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Effect of Foliar Application of Micronutrients and Compost Tea on Chemical Composition and the Productivity of Fenugreek Plants Under Baloza - North Sinai Conditions

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ABSTRACT

Micronutrients are important for plant growth, but plants need relatively small amounts of them, hence, the term "micro. The present investigation was carried out at Baloza Research Station of the Desert Research Center, North Sinai, Egypt during the two successive seasons of 2017/2018 to study the effect of foliar application combination of micronutrients forms and compost tea. The experiment was conducted in a split plot design, with three replicates. The main plots were randomly assigned to compost tea (with, without), the sub plots were represented by four micronutrients spraying of Fe, Cu, Mn and Zn, as (the two chelated forms of humic and EDTA and the mineral form). The objectives of the present study were to investigate the effect of foliar application of some chelated micronutrients and compost tea on growth and yield productivity of Fenugreek plant and macro and micro nutrient contents in herb and seed. The results showed that, the best treatments were ((Mn,Zn,Cu,Fe) Humic form with compost tea which gave the highest yield components: the average percentage increment of dry weight of seed (g/ plant), dry weight of seed(kg/ fed.), fixed oil (ml/ plant) and fixed oil(kg/fad.) (76.80, 77.62, 122.08 and 137.9) in two season, respectively. In addition, macro and micro elements contents were significantly increased in herb and seeds. These results also indicated that the concentrations of Fe, Mn, Zn, Cu in seeds and herb, of Fenugreek plants were lower the normal ranges.

Keywords: micronutrients**,** chelated form, Humic form, compost tea, Fenugreek yield,

INTRODUCTION

In the latest decades, medicinal plants gained a substantial importance in agricultural production, pharmacy and exportation because of their use as a raw material for the pharmaceutical industry. Fenugreek (Trigonella foenum-graecum L.), an annual forage legume belonging to the family Fabaceae, is well identified as a herb and spice crop (Acharya *et. al.,* 2011). Fenugreek leaves and seeds are used in many countries around the world for different purposes such as medicinal uses (anti-diabetic, lowering blood sugar and cholesterol level, anti-cancer, anti-microbial, controlling insects in grain storages, perfume industries. Fenugreek can be a extremely useful legume crop for incorporation into short-term rotation and for hay and silage for livestock feed, for fixation of nitrogen in soil and its fertility. Fenugreek seeds have been identified and valued as medicinal material. Its seeds are considered to be of commercial interest as a source of a steroid diosgenin, which is of importance to the pharmaceutical industry (Mehrafarin *et. al.,* 2010). Fenugreek seeds are reputed to have numerous medicinal virtues, as a tonic, emollient, carminative, demulcent, diuretic, astringent emmenagogue, expectorant, restorative, aphrodisiac and vermifugal properties and were used to cure mouth ulcers, chapped lips and stomach irritation (Duke 1986).

Plants absorb nutrients from soils through their roots although nutrients can be supplied to plants as fertilizers by foliar sprays. Foliar fertilizer is a new and controversial technique of feeding plants by applying liquid fertilizer directly to their leaves (Bernal *et. al.,* 2007; Baloch *et. al.,* 2008).The application of chelated forms of micronutrients, characterized by high solubility in water and low value of dissociated constant, is crucial for the prevention of immobilization. Chelates make metal cations being slowly released to a medium solution or absorbed by plants in complexes forms (Wreesmann, 1996). As proven by Komosa *et.al.* (2005), durability and availability of microelements to plants depend on properties of ligands. The most ordinary chelating agents used in fertilizers include EDTA, DTPA and EDDHA (Lucena, 2003), which differ in strength of chemical bonds of the ionic and complex with metals as a function of pH. The shortcoming of these chelating agents, especially EDTA, is their low biodegradability (Borowiec *et. al.* 2007, Albano and Merhaut 2012).

Micronutrients as Fe, Zn, Mn and Cu are involved in many physiological processes that are essential for plant, in order to compensate their deficiency especially in arid and semi aid regions (Kaya *et. al.,* 2005).Micronutrients, Fe and Zn, proceed either as metal components of various enzymes or as functional, structural, or regulatory cofactors. Thus, they are associated with saccharide metabolism, photo-synthesis, and protein synthesis Marschner (1995). Iron is essentially present in the form of insoluble Fe (III), therefore, unavailable to higher plants, mainly in neutral and alkaline soils (Shao *et.al.,* 2007). Copper plays an important role in the metabolism of N compounds. Manganese, beside with Zn, has an effect on protein biosynthesis by adjusting the activity of peptidases and controlling protein metabolism (Hänsch and Mendel, 2009). Kozik , *et.al.,* (2008) reported that after the folair application of chelated manganese, there was more copper and iron in the lettuce, but a smaller amount of zinc than in case of manganous sulphate application.

