Potassium Status and Some Chemical Properties in Calcareous Soil As Affected by Farmyard Manure, Moisture Content and Irrigation Water Salinity

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Abstract: The current work was carried out to study the effect of irrigation water salinity, farmyard manure levels and moisture content on potassium content and uptake of wheat plants grown on a calcareous soil. A pot experiment was carried out in green house of Soils and Water Department, Faculty of Agriculture, Al-Azhar University) Nasr city, Cairo, Egypt), during the winter of season 2009. Wheat plant (*Triticum aestivum*, L.) Sakha 93 Variety, used as an indicator plant to experiment treatments. Twenty grains were sown in each pot and the treatments were three replicates including control. After 15 days, the pots were thinned to 10 seedlings. Completely randomized block design was used. Four salinity levels of irrigation water were prepared (control, 0.44, 1.56, 3.12 and 6.25 dSm^{-1}) under different moisture contents (100%, 75% and 60%) of field capacity determined by weight and four organic matter levels (0%, 1%, 2% and 4%) farmyard manure (FYM). Results showed that Potassium content and uptake in straw significantly decreased with increasing salinity levels. The lower values were 2.89 % and 238.39 mg pot^{-1}, respectively, at salinity level 6.25 dSm^{-1}. Increasing of farmyard manure application rates up to 2% induced significantly of potassium content and uptake in straw. The higher values were 3.56 % and 360.62 mg pot^{-1}, respectively. While being less pronounced with 4% farmyard manure. Potassium content and uptake in straw significantly increased with increasing moisture levels. The higher values were at 100% of field capacity 3.30 % and 335.95 mg pot^{-1}, respectively. Also, data showed that soil electrical conductivity increased as a result of increasing salinity levels of irrigation water and increasing moisture levels led to increase soluble cations and anions in soil under all treatments. Regarding to farmyard manure it's cleared that increasing farmyard rates increased soluble cations and anions in soil under all treatments.

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1. Introduction

Potassium is an essential plant nutrient and is required in large amounts for proper growth and reproduction of plants, **Kalavati and Modi (2012)** and **Mohamed *et al.* (2014)**. Potassium is considered second only to nitrogen, when it comes to nutrients needed by plants, and is commonly considered as the "quality nutrient." It affects the plant shape, size, color, taste and other measurements attributed to healthy produce. Potassium is absorbed by the roots as a K^+ ion. **Hassan and Mostafa (2002)** studied the effect of irrigation water salinity (2000, 4000, 6000 and 800 mgl^{-1}) and sewage sludge application on dry matter yield, uptake of macronutrients (NPK), in a pot experiment by barley plants grown on sandy and calcareous soils. They found that increasing salinity levels of irrigation water significantly decreased the dry matter yield and macronutrients uptake for both sandy and calcareous soil. Addition of sewage sludge increased the dry matter yield, NPK uptake; this was found true under all salinity levels of irrigation water.

Goudarzi and Pakniyat (2008) tested in a greenhouse fifteen Iranian wheat cultivars (*Triticum aestivum, L.*) for salt tolerance using three salt concentration 1.26, 6.8, and 13.8 dSm^{-1} using (Nacl and Na_2SO_4 in 1:1 ratio). During vegetative growth stage. In general, increasing salinity level decreased K level in all cultivars but tolerant cultivars with better agronomic performance, contained low Na and higher K compared to non-tolerant ones**. Dahdoh *et al.* (1993)** found that the highest K content was associated with 25 % soil moisture depletion compared to the 50% level. **Dahdoh *et al.* (1994)** found that K content in barley shoots grown in calcareous soil decreased with increasing soil moisture depletion. The 25% soil moisture depletion gave the highest values when compared with 50 or 75% soil moisture depletions. **Mater *et al.* (1987)** reported that farmyard manure was more effective than sugar beet composting material in increasing soil available potassium. The increase was more in sandy loam than the clayey soil. **Montasser (1987)** pointed out that the addition of farmyard manure, chicken manure, town refuse and poudrette increased the availability of N P K in a sandy soil gradually during the whole incubation period. **El-Leboudi *et al.***

(1988) stated that organic residues (Orange and guava) led to general significant positive increases in the content of total N, and available P and K in the both studied soils (calcareous and silty clay loamy) particularly in the second one.

