growth stages on some chemical traits of groundnut seeds (macro and micronutrients seed content (%), essential and non-essential amino acids composition, saturated and unsaturated fatty acids composition and saturated and unsaturated fatty acids ratios) under reclaimed sandy soil condition. The data showed that groundnut cultivars were differed in macronutrients seed content (%) affected by micronutrient foliar spraying application treatments, Giza 6 surpassed Gregory cultivar in macronutrient seed content (N, P and K %), where the lowest values of macronutrients seed content % were observed by control treatments (without foliar application). The highest micronutrients seed content were obtained by the mixture of thrice micronutrient foliar application treatment (Zn + Mn + B) with Giza 6 and Gregory cultivars, which records 107.65 and 96.47, 50.65 and 55.0, 27.95 and 26.20, 1.60 and 1.83 (ppm) for Fe, Zn, Mn and B, respectively. Amino acids profile of seed protein indicated that Leucine and Phenylalanine acids were the major content of essential amino acids in the seed protein content. The interaction between groundnut cultivars and micronutrients foliar application on non-essential amino acids composition that, Giza 6 surpassed Gregory cultivar in most non-essential amino acid; aspartic, serine, glutamic, glycine, argnine, proline and cystine, while Gregory cultivar recorded highest value of alanine, histidine. Slightly differences were observed between groundnut cultivars and micronutrients foliar spraying treatments on unsaturated fatty acid composition. Gregory cultivar recorded the highest value of oleic/linoleic ratio (1.88) when treated with dual application of micronutrients foliar Zn + B. On the contrary, the least value of O/L ratio recorded 1.77 with Gregory cultivar when treated with control treatment.

Keyword: Amino acid composition, Fatty acid, Groundnut, Micronutrients

Introduction

Groundnut (*Arachis hypogaea* L.) or peanut is an annual herbaceous plant of the Fabaceae or Legume family. Groundnut Seed oil content of groundnut is 40-50 % (more oleic acid, less linoleic acid), while carbohydrates and protein percentage is 18 and 25 % respectively (Nasar *et al.,* 2018). Micronutrients are essential elements that are used by plants in small quantities. Yield and quality of agricultural products increased with micronutrients application, therefore human and animal health is protected with feed of enrichment plant materials. Each essential element can perform its role in plant nutrition properly that other necessary elements are available in balanced ratios for plant (Tavakoli *et al*., 2014).

Oils and fats play an essential role for humans as they are good source of energy for human life. The major eight fatty acids in groundnut oil seed, i.e. palmitic (16:0), arachidic (20:0), lignoceric (24:0), oleic (18:1), stearic (18:0), linoleic (18:2), behenic (22:0) and eicosenoic (20:1). On the other side, oleic acid accounted a monounsaturated fatty acid and linoleic acid considered a polyunsaturated fatty acid represented about 75 to 80 % of the total fatty acids composition in groundnut oil. The residual of total fatty acid represented about 20%, among them, palmitic acid represented about 10% (Kavera, 2008). In addition to, oleic considered profitable in prohibiting cancer, increasing insulin allergy, and improving some inflammatory diseases. Chaiyadee et al. (2013) reported that the ratios of oleic to linoleic fatty acid (O/L ratio) is very important for determining the quality of oil, shelf-life and storability of groundnut oil. Therefore, high oleic fatty acid groundnut has longer self-life and favorable for oil quality or stability than low-oleic groundnut. The high stability of oleic acid also makes the catalytic hydrogenation of vegetable oil unnecessary, regarding oil stability; high O/L ratios in groundnut oil exceed shelf life by delaying the development of rancidity (Chong et al., 2006). On the other hand, groundnuts which are a rich source of essential amino acids and protein can help in prohibiting malnutrition. In addition, groundnuts contain fats and carbohydrates which are rich energy compounds, qualified for supplementing the basic energy demands of the human body (Pelto and Klemesu, 2011).

Zinc, Manganese and Boron are an essential micronutrient involved in a wide variety of physiological processes (Marschner, 1995). The main functions of zinc are tendency to make up tetragonal complexes with nitrogen, oxygen and sulfur, thus zinc have a catalytic, building and activating role in the enzymes. Zinc is main building part of some enzymes and is needed for the plant enzymes formation; in addition, many enzymatic reactions active by zinc (Alloway, 2008; Galavi et al., 2011 and Maleki et al., 2014). However, Manganese has important role on activates several enzymes which involve the oxidation reactions, carboxylation, carbohydrates metabolism, phosphorus reactions and citric acid cycle. The most important these enzymes, protein-manganese in Photosystem II and superoxide dismutase can be pointed (Millaleo et al., 2010; Mousavi et al., 2011, and Sharifianpour et al., 2013).

Boron is important element in many plant processes, including protein synthesis, translocation of sugars and nutrients, respiration, and metabolism of plant hormones. It is non-mobile in plants, and a continuous supply is needed throughout the growing season. Many researches illustrated the importance role of micronutrients foliar application on groundnut varieties and their effects on chemical composition (Mousavi et al., 2011; Abdel-Motagally et al., 2016 and Gowthami and Ananda, 2017).

Materials and Methods

Two field experiments were carried out during two summer successive seasons (2016 and 2017) at the Production and Research Station, National Research Centre, El- Nubaria Province, El-Beheira Governorate, Egypt. Such work aimed to investigate the response of two groundnut (Giza 6 and Gregory) cultivars to some micronutrients foliar application at different growth stages on chemical characteristics of seeds under reclaimed sandy soil conditions.

The experimental design of this investigation was laid out in 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. Unit area was 10.5 m^2 (3.5 m in length and 3 m in width) contained five rows, 60 cm between the rows. Seeds of two groundnut cultivars (Giza 6 and Gregory) are sown in hills 10 cm between the rows at the rate of 40-45 kg/faddan. Seeds of groundnut cultivars were sown at the mid of May in the two successive seasons, however, the seeds were coated just before sowing with the specific bacterial inoculants, using Arabic gum (40 %) as adhesive agent. Soil samples were taken before sowing in each season at the depth of 30 cm to determine the physical and chemical properties of soil site as illustrate in Table (1).

Table 1 : Mechanical and chemical analysis of the field experiments soil from two seasons 2016 and 2017.

Mechanical analysis			Chemical analysis		
Properties	**2016**	**2017**	Properties	**2016**	**2017**
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)**		
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 preceding crop was wheat in both cultivation seasons, seeds of groundnut (3-4 seeds) were deposited in the hill, and then the plants were thinned after complete emergence (two weeks after sowing) to two plants. 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 three equal doses at 21, 45 and 60 days after sowing. Sprinkler irrigation was applied as plants needed. Micronutrients (zinc, manganese and boron) 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.

The experimental treatments

1. Groundnut cultivars

Giza 6**:** Produced by Oil Crop Research Department, Field Crops Institute, Agriculture Research Center, Giza, Egypt. Gregory: It is a large-seeded Virginia groundnut, was introduced by Oil Crop Research Department, Field Crops Institute, Agriculture Research Center, Giza, Egypt.

