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The Influence of Some Secondary Tillage Implement and Mixing Organic Residues on Some Physical Properties of Soil at the Beginning and End of the Oat (*Triticum aestivum* L.) Growing Season

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Abstract. The study was conducted in one of the fields affiliated to the Agricultural Research Station at the University of Basra, Karmat Ali site. The agricultural field experiment was carried out by dividing the field land according to the Randomized Complete Block Design (RCBD) in a one-time split plots design, where the main plots represent smoothing machines and sub-plots, the levels of organic residues and three replicators. The soil was plowed with a moldboard plow at a depth of 25-30 cm, and the organic residues were mixed with the soil by use of secondary tillage equipment. While the area of the experimental unit was (150 * 250) cm^2, a distance of 2m was left between the experimental sectors and units to ensure that there was no overlap between the treatments. Seeds of oats were planted for all experimental units after the implementation of the treatments and at a seeding rate according to the recommendation followed in the region. Soil characteristics are measured for depths (0-15, 15-30) cm and for two periods (beginning and end of the plant growing season), and plant growth and yield indicators are measured at the end of the growing season. The aim of the research is to study the effect of adding levels of manure residues mixed with the surface layer in different ways on soil characteristics at the beginning and end of the oat crop growing season. The results of the experiment indicate the superiority of the spring cultivator and the percentage of adding organic residues (40 tons. Ha^{-1}) over the rest of the machines and fertilization treatments by achieving the lowest apparent density at the beginning and end of the oats growing season, which amounted to 0.992 and 1.113 Mg m^{-3}, respectively. In addition, they have achieved the highest the percentage of total porosity was 62.56 and 57.97 %, respectively. It also gave the highest weighted average diameter, which reached 0.859 and 0.688 mm, respectively. In addition, it gave the lowest soil penetration resistance, which reached 0.887 and 1.130 MPa, respectively.

Keywords. Disc harrows, Axe harrows, Spring cultivator, Rotary plough, Bulk density.

1. Introduction

The use of agricultural mechanization in an integrated manner in the performance of agricultural operations has achieved a great leap in agricultural production in terms of quantity and quality by conducting plowing operations with multiple systems and performing smoothing operations. The optimum selection of tillage equipment maintains the soil quality characteristics, and if such equipment is not selected correctly, this leads to negative effects on the physical and biological characteristics of the soil and makes it unsuitable for plant growth. The process of plowing the soil is defined as the process by which the soil can be reconstituted to prepare a suitable bed for the germination and growth of seeds [1]. Secondary soil preparation equipment is the machines that are used immediately after the plowing process to soften and compress suitable for the seed bed to an appropriate degree of cohesion of the soil granules so that there is a balance between the amount of water and air for the seed that will be placed in the soil in addition to killing weeds [2].

