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Implications of Humic, Fulvic and K-Humate Extracted from Each of Compost and Biogas Manures as well as Their Teas on Faba Bean Plants Grown on A Typic Torripsamment Soil and Emissions of Soil CO_2

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The current study assumed that foliar application of organic extracts might be as beneficial in improving plant growth as amending soils with organic amendments. Moreover,the foliar application of these extracts can minimize, to some extent, the emissions of CO_2 which is an obligatory option to attain desirable environmental conditions. To investigate this assumption, (1) different organic extracts, *i.e.* humic acid, fulvic acid and K-humate prepared from each of a biogas manure and a mature compost (consisting of composted rice straw and farmyard manure) and (2) a tea of each of the aforementioned manures (TEA) prepared by soaking the latter organic materials in distilled water, were studied for their effects on dry matter yield of faba bean plants grown on a Typic Torripsamment soil sampled from Meet Kenana village, Qalubia, Egypt under greenhouse conditions. Each of these extracts and TEAs was applied either solely or in different combinations with each other, foliarly or through soil applications, at two different rates, *i.e.* 48 and 96 L ha-1. Results revealed that the applications of the investigated organic extracts as well as the compost/biogas tea increased significantly NPK uptake by the grown plants and consequently improved the dry matter yield of faba bean plants especially with increasing the rate of the applied organic extract or tea. Mixed type extracts seemed to be more efficient in this concern than the single type extracts. It seemed preferable to use the single type extracts foliarly; whereas, the mixed type ones seemed more preferably to be used through soil applications. Results also revealed that the investigated organic amendments stimulated both the number and dry weights of nodules with significant effects on reducing the emissions of CO_2 especially when added as foliar applications. In conclusion, the foliar application of the liquid organic amendments (as extracts or teas) is recommended to improve the plant growth on one hand, and decrease the emissions of CO_2 on the other hand to attain more desirable environmental conditions.

Keywords: Organic extracts; Tea biogas/compost; Foliar application; Soil application; Carbon dioxide emissions; Bacterial nodules

Introduction

Agriculture is the capital of human civilization (Scotti et al., 2015). The shocking news is that hunger is increasing nowadays (Weis, 2007). This is because of the increasing demands for plant production to meet the concurrent increases in human population (Weber, 1999). Consequently, more intensive cultivation practices have been followed to satisfy human needs for food production (Boserup, 2010). However, such intensive cropping with no return of crop residues can, on the other hand, threat soil sustainability (Yadvinder-Singha et al., 2004). Moreover, extensive use of agro-chemicals in agriculture considerably decreases soil biodiversity (Tilman et al., 1996) and this might cause soil degradation (Diacoco and Montemurro, 2010). There is no doubt that soil sustainability depends mainly on soil biodiversity (Tilman et al., 1996). Thus, recycling organic wastes in agriculture might restore soil sustainability (Diacoco and Montemurro, 2011) probably through stimulating the activities of soil microorganisms (Ros et al., 2003) and enzymes (dehydrogenase, alkaline phosphomonoesterase, phosphodiesterase, arylsulphatase, and urease) (Albiach et al., 2000). The recycling of organic wastes can also increase soil fertility on the long run through increasing soil organic carbon and the storage of nutrients (Herencia et al., 2008).

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Besides, they improve the physical, chemical and biological characteristics of soils (Liu et al., 2007) even the poor soil structure of the sodic soils (Farid et al., 2014b and Kamel et al., 2016).

Faba bean (*Vicia faba* L.) is an important protein source for food and feed (Amanuel et al., 2000 and Cazzato et al., 2012). In Egypt, it is considered a strategic crop (Hegab et al., 2014) and is thought to be the third important feed grain worldwide (Singh et al., 2013) being a good source of energy and amino acids (Nalle et al., 2010), beside of its low contents in tannin, vicine and convicine (Crépon et al., 2010). Moreover, Faba beans can fix atmospheric nitrogen (Köpke et al., 2010) via biological N2 (Jensen et al., 2010) e.g. rhizobium which is considered a relatively low-cost alternative to N-fertilizers (Amanuel et al., 2000). In this concern, amending soils with organic amendments can further stimulate root nodulation (Abbas et al, 2011). Faba bean cropping might save up to 100–200 kg N ha−1 in N fertilizers needed for crops which are grown after broad bean (Jensen et al., 2010).

It is worthy to mention that the mineral fertilizers can increase the microbial biomass carbon to levels exceeding those attained due to application of the organic fertilizers(Francioli et al., 2016). In soil, there exists soil-borne herbivorous, pathogenic, symbiotic and decomposer organisms(Bardgett and van der Putten, 2014). However, amending soils with the organic amendments can antagonize soil-borne diseases e.g. nematodes (Akhtar and Malik, 2000) probably through releasing allelochemicals generated during product storage or by subsequent microbial decomposition(Bailey and Lazarovits, 2003). In this concern, compost application can be more beneficial for soil characteristics than the fresh organic matter (Ros et al., 2003). There is an assumption indicating that the root exudates of the grown plants are the main factor responsible for initiating and modulating the dialogue between plants and soil biota(Badri and Vivanco, 2009) e.g. bacteria (Baudoin et al., 2003) and fungi (Broeckling et al., 2008). Probably, improving the plant growth through the foliar application of the organic extracts might be as beneficial as amending soils with the organic amendments.

On the other hand, degradation of the organic carbon in soil is associated with considerable emissions of the greenhouse gases (GHGs) especially under extensive cropping (Burney et al., 2010). Owing to these emissions, the levels of atmospheric CO_2 were doubled (Stainforth et al., 2005)and this might increase the earth temperature with significant consequences on rainfall, retreat of glaciers and sea ice, sea level (Ramanathan and Feng, 2009). “No region will be left untouched”(Stern, 2006). Thus, minimizing the GHGs is thought to be an obligatory option to improve the environmental conditions(Smith, 1996).

