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The Residual Effect of Phosphogypsum on Ca and K: Na Ratio in Barley Plant Grown in Salt-Affected Soil

AL-GHRAIRI, FADHIL O. K.[1]
AL-TEMIMI, AMAL F. H.
ALSAADIE, NASEER A.
AL-GHRAIRI, SAADI M.
Soil & Water Res. Cent., Direct. of Agric. Research
Minist. of Sci. & Technology, Baghdad, Iraq

Abstract

To study the residual effect of phosphogypsum on Ca:Na and K:Na ratio in barley plant tisues grown in salt-affected soil, field experiment was carried out at Al-Tuwiatha salinity research station 30 km south- esat Baghdad,Iraq at 2015/2016 and 2016-2017 seasons. Five rates of phosphogypsum were used included 25%, 50%, 75%, 100% and 125% of gypsum requirements as well as control treatment (PG_0). Saline ground water used to irrigate plants. Resullts showed that percentage of sodium content and in plant tissue decreased with increasing the amount of phosphogypsum added Ca:Na and K: Na ratio were increased . The Ca:Na ratio were 18.46 and 41.82 and K:Na ratio 11.02 and 41.65 of the rate of 0% and 125% of gypsum requirements.

Keywords: Chemical amendments; Phosphogypsum**;** barley**;** Saline water.

1. INTRODUCTION

The concept of reclamation of salt affected soils mainly depend on the field activities which leads to convert saline soils to production soils , and provide necessary possibilities to remove sodium from soil as well

[1] Corresponding author: fadhilalgrairy@yahoo.com

as riddance of excess salts after chemical reclamation processes with the prevention of secondary salts accumulation and followed the garanty ways to improve fertility of soil reclaimed , such as addition of organic , chemical fertilizers and appropriate management [1]. The salt affected soils can be reclaimed using chemicals amendments containing calcium (Ca^{+2}) to replace (Na^{+}) on the exchange complex and the displacement Na^{+}outside the root area with irrigation water [2, 3, 4, 5, 6, 7]. Nutritional disorders (deficiency/toxicity) limit crop yields in all types of soils around the world . plants sometimes are unable to fulfill their nutritional requirements [8]. Nutrients imbalances may be result from the effect of salinity on nutrient availability, competitive uptake, transport or partitioning within the plant or may be caused by physiological inactivation of a given nutrient resulting in an increase in the plants internal requirement for that essential element [9, 10]. A need, therefore, exists for low-cost, efficient treatment strategies to reduce the salt toxicity of soils and to improve the soil properties. Calcium is expected to speed removing the excess sodium content of the soil , consequently, will improve soil conditions and reduce osmotic potential of soil solution . Accordingly, crop productivity of such amended soil is expected to increase as the salt toxicity reduced and poor soil properties to improve [11, 12]. Therefore, objective of this work is to evaluate effectiveness of phosphogypsum, as a direct source of calcium in alleviating sodium hazardous effect to Barley in salt affected soils.

2. MATERIALS AND METHODS

Field experiment was carried out at 2015/2016 and 2016-2017 seasons at Al-Tuatha salinity research station 35Km south-east of Baghdad in calcareous salt affected soil with silty clay texture with 11-14 dSm^{-1} EC of 1:1 soil solution and 20.4 to 24.0 SAR. Randomized complete block design (RCBD) was used with four replicates(blocks) and experimental area was divided in a plots of 6 m^2 area each. Gypsum requirements were calculated according to Richards, 19*54* [13] and added as phosphogypsum in a rate of 25%, 50%, 75%, 100% and 125% of the total gypsum requirements. Phosphogypsum was well mixed in soil surface layer at 0-30 cm depth. Saline ground water of 3.5 dSm^{-1} and 12.1 SAR was used in irrigation. Tensiometers were installed in the experimental

units for monitoring soil moisture content to determine irrigation timing . Barley crop was cultivated and irrigated with saline ground water whenever it need it. Nitrogen and phosphorus fertilizers were added in a rate of 200 and 80 kg ha^{-1} N and P respectively. Experimental units were sampled at different periods along soil profile to monitor behavior of nutrients and salinity during growing season. Barely was harvested at the end of the growing season. Soil and plant samples were analyzed according to approved and suggested procedures in Page et al., 1982 [14]

Table 1. Characteristics of the soil used in the study .