The bulk density is one of the important characteristics affected by soil management processes, especially tillage and smoothing, as the plowing and smoothing change the bulk density of the soil in a very large way, and that this change lasts for a long or short period depending on several factors, including soil texture and type of plow or smoothing machine or other machines. As well as the nature of the agricultural process. By definition, it is the mass of a unit volume of dry soil, and it is measured in ($gm.cm^{-3}$), and the volume here includes both the solid and the interspaces [3]. In a study in which primary and secondary soil preparation equipment was used in two types of soils (silty loam and clay) when plowing at a depth of 20 cm that the moldboard plow achieved the highest bulk density of 1.32 and 1.36 $Mg.m^{-3}$ for both types of soils on the respectively, while the suspended and pulled disc harrows recorded a lower density of 1.14, 1.25 $Mg.m^{-3}$ for silty loam soil and 1.26, 1.28 $Mg.m^{-3}$ for clay soil for both harrows, respectively. It was also found that the moldboard plow gave less porosity, which was 5.27 % and 48.80% for both types of soils, respectively, while the suspended and drawn disc harrow recorded a higher porosity of 57.10% and 52.75% for silty loam and 52.36% and 51.53% for clay soil for both harrows, respectively [4]. In a study that included the addition of organic residues at the level (0, 10, 20, 40 tons ha-1) mixed with the soil in a silty mixture, the bulk density of the soil decreased significantly at the depth 0-20 cm at the end of the maize season with the addition of the residues, as the density values reached Apparent 1.35, 1.27, 1.25, and 1.21 Mg m^{-3} respectively, and he explained this to the effect of animal waste through an increase in the average weighted diameter and soil aggregates greater than 1 mm and a decrease in the density of organic matter compared to the bulk density of soil, which led to a decrease in the values of the bulk density. Animal waste is a food source for soil microorganisms that improve soil structure by linking soil particles through hygroscopic and secretions resulting from decomposition and the formation of soil aggregates, thus reducing its bulk density [5]. The bulk density is one of the important characteristics affected by the processes of soil stirring, especially tillage and smoothing, as the plowing and smoothing change the value of the bulk density of the soil in a very large way, and that this change lasts for a long or short period depending on several factors, including soil texture and type of plow or smoothing machine or machinery. As well as the nature of the agricultural process. Density can be used to determine the degree of compression, and to detect compressed sites in agricultural fields [6]. In studying the effect of plowing depth on the bulk density, it showed that there are highly significant differences in depth of 20 and 30 cm in the Shatt Al-Arab site between the values of the bulk density during the experiment period. The highest bulk density recorded before tillage was 15.385%, 11.349% and 12.712% higher after tillage and 7.362%, 4.000% and 3.502% higher after harvest at depths of 10, 20 and 30 cm, respectively. At Al-Qorna district site, the bulk density before tillage was 16.481, 12.500 and 15.086% higher than after tillage and 7.172, 3.012 and 5.743% higher than after harvest for depths of 10, 20 and 30 cm, respectively. They attributed the reason for the decrease in bulk density after plowing to loosening of the soil, crushing and softening of soil masses, and an increase in the pores between the soil grains. The addition of organic residues also reduces the bulk density of the soil, as its density is low which leads to a lower density of the soil [7].

Soil resistance to penetration is a measure of soil hardness, as increasing soil resistance to penetration hinders the spread of roots in the soil, and conducting plowing operations reduces soil resistance to penetration and increases the spread of roots in the soil [8]. Study [9] the effect of using two systems of plowing (minimum plowing using disc harrows at a depth of 10 cm and conventional plowing at a depth of 20 cm using a digger plow) on the soil’s resistance to penetration in a sandy loam and they found that conventional tillage outperformed minimum tillage in recording the lowest penetration resistance, as it reached at depth 0-20 cm it was 783, 1127 kN m^{-2} for both conventional and minimum tillage, respectively, while it reached at depth 0-35 cm it was 912, 1203 kN m^{-2}, respectively. [10] Also studied the effect of adding plant and animal residues at a rate of 0.6% in the soil of a silty clay mixture, and they noticed a decrease in the rate of soil resistance to penetration with the addition of plant and animal residues. When the comparison treatment achieved 260.50 KN.m^{-2}, they attributed this to the role of organic residues in decreasing the bulk density of the soil, which in turn reduced the soil's resistance to penetration.

2. Material and Methods

2.1. The Experiment Design

The agricultural experiment was conducted during the fall agricultural season in 2021 at the Agricultural Research Station of the College of Agriculture - Basra University - Karmat Ali. The experiment was conducted on the texture of clay loam soil. The soil was plowed to a depth of 30 cm by a moldboard plow, and then the organic residues were added to the soil in proportions (0, 20, 40 tons ha^{-1}) randomly according to the design of the complete random sectors in a one-time split method. The organic residues were mixed with the soil by four types of secondary preparation equipment of soil, which is as follows: disc harrows, Axe harrows, spring cultivators and rotary plows. Data was analyzed quantifiably with examination of contrast (ANOVA) system using Genstat v. 12. A difference among treatments infers were surveyed with the most un-huge differentiation (LSD) test recognized at 5% likelihood. Table 1 shows the physical and chemical properties of the soil used for research before plowing, and Table 2 shows the physical and chemical properties of the manure residues.