The current research aimed at investigating the effectiveness of using different organic components, *i.e.* humic and fulvic acids, K-humates andtea extracted from a mature compost and biogas (foliar versus soil applications) on the nutrient uptake and growth performance of faba beans cultivated in a low fertile sandy soil. Soil biodiversity (bacterial and fungal populations as well as the number and weights of the beneficial nodular bacteria was also a matter of concern in this study.

Materials and Methods

Materials of study

Soil of study

A surface soil sample (0-30 cm) was collected from Meetkenana village, Qalubia Governorate (Egypt). This soil is classified as Typic Torripsamments. This sample was, air dried, finely ground to pass through a 2 mm sieve and the particle size distribution was determined by the pipette method according to Klute (1986). The chemical characteristics were determined using the standard methods outlined by Page et al. (1982) *i.e.* (1) total carbonates volumetrically by means of Collin`s calcimeter, (2) EC in soil paste extract using electric conductivity-meter, (3) organic matter content according to Walkley and Black method, (4) soil pH in (1:2.5 soil: water suspension) by pH Meter, (4) Ca^{2+} and Mg^{2+} volumetrically with versenate, (6) Na^+ and K^+ using flame photometer, (7) CO_3^{2-} and $HCO_3^-$by titration against HCl, (8) Cl- volumetrically by titration against silver nitrate, while SO_4^{2-} was calculated as the difference between total determined cations and anions. Physical and chemical properties of the investigated soil are presented in Table 1.

Extraction of the humic and fulvic acids as well as the K-humate and preparation of the compost/

biogas tea

Both the compost and biogas manures were obtained from The Training Center for Recycling of Agricultural Residues at Moshtohor, Soils, Water and Environment Research, Institute, Agricultural Research Center (Cairo, Egypt). Extraction of the different humic substances was carried out according to the standard method described by Sanchez – Monedero et al. (2002)where each of the compost and the biogas manures was mixed with deionized water at a rate of 1:5 (w/v) and thentreated with 0.5 *N* KOH solution to extract the humic substances. Humic acid was separated from humus extract by acidification with 0.1 *M* HCl to reach a pH of 2.0, after being left overnight. Humic acid (HA) precipitates werethenseparated from soluble fulvic acids by centrifugation at 6000 rpm for 15 minutes. The precipitates (HA) were purified by electro-dialysis to reduce minerals such aspotassium and chloride contents (Chen and Schnitzer, 1978). Fulvic acid was purified according to Susilawti et al. (2007)as follows:the supernatant containing fulvic acid was passed through activated charcoal followed by elution of the charcoal. The solution was concentrated and then transferred to a membrane filter and dialyzed against distilled water until the water analysis recorded negative chloride test.

Each of the biogas manure and the mature compost was blended with previously stored tap

TABLE 1. Physical and chemical characteristics of the investigated soil

Parameter	Value	Parameter	Value	Parameter	Value
Particle size distribution, %		pH*	7.4	$CaCO_3$, g kg^{-1}	7.4
Sand	83.2	EC**	4.3	Organic matter, g kg^{-1}	6.5
Silt	4.7	**Soluble cations (mmolc L^{-1})**		**Soluble anions (mmolc L-1)**	
Clay	12.1	Na^+	31.6	CO_3^{2-}	0.0
Textural class	Loamy sand	Mg^{2+}	1.4	HCO_3^-	2.4
Field capacity	12.70	Ca^{2+}	10.7	Cl^-	5.8
Wilting point	7.30	K^+	0.6	SO_4^{2-}	36.1

* (1:2.5 soil:water suspension) **(saturation paste extract)

TABLE 2. Elemental and chemical compositionsof the K-humate,humic and fulvic acids extracted from the compost and the biogas manures

Parameter	**Compost**			Biogas		
	KH	HA	FA	HK	HA	FA
C %	52.0	51.1	48.1	48.5	51.7	48.9
N %	2.2	4.3	3.5	2. 8	4.0	2.9
H %	1.5	3.2	2. 4	3.2	2.9	2.0
S %	5.0	4.7	6. 5	4.7	2.9	3.9
O2 %	39.3	36.7	39.5	40.8	38.5	42.3
Total acidity(m mole/100g)	570.0	580.0	620.0	560.0	590.0	780.0
COOH group(m mole/100g	360.0	232.0	310.0	330.0	225.0	240.0
Phenolic OH group (mmole/100g)	480.0	490.0	530.0	430.0	420.0	450.0
C/N ratio	23.0	11.9	13.7	17.4	12.9	16.9
C/H ratio	34.9	15.8	19.6	15.1	17.8	24.5
C/O ratio	1.3	1.4	1.2	1.2	1.3	1.2
O/H ratio	26.4	11.3	16.1	12.7	13.3	21.2
N/H ratio	1.5	1.3	1.4	0.9	1.4	1. 5
Alcoholic_OH(mmole/100g)	300.0	350.0	140.0	290.0	380.0	130.0
C.E.C(cmole/kg)	400.0	390.0	320.0	420.0	410.0	300.0

KH: K-humate HA: humic acid FA: fulvic acid water at a dilution ratio of 1:10 (W/V) in plastic barrel as mentioned by Brinton et al. (1996) and then left in a shaded place for 7 days, while stirring by air compressor using a PVC pipe dipped into the barrel. Afterwards, the liquid mixtures were filtrated using a 100 mesh screen. Chemical and microbiological properties of the prepared tea compostsare shown in Table 3.

Seeds and inocula preparation

Seeds of faba beans (*Vicia faba*, c.v Giza-2) were obtained from the Field Crops Research Institute, Agricultural Research Center, Giza, Egypt. Rhizobium leguminosarium was obtained from Biofertilizers Production unit, Soils, Water and Environment Research Institute, Agricultural Research Center, Giza, Egypt. To prepare the Rhizobium inoculum, yeast minitol broth medium was inoculated with an effective strain of Rhizobium and then incubated at 32˚C for 7 days. Seeds of Faba beans were washed with water, air dried, and then soaked in cell suspension of Rhizobium Sp.(1 mL contains about 8 ×107 viable cell) for 30 min. Gum Arabic (16%) was added as an adhesive agent prior to inoculation, then the seeds were air dried for one hour before sowing.

