Effect of Soil Management and Its Texture on Aggregate Stability Parameters and Wetting Rate

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ABSTRACT

The present study was carried out to evaluate the soil management and soil texture on the structure parameters and soil water wetting rate. Six soil samples of 0-30 cm depth were selected from three different sites in the texture of Clay, loam and Sandy loam in Basra Governorate (Abi Al-Khasib, Madinah and Zubair). Three samples represented the treatment of soil management (soil cultivated with alfalfa crop for 7 years respectively). The other three samples were from the same sites for uncultivated soil (bare soil), with three replicates for each sample. Soil organic matter content, bulk density, mean weight diameter, aggregate stability percentage and water wetting rate were measured. The results showed that the soil management factor had a highly significant effect in raising the values of OM, MWD and WSA%. It was as a general average of 56.337 gm. Kg^{-1}**,** 0.893 mm, 71.33%, respectively, and on the other hand, soil management led to a decrease in the values of ρb (1.38 Mgm.Kg^{-1}) and WR (0.2522 cm^{3}3gm^{-1} min^{-1}), and its rise in uncultivated soil of 1.51 Mgm.Kg^{-1}, 0.3989 cm^{3}3gm^{-1} min^{-1}, respectively. While the soil texture factor effect that the clay texture had the highest values as the average of OM (34.71 gm. Kg^{-1}), MWD (0.8 mm) and WSA (62.67%), followed by loam and sandy loam, respectively. While a decrease in the values of ρb (1.325 Mgm.Kg^{-1}) and WR (0.265 cm^{3}3gm^{-1} min^{-1}) in Clay soil with a significant difference compared to loam and sandy loam soil, and the interaction between the soil management factor and the increase in its content of silt and clay led to an improvement the soil properties.

Keywords: soil management, mean weight diameter, aggregate stability percentage, water wetting rate.

تأثير ادارة التربة نسجتها في معايير ثباتيه تجمعات التربة وسرعة ترطيبها

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المستخلص

تهدف هذه الدراسة التعرف على دور كل من عاملي إدارة التربة ونسجتها في بعض خصائصها ومؤشرات بنائها ومعدل سرعة ترطيب تجمعاتها. تم اختيار 6 نماذج من مادة التربة للعمق 0-30 سم من ثلاثة مواقع ذات نسجات مختلفة وهي Sandy loam, loam, Clay في محافظة البصرة ضمن أبي الخصيب، المدينة والزبير. ثلاثة من هذه النماذج تمثل معاملة ادارة التربة (تربة مزروعة بمحصول الجت لمدة 7 سنوات متتالية) والثلاثة الأخرى من نفس المواقع لتربة غير مزروعة (بور) بثلاثة مكررات. قدر محتوى التربة من المادة العضوية، كثافتها الظاهرية، معدل القطر الموزون، ثباتيه ومعدل سرعة ترطيب تجمعاتها. بينت النتائج ان لعامل إدارة التربة تأثير عالي المعنوية في رفع قيم كل من OMو MWD و WSA% وكانت كمعدل عام بواقع gm.Kg^{-1} 56.337, 0.893mm, 71.33% . مقارنة بالتربة غير المزروعة 3.397gm. Kg $^{-1}$ 0.223mm, 33.78%, على التوالي, كما ادت إدارة التربة إلى انخفاض قيم ρb (1.38 Mgm.Kg^{-1}) و WR (0.2522 cm^{3}3gm^{-1} min^{-1}) وارتفاعها في التربة غير المزروعة 1.51 Mgm.Kg $^{-1}$ 0.3989 cm^{3}3gm^{-1} min^{-1}, وعلى التوالي. أما عامل النسجة فقد تفوقت clay بأعلى القيم كمعدل لل OM (34.71gm.Kg^{-1}) (62.67%) , MWD (0.8mm), WSA تليها النسجة loam و Sandy loam على التوالي . في حين لوحظ انخفاض قيمρb (1.325 Mgm.Kg^{-1}) WR, (0.265 cm^{3}3gm^{-1} min^{-1}) في التربة Clay وبفارق معنوي مقارنة بالتربة loam و Sandy loam , وأن التداخل بين عامل إدارة التربة وزيادة محتواها من الغرين و الطين أدى إلى تحسن بعض خصائصها ومنها MWD ,WSA% وخفض قيم معدل سرعة ترطيب تجمعات التربة (WR).