2. Micronutrients foliar spraying application

- Control (Water with out foliar application) .
- Zinc 400 ppm { Zn chelates (EDTA, 20 % Zn) }.
- Manganese 400 ppm { Mn chelates (EDTA, 17 % Mn)}.
- Boron 0.06% as Boric acid (98%) .
- Zinc 400 ppm + Manganese 400 ppm .
- Zinc 400 ppm + Boron 0.06% .
- Manganese 400 ppm + Boron 0.06% .
- Zinc 400 ppm + Manganese 400 ppm + Boron 0.06 % .

Chemical characteristics of the seed

1. Macronutrients

- **Nitrogen content (N %)**. was determined using Micro Kjeldahl, Büchi 320.
- **Phosphorus content (P %).** was determined according the procedure described in the methods of analysis of the **A.O.A.C (1980).**
- **Potassium content (K %).** was determined using Flame Photometer (Jenway PEP 7) according to **Brown and Lilliand (1964).**

2. Micronutrients

Iron (Fe %), Zinc (Zn %), Manganese (Mn %) and Boron (B %) (mg/g dry weight) were determined by using atomic absorption apparatus.

3 Seed quality

- **Amino acids % :** Amino acids composition estimated of seeds (2nd season only) by using Amino acid analyzer (Biochrom 30) **A.O.A.C. (2012)**.
- **Fatty acids composition %** : Crude oil of seeds (2nd season only) was used as authentic material for identification the following fatty acids according to Stahl (1967). Procedure fatty acids methyl esters were analyzed by Gas Liquid Chromatography (GLC), Hp-6890 GC Method-HEWLEH Packard Hp-6990 series. The fractionation of fatty acid methyl ether was conducted using coiled glass, column (30 m x 320 mm “diameter” x 0.25 mm “film thickness”). The column oven temperature was programmed at 8°C/min. from 70 to 270°C, then isothermally at 270°C for 10 minutes with nitrogen at 30 ml/min. Standard fatty acid methyl /

esters mentioned before were used as standard authentic sample for identification of fatty acids. The amount of each individual fatty acid in the oil under investigation was determined according to Nelson *et al.* (1970) and relative percentages were calculated from the following equation: Fatty acid % = (Area under each preak / Area under all preak) x100.

Statistical analysis:

The analysis of variance (ANOVA) procedure of split-plot design according to Snedecor and Cochran (1990). The data tasted for homogeneity before the combined analyses of the two seasons were applied according to Steel and Torrie (1980). Treatments means were compared using Duncan's (1955) test at 5% of probability.

Results and Discussion

Effect of groundnut cultivars and micronutrient foliar application treatments on macronutrients seed content %

Data presented in Table (2) showed the effect of groundnut cultivars (Giza 6 and Gregory) and micronutrients foliar spraying application (control), (Zn 400 ppm), (Mn 400 ppm), (B 0.06 as boric acid), (Zn 400 ppm + Mn 400 ppm), (Zn 400 ppm + B 0.06), (Mn 400 ppm + B 0.06) and (Zn 400 ppm + Mn 400 ppm + B 0.06) treatments on macronutrients seed content from nitrogen, phosphor and potassium. However, the data reveal that the groundnut cultivars were differed in macronutrients seed content (%) affected by micronutrient foliar spraying application treatments, Giza 6 surpassed over Gregory cultivar in macronutrient seed content (N, P and K %). Where, seed of Giza 6 cultivar contains 4.19, 0.82 and 0.62 % for N, P and K %, respectively, while seed of Gregory cultivar contains 3.83, 0.73 and 0.53 for N, P and K %, respectively.

The data illustrate that the highest nutrient content and uptake by groundnut cultivars for macronutrient seed content % were obtained when the plants treated with the mixture of thrice micronutrients foliar application (Zn + Mn + B) that recorded the highest values of N, P and K % seed content for Giza 6 and Gregory cultivar followed by the dual effect of micronutrients foliar application (Zn + Mn), (Zn + B) and (Mn + B) in most macronutrient seed content, while most of the few values of macronutrients seed content % were observed by control treatments (without foliar application). Nassar and Osman (2008) indicated that foliar application was done twice at vegetative stage at 45 and 60 day after sowing of micronutrients (Fe, Zn and Mn) in a chelated form (EDTA) at rate of 0.3 and 4.5 g/L increased significantly N, P and K uptake under reclaimed sandy soil.

Table 2 : Effect of groundnut cultivars and micronutrient foliar application treatments on macronutrient (%) of seeds (2 nd seasons 2017).

Treatments	**Macronutrient seed content %**					
	Giza 6			**Gregory**		
	N	**P**	**K**	**N**	**P**	**K**
Control	4.00	0.75	0.55	3.20	0.65	0.50
Zn	4.20	0.86	0.59	3.50	0.75	0.51
Mn	4.18	0.78	0.58	3.95	0.73	0.50
B	4.16	0.83	0.60	3.90	0.71	0.52
Zn + Mn	4.19	0.85	0.67	3.98	0.73	0.53
Zn + B	4.23	0.78	0.68	4.00	0.69	0.55
Mn + B	4.22	0.88	0.65	4.05	0.73	0.53
Zn + Mn + B	4.35	0.90	0.69	4.10	0.83	0.58
Mean	4.19	0.83	0.62	3.83	0.73	0.53

Effect of groundnut cultivars and micronutrient foliar application treatments on micronutrients seed content (ppm).

Data presented in Table (3) showed that the effect of groundnut cultivars (Giza 6 and Gregory) and micronutrients foliar spraying application (control), (Zn 400 ppm), (Mn 400 ppm), (B 0.06 as boric acid), (Zn 400 ppm + Mn 400 ppm), (Zn 400 ppm + B 0.06), (Mn 400 ppm + B 0.06) and (Zn 400 ppm + Mn 400 ppm + B 0.06) treatments on micronutrients seed content of Iron, zinc, manganese and boron. The data reveal that the groundnut cultivars were differed in micronutrients seed content (%) which affected by micronutrient foliar spraying application treatments, Giza 6 surpassed over Gregory cultivar in micronutrient seed content (Fe and Mn %), Giza 6 cultivar records 103.15 and 25.79 (ppm) for Fe and Mn, respectively, while Gregory cultivar records 93.52 and 23.13 (ppm) for Fe and Mn, respectively. On contrary, Gregory cultivar surpassed over Giza 6 in Zn and B, however, Gregory cultivar records 47.48 and 1.69 in Zn and B, respectively, while Giza 6 records 45.83 and 1.43 with Zn and B, respectively.

The highest micronutrient seed content were obtained by the mixture of thrice micronutrient foliar application treatment (Zn + Mn + B) for Giza 6 and Gregory cultivars which records 107.65 and 96.47, 50.65 and 55.0; 27.95 and 26.20; 1.60 and 1.83 for Fe, Zn, Mn and B, respectively. Followed by the dual effect of micronutrients foliar application (Zn + Mn), (Zn + B) and (Mn + B), while the lowest values of macronutrients seed content % were observed by control treatments (without foliar application).

