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Effect of Bio-Digester Products, Organic Fertilization and Treated Irrigation Water on Soil Organic and Mineral Carbon

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Abstract

A field experiment was carried out at the second research station located in Al Bandar affiliated to the College of Agriculture / Al-Muthanna University. The experiment included two factors and three replications. The first factor included three treatments, which are: comparison without adding organic fertilizer (C), aerobic decomposing (A) and anaerobic decomposing (An). The second factor included 3 irrigation water treatments, which are: Euphrates water (E), Euphrates water used in biogas purification (P) and Euphrates water mixed with liquid fertilizer coming from the bio-digester in a ratio of 1: 1(F). The results showed that the quality of irrigation water did not significantly affect the values of total organic carbon, while the effect of organic fertilization was significant on the values of total organic carbon, as the two treatments An and A significantly outperformed treatment C, and the values reached 20.7, 18.8 and 11.8 $gmKg^{-1}$ respectively, while there were no significant differences between the treatments An and A, the interaction between irrigation water quality and organic fertilization did not affect the total organic carbon values statistically. The quality of irrigation water did not significantly affect the values of organic matter in the soil, while organic fertilization had a significant effect on the values of organic matter in the soil, as the treatments An and A were significantly superior to the treatment of C, and the values reached 35.7, 32.3 and 20.3 $gmKg^{-1}$ respectively, while there was no Significant differences between the two treatments An and A. The quality of irrigation water and organic fertilization and the interaction between them did not affect the values of lime and active lime in the soil.
Keywords: irrigation, organic matter, bio-digester

Introduction

Soil carbon including two parts: organic and inorganic. Soil organic matter is at the core of soil quality, and is important for soil fertility, sustainable agricultural systems, climate change, and many other factors related to the survival and development of land and humans (Wang et al., 2019). Soil organic carbon is one of the parts of the carbon cycle in nature, which includes the carbon cycle through soil, vegetation, oceans and the atmosphere, autotrophic organisms as well as chemical and photosynthetic autotrophs convert carbon dioxide into organic matter from the atmosphere, and dead organic materials are mixed with Soils by soil organisms, and non-autotrophic organisms decompose organic matter and release carbon into the soil from the process of decomposition (Clara et al., 2017). It can bind with soil minerals and encapsulate within soil aggregates, in this way, soil organic carbon can remain in the soil for decades, centuries, or even thousands of years (Schmidt et al., 2011). The decomposition of soil organic matter is one of the main methods to release CO2 into the atmosphere from soil, and thus it has a major impact on global climate change, the stability of soil organic carbon depends largely on the complex relationship between soil organic matter and mineral composition in the soil (Yang et al., 2021). Soil organic carbon storage levels can be controlled mainly through managing the quantity and quality of organic waste that is added to the soil and reducing the amount of carbon lost (FAO and ITPS, 2015). One of the main factors that must be taken into consideration in the process of anaerobic decomposition

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of organic matter is the volume of organic waste, its content of bioenergy and its biodegradation, anaerobic digestion is a process in which a multitude of microbes work together in a sequential manner to convert a portion of organic matter into biogas, Complex organic materials present in animal waste and other biomass sources are broken down by microorganisms in the absence of oxygen (Shelford et al., 2019). The products of bio-digester are very important in improving soil properties, as the water used to purify biogas, its used irrigation and the use of liquid and solid organic fertilizer coming from the bio-digester to soil fertilization, it can be used to sequester carbon, improve agricultural soil properties, reduce environmental pollutants, and take advantage of biogas as an alternative to renewable and sustainable energy (AL-Zubaidi and Saad, 2020a). It is environmentally, agricultural and economically important to establish bio-digester systems because of its benefit in improving organic waste management and its positive impact on plant growth (AL-Zubaidi and Saad, 2020b).