TABLE 3. Chemical and microbiological characteristics of compost/biogas tea (TEA)

Parameter	Compost	Biogas
EC dSm^{-1}	3.52	3.89
pH	7.21	6.98
NH_4-N µg mL^{-1}	64.50	70.40
NO_3-N µg mL^{-1}	8.34	11.20
Total –P %	0.09	0.07
Total count of bacteria (cfu/g)	11.50× 10^7	8.60 × 10^7
Total count of fungi (cfu/g)	9.20 × 10^5	6.70 × 10^5
Total count of actionmycets (cfu/g)	9.60 × 10^5	1.40 × 10^5
Organic carbon %	3.95	3.24
Available –P,µg mL^{-1}	48.70	26.30
Available –K, µg mL^{-1}	79.90	58.20

The greenhouse experiment

A pot experiment was conducted under the greenhouse conditions of the Training Center for Recycling Agricultural Residues at Moshtohor, Qalubia Governorate (Soils, Water and Environment Research Institute (SWERI), Agriculture Research Center (ARC)). Three kilogram portions of the soil under investigation were placed in plastic pots with dimensions of 16 cm height and 21cm diameter. Each pot received one of the amendments shown thereafter at tworates, *i.e.* 47.6 and 95 Lha^{-1} either as soil or foliar application.The used amendments were: potassiumhumate (KH), humic acid (HA), fulvic acid (FA), compost/ biogas tea (TEA), potassium humate+ compost/ biogas tea, (KH+TEA), humic acid +compost/ biogas tea (HA+TEA) and fulvicacid+ compost/ biogastea(FA+TEA). Five seeds of fababean were then broadcasted in each pot and the experiment was conducted in a randomized complete block design with three replicates. All treatments received ammonium sulphate (205 gNkg^{-1}) at a rate of 36 kg N ha^{-1}during planting as a starter dose for microbial activation. Superphosphate (85 g P kg^{-1}) and potassium sulphate (400gKkg^{-1}) were incorporated into soil before planting at rates of 75kg P ha^{-1} and 48kg K ha^{-1}, respectively.

Two weeks after cultivation, seedlings of faba beans were thinned to 3 onesper pot and the moisture content was kept at field capacity by daily compensation of water loss with distilled water. At the flowering growth stage, soil samples were collected from the rhizosphere of each pot to determine CO_2 evolution. The dry weigh and the number of nodules per plant werealso recorded. After 80 days from germination, the plants were harvested, dried at 70 ˚C and the dry matter yield was recorded.

Soil, plant and the organic extracts analyses

The dried plant materials were finely grounded in a porcelain mortar.Subsamples of 0.5g were wet digested in a mixture of conc.sulphuric and perchloric acids (2:1ratio) and then analyzed for their NPK contents according to Page et al. (1982): Nitrogen was determined using micro Kjeldhalmethod**,** phosphorus was determined colorimetrically using ammonium molybdate and ascorbic acid reagents and then measured using Perkin Elmer spectrophotometer. Potassium was determined by flame photometer. Carbon dioxide emissions were determined according to Antoun and Jensen (1979) as follows: soil portions equivalent to 20 grams (moisture contents adjusted to 60% water holding capacity, WHC) were placed in a hollowed glass stopper fitting into a 500 mL Erlenmeyer flask and then kept by a loose filling of glass-wool where 25 mL of 0.05 *N*$Ba(OH)_2$ solution were placed in the flask before replacement of the stopper. The flasks were incubated at 30°C for 24 hours and then titrated with 0.05 *N*HCl. Analysis for C,H,N and S within the purified humic and fulvic acids were performed by gas chromatography on a Hewlett – Packard 185 Analytical center, Faculty of Science, Cairo University. Oxygen was calculated by subtracting the percentages of C,H,N and S from 100 according to Goh and Stevenson (1971). Dried samples were then prepared for infrared spectra using K Br pellets technique as reported by Schnitzer and Khan (1972)and scanned using Backman IR 250 double beam grading spectrophotometer from 4000 to 5000 cm^{-1}.

Determination of total counts of bacteria and fungi

Number of nodules per plant was recorded. Also, the nitrogenase (N2- ase) activity was estimated by the acetylene-ethylene assay according to Hardy et al. (1973). Afterwards, the nodules were oven dried for 78 hr at 70°C and the dry weights were recorded. The numbers of total viable bacteria and fungi were determined by pouring one mL of the soil suspension (1:5, w:v) in Petri dishes together with agar media and then incubated at 30°C. Each treatment was replicated 5 times. Bacteria and fungi colonies were counted after 48hr and 5 days, respectively (Allen, 1950 and Reinhold et al., 1985).

Statistical analysis

The obtained results were statistically analyzed using Minitab program according to Ryan and Joiner (1994) and the LSD test was conducted at 0.05 level of probability to compare among the means attained by the different treatments.

Results

Dry matter yield of faba bean plants grown on the investigated soil as affected by the applied organic extracts and the compost/biogas tea

Data presented in Table 4 reveal that the application of the investigated organic extracts as well as the compost/biogas tea could significantly increase the dry matter yield of faba bean plants as compared with the control treatment. In this concern, the combined type extracts seemed to be more efficient than the single ones especially those extracted from Biogas rather than compost. Moreover, the foliar application of these extracts and their tea seemed of more pronounced effect on the plant growth than their soil application.

Generally, the soil applied organic extracts and the compost/biogas tea could be arranged according to their effects on the dry matter yield of faba bean in the following descending order: HK+TEA> HA+TEA> FA+TEA> HK> FA> HA>TEA, while, upon theirfoliar application they resulted in effects on the dry matter yield followed the sequence: HK+TEA>HA+TEA>HK> FA+TEA>HA>FA>TEA.

The increases that occurred in dry matter yield of bean plants owing to the application of the organic extracts or TEA originated from biogas manure (except HA and FA) were higher than those occurred due to the corresponding ones extracted from the compost. The increases in dry matter yield of bean plants that occurred due to the application of either HA or FA extracted from compost seemed; however, higher than those occurred due to application of HA or FA extracted from Biogas manure.