الكلمات المفتاحية: ادارة التربة، معدل القطر الموزون، ثباتية تجمعات التربة، معدل سرعة ترطيب تجمعات التربة

Introduction

Most soils of central and southern Iraq are characterized by their weak structure and deterioration of their physical, chemical and fertility characteristics because of their low content of organic matter and high salinity, as well as the poor management of these soils or leaving them without cultivation for several years (bare soil), which negatively affects their productivity (Hoshan et al, 2020). Therefore, the excellent management of these soils by following a specific cultivation system and the accompanying effects of positive trends in the characteristics of the soil itself and the improvement of these qualities or what is expressed by Soil health, which represents the ability of the soil to provide the appropriate medium for plant growth, represented by the physicochemical, fertility, water and aerobic qualities with The relationship with plant life requirements (Antisari et al., 2017). Soil structure is that affects the absorption and water movement in the soil, as the various components of the soil have an impact on the stability of this structure and on the physical properties of the soil as it is one of the critical properties in the soil ecosystem and is affected by several physicochemical and biological processes. Soil aggregates and the water wetting rate are a function of this property through the process of arranging, organizing, and cohesion of soil particles, representing the soil texture due to the presence of organic carbon, multivalent positive ions, and the quality of clays, minerals and microorganisms that have a significant effect in this process (Neelam et al., 2010). Mahboubi et al, 1998 found that one of the most important characteristics that determine the degradation of soil aggregates is their texture, organic matter content, calcium carbonate, cation exchange capacity, and ability to store moisture. Water is also one of the most important forces affecting the deterioration of soil aggregates through significant changes in soil moisture before and after the addition of irrigation water and the occurrence of wetting and drying processes, as well as the swelling of the various parts of the aggregates and the confinement of air within the pores causing air explosions (Monroe and Kladirko, 1987). In view of the variance in the effect of soil components on their properties, especially those related to the soil structure, water absorption for their aggregates and the impact of this on the deterioration of these soil aggregates, this study aims to determine the effect of some soil properties on some of the stability parameters of their aggregates and the water wetting rate of these aggregates under different management conditions.

Materials and Methods

Six soil samples were collected randomly from three different soil texture of Clay, loam, sandy loam in Basra Governorate sites of Abi Al-Khasib, Madinah and Al-Zubayr. Three of these textures represented the treatment of soil management (cultivated soil with the alfalfa crop for 7 years consecutively), and the other three samples from the same sites for uncultivated soil (bare soil) with three replications for each sample, to a depth of 0-30 cm. The study used two factors. The first factor was soil management by two treatments,

the first treatment was cultivated soil and the second was uncultivated soil, and the second factor was the soil texture with three treatments, namely Clay, Loam and Sandy loam. The number of experimental units was 2×3×3=18.

A soil sample was taken to estimate some of the physical and chemical properties of the soil (Table 1).

Soil samples were air-dried and sieved after breaking up by hand at suitable moisture through a sieve with an opening diameter of 4-9 mm to determine mean weight diameter (MWD) and water-stable aggregate percentage (WSA%).

The method of Van Bevel (1949), as modified by Kemper and Rosenau,1986 was used to determine the WSA% and MWD. The WSA% was calculated using the equation as follows:

