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Changes in Yield and Nutrients Uptake of Rice Plants under Different Moisture Levels, Textured Soils and Fertility Levels

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ABSTRACT

A pot experiment was conducted in the greenhouse of NRC, Dokki, Cairo, Egypt to study the effect of three moisture regimes M1, M2 and Mg (irrigation every 4, 6 and 8 days respectively) and 8 soils differ in their texture and fertility levels on growth, yield and nutrient uptake by rice plants.
The most important results could be summarized as follows:

Results show that growth parameters, yield of straw and regains and the uptake of N, P, K, Fe and Mn by roots, shoots and grains of rice plants significantly affected by soil moisture regimes. Regardless of the soil texture and fertility level effects, results show that the highest values of the mentioned parameters were obtained by using soil moisture of M1 (irrigation every 4 days) followed by M2 (irrigation every 6 days) and M3 (irrigation every 8 days) in decreasing order.

Results indicate that the different used soils significantly affected growth, parameters and yield of straw and grains of rice plants. The highest levels were obtained when plants grown on Damietta clayey soil (L1) and the lowest ones were obtained by grown rice plants on Abo El-Matameer calcareous sandy loam soil (L7) and Janaklies calcareous loamy sand soil (L8).

Regardless of soil moisture regimes, results show that soils differ in texture and fertility levels, significantly affected N, K, Fe and Mn uptake by roots, straw and grains of rice plants. The highest values of all the mentioned nutrients uptake were found by growing rice plants on Damietta clayey soil (L1) followed by Kafr El-Sheikh clay loam soil (L2), Sakha clay loam soil (L3), El-Kanater clay loam soil (L4), El-Katiba silty loam soil (L5), El-Gafaria sandy loam soil (L8), Abo El-Matameer calcareous sandy loam soil (L7) and Janaklies calcareous loamy sand (L8) in decreasing order.

Concerning phosphorus uptake by roots, took the same trend of the uptake of N,P, Fe and Mn by roots, shoots and grains (L1 followed by L2, L3, L4, L5, L6, L7 and L8 in decreasing order). While phosphorous uptake by straw and grains were higher, when rice plants grown on El-Gaf'aria (L6) followed by El-Kanater (L4), Sakha soil (L3), El-Katiba soil (L5), Kafr El-Sheikh soil (L2) and Damietta soil (L1) in decreasing order.

Moreover, phosphorus uptake by straw and grains of rice plants grown on Abo El-Matameer soil L8 were significantly higher than those grown on Janaklies soils (L8).

The interaction between soil moisture regimes and different soils significant affected all the growth and yield parameters as well the nutrients uptake by the different parts of rice plants. The highest values of all the mentioned parameters were found by growing rice plants on Damietta clayey soil (L1) and using the soil moisture regime of M1 (M_1L_1). While the lowest values of the previous parameters were obtained by growing rice plants on calcareous Janaklies soil (L8) and the moisture of M3 was used (M_3L_8).

Key word: Rice plant, soil moisture, soil texture, nutrients uptake, fertility, calcareous soils.

Introduction

Rice crop easily adapts to the environment. It can grow in types of soils under a wide range of climatic and soil moisture conditions. Rice can be grown with a thin film of moisture on the soil surface, to about 10-50 cm of standing water (Mandal,1984) . It is mostly grown, whoever, in submerged soils with 10-30 cm standing water during most of its growth period. Rice can also be grown under continuous flooded soil, or under alternate welting and drying conditions. These changes in soil conditions and soil moisture regimes in rice field affect the changes in soil, which in turn influence the transformation and concentration of native and applied nutrients, availability, and consequently, rice nutrition and growth.

The most effective factors which have bearing on the losses of plant nutrients from soil are; soil type (texture, structure and fertility levels) Fundara *et al.,* (1975) , kind of plant, amount of water passing through the soil Pratt, (1978), and addition of plant nutrients (Sigrid and Johannes,1978) .

Fundara *et al*. (1975) , found that P moved to a depth of 18 cm in a soil with a sandy loam texture, and to 6 cm in a soil with clayey texture. Furthermore, Hartikner, (1978), found that the relative and absolute losses of plant nutrients were lowest in sandy clay and greatest in the sandy soils.

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This led us to attempt to find out the effect of soil moisture regimes used to different soils varied in their texture and levels of fertility on rice growth, yield and nutrients content in rice plants.

