



Effect of Chemical Composition of Irrigation Water on Some Growth and Yield of Corn and P-availability in Calcareous Soil

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Article info	Abstract
Original: 31/12/2017 Revised: 16/01/2018 Accepted: 06/02/2018 Published online: Keywords: Ratio between cations, P- availability, Water quality, Corn	The study was conducted during growing season of 2016, to study the effect of five water qualities (W) having the same electrical conductivity but differing in chemical composition (one of them natural water the others are artificial) and three levels of phosphorus fertilizer (P) on growth of corn and p-availability using factorial experiment based on completely randomized design (CRD) with 4 replicates. The results indicated that the water qualities, levels of applied P and their interactions affected significantly on dry weight and chlorophyll content and P concentration in both plant leaves and soil. The highest values of dry matter (146.13 , 138.32 and 151.501) g pot ⁻¹ were recorded from W2, P2 and W2P1. The highest values of chlorophyll content (40.85, 37.02 and 41.56) SPAD were obtained from W2, P1 and W2P1 respectively. On the other hand, the highest phosphorus concentration (0.68, 0.54 and 0.83) mg g ⁻¹ of dry matter were obtained from W2, P 2 and W2P2 respectively.

Introduction

Irrigation water quality is mainly defined by the total quantity of dissolved salts and its ionic composition which depends on the water source, location and time of water sampling, also depends on the nature, composition of the soil, sub-soil, depth and climate [1]. According to Al- Tahir et al., (1997) [2] irrigation water quality determine the concentration and composition of dissolved constituent in water . Supplying of good water quality is the most important limiting factor for agriculture expansion. On the other hand the chemical constituents of irrigation water can affect plant growth directly through deficiency or toxicity and indirectly by altering plant availability of nutrients [3]. Soils, crop yield, and their management are affecting directly by chemical composition of irrigation water [4]. The irrigation water quality can be determined depending on its chemical composition as mentioned by Rahman *et al.*, (2012)[5]. The increase of Mg/Ca ratio from (1 to 3) at the same EC value of irrigation water caused increase in P concentration of corn plant and soil [6].

Ionic composition of irrigation water plays a significant role in water classification for different purpose such as irrigation purpose, due to its effect on the values of sub-indices variables, soil properties, growth and

yield of plant, increase in Mg/Ca ratio of both irrigation and soil extract caused significant increase in available P and chlorophyll content of corn leaves [7].

Science there are several studies about effect of water quality on plant growth and nutrient availability but very little of them included the role of chemical composition of irrigation water such as the ratio between cations on plant growth and phosphorus availability in calcareous soil for this reason this investigation was selected to study the effect of chemical composition of irrigation water especially Mg/Ca on corn growth and phosphorus availability.

Materials and Methods

This investigation was included the pot experiment which conducted during 26th July 2016 to 26th September) at Grdarasha field ,College of Agriculture University of Salahaddin ,Erbil with GPS reading of (N =36° 06' 49'' E=44° 00' 47'' and Elevation 407m)to study the effect of 5 water qualities (artificial water) having the same electrical conductivity (except control treatment W1) ,they were prepared depending on the fact that EC approximately equal to sum of cations (meq L⁻¹) divided by 10 and the soluble salts such as MgSO₄.7H₂O ,CaCl₂.2H₂O, NaCl and KCl were applied for preparing artificial waters [6] as shown from table (1). Three levels (0,0.92 and 1.84 g P₂O₅ which equivalent to (0,160 and 320 kg Triple superphosphate (TSP) per hectare with constant level of urea (0.28) g N pot⁻¹, which equivalent to(200kg urea ha⁻¹) [6 and 7]. The factorial experiment was done using completely randomized design (CRD) with 4 replicates.

The soils were sieved through a 4 mm sieve; 12.25 kg of sieved soils were packed in plastic pot 28 cm in top diameter 22cm in bottom diameter and 25 cm in height, after packing (800) g of gravels in the bottom of each pot. Some physical and chemical properties of the selected soil were shown in table (2). On 26th of July, 2016 four seeds of *Zea mays* (*Talar*) were planted in each pot at 3 cm depth. One week after germination the plants were thinned to three plants per pot.