Essential oil biosynthesis in basil *(Ocimum sanctum* L.) is strongly influenced by Fe and Zn (Misra *et. al.,* 2006). Foliar spraying with zinc (100 ppm) in blue sage (*Salvia farinacea* L.) enhanced the length of peduncle, length of main inflorescence, number of inflorescence and florets, and fresh and dry weight of inflorescences/ plant (Abd El-Aziz and Balbaa, 2007).

Compost tea, a liquid organic fertilizer, contains available chelated micronutrients to absorb by plants and nutrients in suitable form to uptake by soil microorganisms and plants (Hendawy 2008) Compost tea, significantly, increased plant height (cm), fresh and dry weight, seed weight (g) and oil percentage in Borage plants (El-Din and Hendawy 2010). Compost tea when used as a soil drench increased the% N and % P uptake rates by 126% and 255% respectively (Ibrahim and Ibrahim 2014), and

increased carbohydrate content of turnip roots (El-Sherbeny *e.t al.*, 2012). Foliar fertilizers of Nigella plants during active vegetative growth increased yield significantly comparing with soil-applied fertilizers (Alrubaie and alzaidi 2011).

The objective of this study was conducted to investigate the effect of combination of microelements forms and compost tea on Fenugreek productivity and some macro and micro nutrients availability and contents.

MATERIALS AND METHODS

A field experiment was carried out at Baloza Research Station of the Desert Research Center, located at 31° 3′ 0″ N, 32° 36′ 0″ E on Fenugreek crop during the two successive winter growing seasons of (2016-2017) and (2017-2018) season. The study the effect of some micronutrients (Fe, Cu, Mn and Zn) added in two chelated forms of (humic and EDTA) and mineral form as foliar application on Fenugreek growth, yield and its components was studied. The experiment was designed in a randomized complete block design split plot with 8 combinations, The main plots were randomly assigned to compost tea (with, without), the sub plots were subjected to mixture of some micronutrients (Fe, Cu, Mn and Zn)) added in chelated forms of(Humic and EDTA), mineral forms and without as (control), added as foliar application, each treatment included three replicates. Micronutrients solution was as sulfate form with concentration: 300 mg L-1 for Fe, 100 mg L-1 for Mn, 50 mg L-1 for Zn, and 50 mg L-1 for Cu. The chelating agents were EDTA and humic acid. Aerated compost tea produced by mixing mature compost made by El-Arabeya for Organic Fertilizer Factory with distilled water in ratio of 1:5(w/v) and supplemented with 2% molasses for microbial growth stimulation .The entire contents were continuously aerated at room temperature with a fish-tank bubbling-pump for 72 hours, The chemical analysis of the used compost tea is shown in Table (1).

Table 1. Nutrient contents of compost tea

Nutrients mg/l						
N	**P**	**K**	**Fe**	**Zn**	**Mn**	**Cu**
2025	289	1725	1.36	1.95	0.86	*N

***N=not detected**

All treatments and the control were applied at the tillering stage (35 days from sowing) and at the booting stage (70 days from sowing). The experimental field was irrigated by drip irrigation system. Fenugreek Seed were sowing during 15th November in rows spacing 50 cm apart and 15 cm between seed hills (17500 plant/fed). All treatments received 18 kg K_2O/fed as potassium sulfate was applied in two equal doses while 15 kg N/fed as ammonium sulfate and Phosphorus was applied as super phosphate (15.5% P_2O_5) at the rate of 48 kg P_2O_5 fed^{-1} during the soil preparation. The other agricultural practices were done as the recommendation of Ministry of Agriculture. Fenugreek plants were harvested at maturity at the end of April. Soil samples were collected from the studied plots at two depths (0-30 cm and 30-60 cm) before initiating the experiment for physical and chemical analysis The mechanical and chemical properties of the used soil are shown in Table (2) according to (Page *et al.*, 1984).

Table 2. Some chemical and physical properties of the experimental soil

Depth	**0-30 cm**	**30-60 cm**
Particle size distribution %		
Sand	89.12	90.73
Silt	6.34	5.56
Clay	4.54	3.71
Texture class	sandy	sandy
pH saturated soil paste	8.20	8.06
EC(ds/m)	1.37	1.21
Soluble ions in saturated soil extract (meq/L)		
Na	5.13	2.84
K	0.54	3.91
Ca	3.65	4.89
Mg	4.40	0.48
Cl	3.30	3.12
HCO_3	3.85	3.54
SO_4	6.57	5.47
Available nutrients (mg/kg)		
N	35	27
P	2.66	1.74
K	44	32

The applied irrigation water was added through trickle irrigation system with the drippers of four liters/hr for half an hour every day. The chemical analysis of the used water for El-Salam Canal irrigation is shown in Table (3). At harvesting stage, plants were harvested at the end of April. Crop was harvested manually. Grains were separated from straw and weighed in the field, the following data were recoded

Growth and Yield characters:

Plant height (cm), seed weight per plant (g), seed weight per plant (kg/fed) and oil content (ml/plant) and (L/fed) of Fenugreek were isolated using a Clevenger-type apparatus according to British Pharmacopoeia, (1963).

