Effective Management Practices to Enhance soil physical characteristics in salt – affected soils irrigated with saline ground water

Adnan Sh. Falih
Scientific Research Commission/ Baghdad- Iraq
E- mail: adnanshbar@yahoo.com

Abstract

This field experiment was carried out during the winter season of 2017 at the Central Agricultural Experiment Station for Soil and Water Resources in Baghdad- Iraq. The primary aim of the study was to enhance the physical properties of saline soils irrigated with saline groundwater. The study was conducted using a randomized completely block (RCBD) field experiment with three replications. Treatments involved four different approaches: C, M, G and P. The soil moisture content in the field was determined using the gravimetric method for a depth of 0-0.3 meters. The outcomes demonstrated that the practice of applying mulch (M) increased the volume of available water, organic matter, the percentage of stable aggregates, and the hydraulic conductivity of the soil, all of which were (47.8, 28.1, 26.9, and 42.3) percent respectively, compared with control treatment. Phosphogypsum (G) application as chemical amendment caused increasing in (Available Water, organic matter, percent of aggregate stable and hydraulic conductivity) with 25.0, 11.5, 16.0 and 25.1% respectively compared with control treatment. Peat (P) application practices caused increasing in (available water, organic matter, percentage of aggregate stable and hydraulic conductivity) with 57.1, 51.6 %, 36.4 and 48.7% respectively Compared with the control treatment, the soil density of the control treatment was the largest (1.46 Mg.m-3), and the soil density of the peat treatment was the smallest (1.30 Mg.m-3).

Keywords: Mulch, Gypsum, Organic Matter and Soil Physical Characteristics.

ممارسات الإدارة الفعالة لتحسين الخصائص الفيزيائية في الترب المتأثرة بالأملاح والمروية بمياه جوفية مالحة

د. عدنان شبار فالح
هيئة البحث العلمي- مركز البحوث الزراعية/ بغداد- العراق

الخلاصة

أجريت تجربة حقلية خلال موسم الشتاء للعام 2017 في محطة أبحاث مركز البحوث الزراعية- قسم إدارة التربة والمياه في بغداد- العراق. الهدف الأساسي من الدراسة تحسين الخصائص الفيزيائية للترب المالحة المروية بمياه جوفية مالحة. استخدم القطاعات العشوائية الكاملة (RCBD) وبثلاث مكررات. اشتملت الدراسة على أربعة ممارسات مختلفة. المقارنة (C) Control وتغطية التربة (M) Mulch و الجبس الفوسفاتي(G) Phosphogypsum و مصلح عضوي (P) Peat. تم مراقبة وتحديد المحتوى الرطوبي للتربة باستخدام الطريقة الوزنية لعمق 0-0.3م. أظهرت النتائج ان ممارسة تطبيق تغطية التربة (M) أدت الى زيادة حجم الماء الجاهز، المادة العضوية، نسبة المجاميع الثابتة والتوصيل الهيدروليكي للتربة والتي بلغت (17.8، 28.1، 26.9، 42.3 %)على التوالي، مقارنة بمعاملة المقارنة (C). أدى إضافة الفوسفوجيم (G) كمصلح كيمياوي في زيادة حجم الماء الجاهز، المادة العضوية، نسبة المجاميع الثابتة، التوصيل الهيدروليكي وبنسبة (25.1،25.0، 16.0، 11.5 %) على التوالي بالمقارنة مع معاملة المقارنة (C)،كما أدت إضافة البتموس (P) كمصلح عضوي الى زيادة حجم الماء الجاهز، المادة العضوية نسبة المجاميع الثابتة، التوصيل الهيدروليكي بنسبة (57.1، 48.7، 36.4، 51.6 %) على التوالي مقارنة بمعاملة المقارنة (C). كانت كثافة التربة الظاهرية في معاملة المقارنة هي الأكبر اذ بلغت (1.46 ميكاغرام.م^3) في حين كانت الأقل في معاملة إضافة البتموس كملح عضوي(1.30 ميكاغرام.م^3).

الكلمات المفتاحية: تغطية التربة، الجبس الفوسفاتي، المادة العضوية، خصائص التربة الفيزيائية.

Introduction

Water plays a vital role in agricultural productivity and development, particularly in arid and semi-arid regions. In the Arab world, agriculture accounts for nearly 90% of total freshwater consumption, making it the largest water-consuming sector. Improvements in agricultural development depend largely on the quantity and quality of freshwater available for irrigation. Water scarcity and increasing competition for water use are reducing the supply of freshwater available for irrigation. At the same time, meeting growing food demand requires increasing crop yields with less water. More efficient water use will be a key challenge in the near term, requiring the adoption of technologies and techniques that ensure more precise delivery of water to crops.

