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Improving Chemical and Microbial Properties of Calcareous Soil and Its Productivity of Faba Bean (*Vicia faba* L.) Plants by Using Compost Tea Enriched with Humic Acid and Azolla

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THIS STUDY evaluated the effect of compost teas enriched with humic acid and/or azolla on soil chemical and microbial properties as well as on yield and plant measurements of faba bean (*Vicia faba* L.c.v. 843) plants. A field experiment was carried out on calcareous soil of El Nobaria area, El-Beheira Governorate, Egypt during grown winter season of 2018/2019. The four compost teas treatments were: without any supplemental (NECT), enriched with humic acid (ECTH), enriched with azolla extract (ECTAz) and enriched with humic acid and azolla extract (ECTHAz). All treatments were applied to calcareous soils at two different rates (120 and 240 $L.ha^{-1}$),through drip irrigation system. At 50 day of planting, nodules number, dehydrogenase activity (DHA) as well as fresh and dry weights of shoots were determined. Also, at harvest stage, straw and seeds yields of faba bean and soilchemical properties (pH, EC, CEC, $CaCO_3$ and OM) and its content of macro-micronutrients (N, P, K, Fe, Mn, Zn and Cu) were determined.Generally, in most of the studied attributes in soil or plants, the greater effect was found with the treatment of ECTH, ECTAz and/or ECTHAz treatments. There is a superior increase effect of enriched compost teas (ECTH, ECTAz, ECTHAz) on nodules numbers, DHA, straw and seeds yield of faba bean plants compared to these of NECT and control treatments. The treatments of enriched compost teas significantly increased the seeds macro-micronutrients content compared to control. Also, enriched compost teas applications improved soil chemical and microbial properties and its content of available macro and micronutrients than those found with NECT treatments.Compost tea especially that enriched with humic acid and azolla extract can be used to improve calcareous soil and its productivity of faba bean plant.

Keywords: Calcareous soil, Chemical properties, Faba bean, Compost tea, Humic acid and Azolla

Introduction

Calcareous soil covers more than 30 % of the earth's surface and their $CaCO_3$ content varies from a few percent to 95 %. They are common in arid and semi-arid climates and occur as inclusions in more humid regions, affecting over 1.5 billion acres of soil worldwide (Marschner, 1995 andFAO, 2006). In Egypt, calcareous soils cover around 0.65 million feddans "feddan = 4200 m^2". Also, the newly reclaimed soils at El-Nobaria and Borg El Arab region cover more than 900,000 feddans of which 290,000 feddans are calcareous and the rest are sandy soils. Then, the $CaCO_3$ content of Egyptian calcareous soils under reclamation various among 10 to 50 % (Hassan, 2012). Cultivation of calcareous soils encountered many obstacles, such as low water holding capacity, weakly structure, low organic matter (OM), surface crusting and cracking, high pH, low availability of nutrients especially phosphorous (P) and micronutrients, and a nutritional imbalance between nutrients like potassium (K), magnesium (Mg) and calcium (Ca) (El-Hady and Abo-Sedera, 2006). In such harsh conditions, it is difficult to achieve the desired yield. Calcareous soil lacks the OM, which is the cornerstone of obtaining an

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optimum agricultural soil. The addition of organic amendments improves soil chemical, physical and microbial properties, thus providing a favorable environment for plant growth (Aboukila et al., 2018).

Compost tea is organic solution acquired by the fermentation of compost in a liquid phase for a few days, with or without aeration. Basically, teas are prepared by soakin gripe compost with water in the ratios of 1:5 to 1:10 (v/v) (Al-Dahmani et al., 2003 and Ingham, 2005). These types of teas began to be use in agriculture due to their ability to suppress a wide range of pathogens (Martin, 2014). The effectiveness of compost teas may vary depending on the type of compost and the method of its preparation (Egwunatum and Lane, 2009 and Pant et al., 2012). Arancon et al. (2007) and Martin (2014) indicated that, the best results are associated with the aerated compost teas rather than non-aerated teas, probably due to the dissolved oxygen upholds microbial activity. Most of the previous studies have focused on using compost tea to enhance disease suppression or resistance towards diseases, to promote crop health and to reduce the need for pesticides. However, little researches were interested in studying its effect on soil chemical properties and their available nutrients. Following Reeve et al. (2010), the possibility of compost teas for supplementing or replacing other types of fertilizers also appear to be available, but further studies under both greenhouse and field conditions are still required.

On the other hand, humic acid seems to be valuable in improving plant growth and modifying certain nutrient deficiency symptoms. This is achieved through increasing the soil water retention, improving soil pH and promoting soil microorganisms by providing them with energy which enhances their activity. They also may be a source of N, P, K and micronutrients for plants (Khaled and Fawy, 2011 and Yang et al., 2013). In this respect, humic acid has many effects due to its increase of cation exchange capacity, which affects the retention and availability of nutrients, or due to a hormonal effect, or a combination of both (Mehrizi et al., 2015). Moreover, to increasing the crop yield, addition of azolla into the field sustains the soil fertility by increasing organic carbon, N and P contents of the soil (El-Shahat et al., 2011), improves soil pH and other physico-chemical properties (Awodun, 2008). El-Sherif et al. (2013) mentioned that application of azolla gave the highest significantly increase in nodule number and its dry weight of faba bean yield components. Also, they increased the soil availability of N, P and K and its content in seeds and straw. Recently, Abou Hussien et al. (2020 a) pointed out that, azolla application resulted in a significant increase in grains yield of rice plants and its content of N, P and K under saline soil condition.

Faba bean (*Vicia faba* L.) is one of the most important food legume crops as a source of plant protein in the popular Egyptian food and could also be eaten and cooked as green bean. In addition, straw yield of faba bean is required for animal feeding (Doughty and Walker, 1982). Due to the difficult physicochemical conditions of calcareous soil, adding enriched compost tea with irrigation water may be utilized as alternatives to traditional organic fertilizers. Moreover, few studies have investigated the use of compost tea as a soil amelioration and there is little information for using enriched compost tea by humic acid and azolla extract as an amendment for calcareous soil. So, the objectives of this research were to investigate the beneficial effect of different types of enriched compost tea on chemical and microbial properties of alkaline-calcareous soils as well as the combating of macro-micronutrients deficiency for faba bean plant.

Materials and Methods

Site of experiment and soil sampling

A field experiment was carried out on calcareous soil at a private Farm of El-Nobaria area, El-Beheira Governorate, Egypt (30° 31′ 04″ N, 3014″ 19″° E and mean altitude 24 m above sea level). It was established to evaluate the effect of compost tea enriched by humic acid and biological additives (azolla extract) on some soil chemical and microbial properties and its productivity of faba bean (*Vicia faba* L.). Before planting, soil samples of the experimental soil were taken separately at soil depth of 0 – 20 and 20 – 50 cm, air – dried, ground, sieved through a 2 mm sieve, kept and analyzed for some physical and chemical properties and its content of available N, P, K, Fe, Mn, Zn and Cu according to the methods described by Cottenie et al. (1982), Page et al.(1982) and Klute (1986). The obtained data were recorded in Table 1.