Table 1. The physical and chemical properties of the soil.

Soil properties			**Soil depth (cm)**	
			0-15	**15-30**
Soil Separators	Sand	gm. kg^{-1}	202.39	183.48
	Silt		587.91	594.97
	Clay		209.70	221.73
soil texture			Silty loam	Silty loam
Dry bulk density		Mg.m^{-3}	1.27	1.34
Particle density			2.61	2.66
Porosity		%	51.34	49.62
Soil moisture		%	21.46	26.17
Mean Weight Diameter		mm	0.291	0.265
Soil resistance to penetration		MN m^{-2}	2.47	3.28

Table 2. The physical and chemical properties of the manure residues used.

characteristics	**Units**	**Values**
Bulk density	Mg cm^{-3}	0.49
Organic Matter	gm kg^{-1}	393.16
C/N ratio	---	9.65
EC	ds m^{-1}	11.93

2.1.1. Moldboard Plough

A mounted moldboard furrow was used in the audit. The wrinkle judgments are: weight 220 kg, width 1.05 m, and includes three moldboards (all around valuable) of 35 cm width for each moldboard.

2.1.2. Mounted Disc Harrows, Axe Harrows, Spring Cultivator, Rotary Plough

was utilized to friability soil block after soil tilth by moldboard furrow.

2.1.3. Tractors

MF 440 xtra tractors was given diesel engine of 77 kW (4 cylinders).

2.2. Measuring the Physical Properties of the Soil

2.2.1. Dry Bulk Density

The bulk density of the soil was estimated by the core sample method and was calculated from the following equation after drying the soil samples in the oven at a temperature of 105°C until the weight was stabilized according to the method described by [11].

$$\boldsymbol{\rho}\mathrm{b} = \frac{\mathrm{Ms}}{\mathrm{V}}$$

Where:
$\boldsymbol{\rho}$b= Dry bulk density (gm. cm^{-3})
Ms= Mass of dry soil particles (gm.)
V= the total volume of the soil is the volume of a cylinder (cm^3)

2.2.2. Total Porosity

The total porosity of the soil was calculated from the following equation and according to the method presented in [11].

$$\mathrm{f} = \left(1 - \frac{\rho b}{\rho s}\right) \times 100\ \%$$

Where:
f= Total porosity (%)
$\boldsymbol{\rho}$b= Particle density (gm. cm^{-3})

2.2.3. Mean Weight Diameter (MWD)

The mean weight diameter was measured using the wet sieving method, by passing air-dried soil samples through a sieve with holes diameter of 8 mm and they were received on a sieve with holes diameter of 4 mm, then the weight of 25 g of soil sample was taken over a 4 mm sieve and capillary moistened for six minutes and then transferred to a set of sieves with diameters of 0.25, 0.5, 1.0, 2.0 and 4.0 mm. The sieving process was carried out by wet sieving method for a period of six minutes using a wet sieving device with water vibration type (Retsch As200, 2009) at a shaking speed of 60 rpm^{-1}; the water discharge through the device is 200 ml min^{-1}. After the end of the sieving process, the sieves were separated and the remaining soil was transferred on each sieve to a glass beaker and dried in the oven at a temperature of 105°C for the purpose of calculating its dry weight. Then the values of the mean weight diameter (MWD) were calculated from the following equation mentioned in [11].

$$\mathrm{MWD} = \sum_{\mathrm{i}=1}^{\mathrm{n}} \mathrm{xi\ wi}$$

Where:
MWD= Mean Weight Diameter (mm)
Xi= Diameter rate for any volumetric range of separated assemblies (mm)
Wi= The weight of the remaining aggregates within one volumetric range as a proportion to the total dry weight of the soil model.

