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Effect of fertilizers treatments and soil moisture regimes on Rice Plants (*Oryza sativa* L.) Macro Nutrients by different rice parts of two varieties at harvest.

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Abstract: A pot experiment was conducted using El kanater clay loam soil to study the influence of soil moisture regimes and different fertilizer treatments on yield of two rice varieties and macro nutrients content.

The obtained results can be summarized in the following:

Yield of rice plants were highly significantly increased by using soil moisture regime of (M1) followed by M2 and M3 in decreasing order.

Soil moisture regimes significantly affected the uptake of N, Pand K by the different rice parts (roots, straw and grains) of the two rice varieties (Giza 176 and Sakha 102). Nitrogen, P and K uptake by rice plants grown on soil kept at submergence (M1) were significantly higher than those in plants grown under soil moisture regimes of M2 and M3.

Also, results indicated that all the used fertilizer treatments i.e. inorganic fertilizer (F1 and F2) organic fertilizer (F4) and their combination (F3) significantly increased grain yield, the total uptake of N, P and K by different rice part (roots, straw and grains) as compared with those obtained under non fertilized treatment (F0).

Inorganic fertilizers (F1 and F2) treatments significantly increased the grain, straw and root yield, concentration and the total uptake of N, P and K as compared with those obtained by using the organic fertilizer treatment (F4).

The highest values of the yield of the two rice varieties, concentration and the total uptake of N, P and K were obtained by using the fertilizer treatment of F3 (organic and inorganic in combination) followed by the two rates of inorganic fertilizer treatments (F2 and F1) and F4 (organic fertilizer alone) in descending order.

The interaction between soil moisture regimes and fertilizer treatments significantly affected the yield of rice plants, concentrations and the total uptake of N, P and K by the two rice varieties. The highest concentration and uptake values were obtained under soil moisture regime of M1 and using fertilizer treatment of F3 (M1F3), while the lowest values were obtained under soil moisture regimes of M3 and without fertilizers (M3 F0).

Key words : Organic and Inorganic fertilizers, Soil moisture, Macro, Rice varieties, Yield, Nitrogen.

Introduction:

In order to enhance rice productivity under water-deficient conditions, it is essential to improve nitrogen (N) uptake ability or its use efficiency, a significant interactive effect on the amount of aboveground N uptake between cultivars and soil moisture regimes was observed[1].

A meliorate soil, water and fertilizer management are considered the most important factors in rice production. Nitrogen is frequently the most limiting nutrient in rice production. It is usually low in most areas under arid conditions[2].

[3]found that, with the cost of chemical fertilizers as agriculture al inputs, chiocken manure produced the highest uptake of the essential nutrients, Also, found that mixing chicken manure with could low the C/N Ratio and pointed out that N, P, K, Ca and Mg of soil ware increased by application of chicken manure.

Urea plus FYM treatment recorded maximum grain yield of wheat. Agronomic efficiency (AE) of N in rice doubled in saturated moisture regime compared to intermittent wetting and drying with application of urea. When a part of N was provided through FYM, this increase was 25% [4].

The balanced application of mineral fertilizers and farm yard manure is very important to protect soil and underground water from potential NO_3^- N pollution while sustaining high productivity in the oasis agro-ecosystem[5]. This research was conducted to study the effects of organic and inorganic nitrogen fertilizers as well as soil moisture on macronutrients.

Materials and Methods:

Pot experiment was conducted in the greenhouse of NRC, Dokki, Giza, Egypt, to study the influence of different moisture regimes and fertilizer treatment on macro nutrients and yield of rice plants.

Soil samples at a depth of (0-03cm) from the surface layer of clay loam soil has a pH of 7.96; 1.8% O.M; 2.7% CaCo3; 26.7% sand, 39.6% silt and 33.7% clay. A total of 45 plastic post, contain air dried soil were arranged in a complete randomize design.

The irrigation treatments were used as follow: M1, M2 and M3, watering at every 4, 6 and 8 days irrigation interval respectively, and the fertilizer treatment were:

F0: control (11. 56kg N+ 3.75 kg P2O5 + 13 kg K2O/fed).
F1: (46 kg N+ 15 kg P2O5 + 52 kg k2O/fed).
F2: (69kg N+ 15 kg P2O5 + 52 kg K2O/fed).
F3: (23 kg N+ 15 kg P0O5 + 52 kg K2O/fed + 1.5 ton chicken manure).
F4: (3 ton chicken manure).

Table 1: some properties of the organic composts used in the experiments:

Compost	*pH (1:10)*	*Ec ds/ᵐ*	*C/N*	*N P K %*			*Fe Mn Zn (ppm)*		
Chicken manure	6.43	3.00	19.8	2.20	00.70	2.20	176.6	170.00	48.00

Urea (46% N), superphosphate (15.5% P2O5) and potassium sulphate (48% K2O) were the sources of nitrogen, phosphorus and potassium, respectively. The chicken manure properties was as table (1). Four weeks old seedling of Sakha 102 and Giza 176 were transplanted at rate of 9 plants per pot containing different treatment. Each treatment was replicated thrice, the numbers of tillers were recorded and the plants were finally harvested at maturity. Root volume, root weight, grain and straw yields were also recorded. Straw and grains were oven dried at 70ºC and ground samples of straw and grains were digested with concentrated sulphuric acid and hydrogen peroxide then the total N, P and K were determent.