Limestone is common in arid and semi-arid regions, and has a high calcium carbonate content (Wahba et al., 2019). Limestone soils constitute more than a third of the land area, usually the degree of reaction of these soils is more than 7 and may reach 8.5, and when this soil contains sodium carbonate, the pH may exceed 9, so the calcareous soil is defined as soil that contains relatively large amounts of Calcium carbonate, which affects soil properties related to plant growth, as plants suffer from a decrease in phosphorous and potassium availability (Taalab et al., 2019). Calcareous soils often negatively affect root growth through the formation of a solid surface crust on the soil surface, and reduce the ability of the soil to retain water, and it is often low in the content of organic matter and available nitrogen, a high pH level leads to the unavailability of phosphates (formation Unavailable calcium phosphate as apatite) usually reduces the availability of most micronutrients, and problems with potassium and magnesium feeding due to nutritional imbalances between nutrients (Wahba et al., 2019).

Therefore, the aim of the experiment is the possibility of reserving organic carbon in the soil and the extent of its effect on soil organic and mineral carbon.

Materials and Methods

A field experiment was carried out at the Second Agricultural Experiments Research Station of the College of Agriculture - Al-Muthanna University, located at a longitude of 45◦ 18 '12.33 "east and latitude 19 31" 10.89 "north. The soil was prepared for cultivation on 2/8/2018, and a soil sample was taken to conduct some chemical and physical analyzes for it, as shown in Table (1). crop potatoes was planted.

The buffalo manure was placed in a pile and moistened and turned over weekly for 3 months for the purpose of aerobic decomposition. Fertilizer was added to the experimental units at a rate 50 Mg ha^{-1}, its symbol (A) and table (2) showing some of its characteristics. As for the anaerobic decomposition of the buffalo wastes, they were added to the bio digester for a 30-day fermentation period, with a solid-to-liquid ratio of 10%, and after separating the solid fertilizer from the liquid, a symbol for solid fertilizer (An), and Table (2) shows some of its characteristics.

The experiment included two factors: The first factor included three factors: comparison without adding organic fertilizer (C), aerobic decomposition (A) for buffalo manure and anaerobic decomposition (An) for buffalo manure. The second factor included three irrigation water treatments, which are: Euphrates water (E), Euphrates water used in purifying biogas by compressing it in a tank with biogas at a pressure of 5 bar, to dissolve gases that are soluble in water, in order to purify biogas, its symbol (P), the water of the Euphrates River mixed with liquid manure coming out of the bio-digester in a ratio of 1: 1

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(F). Data were collected and analyzed and statistically analyzed with GenStat V12 software, according to Strip Block Design.

Table (1) Some chemical and physical properties of field soil before planting

Properties	Values	Units	References
pH 1:1	7.4	-	Richards (1954)
EC1:1	5.9	dSm^{-1}	Richards (1954)
Mineral Carbonates	190	$g.Kg^{-1}$	Balazs et al. (2005)
Active carbon	19		Jackson (1985)
Total organic carbon	10		Estefan et al. (2013)
Organic matter	17		Walkley and Black (1934)
Available N	49.0		Bremner and Keeney (1965)
Available P	23.6		Olsen et al. (1954)
Available K	116.1		Martin and Sparks (1983)
Sand	720		Bouyoucos (1962)
Silt	135		
Clay	145		
Texture	Sandy Loam	-	

Table (2) Some Properties of the organic fertilizers used in the study

Properties	Aerobic decomposition(A)	Anaerobic decomposition (An)	Unites	References
Total Organic Carbon	34.4	31.6	%	Estefan et al. (2013)
Organic Matter	59.3	54.4		Faithfull (2002)
C/N ratio	23.9	22.2		

Results

Table (3) shows effect of the quality of irrigation water and organic fertilizer and the interaction between them on the percentage values of total organic carbon. The results of the statistical analysis showed that the quality of irrigation water did not significantly affect the values of total organic carbon, while the effect of organic fertilization was significant on the values of total organic carbon, as the two treatments An and A significantly outperformed treatment C, and the values reached 20.7, 18.8 and 11.8 $gmKg^{-1}$ respectively, and the increase in treatment An was 75.4% over treatment C, while the increase was 59.3% for treatment A over treatment C, while there were no differences significance between An and A treatments. While the interaction between irrigation water quality and organic fertilizer did not affect the total organic carbon values statistically.

