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EFFECT OF TILLAGE DEPTH ON SOME PROPERTIES OF SALINE SOIL

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ABSTRACT: A field experiment was conducted to quantify the effect of tillage depth and irrigation application rates on total porosity, saturated hydraulic conductivity, EC and pH of Al-Hussainiya saline clay soil. Wheat crop (Triticum aestivum; misr-1) was cultivated. Soil physical and chemical properties were measured before and after wheat cultivation. The irrigation water was, also, chemically analyzed. The soil properties were measured at three tillage depths and four irrigation application rates.

The obtained results showed a reduction in both EC and pH and increase in both total porosity and hydraulic conductivity with increasing tillage depth. Therefore, the study recommended a deep tillage and water application not less than field capacity to improve soil properties and increase soil hydraulic conductivity and, hence, enhance leaching salts in the clay saline soil, especially, from the surface layers.

Key words: Tillage, Saline soil, Clay soil, Total porosity, Hydraulic conductivity, EC, pH.

INTRODUCTION

Tillage practices and climate conditions may influence the distribution pattern of organic carbon in soil, the most valid indicator of soil quality due to its crucial effect on soil properties. In this regard, Bilandzija et al. (2016) and Gajda et al. (2017) recommended no-tillage practice. Also, different tillage management, may poorly affect long-term productivity of the soil because of their negative effect on organic matter and soil erosion along with further negative environmental effects, such as the decline in biodiversity (Geissler et al., 2009 and Gajda et al., 2018). Accordingly, the chosen tillage system should be driven by definite soils and weather conditions (Lambers, 2003). Moreover, tillage has decisive impact on soil moisture, soil surface roughness and crust strength, wetting and drying cycle and, also affect crop productivity (Khan et al., 2017; Ahuchaogu et al., 2015; Alletto et al., 2015 and Schwen et al., 2011). Many researchers suggested alternative practices for salt affected soils and saline irrigation water, such as magnetization (Omran et al., 2014 and Omran, 2017) and improving soil physical properties by applying compost (Wanas and Omran, 2006, Omran, 2019 and Abou Hussien et al., 2022). Such irrigation and soil managements are not enough, especially in case of saline-alkaline soils. On the other hand, tillage improves some soil properties and enhances salt leaching (Zhang et al., 2018 and Roy et al., 2014).

This study aims to evaluate the effect of tillage depth on the total porosity, saturated hydraulic conductivity, EC and pH of Al-Hussainiya saline clay soil in different soil depths and irrigation application rates.

MATERIALS AND METHODS

A field experiment was conducted in the experimental farm of Al-Hussainiya Agricultural Research Station, Agricultural Research Center, Sharkia Governorate, Egypt. The experiment was carried out and wheat crop (Triticum aestivum; misr-1) was cultivated in two winter seasons 2018/2019 and 2019/2020 to study the effect of different tillage depths and irrigation levels on total porosity, saturated hydraulic conductivity, EC and pH of the experimental soil. A soil profile was dug up to 120cm depth. Disturbed and undisturbed soil samples were collected from soil depths of 0-20, 20 - 40, 40-60 and 60 - 100 cm, respectively, to determine the chemical and physical characteristics of the experimental soil. The disturbed soil samples were dried in open air, ground and sieved by a 2mm sieve. Soil

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physical and chemical properties are listed in Table (1).

The total experimental area was 576 m^2. This area was divided into 36 experimental units (plots). Each plot has area of 16 m^2 (4 m × 4 m). These plots were divided into three main groups (12 plot / main group) representing the studied main factor (tillage depth treatments, i.e., 0-20, 0-40 and 0-60 cm). The plots of each main-group were divided into four sub-main groups (3 plot / sub-main groups) representing the studied sub-factor (irrigation rate treatments, i.e., 70, 80, 100 and 120% of soil field capacity). The experimental plots were treated with equal doses of compost and super phosphate, and cultivated with wheat. After wheat harvesting, of each season, the studied properties were measured in the disturbed and undisturbed soil samples. The soil samples were collected from different soil depths (i.e., 0-20, 20-40, 40-60 and 60-100 cm).

The resource of irrigation water was EL-Salam Canal where the applying irrigation system was flooding surface system. The chemical composition of the irrigation water was pointed in Table (2).

Particle size distribution (%) was determined by pipette method (Klute, 1986).