Rice grains and straw yield of the two varieties obtained from each pot was separately determined and chemically analyzed (determination was carried out as described by[6,7]. Statistical analysis were performed using the least significant difference L.S.D) method at 1% and 5% according to[8].

Results and discussion:

Rice is unique among cereal crops because all varieties are able to grow under water. Higher yields are generally obtained when rice fields are submerged. One of the main reasons for this is due to its ability to grow under partial anaerobic conditions.

The flooded soils in which rice grows serve as a source of nutrient supply in forms conditioned by oxidation-reduction potential. In fact, submerged soils are characterized by low or negative redox potential which greatly influences this supply. Consequently, the soil nutrients availability is highly affected by its moisture content and fertilizer treatments.

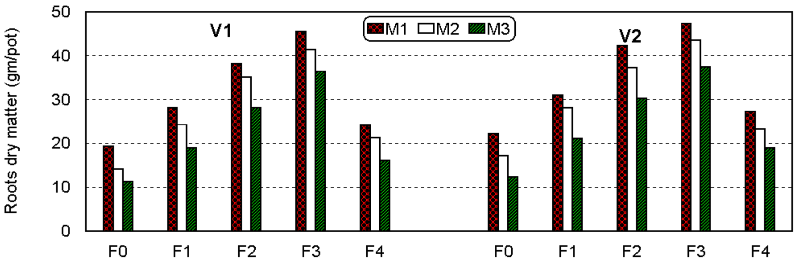

Fig. (1): Roots dry matter (gm/pot) at harvest of two rice varieties as influnced by fertilizer treatments and soil moisture regimes.

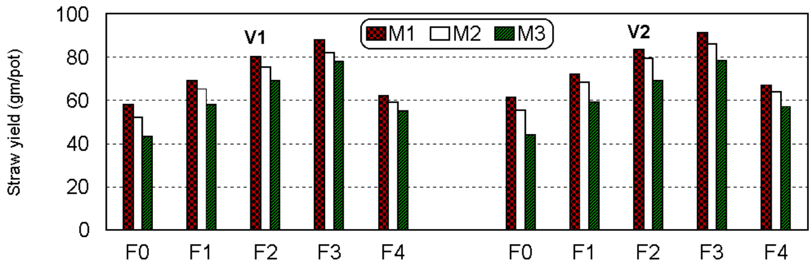

Fig. (2): Straw yield (gm/pot) of two rice varieties at harvest as influnced by fertilizer treatments and soil moisture regimes.

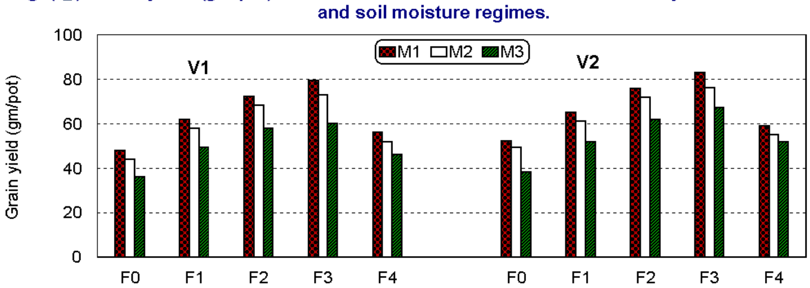

Fig. (3): Grain yield (gm/pot) of two rice varieties at harvest as influnced by fertilizer treatments and soil moisture regimes.

Effect on Nitrogen:

The results shown in Tables (2-7) and illustrated in Figs. (1-6) present the growth yield at the harvest time concentration and total uptake of N, P and K in the roots, straw and grains of two rice varieties as affected by soil moisture regimes and fertilizer treatments. Tables (2&3) and Fig. (1-4) illustrate the growth yield concentration and uptake of nitrogen in different rice parts of two varieties at harvest as affected by different fertilizer treatments and soil moisture regimes M1, M2 and M3.

Effect of soil moisture regimes:

The results indicate that the soil moisture regimes significantly affected yield and concentration and uptake of nitrogen by the different rice parts (roots, straw and grains) for the two rice varieties (Giza 176 and

Sakha 102). Nitrogen uptake of rice plants grown on soil kept at submergence (M1) were significantly higher than those in plants grown under soil moisture regimes of M2 and M3. However, data show lower nitrogen concentration in the roots of rice plants grown under soil moisture regime of M1 followed by M2 and M3 in descending order. Generally, the soil moisture regime M1 gave the highest values of concentration and uptake of nitrogen in roots, straw and grains followed by M2 and M3 in decreasing order.