Generally, these results might be due to the important role of micronutrients foliar spraying treatments, micronutrients often act as cofactors in enzymatic systems and participate in redox reactions, in addition to having several other vital functions in plants. Most importantly, micronutrients are involved in the key physiological processes of photosynthesis and respiration (Marschner, 1995). However, micronutrient deficiencies can result in great deal of limitation in the physiological and metabolic processes even if the plants need only small amount of micronutrient for satisfactory crop growth and production. In order to increase production of crops with high yield and quality, an adequate fertilization of macro- and micronutrients should be implemented in plant nutrition, (Sawan *et al*., 2008). Zinc functions in plants are largely associated with activity. It plays as an activator of several enzymes in plants and is directly involved in the biosynthesis of growth substances such as auxin which produces more plant cells and more dry matter that in turn will be stored in seeds as a sink. Thus seed yield increase is more expected. Some investigators have reported that foliar spraying with Zn could correct Zn deficiency, improve growth, yield and seed quality of peanut. Boron has found a wider use for agronomic and horticultural crops. Boron plays an important role in cell wall synthesis and structure and possibly membrane stability. They added that boron is associated with one or more of the following processes: calcium utilization, cell division, flowering and fruiting, water relations, and catalyst for certain reactions (Abd EL-Kader-Mona, 2013). Singh *et al*. (1990-b) indicated that iron sulphate, zinc sulphate and Fe-EDTA on the foliage at 20, 35, 50 and 65 DAS, increased the N, P, K and Mg concentration of groundnut seeds. Helmy and Shaban (2007) indicated that the highest nutrient content and uptake by plant were obtained when treated with K combined with foliar spraying with (Zn + B). The highest N, P and K values (50.1, 5.18 and 160 mg kg^{-1} soil, respectively) were observed under the combined treatment of (K + Zn + B). The highest values of available Zn, B, Mn and Cu (1.19, 0.92, 3.75 and 0.86 mg kg^{-1} soil, respectively) were obtained due to the combined treatment (K+ Zn+ B). **Islam et al. (2018)** reported that micronutrient foliar application Zn, B, and Mo had a significant effect on the seed content. The uptake of N, P, K, S, Zn, and B by grain lentil was markedly influenced by micronutrients.

Table 3 : Effect of groundnut cultivars and micronutrient foliar application treatments on micronutrient (ppm) of seeds (2 nd seasons 2017).

Treatments	**Micronutrient seed content (ppm)**							
	Giza 6				**Gregory**			
	Fe	**Zn**	**Mn**	**B**	**Fe**	**Zn**	**Mn**	**B**
Control	95.02	40.33	24.05	1.30	89.47	43.48	20.36	1.45
Zn	98.58	46.20	24.80	1.38	92.49	44.65	20.98	1.68
Mn	101.68	44.50	25.30	1.35	93.45	45.65	21.65	1.64
B	105.97	46.15	25.80	1.44	95.47	46.58	21.50	1.70
Zn + Mn	102.65	47.45	27.70	1.40	94.45	46.25	23.78	1.65
Zn + B	107.60	46.12	23.70	1.47	94.69	48.70	24.68	1.78
Mn + B	105.98	45.30	26.98	1.50	91.65	49.60	25.90	1.80
Zn + Mn + B	107.65	50.65	27.95	1.60	96.47	55.00	26.20	1.83
Mean	103.15	45.83	25.79	1.43	93.52	47.48	23.13	1.69

Effect of micronutrient foliar application treatments on essential amino acids composition

Groundnut seeds were vital source of protein which contains all the essential amino acids which characterized a very important for normal body growth and metabolism process (Hoffmann and Falvo 2004). Groundnut protein became important source as food and feed, especially in developing countries where suffering from protein decreasing for animal sources are not within the means of the majority of the people (Yaw *et al*., 2008 and Yenagi *et al*., 2015). The data presented in Table (4) illustrate the effect of micronutrients foliar application treatments; control, Zn, Mn, B, Zn + Mn, Zn + B, Mn + B and Zn + Mn + B on essential amino acid composition of groundnut seeds protein (lucine, isolucine, tyrosine, phenylalanine, lysine, therionine, valine and methionine). The highest values of lucine, isolucine, lysine, therionine and tyrosine recorded by the thrice micronutrients foliar application treatment (Zn + Mn + B), methionine amino acid recorded the greatest value by Zn, Mn and Mn + B treatments, phenylalanine and valine amino acid recorded the highest value by Zn foliar application treatment. Regarding to mean values of saturated amino acid profile of seed protein and (Fig. 7), it can be observed that Lucine and Phenylalanine acids were the major content of essential amino acid in the seed protein content by 2.61 and 2.11mg/g dry weight, respectively, followed by Valine (1.68), Tyrosine (1.65), Lysine (1.56), Isolucine (1.35), Therionine (1.12), and Methionine (0.63) mg/g dry weight.

Table 4 : Effect of micronutrient foliar application treatments on essential amino acids composition (mg/g dry weight) in 2017 season.

Treatments foliar application	**lucine**	**Isolucine**	**Lysine**	**Therionine**	**Methionine**	**Phenylalanine**	**Valine**	**Tyrosine**
Control	2.20	1.15	1.37	0.98	0.58	2.05	1.48	1.36
Zn	2.65	1.39	1.51	1.14	0.65	2.15	1.77	1.70
Mn	2.69	1.40	1.60	1.16	0.65	2.14	1.74	1.74
B	2.71	1.40	1.67	1.14	0.62	2.12	1.70	1.71
Zn + Mn	2.59	1.39	1.47	1.12	0.64	2.11	1.65	1.55
Zn + B	2.61	1.33	1.63	1.12	0.64	2.11	1.66	1.74
Mn + B	2.67	1.32	1.59	1.14	0.65	2.09	1.73	1.64
Zn + Mn + B	2.80	1.43	1.67	1.18	0.64	2.14	1.70	1.82
Means	2.61	1.35	1.56	1.12	0.63	2.11	1.68	1.65

Effect of the interaction between groundnut cultivars and micronutrient foliar application on essential amino acids composition

The data presented in Table (5) showed the effect of the interaction between groundnut cultivars and micronutrient foliar application on essential amino acids composition. The data revealed that Giza 6 surpassed over Gregory cultivars in most essential amino acid composition except lysine acid. The amino acid profile shows that lucine, Isolucine, lysine, therionine, methionine, phenylalanine, valine and tyrosine recorded 2.63 and 2.59, 1.39 and 1.31, 1.55 and 1.57, 1.13 and 1.11, 0.66 and 0.60, 2.14 and 2.09, 1.69 and 1.67, 1.70 and 1.61mg/g dry weight, by Giza 6 and Gregory cultivar, respectively.

Table 5 : Effect of the interaction between groundnut cultivars and micronutrient foliar application on essential amino acids composition (mg/g dry weight) in 2017 season.