Table (3) effect of irrigation water quality, the organic fertilization and their interaction on the percentage values of total organic carbon ($g.\ Kg^{-1}$).

Treatments	E	F	P	Average
C	11.6	11.8	12	11.8
A	17.7	17.7	20.9	18.8
An	18.7	19	24.5	20.7
average	16	16.1	19.1	
LSD 0.05	Irrigation water	Organic fertilization	Interaction	
	n. s.	0.26	n. s.	

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Table (4) shows the effect of the quality of irrigation water, organic matter and the interaction between them on the percentage values of organic matter, as the results of the statistical analysis showed that the quality of irrigation water did not have a significant effect on the values of organic matter in the soil, while organic fertilization had a significant effect on the values of organic matter in the soil , as the two treatments An and A significantly outperformed treatment C, and the values reached 35.7, 32.3 and 20.3 $gmKg^{-1}$ respectively, the percentage increase for treatment An was 75.9% over treatment C, while the percentage of increase was 59.1% for transaction A over treatment C, while there was no Significant differences between the two treatments An and A. There were no significant differences for the interaction between irrigation water quality and organic fertilization in the values of soil organic matter.

Table (4) effect of irrigation water quality, organic fertilization and their interaction on the percentage values of organic matter (g. Kg^{-1}).

Treatments	E	F	P	Average
C	20.7	20	20.3	20.3
A	36.1	30.5	30.4	32.3
An	42.2	32.2	32.8	35.7
average	19.1	16	16.1	
LSD 0.05	Irrigation water	Organic fertilization	Interaction	
	n. s.	0.45	n. s.	

Table (5) shows the effect of irrigation water quality and organic fertilization and their interaction on the percentage of lime percentage in the soil. The results of the statistical analysis showed that the types of irrigation water and organic fertilizer and the interaction between them did not statistically affect the values of lime in the soil.

Table (5) effect of irrigation water quality, organic fertilization and their interaction on the percentage of lime percentage in the soil (g. Kg^{-1})

Treatments	E	F	P	average
C	165.6	219.4	187.1	190.7
A	176.4	230.2	168.3	191.6
An	197.9	179.1	181.7	186.2
average	179.9	209.6	179.1	
LSD 0.05	Irrigation water	Organic fertilization	Interaction	
	n. s.	n. s.	n. s.	

Table (5) shows the effect of irrigation water quality and organic fertilization and their interaction on the percentage of lime in the soil. The results of the statistical analysis showed that the types of irrigation water, organic fertilization and the interaction between them did not statistically influence the values of active lime in the soil.

Table (6) effect of irrigation water quality, organic fertilization and their interaction on the values of active lime (g. Kg^{-1})

Treatments	E	F	P	average
C	15.5	32.0	39.7	29.1
A	23.5	35.5	24.3	27.8
An	18.8	26.2	39.2	28.1
average	19.3	31.2	34.4	

LSD 0.05	Irrigation water	Organic fertilization	Interaction	
	n. s.	n. s.	n. s.	

Discussion

It is known that organic fertilization has positive effects in improving soil properties and plant growth, and it is noted from Table (3 and 4) that organic fertilization has increased the percentage of total organic carbon and organic matter in the soil, and it is important to focus on anaerobic decomposition for organic matter (An), which gave an increase in total organic carbon and organic matter in the soil by 10.1% and 10.5% compared to aerobic compost (A). In addition to this, renewable energy (biogas) and solid and liquid organic fertilizers can be obtained, in addition to biogas purification by compressing Biogas to water to dissolve gases that are soluble in water and these gases are CO2, N_2O, H_2S and others (these gases cause acidity of water), and the use of this water in irrigation, instead of losing the gases resulting from the aerobic decomposition of organic fertilizer to the atmosphere and increasing the problem of global warming. The anaerobic decomposition of organic materials may contribute to reducing this phenomenon, benefiting from the products of bio-digesters, sequestering carbon in the soil, and supporting the development of sustainable agriculture.

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