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PHOSPHORUS FORMS IN CALCAREOUS SOIL AS AFFECTED BY IRRIGATION WATER SALINITY

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Abstract: This study was carried out on five calcareous soils of Egypt characterized by different content (%) of calcium carbonate ($CaCO_3$) and other physical and chemical properties to study their content of different forms of phosphorus and its affected by soil properties and irrigation water salinity. The tested calcareous soils were used in a greenhouse experiment, where these soils were planted by barley and irrigated by tap water and four sources of artificial saline water. The artificial saline water were prepared at 1000 and 2500 mg TSS/l (A1 and A2). Each level of TSS (total soluble salts) have one values (B1 or B2) of sodium adsorption ratio (SAR) of 6.31 and 23.26 for A1 and 9.97 and 36.11 for A2. Plants were harvested at harvesting stage. The dry matter yield of the harvested plants was measured and also its content of P was determined. Some chemical properties of the studied calcareous soils and the content of different P forms .i.e. total, available, organic, inorganic, calcium, aluminum and iron phosphate (T-P,A-P, O-P, I-P, Ca-P, Al-P and Fe-P) were determined. Chemical properties .i.e. pH , EC and the content of soluble ions were increased with the increase of irrigation water salinity and sodicity . The found changes in these properties were varied from soil to another. Dry matter yield of barley plants (straw and grains) and its content of P were clearly decreased with the increase of soil content of $CaCO_3$ and increase of irrigation water salinity and sodicity .The level of this negative effect on grains was high than that found with straw. Generally the studied calcareous soils characterized by low content of P. Most of this content was found in I- P form (>90% of T-P). The major fraction of I-P was Ca-P followed by Al-P. The content of different P-forms was related with the studied soil properties. Irrigation water salinity and sodicity have a clear effect on calcareous soils content of P-forms especially O-P, Al-P and Ca-P. The conclusion of this study is : under similar conditions some sources of saline water may be used in irrigation especially at the short-term of the earlier periods of calcareous soils reclamation.
Key Words: Calcareous soils, Salinity, Sodicity, Phosphorus, Barley

1. INTRODUCTION

Calcareous soils cover more 30% of the earth's surface and their $CaCO_3$ content varies from a few percent to 95% (Marschnen, 1995). Calcareous soils occur naturally in arid and semi-arid zones as well as humid and semi-humid zones particularly where their parent material is rich in $CaCO_3$ (Brady and Weil, 1999). In Egypt the newly reclaimed soils at Nubaria and Borg El-Arab regions cover more than 900.000 fed. of which 290.000 fed. are calcareous soils (Moursy, 2002). These soils are distributed to graduates, beneficiaries and private sector for agricultural utilization . Also, these soils are mainly characterized by slightly alkaline reaction, poor fertility, low organic matter content and poor physical properties.

Since barley is a major cereal crop in such soils for human and animal feeding as well as in many industries. Therefore, more efforts and studies are necessary to improve its productivity.

Surface irrigation with water from shallow wells is utilized on approximately about 30% of irrigated land in Egypt. The quality of the well water is variable with some areas using water with high sodium and total electrolyte concentrations. However, the impact of the water quality on the soil structure, infiltration function and irrigation performance is not always recognized and the quality of the water used for irrigation is not always reported. Hence, few workers have been able to distinguish the physio-chemical impacts associated with the quality of the water applied (El_Sheikh 2000).Phosphorus is very important element to plant and plays a role in metabolic process such as the conversion of sugar into starch and cellulose. As a result, phosphorus deficiency causes stunting delayed maturity and shriveled seed (Basak, 2006).

This study was carried out on some calcareous soils of Egypt varied widely in their properties to evaluate its content of different P forms. Also, effect of irrigation water quality on: 1)Soil chemical properties, 2) The content of different P forms and 3) Plant growth were studied.

2. MATERIAL AND METHODS

2.1. Soil Sampling

In this study, five surface (0-20 cm) samples of different soils represent calcareous soils of Egypt were selected from different five locations i.e. 1- El-Bostan (Behara Governorate); 2-Terat El-Nasr (Alexandria Governorate); 3-Kilo 52 Cairo-Alexandria Desert Road (El-Giza Governorate); 4-El-Nobariya (Behara Governorate); and 5- Borg El-Arab (Alexandria Governorate),. The collected soil samples of each locations were air dried, good mixed and ground to pass through a 2mm sieve. Fine soils(<2mm) were kept and analyzed for some physical and chemical properties and the content of different P forms according to Black(1965) Cottenie et al. (1982) and Page et al (1982) . The obtained data were recorded Table (1).