2.2.4. Soil Penetration Resistance

The soil resistance to penetration (CI) was measured using a field device (Cone Penetrometer) by applying constant pressure to the device in a vertical direction to push the cone into the soil to depths (0-15, 15-30) cm with three repetitions, recording the device reading from the pointer and then calculating the cone index (CI) in $kN.m^{-2}$ from the following equation mentioned in [12].

$$CI = \frac{F}{A}$$

Where:
CI= Cone Index (kN.m^{-2})
F= Penetration Force (kN)
A= Cone base area (m^2)

3. Results and Discussion

3.1. Dry Bulk Density

The data shown in Table 3 indicate that there are no significant differences for the effect of secondary soil preparation equipment at the beginning of the season on reducing bulk density, but in the bilateral interactions between softening systems and the addition of organic residues and depth, there is a highly significant effect, but at the end of the growing season for oats, there are high differences Significance between the factors included in the experiment and the character studied. The treatment of mixing organic residues with a concentration of 40 tons ha^{-1}, Spring cultivator and the depth (0 - 15) achieved the lowest bulk density, which reached 1.05 Mg m^{-3}, while the treatment without adding the organic residues, rotary plow and the depth (15-30) achieved the highest bulk density of the soil was 1.47 Mg m^{-3}. The reason for this is due to the type of the work of secondary tillage implements in stirring soil layers and mixing manure residues and the extent of their access to different depths, in addition to the role of manure residues in reducing the bulk density of soil by mixing it with soil particles. All of the above is consistent with [13].

Table 3. Effect of tillage systems, organic residues and soil depth on dry bulk density (Mg.m^{-2}) at the beginning and end of the growing season.

Secondary Tillage	Manure Residues	Beginning of the growing season			The end of the growing season		
		Soil depth			Soil depth		
		D1	D2	Means	D1	D2	Means
SC	M0	1.2033	1.2483	1.2258	1.3220	1.3477	1.3348
	M20	0.9877	1.1193	1.0535	1.1240	1.2653	1.1947
	M40	0.9350	1.0497	0.9923	1.0520	1.1753	1.1137
AH	M0	1.2493	1.3113	1.2803	1.3187	1.4220	1.3703
	M20	1.1787	1.3050	1.2418	1.2353	1.3583	1.2968
	M40	1.1093	1.2987	1.2040	1.1900	1.3683	1.2792
DH	M0	1.2120	1.2893	1.2507	1.2350	1.3993	1.3172
	M20	1.1043	1.1873	1.1458	1.2213	1.3073	1.2643
	M40	1.0223	1.1790	1.1007	1.1123	1.2510	1.1817
RP	M0	1.3203	1.2687	1.2945	1.4217	1.4693	1.4455
	M20	1.2013	1.2947	1.2480	1.3023	1.3477	1.3250
	M40	1.1397	1.2390	1.1893	1.2320	1.3070	1.2695
Means		1.1386	1.2325	1.1856	1.2306	1.3349	1.2827
$RLSD_{0.05}$		0.05449^{ns}			**0.06250****		

DH=Disk harrows, AH=Axe harrows, SC=spring cultivator, RP=Rotary plough.

M0 = Manure Residues (0 tons.ha^{-1}), M20= Manure Residues (20 tons.ha^{-1}), M40= Manure Residues (0 tons.ha^{-1}).
D1= Soil depth (0-15) cm, D2= Soil depth (15-30) cm.

3.2. Total Porosity

The data shown in Table 4 indicate the presence of highly significant differences at the end of the oats growing season, as the spring cultivator achieved the best mixing ratio of organic fertilizers by giving them the highest soil porosity for depths (0 - 15), (15 - 30) cm, as the soil porosity reached when mixing organic residues At 40 tons ha^{-1} are 60.29, 55.65%, respectively. While the rotary plow achieved the lowest percentage of total porosity without adding organic residues at the end of the oats growing season at the two depths (0-15), (15-30) cm, which amounted to 46.35 and 44.56%, respectively. The reason for the difference in the total porosity is due to the increase in the bulk density of the soil layers formed after the soil softening process and the arrival of soil particles to the soil powder, which when irrigated will turn into a solid layer of high density and this is what happened to the soil when plowed with the rotary plow, in contrast when the organic residues were mixed With the spring cultivator, the bulk density of the soil decreased, which increased the total porosity of the soil. Some researchers [14] agree on what was previously mentioned, as they mentioned that when using a moldboard plow and a spring cultivator, it will outperform the use of moldboard plow with disc harrows or rotary plows by giving it the highest percentage of total porosity, reaching 56.83%, and thus it is superior to in giving the lowest apparent density and the reason for this is the inverse relationship between the total porosity and bulk density of the soil.