Table (2): Nitrogen concentration (%) in different rice parts of two varieties at harvest as affected by different fertilizer treatments and soil moisture regimes (M_1, M_2,M_3).

Treatments	**Roots**			**Mean of fertilizer**	**Straw**			**Mean of fertilizer**	**Grains**			**Mean of fertilizer**
	Soil moisture regimes				**Soil moisture regimes**				**Soil moisture regimes**			
	M_1	**M_2**	**M_3**		**M_1**	**M_2**	**M_3**		**M_1**	**M_2**	**M_3**	
First variety (Giza 176)												
F_0	0.27	0.29	0.33	**0.30**	0.33	0.30	0.25	**0.29**	0.84	0.81	0.78	**0.81**
F_1	0.33	0.35	0.38	**0.35**	0.40	0.38	0.35	**0.38**	1.10	0.92	0.86	**0.96**
F_2	0.36	0.38	0.43	**0.39**	0.46	0.43	0.40	**0.43**	1.29	1.19	0.98	**1.15**
F_3	0.44	0.47	0.51	**0.47**	0.52	0.49	0.45	**0.49**	1.49	1.38	1.28	**1.38**
F_4	0.31	0.33	0.36	**0.33**	0.38	0.35	0.31	**0.35**	0.98	0.86	0.82	**0.89**
Mean of S.M.R.	**0.34**	**0.36**	**0.40**	**0.37**	**0.42**	**0.39**	**0.35**	**0.39**	**1.14**	**1.03**	**0.94**	**1.04**
L.S.D. for S.M.R. at	5% : 0.008		1%: 0.01		5%: 0.010		1%: 0.01		5% 0.018		1% 0.02	
L.S.D. for fertilizer at	5% : 0.006		1%: 0.01		5%: 0.008		1%: 0.01		5% 0.014		1% 0.02	
L.S.D. for (M × F) at	5% : 0.013		1%: 0.02		5%: 0.018		1%: 0.02		5% 0.032		1% 0.04	
Second variety (Sakha 102)												
F_0	0.30	0.33	0.37	**0.33**	0.37	0.34	0.28	**0.33**	0.91	0.88	0.84	**0.88**
F_1	0.36	0.38	0.41	**0.38**	0.44	0.41	0.39	**0.41**	1.22	1.08	0.92	**1.07**
F_2	0.40	0.42	0.45	**0.42**	0.49	0.46	0.44	**0.46**	1.36	1.27	1.12	**1.25**
F_3	0.47	0.49	0.54	**0.50**	0.56	0.53	0.50	**0.53**	1.55	1.45	1.32	**1.44**
F_4	0.33	0.35	0.38	**0.35**	0.41	0.38	0.36	**0.38**	1.10	0.98	0.89	**0.99**
Mean of S.M.R.	0.37	**0.39**	**0.43**	**0.40**	**0.45**	**0.42**	**0.39**	**0.42**	**1.23**	**1.13**	**1.02**	**1.13**
L.S.D. for S.M.R. at	5% : 0.011		1%: 0.02		5%: 0.010		1%: 0.01		5%: 0.024		1%: 0.03	
L.S.D. for fertilizer at	5% : 0.009		1%: 0.01		5%: 0.008		1%: 0.01		5%: 0.019		1%: 0.03	
L.S.D. for (M × F) at	5% : 0.020		1%: 0.03		5%: 0.018		1%: 0.02		5%: 0.042		1%: 0.06	
L.S.D. for (1^{st} × 2^{nd}) varieties at	**5%: 0.004**		**1%: 0.006**		**5%: 0.004**		**1%: 0.006**		**5%: 0.009**		**1%: 0.013**	

Table (3): Nitrogen uptake (mg/pot) by different rice parts of two varieties at harvest as affected by different fertilizer treatments and soil moisture regimes.