$$WSA\% = \frac{(M(a+s) - Ms)}{(Mt - Ms)} * 100$$

Where $M_{(a+s)}$ is the mass of resistant aggregate plus sand (g), Ms is the mass of the sand fraction (g). and Mt is the total mass of the sieved soil (g). The MWD was determined as follows:
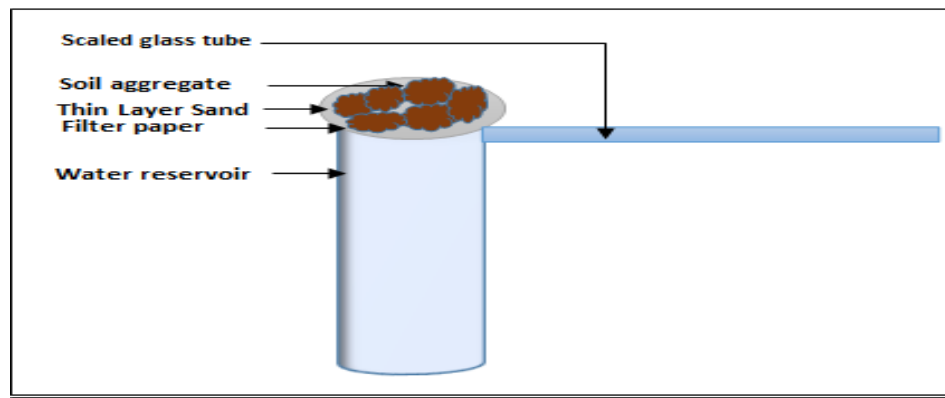
$$MWD = \sum_{i=1}^{n} XiWi$$

MWD is the mean weight diameter of water-stable aggregates, Xi is the mean diameter of each size fraction (mm), and Wi is the total soil sample mass proportion. Other soil aggregates with the same diameter of 4-9 mm were also used to measure the water wetting rate (WR) (Al-Ani and Dudus, 1988) using the water wetting rate device shown in figure 1 by taking 6 soil aggregates of the same size and nearly to a spherical shape with a total air-dry weight of 3gm and after placing the filter paper on the upper opening of the water reservoir and placing a layer of washed medium-coarse sand to increasing the contact of aggregates with water. The device calibrates, then the six aggregates are quickly placed on the sand and the time it takes for each sample to absorb a specific volume of water is measured, which is measured from the graduated glass tube attached to the device. The bulk density of the soil was estimated by the core sampler method according to (Blake and Hartage, 1986), and the texture was estimated by the Pipette method. The organic matter was estimated according to the Nelson and Sommers 1982 method.

Figure 1. Schematic diagram of apparatus to measure the wetting rate of soil aggregates

Table 1. Some physical and chemical properties of the soil

Soil management	Soil texture	Sand	Silt	Clay	Ec	PH
		gm.Kg^{-1}			ds.m^{-1}	
Cultivated	clay	60	340	600	6	7.36
	loam	392	440	168	5.3	7.33
	loamy sand	773.8	139.4	71.8	4.1	7.2
Uncultivated	clay	60	340	600	65	7.55
	loam	392	440	168	50	7.45
	loamy sand	773.8	139.4	71.8	30	7.4

Statistical analysis

A factorial experiment within a completely randomized design was used to analyze the data. The data were statistically analyzed by using the Gen.Stat program. The revised least significant difference (RLSD) was used to compare the mean of the treatments at the probability level of 0.05.

Results and Discussions

The results of the statistical analysis of the F-test (Table 2) show a highly significant effect of soil management and soil texture factors and their interaction in the values of soil organic matter content (OM).

Figure 1A shows that the treatment of soil management (represented by soil cultivation with the alfalfa crop for 7 years consecutively) (Cu) led to an increase in its content of OM as a general average, which was 56.337 gm kg^{-1}, with a significant difference compared to the uncultivated soil (UCu) (3.397 gm kg^{-1}). Figure 1B shows that significant difference in soil organic matter by using RLSD between texture treatment, as the Clay soil (C) recorded 34.71 gm kg^{-1} with a significant difference with Loam soil (L) (31.45 gm kg^{-1}) and Sandy loam soil (SL) (23.44 gm kg^{-1}), which recorded the lowest values of OM. As for the interaction between the two factors of soil management and its