Materials and Methods

A pot experiment was conducted in the greenhouse of NRC, Dokki. Cairo, Egypt, to study the effect of three moisture regimes of M1, M2 and M3 and 8 soils differ in their texture and fertility levels (Tables 1 and 2), on growth, yield and nutrients uptake by rice plants.

Plastic pots (diameter 32 and high 37 cm) were filled with 20 kg from every soil. Each pot received a basic dressing of 11.5 Kg as urea (46% N), 3.75 Kg P_2O_5 as superphosphate (15.5% P_2O_5) and 13 Kg K_2O as potassium sulphate (48% P_2O) per feddan. One day after soil flooding, 15 seedling of 28 day, old of Shaka 102 variety were transplanted in each pot.

The irrigation treatments were used as follows : M1 watering at every 4 days irrigation intervals, M2 watering at every 6 days irrigation intervals and M3 watering at every 8 days irrigation intervals. In all the three moisture treatment (M1, M2 and M3). Submergence was raising to 5 cm at first month, 10 cm at the second month and 7 cm at the third month during irrigation.

The pots were arranged in completely randomized design with three replicates.

The numbers of tillers were recorded and plants were finally harvested at maturity, root volume, root weight, grain and straw yields were also recorded.

Straw and grains, were oven dried at 70°C. Ground samples of plants were digested with concentrated sulphuric acid and hydrogen peroxide, then N,P,K, Fe and Mn nutrients were determined as described by Lindsay and Norvell (1978) , and Cottenie *et al*., (1982). All the physical and chemical properties of the used soils were determined as descried by Jackson, 1982. Statistical analysis were carried out as described by Steel and Torrie, (1980).

Table 1. Particle size distribution, $CaCO_3$ % Organic matter % and pH values of the studied soils.

Soil location	Sand %	Salt %	Clay %	Texture class	CaCO3 %	O.M %	pH
	Alluvial soils						
L1 Damietta	22.00	27.2	48.08	Clayey	1.66	3.40	8.10
L2 Kafr El-Sheikh	31.00	28.0	41.00	Clayey	2.21	2.10	2.00
L3 Sakha	26.70	35.8	37.05	Clay loam	2.61	1.91	7.90
L4 El-Kanater	26.70	39.6	33.70	Clay loam Silty loam	2.70	1.80	7.96
L5 El-Katiba	33.30	51.0	15.70	Sandy loam	2.90	1.36	7.80
L6 El-Ga'faria	47.00	31.0	13.00		3.60	1.10	7.90
	Calcareous soils						
L7 Abo El-Matameer	78.00	9.60	12.40	Sandy loam	10.2	0.60	8.20
L8 Janaklies	79.00	10.0	11.00	Loamy land	11.1	0.40	8.30

Table 2. Some chemical properties of the used soils

Soil location	E.C. ds/m	Available nutrients (ppm)			DTPA extractable (ppm)	
		NH4+	P	K	Mn	Fe
	Alluvial Soils					
L1 Damietta	0.84	63.0	39.0	680	26.0	48.0
L2 Kafr El-Sheikh	1.60	52.0	31.0	560	22.0	41.0
L3 Sakha	0.83	36.0	27.0	490	14.0	35.0
L4 El-Kanater	1.08	31.0	23.0	420	13.0	32.0
L5 El-Katiba	1.35	19.0	14.0	310	7.8	19.0
L6 El-Ga'faria	2.24	14.0	11.0	240	6.4	16.0
	Calcareous soils					
L7 Abo El-Matameer	0.89	9.0	5.10	150	2.8	8.4
L8 Janaklies	0.99	7.0	4.30	110	1.1	7.0

Results and Discussion

Growth and yield of rice plants :

Effect of soil moisture regimes :

Results presented in Tables (3 and 4) show that the growth parameters (root dry weight, roots volume and tillers numbers) and yield of straw and grain of rice plants significantly affected by soil moisture regimes. Regardless the effect of soil texture, data show that the highest values of all growth parameters as well as yield of rice were obtained by using soil moisture regime of M1 (irrigation every 4 days), followed by M2 (irrigation every 6 days) and M3 (irrigation every 8 days) in decreasing order.

These results indicate that as the amount of irrigation water decreased, growth parameters and yield of rice also decreased. Confirm these results Chi, *et al*. (2001) and Bouman and Toung (2001) , who stated that continuous flooding with 5-7 cm of water depth is considered desirable for optimum grain yield. They also added that soil moisture less than submergence increased mechanical impedance in the 0-20 cm soil layer and decreased root length by 47% compared with continuous flooding.