2.2. Irrigation Water

Five solutions (Tap water or Nile water and four of artifices solutions) varied in their salinity and sodicity and also in their content of Na^+, Ca^{2+} and Mg^{2+} were used in this study. The chemical composition of these solution was recorded in Tables 2 and 3.

2.3. Greenhouse Experiment

This experiment was carried out to study the effect of salinity and sodicity irrigation water on some soil properties P-forms and plant growth. Plastic pots (75 pot) with 20 cm in diameter and 18 cm depth were used in this study. The pots were divided into five main groups (15 pot for each group). Five kg of one soil were placed in each pot of these groups. All pots were fertilized by super phosphate (15.5 % P_2O_5) at application rate of 1.50g super phosphate /pot(300kg fed^{-1}). After that, the pots of each main group were divided into five sub groups (3 pots for each sub group) which represent treatments of the used irrigation solutions. The pots were arranged in split design with three replicates. Each pot was planted with ten seeds of barley and irrigated with tap water to about 60% of water holding capacity of each soil. After 15 days from sown, the plants were thinned to five plants for each pot. Each pot was fertilized with ammonium nitrate (33.5% N) at 0.75 g NH_4NO_3 /pot (equivalent to 50.25 Kg N fed^{-1}) and potassium sulphate (48-50% K_2O) at 0.3g K_2SO_4/pot(equivalent to about 29.4 Kg K_2O fed^{-1}). After that, the pots were irrigation with the tested irrigation solutions. The pots were irrigated every three days by alteration between artificial saline solution and tap water or Nile water by 2:1. The moisture content of pots must be still at 60% of water holding capacity of each soil. The plants were harvested above the soil surface and the spikes were separated from straw. Also, the grains were separated from the spikes. The separated straw and grains were air-dried, oven dried at 70° C until their weights became constant, weighted and kept for the content of P.

2.4. Plant Analysis

0.2 g of the ground oven dry plant sample was digested with 5 ml of concentrated H_2SO_4 on sandy hot plate. Repeatedly small quantities of concentrated $HClO_4$ were added until the digest became clear and uncolored. The digest was diluted to 50 ml with distilled water (Cottenie, et al, 1982). Phosphorus (P) was determined in the digest using the ascorbic acid method of Murphy and Riley (1962).

Table 1. Some physical and chemical properties of the studied calcareous soils

Soil properties.	Soil number				
	Soil 1	Soil 2	Soil 3	Soil 4	Soil 5
Particle size distribution*, (%)					
Coarse sand	67.0	39.8	51.6	43.5	19.4
Fine sand	24.5	29.0	14.8	5.6	22.1
Silt	3.5	10.0	13.1	19.3	12.1
Clay	1.2	9.8	1.1	2.2	4.2
Texture. class	Sand	Sand- loamy	loamy- sand	sand - loam	sand – loam
Total $CaCO_3$%	3.80	11.40	19.40	29.40	42.20
Active $CaCO_3$,%	1.00	4.60	10.00	14.00	18.80
W.H.C,%	25.70	27.40	30.70	33.40	40.50
O. M,%	0.30	0.40	0.90	1.76	1.87
pH **	7.87	7.88	7.92	8.10	8.01
E C***,dSm^{-1}	1.61	2.83	12.65	8.20	7.22
Soluble ions, meq/100g					
CO_3^{2-}	0.00	0.00	0.00	0.00	0.00
HCO_3^-	1.56	1.56	2.25	1.30	1.82
Cl^-	6.93	11.88	82.67	60.30	43.46
SO_4^{2-}	7.68	14.85	41.58	20.43	26.99
Ca^{2+}	6.42	10.16	31.27	19.02	23.00
Mg^{2+}	2.85	6.83	22.90	11.46	19.54
Na^+	6.50	10.40	69.62	50.42	28.43
K^+	0.40	0.90	2.71	1.10	1.30
Phosphorus (P) forms (mg/kg)					
T-P	24.77	73.45	92.10	76.37	33.71
A-P	0.21	0.62	0.72	0.57	0.22
O-P	2.97	7.45	10.96	9.96	4.39
I-P	21.59	65.39	80.42	65.84	29.10
Ca-P	14.68	45.10	56.86	49.10	22.58
Al-P	2.42	7.32	8.80	7.15	3.00
Fe-P	0.15	0.44	0.52	0.42	0.18
Res-P	4.33	12.53	12.24	9.17	3.33