Characteristic		Value
EC $_{1:1}$ dS m^{-1}		17.70
PH $_{1:1}$		7.1
CEC (Cmolc.kg-1soil)		20.1
$CaCO_3$ (gm.kg-1soil)		249.0
O.M (gm.kg-1soil)		8.00
Soil texture		Silt Clay
Available-P (gm.kg^{-1}soil)		28.1
Available-N (gm.kg^{-1}soil)		92.0
Available-K (mg.kg^{-1}soil)		201.0
Soluble ions mmol kg^{-1})(	Na	132.01
	Ca	8.75
	Mg	17.21
	SO_4	38.41
	Cl	118.01
	HCO_3	1.86
SAR		25.25

3. RESULTS AND DISCUSSION

3.1. Properties of Phosphogypsum

The rate of Phosphogypsum is estimated at 2.43 gm L^{-1}, it was high ratio that can lead to the release of relatively large quantities of calcium to the soil solution, which results in calcium ion replacing sodium ion on the exchange complex (Lytropic series) , according to [15]. The results obtained from the analysis of a sample of this substance show

that phosphorus concentration in phosphogypsum is 0.2%. This contributes to increasing the level of HPO_4 and H_2PO_4 in the soil, thus increasing the phosphorus available for plant growth. Radiation activity is also very low below the universally permissible limits (<0.3 $Bq.g^{-1}$) of uranium isotopes, also the measured radiation dose was less than 0.005 marokeen $.h^{-1}$, which is far below the allowable limits. Results showed the total radiological activity of the Iraqi phosphogypsum used in this research (first season 2011) when measured in the laboratories of International Atomic Energy Agency was 0.4 (($Bq.g^{-1}$) , which is less than the radiological activity of the global phosphogypsum world [10] when compared to the results of measurements by Zvomuya, 2005 [16] and the concentration of fluorine in Iraqi phosphogypsum is also low, it was less than 1.8% because the metal in Iraq is hydroxapatite and not fluoraxyapatite. The properties of Iraqi phosphogypsum (Table 2) can be used in reclamation of salts-affected soils in central and southern Iraq.

Table 2. Chemical properties of Phosphogypsum

EC $dS.m^{-1}$ 1:1	pH	Soluble ions ($mmol.kg^{-1}$)						
		Na^{+}	Ca^{+2}	Mg^{+2}	Cl^{-1}	SO_4^{-2}	P	F
2.4	2.66	Nil	58.56	10.35	2.93	61.20	64.50	95.00

3.2. Properties of saline ground water used

The ground water which used in the experiment was obtained from drilling in the same site of the experiment, It has an electrical conductivity (3.5 dS.m-1) which is somewhat low and within the limits allowed in agriculture according to [17] . Also it has a low content of dissolved sodium ions (Table 3), which encourages their use in irrigation of the experiment yield without affecting the chemical and physical properties of the soil [18]..

Table 3. Properties of well water used in irrigation

EC $dS.m^{-1}$	pH	Soluble ions ($mmol.L^{-1}$)						
		Na^{+}	Ca^{+2}	Mg^{+2}	Cl^{-1}	SO_4^{-2}	HCO^{-3}	SAR
3.25	7.30	24.00	0.44	3.00	12.84	9.17	5.80	12.10

3.3. Sodium content in the barley plant tissues

The results showed in Fig.1 the effect of the addition of phosphogypsum in the absorption of sodium by the barley plant tissues has been found that the concentration of sodium in the plant decreases by increasing the amount of phosphogypsum added. This is an important feature of phosphogypsum because of the harmful effects of sodium, such as effect of raising the plant's pressure [19]. Also the results showed lowest percentage of sodium represented by the lowest point on the graph linking the absorption of sodium when phosphogypsum was added at rate125% of gypsum requirements, reaching 0.475 g kg $^{-1}$ dry matter, because increased calcium in the plant's root lead to reduce the amount of sodium within the plant tissue. This result was agreed with reported by [10, 20, 21, 22] .The mathematical analysis of the sodium curve can be described by the following mathematical equation : Na content = - 0.0096 phosphogypsum + 5923 R2 = 0.680 , it is clear that the response curves in the sodium concentration of the added phosphogypsum quantity decreases with the added quantity