texture, shown in Figure 1AB, the differences were significantly by using RLSD between the interaction treatments. The cultivated clay soil (Cu) recorded the highest values 65.11 gm kg^{-1}. In contrast, the uncultivated LS soil treatment (UCu) recorded the lowest (2.68 gm kg-1) value. Generally, the soil management processes for all the texture at this study gave high values of OM, which was more evident by the increase of clay and silt particles in the soil. The reason for the increase in OM in the Cu treatment compared to the UCu treatment is because of the various soil management processes, including cultivating the soil for 7 years consecutively with the alfalfa crop, leading to the survival of some residues of this crop in the soil pedon, as well as the root secretions and other organisms coexisting with the roots and collected in the soil profile, which in turn leads to an increase in OM (Deksisso, 2008). As for the rise of OM in soil textures, according to the increase in its content of clay and silt particles (Table 1), due to the fine particles have a high surface area and physical, chemical and fertility properties that help in increasing the growth of plants and other living organisms as well as increasing their moisture content, which in turn increases biological shifts, and this is reflected in an increase in OM,

and that this rise is more evident by the interaction of soil management processes with the increase in the soil content of clay and silt particles (Chan, 2005), as it was found (Reynolds et al., 2002) that the percentage of organic matter increases in the soil with fine textures compared with the coarse texture because the coarse texture is good aeration, which increases the rate of oxidation and decomposition of the organic matter.

Table 2. The result of analysis of variance (ANOVA) for selected soil properties under different treatments.

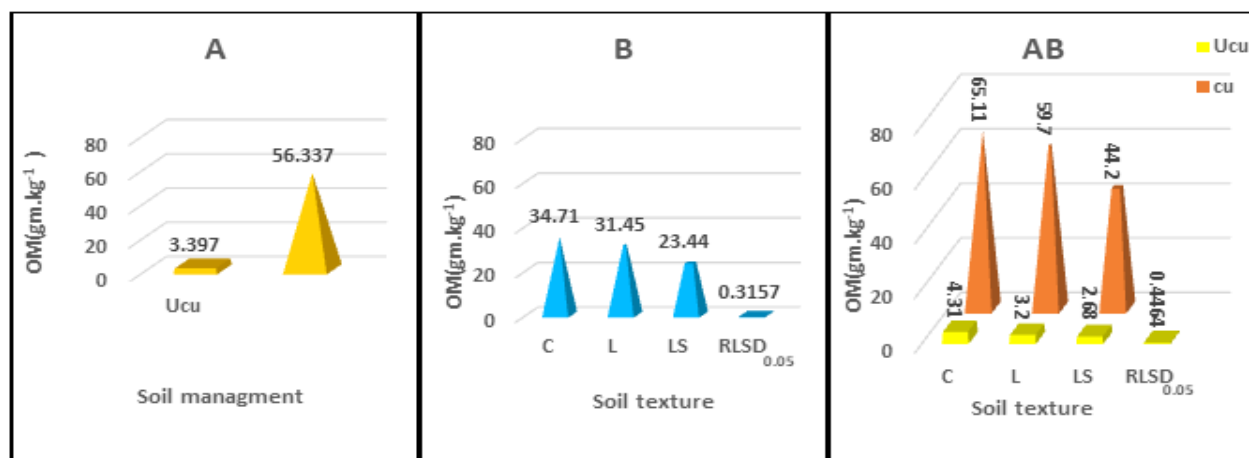| Source of variation	df	O.M.	ρb	MWD	WSA%	WR.
Soil management	1	2.5**	63.2**	569.03**	1020**	726**
Soil texture	2	3204.9**	95.26**	121.45**	143.61**	181.54**
Soil manage.*Soil text.	2	2240.2**	5.17*	52.3**	5.3*	11.4*

Figure1. Effect of soil management (A), soil texture (B) factors and their interaction(A B) on soil organic matter content

The results of the statistical analysis of the F-test show that there is a highly significant effect of each of the soil management and soil texture factors and significant interaction in soil bulk density (ρb) (Table 2). When comparing the treatment of soil management Cu with the therapy of UCu (Fig. 2A), there is a highly significant difference. Cu treatment recorded a decrease in pd values of 1.38 Mgm kg^{-1} compared with the UCu treatment of 1.51 Mgm kg $^{-1}$ with a decreasing percentage of 8.61 %.