* = With $CaCO_3$ removal , ** = In 1:2.5 (soil : water) susp. , *** = In soil saturated extract

2.5. Soil Analysis

After plant harvesting, the soil of each pot was token, air-Aried ground and seined through a 2mm sieve. The fine soils were analyzed for some chemical properties according to Cottenie et al. (1982) and Page et al (1982) . Also, the content of different P forms was determined as follows.

Determination of P concentration in different forms was performed according to the methods described by Olsen and Sommers, (1982) and (Editorial Committee for Methods of Soil Environmental Analysis, 1997).

Total P concentration was determined after dissolution with Na_2CO_3 extracted by 0.5N sodium bicarbonate according to Olsen et al., (1954) and determined colorimetrically by ascorbic acid according to Murphy and Riley (1962).

Available –P was extracted by 0.5N sodium bicarbonate according to Olsen et al. (1954) and determined colorimetrically by ascorbic acid according to Murphy and Riley (1962).

Organic P concentration was calculated by subtracting the concentration of inorganic P from that of total P.

Fractionation of inorganic P was subjected to the methods proposed by Editorial Committee for Methods of Soil Nutrients Analysis, (1970). In this fraction no occluded Ca-bound P (Ca-P), Al-bound (Al-P), and Fe-bound (Fe-P) were sequentially extracted with 2.5% CH_3COOH, 1M NH_4 F, and 0.1 M NaOH, respectively. The amount of P in the extracted solution was determined colorimetrically. The concentration of occluded P was calculated by subtracting the concentration of total Ca-P, Al-P and Fe-P from that of inorganic P.

3. RESULTS AND DISCUSSION

3.1. Soil Chemical Properties

The chemical properties (soil pH, EC and soluble ions) of the studied calcareous soils as affected by irrigation water content of total soluble salts (TSS) as EC and Na^+ and values of SAR were recorded in Table(4). These data show that, the soil pH was increased by different treatments of irrigation . Generally the obtained data of pH indicate that, the studied soils takes the order : soil 4 > soil 5 > soil 3 > soil 2 > soil 1. This results are in agreement with the results obtained by (Al- Busaid and Cookson 2003) .The relationships between soil pH and TSS , Na^+ and SAR were by the straight linear equations as follows:

$y = 2E\text{-}08\,(TSS)^2 + 3E\text{-}05\,TSS + 7.8516$

(r=0.94) ……..(1)

where y: pH value , TSS =total soluble salts. (mgl^{-1})

$y = -0.0002(SAR)^2 + 0.0152\,SAR + 7.8087$

(r=0.88)…………………………………....….(2)

where y: pH value , SAR =sodium adsorption ratio.

$y = -2E\text{-}08(Na^+)^2 + 0.0001\,Na^+ + 7.8304$

(r=0.90)……………………………..………...(3)

where y: pH value , Na^+= concentrations Na^+ (mgl^{-1})

The increase in total soluble salts, Na^+ concentrations, and SAR of water led to an increase in soil EC (Table, 4). In this respect Abou Hussien et al (2009) and Shalaby, et al (2009) obtained on similar results. To explain the relation between the three properties of the used irrigation water and soil EC , may be ploted the data of three properties against soil EC and derived the equation described these relations .These equations revealed that all found relationships were positive and highly significance. These relations were:

$y = -2E\text{-}06(TSS)^2 + 0.0071x + 1.5407$

(r = 0.74) ……………………………………….(4)

where y: EC value(dSm^{-1}) , TSS =total soluble salts. (mgl^{-1})

$y = -0.0114(SAR)^2 + 0.5144x + 2.2523$

(r = 0.80) …………………………………..……(5)

where y: EC value(dSm^{-1}) , SAR =sodium adsorption ratio.