The pots were irrigated whenever needed after depletion 50-60% of the available water depending on gravimetric (weighting method) method [6]. Table (2) refers to some properties of irrigation water. Chlorophyll was determined 4 times during the study.

Plants were harvested on 26 September 2016, and then oven dried at 65C° for 72 hours. The plant and soil samples were stored in plastic container for chemical analysis.

Soil physical and chemical analyses

The selected soil physical and chemical properties in this study were determined according to Black, (1980) [8] ,except soil moisture content at field capacity(FC) and wilting point(WP) which were determined depending on the equation mentioned by Karim, (1999) [9] as follow:

$$F.C = 13.28 + (0.397 * \% \text{ clay}) \text{ ----- (1)}$$

$$W.P = 4.57 + (0.35 * \% \text{ clay}) \text{ ----- (2)}$$

Soil calcium determined by titrimetric method by using (0.01 N) EDTA-2Na [10].

Soil phosphorous was determined by (Olsen's method), spectrometrically at 880 nm [11].

Plant analysis:

Plant material was digested using (1:1 Conc. H₂SO₄, H₂O₂) mixture [12]. Phosphate was determined according to colorimetric method [11].

Chlorophyll content was determined by using chlorophyll meter [13].

Table-1: EC, concentration of cations and the ratio between some of them in control (W1) and artificial waters (W2,W3,W4 andW5).

	<i>EC (dS m⁻¹)</i>	<i>Ca²⁺</i>	<i>Mg²⁺</i>	<i>Na⁺</i>	<i>K⁺</i>	<i>Mg/Ca</i>	<i>Mg/Na</i>	<i>Na/K</i>	<i>Na/ Ca</i>
		<i>meq L⁻¹</i>				<i>Ratio</i>			
W1	0.44	2.58	1.38	0.46	0.03	0.53	3.00	15.33	0.17
W2	1.50	5.00	10.00	0.46	0.03	2.00	21.70	15.33	0.09
W3	1.50	2.58	1.38	1.50	8.50	0.53	0.92	0.17	0.58
W4	1.50	2.58	1.38	8.50	3.50	0.53	0.16	2.42	3.30
W5	1.50	10.00	2.50	0.46	2.50	0.25	5.43	0.18	0.05

Table-2: Some chemical and physical properties of study soil.

<i>pH</i>	<i>EC</i>	<i>ECACO₃</i>	<i>Ca²⁺</i>	<i>Mg²⁺</i>	<i>Na⁺</i>	<i>K⁺</i>	<i>SO₄²⁻</i>	<i>HCO₃⁻</i>	<i>Cl⁻</i>	<i>CO₃²⁻</i>	<i>P</i>
	<i>dS.m⁻¹</i>	<i>mg kg⁻¹</i>			<i>mmol_c L⁻¹</i>				<i>mg L⁻¹</i>		
7.34	0.80	223	5.00	2.60	0.60	0.04	1.25	4.89	2.11	0.0	3.80
<i>Sand</i>	<i>Silt</i>	<i>clay</i>	<i>Textural name</i>			<i>Moisture at field capacity (F.C.)</i>		<i>Moisture at Wilting point(W.P.)</i>			
<i>mg kg⁻¹</i>								<i>%</i>			
320	335	345	<i>Clay loam</i>			24.50		14.78			

Results and discussion

Table (3) explains the significant effect of chemical composition of irrigation water on P concentration in corn plant , the highest value (0.68 mg g plant⁻¹) was recorded from irrigation water (W2), while the lowest value was obtained from treatment(W5),This may be due to chemical composition of irrigation water especially Mg/Ca ratio (table,1) both W2 and W5 having the same EC (1.50 dS m⁻¹) but they are differing in Mg/Na ratio, this refers to the importance of chemical composition of irrigation water or it means chemical composition of irrigation water is an interest factor in case of similarity in EC values of irrigation water. The second point the irrigation waters (W2, W3, W4 and W5) having the same EC value while the EC for W1 is

