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THE EFFECT OF BIO-DIGESTION PRODUCTS, ORGANIC MATTER AND TREATED WATER QUALITY ON THE CONCENTRATIONS OF DISSOLVED CATIONS AND ANIONS IN THE SOIL AND THEIR SALINITY PLANTED WITH POTATOES

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Abstract

A field experiment was carried out at the second research station Al Bandar, College of Agriculture, University of Al-Muthanna. Therefore, Attempt was made to establishment of a bio digester (25.6 m^3), equipped with biogas collection tank (15.9 m^3) to produce biogas through anaerobic decomposed of organic manure mixed with liquid fertilizer. This trail included two main factors the first included four types of watering, namely water of Euphrates river (N), Euphrates water magnetized by 2000 gauss (M), Sold free bio-digester water mixed with Euphrates water 1:1 ratio (F), and Euphrates water pressed into biogas tanks under 5 bar (A). The second factor was fertilizing potato plants with 50ton ha^{+1} by a. Aerobically decomposed buffalo manure mixed with water 10: 90 (A), and b. Deposited buffalo manure from previous tanks mixed with water 10: 90, (An) besides untreated control, treatments were replicated 3 times, to investigate the responses of potato growth, yield and soil properties. All detected traits were significantly affected by four water types and both manure fertilizers. However, insignificant differences were observed with interaction treatments.

***Keywords*:** bio-digestion, organic matter, water quality, dissolved cations, anions, soil, potatoes.

Introduction

Biogas production has been applied around the globe (Kemausour *et al.*, 2018), owing to the advantages of anaerobic digestion techniques, since raw manure can be used without waiting for manure decomposition, besides various organic raw materials can be applied, small household, and large systems can be made by manufacturer (Wang *et al.*, 2016 and Dahiya *et al.,* 2018). This system is a source of renewable energy, capable of providing basic energy as well as a balance of the elasticity of energy supply and demand (Lauer, 2018). Anaerobic fermentation has many benefits which are the production of renewable energy that can be stored and used in generating electricity or pumping it to the gas network after purification and converting it to a vital methane, as locally generated energy, which reduces greenhouse gas emissions by replacing it with fossil fuel. The result of anaerobic fermentation as an organic fertilizer source and its replacement with industrial and mineral fertilizers such as nitrogen, phosphorous and potassium fertilizer. The treatment of animal fat by anaerobic fermentation is very beneficial compared to its direct use, since it reduces the seed furnishing resulting in increasing the storage energy. In addition to that, recycling the waste of organic food into organic fertilizers (Stiles *et al.,* 2018; Theuerl *et al.*, 2019; Jain *et al.,* 2019; Carlu *et al.*, 2019). Primary salinization caused by salt formation factors in nature including dissolving minerals present in rock weathering, volcanoes, wind erosion, and death of living organisms, which transported by rain, rivers, groundwater, sea water and wind, then salts deposited in the soil (Montoroi, 2017). Secondary salinization is usually caused by human activities, through the accumulation of soluble salts in water, which resulted in deterioration or loss of some soil properties (Cuevas *et al.*, 2019). Salinization is also brought up from improper irrigation for instance applying low water qualities and salt polluted rainfalls, particularly in dryland cultivation systems, where water shortages (Cuevas *et al.*, 2019). Magnetic field called was found to improve the physical, chemical and biological properties of water in many different cases, despite it using for decades, still some scientists consider it pseudoscience. However, some still believe it a beneficial effect on plant performance (McMahon, 2009). Definite evidence for magnetic water mechanisms has not been established yet. However, some reported significant improvements in seed germination, growth, physiological processes and outcomes (Alderfasi *et al.,* 2016). Ahmed and Abd EL-kader (2016) obtained a decrease in soil salinity when irrigating with highly purified magnetized water (1000 gauss) compared to untreated water.

Materials and Methods

A field experiment was carried out at Al Bandar research station, Agriculture College, Al-Muthanna University, during 2017 -2018 potato growing season. Samawa is located at 31.3188°N, 45.280° E, 9m elevation. A bio digester (25.6m^3), where, 10% diluted buffalo waste mixed with water was added, on 2nd October 2018, with daily feeding of 80 kg mixed with 800 liters of water, addition was continued up to 10th. October 2018, addition was accompanied with the collection of biogases. Experimental area was plowed by the flip-flop plow to a depth of 30 cm, Soil samples were taken chemical and physical analysis (Table 1).