Cultivars	Treatments foliar application	lucine	Isolucine	Lysine	Therionine	Methionine	Phenylalanine	Valine	Tyrosine
Giza 6	Control	2.40	1.29	1.48	0.92	0.60	2.10	1.41	1.46
	Zn	2.67	1.38	1.50	1.11	0.71	2.15	1.80	1.75
	Mn	2.66	1.41	1.49	1.18	0.69	2.12	1.76	1.72
	B	2.70	1.41	1.65	1.17	0.63	2.11	1.66	1.82
	Zn + Mn	2.55	1.47	1.49	1.11	0.68	2.12	1.64	1.59
	Zn + B	2.58	1.30	1.59	1.14	0.63	2.16	1.68	1.80
	Mn + B	2.65	1.34	1.56	1.18	0.70	2.17	1.84	1.64
	Zn + Mn + B	2.86	1.48	1.65	1.19	0.64	2.16	1.69	1.85
	Means	2.63	1.39	1.55	1.13	0.66	2.14	1.69	1.70
Gregory	Control	1.99	1.01	1.25	1.03	0.55	2.00	1.54	1.26
	Zn	2.63	1.39	1.52	1.16	0.59	2.14	1.74	1.64
	Mn	2.72	1.39	1.71	1.14	0.61	2.15	1.71	1.76
	B	2.71	1.39	1.69	1.10	0.60	2.13	1.74	1.59
	Zn + Mn	2.63	1.31	1.45	1.12	0.60	2.09	1.65	1.50
	Zn + B	2.63	1.35	1.67	1.10	0.64	2.05	1.64	1.68
	Mn + B	2.69	1.30	1.62	1.10	0.60	2.01	1.62	1.63
	Zn + Mn + B	2.73	1.37	1.68	1.16	0.64	2.12	1.71	1.78
	Means	2.59	1.31	1.57	1.11	0.60	2.09	1.67	1.61

Effect of micronutrient foliar application treatments on non-essential amino acids composition

The data presented in Table (6) illustrate the effect of micronutrients foliar application treatments; control, Zn, Mn, B, Zn + Mn, Zn + B, Mn + B and Zn + Mn + B on non-essential amino acid composition of groundnut seed protein; aspartic, serine, glutamic, glycine, alanine, histidine, argnine, proline and cystine. the highest value of aspartic and glutamic amino acid recorded by B treatment foliar application with 4.42 and 7.95, respectively, the effect of Zn + Mn micronutrient foliar spraying treatment recorded the highest value of serine and histidine by 1.92 and 1.10 mg/g dry weight, respectively, while, glycine, alanine, argnine and proline amino acid recorded the highest value 3.01, 1.93, 4.78 and 1.88 mg/g dry weight, respectively, by the thrice micronutrient foliar application treatments (Zn + Mn + B). While, cystine amino acid recorded the highest value 1.11by the dual effect of micronutrient foliar spraying treatment (Zn + B).

Concerning tomeans ofnon-essential amino acids composition (mg/g dry weight) Fig. (9),The data revealed that the highest values of non-essential amino acid profile were observed in glutamic, argnine and aspartic that recorded 7.61, 4.66 and 4.16 mg/g dry weight, respectively, followed by glycine (2.57), proline (1.81), serine (1.77), alanine (1.77), histidine (1.05) and cystine (0.99) mg/g dry weight.

These results were agreement with those obtained by Abdualrahman (2013) that recorded that, Glutamic and Aspartic amino acids recorded the major values. Ingale and Shrivastava (2011) indicated that groundnut seeds contained Essential Amino Acid (EAA) and non essential Amino Acid (NEAA) composition of the test protein. He reported that the tested protein of oil seed like groundnut is a good source of essential amino acids notably argnine, glycine, leucine, alanine and methionine, the other amino acids in moderate amounts, Serine is the most limiting amino acid, in developing countries, there is high interest and request of oilseeds for utilization of animal and human feeds and for oil extracting industries, sunflower, safflower and groundnut seeds are an excellent source of oil. With percentage oil content of 40-50%, it compares favorably with the richest oil producing legumes like peanut and soybeans.

Table 6 : Effect of micronutrient foliar application treatments on non-essential amino acids composition (mg/g dry weight) in 2017 season.

Treatments foliar application	Aspartic	Serine	Glutamic	Glycine	Alanine	Histidine	Argnine	Proline	Cystine
Control	3.42	1.55	7.12	2.07	1.53	0.93	4.46	1.68	0.81
Zn	4.36	1.83	7.72	2.57	1.80	1.09	4.58	1.80	1.01
Mn	4.37	1.91	7.90	2.58	1.90	1.09	4.68	1.79	0.93
B	4.42	1.76	7.95	2.51	1.87	1.08	4.72	1.81	0.92
Zn + Mn	4.08	1.92	7.15	2.57	1.59	1.10	4.72	1.83	1.03
Zn + B	4.24	1.76	7.56	2.37	1.76	1.05	4.71	1.85	1.11
Mn + B	4.18	1.72	7.53	2.88	1.85	1.02	4.66	1.83	0.87
Zn + Mn + B	4.27	1.76	7.94	3.01	1.93	1.09	4.78	1.88	0.94
Means	4.16	1.77	7.61	2.57	1.77	1.05	4.66	1.81	0.95

Effect of the interaction between groundnut cultivars and micronutrient foliar application on non-essential amino acids composition

The data presented in Table (7) show that the effect of the interaction between groundnut cultivars and micronutrient foliar application on non-essential amino acids composition. The data showed that Giza 6 surpassed over Gregory cultivar in most non essential amino acid; aspartic, serine, glutamic, glycine, argnine, proline and cystine, while Gregory cultivar recorded highest value of alanine, histidine. These results in harmony with this obtained by Radhakrishnan *et al*. (2014) who decided that some tested groundnut cultivars had higher content of amino acid (Asp, Thr, Ser, Glu, Pro, Gly, Ala, Cys, Val, Met, Ile, Leu, Tyr, Phe, His, Lys, and Arg) than other groundnut cultivars. Meanwhile, Muniappan *et al.* (2016) stated that the protein contents varied among the different cultivars of groundnut cultivars, and there was a slightly difference in protein content among the different cultivars.

Table 7 : Effect of the interaction between groundnut cultivars and micronutrient foliar application on non-essential amino acids composition (mg/g dry weight) in 2017 season.