The inhibitory of soil moisture regime treatments was reflected on tillers numbers straw and grain yield. Came to the same results (Singh *et al.,* 1977). On the other hand Nwadukwe and Chudel, (1998), stated that the results showed that the best yield, water use efficiency and irrigation efficiency were achieved when the soil moisture regime was held at saturation rather than at field capacity or at submergence.

The significantly reduction of growth parameters and yield of rice under soil moisture regimes of M2 and M3 as compared with M1 may be attributed to reduced shoot P levels resulting from the decline in P availability during the loss of soil water saturation (Seng *et al.,*1999) . The higher yield obtained by using continuous flooding may be partly related to the low infestation of weeds compared with the other treatments. Flooding checked the growth of grasses and sedge, but not-broad-leaf weeds. The reduced yield of rice under M2 and M3 treatments compared with M1 (irrigation every 4 days) have been associated with factors such as water stress and weeds (Belder *et al.,* 2004).

Table 3. Roots dry matter (gm/pot), roots volume (cm3/pot) and tillers number (per pot) of rice plants grown on different soils as affected by soil moisture regimes.

Soils location	Roots dry weight			Mean of soils location	Roots volume			Mean of soils location	Tillers number			Mean of soil location
	Soil moisture regimes				Soil moisture regimes				Soil moisture regimes			
	M1	M2	M3		M1	M2	M3		M1	M2	M3	
L1 Damietta	31.45	27.18	22.10	26.91	90	78	56	74.67	59	51	44	51.33
L2 Kafr El-Sheick	20.10	25.75	19.85	24.90	84	71	51	68.67	56	48	40	48.00
L3 Sakha	27.35	23.16	17.00	22.50	79	68	47	64.67	50	43	35	47.67
L4 El-Kanater	24.25	19.10	14.15	19.17	72	60	43	58.33	47	41	34	40.67
L5 El-Katiba	19.35	16.10	11.00	15.48	56	47	33	45.33	38	31	25	31.33
L6 El-Ga'faria	17.00	14.00	9.00	13.33	48	41	27	38.67	32	28	21	27.00
L7 Abo El-Matameer	14.00	11.75	7.35	11.03	36	29	19	28.00	25	21	15	20.33
L8 Janaklies	13.00	10.35	6.15	9.83	31	25	17	24.33	21	18	13	17.33
Mean of S.M.R.	21.94	18.42	13.33	17.90	62.00	52.38	36.63	50.33	41.00	35.13	28.38	34.83
L.S.D for S.M.R at	5% : 1.613		1% : 2.150		5% : 2.847		1% : 3.794		5% : 1.743		1% : 2.322	
L.S.D for soils location at	5% : 0.988		1% : 1.317		5% : 1.743		1% : 2.323		5% : 1.067		1% : 1.422	
L.S.D for (M x L) at	5% : 2.794		1% : 3.724		5% : 4.930		1% : 6.571		5% : 3.018		1% : 4.023	

S.M.R : Soil moisture regimes *M : Moisture regimes* *L : Soil location*

The obtained results of growth parameters as well as straw and grains yields of rice plants (Tables 3 and 4) are in good agreement with those obtained by Rao *et al.* (2000) , and Grigg *et al.*(2000), who stated that all growth parameters of rice plants were significantly higher by submergence as compared with another soil moisture regimes.

Effect of different soils :

Regardless of soil moisture regimes, results (Table 3 and 4) indicate that the different used soils significantly affected all the studied growth and yield parameters of rice plants. The highest values of growth and yield of rice plants were obtained when rice plants, grown on Damietta clayey soil (L1) followed by Kafr El-Sheik clayey soil (L2), Sakha clay loam soil (L3), El-Kanater clay loam soil (L4), El-Katiba silty loam soil (L5), El-Gaf'ara sandy loam soil (L6), ABo El-Matameer sandy loam soil (L7) and Janaklies loam sand soil (L8) in decreasing water.

The good growth of rice plants on the alluvial soils (L1, L2, L3, L4, L5 and L6) may be due to the favorable growth conditions of these soils and the good structure of the clayey and clay loam soil which could be an option to minimize water percolation into deep layers to maintain the traffic ability. On the other hand, the lowest growth and yield parameters values were obtained by growing rice plants on calcareous soils (L7 and L8) and this may be due to the poor fertility levels of these soils and their physical and chemical characteristics which highly affected by $CaCO_3$ % which cause the high EC and/or pH, $CaCO_3$ values, micronutrients fixation and/or precipitation as well as crust formation. The reduction of roots growth (roots dry weight and volume) and yield of rica plants grown on calcareous soils may be due to the disturbance of root activity for nutrients uptake (Yellamanda and Kuladaivelu, 1992) [18]. Results show a tight linear correlation between the growth parameters and yield of rice plants, clay content and organic % in the used soils (see Table 1). Data in Table (3 and 4) show that the higher of clay content and organic matter %, the higher growth and yield of rice plants. Ahmad *et al.* (2008) , stated that soil clay showed significant correlation with organic and total sulfur. Similarly organic matter was correlated with sulfur.