Figure 2B shows significant differences by using RLSD between soil texture treatments in ρb values, as Clay soil treatment recorded the lowest values of 1.325 Mgm kg^{-1}, followed by Loam soil treatment at 1.425 Mgm kg^{-1}, while the highest values Loamy sand soil treatment 1.585 Mgm kg^{-1}. In contrast, the interaction between the factors of soil management and its texture is shown in Figure 2AB, where the decrease in ρb varies according to the two soil management treatments. The lowest value was 1.23 Mgm kg^{-1} in the cultivated clay soil, while the highest was in the uncultivated loamy sand soil, while the other treatments were

between these two treatments. The reason for the decrease in the values of ρb as a general average in the treatment of soil management Cu compared with the treatment UCu is due to its high content of OM (Fig. IA), as well as the fact that the processes of soil management, ploughing and crop service process lead to agitation and dismantling of the soil, thus reducing ρb (Osunbitan, 2005), Where Ding et al., 2002 indicated that the various soil servicing and management processes are one of the essential factors that affect the reduction of ρb values.

The reason for the decrease in the values of ρb in C soil texture and its interaction with the soil management treatment, and it gradually rises in soil L and LS, respectively, is due to its high content of OM (Fig. 1B, 1AB), as the increase in soil content of OM reduces ρb because the density of OM is low when compared with the density of the mineral part in the soil (Chen, 2001).
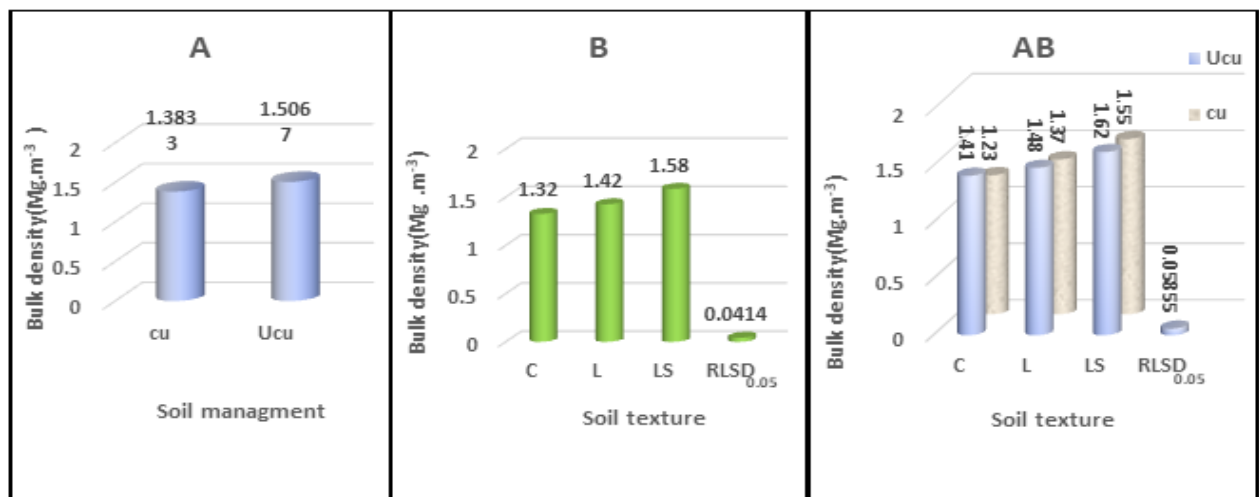

Figure 2. Effect of soil management (A), soil texture (B) factors and their interaction (AB) on soil bulk density

Results of the statistical analysis of the F-test (Table 2) show that there is a highly significant effect of each of the soil management and soil texture factors and their interaction in the MWD values, as is generally clear from Figure 3A and when comparing the two soil management treatments that the Cu treatment was with MWD high (0.893 mm) compared to the UCu treatment, which recorded a low value of MWD (0.223 mm) with a height percentage of 300%.