Plant analysis

Plant samples including straw and seeds were thoroughly washed and dried at 70 °C. Plant samples were wet digested using H_2O_2 and H_2SO_4 according to procedure described by Nicholson (1984). N, P and K were determined in acid digested solution, which was prepared according to Cottenie *et. al*., (1982). Total heavy metals content were determined using Ionic Coupled Argon Plasma according to Ure,(1995).

Table 3. physicochemical composition of El-Salam Canal irrigation water in Baloza Station

Parameter	**Irrigation water**	**Permissible Limit For irrigation**
pH	8	Normal range 6.5-8.40
EC (dsm^{-1})	2.8	<3.00 dsm^{-1}
Ca^{2+} (mgl^{-1})	80.16	
Mg^{2+}(mgl^{-1})	72.95	
Na^{+} (mgl^{-1})	407.08	
K^{+} (mgl^{-1})	31.37	
CO_3^{2-} (mgl^{-1})	--	
HCO_3^{-}(mgl^{-1})	73.22	
Cl^{-} (mgl^{-1})	815.60	
SO_4^{2-} (mgl^{-1})	206.73	
Al (mgl^{-1})	n.d.	-
Cd (mgl^{-1})	0.01	0.01*
Co (mgl^{-1})	n.d.	0.05*
Cu (mgl^{-1})	n.d.	0.2*
Fe (mgl^{-1})	n.d.	5.0*
Mn (mgl^{-1})	n.d.	0.2*
Mo (mgl^{-1})	0.0048	-
Ni (mgl^{-1})	0.001	0.2*
Pb (mgl^{-1})	n.d.	58

***FAO for irrigation water (Ayers and Wescot, 1994)**

Statistical analysis:

Data of the present work were statistically analyzed and the differences between the means of the treatments were considered significant when they were more than the least significant differences (L.S.D) at the 5% level by using computer program of Statistix version 9 (Analytical software, 2008).

RESULTS AND DISCUSSION

Growth and Yield characters

Data in Table (4) show that the yield of Fenugreek plants was significantly affected by the studied different treatments through two seasons. Foliar application with micronutrients forms recorded significant differences in all parameters under the study. Application of humic form gave significantly higher increase than EDTA and mineral form. The combined use of humate and metal chelates seems to have a greater potential rather than metal only. Micronutrients play main roles in the release of carbon dioxide, and in optimizing the function of vitamin A and the immune system, Where Chelates are much more easily absorbed by plant leaves because chelates are of organic nature. The chelation process removes the positive charge from the micro nutrients allow the negatively charged chelates to fall through the pores on the leaf surface more rapidly, as stated by Marschner (1995). Similar trends were reported by El-Saady (2012) ; Gad El-Hak *et al*. (2012) and Faizy *et. al.,(*2017) who reported that foliar with humic form was significantly effects higher on grain yield (16.08 and 16.55 ardab fed- 1), straw yield (3.32 and 3.06 ton fed-1) and 1000 grain weight (49.15 and 47.51 gm) in the first and second seasons. (Raza et al., (2014), reported that the grain yield of wheat increased due to the application of Fe and B solitary or association with other micronutrients. Fenugreek plants which were sprayed with compost tea gave significantly higher increase in plant height, seed dry weights/ plant and fed than without C.T. in two seasons. These results were in agreement with those found by El-din and Hendawy (2010) on Borage plants. Where, Compost tea contains many useful microbes and nutrients of compost but more easily applied to plants, and could be used as an agent for promoting plant growth. The interaction of chelates forms with compost tea was the superior treatment showed significantly higher increase of yield comparing with chelated forms alone. The chelated humic interacted with compost tea increased the seed dry weight kg/fed by 90.13% and 65.10% at season 1 and 2, respectively, while chelated humic alone increased it only by 50.24% and 33.27% at season 1 and 2.

Fixed oil production

Fenugreek fixed oil content / plant and Feddan significantly increased by foliar application with micronutrients forms, Application of Humic form gave significantly higher increase than EDTA and mineral form in both seasons as listed in Table 5. Sprayed with C.T. gave significant higher increase in oil content / plant and Feddan than without C.T. in two seasons. Similar trends were reported by El-din and Hendawy (2010) on Borage plants. The interaction of chelates forms with compost tea was the superior treatment showed significant higher increase of yield comparing with chelated forms alone. The chelated humic interacted with compost tea increased the Fixed oil yield / fed (Kg) by 131.1% and 144.6% at season 1 and 2, respectively, while chelated humic alone increased it only by 84.5% and 88.6 % at season 1 and 2.

Table 4. Effect of the studied treatments on plant height, seed dry weight /plant and seed dry weight /plant Fenugreek plant during the two seasons (2017- 2018).