low (Table 1) but the P value in all treatments except W5 is higher than value of W1 this may be due to the role of chemical composition of irrigation water or the ratio between cations which may lead to nutrient absorption by plants. Similar results were obtained by Kareem , (2010) [14] whom explained an increase of Mg/Ca ratio from (1 to 3) at the same EC value of irrigation water caused increase in P concentration of corn plant and soil. On the other hand the level of applied P was not affected significantly on P concentration in plant this may be due to high capacity of calcareous soil to fix 70-90% of applied phosphorus fertilizer as mentioned by Havlin et al., (2005) [15] The interaction between chemical composition of irrigation water (W) and levels of applied phosphorus (P) affected significantly on p concentration in plant, the highest value (0.83 mg g plant⁻¹) was recorded from treatment combination (W2P2) and the lowest value (0.30 mg g plant⁻¹) was recorded from (W5P1). This may be due to the single effect for the studied factors as mentioned before.

Table-3: Interaction effect of chemical composition of water, levels of applied phosphorus on phosphorus concentration in leaves of corn plant (mg g plant⁻¹).

<i>Irrigation Water</i>	<i>P0</i>	<i>P1</i>	<i>P2</i>	<i>mean</i>
<i>W1</i>	0.46	0.40	0.43	0.43
<i>W2</i>	0.50	0.70	0.83	0.68
<i>W3</i>	0.49	0.69	0.61	0.60
<i>W4</i>	0.62	0.51	0.56	0.56
<i>W5</i>	0.38	0.30	0.31	0.33
<i>mean</i>	0.51	0.52	0.54	0.52

RLSD_{.01} for W=0.11 RLSD_{.01} for P=0.16 RLSD_{.01} for WP=0.08

Table (4) refers to significant effect of irrigation water on LCC, the highest values (40.85 and 39.29) were recorded from treatments W2 and W5 respectively. This may be due to magnesium concentration in irrigation water and Mg/Ca and Mg/Na, it means increase of them caused increase in leaf chlorophyll content [LCC] (table, 1) since Mg is a part of chlorophyll or its apart of chlorophyll structure [15]. Similar results were recorded by Kareem , (2010) [14]. The level of applied P was not caused significant increase in LCC of corn. The combination treatments affected significantly on LCC, the highest value (41.56 SPAD) was recorded from combination treatment (W2P1) and the lowest value (30.91) was obtained from (W1P2) This could be due to the single effect of the studied factors especially Mg concentration and Mg/Ca ratio in the studied artificial waters (Table 1). These results agree with those recorded by Kareem , (2010) [14] since adding of P may cause increase in root growth then nutrient absorption and increase in chemical composition of water, levels of applied phosphorus on LCC of wheat plant dry matter weight [16]. The increase in Mg/Ca ratio caused significant increase in plant growth and chlorophyll content [16].

Table (5) shows significant effect of chemical composition of irrigation water, levels of applied P and their combinations on weight of dry matter. The highest values (146.13, 138.32 and 151.501) g pot⁻¹ were recorded from W2 , P2 and W2P1 . This may be due to the higher Mg/Ca ratio of W2 in comparing with other treatments (Table 1) which caused increase in chlorophyll formation to (40.85 SPAD) as mentioned

from table(4). This may be due to the role of chemical composition of irrigation water because they have the same EC value (1.50 dS m^{-1}) except control treatment (W1) (Table 1) this explain the role of chemical composition of irrigation the studied waters in limiting plant growth and phosphorus availability, similar results were recorded by Rowell, (1996) [11] and Kareem, (2010) [14]. At the same time the lowest dry matter weight was recorded from W5,P0 and W5P1, this may be due to the low Mg/Ca, and Na/Ca ratio in W5 in comparing with other treatments(table,1) since decrease in the mentioned ratios causes precipitation of P in the insoluble form $\text{Ca}_3(\text{PO}_4)_2$ then decrease in available P for plant then decrease in dry matter weight [11 and 15]. The positive role of P treatments was due to low available P in the studied soil (3.80 mg L^{-1}) since the critical level of P is (7 mg L^{-1}) for calcareous soil.

