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EFFECT OF PHOSPHOGYPSUM IN SOME PHYSICAL PROPERTIES OF SOIL

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Abstract

Alaboratory experiment was carried out during 2020 in the laboratories of the College of Agriculture / University of Anbar in order to study the role of phosphogypsum in the values of saturated hydraulic conductivity, capillary height and water holding capacity of soil in clay soil. The phosphogypsum was added mixed with the soil at four levels (without adding, 0.3%, 0.6% and 0.9%) by weight of the soil .The treatments were incubated for 90 days by adding water at the limits of the field capacity and compensation the lost water after deplete 50% of the available water. The amount of available water, the saturated hydraulic conductivity, and the capillary height has been estimated. The soil water holding capacity increased significantly, which was 16.91% at the addition of 0.9% compared to the treatment without addition. While the highest value of the saturated hydraulic conductivity was 0.35 cm per hour $^{-1}$at the level of 0.9% addition. The capillary height decreased significantly with the increase in the level of phosphogypsum addition, and the lowest value was 52 cm when adding 0.9%.

Keywords: Water Capacity, Hydraulic Conductivity, Capillary water, Phosphogypsum.

تأثير الجبس الفوسفاتي في بعض الخصائص الفيزيائية للترب

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الخلاصة

اجريت تجربة مختبرية خلال 2020 في مختبرات كلية الزراعة / جامعة الانبار بهدف دراسة دور الجبس الفوسفاتي في قيم الايصالية المائية المشبعة والارتفاع الشعري وسعة احتفاظ التربة بالماء في تربة طينية. تم اضافة الجبس الفوسفاتي خلطا مع التربة بأربعة مستويات بدون اضافة و0.3% و0.6% و0.9% وزنا من التربة. حضنت المعاملات لمدة 90 يوما بإضافة المياه عند حدود السعة الحقلية وتعويض المياه المفقودة بعد استنفاذ 50% من الماء الجاهز. قدر الماء الجاهز والايصالية المائية المشبعة والارتفاع الشعري.

ازدادت سعة احتفاظ التربة بالماء معنويا وبلغت نسبة الزيادة في سعة احتفاظ التربة بالماء 16.91% عند اضافة 0.9% مقارنة بمعاملة بدون اضافة. فيما بلغت أعلى قيمة للإيصالية المائية المشبعة 0.35 سم ساعة$^{-1}$ عند مستوى إضافة 0.9%. انخفض الارتفاع الشعري معنويا بزيادة مستوى اضافة الجبس الفوسفاتي وبلغت اقل قيمة 52 سم عند اضافة 0.9%.

كلمات مفتاحية: سعة احتفاظ التربة بالماء، الايصالية المائية المشبعة، الارتفاع الشعري، الجبس الفوسفاتي.

Introduction

Phosphogypsum is one of the by-products of the phosphate fertilizer industry, as large quantities cause many environmental effects (13). Therefore, it requires serious thinking about its scientific and safe exploitation and benefit from it in various fields. Phosphogypsum has been used in agriculture to improve the physical and chemical properties of soil (1).

Soils with high clay content have negative physical properties, including low saturated hydraulic conductivity values due to low pore volumes and low infiltration, which causes surface run-off and soil erosion (7). The addition of phosphogypsum mixed with the soil increased the soil water holding capacity and reduced surface run-off and soil erosion (15). The addition of phosphogypsum to the surface of the soil reduced soil erosion by 4-10 % and increased soil aggregations and the particles stability (2 and 10).

Found (11) that the addition of phosphogypsum to the soil increased the stability of soil aggregates and the formation of a particle structure (8) showed that the addition of phosphogypsum and cement to the soil increased the ability of the soil to hold water and moisture content (14). Mentioned that the addition of phosphogypsum at a rate of 2, 4 and 6 mg.kg^{-1} led to an increase in the values of saturated hydraulic conductivity. Added (3) found that the addition of phosphogypsum mixed with clay soil led to an increase in saturated hydraulic conductivity and a decrease in capillary height with an increase in the percentage of addition, and the highest value of hydraulic conductivity was 0.25 cm hour^{-1}.

This study was conducted in order to reach the role of phosphogypsum in the values of soil water holding capacity, saturated hydraulic conductivity and capillary height in clay soil.

Materials and Methods

Experimental conditions: Clay soil samples were taken from a depth of 0-30 cm, were dried aerobically, crushed and passed through a 2mm sieve size. Some physical and chemical properties were estimated based on (12) (Table 1).