Treatments		plant height (cm)		Seed dry Weight /plant (g)		Seed dry weight / fed (Kg)	
		2017	2018	2017	2018	2017	2018
Effect of compost tea:							
with C.T		45.6	46.4	11.9	12.3	208.1	215.3
without C.T		35.0	35.5	9.2	9.8	160.4	171.7
LSD 0.05		1.1	1.2	0.8	0.5	14.8	8.3
Effect of micronutrients:							
control		33.1	33.6	8.2	9.2	143.2	160.9
(Mn,Zn,Cu,Fe)mineral form		38.7	39.5	10.2	10.5	178.4	183.8
(Mn,Zn,Cu,Fe) Humic form		46.0	46.7	12.4	12.9	216.5	226.0
(Mn,Zn,Cu,Fe) EDTA form		43.7	44.1	11.4	11.6	199.0	203.3
LSD 0.05		1.2	1.0	0.7	0.4	12.4	6.6
Effect of interaction:-							
without C.T	control	30.5	30.8	7.3	8.7	127.2	151.5
without C.T	(Mn,Zn,Cu,Fe)mineral form	31.8	32.7	8.5	8.8	149.4	153.7
without C.T	(Mn,Zn,Cu,Fe) Humic form	40.9	41.5	10.9	11.5	191.1	201.9
without C.T	(Mn,Zn,Cu,Fe) EDTA form	36.7	37.1	9.9	10.3	174.1	179.7
with C.T	control	35.7	36.5	9.1	9.7	159.3	170.4
with C.T	(Mn,Zn,Cu,Fe) mineral form	45.1	46.2	11.8	12.2	207.3	213.9
with C.T	(Mn,Zn,Cu,Fe) Humic form	51.1	51.9	13.8	14.3	241.9	250.1
with C.T	(Mn,Zn,Cu,Fe) EDTA form	50.8	51.0	12.8	13.0	223.9	226.9
LSD 0.05		1.7	1.6	1.2	0.6	20.2	11.0

C.T. compost tea

Table 5. Effect of the studied treatments on Fixed oil yield / fed (Kg) and Fixed oil ml/plant of Fenugreek plant during the two seasons (2017-2018)

Treatments		Fixed oil yield / fed (Kg)		Fixed oil ml/plant	
		2016	2017	2016	2017
Effect of compost tea:					
with C.T		17.40	18.18	0.99	1.04
without C.T		12.93	13.54	0.74	0.77
LSD 0.05		0.94	0.15	0.05	0.01
Effect of micronutrients:					
control		11.07	11.95	0.64	0.68
(Mn,Zn,Cu,Fe)mineral form		14.64	15.25	0.84	0.87
(Mn,Zn,Cu,Fe) Humic form		18.64	19.43	1.07	1.11
(Mn,Zn,Cu,Fe) EDTA form		16.30	16.80	0.93	0.96
LSD 0.05		0.35	0.50	0.02	0.03
Effect of interaction:-					
without C.T	control	8.97	10.14	0.52	0.58
without C.T	(Mn,Zn,Cu,Fe)mineral form	12.16	12.73	0.69	0.73
without C.T	(Mn,Zn,Cu,Fe) Humic form	16.55	16.92	0.95	0.96
without C.T	(Mn,Zn,Cu,Fe) EDTA form	14.03	14.36	0.80	0.82
with C.T	contol	13.17	13.76	0.75	0.78
with C.T	(Mn,Zn,Cu,Fe) mineral form	17.12	17.77	0.98	1.01
with C.T	(Mn,Zn,Cu,Fe) Humic form	20.73	21.94	1.18	1.26
with C.T	(Mn,Zn,Cu,Fe) EDTA form	18.57	19.24	1.06	1.10
LSD 0.05		0.99	0.62	0.05	0.04

C.T. compost tea

N, P, K, Ca and Mg content in dry seed and herb of plant

It is clear from data in Table (6, 7) that the macronutrients status of Fenugreek plants significantly affected by the studied different treatments through the two seasons. Foliar application with micronutrients forms recorded significant differences in all parameters under the study. Application of humic form gave significantly higher results than EDTA and mineral form. It may be due to humus stimulating effect on absorption of the nutrients, where Chelates forms are easily assimilated within the plant system. Similar trends were reported by Wojtkowiak *et al*. (2014). Fenugreek plants which were sprayed with C.T. gave significant higher increase in N, P, K, Ca and Mg content than without C.T. in the two seasons. Compost tea enhancing the uptake and accumulation of nutrient elements in the plant (Rodríguez-Ortíz *et. al.,* 2006), Foliar application of compost tea increased the time stomata stay open, reducing loss from the leaf surface, so the availability of mineral nutrients is higher for foliar than drench application (Mahmoud *et. al.,* 2014) . The interaction of humic forms with compost tea was the superior treatment which recorded significant increases (2.99, 3.33, 0.38, 0.41, 1.58, 1.65, 0.39, 0.41, 0.23 and 0.24% in seeds). Also, in herb was (2.40, 2.44, 0.21, 0.22, 1.89, 2.13, 1.16, 1.21, 0.42 and 0.44%) for N, P, K, Ca and Mg content in season 1 and 2, respectively.