$y = -3E\text{-}06(Na^+)^2 + 0.0082x + 2.1261$

(r = 079)…………………………………………..(6)

where y: EC value(dSm^{-1}) , Na^+= concentrations Na^+ (mgl^{-1})

Table 2. Chemical analysis of tap or Nile water (Co)

pH	EC dSm^{-1}	Soluble ions ($meql^{-1}$)								SAR
		Cations				Anions				
		Ca^{2+}	Mg^{2+}	Na^+	K^+	CO_3^{2-}	HCO_3^-	Cl^-	SO_4^{2-}	
7.80	0.37	1.14	1.21	1.15	0.20	0.00	1.81	0.94	0.95	1.06

Table 3. Chemical composition of the artificial saline solutions

Artificial saline solutions	Na Cl		$CaCl_2$		$MgCl_2$		SAR	TSS mgl^{-1}	Na+ Conc. meq/l
	$mg1^{-1}$	$meql^{-1}$	$mg1^{-1}$	$meql^{-1}$	$mg1^{-1}$	$meql^{-1}$			
A1B1	666.6	11.39	166.7	3	166.7	3.51	6.31	1000	666.6
A2B2	950	16.23	25	0.45	25	0.52	23.26	1000	950
A2B1	1666.6	28.48	416.7	7.5	416.7	8.77	9.97	2500	1666.6
A2B1	2375	40.52	62.5	1.12	62.5	1.36	36.11	2500	2375

Similar results were obtained by Ragab et al (2008) and Fayed (2009). The studied calcareous soils could be arranged based on their EC values in the following order: soil4>soil5~soil3>soil2>soil1. The effect of irrigation water properties on the studied calcareous soils content (meql^{-1}) of soluble ions (cations and anions) are shown in Table (4). The obtained data show that, increasing total soluble salts , Na^+ ions and SAR of irrigation water, increase the content of soluble ions in the studied soil solutions. These results are in agreement with those obtained by Abou Hussien et al. (2009) and Shalaby et al (2009).

3.2. Phosphorus Forms (P-forms)

The presented data in Table (5) show, the studied calcareous soils content (mg kg^{-1}) of P-forms under study was dissimilar where this content varied from soil to another and also was related with salinity and sodicity levels of irrigation water. The arrangement of the soils according to their content (mg kg^{-1}) of total – P (T-P) was soil3>soil4> soil2>soil5> soil1. This order was in relation with studied soil properties especially their content (%) of total and active $CaCO_3$, clay and O.M and EC values(dSm^{-1}). The content of T-P was increased with the increase of soil content of $CaCO_3$, clay and OM. This positive effect was resulted from the effect of these factors on the decrease of rate of decomposition processes of P compounds. Similar findings were reported by (Abd Alla et al , 2007 and Alshahri, 2008).

The recorded data in Table (5) show increase of irrigation water salinity and sodicity resulted in a decrease of calcareous soils content of T-P. The obtained decrease resulted from the increase of irrigation water sodicity level was higher than that found as a result of increase of salinity level.

This decrease was resulted from the dissolved effect of salinity and sodicity water for some P compounds especially which namely by organic P compounds (Basak, 2006). These results were in agreement with those obtained by Shaban (2005).

Regarding to the calcareous soils content (mg kg^{-1}) of available P (A-P) as recorded in Table (5) it may be noticed that, these soils characterized by low content of A-P where this content was lower than 0.60 mg/kg and also its represent lower than 0.7% of T-P. The low content of A-P resulted from the high content of $CaCO_3$ which converted soil P to un available form (fixed or precipitate) as premonition by Basak (2006).The arrangement of the studied soils according to their content (mg kg^{-1}) of A-P was soil3> soil 2> soil 4> soil 5> soil 1. Similar results were found by Khalil (2000). Also, the calcareous soils content of A-P was in relations with many properties of the studied soils.

The salinity and sodicity levels of irrigation water have a greater and positive effect on calcareous soils content (mg kg^{-1}) of A-P. This positive effect was resulted from the dissolved effect of saline and alkaline solution for organic P compounds. The increase of A-P content associated the increase of water sodicity was higher than that found with the increase of water salinity level. Similar results were obtained by Egashira et al. (2003) and Fayed (2009).

The second main form of P in the studied calcareous soils was a organic form (O-P) where this content represent less than 12% of T-P (Table,5). The high content (mg kg^{-1}) of O-P was found in soil 3 and the lowest one was found in soil1 under different treatments of irrigation water. The content of O-P was in agreement with these soils content of OM. On the other hand, the relationships between the soils content of O-P and either of soil pH or soil content (%) of $CaCO_3$ were negative. (Basak, 2006 and Alshahri, 2008).