Enriched compost tea (ECT) preparation

In this study, the compost used in preparing the compost tea was produced followed by the method described by Abou Hussien et al. (2016). Polyethylene vessels of 50 cm diametersand 100 cm depth filled with about 20 kg of air-dried mixture (minced maize stalks and farmyard manure), at C/N ratio of 30:1. An activating mixture containing of about 3.20 g $Ca(H_2PO_4)$, 10 g $CaCO_3$, 0.32 g urea and 100 mL of fresh fertile soil-water suspension (1:5) was added. The mixture of each pot was properly moistened to reach about (50- 60%) of its water holding capacity and left to decompose up to 60 days (Nada, 2015). The piles were turned upside down every 15 days to enhance the aerobic decomposition process. The organic wastes were satisfactorily decomposed by this method after 60 days. The final product was used to prepare compost tea according to the method pointed out by Ingham (2005) with modifications described by Hegazy et al. (2015) as follows: 100 L of tap water without chlorine (by pump to aerate for 30 min) in 200 L plastic container, where the presence of chlorine has a harmful effect on microbial activity. 5 kg of fresh prepared compost submerged into this water and molasse was added to mixture at ratio of 0.5% (v/v). Steeping of compost was done at room temperature (25±2 oC) for 4 days with aeration in the bottom of the container by a flexible tube connected to pump (10 $L.min^{-1}$) to ensure there's plenty of oxygen and circulation in the mixture as it brews. To strain the tea, the mixture was poured in a second lined container with a large piece of cheese cloth then was squeezed it gently to remove excess tea. The previous steps were carried out in four containers separately, where each one of these containers represented one of the studied compost teas. The first was without any additives (non-enriched) (NECT), the second was enriched by humic acid (ECTH), where was supplied by humic acid at a rate of 2.5 $g.L^{-1}$, the third was enriched by azolla extracted (ECTAz), where was supplied by 10 $ml.L^{-1}$ of azolla extract (1:1) and the fourth compost teas was enriched with both of humic and azolla extract (ECTHAz) at rate of 1.25 g and 5 $ml.L^{-1}$, respectively. The different treatments of NECT, ECTH, ECTAz and ECTHAz were analyzed for their main chemical composition according to the methods of A.O.A.C. (2002). The obtained data were listed in Table 2.

TABLE 1. Initial main physical and chemical properties as well as the content of available nutrients of the studied soil

Soil depth (cm)	Particle size distribution (%)				Texture grade	WHC (%)	
	C. sand	F. sand	Silt	Clay			
0 - 20	20.20	59.30	10.80	9.50	Sandy	18.20	
20 - 50	19.70	62.70	9.50	8.10	Sandy	17.50	
	Soil chemical properties						
	pH	EC ($dS.m^{-1}$)	OM ($g.kg^{-1}$)	CEC ($cmol.kg^{-1}$)	$CaCO_3$(%)		
0 - 20	8.38	1.42	4.35	13.32	13.22		
20 - 50	8.52	1.58	2.65	10.45	14.14		
	Available nutrients ($mg.kg^{-1}$)						
	N	P	K	Fe	Mn	Zn	Cu
0 - 20	35.13	4.11	810.0	4.03	6.50	1.63	0.65
20 - 50	21.20	3.05	685.0	2.95	4.11	0.92	0.42

pH was determined in 1:2.5 (soil: water Susp.), EC (electrical conductivity) was in 1:5 (soil: Dist. water extract).

TABLE 2. Main properties of the tested types of compost tea

Properties	Compost tea types			
	NECT	ECTH	ECTAZ	ECTHAZ
pH	7.13	6.70	6.95	6.83
EC (dSm^{-1})	1.95	3.35	2.50	2.82
Total N (mgL^{-1})	1.92	3.65	5.95	4.23
Total P (mgL^{-1})	1.50	2.50	3.11	2.76
Total K (mgL^{-1})	350.50	380.10	360.07	368.70
Organic carbon (%, v/v)	9.52	10.34	11.13	10.85

NECT= non-enriched compost tea, ECTH= enriched compost tea by humic acid, ECTAZ= enriched compost tea by azolla extract, ECTHAZ= enriched compost tea by humic acid and azolla extract.

Preparation of humic acid and azolla

The additive humic acid was isolated from potassium humate supplied by Humintech Company. Humic acid isolation and purification were carried out according to the methods described by Mladkova et al. (2006). Also, the isolated humic acid content of some functional groups and its elemental composition (Table 3) were carried out by using the methods described by Swift (1996).

Azolla was kindly provided by Agricultural Microbiology Research Department, Soil, Water and Environment Research Institute (SWERI), Agriculture Research Center (ARC), Giza, Egypt. Data in Table 3 show the main chemical compounds of the used azolla which carried according to the methods described by El-Berashi (2008). Azolla extract was prepared from crushed fresh azolla which good mixed with distilled water through a mixed ratio of 1:1 at room temperature (25±2 °C). Then the mixture was shacked for an hour to obtain a good suspension which was filtered through a sheet of cheesecloth to obtain azolla extract (Bindhu, 2013).

Field experiment

The field experiment was layout at the studied during a grown winter season of 20182019/, where the studied nine treatments were distributed in randomized block design with three replicates. The experimental area (567 m^2) was divided into 27 equal experimental plots with area of 21 m^2 (7×3 m) for each plot. These nine treatments were: (1) control without any application of compost tea (T1); (2) NECT at application rate of 120 $L.ha^{-1}$(T2); (3) NECT at application rate of 240L.ha^{-1}(T3); (4) ECTH at application rate of 120L.ha^{-1}(T4); (5) ECTH at application rate of 240L.ha^{-1}(T5); (6) ECTAz at application rate of 120L.ha^{-1}(T6); (7) ECTAz at application rate of 240L.ha^{-1}(T7); (8) ECTH+ECTAz at application rate of 120L.$ha^{-1}$of their equal mixture (T8) and (9) ECTH+ECTAz at application rate of 240L.ha^{-1} of their equal mixture (T9).

All farming practices were carried according to the recommendation of Egyptian Ministry of Agriculture and Land Reclamation for faba bean under calcareous soil conditions. Before sowing, surface layer of all plots were mixed with calcium superphosphate (15.5% P_2O_5) and farmyard manure at 477 $kg.ha^{-1}$ and 12.0 $Mg.ha^{-1}$rates, respectively. All treatments received a doses of 233 $kg.ha^{-1}$ of ammonium sulfate (20.5% N) and 120 $kg.ha^{-1}$ of potassium sulfate (48% K_2O) after 10 days and 35 days from sowing, respectively. Seeds of faba bean (*Vicia faba* L., c.v. 843) was used due to its tolerance to drought stress conditions. Directly before planting, the seeds of faba bean were inoculated with diazotrophic namely Rhizobium Leguminous as described by El-Sherif et al. (2013). Two inoculated seeds were planted in each hole at 3 cm depth and 20 cm distance between the holes and 50 cm between the rows (12 rows in each plot). The boundary rows in each plot were not involved in calculations. The irrigation water system in this study was surface drip irrigation. Application rates of compost tea were added in two equal doses after 20 and 40 days of planting with irrigation water (fertigation technique).

TABLE 3. Main properties of the used humic acid and azolla

a) Chemical composition of the used humic acid.

Functional groups ($molg^{-1}$)					Elemental content (%)					C/N ratio
Total acidity	COOH groups	Total OH	Phenolic OH	Alcoholic OH	C	H	N	O	P	
7.54	4.32	3.87	3.32	0.55	52.30	4.35	2.65	41.72	0.17	19.74

b) Chemical composition of the used azolla ($g.kg^{-1}$).

Ash content	Organic matter	Crude fat	Crude protein	Soluble sugars	Elemental content						
					N	P	K	Fe	Zn	Mn	Cu
105.0	848.0	31.0	261.0	35.0	43.0	9.3	25.6	7.7	3.4	1.5	0.7

After 50 days of sowing, five whole plants of each plot (15 plants for each treatment) were randomly uprooted. The rhizosphere soil of each sample was separated to determine dehydrogenase activities according to Page et al. (1982). Plant materials were washed well and carefully with tap water to remove the soil particles attached to the plant roots and again washed with distilled water, and then the whole plants were separated into shoots and roots. The shoots were washed to take the fresh weight (g $plant^{-1}$). The nodules formed on the fresh roots per plant were counted. The shoots were oven-dried at 70°C for 48 hrs to record its dry weight (g $plant^{-1}$).

At harvest stage (after 130 days of planting), the plants of each plot were taken separately above 5 cm of soil surface, the seeds of each plot were separated from straw to measure: weight of seeds and straw yield as Mg ha^{-1} and agronomical efficiency were calculated. Seeds and straw samples were air-dried then, oven-dried at 70 °C for 48 hr, weighed, ground and digested for chemical determination according to the method described by Chapman and Pratt (1961). Nitrogen, P and K content in the digests were determined according to the methods described by Cottenie et al. (1982). The atomic absorption spectrophotometer was used to determine Fe, Mn, Zn, and Cu concentrations in the prior parts according to the methods recommended by A.O.A.C. (2002).

After plant harvesting, soil samples of each plot were taken separately at soil depth of 0 – 20 and 20 – 50 cm for some chemical analyses, i.e. pH, EC, OM, CEC, $CaCO_3$ and the content of available N, P, K, Fe, Mn, Zn, and Cu according to the methods described by Cottenie et al. (1982) and Page et al. (1982).