Phosphogypsum was added mixed with the soil at a ratio of 0, 0.3, 0.6 and 0.9% by weight. The treated soil was incubated for 90 days with moisture content at field capacity, and the treatments were distributed according to a complete random design CRD.

Table 1 Some physical and chemical properties of the soil samples.

Parameter		Value	Unit
Electrical conductivity of saturated soil paste extract		2.8	Desisminism^{-1}
Reaction degree		7.8	
Lime		23	%
Organic matter		0.5	%
Cation exchange capacity		18	Cmol / kg soil
Total nitrogen		88	mg/kg soil
Ready-made sulfur		201	mg/kg soil
Ready-made potassium		270	mg/kg soil
Ready-made phosphorous		18	mg/kg soil
Relative distribution of soil particles	Clay	423	g.kg^{-1}
	Silt	303	
	Sand	274	
Soil texture		Clay	

The volumetric moisture content was estimated at different tensions using Haines device for tension between 0.1 and 8 kPa and pressure disc device for tension between 33 and 1500 kPa.(4). The amount of prepared water according to the following equation:

$AW = \Theta_{FC} - \Theta_{WP}$ ……......... 1

Which:

AW = Available Water

Θ_{FC} = Volumetric moisture at field capacity

Θ_{WP} = Volumetric moisture at permanent wilting point

The saturated hydraulic conductivity was estimated by the Constant head method (9) by filling a tube (5 cm long and 5 cm diameter) with soil at a bulk density of 1.35 mg.m^{-3}. The tube was moistened by capillarity then put a tube of water at 1 cm. The percolating water was collected from the bottom of the soil tube in a plastic container, the volume of percolating water was measured with time. Continuous readings was token for an hour until getting the similar values. The hydraulic conductivity was calculated from Darcy's law as follows:

$K_s \frac{VL}{At(h+L)}$ ………….. 2

Which:

Ks = saturated water conductivity, cm h^{-1}

V = volume of percolating water, cm^3.

t = time, hours.

A = cross-sectional area of the soil column, cm^2.
h = height of the water column, cm.
The capillary height was estimated by filling the soil into an organic glass tubes with a bulk density of 1.35 $mg.m^3$ and preparing the water from the bottom under a water pressure of 1 cm. The height of the water was measured with time and the total height was recorded. The rate of pore radius (r) coefficients of soil was measured according to the proposed equation by (6), as follows:

$$r = \frac{4X_\circ I_\circ \lambda}{f t_\circ \, Cos\, \alpha\, \gamma} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad 3$$

Which:
X_O = total distance to the wet front, cm
I_O = total water tip depth. cm
λ = viscosity of water
f = porosity %
γ = surface tension of water
Cos α = contact angle assuming α = zero

Table 2 values of the particle density, bulk density, porosity and effective pore radius.

% Phosphate gypsum	bulk density Mg / m^3	particle density Mg / m^3	porosity %	Effective pore radius micron
0	1.48	2.60	43.08	2.01
0.3	1.39	2.60	46.54	5.15
0.6	1.34	2.60	48.46	5.48
0.9	1.30	2.60	50.00	5.69

Results and Discussion

Soil water holding capacity: Figure 1 shows the effect of phosphogypsum on soil water retention capacity, as it is noted that the values of water content increased with the increase in the percentage of phosphate gypsum added at the field capacity and the permanent wilting point, as the highest value reached 0.3378 and 0.1601 cm^{-3} at the rate of adding 0.9%, respectively. It is noticed from the figure that the percentage of increase in soil water holding capacity was 16.91% when adding 0.9% compared to the treatment without addition.
The addition of phosphogypsum led to an increase in the values of soil porosity and a decrease in the values of bulk density (Table 2), and thus increased the soil's ability to absorb water, which contributed to an increase in the soil's water-holding capacity.