Soil moisture salinity affects the physical properties of soil by causing the clumping of fine particles into aggregates. This process positively influences soil aeration, enhances root penetration, and promotes root development. However, high salt concentrations lead to soil dispersion and the swelling of clay particles and aggregates. As a result, dispersed clay particles clog soil pores, thereby reducing soil permeability. In arid regions, salt accumulation in the root zone can be controlled by reducing salt upwelling and evaporation.

Mulching is a stable alternative to maintain optimal soil moisture and heat conditions and improve water use efficiency by reducing evaporation, thereby increasing food production. Straw is considered one of the most serious crop waste problems. Farmers must give up the use of wheat straw.

Wheat straw serves as an effective and economical mulching material due to its low cost. Mulching with wheat straw has been shown to improve water retention within the soil profile and reduce competition for water and nutrients from surrounding vegetation. Moreover, the use of wheat straw as ground cover can decrease irrigation water requirements by approximately 30%, thereby enhancing water use efficiency.

The erosive effects of salinization and siltation are a worldwide issue. The FAO's Food and Agriculture Organization documented that over 1 billion hectares of land worldwide is salinized or siltated to a degree or another. (FAO, 1992). Gypsum is commonly employed to address soil salinity and sodicity. Additions employed include gypsum and organic matter (Ameezketa *et al*., 2005). Gypsum is widely regarded as the most effective soil amendment for reclaiming sodic soils and mitigating the adverse effects of sodium-rich irrigation water. Its popularity stems from its high solubility, affordability, availability, and ease of application (Wong and Dala, 2009). Research on the impact of gypsum on saline-alkali and sodic soils has demonstrated that higher application rates effectively remove greater amounts of sodium (Na^+) from the soil profile, leading to notable reductions in both soil electrical conductivity (EC) and the sodium adsorption ratio (SAR) (Hamza and Anderson, 2003). The application of organic material and mulching is considered to be beneficial methods for enhancing salinated soil and promoting plant growth (Bhatti. *et al*., 2005, Pang. *et al*., 2010). Organic soil amendments have traditionally been employed as a means of providing plant nutrients and organic matter to enhance the fertility of farmland (Dao and Cavigelli, 2003). In general, the incorporation of organic matter into soils leads to improvements in their physical, chemical, and biological properties.

Material and Methods

Field experiment was conducted during the winter season of the year 2017 to enhance soil physical properties in salt-affected soil such as hydraulic conductivity (H.C), aggregate stability (A.S), organic matter (O.M) and bulk density (B.D) ,Some field effective practices (Mulching, application of organic matter, phosphogypsum as amendment) will be made to achieving objectives above and prevention soil degradation. The study was conducted at the Soil and Water Resources Research Center Station, located in central Iraq at coordinates 33.140°N, 44.400°E, and an elevation of 34 meters above sea level. The soil is of loam texture and classified as (fine loam, mixed, hypothermic, typic , terrified events), Relevant soil physical and chemical characteristics (Table1), and chemical characteristics for irrigation water (Table2) were determined according to standard methods (Black,1965, Page *et al*,1982,Richarads, 1931). The field was duplicated three times in a randomized completed block design (R.C.B.D) using a plot 16 m (4X4m). Four field effective practices randomly applied to each block were:

C = Control

M = Mulching (12 ton / ha)

G = Phosphogypsum (12 ton / ha)

P = Peat (12 ton / ha)

Table 1: Relevant physical and chemical properties to the soil studied

Properties	Unit	Value28/11/2018
Sand	g. Kg^{-1}	355
Silt		393
Clay		252
Texture		Loam
Bulk density	$\mu g.m^{-3}$	
Volumetric moisture content at 33 Kpa	cm^{-3} .cm^{-3}	0.35
Volumetric moisture content at 1500 Kpa	cm^{-3} .cm^{-3}	0.21
Available water	cm^{-3} .cm^{-3}	0.14
ECe	$dS.m^{-1}$	17.0
PH		6.9
Organic matter	0.56	%
Na^{+2}	836.1	Ppm
Ca^{+2}	436.8	Ppm
Mg^{+2}	20.0	Ppm
K^{+1}	26.1	Ppm
Cl^{-1}	580.0	Ppm
So_4^{-2}	2378.4	Ppm

Table 2: Relevant physical and chemical properties to the water irrigation.

saline ground water	EC	PH	Na^{+1}	K^{+1}	Ca^{+2}	Mg^{+2}	Cl^{-1}	So^{--4}
								PPM
	3.68	7.41	1245.8	Nil	382.6	111.6	534.328	483.74

Nitrogen fertilization was applied using urea (46% N) at a rate of 200 kg·ha^{-1}. Two different treatments were used: the first involved the application of 200 kg·ha^{-1} of triple superphosphate (T.S.P), while the second included 200 kg·ha^{-1} of potassium sulfate (K_2SO_4), which was incorporated into the soil five weeks after planting. Barley seeds were sown on November 22, 2017, in rows spaced 0.25 meters apart. The required irrigation volume was determined by estimating soil moisture content using the gravimetric method, this method was used to water the soil from planting to the end of the tillering stage, the water was then added to the soil as needed by the growing season. The equation used by Kovda et al (1973) was employed to add the water to the soil.