2. Material and Methods

In green house of Soils and Water Department, Faculty of Agriculture, Al-Azhar University) Nasr city, Cairo, Egypt), a pot experiment was designed to study the effect of farmyard manure, moisture content and irrigation water salinity on potassium status and some chemical properties in calcareous soil, during the winter of season 2009. Wheat plant (*Triticum aestivum, L.*) Sakha 93 Variety, used as an indicator plant to experiment treatments. Plastic pots of 25 cm in side diameter and 30cm depth, pots were filled with 5.0 kg of calcareous soil samples which selected from EL-Nobaria region ($CaCO_3$ 30%) Cairo Alexandria, Desert Road. Soil samples were air dried and analyzed to estimate some physical and chemical characteristics according to the general methods of **Black (1965)**; **Table 1**.

Table 1: Some Physical and Chemical Characteristics of Soil Sample.

Physical properties									
Particle size distribution (%)				Texture Class	O.M %	$CaCO_3$ %	Moisture content %		
Coarse Sand	Fine Sand	Silt	Clay				F.C	W.P	A.W
9.56	57.96	24.98	7.5	Sandy Loam	1.43	30	23.21	9.27	13.94
Chemical Properties									
pH (1:2.5)	EC dSm^{-1}	Soluble cations meq l^{-1}				Soluble anions meq l^{-1}			
		Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3^{--}	HCO_3^{-}	Cl^{-}	SO_4^{--}
8.11	2.61	15.21	3.76	6.92	1.23	0.00	1.83	2.50	22.79

The cultivated plants were fertilized according to the general recommendations of Ministry of Agriculture. Twenty grains were sown in each pot and the treatments were three replicates including control. After 15 days, the pots were thinned to 10 seed lings. Completely randomized block design was used. Four salinity levels of irrigation water were prepared (control 0.44, 1.56, 3.12 and 6.25 dSm^{-1}) under different moisture contents in a green house. Irrigation was practical to maturity when the soil water depletion reached (100%, 75% and 60%) of field capacity determined by weight and four organic matter levels (0%, 1%, 2% and 4%) farmyard manure(FYM). The farmyard manure was taken from station of Animal production, Faculty of Agriculture, Al-Azhar University. Some chemical characteristics of organic manure were recorded in **Table 2.** The plant samples were collected from each treatment after harvesting then dried in an oven at 70° C for 48 hour, ground in stainless steel mill and stored in polyethylene bags for analysis according to the methods of **Chapman and Pratt (1961)**.

Table 2: Some Chemical Properties of Farmyard Manure Used:

pH (1:10)	EC dSm^{-1} (1:10)	O.M. (%)	O.C. (%)	C/N ratio	Total macronutrient (%)		
					N	P	K
7.62	6.89	42	24.4	17.06	1.43	0.78	1.99

3. Results and Discussion

I. Effect of Water Salinity, Farmyard manure and Moisture levels on Potassium Content and Uptake of Wheat Plant Straw:

Potassium content and uptake of wheat plant straw as affected by water salinity levels, farmyard manure and moisture were presents in **Tables 3, 4.** It was noticed that, increasing salinity levels significantly decreased potassium content and uptake in straw of wheat plant. This was true at rates of water salinity, where potassium content in straw reached 3.58, 3.35,3.22 and 2.89 % at salinity levels (control, 1.56, 3.12 and 6.25 dSm^{-1}), respectively. The corresponding values for potassium uptake by straw were 364.94, 319.10, 287.21 and 238.39 mg pot^{-1} at the same levels of salinity.