Treatments	Roots			Mean of fertilizer	Straw			Mean of fertilizer	Grains			Mean of fertilizer
	Soil moisture regimes				Soil moisture regimes				Soil moisture regimes			
	M_1	M_2	M_3		M_1	M_2	M_3		M_1	M_2	M_3	
First variety (Giza 176)												
F_0	51.89	40.60	36.80	**43.10**	191.40	156.00	107.50	**151.63**	403.20	357.29	281.74	**347.41**
F_1	92.80	84.77	72.20	**83.26**	276.40	247.57	203.35	**242.44**	682.00	533.60	423.64	**546.41**
F_2	137.45	133.46	120.83	**130.58**	368.97	323.27	276.00	**322.75**	930.09	810.99	568.40	**769.83**
F_3	199.98	194.49	185.64	**193.37**	457.60	401.80	351.00	**403.47**	1180.83	1008.92	768.00	**985.92**
F_4	74.80	70.22	57.60	**67.54**	235.98	207.30	170.87	**204.72**	548.80	447.20	379.50	**458.5**
Mean of S.M.R.	**111.38**	**104.71**	**94.61**	**103.57**	**306.07**	**267.19**	**221.74**	**265**	**748.98**	**631.6**	**484.26**	**621.61**
L.S.D. for S.M.R. at	5%: 5.106			1%: 6.89	5%:5.055		1%: 6.82		5% 5.725			1% 7.72
L.S.D. for fertilizer at	5%: 3.955			1%: 5.34	5% 3.915		1% 5.28		5% 4.435			1% 5.98
L.S.D. for (M × F) at	5%L 8.843			1%: 11.93	5% 8.755		1% 11.81		5% 9.916			1% 13.38
Second variety (Sakha 102)												
F_0	66.51	56.43	45.70	**56.21**	226.44	187.61	123.20	**179.08**	474.11	433.66	20.04	**409.27**
F_1	109.01	106.97	86.72	**100.9**	316.80	279.21	230.61	**275.54**	795.68	660.20	78.40	**644.76**
F_2	168.60	155.90	135.68	**153.39**	408.27	364.41	304.13	**358.94**	1033.60	914.40	94.40	**814.13**
F_3	221.75	212.16	202.28	**212.06**	509.60	455.80	390.75	**452.05**	1288.05	1104.18	85.98	**1092.74**
F_4	89.69	81.27	72.2	**81.05**	274.00	243.20	205.20	**240.8**	650.01	540.46	62.80	**551.09**
Mean of S.M.R.	**131.11**	**122.55**	**108.52**	**120.72**	**347.02**	**306.05**	**250.78**	**301.28**	**848.29**	**730.58**	**568.32**	**702.40**
L.S.D. for S.M.R. at	5% : 4.356		1%: 5.88		5%: 5.382		1%: 7.26		5%: 9.070		1%: 12.24	
L.S.D. for fertilizer at	5% : 3.374		1%: 4.55		5%: 12.387		1%: 16.71		5%: 7.025		1%: 9.48	
L.S.D. for (M × F) at	5% : 7.545		1%: 10.18		5%: 9.321		1%: 12.58		5%: 15.709		1%: 21.19	
LS.D. for (1^{st}×2^{nd}) varieties at	**5%: 2.031**		**1%: 2.079**		**5%: 2.283**		**1%: 3.045**		**5%: 3.284**		**1%: 4.380**	

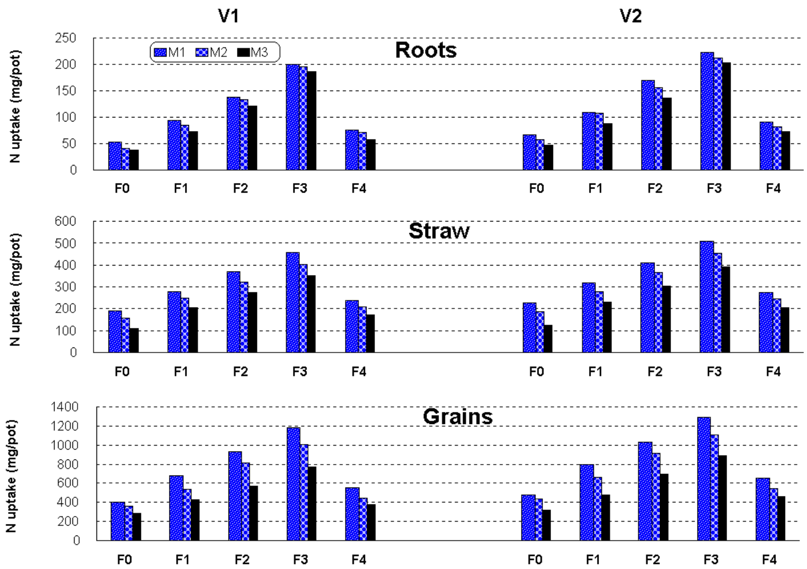

Fig. (4) : Nitrogen uptake (mg/pot) by different rice parts of two varieties at harvest as affected by different fertilizer treatments and soil moisture regimes (M1, M2 and M3).

[9,10]stated that soil moisture regime significant affected concentration and uptake of nitrogen. The significant lower N. concentration in the rice roots under M1 may be explained by its vigorus growth, which diluted the nitrogen in the tissue. Results show that the concentration and uptake of nitrogen were higher in Sakha 102 plants as compared with Giza 176. Also the highest nitrogen concentration and uptake were obtained in grains followed by straw and roots in decreasing order. In accordance with the obtained results, These results agreement with these by [11,12]stated that the higher nutrient content in rice plants under soil moisture M1 than the other two soil moisture regimes M2 and M3 may be due to higher mobility of inorganic nitrogen in soil solution and hence facilitated absorption by plant roots, whereas under M2 and M3 increased moisture stress might have resulted the plant roots to spend more energy to extract an unit amount of N. Also nitrogen uptake increased with increasing moisture levels due to more root growth, grain yield were higher with higher moisture. The poor growth of rice under stress moisture condition was due to reduced root growth which resulted in reduced nutrient uptake.