Total soil porosity was calculated according to the following formula:

$$Total\ porosity = \frac{\rho_r - \rho_b}{\rho_b}$$

Where: ρ_r and ρ_b are real and bulk density, respectively (Klute, 1986).

Irrigation application treatments were estimated through determination of both field capacity and permanent wilting point. The determination was done by using the pressure membrane apparatus (Stakman and Hast, 1962).

The saturated hydraulic conductivity of the soil was conducted using undisturbed soil samples, taken by soil cores (Klute, 1986).

Organic matter content, pH and EC of the experimental soil were measured according to the method described by Page et al. (1982).

Three-way-ANOVA was followed to test effect of the tillage and irrigation treatments as well as soil depth and their interactions on studied soil properties, according to the procedure described by Snedecor and Cochran (1980).

Table (1): Physical and chemical analysis of three depths of the studied soil.

Soil depth (cm)	Particle size distribution (%)				Texture	Soil moisture constants (% by volume)		Organic Mutter %	EC dS/m, in 1:5 water extract	pH in 1:2.5 Suspen-tion
	Coarse Sand	Fine Sand	Silt	Clay		FC	PWP			
0-20	4.2	8.0	35.3	52.5	Clay	73.2	29.6	0.43	12.6	8.2
20-40	3.1	9.2	33.4	54.3	Clay	76.5	30.6	0.45	13.7	8.7
40-60	5.6	11.3	35.7	47.4	Clay	70.4	27.3	0.21	14.6	8.1

Table (2): Chemical properties of irrigation water

Ec ($dS.m^{-1}$)	pH	K	Na	Ca	Mg	CO_3	H CO_3	Cl	SO_4
		meq. /l							
1.1	7.59	0.3	6.1	3.2	1.4	--	0.7	7.6	2.7

RESULTS AND DISCUSSION

Soil EC as affected by tillage and irrigation treatments:

The results in Fig (1) indicated that, the Increasing of tillage depth caused a significant decrease in soil EC. Such decrease was observed at all of the studied soil depths. The highest decreased in EC values were found in the surface layer of soil profiles followed gradually by sub-surface layers up to the deepest one (60-100 cm). For example, the EC values (Fig, 1) were 12.3, 10.1 and 9.6 dS m^{-1} under the effect of tillage depths of 0-20, 0-40 and 0-60 cm, with irrigation rate of 100% and 120% of field capacity and at soil depth of 40-60 cm, respectively. This decrease could be related to the increase of the total soil porosity which resulted from the occurred decrease of the bulk density (Kg m^{-3}). Similar results about the effect of tillage are mentioned by El-Sanat et al. (2017). The results pointed out that, the increase of tillage depth led to a significant decrease of EC under saline soil conditions at North of Nile Delta. In this respect, in a field experiment on a similar texture soil, Omran (2005) found a linear relation between amount of applied water and maize grain yield.

Generally, the increase of tillage depth caused a high decrease on soil EC. Therefore, tillage practices are very important to reduce soil salinity, especially in the surface layers (rhizosphere).

Soil pH as affected by tillage and irrigation treatments:

Soils could be initially acidic and/or alkaline, and this can be measured by testing their pH value. Soils are classified into three types according to their pH values as: neutral (pH 6.5 to 7.5), alkaline (more than 7.5) and acidic (less than 6.5). The reduction in soil pH resulted in improving in water movement and enhancing salt leaching. The highest decreases of soil EC were found in the surface layers of soil profiles and this decrease was linked to the increase of the soil depth.

The precise measurement of soil pH is important for healthy plant growth. Therefore, the long-term effects of the different agricultural practices on soil pH are also imperative. The presented data in Fig (2) indicate that, soil pH was increased when the soil depth was increased under all of the studied tillage treatments. This trend of result could be related to the presence of the organic matter in the upper soil layer.

Regarding to the effect of tillage depth on the pH of the studied saline soil, Fig (2) shows a significant decrease of soil pH especially in the upper layers of the soil. As a result of increasing the tillage depth, the pH values were decreased. These results were found in all of the studied soil depths. For example, with irrigation rate of 100% field capacity and at the 40-60 cm soil depth. The pH values were 7.99, 7.87 and 7.81 for the tillage depths of 0-20, 0-40 and 0-60 cm, respectively. This decrease, in soil pH, could be attributed to the high decomposition rate of the organic matter, which produced more organic acids. Similar results were obtained in comparable soil conditions, as mentioned by Hulugalle et al. (2005), who found reduction of pH with tillage treatments. On the other hand, dissimilarity results found by Yuan et al. (2020), who found that, no-tillage caused reduction of the pH compared to tillage treatments, in non-saline soils. Therefore, deep tillage practice is very important to reduce alkalinity of sodic soils conditions especially in the surface layer and rhizosphere.