With regard to the effect of farmyard manure rates on K content and uptake of wheat straw, under different levels of water salinity and moisture content %, the results of **Tables 3, 4** showed that, the K content and uptake of the wheat straw decreased by increasing salinity levels. This was true at all levels of the both moisture and farmyard manure content. This might be due to the presence of excess amount of sodium in soil solution, which limited the uptake of potassium, as results of the antagonistic effect of Na on K absorption. These results are harmony with those obtained by many authors such as **Mostafa (2001) and Ahmadi *et al.* (2009)**. Concerning the effect of FYM on K content and uptake. Data presented in **Tables 3, 4** noticed that, increasing farmyard manure levels up to 2% significantly increased potassium content and uptake in straw, where potassium content in straw reached 2.81, 3.45, 3.65 and 3.22 % at application 0, 1%, 2% and 4% farmyard manure respectively. The corresponding values for potassium uptake by straw were 228.94, 316.95, 360.62 and 303.13 mg pot^{-1} at the same levels of farmyard manure. Regardless the treatment of either moisture or salinity levels, it seen that increasing the rate of farmyard manure level up to the rate of 2% led to increase K content and uptake of straw of wheat plant, but the increase of farmyard manure up to the rate of 4% caused decrease of K content. This was true at all rates of water salinity indicating that the presences of farmyard manure reduce the hazard effect of high salinity. These results are consistent with those obtained by earlier investigators**, Shabana *et al.* (1998), Mostafa (2001), Hassan and Mostafa (2002) and Rodd *et al.* (2002)**, who concluded that increasing salinity levels of irrigation water significantly decreased potassium uptake. They added that application of FYM or any other organic manures increased potassium uptake, which was true under all salinity levels. Similar results are obtained **by Lie *et al.* (1997), El- Shafie *et al.* (2003)**, **Patil (2010) and Hussain (2013)** who pointed out that the uptake of potassium markedly decreased with increasing salinity levels. Addition of farmyard manure led to a significant increase in potassium uptake, as compared with the control.

Further evidence was provided by **Irshed, *et al.* (2002)** who found that application of composted manure and urea fertilizer enhanced plant growth and potassium uptake compared with the non-treated control.

Table 3: Potassium content (%) in wheat plants straw as affected by the interaction among salinity levels, farmyard manure and moisture percentages.

Salinity (S) dSm^{-1}	Moisture (M) %	K content (%) Farmyard manure (FYM) % 0	1	2	4	Mean
Control	100	3.37	3.67	3.78	3.59	3.60
	75	3.35	3.65	3.75	3.57	3.58
	60	3.31	3.63	3.72	3.51	3.54
Mean		**3.34**	**3.65**	**3.75**	**3.56**	**3.58**
1.56	100	2.83	3.53	3.68	3.48	3.38
	75	2.80	3.50	3.65	3.43	3.35
	60	2.78	3.48	3.62	3.40	3.32
Mean		**2.80**	**3.50**	**3.65**	**3.44**	**3.35**
3.12	100	2.65	3.44	3.52	3.37	3.25
	75	2.61	3.41	3.50	3.33	3.21
	60	2.68	3.37	3.47	3.29	3.20
Mean		**2.65**	**3.41**	**3.50**	**3.33**	**3.22**
6.25	100	2.48	3.29	3.37	2.73	2.97
	75	2.45	3.22	3.33	2.56	2.89
	60	2.40	3.15	3.30	2.41	2.82
Mean		**2.44**	**3.22**	**3.33**	**2.57**	**2.89**
Mean	100	2.83	3.48	3.59	3.29	3.30
	75	2.80	3.45	3.56	3.22	3.26
	60	2.79	3.41	3.53	3.15	3.22
Mean		**2.81**	**3.45**	**3.56**	**3.22**	**3.26**
LSD at 5% level						
Salinity (S)			0.039			
Moisture (M)			0.034			
Farmyard manure (FYM)			0.039			
S × M			0.068			
S × FYM			0.079			
M × FYM			0.068			
S × M × FYM			0.137			

Table 4: Potassium uptake (mg pot^{-1}) by wheat plants straw as affected by the interaction among salinity levels, farmyard manure and moisture percentages.

