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Effect Of Soil Compaction In Central And Southern Iraq On Growth And Productivity Of Wheat And Rice Crops

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Abstract

A field study was carried out to reveal the effect of compaction of irrigated soils resulting from the movement of heavy machinery adopted in soil and crop management processes in central and southern Iraq on some physical, water and engineering properties of soil. The effect of compaction of heavy and light soils in the fields of cereal crops "wheat and rice" was studied. The study was conducted on eight sites in four stations of different textures, two sites in each station. The four sites are Al-Fajr district, Dhi Qar governorate (mixed texture soil), sand dunes station located on the FAO project between Dhi Qar and Al-Qadisiyah (mixed sandy soil), rice research station in Al-Mashkhab area/Najaf governorate (clay mixed soil), and Al-Qadisiyah-Hor Salib region (Alluvial clay soil). The study focused on comparing sites with compacted soils with sites with non-compacted soils in terms of some of the growth and yield measures (plant length, horizontal root length, deep root length, and dry weight of total yield) of wheat and rice yields affected by soil compaction. The results showed the clear effect of soil compaction on the vegetative growth of wheat and rice crops. In general, a significant decrease in growth indicators and yield was observed in the frequently cultivated compacted soil sites (C1) compared to the neighboring newly planted (un-compacted) sites (C0). This effect was negatively reflected on plant height, root system and yield, and led to a decrease in total yield in Qadisiyah and Mashkhab stations, which are characterized by clay soil, and Al-Fajr station with mixed soil. In general, the compaction operations affected the physical properties of the soil and led to a clear imbalance in the growth systems and yield indicators. This is in addition to the risk of soil detoriration over time and an increase in compaction due to pressure and repeated cultivation.

Keywords: soil compaction, root penetration resistance, grain crops

INTRODUCTION

The concept of soil compaction refers to the compaction of the unsaturated soil body which leads to a reduction in the air volume in the soil. The basic mechanism of soil compaction is to decrease its porosity, through the partial expulsion of air and/or water from the compacted soil body. Agricultural use is concerned with the soil as the medium of plant growth, so the condition of soil compaction is a separate case for the use of mechanization, which should be avoided as much as possible in the soil, as the soil becomes unsuitable for crop production

(Hillel, 1980). The soil compaction resulting from the passage of tractors and agricultural equipment takes the form of two types, either it is superficial compaction, which occurs within the scope of the agricultural horizon (AP) and can be removed by normal plowing operations, or it is subsurface compaction, which occurs below the depth of the plowing, and the process of removing it is not easy. It requires deep plowing, which is costly, and after the compaction process, rapid changes occur in the physical condition of the soil and these changes continue until the state of equilibrium in the soil (Jorajuria et al., 1997). The soil is exposed to it during the repeated passage of agricultural machinery and machinery in the agricultural lands to carry out the plowing work (Jassim and Walid, 2004).Generally, the unconsolidated soil contains a higher percentage of water at a rate of 4 to 5 times than the soil compacted by machines. On the other hand, the activities of Machinery on soil has a greater effect on soil water infiltration rate caused by soil tillage, and soil pressure is caused not only by agricultural machinery, but also by livestock.

The mechanical behavior of soil is affected by the density, composition or arrangement of the particles, as well as the quantity and distribution of fluids present (such as water and air), in addition to other factors such as the electrical charge of the particles, the chemical composition of the pore water, and the chemical bonds between the particles. All these will result in a soil with a high bulk density offset by low porosity and high penetration resistance, in addition to the deterioration of the soil structure and its physical properties related to the compaction factor. The aim of this study was to evaluate the effect of soil compaction resulting from the movement of heavy machinery used for wheat and rice crop management on growth and yield measures (plant length, horizontal root length, deep root length, and dry weight of total yield).

MATRIALS AND METHODS

The study was conducted on eight sites in four stations of different textures, two sites in each station. The four selected sites were: Al-Fajr district in the province of Dhi Qar (loamy texture soil), sand dunes station located on Al-Fao project between Dhi Qar and Al-Qadisiyah (loamy-sandy soil), the rice research station in Al-Mashkhab area, province of Najaf (clay-loam soil), and Al-Qadisiyah region. Hor Salib marsh (Alluvial clay soil). The research started by taking soil samples for the study sites at different depths (10-50 cm), and the initial records of the physical and chemical properties of the soil (Table1 and 2) were taken using standard methods in estimating the volume distribution of soil particles (Blake et al. 1965).

Table 1. Some physical properties of soil in the studied sites

Station	Soil particle (g/kg) sand silt clay			Texture	Bulk Density $Mg.m^{-3}$	Actual Density $Mg.m^{-3}$	total porosity (%)
Al-Fajer district	Sand	Silt	clay		Depth (30cm)		
	347.2	429.8	223	Loam	1.40	2.65	46.90
					1.34		49.20

Sand dunes/Faw	747.10	110.40	142.50	Sandy-loam	1.82 1.82	2.64	30.86 30.90
Michkhab rice research station	311	407.29	281.71	Clay-loam	1.47 1.45	2.65	44.52 45.28
Qadisiyah-Slaib marsh	27.0	444.8	528.2	Silt-clay	1.47	2.65	44.30

The sampler core method was used to estimate the density The apparent value of the soil, and the water tip was measured using a double ringe infiltrometer according to the method (1956 Haise), which was referred to (1960 by Parr and Bertrand). The penetrometer was used to detect the soil's resistance to penetration and compaction.