The total soil porosity as affected by tillage:

Data of the total porosity of the studied saline soil as affected by tillage depth are presented in Fig (3). The obtained results revealed that, the increase of bulk density was straight relative to soil depth increase. On the other hand, with the same treatments, total porosity was decreased with the increase of soil depth. These findings maybe due to the high compaction of the deeper layers compared to the upper layers. Additionally, these detections are in harmony with the vertical distribution of soil organic matter content that decreased with increasing the soil depth. Fig (3) shows more decrease in the soil bulk density and then more increase in the total porosity with the increase of the tillage depth. The corresponding values of the total porosity at the matching treatments were increased from 50.74% to 53.21 and 53.95% for the surface, sub-surface, and below the sub-surface layer of tillage depths, respectively. Similar results were found by Gajda et al. (2010), who found that, the tillage and organic matter applications improve the soil properties.

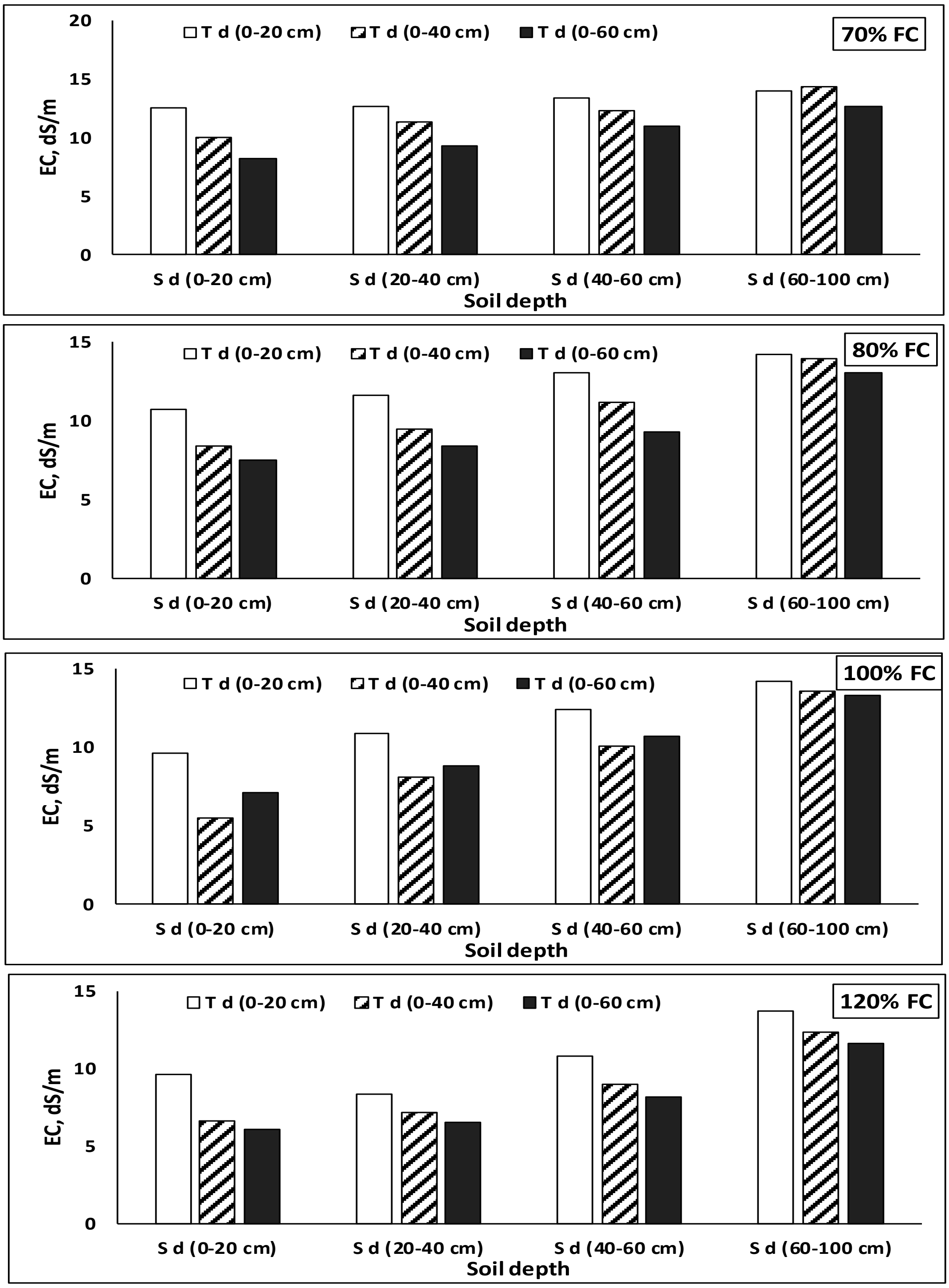

Fig (1): Effect of the tillage depth and irrigation application rate on the EC at different soil depths [LSD = 0.2180 and 02517 for tillage and irrigation rate, respectively].