The effect of the soil texture factor, Figure 3B shows the comparison between the texture treatments, as it is noted as a general average that there are significant differences by using RLSD between all textures in the values of MWD, where the highest value was in clay soil (0.8 mm), followed by Loam soil (0.605 mm) and fewer values in Loamy sand (0.270 mm). The increase in MWD of clay soil compared to Loam and Loamy sand was 32% and 196%, respectively.

When comparing the values of MWD as a result of the interaction between soil management and soil texture factors. Figure 3AB shows that the highest values were in the cultivated clay soil treatment (1.3 mm), while the lowest values were in the uncultivated LS treatment (UCu) (0.12 mm). As observed as a result of this interaction, the importance of MWD increases in all cultivated soil treatments compared with uncultivated soils and for all soil textures. On the other hand, it increases with the increasing softness of soil texture.
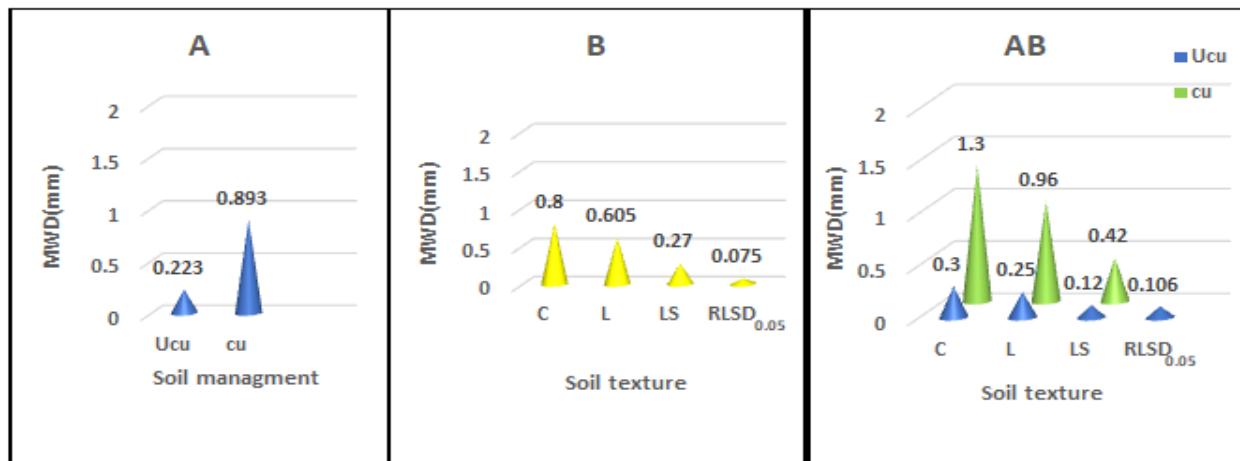

Figure 3. Effect of soil management (A), soil texture (B) factors and their interaction (AB) on soil mean weight diameter

Results of the statistical analysis of the F-test (Table 2) show that there is a highly significant effect of each of the factors, soil management and soil texture, on the second parameter for describing the soil structure, which is a water-stable aggregate percentage (WSA%) and significant for their interaction in this parameter, as it is generally clear as a general average from the figure 4A when comparing the two soil management treatments, the Cu treatment had a high WSA% (71.33%) and a highly significant difference with UCu treatment, which recorded the lowest value (33.78%) with an increasing percentage of 112%. Figure 4B also shows, as a general average, the significant difference by using RLSD between the soil texture treatments in WSA% values, where the higher values are observed in Clay texture (62.67%) and Loam (56%) treatments, with an increasing percentage of 61% and 44%, respectively, compared to the treatment of Loamy sand texture (39%).

Figure 4B shows the interaction between the soil management and soil texture factors in the value of WSA%, where significant differences are observed by using RLSD between the studied treatments, as Cu and its interaction with Clay texture recorded the highest discounts of (7.9%), while the lowest values were for UCu and its interaction with Loamy sand texture (18%), as it is generally clear that the increase of clay partials in the soil texture and its interactions with soil management gives the highest values of WSA%. The higher values of MWD and WSA% in Cu treatments are compared with the UCu, soil due to the soil management processes represented by tillage, cultivation, secretions of the root system and crop service

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processes, which in turn, leads to improving the soil structure parameters (Souza et al., 2014).