Effect of fertilizer treatments:

Results indicate that all the used fertilizer treatments i.e. inorganic fertilizer (F1 and F2) organic fertilizer (F4) and their combination (F3) significantly increased the concentration and total uptake of nitrogen by different rice parts (roots, straw and grains) as compared with those obtained with non-fertilized treatment (F0), confirm these results by [13,14]stated that the uptake of nutrients increased with application of fertilizer at all levels compared with control (unfertilized). Fertilizer treatments of F1 and F2 significant increased the concentration and total uptake of nitrogen as compared with those obtained by using the organic fertilizer treatment (F4). This mean that inorganic fertilizer treatments alone (F1 and F2) increased significantly the concentration and the uptake of nitrogen by rice plants as compared with those obtained by using organic fertilizer alone (F4).

Data also reveal that inorganic treatment of F2 significantly increased concentration and uptake of nitrogen when compared with the inorganic treatment (F1). These results in good agreement with those obtained by [15,16]who found that nitrogen application increased nitrogen percentage in different parts of rice, and increased with increasing levels of nitrogen compared with no nitrogen treatment.

The highest values of the concentration and the uptake of nitrogen were obtained by using the fertilizer treatment of F3 (which included organic and inorganic in combination) followed by the two rates of inorganic fertilizer treatments F2, F1 and F4 (organic fertilizer alone) in descending order. This may be due to the supply of nutrient by addition of organic matter in combination with inorganic fertilizer comprised more nutrients uptake by rice plants. This may be due to its effect on the soil redox potential changes followed by increasing the availability of nutrients to the growing crops [17,18]stated that the use of green manure for growing rice plants can favorably influence the availability of several plants nutrients, improve the physical, chemical and biological condition of the soil, increase soil organic matter, increase water retention and reduce leaching losses of nutrients. Also it may be ascribed to lowering of soil redox, reducing nitrification and subsequent nitrate leaching. The obtained results are supported by findings of [19]who stated that application of inorganic fertilizer in combination with organic matter resulted in higher nutrient uptake by rice than the application of each alone.

Interaction: MXF

The two variables involved in the current investigation (soil moisture regimes and fertilizer treatments) significantly affected concentration and uptake of nitrogen in straw and grains. A positive relation occurred between the soil moisture regimes and fertilizer treatments where increasing the soil moisture regime (M1) resulted in an increases in concentration and uptake of different rice parts of the two rice varieties for nitrogen. On the other hand, an inverse relation occurred only in concentration of nitrogen in rice roots of the two varieties. This results show that the reduction in rice root growth in turn, cause low nutrients uptake, which was compensated to some extent by the addition of fertilizers, while higher moisture regime M1 gave higher root growth and then higher nutrients uptake by rice plants. [20,21,11]found that the nutrients uptake showed a positive correlation with root length and root volume with correlation coefficients more than 0.95.

Comparing the effect of treatment M1F0 with M3F1 and M3F4 on nitrogen uptake by straw and grains of the two rice varieties, data in table (2) show that M3F1 significant increased N-uptake by grains and straw as compared with M1F0, while M1F0 significant increased N-uptake by grains and straw as compared with M3F4.

These results were true for the two varieties. Furthermore, data reveal that M3F1 and M3F4 significant increased N-uptake by rice roots of the two varieties as compared with M1F0, however this effect did not reach the level of significance in the variety Giza .

Effect on Phosphorus:

Effect of soil moisture regimes:

Data in Tables (4&5) and illustrated graphically in Fig. (5) Indicate that concentration and uptake of phosphorus in roots, straw and grains of two rice varieties significantly affected by soil moisture regimes, except concentration of P in roots of the two varieties. Except concentration of P in roots of the two varieties, soil moisture regime of M1 gave the highest values of concentration and uptake of P in roots, straw-and grains followed by M2 and M3 in descending order. Concentration of P in roots took reverse trend i.e. that M1 gave the lowest P concentration followed by M2 and M3 in descending order.

The changes in soil Eh and pH with flooding play an important role in releasing nutrient to the growing plants. Continuous flooding resulted in higher uptake of P in the rice plants than non-flooding and this suggest that the P is the main factor determining the growth of rice plants, and this was strong controlled by soil water regimes. The increases in P absorption by rice plants is expected from increases in solubility of native and applied P and increased rate of diffusion of P to absorbing roots in the continuously flooded conditions[22,23]**.**

Table (4): Phosphorus concentration (%) in different rice parts of two varieties at harvest as affected by different fertilizer treatments and soil moisture regimes.