Cultivars	Treatments foliar application	Aspartic	Serine	Glutamic	Glycine	Alanine	Histidine	Argnine	Proline	Cystine
Giza 6	Control	3.58	1.70	7.58	2.30	1.40	0.90	4.72	1.65	0.83
	Zn	4.41	1.75	7.90	2.55	1.76	1.09	4.90	1.84	1.09
	Mn	4.46	1.97	7.92	2.57	1.95	1.09	4.96	1.78	1.00
	B	4.71	1.78	7.99	2.54	1.93	1.09	5.07	1.82	0.94
	Zn + Mn	4.13	2.40	7.60	2.84	1.42	1.10	4.89	1.85	1.10
	Zn + B	4.22	1.86	7.76	2.37	1.75	1.05	4.85	1.87	0.98
	Mn + B	4.14	1.96	7.78	3.33	1.95	1.02	4.92	1.86	0.91
	Zn + Mn + B	4.24	1.99	7.95	3.36	2.00	1.07	4.95	1.89	0.92
	Means	4.24	1.93	7.81	2.73	1.76	1.05	4.91	1.82	0.97
Gregory	Control	3.27	1.39	6.66	1.83	1.65	0.95	4.20	1.70	0.79
	Zn	4.31	1.91	7.54	2.58	1.83	1.09	4.26	1.75	0.93
	Mn	4.27	1.84	7.87	2.59	1.84	1.09	4.39	1.80	0.85
	B	4.13	1.73	7.90	2.48	1.81	1.07	4.36	1.80	0.90
	Zn + Mn	4.02	1.43	6.70	2.30	1.75	1.10	4.55	1.81	0.95
	Zn + B	4.25	1.65	7.35	2.37	1.76	1.04	4.57	1.82	1.23
	Mn + B	4.22	1.47	7.27	2.43	1.74	1.02	4.40	1.79	0.83
	Zn + Mn + B	4.30	1.53	7.92	2.65	1.85	1.10	4.60	1.87	0.95
	Means	4.09	1.62	7.40	2.40	1.78	1.06	4.42	1.79	0.93

Effect of groundnut cultivars and some micronutrients foliar application on saturated fatty acids composition

Composition of fatty acids in groundnut oil significantly affects on the quality, flavor and nutritional value of the products. The eight main fatty acids in groundnut oil were palmitic (C 16:0), stearic (C 18:0), oleic (C18:1), linoleic, linolenic (C 18:3), arachidic (C 20:0), behenic (C22:0) and lignoceric (C 24:0). However, three fatty acids i.e. palmitic, oleic and linoleic were presented about 80-90 % from total fatty acids composition in groundnut oil (Hassan and Ahmed, 2012).

Data in Table (8) showed that the saturated fatty acid composition profile of groundnut oil of Giza 6 and Gregory cultivars included; palmitic (C16:0), stearic (C 18:0), arachidic (C 20:0), behenic (C 22:0), lignoceric (C 24:0) under the studied micronutrients foliar application treatments, profile data illustrated that the saturated fatty acids affected slightly by micronutrient foliar application treatment and groundnut cultivars. Regarding to the saturated fatty acid; palmitic (C 16:0), stearic (C 18:0) and behenic (C 22:0) were represented to the main components. palmitic fatty acid ranged from 11.03 mg/g dry weight by control treatment to 11.89 mg/g dry weight by B spraying foliar application with Giza 6 cultivar treatment. On the other hand, Gregory cultivar ranged from 11.25 mg/g dry weight by using control treatment to 12.10 mg/g dry weight by using Mn + B spraying foliar application. While, Stearic acid ranged from 2.10 mg/g dry weight by control treatment to 2.60 mg/g dry weight by using Zn + Mn + B spraying foliar application with Giza 6 cultivar. Gregory cultivar ranged from 2.18 mg/g dry weight by using control treatment to 2.86 mg/g dry weight, when treated with Zn + Mn spraying foliar application. Arachidic fatty acid shows that, Giza 6 ranged from 1.08 mg/g dry weight with the control treatment to 1.75 mg/g dry weight with the treatment Zn + Mn + B spraying foliar application and ranged from 1.09 mg/g dry weight with the treatment control treatment to 1.45 mg/g dry weight with the treatment Zn spraying foliar application with Gregory cultivar. Behenic fatty acid ranged from 2.10 mg/g dry weight with the control treatment to 2.66 mg/g dry weight with the dual micronutrient foliar application (Mn + B) by Giza 6 cultivar, and ranged from 2.30 mg/g dry weight by control treatment to 2.95 mg/g dry weight with the treatment (Zn + Mn + B) spraying foliar application by Gregory cultivar, while Lignoceric fatty acid ranged from 1.15 mg/g dry weight for control treatment to 1.72 mg/g dry weight with the treatment (Zn + Mn + B) spraying foliar application with Giza 6, and ranged from 1.35 mg/g dry weight by control treatment to 1.59 mg/g dry weight spraying foliar application (Zn + Mn) with Gregory cultivar.

Table 8 : Effect of interaction between foliar application with some micronutrients and groundnut cultivars on saturated fatty acids composition.

		Saturated Fatty acids composition (%)				
cultivar	**Treatment**	**Palmitic (C16:0)**	**Stearic (C18:0)**	**Arachidic (C20:0)**	**Behenic (C22:0)**	**Lignoceric (C24:0)**
Giza 6	Control	11.03	2.10	1.08	2.10	1.15
	Zn	11.26	2.59	1.25	2.45	1.71
	Mn	11.50	2.53	1.34	2.17	1.43
	B	11.89	2.39	1.74	2.15	1.30
	Zn + Mn	11.51	2.47	1.35	2.36	1.41
	Zn + B	11.60	2.55	1.23	2.20	1.23
	Mn + B	11.75	2.45	1.25	2.66	1.43
	Zn + Mn + B	11.20	2.60	1.75	2.50	1.72
	Mean	11.47	2.46	1.37	2.37	1.42
Gregory	Control	11.25	2.18	1.09	2.30	1.35
	Zn	11.31	2.50	1.45	2.40	1.67
	Mn	11.88	2.49	1.31	2.86	1.57
	B	11.55	2.55	1.31	2.64	1.44
	Zn + Mn	11.75	2.86	1.29	2.38	1.59
	Zn + B	12.00	2.76	1.23	2.83	1.58
	Mn + B	12.10	2.85	1.15	2.75	1.36
	Zn + Mn + B	11.50	2.80	1.25	2.95	1.40
	Mean	11.67	2.62	1.26	2.64	1.50

Effect of groundnut cultivars and some micronutrients foliar application on unsaturated fatty acids composition

Data in Table (9) showed the unsaturated fatty acid composition profile of groundnut oil of Giza 6 and Gregory cultivars included; oleic (C 18:1), linoleic (C 18:2) and linolenic (C18:3) under the studied micronutrients foliar application treatments. Data profile illustrated that the unsaturated fatty acids affected slightly by micronutrient foliar application treatment and groundnut cultivars.

This data revealed that slightly differences were detected between interacted treatments of groundnut cultivar and micronutrients foliar application treatments on fatty acid composition. While, the highest value of oleic fatty acid records 51.44 % with Gregory cultivar by the treatment Zn + Mn + B foliar application treatment and the lowest value recorded the same cultivar and control treatment (48.10 %). On the other side, Giza 6 cultivar records the highest value, 50.78 % when treated by Zn + Mn foliar application and records the lowest value with the control treatment 47.50 %.

