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EFFECT OF LEVEL IRRIGATION AND APPLICATION GYPSUM ON IMPROVING SOIL PROPERTIES AND SORGHUM PRODUCTIVITY UNDER DRIP IRRIGATION SYSTEM

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Abstract: A field experiment was carried out in one of the fields of a mixture of soil in College of Agriculture and Marshes, Dhi Qar University, to study the effect of six treatments of irrigation level and the addition of agricultural gypsum to the soil, namely: T_1: Irrigation level 50% without adding gypsum, T_2: Irrigation level 50% with the addition of gypsum, T_3: Irrigation level 75% without adding gypsum, T_4: Irrigation level 75% with the addition of gypsum, T_5: Irrigation level 100% without adding gypsum and T_6: Irrigation level 100% with the addition of gypsum. By adding gypsum to some soil properties, growth and yield of sorghum, water productivity and water use efficiency, according to a Completely randomized design (CBD) and with three replications. The results showed that there were significant differences between the treatments for all the studied traits. The treatment gave the irrigation level 100% with the addition of gypsum, the highest significant values for all studied traits. The treatments to which gypsum was added also outperformed compared to treatment without addition, as well as irrigation at a level of 100% with the addition of gypsum to improve soil properties, reduce the effect of salinity, increase growth and yield characteristics of sorghum, increase water productivity and water use efficiency.

***Key words*:** Gypsum, Soil properties, Sorghum productivity, Drip irrigation system.

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1. Introduction

The current water deficit in Iraq, especially fresh water, calls for the use of unconventional means to conserve the available quantities of water on the one hand. On the otherhand, achieving food security, as water is one of the most important natural resources necessary for the continuation of the life of living organisms and the reality of water studies in Iraq indicates an increase in the danger of depleting fresh water, and the use of water Agricultural drainage to irrigate field crops, which is characterized by a high concentration of salt in it, which negatively affects the physical and chemical properties of the soil, and consequently, a decrease in the productivity and quality of field crops [Noaema *et al*. (2020a)]. Therefore, this water must be taken care of and the use of all available means to preserve it. In addition to the fact that the Iraqi soil suffers from many problems such as high salinity and low fertility and it needs good care and management to improve its fertility and increase its productivity. Several studies have shown the importance of using soil conditioners, including agricultural gypsum, to improve soil properties and increase the productivity of field crops ($CaSO_4{\cdot}2H_2O$) and Gypsum improves soil structure heavy clay effectively and increase its fertility. It also removes sodium from the soil and replaces it with calcium. Gypsum also improves drainage, reduces acidity and gets rid of soil salts, thus improving the chemical and biological properties of the soil. Many studies have proven the addition of natural gypsum to the soil reduced the electrical conductivity and pH values, and confirmed this. The addition of

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gypsum at a level of 400 mg to irrigation reduced soil salinity, pH, bulk density and sodium, while the total porosity of soil and calcium increased compared to without adding 200 mg of soil. As found adding agricultural gypsum, single or combined with the rest of the treatments, was more effective in changing the values of EC and reduce pH values. As for the effect of adding gypsum on the plant, it was found, when gypsum was added to the soil, it improved the vegetative growth characteristics of the sunflower crop, such as an increase in stem length, fresh weight, disc diameter and total yield. And see the addition of gypsum by 4 tons per acres, increasing the soil gypsum content to 14.2% helped to increase the vocabulary of growth and yield of sorghum, such as increasing plant height, leaf area, weight of 1000 grains, and number of grains per head, total yield and biological yield compared to soil with gypsum content of 4.8% [Gehan *et al*. (2014)]. Therefore, this experiment aims to study the effect of irrigation level adding agricultural gypsum, in some physical and chemical properties of soil, growth and yield of sorghum.

2. Materials and Methods

A field experiment was carried out in one of the fields of the College of Agriculture, University of Dhi Qar in a mixture of soil, during the agricultural season 2020 in spring season for planting the white corn crop, the experiment was carried out using a Completely randomized design (CBD). And with three replicates that consist of two levels of agricultural gypsum, zero and 1000 kg per hectare, and three irrigation levels: 50%, 75% and 100%. The combinations are:

T_1: Irrigation level 50% without adding gypsum.

T_2: Irrigation level 50% with the addition of gypsum.

T_3: Irrigation level 75% without adding gypsum.

T_4: Irrigation level 75% with the addition of gypsum.

T_5: Irrigation level 100% without adding gypsum.

T_6: The irrigation level is 100% with the addition of gypsum.