Treatments	Roots			Mean of fertilizer	Straw			Mean of fertilizer	Grains			Mean of fertilizer
	Soil moisture regimes				Soil moisture regimes				Soil moisture regimes			
	M_1	M_2	M_3		M_1	M_2	M_3		M_1	M_2	M_3	
First variety (Giza 176)												
F_0	0.078	0.09	0.10	**0.089**	0.10	0.094	0.058	**0.084**	0.170	0.160	0.13	**0.153**
F_1	0.10	0.11	0.13	**0.113**	0.12	0.11	0.10	**0.110**	0.220	0.200	0.15	**0.190**
F_2	0.11	0.12	0.14	**0.123**	0.14	0.13	0.11	**0.127**	0.250	0.230	0.18	**0.220**
F_3	0.12	0.13	0.14	**0.130**	0.16	0.15	0.13	**0.147**	0.290	0.270	0.21	**0.257**
F_4	0.088	0.095	0.11	**0.098**	0.11	0.10	0.086	**0.099**	0.190	0.180	0.17	**0.180**
Mean of S.M.R.	**0.099**	**0.109**	**0.124**	**0.111**	**0.126**	**0.117**	**0.097**	**0.113**	**0.224**	**0.208**	**0.168**	**0.200**
L.S.D. for S.M.R. at	5% : 0.005		1%: 0.01		5%: 0.003		1%: 0.01		5% 0.006		1% 0.01	
L.S.D. for fertilizer at	5% : 0.004		1%: 0.01		5%: 0.002		1%: 0.01		5% 0.004		1% 0.01	
L.S.D. for (M × F) at	5% : 0.009		1%: 0.01		5%: 0.005		1%: 0.01		5% 0.010		1% 0.01	

Second variety (Sakha 102)												
F_0	0.085	0.10	0.11	**0.10**	0.11	0.10	0.08	**0.097**	0.18	0.17	0.14	**0.163**
F_1	0.11	0.12	0.14	**0.123**	0.13	0.12	0.11	**0.120**	0.23	0.21	0.19	**0.210**
F_2	0.13	0.14	0.15	**0.140**	0.15	0.14	0.13	**0.140**	0.27	0.25	0.22	**0.247**
F_3	0.14	0.15	0.17	**0.153**	0.17	0.16	0.15	**0.160**	0.32	0.30	0.26	**[illegible]**
F_4	0.10	0.11	0.12	**0.11**	0.12	0.11	0.10	**0.110**	0.21	0.19	0.18	**0.193**
Mean of S.M.R.	**0.113**	**0.124**	**0.138**	**0.125**	**0.136**	**0.126**	**0.114**	**0.125**	**0.242**	**0.224**	**0.198**	**0.221**
L.S.D. for S.M.R. at	5% : 0.004		1%: 0.01		5%: 0.005		1%: 0.01		5%: 0.006		1%: 0.01	
L.S.D. for fertilizer at	5% : 0.003		1%: 0.01		5%: 0.004		1%: 0.01		5%: 0.005		1%: 0.01	
L.S.D. for (M × F) at	5% : 0.008		1%: 0.01		5%: 0.009		1%: 0.01		5%: 0.011		1%: 0.01	
L.S.D. for (1^{st} × 2^{nd}) varieties at	**5%: 0.002**		**1%: 0.003**		**5%: 0.002**		**1%: 0.003**		**5%: 0.003**		**1%: 0.004**	

Table (5): Phosphorus uptake (mg/pot) by different parts of two varieties at harvest as affected by different treatments and soil moisture regimes.

Treatments	Roots				Straw				Grains			
	Soil moisture regimes			Mean of fertilizer	Soil moisture regimes			Mean of fertilizer	Soil moisture regimes			Mean of fertilizer
	M_1	M_2	M_3		M_1	M_2	M_3		M_1	M_2	M_3	
First variety (Giza 176)												
F_0	14.99	12.32	11.15	**12.82**	58.00	48.88	24.94	**43.94**	81.60	70.58	46.96	**66.38**
F_1	28.12	26.64	24.70	**26.49**	82.92	71.67	58.10	**70.90**	136.40	116.00	73.89	**108.76**
F_2	42.00	42.14	39.34	**41.16**	112.29	97.73	75.90	**95.31**	180.25	156.75	104.40	**147.13**
F_3	54.54	53.79	50.96	**53.10**	140.80	123.00	101.40	**121.73**	229.83	197.40	126.00	**184.41**