On the other hand, linoleic unsaturated fatty acid records with Gregory cultivar the highest value by the single micronutrient foliar application (Zn) 27.71 %, while the lowest value was 27.10 % with the control treatment, comparing with Giza 6 cultivar, the highest value was 28.75 % achieved with Zn + Mn + B treatment., while the lowest value was 27.74 % by the control treatment. Gregory cultivar recorded the highest value of linolenic (1.89) by the dual micronutrient foliar application (Mn +B), while the lowest value recorded 1.52 by control treatment. While, Giza 6 cultivar recorded the highest value of linolenic 1.76 by the thrice micronutrient foliar application (Zn + Mn + B), while the lowest value for the same cultivar recorded 1.30 by control treatment. The highest mean value of oleic fatty acid records by Gregory cultivar, 50.57 % and 27.44 for linoleic fatty acid, comparing with Giza 6 cultivar where records 49.58 % from oleic fatty acid and 28.31 % from linoleic fatty acid. These results agreed with (El-Gindy 1988, Goyal and Mansour 2015, El-Hagarey et al. 2015, Mansour et al 2019 a,b, Mansour et al 2015 a,d, and Mansour et al 2016a,c), this was agreed with (Mansour 2006, 2012, 2015 and Mansour and Goyal, 2015, Mansour 2015, Mansour et al., 2015 a, b, c; Mansour et al., 2016a, b, c). These results are in agreements with those obtained by Mandal et al. (2006) who stated that Gregory cultivar was the highest value of oleic as unsaturated fatty acids, as well as the lowest value of Linoleic fatty acid. On the contrary, Giza 6 cultivar presented high level of linoleic fatty acid and lowest value of oleic. palmitic, oleic and linoleic represented about 86-93 % from fatty acid composition. Two saturated fatty acids i.e. oleic (C 18:2) and linoleic (C 18:2) were represented approximately 80 % of total fatty acid composition of oil, quality of groundnut oil depended on height percentage of oleic to linoleic (Ahmed and Young, 1982).

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Table 9 : Effect of foliar application with some micronutrients and groundnut cultivars on unsaturated fatty acids composition.

Unsaturated fatty acids composition (%)				
cultivar	**Treatment**	**Oleic (C18:1)**	**Linoleic (C18:2)**	**Linolenic (C18:3)**
Giza 6	Control	47.50	27.74	1.30
	Zn	49.95	28.20	1.70
	Mn	50.37	28.04	1.52
	B	48.94	28.69	1.73
	Zn + Mn	50.78	27.93	1.64
	Zn + B	49.66	28.43	1.39
	Mn + B	49.76	28.71	1.37
	Zn + Mn + B	49.70	28.75	1.76
	Mean	49.58	28.31	1.55
Gregory	Control	48.10	27.10	1.52
	Zn	50.54	27.71	1.65
	Mn	50.88	27.65	1.60
	B	50.33	27.52	1.72
	Zn + Mn	50.98	27.55	1.85
	Zn + B	51.13	27.19	1.75
	Mn + B	51.15	27.30	1.89
	Zn + Mn + B	51.44	27.50	1.60
	Mean	50.57	27.44	1.70

Effect of foliar application with micronutrients and groundnut cultivars on fatty acid quality parameters of groundnut

Data presented in Table (10) illustrated the effect of micronutrients foliar application, Zn, Mn, B and their combinations with groundnut cultivars, Giza 6 and Gregory on fatty acid quality parameters i.e. oleic to linoleic ratio (O / L ratio), total saturated fatty acid, total unsaturated fatty acids and total saturated/total unsaturated fatty acids ratio.

The data shows that, the least value on Giza 6 cultivar of oleic to linoleic ratio (O/L ratio) was achieved with control treatment (1.71), but the top value of O/L ratio was 1.82 achieved with Zn + Mn foliar application treatment. On the other side, Gregory cultivar recorded the highest value of oleic to linoleic ratio, 1.88 when treated with dual effect of micronutrient foliar application Zn + B. On the contrary, the least value of O/L ratio recorded 1.77 with Gregory cultivar when treated with control treatment.

These results are in harmony with the obtained by Mohamed-Eman *et al.* (2010) who showed that all studied cultivars contained high amounts of oleic fatty acid (47.7-52.9 %) and low amounts of linolenic fatty acid (0.11-0.46%).

Table 10 : Effect of foliar application with micronutrients and groundnut cultivars on fatty acid parameters of groundnut (2017 seasons).

Foliar application treatments	**Giza 6 cultivar**				**Gregory cultivar**			
	O\L ratio	**Total saturated**	**Total unsaturated**	**Sat\unsat.**	**O\L ratio**	**Total saturated**	**Total unsaturated**	**Sat/unsat.**
Control	1.71	17.46	76.54	0.23	1.77	18.17	76.72	0.24
Zn	1.77	19.26	79.85	0.24	1.82	19.33	79.90	0.24
Mn	1.80	18.97	79.93	0.24	1.84	20.11	80.13	0.25
B	1.71	19.47	79.36	0.25	1.83	19.49	79.57	0.24
Zn + Mn	1.82	19.10	80.35	0.24	1.85	19.87	80.38	0.25
Zn + B	1.75	18.81	79.48	0.24	1.88	20.40	80.07	0.25
Mn + B	1.73	19.54	79.84	0.24	1.87	20.21	80.34	0.25
Zn + Mn + B	1.73	19.77	80.21	0.25	1.87	19.90	80.54	0.25

Regarding to saturated and unsaturated fatty acids ratios parameter, data in Table (17) illustrated that, unsaturated fatty acids represented the major component of total fatty acids composition which ranged from 76.54 % to 80.35 % in Giza 6 cultivars, where, ranged from 76.72 % to 80.38 % in Gregory cultivar. On the other hand, the total saturated fatty acids ranged from 17.46 % to 19.77 % with Giza 6 cultivar. While ranged from 18.17 % to 20.40 % in Gregory cultivar, saturated / unsaturated fatty acid ranged from 0.23 to 0.25 in Giza 6 cultivar, while, and ranged from 0.24 to 0.25 in Gregory cultivar. These results indicated that the groundnut oil is considered good edible oil due to lower content of saturated fatty acid **(**El-Habbasha, 2015). The higher percentage of oleic (monounsaturated fatty acid) to linoleic (polyunsaturated fatty acid) ratio (O/L) were lead to stability increasing and longer validity period of groundnut products and give a significant nutritional advantage for the consumer (Kratz *et al*., 2002).

References

A.O.A.C. (1980). Official Methods of the Association of Official Analytical Chemists. 11th Ed. Published by the Association of Official Analytical Chemists, Washington, D.C. USA.

A.O.C.S. (2012). Official Methods and Recommended Practices of the American Oil Chemists' Society. 4th ed., Champaign. IL, U.S.A., (1): 92-100.

Abd EL-Kader, M.G. (2013). Effect of sulfur application and foliar spraying with zinc and boron on yield, yield components, and seed quality of peanut (*Arachis hypogaea* L.) Res. J. of Agric. and Biological Sci., 9(4): 127-135.

Abd-Elmabod, S.K.; Bakr, N.; Muñoz-Rojas, M.; Pereira, P.; Zhang, Z.; Cerdà, A.; Jordán, A.;

Abdel-Motagally, F.M.F.; Mahmoud, M.W.Sh. and Ahmed, E.M. (2016). Response of two peanut varieties to foliar spray of some micronutrients and sulphur application under east of El-Ewinat conditions. Assiut J. Agric. Sci., 47(1): 14-30.