Table 4. Effect of tillage systems, organic residues and soil depth on total porosity (%) at the beginning and end of the growing season.

Secondary Tillage	Manure Residues	Beginning of the growing season			The end of the growing season		
		Soil depth			Soil depth		
		D1	D2	Means	D1	D2	Means
SC	M0	54.59	52.88	53.74	50.10	49.15	49.62
	M20	62.73	57.75	60.24	57.58	52.26	54.92
	M40	64.72	60.40	62.56	60.29	55.65	57.97
AH	M0	52.85	50.51	51.68	50.25	46.34	48.29
	M20	55.52	50.76	53.14	53.38	48.74	51.06
	M40	58.15	50.99	54.57	55.09	48.37	51.73
DH	M0	54.27	51.35	52.81	53.40	47.19	50.29
	M20	58.33	55.20	56.76	53.92	50.65	52.29
	M40	61.44	55.51	58.47	58.03	52.79	55.41
RP	M0	50.18	52.13	51.15	46.35	44.56	45.45
	M20	54.66	51.14	52.90	50.86	49.14	50.00
	M40	56.99	53.25	55.12	53.51	50.67	52.09
Means		57.03	53.49	55.26	53.56	49.62	51.59
$RLSD_{0.05}$			2.057^{ns}			2.360**	

3.3. Mean Weight Diameter (MWD)

The data shown in Table 5: The effect of secondary soil preparation equipment and the addition of organic residues on the average weighted diameter of different soil depths. There is a highly significant difference at the beginning and end of the oats growing season. The treatment of organic waste mixing (40 tons ha^{-1}) with the spring cultivator outperformed the rest of the treatments in giving it the highest weighted average diameter at the beginning and end of the oats growing season and for the two depths (0-15), (15-30) cm, which were 0.988 and 0.730 mm at the beginning of the season. Respectively, and at the end of the season 0.791, 0.585 mm. While the rotary plow achieved the lowest weighted diameter without adding organic residues at the beginning and end of the oats growing season. The reason for the difference between the secondary soil preparation equipment is that some of the equipment break up the soil in a very large way and become close to the powder and quickly turn into a solid layer with grains intertwined with each other after the first irrigation operation of the soil and this is what actually happened with the rotary plow, while some machines By hitting the soil without dismantling it and not mixing the organic residues well, and this is what happened when using the harrows. As for the disc harrows, they outperformed the rest in giving the best mixing of organic residues and soil disintegration. This was demonstrated by the weighted diameter ratio, which is considered as evidence of the stability of soil aggregates. All of the above is consistent with [15].

Table 5. Effect of tillage systems, organic residues and soil depth on mean weight diameter (mm) at the beginning and end of the growing season.

Secondary Tillage	Manure Residues	Beginning of the growing season			The end of the growing season		
		Soil depth			Soil depth		
		D1	D2	Means	D1	D2	Means
SC	M0	0.6290	0.3967	0.5128	0.3923	0.3973	0.3948
	M20	0.7993	0.6960	0.7477	0.6487	0.4613	0.5550
	M40	0.9880	0.7300	0.8590	0.7913	0.5850	0.6882
AH	M0	0.3567	0.2957	0.3262	0.3293	0.2540	0.2917
	M20	0.5267	0.4553	0.4910	0.3917	0.2687	0.3302
	M40	0.5700	0.4983	0.5342	0.4887	0.2997	0.3942
DH	M0	0.5823	0.4003	0.4913	0.4330	0.2830	0.3580
	M20	0.7280	0.4320	0.5800	0.5490	0.3590	0.4540
	M40	0.8977	0.4757	0.6867	0.6883	0.4407	0.5645
RP	M0	0.3023	0.3163	0.3093	0.2300	0.2233	0.2267
	M20	0.3887	0.4430	0.4158	0.2883	0.3320	0.3102
	M40	0.4273	0.4273	0.4433	0.3750	0.3550	0.3650
Means		0.5997	0.4666	0.5331	0.4671	0.3549	0.4110
$RLSD_{0.05}$		0.09525**			0.09281**		