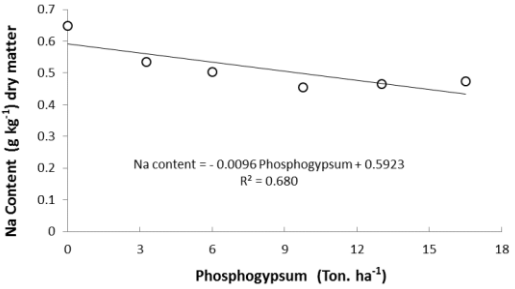

Fig. 1. The effect of Phosphogypsum on sodium content (gm. kg^{-1}) in barley plant

3.4. Ca:Na ratio

The role of calcium becomes very important in the saline medium, as found by [23] . The plant absorbs high amounts of sodium expense of calcium and potassium. Therefore, if the ratio of Ca: Na or K: Na decreases in the root region, roots lead to a negative accumulation of sodium and vegetative parts [10, 24]. Fig.2 shows the ratio of calcium / sodium (Ca: Na Ratio) in the plant tissues under study. This ratio increased to 41.82 at 125% of gypsum requirements compared with the comparison treatment (PG0) which gave ratio of 18.46. The mathematical analysis of the Ca: Na Ratio curve can be described this

results by the following mathematical equation : Ca : Na Ratio = 1.511 phosphogypsum + 18.848 $R^2 = 0.908$

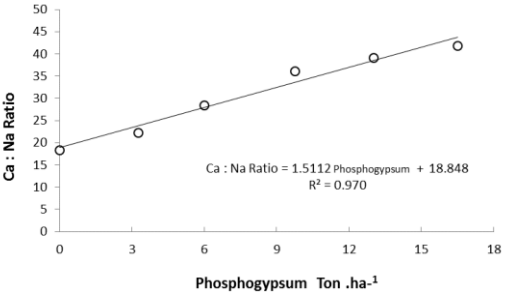

Fig. 2. The effect of Phosphogypsum on Ca: Na Ratio in Barley plant

Ratio 3.5. K:Na

In fig. 3 results indicated the concentration of potassium to concentration of sodium (K: Na) Ratio increased in all treatments phosphogypsum added espicialy at 125% rate of the requirements, this led to increase the concentration of potassium several times the amount of sodium in control (0 PG) , the mathematical analysis of the K: Na Ratio curve can be described this result by the following mathematical equation : K: Na Ratio = 1.7831 phosphogypsum + 15.902 , $R^2 = 0.908$. The high ratio of K: Na is equally important for plant tolerance and resistance to salinity and environmental stress, due to the role of potassium in the regulation of azosis and the construction of high molecular compounds This is consistent with the findings of [19 , 26].

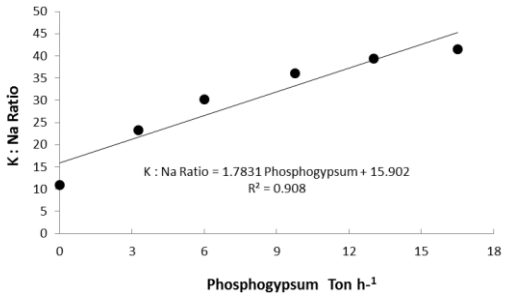

Fig. 3. The effect of Phosphogypsum on K: Na Ratio in Barley plant

4. CONCLUSION

According to the results as shown in this study, we suggest adding the amount of phosphogypsum required for salt affected soils over a period of 2 to 3 years, or the required quantity is divided into equal batches annually. More study may be needed on the effect of phosphogypsum on the physical and biological properties of soils in this field .

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