Abdualrahman, M.A.Y (2013). Chemical, In-vitro protein digestibility, minerals and amino acids composition of edible peanut seeds (*Arachis hypogaea* L.). Sci. International, 1(6): 199-202.

Ahmed, E.M. and Young, C.T. (1982).Composition, quality, and flavor of peanuts. In: Pattee HE and CT Young (eds). Peanut Science and Technology. Yoakum, Texas: AM Peanut Res. Edu. Soc. 1982; 655-688.

Alloway B.J. (2008). Zinc in soils and crop nutrition. Second edition, published by IZA and IFA, Brussels, Belgium and Paris, France.

Anderson, J.M. and Pyliotis, N.A. (1996). Studies with manganese deficient chloroplasts. Biochemistry and Biophysics Acta., 189: 280-293.

Brown, J.D. and Lilliand, O. (1964). Rapid determination of potassium and sodium in plant materials and soil extracts by Flam- photometer, Proc. Amer. Soc. Hort. Sci., 48: 341-346.

Chaiyadee, S.; Jogloy, S.; Songsri, P.; Singkham, N.; Vorasoot, N.; Sawatsitang, P.; Holbrook, C.C. and A. Patanothai (2013). Soil moisture affects fatty acids and oil quality parameters in peanut. International J. of Plant Production, 7: 81-96.

Duncan, D.B. (1955). Multiple ranges and multiple F test. Biometrics, 11: 1-24.

Eldardiry, E.E., Hellal, F., Mansour, H.A.A. 2015, Performance of sprinkler irrigated wheat – part II.Closed Circuit Trickle Irrigation Design: Theory and Applications, pp.41

El-Habbasha, S.F. (2015). Impact of nitrogen fertilizer and zinc foliar application on growth, yield, yield attributes and some chemical constituents of groundnut. International Journal of Plant & Soil Science 4(3): 259-264.

El-Hagarey, M.E.,Mehanna, H.M., Mansour, H.A. 2015, Soil moisture and salinity distributions under modified sprinkler irrigation. Closed Circuit Trickle Irrigation Design: Theory and Applications, pp.3 -21.

Galavi, M.; Yosefi, K.; Ramrodi, M. and Mousavi, S.R. (2011). Effect of bio-phosphate and chemical phosphorus fertilizer accompanied with foliar application of micronutrients on yield, quality and phosphorus and zinc concentration of maize. J. of Agric. Sci., 3(4): 22-29.

Gowthami, S. and Ananda, N. (2017 a). Growth, yield and quality parameters of groundnut (*Arachis hypogaea* L.) genotypes as influenced by zinc and iron through ferti-fortification. International J. of Agric. and Env. Res., 3(2): 2712-2718.

Hassan, F. and Ahmed, M. (2012). Oil and fatty acid composition of peanut cultivars grown in Pakistan. Pakistan Journal of Botany, 44: 627-630.

Helmy, A.M. and Shaban, Kh.A. (2007). Response of peanuts to K fertilization and foliar spraying with zinc and boron under sandy soil conditions. Zagazig J. Agric. Res., 35(2): 343 – 362.

Hoffmann, J.R. and Falvo, M.J. (2004). Protein-which is best. J. of Sports Sci. and Medicine, 3(3): 118-130.

Ingale, S. and Shrivastava, S.K. (2011). Amino acid profile of some new varieties of oil seeds. Advance J. of Food Sci. and Technology.3 (2): 111-115.

Islam, M.; Karim, R.; Hosain, M.; Akter, T.; Hossain, A. and Haque, M. (2018). Impacts of trace element addition on lentil (*Lens culinaris* L.) Agronomy. 8: 100 (1-13).

Kavera, B. (2008). Oil quality improvement in groundnut (*Arachis hypogaea* L.) through induced mutagenesis. University of Agricultural Science, Dharwad, India.

Kratz, M.; Cullen, P.; Kannenberg, F.; Kassner, A.; Fobker, M.; Abuja, P.M.; Assmann, G. and Wahrburg, U. (2002). Effects of dietary fatty acids on the composition and oxidizability of low-density lipoprotein. European Journal on Clinical Nutrition., 56(1): 72-81.

Maleki, A.; Fazel, S.; Naseri, R.; Rezaei, K. and Heydari, M. (2014). The effect of potassium and zinc sulfate application on grain yield of maize under drought stress conditions. Advances in Env. Bio. 8(4): 890-893.

Mandal, S.; Ghosh, S. and Badigannavar, A.M. (2006). RAPD polymorphism among groundnut genotypes differing in disease reaction to late leaf spot and rust. IAN., 25: 25-30.

Mansour H. A., Hu Jiandong, Ren Hongjuan, Abdalla N. O. Kheiry and Sameh K. Abd-Elmabod. 2019b. Influence of using automatic irrigation system and organic fertilizer treatments on faba bean water productivity, International Journal of GEOMATE, Oct., 2019 Vol.17, Issue 62, pp. 256 – 265.

Mansour H. A., Sameh K. Abd-Elmabod and B. A. Engel. 2019a. Adaptation of modeling to the irrigation system and water management for corn growth and yield. Plant Archives Vol. 19, Supplement 1, pp. 644-651.

Mansour, H. A., 2015, Performance automatic sprinkler irrigation management for production and quality of different Egyptian wheat varieties. International Journal of ChemTech Research. Vol.8, No.12 pp 226-237.

Mansour, H. A., Abdel-Hady, M.,Eldardiry, E.I., Bralts, V.F., 2015a, Performance of automatic control different localized irrigation systems and lateral lengths for emitters clogging and maize (Zea mays L.) growth and yield. International Journal of GEOMATE, Vol. 9, No. 2 (Sl. No. 18), pp. 1545-1552.

Mansour, H. A., Pibars, S.K., Abd El-Hady, M., Ebtisam I. Eldardiry, 2014, Effect of water management by drip irrigation automation controller system on Faba bean production under water deficit. International Journal of GEOMATE, Vol. 7, No. 2 (Sl. No. 14), pp. 1047-1053.

Mansour, H. A., Sabreen Kh. Pibars, M.S. Gaballah, and Kassem A. S. Mohammed. 2016a. Effect of Different Nitrogen Fertilizer Levels, and Wheat Cultivars on Yield and its Components under Sprinkler Irrigation System Management in Sandy Soil., Vol.9, No.09 pp.1-9.

Mansour, H. A., M. Abd El-Hady, V. F. Bralts, and B. A. Engel, 2016b. Performance Automation Controller of Drip Irrigation System and Saline Water for Wheat Yield and Water Productivity in Egypt. Journal of Irrigation and Drainage Engineering, American Society of Civil Engineering (ASCE), J. Irrig. Drain Eng. 05016005, http://dx.doi.org/10.1061/(ASCE)IR, 1943-4774.0001042.

Mansour, H.; De la Rosa, D.; Jones, L. 2019, Assessment of Soil Suitability for Improvement of Soil Factors and Agricultural Management. Sustainability 11, 1588. doi: 10.3390/su11061588

Mansour, H.A., Aljughaiman, A.S. 2012, Water and fertilizers use efficiency of corn crop under closed circuits of drip irrigation system. Journal of Applied Sciences Research, 8 (11), pp.5485-5493.