Table 6. Effect of the studied treatments on N, P, K, Ca and Mg % in dry herb of Fenugreek plant during the two seasons (2017-2018).

treatments		N%		P%		K%		Ca%		Mg%	
		2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
Effect of compost tea:											
with C.T		1.89	1.93	0.15	0.16	1.57	1.66	1.02	1.07	0.39	0.41
without C.T		1.28	1.30	0.11	0.12	1.29	1.36	0.74	0.77	0.31	0.33
LSD 0.05		0.16	0.02	0.02	0.01	0.08	0.02	0.05	0.02	0.02	0.01
Effect of micronutrients:											
control		0.94	0.96	0.08	0.09	0.74	0.78	0.69	0.72	0.32	0.33
(Mn,Zn,Cu,Fe)mineral form		1.58	1.61	0.12	0.13	1.49	1.58	0.89	0.92	0.34	0.36
(Mn,Zn,Cu,Fe) Humic form		2.00	2.03	0.17	0.18	1.80	1.91	1.01	1.05	0.38	0.40
(Mn,Zn,Cu,Fe) EDTA form		1.82	1.85	0.15	0.16	1.69	1.79	0.95	0.99	0.36	0.37
LSD 0.05		0.07	0.01	0.01	0.00	0.06	0.02	0.01	0.01	0.00	0.00
Effect of interaction:-											
without C.T	control	0.87	0.89	0.08	0.08	0.66	0.70	0.53	0.55	0.28	0.30
without C.T	(Mn,Zn,Cu,Fe)mineral form	1.19	1.20	0.11	0.12	1.41	0.86	0.79	0.82	0.31	0.32
without C.T	(Mn,Zn,Cu,Fe) Humic form	1.59	1.62	0.13	0.14	1.59	1.68	0.85	0.89	0.34	0.36
without C.T	(Mn,Zn,Cu,Fe) EDTA form	1.46	1.48	0.12	0.13	1.49	1.58	0.80	0.83	0.31	0.32
with C.T	control	1.01	1.03	0.09	0.09	0.81	0.86	0.85	0.89	0.35	0.37
with C.T	(Mn,Zn,Cu,Fe) mineral form	1.97	2.01	0.14	0.14	2.01	1.66	0.98	1.02	0.37	0.39
with C.T	(Mn,Zn,Cu,Fe) Humic form	2.40	2.44	0.21	0.22	1.89	2.13	1.16	1.21	0.42	0.44
with C.T	(Mn,Zn,Cu,Fe) EDTA form	2.18	2.22	0.17	0.18	1.56	2.00	1.09	1.14	0.40	0.42
LSD 0.05		0.17	0.02	0.02	0.01	0.11	0.02	0.05	0.02	0.02	0.01

C.T. compost tea

Table 7. Effect of the studied treatments on N, P, K, Ca and Mg % in dry seed of Fenugreek plant during the two seasons (2017-2018).

treatments		N%		P%		K%		Ca%		Mg%	
		2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
Effect of compost tea:											
with C.T		2.50	2.69	0.30	0.33	1.33	1.38	0.35	0.36	0.21	0.22
without C.T		2.19	2.36	0.24	0.26	1.13	1.18	0.28	0.29	0.18	0.18
LSD 0.05		0.112	0.022	0.031	0.016	0.033	0.007	0.016	0.009	0.012	0.007
Effect of micronutrients:											
control		1.98	2.13	0.20	0.22	1.08	1.13	0.27	0.28	0.17	0.18
(Mn,Zn,Cu,Fe) mineral form		2.28	2.46	0.26	0.28	1.17	1.22	0.30	0.31	0.19	0.20
(Mn,Zn,Cu,Fe) Humic form		2.70	2.91	0.32	0.35	1.39	1.45	0.35	0.36	0.21	0.22
(Mn,Zn,Cu,Fe) EDTA form		2.41	2.60	0.30	0.32	1.28	1.33	0.34	0.35	0.20	0.21
LSD 0.05		0.054	0.011	0.013	0.007	0.016	0.006	0.004	0.003	0.004	0.005
Effect of interaction:-											
without C.T	control	1.85	2.00	0.20	0.21	1.07	1.12	0.25	0.26	0.16	0.17
without C.T	(Mn,Zn,Cu,Fe)mineral form	2.16	2.33	0.22	0.25	1.11	1.16	0.26	0.27	0.18	0.18
without C.T	(Mn,Zn,Cu,Fe) Humic form	2.40	2.58	0.27	0.29	1.20	1.25	0.30	0.32	0.18	0.19
without C.T	(Mn,Zn,Cu,Fe) EDTA form	2.33	2.51	0.26	0.28	1.14	1.19	0.29	0.30	0.18	0.19
with C.T	control	2.10	2.26	0.21	0.22	1.09	1.14	0.28	0.29	0.18	0.18
with C.T	(Mn,Zn,Cu,Fe) mineral form	2.40	2.58	0.29	0.31	1.22	1.27	0.34	0.35	0.23	0.21
with C.T	(Mn,Zn,Cu,Fe) Humic form	2.99	3.23	0.38	0.41	1.58	1.65	0.39	0.41	0.23	0.24
with C.T	(Mn,Zn,Cu,Fe) EDTA form	2.50	2.69	0.33	0.37	1.42	1.48	0.38	0.40	0.21	0.24
LSD 0.05		0.123	0.024	0.033	0.017	0.036	0.010	0.016	0.010	0.013	0.009