Effect of interaction between soil moisture regimes and different soils:

The highest values of the growth parameters (Table 3) as well as straw and grain yield of rice (Table 4) were obtained by growing rice plant on Damietta clayey soil (L1) and using soil moisture regime of M1 (M1L1). On the other hand, the lowest values of growth parameters and yield of rice were found when rice was grown on calcareous sandy loam soil of Janaklies (L8) and using the soil moisture regime of M3 (M3L8). The highest values of growth parameters and yield of rice grown on Damietta clayey soil and using soil moisture M1 may be due to its higher water holding capacity and their higher content of the nutrients needed for rice growth. Furthermore, the lowest values of growth parameters and yield of rice were found when rice grown on calcareous loamy sand and sandy loam soils and using the lower soil moisture regime of M3 (M_3L_7 and M_3L_8). This may be due to the low productivity of the coarse textured soils which due to their poor inherent fertility and low water holding capacity and nutrient availability (Subhani *et al.,*2012) .

Table 4. Straw and grain yield of rice plants (gm/pot) grown on different soils as affected by soil moisture regimes.

Soils location	Straw Yield			Mean of soils location	Grain Yield			Mean of soils location
	Soil moisture regimes				Soil moisture regimes			
	M1	M2	M3		M1	M2	M3	
L1 Damietta	73.00	70.18	62.00	68.39	64.15	60.00	54.00	59.38
L2 Kafr El-Sheick	70.57	67.20	59.00	65.65	61.92	57.00	50.10	56.34
L3 Sakha	68.10	63.45	53.00	61.52	58.61	54.45	47.00	53.35
L4 El-Kanater	66.00	62.00	49.00	59.00	56.00	52.00	44.55	50.85
L5 El-Katiba	51.00	46.00	37.25	44.75	45.00	40.00	32.00	39.00
L6 El-Ga'faria	48.45	43.25	35.00	42.32	41.75	36.55	28.75	35.68
L7 Abo El-Matameer	39.00	37.00	29.00	35.00	29.75	25.35	18.15	24.43
L8 Janaklies	36.75	34.25	26.75	32.58	27.45	23.13	16.72	22.43
Mean of S.M.R.	56.63	52.92	43.88	51.14	48.08	43.56	36.41	22.43
L.S.D for S.M.R at	5% : 1.405		1% : 1.872		5% : 1.657		1% : 2.208	
L.S.D for soils location at	5% : 0.860		1% : 1.146		5% : 1.015		1% : 1.352	
L.S.D for (M x L) at	5% : 2.433		1% : 3.242		5% : 2.870		1% : 3.824	

Nutrients uptake by rice plants:

Effect of soil moisture regimes:

Soil moisture regimes exert considerable influence on the availability of nutrient, to rice plants. Results presented in Table (5-9) reveal that N,P,K, Fe and Mn uptake by roots, straw and grains were higher under the higher soil moisture regimes of M1 followed by M2 and M3 in decreasing order. The higher N uptake under soil moisture regime of M1 may be due to exploitation of larger volume of soil by virtue of more root length and volume (Yellamanda and Kuladaivelu,1992). In this concerns Fageria *et al.(2010)* , stated that the availability of N decreased with the increase in soil water stress, and the increase in availability of N under submergence might be due to accumulation of NH_4^+-N under reduced conditions. They also reported that under submerged conditions due to high accumulation of NH_4^+, gentrification and leaching losses as well as bacterial immobilization were minimum resulting in high N-availability but under water stress conditions, change of NH_4^+-N accumulation, as a result of nitrification to nitrate, was minimum, confirm these results, Yellamanda and Kuladavivelu,(1992) and Valizadeh Fard *et al*.(2012) , who stated that submergence maintained highest values of availability of all nutrients whereas water stress reduced their availability (N, P and K). They added that grain N,P,K, Fe and Mn content were greater under continuous flooded conditions than other soil moisture (alternately flooded and dried or maintained at field capacity). The increases in P absorption by rice plants is expected from increase in the solubility of native phosphate and increased rate of diffusion of P to absorbing roots in the continuous flooded conditions (Willet,1991) .