F_4	21.23	20.22	19.60	**19.68**	68.31	59.15	47.40	**58.29**	106.40	93.60	78.68	**92.89**
Mean of S.M.R.	**32.18**	**31.02**	**28.75**	**30.65**	**92.46**	**80.09**	**61.55**	**78.03**	**146.90**	**126.87**	**85.99**	**119.91**
L.S.D. for S.M.R. at	5% : 1.409		1%: 1.90		5%: 2.991		1%: 4.04		5% 3.831		1% 5.17	
L.S.D. for fertilizer at	5% : 1.091		1%: 1.47		5%: 2.317		1%: 3.13		5% 2.968		1% 4.00	
L.S.D. for (M × F) at	5% : 2.44		1%: 3.29		5%: 5.181		1%: 6.99		5% 6.636		1% 8.95	
Second variety (Sakha 102)												
F_0	18.84	17.10	13.59	**16.51**	67.32	55.18	35.20	**52.57**	93.78	83.78	53.34	**76.97**
F_1	33.31	33.78	29.61	**32.23**	93.60	81.72	65.04	**80.12**	150.01	128.37	98.80	**125.73**
F_2	57.80	51.97	45.23	**50.67**	124.98	110.91	89.86	**108.58**	205.20	180.00	136.40	**173.87**
F_3	66.05	65.13	63.68	**64.95**	154.70	137.60	117.23	**136.51**	265.92	228.45	174.51	**222.96**
F_4	27.18	25.54	22.80	**25.17**	80.40	70.40	57.00	**69.27**	124.11	104.84	93.60	**107.52**
Mean of S.M.R.	**40.04**	**38.70**	**34.98**	**37.91**	**104.20**	**91.162**	**72.87**	**89.41**	**167.80**	**145.09**	**111.33**	**141.41**
L.S.D. for S.M.R. at	5% : 1.250		1%: 1.69		5%: 2.819		1%: 3.80		5%: 4.470		1%: 6.03	
L.S.D. for fertilizer at	5% : 0.968		1%: 1.31		5%: 2.184		1%: 2.95		5%: 3.463		1%: 4.67	
L.S.D. for (M × F) at	5% : 2.164		1%: 2.92		5%: 4.883		1%: 6.59		5%: 7.743		1%: 10.45	
L.S.D. for (1^{st} × 2^{nd}) varieties at	**5%: 0.615**		**1%: 0.820**		**5%: 1.344**		**1%: 1.793**		**5%: 1.784**		**1%: 2.380**	

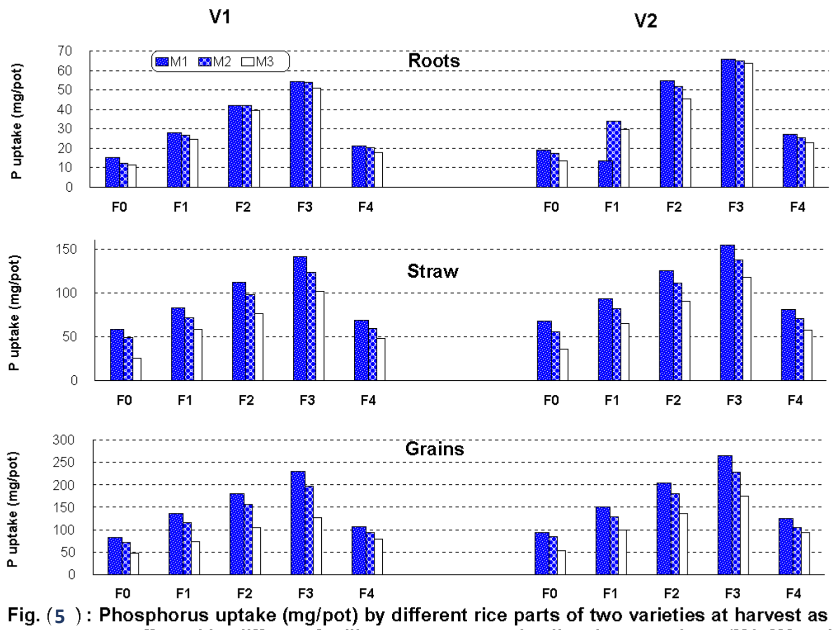

Fig. (5): Phosphorus uptake (mg/pot) by different rice parts of two varieties at harvest as affected by different fertilizer treatments and soil moisture regimes (M1, M2 and M3).

Effect of fertilizer treatments:

Data presented in Table (4&5) and illustrated in Fig. (5) show that fertilizer treatments significantly affected the concentration and uptake of P in the different parts of the two rice varieties. Results indicate that all fertilizer treatments i.e inorganic (F1 and F2), organic (F4) and their combination (F3) significant increased the concentration and uptake of P in rice plants as compared with control treatment (F0). The highest values of concentration and uptake of P were obtained by using the fertilizer treatment F3 followed by F2, F1, F4 and F0 in decreasing order. The obtained results of concentration and uptake of P took the same trend as those of concentration and uptake of N as well as the growth and yield of rice plants tables (2-6). These results are in good agreement with those obtained by [24]who stated significant positive relationship exists among the organic acid exudation, MBP, phosphatase activities and P uptake by rice. The enhanced organic acid in root exudates coupled with higher soil phosphatase activities under elevated CO_2 resulted in increased rate of soil P solubilization leading to higher plant P uptake. [25,26]who stated that uptake of P by rice was increased by application of organic matter and by increasing nitrogen rate. Data also show that the higher P content and uptake were found in grain followed by straw and roots in descending order.