Nutrient uptake was calculated based on dry weight values multiplied by nutrient concentration in plant seeds. Agronomical efficiency (AE) of straw and seeds yields was calculated according to equation.

AE ($Mg.L^{-1}$) = (Data of treatment-Data of control)/ Application rate of compost tea

Statistical analysis

The obtained data were statistically analyzed according to Snedecor and Cochran (1980). The least significant difference (LSD) range test was used to compare different treatment means. Significantly different was calculated at a 5% level of probability. All estimated data of plant growth parameters, nodulation, dehydrogenase activity and seeds macro-micronutrients content were examined for their responses to the applied treatments using the one-way randomized blocks ANOVA procedure. While the split plot method was used to test the effect of both additive treatments and soil depth on soil chemical properties and its available macro-and micronutrients content.

Results

Data of the first growth period (after 50 days of planting)

a- Number of root nodules

Number of the rhizobia nodules formed on the roots of faba bean plants grown on calcareous soil was clearly changed and affected by both types and application rates of the studied compost tea, where there are significant differences within these numbers (Table 4). Compared to the control treatment (T1), applications of compost tea at the two rates (120 and 240L.ha^{-1}) resulted in a significant increase of formed nodules. Compost tea at rate of 240 L.ha^{-1} showed high significant number of nodules (80.0, 76.0, 60.0 and 45.0 No. /plant) for the treatments of T7, T9, T5 and T3, respectively. While the application rate of 120 L.ha^{-1}represented by treatments of T6, T8, T4 and T2 recorded the lower values of the formed nodules numbers which were 55.0, 51.0, 44.0 and 32.0 of nodules $plant^{-1}$, respectively.

b- Dehydrogenase activity

Dehydrogenase activity (DHA) is the frequently used as a good measurement of the overall microbial activity in soil (Table 4). Results of DHA in the rhizosphere soil of faba bean plants treated with the two rates (120 and 240 Lha^{-1}) of four compost tea, i.e. NECT, ECTH, ECTAz and ECTHAz are shown in Table 4. Data reveal that, application of the used compost tea at different rates enhanced the rate of DHA as compared with control. The highest significant value (48.50 µg TPF/g soil) of DHA was found in the soil received ECTAz (T7) followed by those associated T9 (41.95 µg TPF/g soil), T5 (40.40 µg TPF/g soil), T6 (34.55 µg TPF/g soil), T3 (33.50 µg TPF/g soil), T8 (30.95 µg TPF/g soil), T4 (28.70 µg TPF/g soil), T2 (20.20 µg TPF/g soil) and T1 (T1, 13.23 µg TPF/g soil).

c- Shoots fresh and dry weights

Moreover, data in Table 4 show the increase effect in both fresh and dry weights (g $plant^{-1}$) of faba bean plants grown on calcareous soil at age of 50 days as a result of different applications (sources and application rates) of compost teas (NECT, ECTH, ECTAz and ECTHAz). High rate of such enhanced compost tea types as well as advancing their application rates exhibited better results of the relative changes of the treatments confirmed such outcomes for fresh weight of shoots ranged from 7.72% to 60.34% for T2 and T5 treatment, respectively. Similar variations were found with the dry weights. At the same application rate of applied enhanced compost tea types on fresh and dry matter yields of shoots, the order was ECTH (T5) > ECTHAz (T9) > ECTAz (T7) > NECT (T3) > control (T1).

Data at harvest stage (after 130 days of planting)

a- Straw and seed yields and Agronomical efficiency of compost tea

Data in Table 5 show dry yields (Mgha^{-1}) of straw and seeds of faba bean plants in relation with added types and application rates of the tested compost teas in calcareous soil. Application of all enhanced compost teas resulted in a significant increase of straw and seeds yields. Data also show, the increase in the yields of both straw and seeds were high significantly ($P < 0.05$) with most treatments of compost tea compared with the control treatment. The highest significant values of straw (6.32 Mgha^{-1}) and seeds (4.78 Mgha^{-1}) were found with T5 (ECTH at 240 L.ha^{-1}),while the lowest straw (4.32 Mg.ha^{-1}) and seeds yields (3.78 Mg.ha^{-1}) accompanied with T1 treatment (control). The plots treated by T3, T5, T7 and T9 (application rate of 240 Lha^{-1} compost teas) recorded higher straw and seeds values than those found with the treatments of T2, T4, T6 and T8 (manured with 120 Lha^{-1}). Straw yield was increased from 4.32 Mgha^{-1} in the control treatment to 4.91, 6.32, 5.33 and 5.51 at 240 Lha^{-1} applications of NECT (T3), ECTH (T5), ECTAz (T7) and ECTHAz (T9), respectively. Similar findings were found with seeds yield which increased from 3.78 Mgha^{-1} in the control treatment to 4.21, 4.78, 4.35 and 4.55 with increasing percent of 11.38%, 26.46%, 15.08% and 20.37% in the plants treated by 240 Lha^{-1} of NECT, ECTH, ECTAz and ECTHAz, respectively.

Moreover, the agronomical efficiency (AE) as MgL^{-1}of the applied compost teas at the two additive rates (120 and 240 Lha^{-1}) for the yields of faba bean straw and seeds were listed in Table (5). Constantly, the plants fertilized by 240 Lha^{-1} gave the higher AE values of both straw and seed than those treated by 120 Lha^{-1} application rate.Therefore, the plants fertilized by 240Lha^{-1} recorded AE values of 4.89, 6.30, 5.31 and 5.49 Mg.L^{-1} for straw of the plants treated by T3 (NECT), T5 (ECTH), T7 (ECTAz) and T9 (ECTHAz), respectively. Similar trend of seeds AE was found,whereas the highest value (4.79 MgL^{-1}) with the treatment of T5 (ECTH) and the lowest value (3.87 MgL^{-1}) was recorded in the plants fertilized by NECT (T2).

TABLE 4. Nodulation (Nodules number), dehydrogenase activity, shoot fresh and dray weight of faba bean plants as affected by different types of applied compost tea at the age of 50 day

Treatments		Nodules number (No/plant)	Dehydrogenase activity (µg TPF/g dry soil)	Fresh weight (g/plant)	Dray weight (g/plant)
Control	T1	25.0 ± 2.0 f	15.25 ± 0.23 i	14.50 ± 0.09 h	1.65 ± 0.10 f
NECT	T2	32.0 ± 2.6 e	20.20 ± 0.19 h	15.62 ± 0.06 g	1.95 ± 0.04 e
	T3	45.0 ± 2.6 d	33.50 ± 0.53 e	18.05 ± 0.05 ef	2.31 ± 0.09 cd
ECTH	T4	44.0 ± 1.0 d	28.70 ± 0.06 g	19.75 ± 0.20 d	2.50 ± 0.26 cd
	T5	60.0 ± 6.2 b	40.40 ± 0.17 c	23.25 ± 0.18 a	3.25 ± 0.27 a
ECTAz	T6	55.0 ± 1.0 bc	34.55 ± 0.02 d	17.93 ± 0.12 f	2.22 ± 0.10 d
	T7	80.0 ± 7.0 a	48.50 ± 0.53 a	20.11 ± 0.19 c	2.65 ± 0.03 bc
ECTHAz	T8	51.0 ± 1.7 cd	30.95 ± 0.09 f	18.25 ± 0.23 e	2.37 ± 0.01 cd
	T9	76.0 ± 2.6 a	41.95 ± 1.08 b	21.35 ± 0.04 b	2.88 ± 0.11 b
LSD 0.05		6.290	0.806	0.260	0.258

T1 = control, T2 and T3 = non-enriched compost tea (NECT) at 120 and 240 L.ha^{-1} respectively, T4 and T5= enriched compost tea by humic acid (ECTH) at 120 and 240 L.ha^{-1} respectively, T6 and T7= enriched compost tea by azolla extract (ECTAz) at 120 and 240 L.ha^{-1}respectively, T8 and T9 = enriched compost tea by humic acid and azolla extract (ECTHAz) at 120 and 240 L.ha^{-1} respectively, values presented in columns are mean ±standard deviation (n = 3), mean values within each column followed by same letters are not significantly different at 5% level of probability.