Table 1 : Soil chemical and physical properties of the cultivated field pre planting

Property	Values
$pH_{1:1}$	7.4
$EC_{1:1}$	5.9 dSm^{-1}
Ca soluble	3.57 $meqL^{-1}$
Mg soluble	12.08 $meqL^{-1}$
Na soluble	36.43 $meqL^{-1}$
K soluble	1.06 $meqL^{-1}$
CO_3 soluble	-
HCO_3 soluble	3.57 $meqL^{-1}$
SO_4 soluble	15.00 $meqL^{-1}$
Cl soluble	40.33 $meqL^{-1}$
Texture	Sandy Loam
Sand	720 gKg^{-1} soil
Silt	135 gKg^{-1} soil
Clay	145 gKg^{-1} soil

Water diluted buffalo waste was placed on nylon in a pile on 9th, May 2018, and the weekly stirred for 3 months. Finally, aerobically decomposed manure (A) was dried and used as, soil fertilizer at rate of 50 tonsha^{-1}. Whereas, organic waste (An) produced from the biological digester, which was fermented for 30 days, also applied as a fertilize at rate of 50 tons ha^{-1} (table 2). Drip irrigation was applied for each individual types of water namely Euphrates water, as a check treatment (N), Magnetized Euphrates water by 2000 gauss (M), Solid free solution extracted from bio digester mixed with Euphrates water 1:1(F), and Euphrates water compressed into biogas under pressure of 5 bars to 400 liters tanks possesses a side inlet at the bottom and 2 inlets at the top one for monitoring the water level in the tank and the other for bio gas extractions after purifications (A). 300 L tanks inlets were closed before it was filled with water, then biogas was compressed through the bottom inlet of the tanks, at pressure of 5 bars to dissolve the water-soluble gases, especially CO_2.

Table 2 : The applied organic fertilizers

Property	Units	Before decomposition	After decomposition	
			Aerobic	An aerobic
pH $_{1:10}$	-	7.8	7.7	7.6
EC $_{1:10}$	dSm^{-1}	15.8	15.9	5.8
Total nitrogen	%	1.55	1.44	1.42
Total phosphorus	%	0.47	1.58	0.71
Total potassium	%	1.20	0.92	1.19

Potato plants were fertilized by aerobically composed manure fertilizer(A), and anaerobically decomposed manure (An), besides unfertilized control (0), to represent factor B. pH soil, electrical conductivity, dissolved ions, including positive one's calcium, magnesium, potassium, sodium, and negative ions, such as carbonates, bicarbonate, chlorides, and sulfates were measured (Richards (1954). Strip Plot Design was selected to this trail, where collected data was analyzed with GenStat Statistical Program, version 12.

Results and Discussion

The effect of water quality on the salinity of soils and dissolved cations, calcium, magnesium, potassium and sodium in the soil

Water quality type F (table, 3) was superior in reducing soil salinity (4.13 dSm^{-1}), as compared to M and N water types (5.05 and 5.49 dSm^{-1}, respectively). However, insignificant differences were detected between F and A types of water. A water substantially exceeded N water. Insignificant differences were recorded among other treatments. Irrigation water qualities significant influenced the dissolved cations, particularly F1water quality F, since it gave the lowest dissolved calcium, when it was compared to A, M and N water qualities (7.07, 8.76, 9.61 and 10.45 meqL^{-1} respectively). Type A water significantly outperformed water quality N. However, insignificant differences were observed between M and N water types in term of dissolved calcium values.

Table 3 : Effect of water quality on soil salinity and dissolved Cations: Calcium, Magnesium, Potassium and Sodium.

Treatments	EC1:1	soluble Ca	soluble Mg	soluble Na	soluble K
	dS.m^{-1}	meq. l^{-1}			
N	5.49	10.45	10.22	27.23	3.92
M	5.05	9.61	10.17	27.10	2.50
A	4.45	8.76	8.59	24.09	2.99
F	4.13	7.07	5.87	21.51	6.07
L. S. D. 0.05	0.85	1.675	2.695	n. s.	1.184