Furthermore, the increase in the availability and uptake of K under higher moisture (submergence) might be due to partly displacement of it into soil solution by Fe^{+2} and Mn^{+2}, came to the same conclusion Valizadeh Fard *et al*.(2012) , who stated that flooding a soil increased the K concentration in the soil solution as a result of an exchange reaction due to increase in Fe^{+2} and Mn^{+2}. Moreover, the increase of Fe and Mn uptake under soil moisture M1 may be due to the reduction of Fe(III) and Mn (III and IV) compounds to Fe II and Mn II compounds under higher moisture regime of M1. The above obtained results were confirmed by the findings of kundu *et al.(2000)* .

Effect of different soils:

Results presented in Tables (5-9) indicate that regardless of soil moisture regimes, soil differ in texture and fertility levels significantly affected N, P, K, Fe and Mn uptake by roots, straw and grains of rice plants. The highest uptake of N,K, Fe and Mn were found by growing rice plants on Damietta clayey soil (L1), followed by Kafr El-Sheikh clayey soils (L2), Sakha clay loam soil (L3), El-Kanater clay loam soil (L4), El-Katiba silty loam soil (L5), El-Gaf'aria sandy loam soil (L6), Abo El-Matameer calcareous sandy loam (L7) and Janaklies calcareous loamy sand (L8) in decreasing order. These results show that the mentioned nutrients uptake took the same trend of clay%, O.M% and initial nutrients concentration in different soils (see Tables 1&2). This mean that N,K, Fe and Mn uptake by rice plants depend on soil texture fertility and chemical composition which play an important role in nutrients, leaching through the soils under root zone and the uptake of these nutrients by growing crops(Kundu *et al.,*2000) . Concerning the higher nitrogen uptake by different rice parts in the Damietta clayey soil than the other coarse texture may be due to NH_4 fixation by the soils having higher clay content. Zhang *et al*. (2000) , stated that after flooding ammonification was favored, providing NH_4^+ for fixation by clay minerals. NH_4^+ fixation was more pronounced under redox potential (Eh) conditions. The lowest N uptake by the different parts of rice plants grown on coarse texture soils (L5 and L6) as well as coarse calcareous soils (L7 and L8) may be due to the characterization of soil porous which has high infiltration, low moisture retention, low clay content and poor fertility due to limitation of organic matter and nitrogen content (Aulakh and Singh, 1996).

Table 5. Nitrogen uptake (mg/pot) by different parts of rice plants grown on different soils as affected by soil moisture regimes.

Soils location	Roots			Mean of soils location	Straw			Mean of soils location	Grains			Mean of soil location
	Soil moisture regimes				Soil moisture regimes				Soil moisture regimes			
	M1	M2	M3		M1	M2	M3		M1	M2	M3	
L1 Damietta	119.51	114.16	112.71	115.46	306.60	259.67	192.20	252.82	756.97	660.00	507.60	641.52
L2 Kafr El-Sheick	101.85	100.43	95.28	99.19	275.93	235.20	165.20	225.44	619.20	530.10	430.86	526.72
L3 Sakha	90.26	83.38	74.80	82.81	258.78	209.39	143.10	203.76	568.52	490.05	371.30	476.62
L4 El-Kanater	72.75	63.03	56.60	64.13	231.00	192.20	127.40	183.53	520.80	457.60	334.13	437.51
L5 El-Katiba	44.51	40.25	35.20	39.99	147.90	119.60	70.78	112.76	351.00	288.00	176.00	271.76
L6 El-Ga'faria	34.00	32.20	25.20	30.47	121.13	95.15	59.50	91.93	304.78	241.23	140.88	228.96
L7 Abo El-Matameer	18.20	17.63	14.70	16.84	70.20	55.50	31.90	52.53	175.53	129.29	68.97	124.60
L8 Janaklies	13.00	12.42	11.07	12.16	58.80	47.95	26.75	44.50	150.97	111.02	60.19	107.39
Mean of S.M.R.	61.76	57.94	53.20	57.63	183.79	151.83	102.10	145.91	430.97	363.41	261.24	351.87
L.S.D for S.M.R at	5% : 3.767		1% : 5.021		5% : 4.791		1% : 6.385		5% : 7.504		1% : 10.001	
L.S.D for soils location at	5% : 2.307		1% : 3.074		5% : 2.934		1% : 3.910		5% : 9.595		1% : 6.124	
L.S.D for (M x L) at	5% : 6.525		1% : 8.696		5% : 8.298		1% : 11.059		5% : 12.998		1% : 17.322	

Table 6. Potassium uptake (mg/pot) by different parts of rice plants grown on different soils as affected by soil moisture regimes.