TABLE 5. Effect of different types of compost tea on straw and seeds dry yields of faba bean plants as well as the agronomic efficiency (AE) of added composts tea at harvest stage (130 d).

Treatments $Mgha^{-1}$		Straw yield, $Mgha^{-1}$	Seeds yield,	AE straw	AE seeds
			MgL^{-1}		
Control	T1	4.32 ± 0.09 f	3.78 ± 0.06 h	-	-
NECT	T2	4.58 ± 0.11 e	3.90 ± 0.01 g	4.54	3.87
	T3	4.91 ± 0.03 cd	4.21 ± 0.02 e	4.89	4.19
ECTH	T4	5.39 ± 0.03 b	4.45 ± 0.01 c	5.35	4.42
	T5	6.32 ± 0.30 a	4.78 ± 0.01 a	6.30	4.76
ECTAz	T6	4.72 ± 0.16 de	4.09 ± 0.03 f	4.68	4.06
	T7	5.33 ± 0.10 b	4.35 ± 0.03 d	5.31	4.33
ECTHAz	T8	4.97 ± 0.11 c	4.20 ± 0.02 e	4.93	4.17
	T9	5.51 ± 0.08 b	4.55 ± 0.02 b	5.49	4.53
LSD 0.05		0.195	0.048		

T1 = control, T2 and T3 = non-enriched compost tea (NECT) at 120 and 240 $L.ha^{-1}$ respectively, T4 and T5= enriched compost tea by humic acid (ECTH) at 120 and 240 $L.ha^{-1}$ respectively, T6 and T7= enriched compost tea by azolla extract (ECTAz) at 120 and 240 $L.ha^{-1}$ respectively, T8 and T9 = enriched compost tea by humic acid and azolla extract (ECTHAz) at 120 and 240 $L.ha^{-1}$ respectively, values presented in columns are mean ±standard deviation (n = 3), mean values within each column followed by same letters are not significantly different at 5% level of probability.

b- Seeds content of macro and micronutrients

The effect of different types of compost tea and its application rates on macro and micronutrients content of faba bean seeds are shown in Table 6. According to the seeds N, P and K contents, the tested compost tea types takes the order: ECTH > ECTHAz > ECTAz > NECT > control. Applications of NECT, ECTH, ECTAz and ECTHAz at rates of 120 and 240 Lha^{-1} led to a significant increase in the seed content of N, P and K compared with the control treatment.The plots treated by 240 Lha^{-1}(T3, T5, T7 and T9) produced seeds N, P and K contents significantly higher than that obtained with application rate of 120 Lha^{-1}(T2, T4, T6 and T8). Faba bean plants treated by ECTAz (T7) showed the highest seed N-content (3.56%), while the greatest P-content (0.56%) and K-content (2.6%) of seed were appeared with the treatments of ECTH (T5). In the same context, the highest significant N (160.1 $kgha^{-1}$), P (26.8 $kgha^{-1}$) and K (124.2 $kgha^{-1}$) uptakes by seeds were emerged with T5 (Figure, 1). Also, higher fertilization rate (240 Lha^{-1}) were associated with greater values of seed N (130.9, 160.1, 154.9, 155.2 $kgha^{-1}$), and K (95.9, 124.2, 103.1, 112.8 $kgha^{-1}$) contents for T3, T5, T7 and T9, respectively.The same trend was protruded with seeds P-uptake except for ECTHAz whereas T8 (15.94 $kgha^{-1}$) was significantly higher than T9 (14.1 $kgha^{-1}$) (Fig. 1).

The seeds Fe, Mn, Zn and Cu contents increased significantly ($P < 0.05$), as a result of NECT, ECTH, ECTAz and ECTHAz applications either at 120 or 240 Lha^{-1} compared with control (Table 7). At the same application rate, the tested compost tea types take the order: ECTH > ECTHAz > ECTAz > NECT according to their effect on the seeds content of Fe, Mn, Zn and Cu. Also, at the same treatment of added compost teas, the seeds content of the determined micronutrients takes the order: Mn > Fe > Zn > Cu.The highest significant seeds Fe, Mn, Zn and Cu contents were 43.16, 41.85, 17.42 and 11.55 $mg.kg^{-1}$, respectively appeared with T5 (except Mn accompanied T9). Likewise, the calculated values of seeds Fe, Mn, Zn and Cu uptakes as affected by the studied treatments had taken the same trend, as shown in Figure 2. The lowest seeds Fe, Mn, Zn and Cu (76.9, 87.5, 42.0, 31.4 gha^{-1}) uptakes recorded to untreated soil (T1) while the highest uptakes (206.16, 196.7, 85.6, 55.2 gha^{-1}) were associated with T5 (240 Lha^{-1} of ECTH), respectively (Fig. 2).

TABLE 6. Effect of different types of additive compost tea on seeds of faba bean contents of N, P and K under calcareous soil conditions at harvest stage (130 d)

Treatments		N (%)	P (%)	K (%)
Control	T1	2.42 ± 0.01 i	0.27 ± 0.001 h	1.93 ± 0.017 g
NECT	T2	2.80 ± 0.05 h	0.31 ± 0.005 g	2.11 ± 0.010 f
	T3	3.11 ± 0.03 f	0.42 ± 0.005 c	2.28 ± 0.017 d
ECTH	T4	2.98 ± 0.02 g	0.40 ± 0.017 d	2.35 ± 0.010 c
	T5	3.35 ± 0.02 c	0.56 ± 0.011 a	2.60 ± 0.020 a
ECTAz	T6	3.25 ± 0.04 d	0.33 ± 0.010 f	2.16 ± 0.017 e
	T7	3.56 ± 0.03 a	0.48 ± 0.017 b	2.37 ± 0.017 c
ECTHAz	T8	3.16 ± 0.02 e	0.38 ± 0.010 e	2.26 ± 0.010 d
	T9	3.41 ± 0.01 b	0.31 ± 0.009 g	2.48 ± 0.026 b
LSD 0.05		0.036	0.015	0.027

T1 = control, T2 and T3 = non-enriched compost tea (NECT) at 120 and 240 $L.ha^{-1}$ respectively, T4 and T5= enriched compost tea by humic acid (ECTH) at 120 and 240 $L.ha^{-1}$ respectively, T6 and T7= enriched compost tea by azolla extract (ECTAz) at 120 and 240 $L.ha^{-1}$ respectively, T8 and T9 = enriched compost tea by humic acid and azolla extract (ECTHAz) at 120 and 240 $L.ha^{-1}$ respectively, values presented in columns are mean ±standard deviation (n = 3), mean values within each column followed by same letters are not significantly different at 5% level of probability.

TABLE 7. Effect of different types of additive compost tea on seeds of faba bean contents of Fe, Mn, Zn and Cu under calcareous soil conditions at harvest stage (130 d)

Treatments		Fe ($mgkg^{-1}$)	Mn ($mgkg^{-1}$)	Zn ($mgkg^{-1}$)	Cu ($mgkg^{-1}$)
Control	T1	20.35 ± 0.01 i	23.14 ± 0.04 i	11.11 ± 0.09 g	8.32 ± 0.10 i
NECT	T2	24.13 ± 0.11 h	24.65 ± 0.09 h	11.65 ± 0.06 f	8.65 ± 0.01 h
	T3	30.13 ± 0.14 f	31.30 ± 0.26 f	12.77 ± 0.02 d	9.22 ± 0.02 f
ECTH	T4	36.75 ± 0.90 c	38.10 ± 0.26 c	12.85 ± 0.02 d	10.62 ± 0.04 c
	T5	43.16 ± 0.05 a	41.17 ± 0.15 b	17.42 ± 0.03 a	11.55 ± 0.03 a
ECTAz	T6	26.42 ± 0.02 g	27.18 ± 0.31 g	12.05 ± 0.13 e	10.11 ± 0.19 d
	T7	34.85 ± 0.85 d	35.90 ± 0.26 d	13.55 ± 0.48 c	10.85 ± 0.10 b
ECTHAz	T8	33.65 ± 0.09 e	35.11 ± 0.20 e	11.82 ± 0.03 ef	9.03 ± 0.05 g
	T9	39.85 ± 0.07 b	41.85 ± 0.33 a	14.10 ± 0.17 b	9.70 ± 0.08 e
LSD 0.05		0.654	0.272	0.316	0.129

T1 = control, T2 and T3 = non-enriched compost tea (NECT) at 120 and 240 $L.ha^{-1}$ respectively, T4 and T5= enriched compost tea by humic acid (ECTH) at 120 and 240 $L.ha^{-1}$ respectively, T6 and T7= enriched compost tea by azolla extract (ECTAz) at 120 and 240 $L.ha^{-1}$respectively, T8 and T9 = enriched compost tea by humic acid and azolla extract (ECTHAz) at 120 and 240 $L.ha^{-1}$ respectively, values presented in columns are mean ± standard deviation (n = 3), mean values within each column followed by same letters are not significantly different at 5% level of probability.