C.T. compost tea

Micronutrients content in dry seed and herb of plant

It is clear from data in Tables (8, 9) that the micronutrients status of Fenugreek plants significantly was affected by the studied different treatments through the two seasons. Foliar application with micronutrients forms recorded significant differences in all parameters under the study. Application of humic form gave significant higher increases than EDTA and mineral form. In fact, Cakmak (2008) and Hänsch &Mendel (2009) reported that, The advantageous action of micronutrients (Mn, Cu, and Zn) is an effect of plant metabolism stimulation. Similar results were obtained by Narwal *et. al.,*(2012) on wheat and Gomaa *et al.,* (2015), who reported that foliar application of micronutrients significantly increased concentration of micronutrients in flag leaves and grains. Also, Fenugreek plants which were sprayed with C.T. gave significantly higher increase in Fe, Mn, Zn, Cu, Ni content than without C.T. in two seasons. The interaction of Humic forms with compost tea was the superior treatment which recorded significant increases (600.08, 625.51, 34.81, 64.16, 66.88, 7.32, 7.89, 6.28 and 6.67mg/kg in herb). Also, in seeds it was (1262.60, 1316.10, 46.10, 48.05,49.64, 51.74, 10.42, 10.87, 8.07 and 8.56 mg/kg) for Fe, Mn, Zn, Cu, Ni content in season 1 and 2, respectively. The results showed also that Fe, Mn, Zn, Cu, Ni concentration in Fenugreek plants accumulated in seeds> herb. In view of the potential toxicity of these elements to plant, the current results indicate that the concentrations of Fe, Mn, Zn, Cu in seeds and herb, of Fenugreek plants were lower the normal ranges except Ni exceeded the normal ranges reported by Kabata-Pendias & Pendias (1992)and Reeves & Baker (2000).

Table 8. Effect of the studied treatments on Fe, Mn, Zn, Cu, Ni mg/kg in dry herb of Fenugreek plant during the two seasons (2017-2018)

treatments		Fe mg/kg		Mn mg/kg		Zn mg/kg		Cu mg/kg		Ni mg/kg	
		2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
Effect of compost tea:											
with C.T		508.08	529.61	29.35	30.60	56.17	58.55	6.50	7.01	5.80	6.16
without C.T		410.67	428.07	25.75	26.84	47.66	49.68	5.67	6.11	4.72	5.02
LSD 0.05		18.79	6.15	0.70	0.23	1.63	0.54	0.29	0.06	0.30	0.08
Effect of micronutrients:											
control		351.30	366.18	23.98	25.00	35.59	37.09	4.54	4.90	4.80	5.10
(Mn,Zn,Cu,Fe)mineral form		447.91	466.89	27.20	28.36	54.55	56.86	6.43	6.94	5.03	5.35
(Mn,Zn,Cu,Fe) Humic form		534.81	557.47	31.16	32.48	59.04	61.54	6.82	7.36	5.71	6.07
(Mn,Zn,Cu,Fe) EDTA form		503.47	524.80	27.85	29.03	58.49	60.96	6.55	7.06	5.49	5.83
LSD 0.05		8.00	2.62	0.32	0.10	1.10	0.36	0.18	0.04	0.06	0.02
Effect of interaction:-											
without C.T	control	308.28	321.34	23.45	24.45	34.74	36.21	4.25	4.59	4.34	4.61
without C.T	(Mn,Zn,Cu,Fe)mineral form	417.18	434.86	25.47	26.55	48.87	50.94	5.99	6.46	4.51	4.79
without C.T	(Mn,Zn,Cu,Fe) Humic form	469.54	489.44	27.51	28.67	53.91	56.20	6.32	6.82	5.14	5.46
without C.T	(Mn,Zn,Cu,Fe) EDTA form	447.66	466.63	26.55	27.68	53.10	55.35	6.11	6.59	4.90	5.20
with C.T	control	417.18	411.03	24.51	25.55	36.43	37.98	4.82	5.20	5.26	5.59
with C.T	(Mn,Zn,Cu,Fe) mineral form	478.64	498.92	28.94	30.16	60.23	62.78	6.87	7.41	5.56	5.90
with C.T	(Mn,Zn,Cu,Fe) Humic form	600.08	625.51	34.81	36.29	64.16	66.88	7.32	7.89	6.28	6.67
with C.T	(Mn,Zn,Cu,Fe) EDTA form	559.27	582.97	29.16	30.39	63.87	66.57	6.98	7.53	6.09	6.46
LSD 0.05		20.12	6.59	0.76	0.25	2.00	0.66	0.35	0.07	0.30	0.08
Normal range, mg kg-1		6- 600*		30-300**		27-150**		5- 30**		0.1 - 5**	
Contaminated, mg kg-1		2500*		400 - 1000**		100 - 400**		20 - 100**		10 - 100**	