Increase of irrigation water salinity or sodicity resulted in a decrease of soil content (mg kg^{-1}) of O-P. The obtained decrease of the content of O-P resulted from increase of irrigation water sodicity was higher than that associated the increase of irrigation water salinity. This decrease resulted from dissolved effect of the used irrigation water of soil O-P compounds (Khalil, 2000 and Egabira et al, 2003).

The main form of P in the studied calcareous soils was inorganic P(I-P) where its represent more than 87% of T-P(Table,5). The calcareous soils content (mg kg^{-1}) of I-P was varied widely from soil to another depending on the soils properties and the treatments of irrigation water where the arrangement of these soils according to their content of I-P was soil 5> soil 4> soil 3> soil 2> soil 1. The high percentages of I-P (% of T-P) revealed to the high content of $CaCO_3$ (%) in these soils (Basak, 2006 and Elshahri, 2008). Similar results were obtained by Ebrahim et al.(2007). Calcareous soils content of I-P was decreased with increase of water salinity and sodicity. This effect may be reviewed to its effect on the studied soils properties and its effect on soil P transformation and solublility (Bayoumi et al., 1997).

3.3. Inorganic-P Fractions

Data in Table (6) show that calcium-P (Ca-P) represent a main fraction of I-P where the content of this fraction represent more than 70% of I-P. These high percentages resulted from the high content (%) of $CaCO_3$ in the studied soils which played a important role in this respect by reaction with P and transferred to un available calcium phosphate (Basak, 2006). So, and based on the prementioned the studied soils takes the following order according to their content (mg kg^{-1}) of Ca-P soil 3> soil 4> soil 2> soil 5> soil 1. This order was related with the studied soils properties (Ebrahim et al, 2007). Increasing water salinity and sodicity, leeds to an increase the content of Ca-P which may be resulted from its effect on dissolving other P forms especially O-P. This positive effect was also found by Bayoumi et al. (1997).

Table 4. Some chemical properties of the studied calcareous soils as affected by saline irrigation water

Studied soils	Irrigation water	pH 1:2.5	EC dSm^{-1}	Soluble ions ($meql^{-1}$)						
				Cations				Anions		
				Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	HCO_3^{-}	Cl^{-}	SO_4^{2-}
Soil1	Co	7.87	2.31	5.92	5.29	10.59	1.30	1.04	8.08	13.98
	A1B1	7.86	2.34	5.70	5.30	11.90	1.40	1.21	14.31	8.78
	A1B2	7.89	2.51	6.86	2.34	14.48	1.42	1.34	16.85	6.91
	A2B1	7.87	3.07	8.35	5.61	15.23	1.51	1.60	15.63	13.47
	A2B2	7.80	3.80	8.81	2.43	25.16	1.60	1.65	18.22	18.13
Soil2	Co	7.88	3.62	9.70	6.53	18.23	1.74	1.66	23.00	11.54
	A1B1	7.88	4.13	12.80	10.19	16.29	2.02	1.77	23.30	16.23
	A1B2	7.90	4.18	12.53	10.40	17.30	1.57	1.84	22.37	17.59
	A2B1	7.88	4.89	18.23	11.32	18.11	1.24	1.86	13.73	33.31
	A2B2	7.91	4.97	21.16	11.27	15.40	1.87	1.94	13.98	33.78
Soil3	Co	7.92	7.78	16.80	11.18	48.64	1.18	2.07	27.01	48.72
	A1B1	7.91	8.22	23.17	12.23	44.73	2.07	2.21	45.66	34.33
	A1B2	7.92	8.37	24.76	13.11	43.80	2.03	2.33	41.15	40.22
	A2B1	7.93	10.13	25.20	19.87	54.02	2.21	2.50	47.60	51.20
	A2B2	7.91	10.56	25.92	20.55	56.80	2.33	2.67	49.80	53.13
Soil4	Co	8.10	6.09	17.78	4.47	37.00	1.65	2.66	39.66	18.58
	A1B1	8.10	6.61	24.48	9.67	29.80	2.15	2.72	38.25	25.13
	A1B2	8.11	6.70	24.72	9.80	30.23	2.25	3.03	32.21	31.76
	A2B1	8.11	7.83	27.15	9.72	38.88	2.55	3.09	40.21	35.00
	A2B2	8.15	7.92	27.36	12.02	37.50	2.32	3.72	38.29	37.19
Soil5	Co	8.01	6.33	18.25	12.42	30.71	1.92	3.64	30.41	29.25
	A1B1	8.01	6.61	22.84	11.65	30.20	1.41	3.67	29.18	33.25
	A1B2	8.02	6.75	22.21	12.23	31.03	2.03	3.71	31.60	32.19
	A2B1	8.01	7.35	28.25	12.42	30.71	2.12	3.86	38.90	30.74
	A2B2	8.05	7.45	29.25	11.31	32.11	1.83	3.92	40.12	30.46