As for a reason for the high values of MWD and WSA % by increasing the clay particles in the soil texture under this study, especially clay soil treatment, and its interaction with the soil management treatment, it is because the clay particle has a high surface area, which will lead to the formation of more stable soil aggregates compared to the other soil particles with a lower surface area (Ayoubi et al., 2011), besides the increase in

clay particles that made cementing agent with the silt particles, sand and small initial aggregates (Neelam et al., 2010), as well as the increase in the soil content of OM in these treatments (Fig. 1), The interaction between clay particles and OM effects an essential role in improving soil structure and increasing its aggregates by increasing the moisture content and providing appropriate conditions for the effectiveness of microorganisms and the rate of their decomposition of organic matter (Amelung et al., 1998).
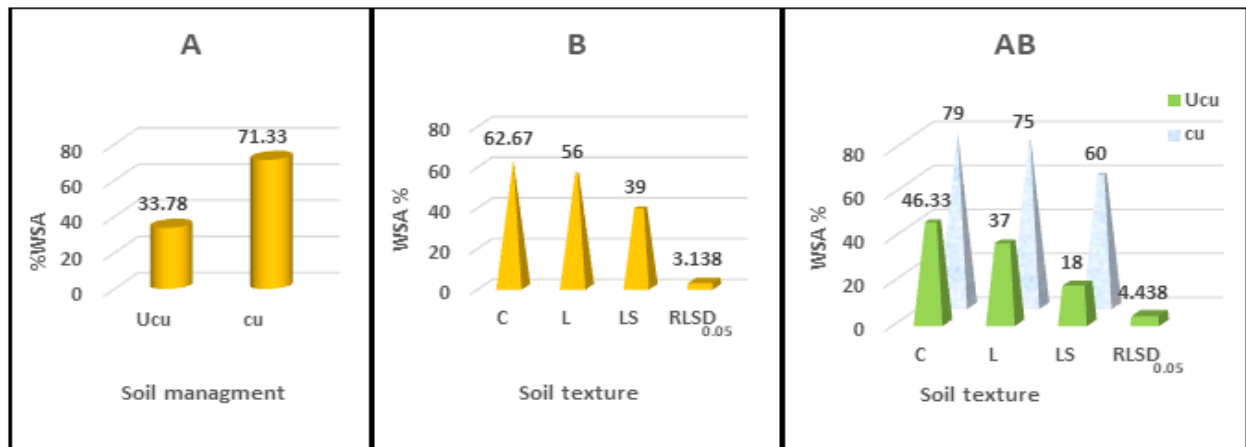

Figure 4. Effect of soil management. (A), soil texture (B) factors and their interaction (AB) on soil water-stable aggregate percentage

The results of the statistical analysis of the F-test (Table 2) show that there is a highly significant effect of soil management and soil texture factors on Aggregate wetting rate (cm^3 $3gm^{-1}$ min^{-1}) (WR) and a significant impact of their interaction. It is observed from figure 5A as a Cu treatment (0.253 cm^3 $3gm^{-1}$ min^{-1}) with a general average that the WR values decreased in the Cu highly significant difference compared with the treatment UCu (0.399 cm^3 $3gm^{-1}$ min^{-1}) with

a percentage decrease in of 37%. As for the effect of soil texture factor on WR values, it is clear from the results in Figure 5B that the lowest values were in C soil (0.265 cm^3 $3gm^{-1}$ min^{-1}) and increased in the two soils of L soil (0.32 cm^3 $3gm^{-1}$ min^{-1}) and LS soil (0.392 cm^3 $3gm^{-1}$ min^{-1}) respectively with significant differences by using RLSD with a percentage decrease of 32% and 18% for the soils C and L compared to with LS soil.