(Reeves and Baker, 2000)* and Kabata-Pendias and Pendias, (1992)**

C.T. = compost tea

Table 9. Effect of the studied treatments on Fe, Mn, Zn, Cu, Ni mg/kg in dry seed of Fenugreek plant during the two seasons (2017-2018)

treatments		Fe mg/kg		Mn mg/kg		Zn mg/kg		Cu mg/kg		Ni mg/kg	
		2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
Effect of compost tea:											
with C.T		1110.50	1157.50	36.07	37.60	45.37	47.29	9.75	10.16	7.15	7.59
without C.T		942.80	982.80	29.94	31.21	40.88	42.61	8.74	9.11	6.22	6.60
LSD 0.05		32.35	10.59	1.18	0.39	0.86	0.28	0.19	0.06	0.25	0.07
Effect of micronutrients:											
control		824.20	859.10	25.95	27.05	36.07	37.59	8.37	8.73	6.23	6.61
(Mn,Zn,Cu,Fe)mineral form		1037.00	1081.90	32.23	33.60	44.11	45.98	9.29	9.69	6.49	6.88
(Mn,Zn,Cu,Fe) Humic form		1168.80	1218.30	39.45	41.12	47.31	49.32	9.77	10.19	7.29	7.73
(Mn,Zn,Cu,Fe) EDTA form		1075.80	1121.40	34.41	35.86	45.02	46.92	9.54	9.95	6.74	7.15
LSD 0.05		15.20	4.97	0.60	0.20	0.49	0.16	0.07	0.02	0.07	0.02
Effect of interaction:-											
without C.T	control	818.60	853.30	25.42	26.50	35.23	36.72	8.31	8.66	5.85	6.20
without C.T	(Mn,Zn,Cu,Fe)mineral form	908.80	947.40	29.77	31.03	40.93	42.67	8.58	8.94	6.16	6.53
without C.T	(Mn,Zn,Cu,Fe) Humic form	1167.00	1120.60	32.80	34.18	44.99	46.89	9.12	9.51	6.50	6.89
without C.T	(Mn,Zn,Cu,Fe) EDTA form	968.80	1009.90	31.79	33.13	42.36	44.15	8.95	9.33	6.38	6.77
with C.T	control	829.70	864.80	26.48	27.60	36.90	38.46	8.43	8.79	6.62	7.02
with C.T	(Mn,Zn,Cu,Fe) mineral form	1167.00	1216.40	34.69	36.16	47.28	49.28	10.01	10.43	6.81	7.23
with C.T	(Mn,Zn,Cu,Fe) Humic form	1262.60	1316.10	46.10	48.05	49.64	51.74	10.42	10.87	8.07	8.56
with C.T	(Mn,Zn,Cu,Fe) EDTA form	1182.70	1232.80	37.02	38.59	47.67	49.69	10.13	10.56	7.11	7.53
LSD 0.05		35.35	11.57	1.32	0.43	0.99	0.32	0.20	0.07	0.26	0.07
Normal range, mg kg-1		6- 600*		30- 300**		27-150**		5- 30**		0.1 - 5**	
Contaminated, mg kg-1		2500*		400 - 1000**		100 - 400**		20 - 100**		10 - 100**	

(Reeves and Baker, 2000)* and Kabata-Pendias and Pendias, (1992)**

C.T. = compost tea

Correlations between micronutrient content in(seed and herb) and Seed yield and oil fixed content of Fenugreek plant in average two season.