,Calcareous soils content of aluminum-P (Al-P) as mg kg^{-1} or as a percentage of I-P as presented in Table (6) show that, this fraction represent a third main group of I-P, where this fraction represent about 7 to 10% of I-P. Soil properties played an important role on their content of Al-P which decreased with the increase of $CaCO_3$ content. The high content of AL-P (mg kg^{-1}) was found in soil 3 follwed by soil 2 where the lowest one was found in soil 1. Little decrease of soil content of Al-P was found with the increase of irrigation water salinity and sodicity. Ebrahim et al. (2007) obtained on similar results.

Regarding to the studied soils content of iron-P (Fe-P) as mg kg^{-1} and % of I-P, the data of Table (6) show that, the calcareous soils characterized by very low content of Fe-P where its was lower than 1 mg kg^{-1} (lower than 1% of I-P). The content of Fe-P was found in soil 3 folloed by soil 2 and the lowest one was found in soil 1. The low content of Fe-P in the soils under study resulted from low content of these soils of free iron compounds. Little decrease of Fe-P content was found as a result of irrigation by saline and sodic water. The obtained decrease resulted from the effect of the used irrigation water on the properties of calcareous soils especially soil pH and the content of both total and active $CaCO_3$ (El_Sheikh , 2000).

Table 5. The studied calcareous soils content (mgkg-1) of different P forms and its percentages(%) of T-P as affected by soil propertiesand irrigation watersalinity and sodicity

P-form	Irrigation water	Soil 1 mgkg-1	Soil 1 %of T-P	Soil 2 mgkg-1	Soil 2 %of T-P	Soil 3 mgkg-1	Soil 3 %of T-P	Soil 4 mgkg-1	Soil 4 %of T-P	Soil 5 mgkg-1
T-P	Co	24.12		73.32		89.67		74.11		32.85
	A1B1	22.25		71.35		87.13		72.17		29.83
	A1B2	22.83		71.92		87.72		72.66		30.50
	A2B1	23.11		72.63		88.50		73.15		30.95
	A2B2	23.55		72.75		88.85		73.71		31.60
A-P	Co	0.12	0.51	0.37	0.50	0.40	0.45	0.32	0.43	0.13
	A1B1	0.12	0.55	0.39	0.54	0.44	0.51	0.35	0.48	0.13
	A1B2	0.13	0.57	0.40	0.55	0.46	0.52	0.36	0.50	0.14
	A2B1	0.13	0.58	0.41	0.56	0.47	0.53	0.37	0.51	0.15
	A2B2	0.14	0.61	0.43	0.59	0.51	0.57	0.41	0.56	0.16
O-P	Co	2.53	10.50	7.93	10.82	9.25	10.32	8.27	11.16	3.75
	A1B1	2.33	10.48	7.58	10.63	8.88	10.19	7.83	10.85	3.32
	A1B2	2.32	10.15	7.49	10.42	8.77	10.00	7.83	10.78	3.37
	A2B1	2.32	10.03	7.39	10.17	8.81	9.96	7.71	10.54	3.34
	A2B2	2.31	9.80	7.24	9.95	8.57	9.65	7.50	10.18	3.27
I-P	Co	21.59	89.50	65.39	89.18	80.42	89.68	65.84	88.84	29.10
	A1B1	19.92	89.52	63.77	89.37	78.25	89.81	64.34	89.15	26.51
	A1B2	20.51	89.85	64.43	89.58	78.95	90.00	64.83	89.22	27.13
	A2B1	20.79	89.97	65.24	89.83	79.69	90.04	65.44	89.46	27.61
	A2B2	21.24	90.20	65.51	90.05	80.28	90.35	66.21	89.82	28.33