$d = (\theta_{fc} - \theta_{bi}) * D$ ………………. (1)

where:

d= depth of water applied (m)

θ_{fc} = Volumetric moisture content at field capacity (m3.m^{-3})

θ_{bi} = Volumetric moisture content before irrigation (m3.m^{-3})

D= soil depth (m).

Result and Discussion

Figure1 showed that the implementation mulching (M) application practices caused increasing in (available water, organic matter, percentage of aggregate stable and hydraulic conductivity) with 47.8, 28.1, 26.9 % and 42.3 %. respectively compared with control treatment. Phosphogypsum (G) application as chemical amendment caused increasing in (Available Water, organic matter, percent of aggregate stable and hydraulic conductivity) with 25.0, 11.5, 16.0 and 25.1% respectively compared with control treatment. Peat (P) application practices caused increasing in (available water, organic matter, percentage of aggregate stable and hydraulic conductivity) with 57.1, 51.6 %, 36.4 and 48.7% respectively compared with control treatment.

Conversely, the maximum value of soil's bulk density was 1.46 Mg.m-3, which was achieved in the control treatment, and the minimum value was 1.30 Mg.m-3, which was achieved through the use of peat in agriculture practices. The utilization of organic substances and covering the soil with a layer of grass or other vegetation is considered a form of soil management that promotes soil improvement and increases crop growth in soil that is affected by salt (Pang *et al*, 2010). Several investigations have demonstrated that organic matter has a positive effect on the properties of soil, these effects include reducing the bulk density, increasing porosity, water percolation, and increasing the soil's saturated conductivity.2008). Dao and Cavigelli (2003) documented that organic amendment has been historically used as a nutrient enhancer and organic matter to promote the fertility of agricultural soil. Additionally, the physical properties of the soil were increased when manures were added to it. (Ould Ahmed *et al*.2010). Hati *et al.* (2007) documented that the inclusion of organic matter in the soil increased the organic content of the soil and decreased the soil's bulk density compared to the control. These findings were in agreement with (Zhang *et al* ,2009). Straw cultivation system can conserve soil water and lower the temperature of the soil because it increases the amount of residue and decreases the frequency of soil contact. Saroa and Lal demonstrated that cover cropping increased the soil organic carbon content in the 0-5 cm soil layer only. Mulumba and la1(2008) documented that straw mulch decreased the bulk density of the soil and increased the total porosity of the soil, these effects were specific to Falih's findings. (2017) and Pervaiz *et al.* (2009). Gurpreet *et al.* (2007) reported that mulching contributes to an increase in soil carbon content, which in turn enhances the overall stability of soil aggregates. Similarly, Paloma *et al*. (2016) observed a slight increase in the percentage of stable aggregates across all treated samples compared to the control, with these differences being statistically significant as confirmed by Falih *et al.* (2017). The application of organic materials such as chopped rice straw, wheat straw, rice husks, and salt grass has also been shown to improve the physical properties of saline soils. Furthermore, Joachim *et al.* (2010) noted an improvement in hydraulic conductivity resulting from soil reclamation. This improvement is attributed to the replacement of sodium ions with calcium in the presence of gypsum, which facilitates gradual flocculation. This process enhances soil