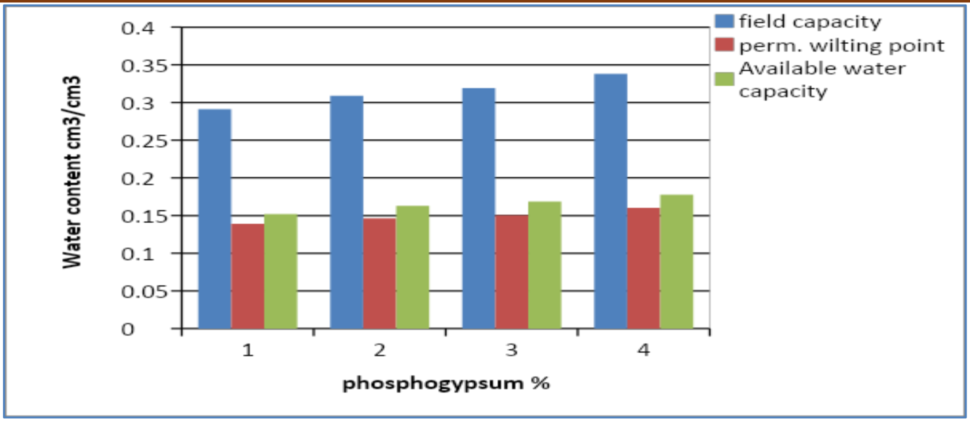

Figure 1 Effect of phosphogypsum on soil water holding capacity.

Figure 2 shows the effect of the phosphogypsum percentage on the saturated hydraulic conductivity values, as its values increased significantly with the increase in the percentage of phosphogypsum added. The highest value was 0.35 $cm.h^{-1}$ at the 0.9% addition level compared to its value of 0.05 $cm\ h^{-1}$ for the control treatment. The increase in the saturated hydraulic conductivity values with the increase in the percentage of phosphogypsum was added is due to the increase in the water-carrying cross-sectional area in order to increase the average of pore radius (Table 2) (3).

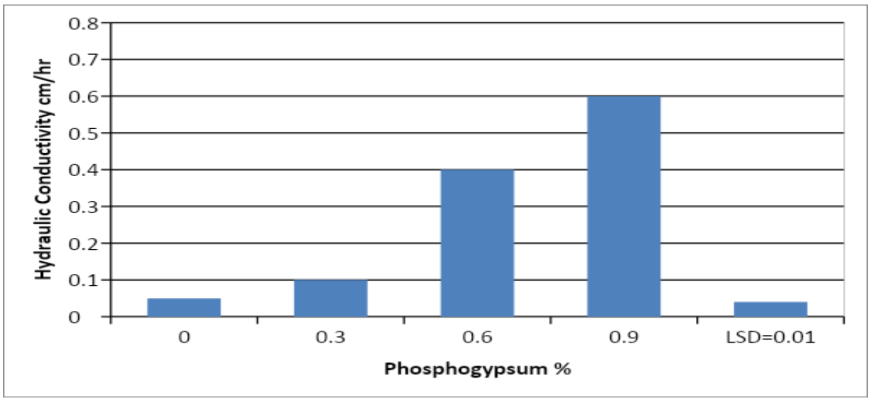

Figure 2 Effect of phosphogypsum on saturated hydraulic conductivity.

The results of Figure 3 indicate the effect of the percentage of phosphogypsum on the capillary height values. The values of the capillary water height decreased significantly with the increase in the percentage of phosphate gypsum added, as its values reached 72, 67, 60 and 52 cm at the percentage of adding 0, 0.3, 0.6 and 0.9%, respectively. The reason for this may be due to the difference in pores diameters (Table 2), as the average of pore diameter increased with the increase in the phosphogypsum content in addition to the increase in the salt concentration due to the solubility of the gypsum (5). The increase in the depth of the water absorbed vertically downwards due to the role of phosphogypsum in increasing the size of the pores, which contributes to an increase in the area of the water-carrying cross-section.

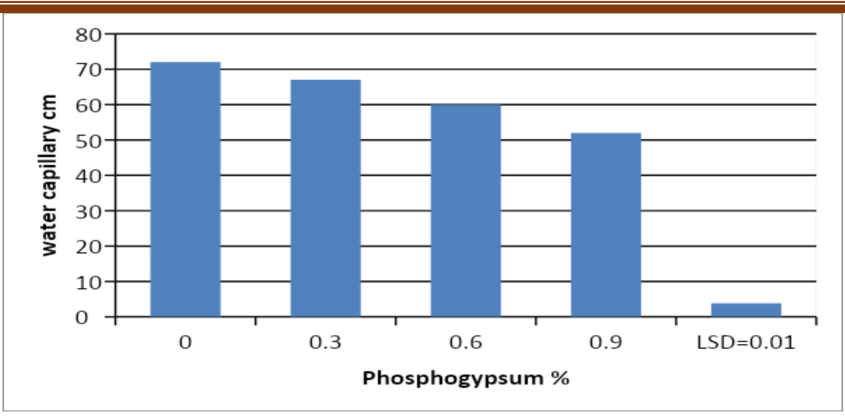

Figure 3 Effect of phosphogypsum on capillary height.

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