Nitrogen uptake by faba bean

Table 5 indicates significant increases in N uptake by faba bean plants owing to the application of the investigated organic extracts as well as the compost/biogas tea compared with the none-amended control treatment. The uptake of N by plants was higher upon application of potassium humate as foliar spray rather than its soil application. On the other hand, mixed type extracts+TEA were more preferably for increasing N uptake upon their soil applications. Generally, increasing the rate of the applied amending extracts was associated with concurrent increases in N uptake by the grown plants. The highest N uptake was attained due to soil application of HA+TEAwith an average of 173.6 mg pot^{-1}. On the other hand, the lowest N uptake was attained by plants treated with TEA with an average of 118.7 mg pot^{-1}. It is worthy to mention that the increases in N-uptake owing to the foliar application of HK which was extracted from biogas and applied at a rate of 48 L ha^{-1} exceeded those attained by the mixed type extracts+TEA; however, such increases seemed to be significantly lower than the corresponding ones attained by the mixed type extracts^{+}TEA in case of increasing the rate of application

TABLE 4. Dry matter yield of faba bean plants (g pot $^{-1}$) grown on the investigated soil as affected by the rate of application (R) of extracts and tea originated (A) from different organic sources (S).

Source (S) and rate (R)	Biogas						Compost					
	Soil Application			Foliar Application			Soil Application			Foliar Application		
	48L ha^{-1}	96L ha^{-1}	Mean	48L ha^{-1}	96L ha^{-1}	mean	48L ha^{-1}	96L ha^{-1}	Mean	48L ha^{-1}	96L ha^{-1}	mean
KH	8.00	9.37	8.69	8.85	9.97	9.41	7.85	9.16	8.51	7.33	8.05	7.69
HA	7.77	8.84	8.31	7.53	8.50	8.02	7.38	8.27	7.83	7.11	7.66	7.39
FA	7.51	8.41	7.96	7.28	8.40	7.84	8.77	9.35	9.10	7.16	7.75	7.46
TEA	7.42	8.02	7.72	7.80	8.09	7.95	7.33	8.44	7.89	6.91	6.93	6.92
KH+ TEA	10.10	10.80	10.50	7.61	10.30	9.00	8.71	9.96	9.34	8.82	9.71	9.27
HA+ TEA	9.99	10.20	10.10	7.38	10.20	8.79	8.59	9.66	9.13	8.07	9.31	8.69
FA+ TEA	9.57	10.60	10.10	7.52	9.03	8.28	8.22	9.80	9.01	8.23	9.11	8.67
Mean	8.62	9.46	9.05	7.71	9.21	8.46	8.12	9.23	8.68	7.66	8.36	8.01
Control	**6.65**											

KH= potassium humate, HA= humic acid, FA=fulvic acid, TEA=compost/biogas tea

L.S.D: $_{0.05}$ A=0.43, S=0.51, R=0.60, A×S=0.28, A×R=ns, S×R=ns, A×S×R= ns

TABLE 5. N-uptake (mg pot $^{-1}$) by the faba bean plants as affected by the rate of application (R) of extracts and tea (A) originated from different organic sources (S).

Organic Source (S) and rate (R)	Biogas manure						compost					
	Soil Application			Foliar Application			Soil Application			Foliar Application		
	48L ha^{-1}	96L ha^{-1}	mean	48L ha^{-1}	96L ha^{-1}	mean	48L ha^{-1}	96L ha^{-1}	mean	48L ha^{-1}	96L ha^{-1}	mean
KH	127.2	156.4	141.6	146.0	171.5	158.7	121.7	148.4	134.5	124.6	148.8	136.7
HA	120.4	144.1	132.1	120.5	145.4	133.0	116.6	138.9	127.6	115.2	134.1	124.7
FA	114.2	133.7	123.4	114.3	138.6	126.5	129.8	148.7	139.2	111.0	127.1	119.1
TEA	107.6	121.1	114.3	120.1	129.4	124.8	112.1	135.0	123.1	112.6	117.8	115.2
KH+ TEA	177.8	196.6	187.9	143.1	197.8	170.5	148.1	172.3	160.6	160.5	180.6	170.6
HA+ TEA	172.8	182.6	177.8	136.5	193.8	165.2	155.5	182.6	168.9	143.6	168.5	160.1
FA+ TEA	162.7	185.5	174.6	135.4	167.9	151.7	139.7	176.4	157.7	150.6	172.2	161.4
Mean	140.4	160.0	150.2	130.8	163.5	147.2	131.9	157.5	144.7	131.2	149.9	141.3
Control	79.8											

See footnotes of Table 4

L.S.D: $_{0.05}$ A=0.43,S=0.51, R=0.60, A×S=0.28, A×R=ns, S×R=ns, A×S×R= ns from48 to 96 L ha^{-1}. Application of FA extracted from compost resulted in further significant increases in the uptake of N by plants exceeding those extracted from biogas manure. Otherwise, the organic extracts and TEA seemed to be more efficient in increasing the uptake of N when extracted from biogas manure rather than compost.

P-uptake by faba bean plants

Data shown in Table 6 reveal that P- uptake increased significantly in plants amended with the organic extractsas well as the TEAcompared with the control one. Increasing the rate of the applied amendments led to further significant increases in P uptake. It is worthy to mention that the combined type amendments were of more efficient effects than the single type ones especially when added in the form of soil applications rather than foliar ones. Concerning the source of organic extract or TEA, it seems that the biogas manure was more efficient than the compost manure in increasing P-uptake by faba bean plants. . It seems that the effect of the combined type amendments on increasing P uptake by faba beans surpassed the effect of increasing the dose of application from 48 to 96 L ha-1.

K-uptake by faba bean plants

Results show that significant increases in K- uptake by faba bean plants occurred due to application of the extracts and tea under study whether as foliar spray or soil application. In this concern, the extracts and TEA of biogas seemed to be more efficient in increasing K-uptake than compost (Table 7). Furthermore, increasing the rate of the applied extract or TEA led to concurrent increases in K-uptake of by bean plants. Generally, the soil application seemed to be more effective on increasing the uptake of K by the grown plants as compared with the foliar application except for the potassium humate treatment which was more preferably used as foliar application.