Mansour, H.A., E.F.Abdallah, M.S.Gaballah and Cs.Gyuricza, 2015b, Impact of Bubbler Discharge and Irrigation Water Quantity on 1- Hydraulic Performance Evaluation and Maize Biomass Yield. Int. J. of GEOMATE, Dec. Vol. 9, No. 2 (Sl. No. 18), pp. 1538-1544.

Mansour, H.A., Pibars, S.K.; Bralts, V.F., 2015c,The hydraulic evaluation of MTI and DIS as a localized irrigation systems and treated agricultural wastewater for potato growth and water productivity. International Journal of ChemTech Research, Vol.8, No.12 pp 142-150.

Mansour, H.A., Saad, A., Ibrahim, A.A.A., El-Hagarey, M.E., 2016c. Management of irrigation system: Quality performance of Egyptian wheat (Book Chapter). Micro Irrigation Management: Technological Advances and Their Applications. pp. 279-293.

Mansour, H.A.A. 2015. Design considerations for closed circuit design of drip irrigation system (Book Chapter). pp.61-133.

Mansour, H.A.A. and Aljughaiman, A.S. 2015.Water and fertilizer use efficiencies for drip irrigated corn: Kingdom of Saudi Arabia (book chapter) closed circuit trickle irrigation design: theory and applications, Apple Academic Press, Publisher: Taylor and Frances. pp. 233-249

Mansour, H.A.A. and El-Melhem, Y. 2015. Performance of drip irrigated yellow corn: Kingdom of Saudi Arabia (Book Chapter), closed circuit trickle irrigation design: theory and applications, Apple Academic Press, Publisher: Taylor and Frances. pp. 219-232

Mansour, H.A.A., Mehanna, H.M., El-Hagarey, M.E.,Hassan, A.S. 2015d, Automation of mini-sprinkler and drip irrigation systems.Closed Circuit Trickle Irrigation Design: Theory and Applications, pp.179-204.

Mansour, H.A.A., Tayel, M.Y.,Lightfoot, D.A.,El-Gindy, A.M. 2015e. Energy and water savings in drip irrigation systems. Closed Circuit Trickle Irrigation Design: Theory and Applications, , pp.149-178.

Mansour, H.A.A., El-Hady, M.A., Gyurciza, C.S. 2015f. Water and fertilizer use efficiencies for drip irrigated maize (Book Chapter). Closed Circuit Trickle Irrigation Design: Theory and Applications.. pp. 207-218.

Marschner, H. (1995). Mineral Nutrition of High Plant. Academic Press, 330-355.

Millaleo, R.; Reyes, D.M.; Ivanov, A.G.; Mora, M.L. and Alberdi, M. (2010). Manganese as essential and toxic element for plants transport, accumulation and resistance mechanisms. Journal of Soil Science and Plant Nutrition. 10: 470-481.

Mohamed, E.A.I.; Abdel-Tawab, Y.M.; Sara, M.A. and El-Dessouky, E.I. (2010). Evaluation of sesame, peanut and canola seed quality using accelerated ageing. Seed Science and Biotechnology, 4(1): 52-58.

Mousavi, S.R.; Shahsavariand, M. and Rezaei, M. (2011). A general overview on manganese (Mn) importance for crops production. Australian Journal of Basic and Applied Sciences. 5(9): 1799-1803.

Muniappan, V.; Palanivel, S.; Parvathi, S.; Viswanathan, M.B. and R. Rajesh (2016). Analysis of seed proteins in groundnut cultivars (*Arachis hypogaea* L.). Int. J. of Engineering Res. and Application. 6 (7): 6-10.

Nasar, J.; Qiang, G. and Alam, A. (2018). Groundnut Response to Boron and Molybdenum. Journal of Science Frontier Research: D Agriculture and Veterinary. 18(1): 16-22.

Nassar, A.N.M. and Osman, E.E.A. (2008). Effect of micronutrients and weed control treatments on peanut yield and associated weeds under sandy soil conditions. Assiut J. Agric. Sci., 39(3): 191-223.

Nelson, J.P.; Millum, A.J. and Fister, H.D. (1970). Gas chromatographic determination of tocopherols and sterols in soya stodges' and residues an improved methods. J. Am. Oil Chem. Sci., 47: 259-261.

Pandy, N.; Pathac, G.C.; Sing, A.K. and Sharma, C.P. (2002). Enzymic changes in response to zinc nutrition. J. of Plant Physiology, 159: 1151-1153.

Radhakrishnan, R.; Pae, S.B.; Kang, S.M.; Lee, B.K.; Lee, I.J. and I.Y. Baek (2014). An evaluation of amino acid, fatty acid and isoflavone composition in korean peanut (*Arachis hypogaea* L.) seeds to improve the nutritional quality of breeding lines.J. Korean Soc. Appl. Biol. Chem., 57(3): 301−305.

Sawan, Z.M.; Mahmoud, M.H. and El-Guibabli, A.H. (2008). Influence of potassium fertilization and foliar application of zinc and phosphorous on growth, yield components, yield and fiber properties of Egyptian cotton (*Gossypium barbadense* L). J. Pl. Ecol., 1(4): 259-270.

Sharifianpour, G.; Zaharah, A.R.; Ishak, C.F.; Hanafi, M.M.; Nejat, N.; Sahebi, M.; Sharifkhani, A. and Azizi, P. (2013). Elucidating the expression of zinc transporters involved in zinc uptake by upland rice landraces in Malaysia. Advances in Environmental Biology, 7(14): 4854-4857.

Singh, A.L.; Joshi, Y.C. and Chaudhari, V. (1990-b). Effect of different sources of iron and sulphur on nutrient concentration and uptake by groundnut. Fertilizer Res. 24: 97-103.

Snedecor, G.W. and Cochran, W.G. (1990). Statistical Methods. 8th Ed. Iowa State Univ., Press, Ames Iowa, USA.

Stahl, E. (1967). Thin Layer Chromatography. A Laboratory Handbook.Ed. Springer Verloag, Berline PP. 359 Heidel Berg, New York.

Steel, R.G.D. and Torrie, J.H. (1980). Principles and Procedures of Statistics: A biometrical approach 2nd edition, McGraw-Hill Book Co., New York, 633 pp.

Tavakoli, M.T.; Chenari, A.I.; Rezaie, M.; Tavakoli, A.; Shahsavari, M. and Mousavi, S.R. (2014). The Importance of Micronutrients in Agricultural Production. Advances in Environmental Biology, 8(10): 31-35.

Yaw, A.J.; Richard, A.; Ose, S.; Kofi, A.H.; Seth, A. and Adelaide, A. (2008). Chemical composition of groundnut, (*Arachis hypogaea* L.) landraces. Ghana.

Yenagi, B.S.; Gurumurthy, R. and Belli, R.B. (2015). Effect of borosan on growth and yield of groundnut (*Arachis hypogea* L.). Agric. Sci. Digest., 35(3): 221-223.