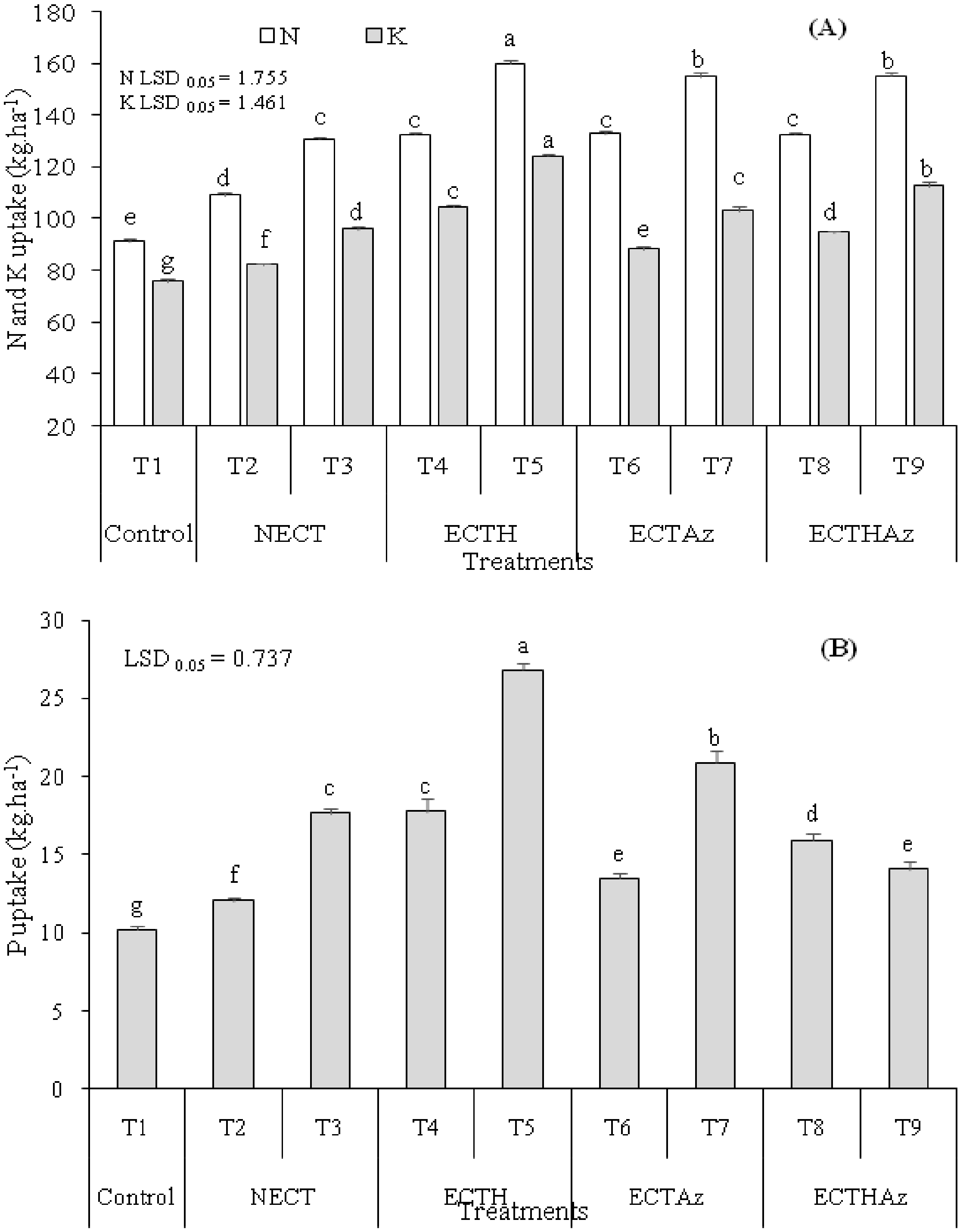

Fig. 1. Macronutrients uptake (mean ± standard deviation) by seeds as affected by different studied treatments of applied compost tea

T1 = control, T2 and T3 = non-enriched compost tea (NECT) at 120 and 240 L.ha^{-1} respectively, T4 and T5= enriched compost tea by humic acid (ECTH) at 120 and 240 L.ha^{-1} respectively, T6 and T7= enriched compost tea by azolla extract (ECTAz) at 120 and 240 L.ha^{-1} respectively, T8 and T9 = enriched compost tea by humic acid and azolla extract (ECTHAz) at 120 and 240 L.ha^{-1} respectively, Different letters on the bars for the same nutrient indicate significant differences between treatments (at 5% level of probability).

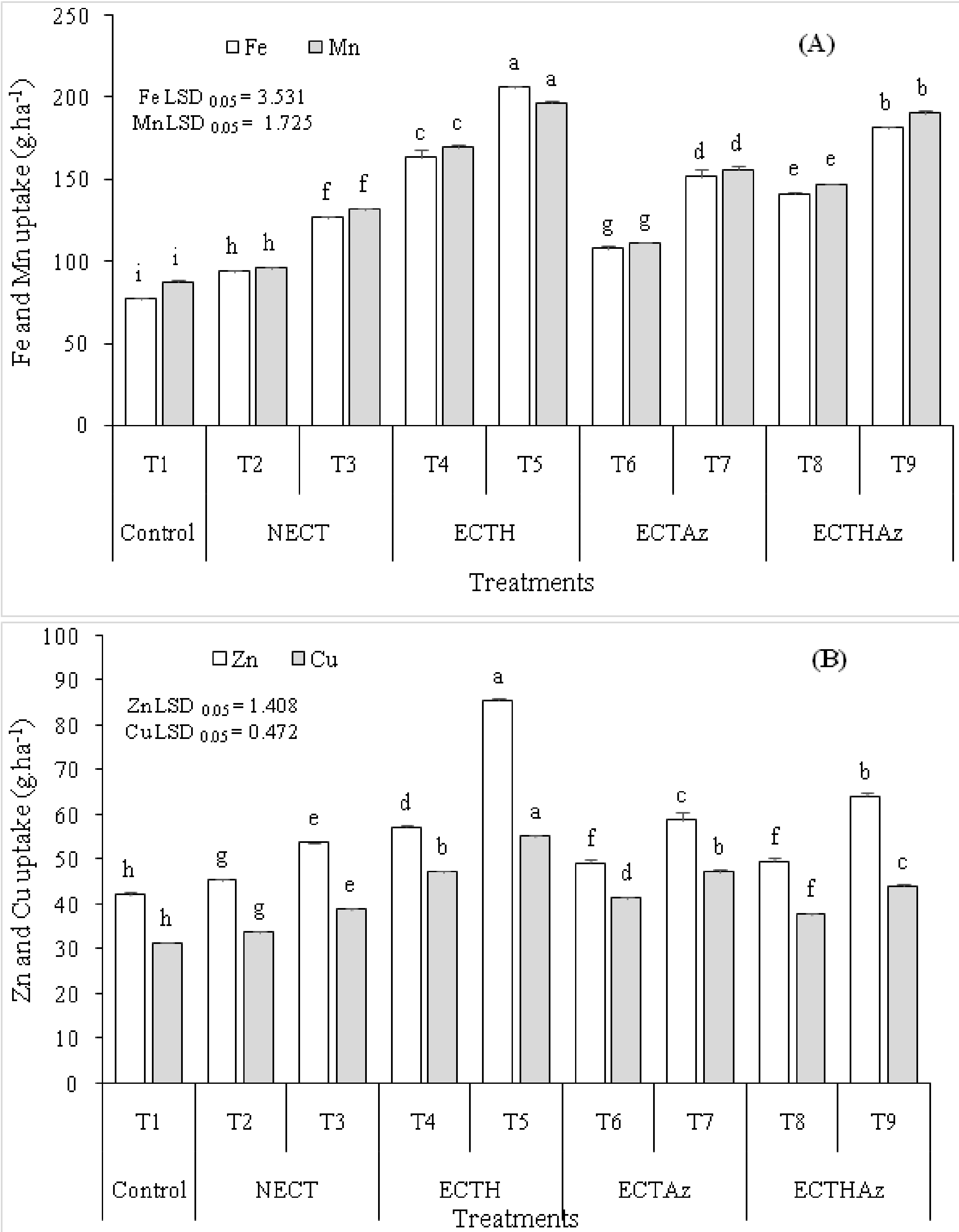

Fig. 2. Micronutrients uptake (mean ± standard deviation) by seeds as affected by different studied treatments of applied compost tea

