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Study of the effect of tillage systems and liquid organic fertilizers on some physical properties of soil

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Abstract:

A field experiment was conducted to study the role of tillage systems and organic fertilizer in some physical properties of soil planted with wheat crop. The treatments of the first factor included zero tillage (P_1), vertical disc plow((P_3). As for the second factor, it included three P_2) and moldboard plow treatments of liquid organic fertilizer produced from the biodigester, in addition to two comparison treatments of chemical fertilizer. The first comparison treatment is half the chemical fertilizer recommendation for the wheat crop and its (L_1), the second comparison treatment is the full chemical fertilizer recommendation for the wheat crop and its symbol is(L_2), and liquid organic fertilizer at a concentration of 4, 8, and 12% and the symbols were taken(L_3),(L_4), and(L_5) in sequence. The study employed a Split Plot Design inside a Randomized Complete Block Design (RCBD) including three replicates. The findings indicated that both the plow and disc plow considerably surpassed zero tillage in terms of bulk density, porosity, moisture content, and soil water holding capacity. The liquid organic fertilizer also outperformed the comparison treatment at all levels of addition in the trait of bulk density, porosity, moisture

content and soil water holding capacity. The interaction between the factors also outperformed the comparison treatment in all studied traits.

Key word: plow and liquid organic fertilizer

Introduction

The term tillage includes a set of operations that are applied before planting, to prepare the soil for crop growth. These operations use different types of tools and machines to loosen, turn and mix the soil, modify the soil surface and change its volume, incorporate fertilizers, soil conditioners and crop residues with the soil, eliminate weeds and prepare the soil for seed placement [1]. The selection of the tillage machine or the inappropriate depth of the plow negatively affects the soil properties such as soil compaction or compaction, increasing its bulk density, etc. Zero tillage involves planting crop seeds by simply covering the seeds in the soil without preparing the land in advance. It positively affects the soil properties, conserves natural resources, biodiversity and labor, increases available soil moisture, reduces heat and drought stress, etc. Zero tillage is the process of placing seeds in narrow furrows in the soil by means of an agricultural machine without prior tillage of the soil, leaving the remains of the previous crop on the soil surface. Zero tillage reduces soil preparation processes and thus reduces economic costs by reducing the time required for cultivation and labor [5]. It also improves water use efficiency [6]. Organic fertilizers are environmentally friendly as they depend on the use of animal or plant waste such as (sheep or poultry waste or green manures). Therefore, organic matter can be defined as a complex mixture of materials remaining in the soil from plant and animal waste and soil microorganisms. Since ancient times, humans have known the importance of organic fertilizers and their role in improving soil fertility and increasing productivity, as farmers used to add animal and plant waste after collecting, mixing and leaving it to decompose for a period of time. Iraqi soils are low in organic matter content, maintaining appropriate levels of organic matter in the soil has become a goal in itself, due to its importance in agricultural production and soil conservation. Organic materials incorporated into the soil, including plant and animal waste, significantly influence the physical properties of the soil by enhancing soil structure, increasing the stability of soil aggregates, improving water holding

capacity, and safeguarding the soil surface from erosion and displacement [10]. The mixture of solid and liquid organic fertilizer is a by-product of anaerobic biodigester, and can be used to improve crop productivity directly or added with other organic materials or synthetic fertilizers [7]. Therefore, the aim of the study is to know the effect of tillage systems and liquid organic fertilizer on some physical soil properties.

Materials and methods

A field experiment was carried out in one of the fields located in the Abu Juwaylana area, which is 5 km away from the center of Al-Muthanna Governorate, during the winter season 2022-2023. Composite random samples were collected from several soil sites at a depth of 0.3 m prior to planting, thoroughly mixed for uniformity, air-dried, refined, and sieved through a 2 mm for further chemical and physical analyses, as detailed in Table (1).

Table [1] some chemical and physical properties of the field soil before planting

Properties	Values	Units
pH 1:1	7.5	-
EC 1:1	5.7	dSm^{-1}
Organic Matter	0.95	%
Bulk density	1.35	Mgm^{-3}
True density	2.61	Mgm^{-3}
Soil Separates		
Sand	22	%
Silt	50	
Clay	28	
Soil Texture	Silty Clay Loam	

Two tanks with a capacity of 5000 liters were prepared, and poultry waste was added to them at a concentration of 15% solids to liquid, on 9/1/2023. The opening of each tank was tightly closed from the top, with a tap connected by a plastic pipe to a rubber tank. The mixture of poultry waste and water was left to ferment for 60 days. The liquid organic fertilizer was separated from the solid, and the liquid fertilizer was used within the experimental parameters. Table [2] shows some of the characteristics of the liquid fertilizer.

Table [2] some specifications of the liquid fertilizer used in the study.