Salinity (S) dSm^{-1}	Moisture (M) %	K uptake (mg pot^{-1}) Farmyard manure (FYM) % 0	1	2	4	Mean
Control	100	317.11	396.36	480.81	398.13	398.10
	75	311.21	364.27	421.12	366.28	365.72
	60	270.42	327.06	402.87	323.62	330.99
Mean		299.58	362.56	434.93	362.68	364.94
1.56	100	252.15	360.41	435.34	390.10	359.50
	75	233.80	336.70	373.39	307.32	312.80
	60	207.94	295.80	332.31	303.96	285.00
Mean		231.30	330.97	380.35	333.79	319.10
3.12	100	223.92	339.87	384.73	332.61	320.28
	75	195.75	293.26	318.15	301.36	277.13
	60	189.11	281.39	299.80	286.55	264.21
Mean		202.93	304.84	334.23	306.84	287.21
6.25	100	203.11	299.71	321.16	239.69	265.92
	75	178.85	268.87	296.37	204.54	237.16
	60	163.92	239.71	261.36	183.40	212.10
Mean		181.96	269.43	292.96	209.21	238.39
Mean	100	249.07	349.09	405.51	340.13	335.95
	75	229.90	315.78	352.26	294.88	298.20
	60	207.85	285.99	324.09	274.38	273.08
Mean		228.94	316.95	360.62	303.13	302.41
LSD at 5% level						
Salinity (S)			3.92			
Moisture (M)			3.39			
Farmyard manure (FYM)			3.92			
S × M			6.79			
S × FYM			7.84			
M × FYM			6.79			
S × M × FYM			13.58			

Data in **Tables 3 and 4** showed also that, the increasing moisture levels significantly increased potassium content and uptake in straw of wheat plant, where potassium content in straw reached 3.30, 3.26 and 3.22 % at moisture levels 100, 75, 60 % of field capacity, respectively. The corresponding values for potassium uptake by straw were 335.95, 298.20 and 273.08 mg pot^{-1} at the same levels of moisture.

The increase of moisture content in soil caused increase of K content and uptake of wheat straw this was true at all levels of both farmyard manure and water salinity. It shows that the importance of maintaining proper level of soil moisture on the availability of the nutrients due to the so-called elements balance in soil as it increases the solubility of elements from their minerals. The drought of soil in all cases led to unsuitable conditions in soil which directly or indirectly affected the absorption of elements from soil as well as the composition, hardness and un favorite soil tilt especially in the calcareous soil which affect distribution and activity in a hazardous way. Therefore, it is necessary to maintain soil moisture in the root zone at the proper level and not to reach permanent wilting at any time of plant growth.

II. Effect of salinity, moisture and farmyard manure on some chemical properties of soil after wheat harvesting.

Data in **Tables 5, 6, 7 and 8** showed that irrigation with saline water increase the total soluble salts in the soil. Soil electrical conductivity increased as a result of increasing salinity levels of irrigation water. This may be due to the great surface area of the fine particles, which adsorb more soluble and exchangeable cations of saline solution. This finding is in agreement with those obtained by **Abdel -Nour (1989),** who found that the significant increases in soil EC was proportional to increase, salts concentration in the irrigation water. The highest value was obtained 6.40 dSm^{-1} for salinity level 6.25 dSm^{-1} treatment and the lowest value was obtained 1.69 dSm^{-1} for salinity level control treatment. The concentration of soluble calcium plus magnesium in soil increased as a result of irrigation with saline water. The highest value were 26.11 and 9.76 meq l^{-1} respectively, for salinity level 6.25 dSm^{-1} treatment while the lowest value 10.36 and 2.66 meq l^{-1} respectively, found for salinity level (control) treatment. Soluble sodium content in the studied soil is increased by increasing sodium content in irrigation water; this could be attributed to the higher adsorption capacity of sodium, this also is probably due to the cation exchange capacity of the calcareous soil. The highest values were 26.64 meq l^{-1} for salinity level 6.25 dSm^{-1} treatment and the lowest value were 3.22 $meql^{-1}$ for salinity level control treatment. Increasing salinity levels of irrigation water effected on potassium and bicarbonate content in the studied soil, the highest value was found for salinity level 6.25 dSm^{-1} treatment while the lowest one was found for salinity level control treatment. The content of chloride ions in the soil increased by increasing of the salinity levels of irrigation water. The highest values were attained for salinity level 6.25 dSm^{-1} treatment and the lowest value was found for salinity level control treatment. Continuous increases in sulfate contents are attained by increase of the levels of irrigation water salinity in soil. This could be attributed to the fact that saline solution increase the solubility of none readily soluble sulfates in soil media. The highest value was 26.22 meq l^{-1} for salinity level 6.25 dSm^{-1} treatment and the lowest value was 3.77 meq l^{-1} for salinity level (control) treatments. **Hassanein *et al.* (1993)** found that the distribution and concentration of most cations and anions were increased with increasing salt concentration in irrigation water.