TABLE 6. P-uptake (mg pot^{-1}) by faba bean plants as affected by the rate of application (R) of extracts and tea (A) originated from different organic sources (S)

Organic Source (S) and rate (R)	Biogas			Compost			Mean		Grand mean
	48L ha^{-1}	96L ha^{-1}	mean	48L ha^{-1}	96L ha^{-1}	mean	48L ha^{-1}	96L ha^{-1}	
Soil application									
HK	15.2	19.7	17.4	14.9	22.0	18.7	15.1	21.3	18.2
HA	13.2	16.8	15.0	14.8	18.2	16.5	13.6	18.0	15.8
FA	13.5	18.5	15.9	15.8	18.7	17.3	14.7	18.6	16.7
TEA	11.9	15.2	13.1	12.5	18.9	16.8	12.2	15.6	13.9
HK+ TEA	29.3	33.5	31.5	22.6	27.9	25.2	26.3	31.2	28.8
HA+ TEA	24.0	26.5	25.3	23.2	29.0	25.6	24.2	27.8	26.0
FA+ TEA	23.9	28.6	26.3	21.4	30.4	26.1	22.3	29.6	25.9
Mean	18.1	22.7	19.9	17.9	23.1	20.0	17.6	22.9	20.3
Foliar application									
HK	18.6	23.9	20.7	16.9	20.9	18.5	17.8	22.5	20.1
HA	17.3	21.3	19.2	15.6	18.4	17.0	16.1	19.4	17.8
FA	14.6	17.6	15.7	14.3	17.8	16.0	14.4	17.8	16.1
TEA	14.0	15.4	14.7	13.8	14.6	14.2	13.9	15.2	14.6
HK+ TEA	23.6	34.0	28.8	25.6	31.1	28.7	24.7	32.5	28.6
HA+ TEA	19.2	28.6	23.7	21.8	26.1	23.5	20.1	27.3	23.7
FA+ TEA	20.3	27.1	23.2	21.4	26.4	24.3	20.5	26.3	23.4
Mean	18.5	23.9	21.2	18.4	21.7	20.0	18.5	22.9	20.7
Control									9.31

See footnotes of Table 4

L.S.D :0.05 A=0.34 S=ns R=0.68SXR=ns AXR=0.26 AXS=0.22 AXSXR=ns

TABLE 7. K-uptake (mg pot^{-1}) byfaba bean plants as affected by the rate of application (R) of extracts and tea (A) originated from different organic sources (S).

Organic Source (S) and rate R)	Biogas manure						Compost					
	Soil Application			Foliar Application			Soil Application			Foliar Application		
	48L ha^{-1}	96L ha^{-1}	mean	48L ha^{-1}	96L ha^{-1}	mean	48L ha^{-1}	96L ha^{-1}	Mean	48L ha^{-1}	96L ha^{-1}	Mean
KH	126.4	151.8	139.0	141.6	165.5	153.4	125.6	149.3	137.9	118.0	135.2	126.1
HA	116.5	136.1	126.3	115.2	136.9	125.9	112.9	129.8	121.4	110.9	124.1	117.5
FA	114.9	132.9	123.4	110.7	135.2	122.3	136.8	149.6	143.8	113.1	124.8	119.4
TEA	107.6	119.5	113.6	116.2	124.6	120.0	109.9	130.8	119.9	107.1	110.2	108.6
KH+ TEA	166.7	183.6	177.5	131.7	180.3	156.6	146.3	172.3	158.8	149.1	167.0	158.5
HA+ TEA	161.8	168.3	164.6	122.5	172.4	147.7	140.0	163.3	151.6	133.2	158.3	146.0
FA+ TEA	156.0	178.1	166.7	119.6	150.8	135.2	136.5	166.6	151.4	137.4	153.9	145.7
Mean	134.5	152.3	143.0	122.6	152.0	137.3	129.1	151.4	139.7	123.3	138.8	131.4
Control	93.1											

See footnotes of Table 4

L.S.D:$_{0.05}$ A=1.45, S=1.58, R=1.77, A×S=1.23, A×R=ns, S×R=ns, A×S×R=ns

Soil biota as affected by the extracts originated from the investigated organic amendments

The applied amendments increased significantly the number of plant nodules as well as their dry weights (Table 8). Likewise, the activity of nitrogenase enzyme increased in such soil amended with the investigated extracts as compared with the non-amended control treatment. However, highest increases in both the number of nodules and their dry weights were achieved upon the application of the studied amendments as soil applications rather than foliar ones. Mixed types of the organic extracts and TEA were of more significant effect on increasing the numbers and dry weights of nodules as well as the activity of nitrogenase enzyme than the single type whether applied as soil or foliar applications. The used organic extracts and TEA can be arranged according to their efficiency in increasing the dry weights of nodules, in case of soil application, in the following descending order: HA+TEA>FA+TEA> KH+TEA> HA > FA > KH >TEA, while, upon the foliar application, the resulted descending order was found: FA+TEA> HA+TEA> KH+TEA>FA> HA >TEA> KH.

The used organic extracts and TEA can be arranged according to their efficiency in increasing the dry weights of nodules, in case of soil application, in the following descending order: HA+TEA>FA+TEA> HK+TEA> HA > FA > HK >TEA, while, upon the foliar application, theresulted descending order was found: FA+TEA> HA+TEA> HK+TEA>FA> HA >TEA> HK.

Evolution of CO_2 as affected by the extracts originated from different organic amendments and compost/ biogastea

Table 9 reveals that the evolution of CO_2 from soil rhizosphere increased in all due to all the applied amendments. The evolution of CO_2 from the studied soil increased significantly with increasing the rate of the applied amendment from 48 to 96L ha^{-1}. In case of soil application, the highest emissions of CO2 took place in soils treated with HA+TEA where it reached 64.9 mg kg-1 hr-1, while, the lowest CO_2 emissions were attained due to application of TEA treatment where it was as low as 39.1 mg kg-1 hr-1. In case of foliar applications, the used amendments can be arranged according to their effects on CO2 evolution in the following descending order: KH+TEA> HA+TEA> FA+TEA> HA≥FA > KH >TEA. Generally, the emissions of CO2 from the soil that received soil applications of the amendments were significantly higher than those received the organic extracts as foliar application on the grown plants.