Characteristics	Value	Unit
pH1:5	7.1	-
EC1:5	8.12	dSm^{-1}
Soluble N	1.93	ppm
Soluble P	1.34	
Soluble K	1.06	

The first factor included the tillage systems and included a no-tillage treatment, a vertical disc plow treatment and a moldboard plow treatment, and took the symbols P_1, P_2 and P_3 respectively. The second factor included the liquid organic fertilizer treatments in addition to the two comparison treatments, which are the first comparison treatment (half the recommendation of chemical fertilizer), the second comparison treatment (full recommendation of chemical fertilizer), the liquid organic fertilizer treatment resulting from the biodigester at a concentration of 4, 8 and 12% respectively, and L_1, L_2, L_3, L_4 and L_5 respectively, noting that the liquid organic fertilizer treatments were added with half the recommendation of chemical fertilizer. The field received fertilization based on the following recommendations: nitrogen as urea 46% at 200 kg ha-1, phosphorus as triple superphosphate 21% at 120 kg ha-1, and potassium as potassium sulfate 42% at 100 kg ha-1, for fully recommended plots, alongside half the recommendation per the experimental parameters. The area was partitioned into three sectors including 15 experimental units, with a separation of 0.7 m between each unit and 1 m between sectors, while each experimental unit covered an area of 4 m². Wheat seeds, Buhuth 22 variety, were planted on 11/19/2023, and harvested on 4/16/2024. After harvest, composite soil samples were taken from each plot for the purpose of conducting the required analyses. Soil pH, electrical conductivity, soluble potassium, were determined in a 1:1 extract according to the method described in [9]. Soluble nitrogen [4].Soluble phosphorus [8]. Soil separates estimated according to the hydrometer method [3]. Porosity, Bulk density and True density were determined according to [2].

Results

1- Bulk density

The results of Table [3] showed that the tillage systems had a significant effect on the bulk density values, as treatment P_3 significantly outperformed parameters P_2 and P_1, and the values were 1.288, 1.369, and 1.421 Mgm^{-3}, respectively. Also, treatment P_2 significantly outperformed treatment P_1. It is

could be due to the fact that tillage has a part in increasing the volume of the soil and breaking it up, which will ultimately result in a decrease in the density of the soil. The results showed that the liquid organic fertilizer had a significant effect in reducing the bulk density values, as treatment L_5 recorded the lowest significant value of 1.346 Mgm^{-3} compared to treatments L_4, L_3, L_2 and L_1, and the values reached 1.352, 1.357, 1.371 and 1.371 Mgm^{-3}, respectively. Also, treatment L_4 outperformed treatments L_3, L_2 and L_1, and treatment L_3 outperformed treatments L_2 and L_1, while there were no significant differences between treatments L_2 and L_1. The results also showed that the interaction between tillage systems and liquid organic fertilizer had a significant effect on the bulk density values of the soil, as the interaction treatment P_3L_5 recorded the lowest significant value compared to the interaction treatment P_1L_1, and their values were 1.288 and 1.288 Mgm^{-3}, respectively.

Table (3) Effect of tillage systems, liquid organic fertilizer and their interaction on bulk density (Mgm^{-3})

Treatments	P_1	P_2	P_3	Mean L
L_1	1.428	1.387	1.296	1.371
L_2	1.428	1.387	1.297	1.371
L_3	1.419	1.364	1.290	1.357
L_4	1.416	1.358	1.281	1.352
L_5	1.415	1.348	1.275	1.346
Mean P	1.421	1.369	1.288	
	P	L	L * P	
L.S.D.0.05	0.004016	0.00377	0.006528	

2- Soil porosity

The porosity of the soil was significantly influenced by the tillage systems, as indicated by the results of Table [4]. Treatment P_3 exhibited the maximum significant value for porosity in comparison to treatments P_2 and P_1, and the values reached 50.65, 47.56, and 45.55, respectively. Treatment P_2 also outperformed treatment P_1 significantly. Additionally, the findings of the investigation demonstrated that the application of organic fertilizer had a noteworthy impact on the overall porosity values of the soil, as treatment L_5 recorded the highest significant value, outperforming treatments L_4, L_3, L_2, and L_1, and the values reached 48.43, 48.21, 48.00, 47.48, and 47.49%, respectively. Treatment L_4 also outperformed L_3, L_2, and L_1

significantly, and treatment L_3 also outperformed L_2 and L_1 significantly, while treatment L_2 did not outperform treatment L_1 significantly. The findings indicated that the interplay between tillage systems and liquid organic fertilizer significantly influenced porosity values, with the interaction treatment P_3L_5 achieving the highest value of 51.16%, while the interaction treatment P_1L_1 recorded the lowest value of 45.28%. A substantial negative correlation of -1.0 exists between perceived density and soil porosity [Table 7].