Table 6. The studied calcareous soils content (mgkg-1) of different I-P fractions and percentages(%) of I-P as affected bysoil propertiesand irrigation, water salinity and sodicity

P-form	Irrigation water	Soil 1 mgkg-1	Soil 1 %of I-P	Soil 2 mgkg-1	Soil 2 %of I-P	Soil 3 mgkg-1	Soil 3 %of I-P	Soil 4 mgkg-1	Soil 4 %of I-P	Soil 5 mgkg-1	Soil 5 %of I-P
Ca-P	Co	14.68	60.87	45.10	61.51	56.86	63.41	49.10	66.25	22.58	68.75
	A1B1	13.57	61.00	44.42	62.25	56.92	65.33	48.53	67.25	20.93	70.15
	A1B2	14.39	63.05	46.51	64.67	59.61	67.95	49.96	68.76	21.73	71.23
	A2B1	14.80	64.05	47.85	65.88	61.55	69.55	51.40	70.26	22.65	73.18
	A2B2	15.36	65.22	49.00	67.35	63.06	70.97	53.11	72.05	23.70	75.00
Al-P	Co	2.42	10.05	7.32	9.98	8.80	9.81	7.15	9.65	3.00	9.13
	A1B1	2.21	9.95	6.99	9.80	8.43	9.67	6.73	9.32	2.66	8.93
	A1B2	2.19	9.60	6.77	9.41	8.09	9.22	6.65	9.15	2.68	8.79
	A2B1	2.13	9.20	6.54	9.01	7.94	8.97	6.52	8.91	2.66	8.60
	A2B2	2.12	9.00	6.48	8.91	7.76	8.73	6.35	8.61	2.68	8.48
Fe-P	Co	0.15	0.61	0.44	0.60	0.52	0.58	0.42	0.57	0.18	0.55
	A1B1	0.14	0.61	0.42	0.59	0.50	0.57	0.40	0.56	0.16	0.54
	A1B2	0.13	0.55	0.39	0.54	0.46	0.53	0.37	0.51	0.15	0.50
	A2B1	0.13	0.55	0.38	0.53	0.46	0.52	0.37	0.50	0.15	0.49
	A2B2	0.11	0.48	0.33	0.46	0.40	0.45	0.32	0.43	0.13	0.42
R-P	Co	4.33	20.06	12.53	19.16	14.24	17.71	9.17	13.93	3.33	11.45
	A1B1	4.00	20.08	11.94	18.72	12.41	15.86	8.67	13.48	2.76	10.41
	A1B2	3.80	18.53	10.76	16.70	10.79	13.67	7.85	12.11	2.56	9.44
	A2B1	3.74	17.99	10.47	16.05	9.74	12.22	7.16	10.94	2.15	7.79
	A2B2	3.65	17.18	9.70	14.81	9.06	11.29	6.43	9.71	1.81	6.39

3.4. Dry Matter Yield of Barley Plant

The present data in Table (7) show that, the obtained dry ,matter yield (g pot^{-1}) of barley plants (straw and grains) were greatly affected by soil properties especially the content of $CaCO_3$ where the obtained dry matter yield was decreased with the increase of soils content of $CaCO_3$. So, the high yield of dry matter was found with the plants grown on soil 1 fillowed by that on soil 2. Also, these results reviewed to un suitable conditions in high calcareous soils (high content of $CaCo_3$) to plant growth especially that related with the nutrients availability and water relationships (Khalil, 2000). Barley straw and grains dry matter yield was greater decreased with the increase salinity and sodicity levels of irrigation water. This negative effect was supported from the calculated negative values of relative change (RC,%) which recorded in Table (7). This negative effect was increased with the increase level of irrigation water salinity and sodicity. Also, the negative effect associated the increase in sodicity level was more clear compared with that resulted from the increase of salinity level. Similar results were obtained by Abuo Hassien and Barasoum (2002) and Alshahri (2008).