Total bacterial and fungal counts as affected by the extracts originated from the investigated organic amendments

Total counts of bacteria and fungi as affected by the applied extracts and TEA originated from the investigated organic amendments either individually or in combinations are presented in Table 9. These treatments increased significantly the total counts of both bacteria and fungi, compared with the control treatment. The used organic extractscan be arranged upon their soil application according to their effects on counts of bacteria and fungi in the following descending order: HA+TEA> FA+TEA> HK+TEA> HA > HK > FA>TEA; however,upon their foliar application, the following sequence was detected i.e. FA+TEA>HA+TEA>HK+TEA>HA > HK >FA >TEA. Data also indicate that increasing the rate of addition of the organic extractincreased significantly the counts of bacteria and fungi.

Discussion

Results obtained herein indicate that the investigated organic extractsi.e.HA,FA,KH beside of the TEA increased the growth of faba beanplants (dry matter yield) and could increase the plant uptake of NPK.This finding was true regardless of the amendments method of application i.e. soil or foliar application. This result stands in well agreement with those of El-Ghozoli and Abd El-Warth (2008) and Farid et al. (2014a). Increasing the uptake of some nutritive elements e.g. N (Hassan et al., 2016), P (Eichler-Löbermann et al., 2007;Hashem et al., 2016) and K (Abbas et al., 2011) may account for such a finding. The organic amendments can increase the efficiency of plants to utilize soil N (Montemurro et al., 2006) without inducing nitrate leaching to groundwater (Diacono and Montemurro, 2011). Probably, through inducing soil microbial biomass and activities (Bastida et al., 2008 and 2015) especially the symbiotic ones (Vaidya et al., 2008).Thus, there is no wonder to find thatthenodules dry weights and numbers increased in the current study with application of the investigated amendments. Similar results indicate that the number of nodules and their dry weights collected from the rhizosphere of faba plants increased with humic acid treatment (El-Ghanam and El-Ghozoli, 2006).Moreover, soil nutrients are chelated by humic, fulvic and amino acid (Cimrin and Yilmaz, 2005; El-Ghamry et al., 2009) therefore can beneficially improve their uptake by plants (Nikbakht, et al., 2008). Humic and fulvic acids also act as growth hormones which can improve the plant growth (Nardi et at, 1999).

TABLE 8. Nodulation of faba bean plants grown on the investigated sandy soil as affected by the rate of application (R) of extracts and tea (A) originated from different organic sources (S)

Organic source S) and) (rate (R	Biogas manure						Compost manure						Mean						Grand mean		
	48L ha^{-1}			96L ha^{-1}			48L ha^{-1}			96L ha^{-1}			48L ha^{-1}			96L ha^{-1}					
	N	D	N2- ase	N	D	N_2- ase	N	D	N_2- ase	N	D	N_2- ase	N	D	N_2- ase	N	D	N_2- ase	N	D	N^2- ase
Soil application																					
HK	23.0	93.3	15.3	24	99.1	17.1	25	101.9	16.0	28	143.9	18.7	24.0	97.6	15.7	26	121.5	17.9	25	109.6	16.8
HA	27.0	103.2	14.9	29	106.2	18.2	26	140.0	15.5	32	180.0	20.6	26.5	121.6	15.2	30.5	143.1	19.4	28.5	132.35	17.3
FA	24.0	100.1	15.0	27	107.5	17.5	28	158.2	16.1	30	171.2	18.9	26.0	129.2	15.6	28.5	139.4	18.2	27.2	134.3	16.9
TEA	22.0	91.7	13.6	23	98.4	15.6	24	105.6	14.2	26	139.7	17.0	23.0	98.7	13.9	24.5	119.1	16.3	23.8	108.9	15.1
HK+TEA	26.0	138.1	19.2	31	151.2	20.3	29	170.0	19.0	33	201.0	22.5	27.5	154.1	19.1	32	176.1	21.4	29.8	165.1	20.3
HA+TEA	30.0	161.2	20.7	32	165.3	22.0	32	179.8	23.3	34	218.6	23.8	31.0	170.5	22.0	33	192.0	22.9	32	181.3	22.5
FA+TEA	28.0	151.0	20.3	30	157.3	23.2	30	172.7	22.8	35	240.1	24.6	29.0	161.9	21.6	32.5	198.7	23.9	30.8	180.3	22.8
Mean	25.7	119.8	17.0	28.0	135.0	19.1	27.7	146.9	18.1	31.1	184.9	20.9	26.7	133.4	17.6	29.6	160.0	20.0	28.2	146.7	18.8
Foliar application																					
HK	21	87.2	14.5	24	93.2	18.2	22	92.1	15.5	26	130.2	19.3	21.5	89.7	15.0	25	111.7	18.8	23.3	100.7	16.9
HA	25	91.8	15.2	27	101.8	17.7	24	95.7	16.2	28	142.3	20.2	24.5	93.8	15.7	27.5	122.1	19.0	26	108.0	17.4
FA	24	93.2	14.8	28	133.9	17.9	28	120.0	16.0	29	162.1	19.8	26	106.6	15.4	28.5	148.0	18.9	27.3	127.3	17.2
TEA	21	85.0	14.1	24	90.0	15.0	23	91.3	15.0	27	137.2	16.8	22	88.2	14.6	25.5	113.6	15.9	23.8	100.9	15.3
HK+TEA	28	138.9	18.9	30	140.1	19.9	28	143.6	20.1	31	148.9	21.7	28	141.3	19.5	30.5	144.5	20.8	29.2	142.9	20.2
HA+TEA	29	150.2	21.0	31	143.2	22.5	29	159.0	22.1	33	177.8	23.5	29	154.6	21.6	32	160.5	23.0	30.5	157.6	22.3
FA+TEA	30	156.7	22.3	32	152.5	22.1	31	166.7	23.7	34	190.9	23.9	30.5	161.7	23.0	33	171.7	23.3	31.7	166.7	23.2
Mean	25.3	114.7	17.3	28.0	122.1	19.1	26.4	124.1	18.4	29.7	155.6	20.7	25.9	119.4	17.9	28.9	138.9	19.9	27.4	129.2	18.9
Control	N=12.0						D=79.7						N2-ase=11.3								