Water types manifested substantial variations in soluble magnesium, where F type significantly profoundly reduced the soluble magnesium (5.87 meqL^{-1}), as compared to A, M and F types (8.59, 10.17 and 10.22 meqL^{-1}, respectively). Soil soluble potassium significantly increased as a result of irrigation types of water A, M and N (6.07, 2.99, 2.50 and 3. 92 meqL^{-1} respectively). Insignificant variations were detected among other treatments. Reductions in soil salinity that brought up by F water type might be attributed the ligand formations of organic acids with calcium, magnesium ions and their deposition, since calcium and magnesium concentrations were decreased (Table 3). Whereas, salinity reductions observed with type A water, in comparison to N can be referred to dissolution of some biogas components. Where, dissolution of some biogas compounds in water reduces the degree of water interaction (Hoyer *et al.*, 2016). As a carbon dioxide gas, carbonic acid is formed, according to the following formula (Bharagava, 2017): $CO_2 + H_2O \rightarrow H_2CO_3$

Since carbonic acid is a weak acid, then it will affect the dissolution of the salts in the soil solution and move with irrigation water to deeper layers. The reason for the superiority of water quality. Significant reductions in dissolved calcium and magnesium caused by water type F could be due to the high affinity for organic acids fore formation of ligands with calcium and magnesium, which reflected positively on reducing soil salinity, and increasing potassium solubility in soil.

Effect of irrigation water quality on soluble anions, bicarbonate, sulfate and chlorides in the soil

Water types had no substantial effects on soluble anions, bicarbonate, sulfate and chlorides (table 4).

Table 4 : Effect of irrigation water quality on soluble anions, bicarbonate, sulfate and chlorides

Treatments	HCO_3 soluble	SO_4 soluble	Cl soluble
	meq.l^{-1}		
N	4.99	27.46	20.74
M	4.47	27.81	20.18
A	4.59	25.06	15.43
F	5.37	18.52	15.10
L. S. D. 0.05	n. s.	n. s.	n. s.

The effect of organic fertilizers A and An on soil salinity and dissolved cations: calcium, magnesium, potassium and sodium

Organic fertilizers A and An slightly affected soil salinity and dissolved calcium and sodium, in comparison to control (Table 4). Organic fertilizer particularly A fertilizer, significantly affected, soluble potassium, their values for A, An, and 0 were (6.37, 3.14 and 2.09 meqL^{-1}, respectively), it is worthy to mention the insignificant differences between an and control.

Table 5 : Effect of organic fertilizers A and An on soil salinity and dissolved Cations: Calcium, Magnesium, Potassium and Sodium.

Treatments	EC1:1	soluble Ca	soluble Mg	soluble Na	soluble K
	dS.m^{-1}	meq.l^{-1}			
0	4.57	8.63	8.40	25.96	2.09
A	5.00	9.12	7.74	24.99	6.37
An	4.78	9.17	10.01	23.99	3.14
L. S. D. 0.05	n. s.	n. s.	1.034	n. s.	1.371

The increases in dissolved potassium caused by compost treatments A and An was due to the high potassium content of fertilizers their selves, because of hydrolysis, potassium ions was released to the soil solution, besides the replacements of potassium during organic decomposition by microorganisms. Additionally, organic acids such as humic acid, fulvic acid and humin might be played an important role in the supplement of potassium and other minerals to soil.

The effect of organic fertilizer A and An on soluble anions: bicarbonate, sulfate, and chlorides

Organic fertilizer A substantially exceeded An and 0 in terms of soluble bicarbonate, sulfate and chlorides (5.22, 4.93 and 4.43 meql^{-1} respectively). An organic fertilizer highly bypassed control (table, 6). Insignificant differences were detected among other treatments. The increase in the concentrations of dissolved bicarbonate caused by compost treatments A and An was due to the release of hydrogen ions from the active groups of organic acids and their association with carbonates and the formation of bicarbonate, according to the following formula: $H^+ + CO_3^{-2} \rightarrow HCO_3^-$

Bicarbonate can be formed from the respiration of microorganisms. Bicarbonate was gradually increased as the manure addition increased. Moreover, CO_2 increased owing to bacterial respirations, and thus solved carbon dioxide in water forming carbonic acid, according to the following formula: $CO_2 + H_2O \leftrightarrow H_2CO^3 \leftrightarrow HCO_3^- + H^+$

Table 6 : The effect of compost A and An on soluble anions: bicarbonate, sulfate, and chlorides

Treatments	HCO_3 soluble	SO_4 soluble	Cl soluble
	meq.l^{-1}		
0	4.43	26.33	16.51
A	5.22	24.20	18.91
An	4.93	23.61	18.17
L. S. D. 0.05	0.2409	n. s.	n. s.