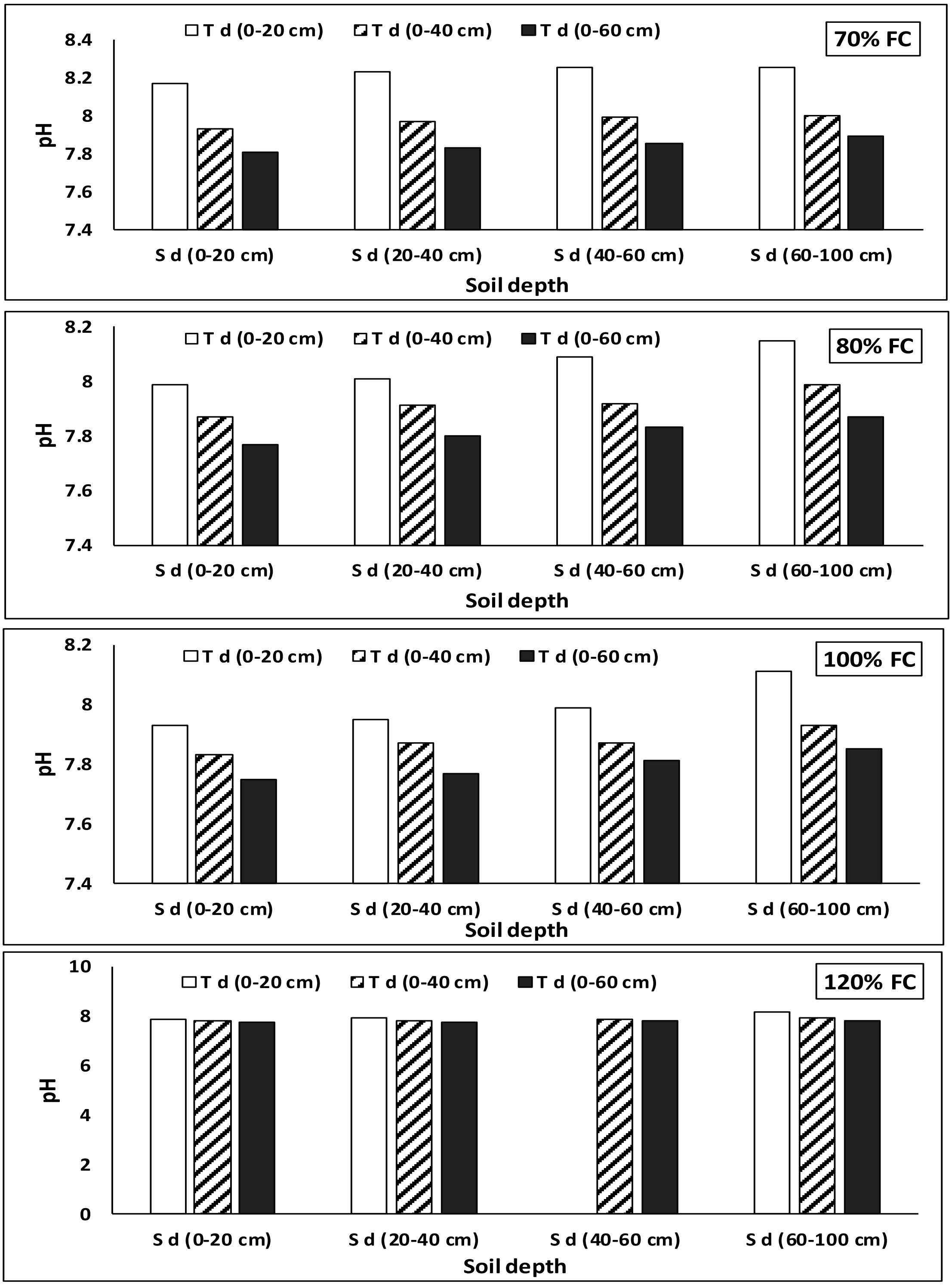

Fig (2): Effect of the tillage depth and irrigation application rate on the pH at different soil depths [LSD = 0.0128 and 0.0148 for tillage and irrigation rate, respectively].

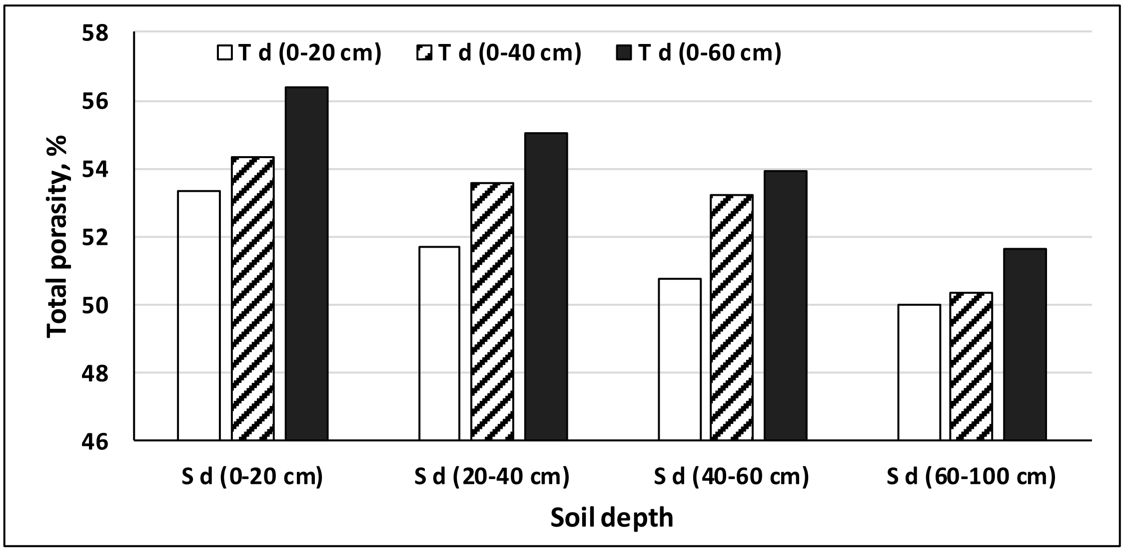

Fig (3): Effect of the tillage depth and irrigation application rate on the total porosity at different soil depths [LSD = 0.3306].

These findings may be resulted from the disturbed effect of tillage on soil aggregates as well as the decease of soil compaction. Therefore, tillage practices especially in saline soils plays a major role on the improve of air soil conditions as well as water movement. These results are similar to those obtained by Sorour et al. (2019) in saline soil conditions of the northern Nile Delta, Egypt.

The hydraulic conductivity as affected by tillage

Soil hydraulic conductivity was already low and decreased over in deeper layers (Fig, 4). The results indicated that, the hydraulic conductivity greatly increased by increasing the depth of tillage. Such increase is in harmony with the occurred decrease in the total porosity. Subsequently, Mahmoud et al. (2017), found that deep tillage of saline soil at the north of Nile Delta, Egypt caused a significant increase of soil hydraulic conductivity. In this regard, Amira et al. (2020) classified soils having sodic horizon under Aridisols, which has poor water movement and low suitability for agricultural production.

Moreover, Jabro et al. (2009) found that tillage significantly affect saturated hydraulic conductivity of a clay soil. This is may be due to that, the tillage reduces the soil compaction and improve the pore sizes geometry of the dispersed soil particles. Furthermore, the improvement of the soil hydraulic properties is related to the occurred changes in the total porosity, where no-till soils have blocked pores, increase in bulk density and reduction in total porosity (Weninger et al. 2019). Moreover, Omran (2019) found increase in saturated hydraulic conductivity with mixing soil particles with different amendments (somehow corresponding to tillage effect). Additionally, Rienzner and Gandolfi (2014) declared the interactions between soil tillage and vegetation, through their influence on both size and shape of large pores, are the explanation key of the variability in hydraulic conductivity of the soils. Finally, it could be concluded that tillage caused increase in hydraulic conductivity of the studied saline soil. The increase in hydraulic conductivity resulted in enhancing salt leaching out from the soil surface layers.