See footnotes of Table 4 L.S.D: $_{0.05}$

(N)= No. of nodules/plant:	A=0.513	T=0.650	R=0.815	AXS=ns
	AXR=ns	SXR=ns	AXSXR=ns	
(D)= Dry weight of nodules(mg/plant) :	A=1.43	S=1.53	R=1.60	AXS=1.19
	AXR=ns	SXR=1.31	AXSXR=ns	
(N_2-ase)=Nitrogenase (n moles C2H4 /hr/g dry nodules)	A=0.341	S=0.411	R=0.522	AXS= ns
	AXR=ns	SXR= ns	AXSXR= ns	

TABLE 9. CO_2 evolved (mg kg-1 hr-1) from rhizosphere soil and the total count of bacteria and fungi as affected by the rate of application (R) of extracts and tea (A) originated from different organic sources (S)

Organic source S) and rate) ((R	Biogas manure						Compost manure						Mean						Grand mean		
	48L ha^{-1}			96L ha^{-1}			48L ha^{-1}			96L ha^{-1}			48L ha^{-1}			96L ha^{-1}					
	CO_2	T.B	T.F	CO_2	T.B	T.F	CO_2	T.B	T.F	CO_2	T.B	T.F	CO_2	T.B	T.F	CO_2	T.B	T.F	CO_2	T.B	T.F
Soil application																					
HK	39.3	7.35	2.51	52.1	8.15	2.79	43.1	8.71	2.70	58.9	8.85	3.44	41.2	8.03	2.60	55.5	8.50	3.11	48.3	8.27	2.85
HA	40.0	8.64	2.10	50.3	9.21	2.55	45.8	9.15	3.30	59.2	10.1	3.52	42.9	8.90	2.70	54.8	9.66	3.03	48.9	9.28	2.87
FA	36.9	7.08	1.83	51.0	8.0	2.46	35.8	7.71	2.65	53.8	8.91	3.25	36.4	7.40	2.24	52.4	8.46	2.85	44.4	7.93	2.54
TEA	32.8	6.53	1.68	43.1	7.23	1.80	34.7	7.13	1.78	45.6	7.83	2.35	33.8	6.83	1.73	44.4	7.53	2.07	39.1	7.18	1.90
HK+ TEA	55.7	10.6	4.23	62.9	12.6	5.67	53.0	11.8	5.32	63.9	12.9	6.26	54.4	11.2	4.77	63.4	12.8	5.96	58.9	12.0	5.36
HA+ TEA	59.2	12.4	5.31	68.8	13.7	6.25	61.3	12.6	5.74	70.2	13.8	6.17	60.3	12.5	5.52	69.5	13.8	6.21	64.9	13.2	5.86
FA+ TEA	52.8	11.3	4.40	61.3	11.8	6.33	51.5	12.1	5.88	64.1	13.2	6.40	52.2	11.7	5.14	62.7	12.5	6.36	57.5	12.1	5.75
Mean	45.2	9.13	3.15	55.6	10.1	3.97	46.5	9.89	3.91	59.4	10.8	4.48	45.9	9.51	3.53	57.5	10.5	4.22	51.7	10.0	3.87
Foliar application																					
HK	29.9	6.83	2.12	39.9	7.71	2.46	32.8	7.10	2.68	40.5	7.81	3.38	31.4	6.97	2.40	40.2	7.76	2.92	35.8	7.37	2.66
HA	31.8	7.35	2.31	37.8	8.12	2.75	33.7	7.78	2.99	41.3	8.23	4.51	32.8	7.57	2.65	40.0	8.18	3.63	36.4	7.88	3.14
FA	32.9	6.71	2.25	38.6	7.61	2.16	34.2	7.20	2.83	39.8	7.72	3.45	33.6	6.96	2.54	39.2	7.67	3.03	36.4	7.32	2.78
TEA	27.5	5.80	1.41	29.8	6.33	1.71	29.1	6.61	1.95	31.7	6.83	2.27	28.3	6.21	1.68	30.8	6.58	1.99	29.6	6.40	1.83
HK+ TEA	45.0	8.83	3.3	52.7	9.25	3.92	46.3	8.90	3.66	53.8	9.75	4.50	45.7	8.87	3.48	53.3	9.50	4.21	49.5	9.19	3.84
HA+ TEA	42.2	9.41	3.4	55.1	9.69	3.63	43.7	9.82	3.83	56.6	10.3	5.13	43.0	9.62	3.61	55.9	10.0	4.38	49.4	9.81	3.99
FA+ TEA	43.7	9.13	3.10	51.9	10.1	3.52	42.0	10.0	3.55	55.9	10.5	4.70	42.9	9.57	3.32	53.9	10.3	4.11	48.4	9.94	3.71
Mean	36.1	7.72	2.55	43.7	8.40	2.94	37.4	8.20	3.07	45.7	8.73	3.99	36.8	7.79	2.81	44.8	8.57	3.46	40.8	8.24	3.13
Control	CO_2 =29.3									T.B=1.31						T.F=1.43					

See footnotes Table 4

CO_2 (µg/g dry soil /hr)
A=2.22 T=2.40 R=2.56 AXS=ns
SXR=ns AXR=ns AXSXR=ns

(T.B) Total count of bacteria
A=0.427 T=0.481 R=0.593 AXS=0.218
SXR=0.312 AXR=ns AXSXR=0.161