Bringing the number of experimental units to 18 experimental units. The soil was prepared and plowed before planting using a four-pitted plow at a depth of 30-25 cm and then use the double disc harrow at a depth of 7 cm for the purpose of softening the soil, its surface is leveled using a leveling machine then the drip irrigation system is installed, the distance between one line and another is 1 m, the distance between the dots is 20 cm and the length of the field tube is 5 m. Some physical properties of the soil were measured before conducting the experiment and the results are shown in Table 1. The experimental land was divided into six experimental units for each replicate and a crop was planted white corn, Sudanese type on 15/03/2021, and three seeds per jar, the distance between one jar and another is 20 cm, the various physical and chemical parameters of the soil were analyzed by the following steps [Shaaban *et al.* (2013)]. The estimation density, total porosity and moisture content were estimated according to the mentioned method; the electrical conductivity was also estimated (EC) for soil by EC scale to maintain a soil-water ratio of 1:5, then the result was converted to a 1:1 ratio (soil: water) as suggested by the USDA (2004).

Soil pH value samples were measured using a pH meter to maintain a soil-water ratio of 2.5:1 as they suggested calcium (Ca^{+2}) was determined by scaling method with 0.01 a standard of Na2-EDTA, while sodium (Na^{+1}) was measured using a light flame device as for the characteristics of the plant, the height of the plant was measured using a graduated ruler, the number of branches and the leaf area by measuring the length of the leaf and its maximum width multiplied by 0.75 and for all plant leaves and stem diameter using the vernier device and the fresh and dry weight of the vegetative part, as well as the calculation of the yield and its components, the number of grains per head, the number of heads per square meter, and the weight of 1000 grain, individual plant yield, total yield and water productivity through Equation (1) [Jackson (1967)], which expresses the relationship between production to the unit volume of water added in the irrigation process, and it is calculated from the given equation.

$$WP = \frac{Yield}{TDM} \quad (1)$$

where, WP: Water productivity (tons m^{-3}), Yield: Production (ton ha^{-1}), TDM: The volume of water added (m^3 ha^{-1}).

And water use efficiency (WUE) by plants was calculated for each experimental unit on the basis of the dry weight of the vegetative part and the amount of water consumption of the plant using the Equation (2) [Allen *et al.* (1998)].

Table 1: Measurement of the physical and chemical properties of the study soil.

Soil layer depth (cm)	Particle size			Texture	BD	Porosity	pH	EC	OM	Na	Ca
	Clay (%)	Silt (%)	Sand (%)		g cm^{-3}	%		dsm^{-1}	%	meq l^{-1}	meq l^{-1}
0 - 15	20.8	23.6	55.6	Loam	1.28	50.76	8.20	3.64	2.43	24.17	3.76
15 - 30	23.4	24.7	51.9	Loam	1.32	49.23	8.03	4.08	1.83	28.73	4.09

$$WUE = \frac{Ya}{Water\ applied} \quad (2)$$

where, WUE: Water use efficiency (kg ha^{-1} mm^{-1}), Ya: Dry weight of the plant (Kg ha^{-1}), Water applied: Added water depth (mm).

3. Results and Discussion

3.1 Soil characterization at Harvest

Table 2 shows the effect of the level of irrigation and the addition of gypsum on some physical and chemical properties of the soil. All treatments increased by increasing the level of irrigation and adding gypsum with a significant difference between them, if the treatment was superior T_6. It gave the lowest values for bulk density, pH, electrical conductivity and sodium at 1.20 gcm^{-3}, 7.63, 2.25 dsm^{-1}, 10.68 meql^{-1}, respectively. And the highest values for moisture content, total porosity and calcium were 17.73%, 53.84%, 5.47 meql^{-1}, while the treatment gave T1, the highest values for bulk density, pH, electrical conductivity and sodium were 1.27 g cm^{-3}, 8.03, 3.11 dsm^{-1}, 21.53 meql^{-1} respectively, and the lowest values for moisture content, total porosity and calcium were 14.20%, 51.15%, 3.39 meql^{-1} [Page *et al*. (1982), Khan *et al*. (2019)]. The reason for the superiority of treatments by increasing the level of irrigation and adding gypsum is due to the role that calcium plays in increasing soil aggregates and improving the physical properties by facilitating the movement of water through the soil and its penetration to the depths [El-Sayed and Soliman (2019)]. Encouraging the exchange rate of the soil by gradually replacing sodium ions with calcium ions, which leads to encouraging colloids together and form aggregates and increase their stability, thus improving soil construction, increasing its porosity and permeability, water retention and a decrease in bulk density, accompanied by a decrease in pH and salinity [Noaema *et al*. (2020b)].

3.2 Growth parameters

Table 3 shows the effect of the level of irrigation and the addition of gypsum on some vocabulary of sorghum crop growth. As all treatments increased by increasing the level of irrigation and adding gypsum and with a significant difference between them, if the treatments containing gypsum outperformed the treatments [Limbachiya *et al*. (2019)]. Without adding to the increase in the level of irrigation, that the increase in the level of irrigation and the addition of agricultural gypsum led to an improvement in the physical and chemical properties of the soil (Table 2) such as water retention, facilitating movement, increasing porosity and decreasing soil salinity, which helped the plant roots to penetrate into the soil and increase its depth and spread, thus increasing the absorption of water and the necessary nutrients for plant growth, which was reflected in the increase in plant height, leaf area and number of leaves [Chi *et al*. (2012), Hafez *et al*. (2015)]. And stem diameter, number of branches, fresh and dry weight, and they were the highest possible in treatment T_6 and lowest in treatment T_1 and this was confirmed by researchers [Khalefah and Shamil (2019), Al-Hasany *et al*. (2020)].