Interaction effect of chemical composition of irrigation water (IW) and levels of applied phosphorus on soil available phosphorus:

The results of statistical analysis refer to significant effect chemical composition of irrigation water, phosphorus application and their combinations on soil available phosphorus (Table 6). The highest values ($15.94, 11.94$ and 17.93 mg L^{-1}) were recorded from W2, P2 and W2P2 respectively, While the lowest values ($5.55, 9.71$ and 4.61 mg L^{-1}) were recorded from W5, P0 and W5P0 in case of similar EC respectively. This could be due to high Mg/Ca ratio (2.00) in W2 and low ratio(0.53) for w5 (Table 1).On the other the Mg/Ca ratio of the soil extract was high (4.01) for W2 in comparing with W5 (0.81) (Table 7), which affected on available Phosphorus as mentioned before, Since increase in the mentioned ratio from 1 to 3 causes increase in available phosphorus in the soil in both pot and field studies [11 and 15].The treatment P2 caused significant increase in available P, while P1 was not affected significantly this may be due to low available P in case of P1 due its low amount in comparing with P2 in additional to precipitation 70-90% of applied P as mentioned by Havlin et al., (2005) [15].

Table-4: Interaction effect of chemical composition of irrigation water (IW), levels of applied P and their combinations on chlorophyll content (SPAD).

Chemical composition of (IW)	Levels of applied TSP (g pot^{-1})			Mean
	P0	P1	P2	
W1	33.92	33.31	30.91	32.71
W2	39.59	41.56	41.40	40.85
W3	37.18	37.39	31.88	35.48
W4	31.87	33.52	34.12	33.17
W5	37.46	39.34	41.08	39.29
mean	36.00	37.02	35.88	36.30

RLSD_{.01} for W =5.22.

RLSD_{.01} for P =2.08

RLSD_{.01} for WP =7.12

Table -5: Interaction effect of chemical composition of water (IW), levels of applied phosphorus on dry matter weight) of corn plant (g pot⁻¹).

Chemical composition of (IW)	Levels of applied TSP (g pot⁻¹)			Mean
	P0	P1	P2	
W1	123.97	119.87	142.55	128.80
W2	144.82	151.50	142.07	146.13
W3	141.03	138.01	133.85	137.67
W4	134.32	147.98	137.45	139.92
W5	121.4	118.47	129.67	123.18
mean	133.108	135.57	138.32	135.66

RLSD_{.01} for W =4.45. RLSD_{.01} for P =3.20 RLSD_{.01} for WP = 8.23

Table -6: Interaction effect of chemical composition of irrigation water (IW), levels of applied phosphorus on available phosphorus in soil at harvesting (mg L⁻¹).

Chemical composition of (IW)	Levels of applied TSP (g pot⁻¹)			Mean
	P0	P1	P2	
W1	5.66	5.24	5.00	5.30
W2	15.45	14.45	17.93	15.94
W3	10.55	14.55	15.98	13.69
W4	10.96	12.91	13.93	12.60
W5	4.61	5.13	6.86	5.53
mean	9.71	10.20	11.94	10.68

RLSD_{.01} for W =5.50. RLSD_{.01} for P =2.20 RLSD_{.01} for WP = 6.40

Table- 7: Interaction effect of chemical composition of water (IW), levels of applied phosphorus on available phosphorus in soil at harvesting.

Chemical composition of (IW)	Mg /Ca ratio			Mean
	P0	P1	P2	
W1	0.41	0.33	0.35	0.36
W2	4.20	4.00	3.82	4.01
W3	0.98	0.76	0.81	0.85
W4	0.88	0.76	0.83	0.82
W5	0.90	0.74	0.77	0.81
mean	1.47	1.32	1.32	1.37

RLSD_{.01} for W =0..40. RLSD_{.01} for P =0.30 RLSD_{.01} for WP = 1.40

Conclusion:

The chemical composition of irrigation waters at the same electrical conductivity has great effect on dry matter weight, chlorophyll content and phosphorus concentration of corn plant. Increase in Mg/Ca and Na/Ca ratio have positive role in increasing the mentioned corn characters. On the other hand increase in Mg/Ca and Na/Ca of irrigation water causes increase in soil available phosphorus due to decrease in precipitation of phosphorus in insoluble phosphorus compound ($\text{Ca}_3(\text{PO}_4)_2$) in calcareous soil and formation of soluble forms of phosphorus compounds such as $\text{Mg}_3(\text{PO}_4)_2$ and Na_3PO_4 .

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