Pearson s Product-Moment correlation analysis between micronutrient content in seed in and seed yield and oil fixed content were presented in Table (10). Yield of seed in Fenugreek plant showed a strong positive and significant correlation with Cu content in the seed (r =0.903), Mn content(r=0.908), Fe content (r=0.937), Zn content (0.908) and Ni content (r =0.896). Also, a strong positive correlation with seed yield and micronutrient content in herb, Fe content(r=0.933), Mn(0.898), Cu(r=0.833), Zn(r=0.872) and Ni(r=0.889). Svečnjak *et. al.,* (2013) and Stepien & Wojtkowiak (2016) confirmed the positive relationship between micronutrient content and seed yield. However, oil fixed content was highly positive significant with available Cu in seed (r=0.892), Mn in seed (r=0.916), Fe in seed(r=0.936), Zn in seed (r=0.916), Ni in seed (r = 0.913), Fe in herb (r=0.959), Mn in herb (r=0.908), Zn in herb(r=0.883), Cu in herb(r=0.865) and Ni in herb(r=0.895)

Table 10. Correlations between micronutrient content in(seed and herb) and seed yield and oil fixed content of Fenugreek plant.

	yield of Seed	oil content	Fe in seed	Mn in seed	Zn in seed	Cu in seed	Ni in seed	Fe in Herb	Mn in Herb	Zn in Herb	Cu in Herb	Ni in Herb
yield of Seed	1											
oil content	0.981**	1										
Fe in seed	0.937**	0.936**	1									
Mn in seed	0.908**	0.916**	0.931**	1								
Zn in seed	0.908**	0.916**	0.931**	1.000**	1							
Cu in seed	0.903**	0.892**	0.973**	0.912**	0.912**	1						
Ni in seed	0.896**	0.913**	0.983**	0.911**	0.911**	0.949**	1					
Fe in Herb	0.933**	0.959**	0.934**	0.945**	0.945**	0.914**	0.942**	1				
Mn in Herb	0.898**	0.908**	0.928**	0.992**	0.992**	0.921**	0.905**	0.927**	1			
Zn in Herb	0.872**	0.883**	0.955**	0.881**	0.881**	0.914**	0.980**	0.929**	0.853**	1		
Cu in Herb	0.833**	0.865**	0.936**	0.879**	0.879**	0.909**	0.981**	0.928**	0.869**	0.975**	1	
Ni in Herb	0.889**	0.895**	0.857**	0.843**	0.843**	0.910**	0.822**	0.901**	0.864**	0.760**	0.781**	1

****. Correlation is significant at the 0.01 level (2-tailed).**

CONCLUSION

Previous results showed that the application of chelate forms combination of micronutrients (Fe, Cu, Zn, Mn) significantly increase yield components and improved the nutritional status of Fenugreek plant compared to mineral forms of these nutrients**.** In addition, the use of compost tea improves the growth of the plant. Also, It could be recommended that, Fenugreek plants should be treated by interaction of (Fe, Cu, Zn, Mn). Humic form with compost tea was the superior treatment showed significantly higher increase of Fenugreek Seed dry weight, Fixed oil and Macro and Micro nutrients status comparing with chelated forms alone in two season under sandy soil. The results showed also that Fe, Mn, Zn, Cu, Ni concentration in Fenugreek plants accumulated in seeds> herb. The results indicate also that the concentrations of Fe, Mn, Zn, Cu in seeds and herb, of Fenugreek plants were lower the normal ranges except Ni exceeded the normal range

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تأثير الرش الورقى بالعناصر الصغرى وشاى الكمبوست على التركيب الكيميائى و انتاجية نبات الحلبة تحت ظروف بالوظة ـ شمال سيناء

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التسميد بالعناصر الصغرى تلعب دورا حيوى وضرورى فى حياة النبات، وتحتاجة النباتات بكمية ضئيلة جدا (ميكرو). تم إجراء هذا البحث في محطة بحوث بالوظة بمركز بحوث الصحرء - شمال سيناء – مصر. خلال موسمى 2017/2018 لدراسة تأثير تطبيق الرش الورقى بخليط من العناصر الصغرى وشاى الكمبوست. تم تنفيذ البحث بتصميم قطع منشقة مرة واحدة فى ثلاث مكررات، العامل الأول : شاى الكمبوست (اضافة وبدون اضافة)، العامل الثانى: مخلوط من العناصر الصغرى(حديد - منجنيز- زنك- نحاس) فى صورة عضوية- معدنية- مخلبية . الهدف من الدراسة هو دراسة تأثير التداخل بين العناصر الصغرى وشاى الكمبوست على نمو وانتاجية نبات الحلبة ومحتوى النبات من العناصر الكبرى والصغرى. أظهرت النتائج أن أفضل المعاملات كانت المعاملة خليط من العناصر الصغرى (حديد- زنك- منجنيز- نحاس) فى صورة عضوية مع شاى الكمبوست حيث أعطت أعلى قيم انتاجية فمتوسط النسبة المئوية في الموسمين لكل من وزن البذور(جم/ نبات) ، وزن البذور(كجم / فدان) ، محتوى الزيت(مل / نبات) ومحتوى الزيت (كجم/ الفدان)(76.80و 77.62و 122.08و 137.9) ، على التوالي ، وقد أظهرت النتائج أيضًا زيادة فى محتوى نبات الحلبة من العناصر الكبرى و الصغرى . وأوضحت النتائج أيضا أن تركيزات الحديد ، المنجنيز ، الزنك ، النحاس في البذور والعشب لنبات الحلبة كانت أقل من التركيز الحرج .