Data in **Tables 5**, **6, 7 and 8** showed that, increasing moisture levels increased soluble cations and anions in soil under all treatments.

Regarding to farmyard manure it's cleared that increasing farmyard rates increased soluble cations and anions in soil under all treatments.

Table 5: Effect of salinity levels (control), farmyard manure and moisture on some chemical properties of soil after wheat harvesting.

Salinity dSm^{-1}	Farmyard manure %	Moisture %	pH (1:2.5)	EC dSm^{-1}	Soluble cations meq l^{-1}				Soluble anions meq l^{-1}			
					Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3^{--}	HCO_3^{-}	Cl^{-}	SO_4^{--}
Control	0%	100%	8.11	1.69	10.36	2.66	3.22	0.73	0.00	1.70	11.50	3.77
		75%	8.13	1.72	10.43	2.73	3.29	0.76	0.00	1.73	11.71	3.81
		60%	8.12	1.76	10.47	2.80	3.67	0.78	0.00	1.75	11.76	3.85
	1%	100%	8.25	1.59	10.51	2.71	2.00	0.74	0.00	1.65	10.71	3.60
		75%	8.28	1.70	10.61	2.77	2.82	0.78	0.00	1.68	11.63	3.70
		60%	8.28	1.71	10.64	2.88	2.90	0.80	0.00	1.72	11.67	3.74
	2%	100%	8.46	1.79	11.33	3.01	2.63	0.97	0.00	1.78	11.56	4.60
		75%	8.36	1.85	11.34	3.11	3.09	1.00	0.00	1.80	12.01	4.73
		60%	8.32	1.89	11.35	3.21	3.30	1.11	0.00	1.82	12.32	4.83
	4%	100%	8.37	1.99	11.49	3.51	3.14	1.77	0.00	1.82	12.99	5.10
		75%	8.42	2.03	11.62	3.63	3.28	1.80	0.00	1.87	13.32	5.14
		60%	8.42	2.07	11.71	3.81	3.44	1.82	0.00	1.90	13.45	5.43

Table 6: Effect of salinity levels 1.56 dSm^{-1}, farmyard manure and moisture on some chemical properties of soil after wheat harvesting.

Salinity dSm^{-1}	Farmyard manure %	Moisture %	pH (1:2.5)	EC dSm^{-1}	Soluble cations meq l^{-1}				Soluble anions meq l^{-1}			
					Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3^{--}	HCO_3^{-}	Cl^{-}	SO_4^{--}
1.56	0%	100%	8.13	2.42	11.91	3.98	7.64	0.70	0.00	1.50	17.56	5.21
		75%	8.14	2.52	11.99	4.34	7.99	0.78	0.00	1.56	18.34	5.30
		60%	8.11	2.61	12.09	5.10	8.25	0.89	0.00	1.63	19.19	5.33
	1%	100%	8.28	2.61	12.91	4.76	7.61	0.91	0.00	1.64	20.01	4.54
		75%	8.30	2.67	13.20	4.89	7.65	0.96	0.00	1.69	20.30	4.73
		60%	8.34	2.80	13.44	5.01	7.66	0.98	0.00	1.70	20.32	4.83
	2%	100%	8.37	2.86	13.67	5.22	8.78	0.91	0.00	1.74	21.01	5.87
		75%	8.31	2.95	13.71	5.42	9.48	0.94	0.00	1.79	21.22	5.50
		60%	8.28	3.12	14.21	5.77	10.23	0.99	0.00	1.80	22.42	6.98
	4%	100%	8.36	3.27	14.77	5.89	10.32	1.74	0.00	1.74	22.87	8.11
		75%	8.42	3.32	14.81	5.99	10.68	1.76	0.00	1.81	23.21	8.22
		60%	8.46	3.37	15.01	6.11	10.83	1.78	0.00	1.85	23.34	8.54

Table 7: Effect of salinity levels 3.12 dSm-1, farmyard manure and moisture on some chemical properties of soil after wheat harvesting.