3.4. Soil Penetration Resistance

The data shown in Table 6 indicate a highly significant difference between the factors included in the experiment and the soil resistance to penetration at the beginning and end of the growing season of oats. It was noted that the spring cultivator were superior in mixing the organic waste by 40 tons. Ha^{-1} and gave it the least penetration resistance to the soil at the two depths (0 - 15), (15 - 30) cm. straight. While the rotary plow recorded the highest resistance to soil penetration without adding organic residues to the surface depth (0-15) cm, as it was recorded for the beginning and end of the season

1.963 and 2.773 MPa, respectively. While the Axe harrows without adding organic residues and for a depth of (15-30) cm recorded the highest resistance to soil penetration, as it reached to the beginning and end of the season 1.923 and 2.670 MPa, respectively. The reason for the superiority of the disc harrows over the rest of the machines is due to the quality of the action of the disc harrow in loosening the soil and mixing the fertilizers, and the possibility of reaching a greater depth than other machines. Disc harrows have many advantages that help it outperform other machines, most notably its large weight and the number of discs it carries, and it consists of two successive rows of discs. All of the above is consistent with [16].

Table 6. Effect of tillage systems, organic residues and soil depth on soil resistance to penetration ($MN.m^{-2}$) at the beginning and end of the growing season.

Secondary Tillage	Manure Residues	Beginning of the growing season			The end of the growing season		
		Soil depth			Soil depth		
		D1	D2	Means	D1	D2	Means
SC	M0	1.2833	1.6567	1.4700	1.733	2.147	1.940
	M20	1.0533	1.2633	1.1583	1.423	1.710	1.567
	M40	0.6933	1.0800	0.8867	0.940	1.320	1.130
AH	M0	1.6300	1.9233	1.7767	2.010	2.670	2.340
	M20	1.3667	1.5733	1.4700	1.697	1.960	1.828
	M40	1.0900	1.5167	1.3033	1.457	1.813	1.635
DH	M0	1.1567	1.5967	1.3767	1.607	2.003	1.805
	M20	1.0300	1.3967	1.2133	1.373	1.703	1.538
	M40	0.7500	1.3167	1.0333	1.023	1.413	1.218
RP	M0	1.9633	1.7333	1.8483	2.773	2.373	2.573
	M20	1.6867	1.7600	1.7233	1.850	2.030	1.940
	M40	1.5400	1.7367	1.6383	1.430	1.930	1.680
Means		1.2703	1.5461	1.4082	1.610	1.923	1.766
$RLSD_{0.05}$		0.09442**			0.2575**		

Conclusion

It is evident from the results shown above and through the effect of the intervening factors in the experiment with a significant high level at the beginning and end of the oats growing season on the soil characteristics that were measured. It was concluded that the best combinations were when the percentage of organic residues added to the soil (M20, M40) increased, the physical properties of the soil improved. In the above, it was found that the best secondary plowing equipment that was used in combing the surface layer of the soil and mixing the organic residues is the spring cultivator, which achieved the lowest bulk density, soil resistance to penetration, the highest total porosity and a balanced diameter rate at all levels of manure residue addition. While the rotary plow achieved the lowest percentages due to its dismantling of the surface layer to the formation of soil powder, which quickly turns into a shallow layer after the first soil irrigation process, and this layer has a higher soil penetration resistance than the lowest layer.

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