Soils location	Roots dry weight			Mean of soils location	Roots volume			Mean of soils location	Tillers number			Mean of soil location
	Soil moisture regimes				Soil moisture regimes				Soil moisture regimes			
	M1	M2	M3		M1	M2	M3		M1	M2	M3	
L1 Damietta	103.79	100.57	99.45	101.27	1124.20	919.36	694.40	912.65	230.94	198.00	151.20	193.38
L2 Kafr El-Sheick	87.30	84.98	81.39	84.56	983.00	819.84	578.20	793.68	210.53	171.00	125.25	168.93
L3 Sakha	76.58	71.80	66.30	71.56	905.73	729.68	492.90	709.44	187.55	157.91	112.80	152.75
L4 El-Kanater	65.48	57.30	52.36	58.38	844.80	682.00	431.20	652.67	173.60	145.60	98.01	139.07
L5 El-Katiba	40.64	38.64	31.90	37.06	499.80	381.8	219.78	367.13	117.00	92.00	54.40	87.80
L6 El-Ga'faria	30.60	28.00	22.50	27.03	440.90	315.73	185.50	314.04	87.68	69.45	40.75	65.96
L7 Abo El-Matameer	19.60	18.80	16.71	18.37	312.00	240.5	133.4	228.63	53.55	40.56	19.97	38.03
L8 Janaklies	16.90	15.53	11.69	14.71	275.63	198.65	109.68	194.65	46.67	32.38	16.72	31.92
Mean of S.M.R.	55.11	51.95	47.79	51.62	673.26	535.95	355.63	521.20	138.44	113.36	77.39	109.73
L.S.D for S.M.R at	5% : 2.452		1% : 3.268		5% : 17.881		1% : 23.830		5% : 4.669		1% : 6.223	
L.S.D for soils location at	5% : 1.502		1% : 2.001		5% : 10.950		1% : 14.593		5% : 2.859		1% : 3.811	
L.S.D for (M x L) at	5% : 4.247		1% : 5.660		5% : 30.971		1% : 41.274		5% : 8.088		1% : 10.778	

S.M.R : Soil moisture regimes *M : Moisture regimes* *L : Soil location*

Data in Table (7) show that P uptake by roots of rice grown on the soils L1-L6 took the same trend of the other nutrient (N,K, Fe and Mn). The highest P uptake by straw and grains were obtained in rice plants grown on El-Ga'faria sandy loam soil (L6) followed by El-Kanater clay loam soil (L4), Sakha clay loam soil (L3), El-Katiba silty loam soil (L5), Kafr El-Sheikh clayey soil (L2) and Damietta clayey soil (L1) in decreasing order. These result are in good agreement with these found by Phongpan, (1989). Results, also show that there was no significantly differences between P uptake by roots of rice grown on calcareous soil of Abo El-Matameer (L7) and those obtained by growing rice plants on Janaklies calcareous soil (L8). While P uptake by straw and grains of rice plants grown on Abo El-Matameer (L7) was significantly higher than those of rice plants grown on Janaklies calcareous soil (L8).

Results in Tables (5 and 7) show that the highest N and P uptake by the different rice parts were obtained in grain followed by straw and roots in decreasing order, while K uptake was higher in straw followed by grains and roots in decreasing order. Moreover, results show that the highest Fe (Table 8), uptake was in roots followed by straw and grains, while for Mn (Table 9) uptake was higher in straw followed by roots and grains in decreasing order.

Effect of the interaction between soil:
Moisture regimes and different soil:

Results presented in Tables (5,6,8 and 9) indicate that the interaction between the used soils and soil moisture regimes significantly affected N,K, Fe and Mn uptake by roots, straw and grains of rice plants. Data show that the higher N,K, Fe and Mn were found when rice plants grown on Damietta clayey soil (L1) and using soil moisture regime of M1 (L_1M_1). The lowest values of the mentioned nutrients were obtained when rice plants grown on Janaklies loamy sand (L8) and using the soil moisture regime of M3(L_8M_3). The other values of the combined effect of different soils and soil moisture regimes were found in between the highest and the lowest values.