T1 = control, T2 and T3 = non-enriched compost tea (NECT) at 120 and 240 $L.ha^{-1}$ respectively, T4 and T5= enriched compost tea by humic acid (ECTH) at 120 and 240 $L.ha^{-1}$ respectively, T6 and T7= enriched compost tea by azolla extract (ECTAz) at 120 and 240 $L.ha^{-1}$ respectively, T8 and T9 = enriched compost tea by humic acid and azolla extract (ECTHAz) at 120 and 240 $L.ha^{-1}$ respectively, Different letters on the bars for the same nutrient indicate significant differences between treatments (at 5% level of probability).

c- Soil chemical properties

Data in Table 8 show the effect of added compost tea types and their application rates on some chemical properties of calcareous soil planted by faba bean plants. All applications of compost teas resulted in a decrease of soil pH and its content of $CaCO_3$, whereas resulted in an increase of soil EC, CEC and its content of OM. The high decrease or increase effects were found in the soil treated by ECTH followed by these of ECTHAz and NECT treatments. Also, the 240 $L.ha^{-1}$ of applied compost teas recorded the highest positive on the change of the studied soil chemical properties, compared to the 120 $L.ha^{-1}$ doses and control. Moreover, the 0 – 20 cm layer was accompanied by the higher values of soil OM and CEC against that of 20 – 50 cm layer. In contrast, the values of soil pH, EC, $CaCO_3$ were higher in 20 – 50 cm than those in the 0 – 20 cm layer (Table 8). The differences in the pH values among the treatments and the control were significant. The treatment of ECTH (T5) possessed the lowest pH (8.20) and $CaCO_3$ (12.38 %) values compared to the highest values, i.e. 8.44. and 13.67 % of control (T1), respectively. In contrast, the greatest effect of the applied compost teas on soil EC (1.67 $dS.m^{-1}$), OM (4.09 $g.kg^{-1}$) and CEC (14.38 $cmol.kg^{-1}$) values were observed in T5, against the lower values that noticed in control. Significant ($P < 0.05$) interactive effects of compost teas addition and soil depth were found on pH, EC, CEC and $CaCO_3$ of the studied calcareous soil (Table 8).

d- Soil contents of available macro and micronutrients

Calcareous soil contentof available N, P and K were increased as a result of compost teas applications at 120 and 240 Lha^{-1} (Table 9). According to these increases, the added compost teas take the order: ECTAz > ECTHAz > ECTH > NECT > control for the content of available N and was ECTH > ECTHAz > ECTAz > NECT > control for the content of available P and K. Soil content of available N, P and K were increased as the application rate of compost teas increased. Generally, with all treatments under study, the soil layer of 0-20 cm characterized by high contents of available N, P and K compared with those found in the layer of 20-50 cm (Table, 8). Also, the content of available N, P, and K were significantly ($P < 0.05$) increased by all compost teas treatments compared to the control (ranged from 2 to 27.3% for N; 2.6 to 18.6% for P; and 1.4 to 7.8% for K) suggesting that all treatments of compost teas were effective in adding N, P and K to calcareous soil (Table 9). The ECTAz (T7, 240 Lha^{-1}) treatment showed the highest and significant available N content (37.33 $mg.kg^{-1}$) compared to the lowest content (28.07 $mg.kg^{-1}$) found in control treatment.The high rate of ECTH (T5, 240 Lha^{-1}) significantly produced larger increases in soil content of available P (4.15 $mg.kg^{-1}$) and K(830.0 $mg.kg^{-1}$) than those found in the other treatments. There were a significant interactive ($P < 0.01$) effect of applied compost teas and soil depth on soil content of available N and P. While the interaction effect among compost teas and soil depth on soil content of available K was not significant (Table 9).

Table 10 shows that calcareous soil content of available Fe, Mn, Zn and Cu ($mg.kg^{-1}$) had similar trend that found its content of available N, P and K with all treatments under study. These contents were increased as a result of composts tea applications especially at application rate of 240 Lha^{-1} at the two soil depths (0-20 and 20-50 cm). The increases of these contents in the surface layer were higher than those found in the deeper layer. The high content of the determined micronutrients in the two soil layers was found in the soil treated by ECTH followed by the treatments of ECTHAz or ECTAz, NECT and the lowest one was found with the control treatment. Also, Fe, Mn, Zn and Cu contentin the soil treated with 240 Lha^{-1} were higher than in those treated with 120 Lha^{-1} doses. For all studied micronutrients, the highest increases were observed with the T5 (ECTH) treatment while the lowest increases were observed with NECT treatment. Available micronutrients were significantly increased by T5 treatment compared to control (1.20, 1.19, 1.34, and 1.87-folds increase in Fe, Mn, Zn and Cu, respectively). Also, a positive significant ($P < 0.01$) of interaction between compost teas and soil depth were evident on soil content of available Mn and Cu, while there was no significant effect of the interaction on soil available Fe and Zn (Table 10).

Discussion

The results of this study indicated the substantial effect of enriched compost teas on faba bean plant growth in calcareous soil. The addition of compost teas to calcareous soil increases nodulation, dehydrogenase activity (DHA) and faba bean yields compared to the control. These increases may be due to microbial activity that found in enriched compost teas improve local environmental of rhizosphere and hence increase

TABLE 8. Effect of different types of additive compost tea on some chemical properties of calcareous soil at two soil depth (0 – 20 and 20 – 50 cm) after plant harvesting

Treatments		pH	EC(dSm^{-1})	OM(gkg^{-1})	CEC(cmol$_c$kg^{-1})	$CaCO_3$(%)
			A) Compost tea			
Control	T1	8.44± 0.09 a	1.49± 0.09 d	3.47± 0.92 h	11.88± 1.58 g	13.67± 0.53 a
NECT	T2	8.38± 0.13 b	1.52± 0.11 c	3.50± 0.91 g	12.14 ± 1.60 f	13.57± 0.57 a
	T3	8.30± 0.17 c	1.48 ± 0.18 d	3.80± 1.17 d	12.59 ± 1.66 d	13.15± 0.82 b
ECTH	T4	8.25± 0.17 d	1.60± 0.05 b	3.77± 1.13 e	12.55 ± 1.65 d	12.94± 1.14 c
	T5	8.20± 0.30 e	1.67± 0.04 a	4.09± 1.35 a	14.38 ± 1.89 a	12.38± 1.37 d
ECTAz	T6	8.32± 0.13 c	1.58± 0.07 b	3.69± 1.09 f	12.34 ± 1.62 e	13.19± 0.84 b
	T7	8.26± 0.25 d	1.62± 0.04 b	3.92± 1.24 c	13.77 ± 1.81 c	12.80± 1.15 c
ECTHAz	T8	8.31± 0.18 c	1.54± 0.09 c	3.74± 1.12 e	12.46 ± 1.64 de	13.14± 0.92 b
	T9	8.22 ± 0.26 e	1.61± 0.07 b	3.99± 1.30 b	14.17 ± 1.87 b	12.92± 1.10 c
LSD 0.05		0.036	0.032	0.028	0.156	0.143
			B) Soil depth (cm)			
0-20		8.24 ± 0.29 b	1.49± 0.10 b	4.81± 0.34 a	14.47± 1.01 a	12.23± 0.63 b
20-50		8.47± 0.04 a	1.64± 0.05 a	2.73± 0.07 b	11.37 ± 0.79 b	13.94± 0.17 a
LSD 0.05		0.018	0.055	0.021	0.085	0.063
F-test (A * B)		**	**	**	*	**

T1 = control, T2 and T3 = non-enriched compost tea (NECT) at 120 and 240 L.ha^{-1} respectively, T4 and T5= enriched compost tea by humic acid (ECTH) at 120 and 240 L.ha^{-1} respectively, T6 and T7= enriched compost tea by azolla extract (ECTAz) at 120 and 240 L.ha^{-1} respectively, T8 and T9 = enriched compost tea by humic acid and azolla extract (ECTHAz) at 120 and 240 L.ha^{-1} respectively, values presented in columns are mean ±standard deviation (n = 3), mean values within each column followed by same letters are not significantly different at 5% level of probability, *, ** significant at the 0.05 and 0.01 probability levels, respectively.