Figure 5AB shows the interaction between soil management and soil texture factors in the values of WR, where it is noticed that there are significant differences between the interaction treatments, as the lowest values were for the cultivated clay soil treatment (0.20 cm^3 3gm^{-1} min^{-1}), while the highest values were in the uncultivated LS soil treatment (0.483 cm^3 3gm^{-1} min^{-1}). Generally, the WR values decrease with the increase in the percentage of clay content in the textures under this study. The reason for the decrease in the WR of soil aggregates as a general average in the treatment of soil management (Cu) is due to the high values of OM, MWD and WSA% (Fig. 1, 3, and 4), and low ρb values (fig. 2), as OM effects of reducing the soil's wettability by forming hydrophobic complexes (Mahboubi and Lal, 1998), as well as leading to the coating of soil particles with organic colloids (Neelam et al., 2010). Also, OM decreases the water

movement it is entering at the large pores, which reduces the size of the water-convincing pores, especially in coarse-textured soils (Osunbitan, 2005). Also, soil management affects the soil pore size distribution by increasing the number or density of the small pores at the expense of the large water-convincing pores (Greenland, 1981). Soils are due to their being factors affecting soil properties and consequently influencing structure parameters and water absorption of soil pools (Deksissa et al., 2008). Increasing the hydration rate of soil aggregates depends on improving the percentage of large pore diameters by increasing its sand content to the degree that allows water to enter the aggregates at a certain speed without causing great pressure that leads to the destruction of aggregates as a result of reducing air explosions due to reducing the volume of trapped air (Greenland, 1981).
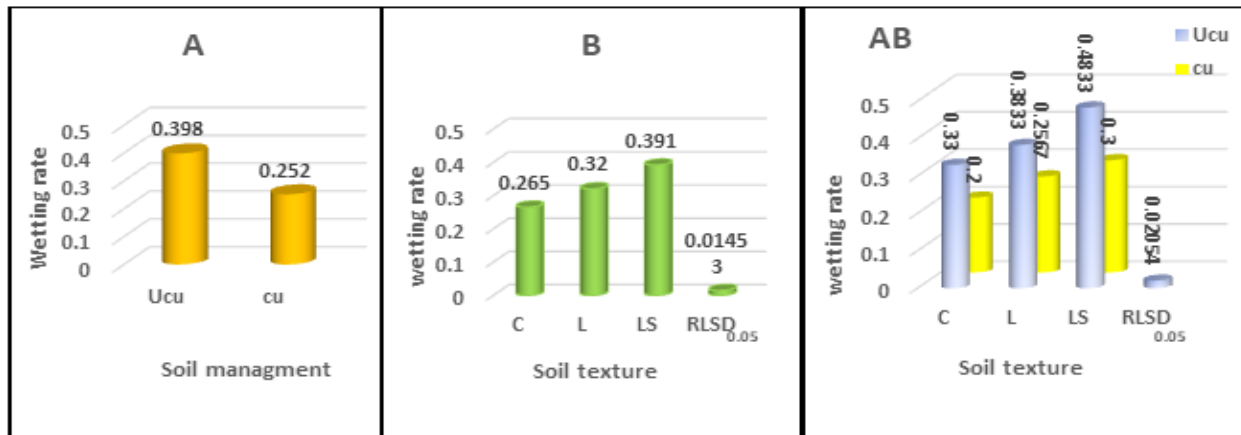

Figure5. Effect of soil management (A), soil texture (B) factors and their interaction (AB) on water wetting rate (cm^{3}3gm^{-1} min^{-1}).

Conclusion

Because most of the soils of central and southern Iraq are characterized by the deterioration of their physical and chemical

properties, especially their structure, therefore, the results of this study showed that the processes of soil management represented in the cultivation of the alfalfa

crop and its service operations for several consecutive years has led to the improvement of some soil physical properties represented by soil structure parameters such as MWD and WSA% through increasing OM and decreasing **ρb** values. This effect varies with the soil textures. It was noted that the interaction between the soil management factor and the increase in the content of clay and silt led to an improvement in the soil properties in this study, and its effect was apparent on the soil structure parameters, which are MWD and WSA%. And this effect was reflected in reducing the WR values of soil aggregates, which is one of the improved characteristics of water movement under field irrigation conditions.

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