3.5. Plant Content Of Phosphorus

These data in Tables (8) show that, P uptake (mg pot^{-1}) was decreased with the increase soil content of $CaCO_3$. Thus the high content of P was found in the plants grown on soil 1 followed by that grown on soil 2. Also P uptake by straw were lower than those of grains. Generally, the obtained values of P content were low which resulted from presence high content of $CaCO_3$ which transferred soil P to un available forms (Basak, 2006). With different soils and under the treatments of irrigation water, the obtained values of RC(%) in Table (8)were negative. The negative effect was increased with the increase of irrigation water salinity and sodicity. Also, this effect was become more clear in the soils have high content (%) of $CaCO_3$ Khalil (2000) and Alshabry (2008) obtained an similar results.

$$RC(\%)= \frac{\text{Dry mater yieald of trated plants - Dry matter of untreated plants}}{\text{Dry mater yieald of trated plants}} X100 \quad ......(7)$$

$$RC(\%)= \frac{\text{P uptake by plants irrigated by salnity water - P uptake by plants irrigated by tap water}}{\text{P uptake by plants irrigated by tap water}} X100 \quad ....(8)$$

Table 7. Dry matter yield (g/pot) of barley plants (straw and grains) and its relative change (RC,%) as affected by thestudied calcareous soils and irrigation water salinity and sodicity

Irrigation water	Soil 1		Soil 2		Soil 3		Soil 4		Soil 5	
	g/pot	RC %	g/pot	RC %	g/pot	RC %	g/pot	RC %	g/pot	RC %
	Straw									
Co	11.32	0.00	10.22	0.00	9.28	0.00	8.33	0.00	7.78	0.00
A1B1	11.07	-2.21	10.15	-0.68	8.95	-2.84	7.74	-7.08	7.62	-2.06
A1B2	10.96	-3.18	10.08	-1.37	8.86	-5.68	7.63	-8.40	7.51	-3.47
A2B1	10.25	-9.45	8.53	-16.54	8.01	-11.14	7.49	-10.08	7.37	-5.27
A2B2	9.38	-17.14	8.49	-16.93	7.98	-23.36	7.47	-10.32	7.29	-6.30
	Grains									
Co	3.89	0.00	3.00	0.00	2.78	0.00	2.56	0.00	2.27	0.00
A1B1	3.64	-6.43	2.99	-0.33	2.69	-3.24	2.38	-7.03	2.22	-2.20
A1B2	3.33	-14.40	2.97	-1.00	2.66	-4.32	2.34	-8.59	2.15	-5.29
A2B1	3.11	-20.05	2.51	-16.33	2.41	-13.31	2.31	-9.77	2.12	-6.61
A2B2	2.84	-26.99	2.49	-17.00	2.40	-13.67	2.30	-10.16	2.11	-7.05

Table 8. P uptake (mg/kg) and its relative change (RC, %) by barley plants (straw and grains) as affected by the studied calcareous soils properties and irrigation water salinity and sodicity

Irrigation water	Soil 1		Soil 2		Soil 3		Soil 4		Soil 5	
	$mgkg^{-1}$	RC %	$mgkg^{-1}$	RC %	$mgkg^{-1}$	RC %	$mgkg^{-1}$	RC %	$mgkg^{-1}$	RC %
Straw										
Co	61.13	0.00	30.66	0.00	13.74	0.00	23.32	0.00	10.11	0.00
A1B1	54.24	-11.26	26.39	-13.93	9.35	-31.95	15.48	-33.63	7.62	-24.66
A1B2	49.32	-19.32	26.21	-14.52	8.21	-40.25	13.73	-41.12	6.01	-40.60
A2B1	37.93	-37.96	15.35	-49.92	6.11	-55.53	10.49	-55.04	4.42	-56.28
A2B2	31.89	-47.83	13.58	-55.69	4.56	-66.81	9.71	-58.36	3.65	-63.96
Grains										
Co	28.40	0.00	18.60	0.00	8.52	0.00	12.29	0.00	9.76	0.00
A1B1	22.20	-21.81	17.94	-3.55	7.12	-16.43	9.52	-22.55	8.66	-11.30
A1B2	18.98	-33.16	16.63	-10.58	5.72	-32.86	8.89	-27.64	6.88	-29.52
A2B1	14.93	-47.43	10.29	-44.67	4.75	-44.25	6.93	-43.60	5.94	-39.19
A2B2	10.22	-64.00	8.96	-51.81	0.00	-100.00	6.67	-45.72	4.64	-52.44

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