TABLE 9. Effect of different types of additive compost tea on calcareous soil content of available N, P and K at two soil depth (0 – 20 and 20 – 50 cm) after plant harvesting.

Treatments		N(mgkg^{-1})	P(mgkg^{-1})	K(mgkg^{-1})
		A) Compost tea		
Control	T1	28.07 ± 7.65 h	3.50 ± 0.53 f	770.0± 99.1 e
NECT	T2	28.63± 8.19 g	3.59± 0.58 ef	781.0 ± 103.2 d
	T3	32.60± 10.85 d	3.82± 0.66 cd	798.5± 106.1 c
ECTH	T4	29.88 ± 9.45 f	3.78± 0.60d	801.0± 99.9 c
	T5	33.82± 11.30 c	4.15 ± 0.77 a	830.0± 98.7 a
ECTAz	T6	33.90± 12.27 c	3.69± 0.62 de	785.0 ± 103.0 d
	T7	37.33 ± 14.65 a	3.91± 0.76 c	816.5± 103.7 b
ECTHAz	T8	31.13± 10.16 e	3.74± 0.59 d	796.5± 100.5 c
	T9	35.74± 13.24 b	4.03± 0.80 b	825.5± 100.4 ab
LSD 0.05		0.233	0.109	9.909
		B) Soil depth (cm)		
0-20		42.26 ± 5.06 a	4.39 ± 0.29 a	893.0 ± 21.15 a
20-50		22.43± 1.10 b	3.20± 0.14 b	708.0 ± 20.75 b
LSD 0.05		0.120	0.030	5.287
F-test (A * B)		**	**	ns

T1 = control, T2 and T3 = non-enriched compost tea (NECT) at 120 and 240 L.ha^{-1} respectively, T4 and T5= enriched compost tea by humic acid (ECTH) at 120 and 240 L.ha^{-1} respectively, T6 and T7= enriched compost tea by azolla extract (ECTAz) at 120 and 240 L.ha^{-1} respectively, T8 and T9 = enriched compost tea by humic acid and azolla extract (ECTHAz) at 120 and 240 L.ha^{-1} respectively, values presented in columns are mean ±standard deviation (n = 3), mean values within each column followed by same letters are not significantly different at 5% level of probability, ** = significant at the 0.01 probability level, ns = not significant.

TABLE 10. Effect of different types of additive compost tea on calcareous soil content of available Fe, Mn, Zn and Cu at two soil depth (0 – 20 and 20 – 50 cm) after plant harvesting

Treatments		Fe ($mgkg^{-1}$)	Mn ($mgkg^{-1}$)	Zn ($mgkg^{-1}$)	Cu ($mgkg^{-1}$)
			A) Compost tea		
Control	T1	3.45± 0.60 f	5.28± 1.29 g	1.25± 0.39 c	0.510± 0.13 f
NECT	T2	3.55± 0.63 ef	5.38± 1.37 fg	1.31± 0.38 c	0.565± 0.15 ef
	T3	3.81± 0.65 c	5.71± 1.52 c	1.49± 0.42 b	0.705± 0.22 cd
ECTH	T4	3.73± 0.67 cd	5.65± 1.32 cd	1.48± 0.45 b	0.715± 0.15 cd
	T5	4.15± 0.78 a	6.30± 1.78 a	1.67± 0.43 a	0.925± 0.30 a
ECTAz	T6	3.61± 0.65 de	5.44± 1.36 ef	1.38± 0.45 bc	0.645± 0.11 de
	T7	3.94± 0.75 b	6.11 ± 1.78 b	1.55± 0.45 ab	0.835± 0.26 b
ECTHAz	T8	3.70± 0.64 cde	5.54± 1.29 de	1.38 ± 0.41 bc	0.645± 0.18 de
	T9	4.07± 0.76 a	6.21± 1.80 ab	1.55± 0.40 ab	0.770± 0.26 bc
LSD 0.05		0.129	0.126	0.123	0.069
			B) Soil depth (cm)		
0-20		4.39± 0.30 a	7.10± 0.56 a	1.82 ± 0.17 a	0.872± 0.18 a
20-50		3.16± 0.20 b	4.36± 0.21 b	1.08± 0.14 b	0.532 ± 0.09 b
LSD 0.05		0.063	0.057	0.054	0.031
F-test (A * B)		ns	**	ns	**

T1 = control, T2 and T3 = non-enriched compost tea (NECT) at 120 and 240 $L.ha^{-1}$ respectively, T4 and T5= enriched compost tea by humic acid (ECTH) at 120 and 240 $L.ha^{-1}$ respectively, T6 and T7= enriched compost tea by azolla extract (ECTAz) at 120 and 240 $L.ha^{-1}$ respectively, T8 and T9 = enriched compost tea by humic acid and azolla extract (ECTHAz) at 120 and 240 $L.ha^{-1}$ respectively, values presented in columns are mean ±standard deviation (n = 3), mean values within each column followed by same letters are not significantly different at 5% level of probability, ** = significant at the 0.01 probability level, ns = not significant.

bacterial nodules.The results of this study are similar those with other researchers which cleared that addition of organic matter in different sources increased the microbial activity and subsequently a greater of bacterial root nodules and DHA were detected (El-Shouny and Behiry, 2011 and El-Sherif et al., 2013). Organic substance compounds and its consisting of nutritional elements very important for living binges (Márquez-Quiroz et al., 2014) as well as by its content of energy compounds (Hegazy et al. 2015). Gad et al. (2017); Abou Hussien et al. (2020 a and b) and El-Noamany (2020) pointed out that, nodules number formed on the roots of faba bean, common bean and peanut plants was affected clearly with resource, chemical composition and application rate of added organic materials under different soil conditions. Also, the found increases of soil microbial activity as a result of organic substances applications to calcareous soil their reduce effect on soil pH and its content of $CaCO_3$ (Sweed, 2012 and Abou Hussien et al., 2019) and increased the soil content of available essential nutrients (Elgezary, 2016 andAboukila et al., 2018).The superior increase of enriched compost tea with azolla (ECTAz, T7) on soil microbial activity compared the others reveal to the high use efficiency of azolla as fertilizers under different soil conditions (Edwards et al., 2006; Awodun, 2008; Egwunatum and Lane, 2009; Márquez-Quiroz et al., 2014 and Abou Hussien et al., 2020 a).

Increasing faba bean yields either at 50-day age or at harvest stage could be related to the high positive impact of applied compost teas on soil chemical properties (i.e. decreased soil pH and $CaCO_3$ and increased macro-micronutrients) which reflected on the nutritional case of the studied soil. Before that similar conclusions were mentioned by Aboukila et al. (2018), Morales-Corts et al. (2018) and Abou Hussien et al. (2019; 2020 a and b) with different sources of organic substances.The high increase effect of ECTH followed by ECTHAz application on the yields of both straw and seedswas in harmony with the chemical composition of the added compost tea and its effect on the improve of soil chemical properties (Arancon et al., 2007; Awodun, 2008; Pant et al., 2009 and Hegazy, 2015).