Table 7. Phosphorus uptake (mg/pot) by different parts of rice plants grown on different soils as affected by soil moisture regimes.

Soils location	Roots			Mean of soils location	Straw			Mean of soils location	Grains			Mean of soil location
	Soil moisture regimes				Soil moisture regimes				Soil moisture regimes			
	M1	M2	M3		M1	M2	M3		M1	M2	M3	
L1 Damietta	34.91	32.62	32.27	33.27	65.70	49.13	31.00	48.61	89.81	60.00	42.12	63.98
L2 Kafr El-Sheick	29.97	28.58	26.80	28.45	70.75	53.76	35.40	53.30	92.88	62.70	44.59	66.72
L3 Sakha	25.98	23.85	21.76	23.86	74.91	57.11	37.10	56.37	99.64	81.68	61.10	80.81
L4 El-Kanater	21.83	18.72	16.98	19.18	78.54	62.00	44.10	61.55	106.40	88.40	62.37	85.72
L5 El-Katiba	16.06	14.33	12.10	14.16	66.81	55.20	37.25	53.09	94.50	80.00	54.40	76.30
L6 El-Ga'faria	9.69	8.82	6.84	8.45	81.40	64.87	49.00	65.09	116.90	98.69	71.88	95.82
L7 Abo El-Matameer	8.68	7.99	6.17	7.61	60.84	51.80	37.70	50.11	80.33	65.91	41.75	62.66
L8 Janaklies	9.23	8.07	5.97	7.76	52.55	44.53	32.10	43.06	68.63	53.20	33.34	51.72
Mean of S.M.R.	19.54	17.87	16.11	17.84	68.94	54.8	37.96	53.90	93.64	73.82	51.44	72.97
L.S.D for S.M.R at	5% : 1.465		1% : 1.952		5% : 1.984		1% : 2.643		5% : 2.773		1% : 3.695	
L.S.D for soils location at	5% : 0.897		1% : 1.195		5% : 1.215		1% : 1.619		5% : 1.698		1% : 2.263	
L.S.D for (M x L) at	5% : 2.537		1% : 3.381		5% : 3.436		1% : 4.579		5% : 4.802		1% : 6.400	

Generally, data in Tables 5,6,8 and 9 show that the application of soil moisture regime as well as the different soil to grow rice plants both individually and collectivity had a positive effect on the N,K, Fe and Mn uptake by rice plants. This ideating thereby, that the application of soil moisture regime of M1 in Damietta soil might prove useful in increasing the uptake of rice plants at harvest stage of growth, while using the treatment M_3L_8 significantly lower concentration and uptake of the mentioned elements (N,K, Fe and Mn) by rice plants. In this concern, Larson *et al*.(1991) , found that flooding calcareous soils, increased the availability of cation such as NH_4^+, Ca^{++}, Mg^{++}, K^+, Fe^{++} and Mn^{++} in the solution phase. The increased solubility of Ca, Mg, K was attributed to increase competition between camions for the negatively charged sites due to increased levels of Fe and Mn under reducing conditions. (Kundu *et al.,* 2000) , found that uptake of N,K, Fe and Mn in straw and grains in sandy loam soil were lowest under flooded and highest under the moist regime.

Table 8. Iron uptake (mg/pot) by different parts of rice plants grown on different soils as affected by soil moisture regimes.

Soils location	Roots			Mean of soils location	Straw			Mean of soils location	Grains			Mean of soil location
	Soil moisture regimes				Soil moisture regimes				Soil moisture regimes			
	M1	M2	M3		M1	M2	M3		M1	M2	M3	
L1 Damietta	40.89	38.60	34.03	37.84	13.51	11.44	8.25	11.07	6.74	5.64	3.67	5.34
L2 Kafr El-Sheick	36.33	35.10	29.38	33.57	12.52	10.42	7.26	10.07	6.13	4.85	3.16	4.71
L3 Sakha	32.82	30.69	24.40	29.30	11.65	9.58	6.10	9.11	5.33	4.30	2.77	4.13
L4 El-Kanater	27.89	24.45	19.74	24.03	10.89	8.93	5.29	8.37	4.65	3.85	2.23	3.58
L5 El-Katiba	19.54	17.31	13.00	16.62	6.38	4.88	2.91	4.72	2.93	2.08	0.99	2.00
L6 El-Ga'faria	14.88	13.44	9.50	12.61	4.60	3.33	1.93	3.29	2.17	1.39	0.60	1.39
L7 Abo El-Matameer	9.94	8.93	6.87	8.58	2.46	1.74	0.93	1.71	1.28	0.51	0.24	0.68
L8 Janaklies	8.65	7.47	5.37	7.16	1.95	1.34	0.64	1.31	1.07	0.32	0.17	0.52
Mean of S.M.R.	23.86	22.00	17.79	21.21	8.00	6.46	4.16	6.21	3.79	2.87	1.73	2.80
L.S.D for S.M.R at	5% : 1.086		1% : 1.448		5% : 0.098		1% : 0.131		5% : 0.750		1% : 0.563	
L.S.D for soils location at	5% : 0.665		1% : 0.887		5% : 0.060		1% : 0.080		5% : 0.345		1% : 0.460	
L.S.D for (M x L) at	5% : 1.882		1% : 2.508		5% : 0.170		1% : 0.227		5% : 0.975		1% : 1.300	