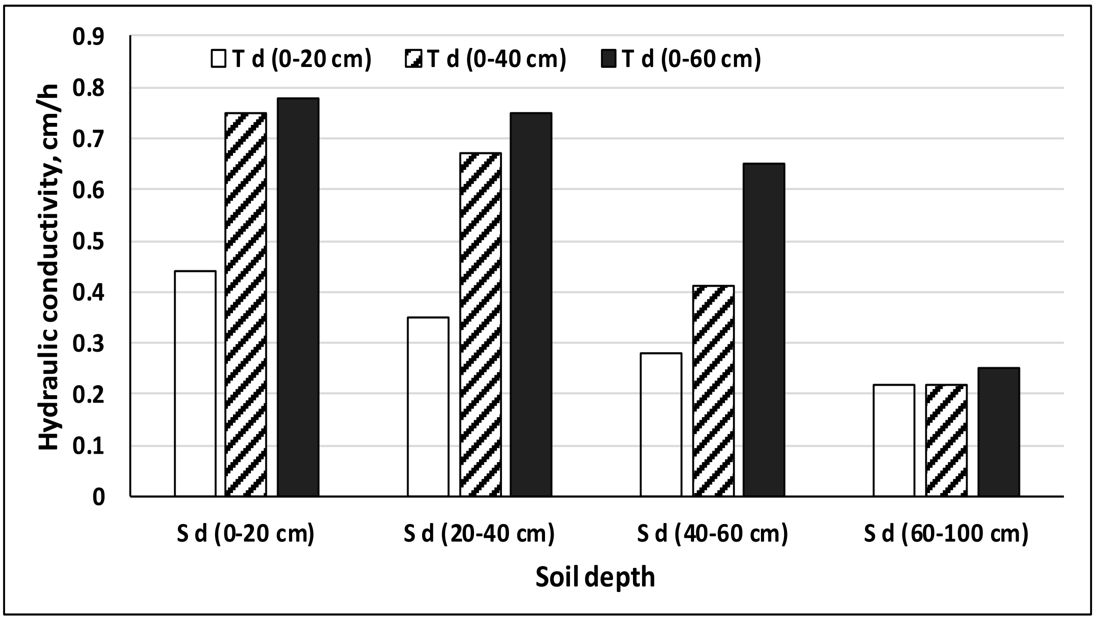

Fig (4): Effect of the tillage depth and irrigation application rate on the saturated hydraulic conductivity at different soil depths [LSD = 0.0063].

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تأثير عمق الحرث على بعض خصائص التربة الملحية

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الملخص العربي

أجريت تجربة حقلية بغرض تقييم تأثير عمق الحرث ومعدلات الري على المسامية الكلية والتوصيل الهيدروليكي المشبع ورقم الأس الهيدروجيني (pH) والتوصيل الكهربي (EC) لتربة الحسينية الطينية الملحية، وقد تم عمل تجربة حقلية بزراعة نباتات القمح (صنف مصر-١) تحت تأثير ثلاث أعماق حرث وأربع معدلات ري، وتم قياس الخواص الفيزيائية والكيميائية للتربة تحت الدراسة قبل وبعد الزراعة عند أعماق مختلفة للتربة، كما تم قياس الخواص الكيميائية لمياه الري.

وقد دلت نتائج الدراسة على انخفاض في كل من EC و pH التربة، وزيادة في كل من المسامية الكلية والتوصيل الهيدروليكي مع زيادة عمق الحرث، وقد دلت الدراسة علي أن الحرث واستخدام اماء الري بكمية لا تقل عن السعة الحقلية قد أدي الي زيادة سرعة التوصيل الهيدروليكي في الحالة المشبعة والتالي زيادة كفاءة عملية غسيل الأملاح وتخليص التربة خصوصا الطبقات السطحية من الأملاح وذلك في التربة الطينية الملحية موضع الدراسة.

الكلمات المفتاحية: الحرث - التربة المالحة - التربة الطينية - المسامية الكلية - التوصيل الهيدروليكي – التوصيل الكهربي - الأس الهيدروجيني.