Measurements

At the end of each crop season, the vegetative growth and yield indicators (wheat and rice) were measured for 10 replicates of five plants for each replicate. Indicators included plant height (cm), average root depth, average horizontal root length (Radford, 1967), and yield dry weight.

Table 2 . Some of chemical properties of soil in the studied sites

Trait	Station							
	Al-Fajer district		sand dunes/Faw		Michkhab rice research station		Qadisiyah-Slaib marsh	
	C1	C0	C1	C0	C1	C0	C1	C0
pH	7.8	7.6	7.5	7.5	7.4	7.4	7.5	7.4
EC $mS.m^{-1}$	8.4	7.6	3.5	4.0	4.5	4.2	5.3	4.7
% OM	1.19	1.11	0.96	0.93	1.19	1.15	1.18	1.22
Available N $Mg.Kg^{-1}$	39.2	44.1	27.44	23.52	36.26	46.06	35.28	36.26
Available P $Mg.Kg^{-1}$	51.85	56.56	3.647	2.290	50.82	44.85	43.36	55.41
Available K $Mg.Kg^{-1}$	1018	1048	55.66	58.05	965	1003	795	682

RESULTS AND DISCUSSION

The results showed that there were significant differences for the effect of soil compaction on growth parameters and yield under study (plant height, deep root length, adventitious root length and total plant yield) in Al-Fajr station, rice research station, and in Al-Qadisiyah district station compared to sites with uncompounded soils C0. There was no clear effect of compaction on the previous indicators at the sites of the sand dune station, but the effect of compaction was significant in the clay soil rice research station (Tables 2 and 3). A clear effect of the interaction of compaction and physical characteristics on growth characteristics in Al-Qadisiyah sub-district was also shown. This is due to the role of machines and the weight imposed on the soil as a result of repeated use, which caused a change in the soil's physical properties, and thus affected the plantb growth of the plant.

Table 3. Comparison between compacted and non-compacted soils in different locations on some growth and production characteristics of wheat crop

Measurements	Location (station)							
	Al-Fajer		Sand dunes/Faw		Mishkhab rice research station		Qadisiyah-Slaib marsh	
	C0	C1	C0	C1	C0	C1	C0	C1
Plant height (cm)*	98.900	82.500	99.600	99.000	95.200	84.900	78.600	75.400
deep root length (cm)	14.600	12.700	15.200	15.000	14.400	13.600	13.800	12.300
horizontal roots length (cm)	12.500	13.500	13.200	13.500	14.100	13.900	12.400	13.000
Yield dry weight (g.plant^{-1})	14.429	12.973	14.630	14.620	14.058	13.476	13.288	12.220

*Values are means of ten replicates, five plants for each replicate. C1 and C0 are silts of compacted and non-compacted soil, respectively.

Table 4. Comparison between compacted and non-compacted soils in different locations on some growth and production characteristics of rice crop

Measurements	Location (station)			
	Mishkhab rice research station		Qadisiyah-Slaib marsh	
	C0	C1	C0	C1
Plant height	97.900	96.300	74.700	72.500
deep root length	14.000	12.900	14.300	12.400

horizontal roots length	**13.100**	**14.100**	**13.700**	**13.900**
Yield dry weight	**3.190**	**3.050**	**3.010**	**2.820**

*Values are means of ten replicates, five plants for each replicate. C1 and C0 are silts of compacted and non-compacted soil, respectively.

Continuous use of machines led to soil compaction, and consequently the total porosity decreased, which negatively affected the growth and movement of the roots. Large pores in the soil are of great importance for aeration and water movement in the soil. When there is a decrease in the large pores due to external pressures, the soil becomes saturated with water for a long time at the expense of the presence of oxygen, and this in turn is negatively reflected in the water penetration in the soil and plant growth (Hanna, & Al-Kaisi 9200).

There was no effect of compaction operations on sandy soil, and this is due to the fact that the properties of sandy soils represented by bulk density and soil penetration resistance were not affected by pressing operations. In addition to the nature of the sandy soil, which is considered to have a coarse texture, which allows for a good exchange of water and air among pores of the soil. This allows the roots to grow in all directions in the soil, especially the deep vertical growth without mechanical obstruction. In coarse textured soils, the dominant root penetration was in the vertical direction, while in fine textured soils the root spread was multidirectional (Ellies et al., 2000; Sangakkara et al., 2004).

The pressure below the surface led to an increase in root growth in the surface soil layer with a corresponding squared decrease in root growth in the compacted layer (Rosolem and Takahashi, 1998; Akay et al., 2007). The plants in the compacted lands had more root concentrations near the base of the plants than the plants in the zero-loaded lands, which are less compressed (Abu-Hamdeh., 2003; Botta et al., 2006). In the stations with clay soil, the compaction operations affected all the physical properties of the soil, which affected the dry weight of the yield and its total productivity. This is due to the increase in the proportion of clay in the soil of these stations, which negatively affected the process of absorption of nutrients and the dry weight of the yield (Defossez and Richard. , 2002).

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