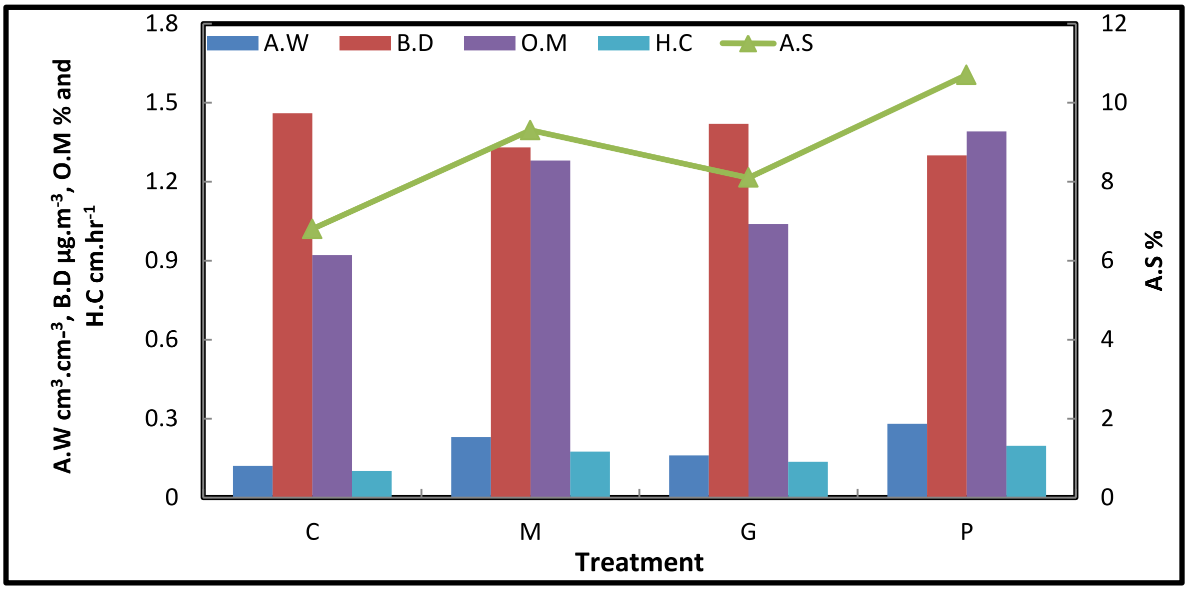

Fig (1) Effect of Different Treatment on Some Soil Physical Characteristics.

aggregation, reduces bulk density, and increases hydraulic conductivity. (Patel and Suthar, 1993). these are certain by Ravinder *et al*. (2017) and Khalil Ahmed *et al*. (2017). Assessment the relationship between soil physical characteristics which was studied with each of the treatments used in the study. The results in dictated the presence positive and significant correlation between soil physical characteristics, except soil bulk density which have a negative and significant correlation at the level of probability 5 %. The range of correlation were 96.9 – 99.8 for organic matter with the rest characteristics (AW, B.D, A.S and H.C) Figure2. This mean increasing one unit of organic matter add leads to increasing 0.330 cm^3. cm^3, 7.6 % and 0.196 cm. day^{-1} from A.W, A.S and H.C respectably, but increasing one unit for organic matter add leads to decreasing –0.347 Mg. kg^{-1} from soil bulk density.

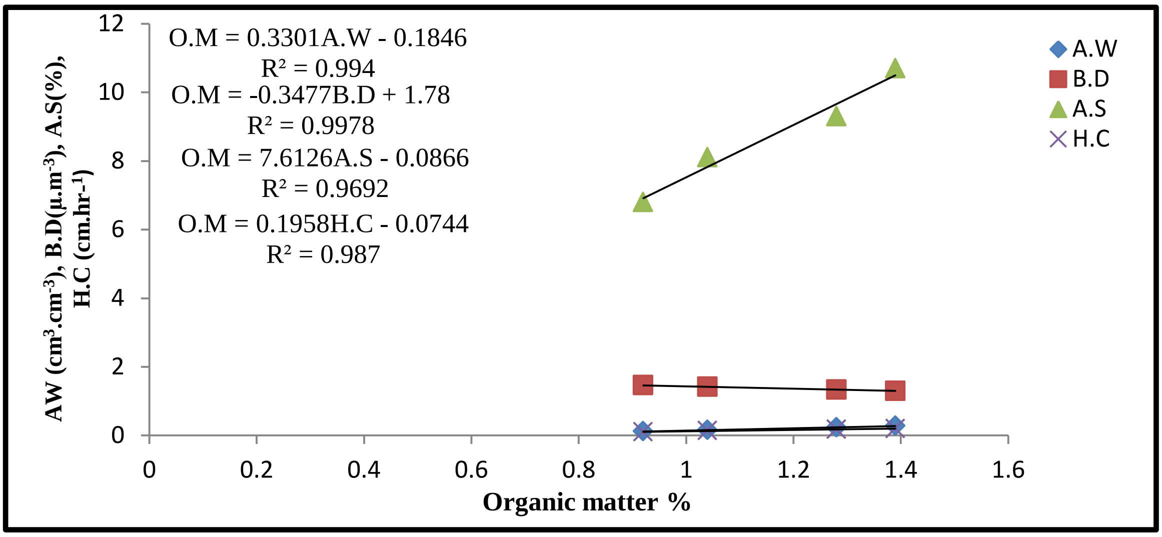

Fig (2) Relationship Correlation Between Organic Matter with Some Soil Physical Characteristics.

The highest effect of the organic matter adding and most efficient correlation relationship was found between organic matter and soil bulk density. Several studies have demonstrated the beneficial effects of organic matter towards soil quality, by decreasing bulk density, increasing porosity, increasing water percolation rate, and having a saturated hydraulic conductivity.

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