Salinity dSm^{-1}	Farmyard manure %	Moisture %	pH (1:2.5)	EC dSm^{-1}	Soluble cations meq l^{-1}				Soluble anions meq l^{-1}			
					Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3^{--}	HCO_3^{-}	Cl^{-}	SO_4^{--}
3.12	0%	100%	8.21	3.68	16.54	6.17	13.57	0.54	0.00	1.54	23.56	11.72
		75%	8.32	3.82	17.13	6.77	13.80	0.58	0.00	1.57	24.84	11.87
		60%	8.23	4.04	17.89	7.01	14.86	0.69	0.00	1.61	25.93	12.91
	1%	100%	8.45	4.34	16.10	6.18	16.95	0.67	0.00	1.54	25.98	12.89
		75%	8.40	4.65	16.57	6.71	17.95	0.70	0.00	1.57	25.11	13.78
		60%	8.46	4.77	16.94	6.90	17..08	0.72	0.00	1.58	26.24	13.87
	2%	100%	8.35	4.12	17.00	7.11	16.34	0.83	0.00	1.64	25.66	13.98
		75%	8.38	4.28	18.23	7.33	16.41	0.85	0.00	1.71	26.67	14.44
		60%	8.21	4.47	17.82	7.86	17.18	0.89	0.00	1.76	27.63	15.36
	4%	100%	8.46	4.68	19.79	7.67	17.80	1.60	0.00	1.80	28.00	17.46
		75%	8.45	4.79	19.83	7.88	18.64	1.63	0.00	1.85	28.50	18.03
		60%	8.37	4.92	20.22	8.01	19.31	1.67	0.00	1.91	29.24	18.06

Table 8: Effect of salinity levels 6.25 dSm^{-1}, farmyard manure and moisture on some chemical properties of soil after wheat harvesting.

Salinity dSm^{-1}	Farmyard manure %	Moisture %	pH (1:2.5)	EC dSm^{-1}	Soluble cations meq l^{-1}				Soluble anions meq l^{-1}			
					Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3^{--}	HCO_3^{-}	Cl^{-}	SO_4^{--}
6.25	0%	100%	8.31	5.03	21.34	7.11	21.09	0.57	0.00	1.46	30.25	18.65
		75%	8.23	5.28	21.59	7.45	23.43	0.59	0.00	1.52	32.32	18.97
		60%	8.11	5.88	22.31	7.91	24.21	0.61	0.00	1.56	33.03	19.21
	1%	100%	8.37	5.21	22.57	8.21	22.87	0.45	0.00	1.39	32.70	18.01
		75%	8.38	5.49	23.11	8.34	23.11	0.48	0.00	1.41	32.98	18.21
		60%	8.39	5.82	23.65	8.50	23.52	0.52	0.00	1.45	34.05	18.32
	2%	100%	8.21	5.36	24.33	9.22	22.44	0.66	0.00	1.61	33.32	18.67
		75%	8.25	5.57	24.66	9.67	24.06	0.69	0.00	1.65	34.51	19.56
		60%	8.26	5.78	24.84	9.85	25.28	0.72	0.00	1.70	35.51	20.65
	4%	100%	8.25	6.08	25.77	9.33	24.31	1.44	0.00	1.72	35.69	21.44
		75%	8.31	6.21	25.92	9.45	25.31	1.48	0.00	1.84	36.13	24.19
		60%	8.31	6.40	26.11	9.76	26.64	1.50	0.00	1.88	36.31	26.22

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