Effect of interaction between different irrigation water quality and organic fertilizer A and An on soil salinity and dissolved cations: calcium, magnesium, sodium and potassium in the soil

Table (7) shows the effect of the interference between the quality of the different irrigation water and the organic fertilizer A and An in the soil salinity. The results of the statistical analysis showed that the interaction between the quality of the different irrigation water and the different organic fertilizer treatments did not significantly affect the electrical conductivity of the soil and the values of calcium and magnesium dissolved in the soil. The N*A interaction treatment (31.62 meqL^{-1}) significantly exceeded M*A, N*An, F*An, F*A, A*A, A*An, and F*0 (24.41, 23.17, 22.89, 21.99, and 21.95, 21.41 and 19.65 meqL^{-1}, respectively), in term of soil soluble sodium. Significant differences were also observed between the dual treatments M*An and F*0 (28.50 and 19.28.5 meqL^{-1}, respectively), M*0 and N*0 significantly bypassed F*0 (28.38, 26.89 and 19.65 meqL^{-1}, respectively). However, insignificant differences were found among N*A, A*0, M*An, M*0, N*0 and M*A (table, 7). Soil dissolved potassium (8.66 meqL^{-1}) was confined to F*A dual treatment, which substantially exceeded other treatments. N*A interaction treatment highly outperformed A*A, M*A, F*0, N*An, M*An, A*An, N*0, M*0, and A*0 (7.43, 5.91, 5.61, 3.79, 3.64, 2.56, 2.10, 1.99, 1.76, 1.61, and 1.36 meqL^{-1} respectively). In significant variations were detected among other dual interactions.

Table 7 : Effect of interaction between irrigation water qualities and organic fertilizer A and An on soil salinity, dissolved Cations, Calcium, Magnesium, Sodium and Potassium.

Treatments	EC1:1	soluble Ca	soluble Mg	soluble Na	soluble K
	dSm^{-1}	$meq.l^{-1}$			
N0	4.99	9.81	9.31	26.89	1.76
NA	6.36	11.12	10.47	31.62	7.43
Nan	5.13	10.43	10.89	23.17	2.56
M0	5.23	10.19	11.01	28.38	1.61
MA	4.56	8.76	7.41	24.41	3.79
Man	5.37	9.88	12.10	28.50	2.10
A0	4.49	8.73	7.62	28.91	1.36
AA	4.72	9.31	8.12	21.95	5.61
AAn	4.14	8.24	10.03	21.41	1.99
F0	3.56	5.79	5.65	19.65	3.64
FA	4.36	7.29	4.96	21.99	8.66
Fan	4.47	8.13	7.02	22.89	5.91
L. S. D. 0.05	n. s.	n. s.	n. s.	7.16	1.65

Effect of interaction between irrigation water quality and organic fertilizer A and An on soluble anions, bicarbonate, sulfate and chlorides

Soil soluble chlorides was significantly increased with N*A interaction treatment (29.04 $meqL^{-1}$), as it highly exceeded M*0, N*An, M*A, A*0, F*An, N*0, F*A, A*A, A*An, and F*0 dual treatments (18.97, 17.01, 17.01, 16.94, 16.5, 16. 16, 14.84, 14.76, 14.59 and 13.96 $meqL^{-1}$, respectively). Insignificant differences were found among other dual treatments (table, 8).

Table 8 : Effect of Interaction between Irrigation Water Quality and Organic Fertilizer A and An on Soluble Anions Bicarbonate, Sulfate and Chlorides

Treatments	HCO_3 soluble	SO_4 soluble	Cl soluble
	$meq.l^{-1}$		
N0	4.62	29.33	16.16
NA	5.35	21.72	29.04
NAn	5.01	31.32	17.01
M0	4.28	27.73	18.97
MA	4.50	32.35	17.01
MAn	4.64	23.35	24.57
A0	4.08	26.46	16.94
AA	5.30	21.89	14.76
AAn	4.40	26.84	14.59
F0	4.74	21.79	13.96
FA	5.72	20.85	14.84
FAn	5.65	12.92	16.50
L. S. D. 0.05	n. s.	n. s.	6.48

Biological digester seems to be very important for improving the soil properties. Irrigating with A and F combined with organic fertilizer A and their by-products of the biological digestion system improved the properties of agricultural soils and reduce environmental pollutants. Insignificant differences in most of the studied traits between compost A and An, indicated the efficacy of treating bio-digester for buffalo residues compared to air decomposition reducing duration from 90 days to 30 days. Additionally, to the advantages of released gases from air decomposition into the atmosphere and aggregating them in the digester system, as an alternative to renewable and sustainable energy.

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