(T.F) Total count of fungi
A=0.207 T=0.214 R=0.264 AXS=ns
TXR=ns AXR=ns AXSXR=ns

Concerning the effect of the studied organic extracts and TEA on P uptake by faba bean plants, different mechanisms are thought to take place to improve P solubility and availability in soil, *e.g.* P- released through the decomposition of the organic matter (Guppy et al., 2005). Moreover, low molecular weight organic acids compete with P on the soil sorption sites thus reduce P-sorption (Iyamuremye et al., 199 and Guppy et al., 2005). Also, chelation of P may take place in soils by root or microbial exudates and, therefore, prevent the precipitation of P in soils in the form of calcium phosphate minerals (Chen et al., 2008). In addition,the production of carbonic acid from CO_2 released during organic matter decomposition which encourage solubilization of insoluble Ca and Fe-phosphate (Stevenson, 1986)**.**

Emissions of CO_2 are mainly attributed to the rate of decomposition of the applied organic amendment (Sousa-Souto et al., 2012) or humic acid added to soils (El-Ghozoli and Abd El-Warth, 2008). Although, CO_2 emissions are taken as indicators of the soil biota activities (Bardgett et al., 2008 and Diacono & Montemurro, 2011) and consequently representing a needle pointing towards soil health (Arias et al., 2005); yet, these emissions might also possess a challenge of the global climate change (Knorr et al., 2005 and Lehmann, 2007) especially in sandy soils (Abdelhafez et al., 2018) where the air surrounding sand quartz acts as an efficient thermal resistor (Tarnawski et al., 2009). Thus, reducing CO_2 emissions is favorable to reduce the negative implications of the organic amendments on the ecosystem. In this concern, the lowest CO_2 emissions were detected for the compost/biogas tea (TEA) treatment. Its effects on the plant growth and nutrient uptake were comparable to the extracts of the other organic amendments. This amendment, *i.e.* TEA was used successfully by Sherif et al. (2012) to increase the yields of root, leaves and sugar % in sugar beet.

The foliar application method of the extracts as well as tea of the organic amendments also improved significantly the plant uptake of NPK and consequently increased the plant growth. The obtained results exceeded those attained from the soil application of the investigated extracts originated from different organic amendments. This might take place because of the organic extracts probably contain available macro and micro nutrients beside vitamins and hormones (Ingham, 2003). In this concern, Hashem et al. (2016) found that the liquid organic fertilizers promote all growth parameters including the vegetative growth, nutrients content, *e.g.* N, P and K in the broccoli and cauliflower plants. In conclusion, the foliar application of the organic extracts is recommended to improve the plant growth on one hand, and decrease the emissions of CO_2 on the other hand to attain more desirable environmental conditions.

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الآثار المترتبة على إضافة احماض الهيوميك ، والفولفيك وهيومات البوتاسيوم المستخرجة من كل من سماد البايوجاز علي الفول البلدي النامي على ارض TypicTorripsamments وانبعاثات ثان اكسيد الكربون الناتجة من هذه الارض

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تعد إفرازات الجذور حلقة الوصل والمسئول الرئيسي عن بدء وتعديل الحوار بين النباتات والكائنات الحية الموجودة في التربة، ولذا تبنت هذه الدراسة الفرضية التالية»الرش الورقي للنباتات بالمستخلصات العضوية أو حتي الشاي المحضر من المواد العضويةيكون له تأثير ايجابي علي نمو النباتات، وهذا التأثير يماثل التأثير المتحصل عليه من الإضافات الارضية لتلك المستخلصات»، علاوة علي أن الرش الورقي بتلك المتخصصات يمكن أن يقلل من مقدار انبعاثثاني أكسيد الكربون من التربة إلي الغلاف الجوي، والذي اصبح خيارًا إلزاميًا يهدف إلي تحسين الظروف البيئية المحيطة»، وللتحقق من صحة هذا الفرضيةاحصائياً فإنه تم: (١) استخلاص أحماض الهيوميك و الفلفيك بالإضافة إليهيومات البوتاسيوم من مصدرين عضويين مختلفين هما سماد البيوجاز، وسماد الكمبوست الناضج (يتألف من قش الأرز الأسمدة و روث المزرعة) و (٢) تحضير شاي البيوجاز أو الكمبوست (TEA) عن طريق نقع المواد العضوية (تحت الدراسة) في الماء المقطر، وقد تمت إضافة المستخلصات أو شاي البايوجاز/الكمبوست علي صورة مفرقة أو مع بعضها البعض إلي ارض رملية مزروعة بنبات الفول البلدي (رشا علي النباتات أو من خلال الإضافة الأرضية) تحت ظروف الصوبة الزجاجية بمعدلين مختلفين هما ٤٨ و ٩٦ لتر لكل هكتار، والنتائج المتحصل عليها اكدت حدوث زيادات معنوية فيالكميات الممتصة من النتروجين، الفوسفور، والبوتاسيوم بواسطة النبات النامي نتيجة المعاملات المستخدمة، ترتب عليه ارتفاع معنوي في الوزن الجاف للنباتات النامية، وتلك النتائج كانت اكثر معنوية مع زيادة المعدل المضاف من المستخلصات العضوية أو شاي البايوجاز/الكمبوست، ويبدو أن الإضافات المختلطة للمستخلصات العضوية وكذلك شاي سماد البايوجاز أو الكمبوست كانت اكثر فاعليه في امتصاص العناصر وبالتبعية نمو النباتات من خلال الإضافات الأرضية، بينما يفضل استخدام الإضافات الفردية للمستخلات العضوية أو شاي البايوجاز/الكمبوست رشاً علي النبات، ومن الجدير بالذكر أن إضافات رشاً علي النبات قد حفزت أعداد العقد الجذرية وزادت من اوزانها الجافة، كما ان رش تلك المواد قد خفض بفاعلية من اعداد البكتريا والمفطريات بالإضافة إلي تقليل معدلات انبعاث ثاني أكسيد الكربون من اتربة مقارنة بمثيلتها في حالة الإضافة الأرضية،وبالتاليتتحقق نظرية الدراسة، كما توصى الدراسة بالإضافات العضوية السائلة (كمستخلصات أو شاي) لتحسين نمو النبات من جهة، وخفض انبعاثات ثاني أكسيد الكربون من ناحية أخرى.