Table [4] Effect of tillage systems, liquid organic fertilizer and their interaction on soil porosity (%)

Treatments	P_1	P_2	P_3	Mean L
L_1	45.28	46.86	50.33	47.49
L_2	45.28	46.85	50.30	47.48
L_3	45.64	47.76	50.58	48.00
L4	45.75	47.96	50.90	48.21
L_5	45.79	48.35	51.16	48.43
Mean P	45.55	47.56	50.65	
	P	L	L * P	
L.S.D.0.05	0.1539	0.1447	0.2501	

3- Soil moisture content

The results of Table [5] showed that the tillage systems had a significant effect on the soil moisture content values, as treatment P_3 outperformed by recording the highest value of 12.11% compared to treatments P_2 and P_1, which reached 10.98 and 7.38%, and treatment P_2 also outperformed treatment P_1 significantly. The reason may be that tillage with the plow was deeper, which led to water seepage and storage in the soil, in addition to the role of weather conditions (such as temperature and wind) that helped increase evaporation rates from the soil surface. The results also showed that liquid organic fertilizer had a significant effect on the moisture content, as treatment L_5 recorded the highest significant value of 11.89%, outperforming treatments L_4, L_3, L_2 and L_1, and the values reached 10.89, 9.81, 9.39 and 8.79%, respectively. Treatment L_4 also significantly outperformed treatments L_3, L_2 and L_1, and treatment L_3 outperformed treatments L_2 and L_1, and treatment

L_2 outperformed treatment L_1. There is a significant inverse correlation between moisture content and bulk soil density of -0.85 [Table 7], and there is also a significant positive correlation between soil moisture content and soil porosity of 0.85 [Table 7].

Table [5] Effect of tillage systems, liquid organic fertilizer and their interaction on moisture content (%)

Treatments	P_1	P_2	P_3	Mean L
L_1	6.33	9.90	10.13	8.79
L_2	6.75	10.49	10.92	9.39
L_3	7.21	10.65	11.55	9.81
L_4	7.98	11.10	13.59	10.89
L_5	8.62	12.73	14.33	11.89
Mean P	7.38	10.98	12.11	
	P	L	L *P	
L.S.D.0.05	0.247	0.2746	0.4599	

5- Water holding capacity

The results of Table [6] showed that the tillage systems had a significant effect on the soil water holding capacity, as treatment P_3 gave the highest value of 24.44 hours, thus outperforming treatments P_2 and P_1, whose values reached 21.18 and 18.77 hours, respectively. Treatment P_2 was also significantly superior to treatment P_1, which may be because deeper plowing resulted in lower soil bulk density (Table 3), which led to an increase in the soil water holding. The correlation between the soil water holding capacity and the bulk density was a significant negative correlation of -0.94 [Table 7]. Additionally, the findings demonstrated that the application of liquid organic fertilizer had a noteworthy impact on the results of the soil water holding capacity measurements, as treatment L_5 recorded the highest value of 22.02 hours compared to treatments L_4, L_3, L_2 and L_1, and the values reached 22.12, 21.43, 21.27 and 20.49 hours, respectively. Treatment L_4 also significantly outperformed treatments L_3, L_2 and L_1, and treatment L_3 outperformed treatments L_2 and L_1. Treatment L_2 also outperformed L_1, and the reason may be attributed to the role of organic matter in increasing the soil's ability to retain water, by improving soil structure and reducing bulk density [Table 3]. As

for the interaction between tillage systems and liquid organic fertilizer on the soil water holding capacity, it had a significant effect, as the interaction treatment P_3L_4 gave the highest value of 25.91 hours compared to the treatment P_1L_1, which recorded the lowest value of 16.92 hours.

Table [6] Effect of tillage systems, liquid organic fertilizer and their interaction on soil water holding capacity (hour)

Treatments	P_1	P_2	P_3	Mean L
L_1	16.92	21.10	23.46	20.49
L_2	19.06	21.27	23.47	21.27
L_3	19.42	21.42	23.46	21.43
L_4	19.25	21.19	25.91	22.12
L_5	19.22	20.94	25.90	22.02
Mean P	18.77	21.18	24.44	
	P	L	L * P	
L.S.D.0.05	0.123	0.2343	0.3724	

Table [7] Correlation between the studied traits

Correlation	Water holding capacity	Moisture content	Bulk density	Porosity
Water holding capacity	1.00			
Moisture content	0.87	1.00		
Bulk density	-0.94	-0.85	1.00	
Porosity	0.94	0.85	-1.00	1.00

Conclusions

Although many scientific sources encourage the use of zero tillage, the evidence obtained in our research does not support this trend, and that tillage led to better results in the values of bulk density, porosity, soil moisture content and soil water holding capacity under the conditions of this experiment located in the dry region. It is noted that liquid organic fertilizer is very effective in improving all physical properties of the soil, and its importance is no less than solid organic fertilizer, so we encourage farmers to pay attention to this type

of fertilizer and add it to agricultural soil to get rid of bad odors and prevent the accumulation of insects and the transmission of diseases, thus preserving the environment and managing resources better.

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