3.3 Yield and its components, water productivity and Water Use Efficiency

Table 4 shows the effect of irrigation level and adding gypsum on yield, its components, water productivity and water use efficiency, if all treatments increased by increasing the irrigation level and adding agricultural gypsum with a significant difference, as the table shows the superiority of the treatments T_2, T_4, T_6, which contains gypsum and gave the highest number of grains in the head and the weight of 1000 grains and the yield of one plant total yield, water productivity and water use efficiency compared to T_1, T_3, T_5. Without adding gypsum, the two treatments T_5 and T_6 at the irrigation level were 100% superior. In improving the sorghum yield and its vocabulary compared with the rest of the treatments with an irrigation level of 50%, 75%, the improvement of soil properties and growth vocabulary reflected positively on the yield and its components by increasing the level of irrigation and

Table 2: Soil Characterization at Harvest with irrigation levels and gypsum application.

Treatment	BD g cm^{-3}	PW (%)	Porosity (%)	pH	EC dsm^{-1}	Ca meq l^{-1}	Na meq l^{-1}
T_1	1.27	14.20	51.15	8.03	3.11	3.39	21.53
T_2	1.25	15.71	51.84	7.81	2.83	4.64	15.61
T_3	1.26	16.09	51.53	7.99	3.09	4.08	18.26
T_4	1.23	16.75	52.69	7.74	2.51	5.10	13.26
T_5	1.22	17.23	52.94	7.79	2.91	4.32	13.25
T_6	1.20	17.43	53.84	7.63	2.25	5.47	10.68
LSD	**0.019**	**0.366**	**0.760**	**0.061**	**0.065**	**0.140**	**0.614**

Table 3: The effect of the level of irrigation and the addition of gypsum on some vocabulary of sorghum crop growth.

Treatment	Emergency rate (%)	Plant height (cm)	Number of branches	Leaf area (cm^2)	Stem diameter (cm)	Number of leaves	Fresh weight (ton h^{-1})	Dry weight (ton h^{-1})
T_1	83.33	72.67	1.67	2735	2.10	7.33	11.83	7.51
T_2	93.33	87.67	2.67	4067	2.93	9.00	14.03	9.36
T_3	86.67	80.67	2.33	3246	2.43	7.67	12.57	8.43
T_4	96.67	95.33	3.00	5003	3.20	10.00	15.50	10.40
T_5	90.00	83.33	2.67	3863	2.67	8.33	13.26	8.75
T_6	100.00	108	3.67	5749	3.53	11.00	18.02	11.19
LSD	**3.849**	**2.277**	**0.430**	**113.4**	**0.122**	**0.471**	**0.156**	**0.201**

Table 4: Water productivity, Water Use Efficiency and yield and its components of sorghum plants grown with irrigation levels and gypsum application.

Treatment	Number seed of head	Weight of 1000 seeds (g)	Plant yield (g)	Grain yield (ton h^{-1})	Water productivity (ton m^{-3})	Water Use Efficiency (kg h^{-1} mm^{-1})
T_1	1886	20.50	21.93	2.95	0.63	1.47
T_2	2112	23.50	25.65	3.10	0.91	1.80
T_3	1997	24.30	27.44	3.27	0.74	1.64
T_4	2279	26.53	29.76	3.63	0.95	1.89
T_5	2223	25.00	27.99	3.35	0.85	1.73
T_6	2412	28.60	34.38	4.01	1.12	2.23
LSD	**23.79**	**0.681**	**0.656**	**0.080**	**0.022**	**0.041**

adding agricultural gypsum, as well as increasing the efficiency of water use and water productivity by increasing the level of irrigation and adding gypsum. In the case of adding water to the system as in the current study, the equilibrium state will be changed because the dilution of this soil solution will favor the adsorption of divalent cations (Ca^{+2}) and more monovalent cations (Na^+). The sodium content of the harvest in soil treated with gypsum is much lower than in untreated soil under all irrigation levels (Table 2) [Yamika *et al.* (2018)]. This was due to the dissolution of gypsum in the treated soil, where Ca^{+2} cations were replaced by Na^+ cations on the colloid surface and thus the excess water Na^+ replaced from the upper layer, which contributed to a decrease in sodium and improved sorghum root growth, which was reflected in an increase in water use efficiency and water productivity.

4. Conclusion

The addition of agricultural gypsum with an increase in the level of irrigation (100% of the level of irrigation and the addition of gypsum) led to an improvement in some properties of the soil, physical and chemical, the vocabulary of growth gypsum.

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