The analysis of the growth effect on faba bean plants clearly indicates that both NECT, ECTH, ECTAz and ECTHAz when applied at 120 and 240 Lha^{-1} produce a positive effect on shoot, straw and seeds dry weight and seeds macro and micronutrients content compared to that on control plants. ECTH, ECTHAz and/or ECTAz had the greater impact. This improvement in the weight of shoots, straw and seeds by using compost teas corroborates previous studies (Hargreaves et al., 2009; El-Shahat et al., 2011; Ávila-Juárez et al., 2015 and Márquez-Quiroz et al., 2014). This finding is in agreement with the results of this study in which N, P, and K levels in compost teas could be the principal explanation for the growth effect on faba bean plants (Hargreaves et al., 2009 and Pant et al., 2009 and 2012).

Despite the lower amount of nutrients in ECTH (especially N and P content) (Table 2), plant growth parameters with ECTH application were statistically higher than that submitted to ECTAz and ECTHAz applications. This may be due to the high concentration of humic acid in the treatment of ECTH, which has a greater effect on soil properties such as pH, which affects the retention and availability of nutrients, or due to a hormonal effect, or a combination of both (Khaled and Fawy, 2011; Sweed, 2012; Yang et al., 2013 andMehrizi et al., 2015).

Following Edwards et al. (2006), plant growth hormones, such as auxins, dissolved during the brewing period used to make the teas could be responsible for the increase in tomato plant growth. This may have occurred in the current study, where the increase in faba bean growth could have been related to the nutrients, growth promoters (humic acids and phytohormones), and microorganisms found in the four compost teas. Hence, this effect will be greatest when compost tea is mixed with humic acid and azolla (Pant et al., 2009; Naidu et al., 2010 and Bindhu, 2013). Thus, the growth and positive effect of humic acid and azolla teas may be both biotic in origin for most compost teas (Rivaie et al., 2013). Also, the found significant increases of N, P, K, Fe, Mn, Zn and cu contents in seeds could be related to the impact effect of applied compost teas on decreasing soil pH and $CaCO_3$which enhances the availability of these nutrients in soil (Hargreaves et al., 2009; El-Shahat et al. 2011 and Hegazy et al., 2015).

Moreover, there was a significant effect of the applied compost teas in improving the chemical properties and macro and micronutrients content of the studied soil. These findings attributed mainly to the chemical composition of added compost teas and its reactions with different soil compounds. Abou Hussien et al. (2019) and Sweed (2012) pointed out that, different applications of humic substances to calcareous soils resulted in a decreased soil pH and the content of $CaCO_3$, but increased soil EC, CEC and OM, where these applications have a dissolved and acidic effect on soil compounds especially $CaCO_3$ which transformed to $Ca(HCO_3)_2$ and other soluble salts. The superior effect of ECTH and ECTAz and/or ECTHAz on soil chemical properties may be attributed to its content of functional groups which characterized by activity (Bindhu, 2013 and Márquez-Quiroz et al., 2014). Furthermore, the apparent increase in the availability of N, P, K, Fe, Mn, Zn and Cu in the soil after treated by compost teas, could be due to the improving the soil chemical properties, especially its pH and $CaCO_3$ content.These are in harmony with the effect of the different additives on bio (nodulation and dehydrogenase activity) and chemical (pH, EC, $CaCO_3$, CEC and OM) soil properties.The reason may also be the high efficiency of ECTAz as biofertilizer and N fixation in calcareous soil and the high efficiency of ECTH on the improve of soil chemical properties. In this expect similar conclusions were obtained by Helmi (2018), Aboukila et al. (2019) and Abou Hussien et al. (2019) where they found increases in the soil content of available N, P, K, Fe, Mn, Zn and Cu as a result of different organic matter resources applications.The obvious increase in all measured chemical properties and macro-micronutrients in the surface layer (0-20 cm) compared to the subsurface (20-50 cm) may be resulted from the high content of OM and clay in the surface layer. The surface layer was more susceptible to the studied treatments than with that in the deeper one. Moreover, the differences in the availability of nutrients could be attributed to the high CEC and the content of OM and low pH in the layer of 0-20 cm compared with those in the other (Khaled and Fawy, 2011 and Sweed, 2012).

Conclusion

All compost teas examined in this research, including non-enriched compost tea (NECT), enriched compost tea by humic acid (ECTH), enriched compost tea by azolla extract (ECTAz) and enriched compost tea by humic acid and azolla extract (ECTHAz), were effective at ameliorating soil chemical properties and its content of available macro and micronutrients which reflected in the increase the soil productivity of faba bean plants and its content of essential nutrients.The application of compost teas to calcareous soil proved to be an extremely effective method of increasing nodulation, dehydrogenase activity and shoot fresh and dry yields after 50 day of age. Also, the applied teas increased faba bean yields of straw and seeds at harvest stage, as confirmed by the high value of agronomic efficiency. The seeds macro and micronutrients content and its uptakes were improved under application of different additives compost teas. Either compost tea alone or compost tea + humic acid or azolla was equally effective at enhancing faba bean yields and its biological properties. Mixing compost tea with humic acid and/or azolla was more effective than compost tea alone in increasing electrical conductivity, organic matter, cation exchange capacity, soil macro-micro-nutrients, and reducing soil pH and $CaCO_3$. The use of these compost teas especially that treated with humic acid and azolla extract are of great interest to ameliorate calcareous soils and sustainable agriculture.

Ethics approval and consent to participate

This article does not contain any studies with human participants or animals performed by any of the authors.

Author contribution

This study was designed and implementedby authors,where all authors contributed in writing the manuscript, interpreting information presented and have read and agreed to the version of the manuscript.

Consent for publication

All authors declare their consent for publication.

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تحسين الخواص الكيميائية والميكروبية للتربة الجيرية وإنتاجيتها لنبات الفول (*Vicia faba L.*) بإستخدام شاى الكمبوست الغنى بحامض الهيوميك والأزولا

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قيمت هذه الدراسة تأثير شاي الكمبوست المخصب مع حمض الهيوميك و / أو مستخلص الأزولا على الخواص الكيميائية للتربة والقياسات النباتية لنبات الفول البلدى(Vicia faba L. c.v. 843). أجريت التجربة حقلية على تربة جيرية بمنطقة النوبارية بمحافظة البحيرة بمصر خلال فصل الشتاء لعام 2018/2019. أنواع شاي السماد الأربعة المضافة هي: بدون أي مكمل (NECT) ، مُخصب بحمض الهيوميك (ECTH) ، مُخصب بمستخلص أزولا (ECTAz) ومُخصب بحمض الهيوميك ومستخلص أزولا (ECTHAz) ، حيث تم إضافتهم جميعًا عند معدلات اضافة 120 و 240 لتر/هكتارمن خلال نظام الري بالتنقيط. تم قياس العقد الجذرية والقش والبذور في نبات الفول. تم تقدير نشاط انزيم الدهيدروجينيز في التربة (DHA) ، الخصائص الكيميائية(pH، EC ، CEC ، $CaCO_3$ ، OM) والمحتوى منالمغذيات الكبرى والصغرى الميسرة(N ، P ، K ، Fe ، Mn ، Zn ، Cu). بشكل عام ، في معظم الصفات المدروسة في التربة أو النباتات ، كان التأثير الأكبر لصالح معاملات ECTH و ECTAz و / أو ECTHAz . هناك تأثير زيادة كبير لشاي الكمبوست المخصب (ECTH ،ECTAz، ECTHAz)على عدد العقد الجذرية ، DHA ، قش وبذور نباتات الفول مقارنةً بتلك المزروعة فى معاملة NECT و الكنترول. أدت معاملات شاي الكمبوست المخصب إلى زيادة محتوى المغذيات الدقيقة الكلية للبذور بشكل ملحوظ. أيضًا ، أدت الإضافات من شاي االكمبوست المخصب إلى تحسين الخواص الكيميائية للتربة ومغذياتها الكبرى والصغرى الميسرة عن تلك الموجودة مع معاملات NECT . يمكن استخدام شاي الكومبوست، خاصةً المعالج بحمض الهيوميك ومستخلص الأزولا ، لتحسين التربة الجيرية وإنتاجيتها من نبات الفول البلدى.