S.M.R : Soil moisture regimes *M : Moisture regimes* *L : Soil location*

The obtained results mean that the highest values of N,K, Fe and Mn uptake were found under the higher soil fertility and good structure in combination with higher soil moisture regime (M_1L_1). While the lowest values were found when rice grown on the calcareous loamy sand soil which is poor in texture and soil fertility in combination with the lowest soil moisture regime (M_3L_8).

Data presented in Table (7) indicate that the interaction between soil moisture regimes and different soil significantly affected P uptake by roots, straw and grains of rice plants grown on different soils and treated with three soil moisture regimes (M_1,M_2 and M_3). The highest P uptake by roots were found by using the treatment M_1L_1, while the lowest values were found under the treatment M_3L_8. In this concern, Saleque *et al*.(1996), stated that soil and moisture interaction showed that the mean available P was increased by moisture regime of continuous waterlogged (CWL) over alternate wetting and drying in all the soil samples but the effect was significant only in two soils, where the initial soil P was relatively higher than that of other samples. The decrease in redox potential of waterlogged soil Sah *et al*.(1989), might caused transformation of several chemical species and reversal of these processes after drying would have increased chemical reactivity of soil minerals with P Sah and Mikkelsen,(1986), which increased eventually P sorption in alternate wetting and drying treatments. This phenomenon may be responsible for the low available P status in alternate wetting and drying conditions.

Table 9. Manganese uptake (mg/pot) by different parts of rice plants grown on different soils as affected by soil moisture regimes.

Soils location	Roots			Mean of soils location	Straw			Mean of soils location	Grains			Mean of soil location
	Soil moisture regimes				Soil moisture regimes				Soil moisture regimes			
	M1	M2	M3		M1	M2	M3		M1	M2	M3	
L1 Damietta	4.65	4.48	4.38	4.50	7.15	6.04	3.97	5.72	3.14	2.46	1.57	2.39
L2 Kafr El-Sheick	3.96	3.86	3.53	3.78	6.23	5.04	3.30	4.86	2.54	1.88	1.10	1.84
L3 Sakha	3.36	3.22	2.77	3.12	5.65	4.38	2.49	4.17	2.11	1.52	0.94	1.52
L4 El-Kanater	2.79	2.44	2.14	2.46	5.15	4.53	2.06	3.91	1.79	1.35	0.76	1.30
L5 El-Katiba	1.53	1.42	1.19	1.38	3.11	2.21	1.01	2.11	1.04	0.72	0.35	0.70
L6 El-Ga'faria	1.11	1.06	0.89	1.02	2.28	1.56	0.70	1.51	0.75	0.55	0.26	0.52
L7 Abo El-Matameer	0.55	0.53	0.44	0.51	1.37	0.96	0.38	0.90	0.42	0.20	0.09	0.24
L8 Janaklies	0.40	0.37	0.31	0.36	1.03	0.69	0.27	0.66	0.30	0.14	0.07	0.17
Mean of S.M.R.	2.29	2.17	1.96	2.14	4.00	3.18	1.77	2.98	1.51	1.10	0.64	1.08
L.S.D for S.M.R at	5% : 0.027		1% : 0.036		5% : 0.041		1% : 0.054		5% : 0.038		1% : 0.051	
L.S.D for soils location at	5% : 0.016		1% : 0.022		5% : 0.025		1% : 0.033		5% : 0.024		1% : 0.031	
L.S.D for (M x L) at	5% : 0.046		1% : 0.062		5% : 0.070		1% : 0.094		5% : 0.067		1% : 0.089	

S.M.R : Soil moisture regimes M : Moisture regimes L : Soil location

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