Interaction: MXF

The interaction between soil moisture regimes and fertilizer treatments significantly affected the concentration and the total uptake by the two rice varieties. The highest concentration and uptake values were obtained under soil moisture regime of M1 and using fertilizer treatment of F3 and the lowest values were obtained under soil moisture regimes of M3 in combination with control treatment (F0).

Comparing the treatment M1F0 with M3F1 and M3F4 on p uptake by grains, results show that M1F0 significantly increased p uptake by grains in Giza 176 as compared with M3F1 while, M1F0 did not show any significantly effect on P uptake in grains of the two varieties as compared with M3F4 in Giza 176 and M3F1 & M3F4 in Sakha 102. In straw, M1F0 significantly increased p uptake as compared with M3F4, while this effect was not significant as compared with M3F1. These results are true for the straw of the two rice varieties. Furthermore, M3F1 and M3F4 significantly increased P. uptake in the roots of the two varieties as compared with M1F0[16].

Effect on Potassium:

Effect of soil moisture regimes:

Identification of the kind of influence of soil moisture regimes on nutrient behaviour removes are important flock of information from the realm of speculation. Regarding the effect of soil moisture regimes on K content and uptake by different parts of the two rice varieties are presented in Tables (6&7) and illustrated graphically in Fig. (6).

Potassium content in rice roots significantly increased by decreasing the soil moisture regimes from M1 to M3. On the other hand, K uptake by roots and K content and uptake by straw and grains gave the highest values by using soil moisture regime of M1 followed by M2 and M3 in descending order, confirm these results [27,28,29]who stated that K. concentration in grain were highest under submergence treatment than other soil moisture treatments, they added that K availability at all the stage of crop growth decreased with the increase in soil water stress.

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 [30,31]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[32].

Table (6): Potassium concentration (%) in different rice parts of two varieties at harvest as affected by different fertilizer treatments and soil moisture regimes.

Treatments	Roots			Mean of fertilizer	Straw			Mean of fertilizer	Grains			Mean of fertilizer
	Soil moisture regimes				Soil moisture regimes				Soil moisture regimes			
	M_1	M_2	M_3		M_1	M_2	M_3		M_1	M_2	M_3	
First variety (Giza 176)												
F_0	0.24	0.28	0.31	**0.28**	1.91	1.73	1.63	**1.76**	0.37	0.35	0.31	**0.34**
F_1	0.30	0.33	0.37	**0.33**	2.98	2.76	2.55	**2.76**	0.42	0.40	0.37	**0.40**
F_2	0.37	0.39	0.43	**0.40**	3.40	3.19	2.98	**3.19**	0.46	0.44	0.40	**0.43**
F_3	0.40	0.42	0.46	**0.43**	3.65	3.50	3.20	**3.45**	0.50	0.48	0.44	**0.47**
F_4	0.27	0.29	0.34	**0.30**	2.23	2.00	1.85	**2.03**	0.39	0.36	0.33	**0.36**
Mean of S.M.R.	**0.32**	**0.34**	**0.38**	**0.35**	**2.83**	**2.64**	**2.44**	**2.64**	**0.43**	**0.41**	**0.37**	**0.40**
L.S.D. for S.M.R. at	5% : 0.006		1%: 0.01		5%: 0.022		1%: 0.03		5% 0.006		1% 0.01	
L.S.D. for fertilizer at	5% : 0.005		1%: 0.01		5%: 0.017		1%: 0.02		5% 0.005		1% 0.01	
L.S.D. for (M × F) at	5% : 0.011		1%: 0.01		5%: 0.037		1%: 0.05		5% 0.011		1% 0.01	
0.31Second variety (Sakha 102)												
F_0	0.28	0.31	0.35	**0.31**	2.55	2.00	1.80	**2.12**	0.41	0.36	0.33	**0.37**
F_1	0.35	0.37	0.40	**0.37**	3.30	3.05	2.80	**3.05**	0.47	0.44	0.41	**0.44**
F_2	0.41	0.43	0.49	**0.44**	3.65	3.45	3.26	**3.45**	0.53	0.50	0.47	**0.50**
F_3	0.46	0.48	0.52	**0.49**	3.95	3.78	3.55	**3.76**	0.59	0.57	0.54	**0.57**
F_4	0.33	0.34	0.37	**0.35**	2.50	2.30	2.10	**2.30**	0.44	0.39	0.35	**0.39**
Mean of S.M.R.	**0.37**	**0.39**	**0.43**	**0.39**	**3.19**	**2.92**	**2.70**	**2.94**	**0.49**	**0.45**	**0.42**	**0.45**
L.S.D. for S.M.R. at	5% : 0.007		1%: 0.01		5%: 0.046		1%: 0.06		5%: 0.009		1%: 0.01	
L.S.D. for fertilizer at	5% : 0.006		1%: 0.01		5%: 0.036		1%: 0.05		5%: 0.007		1%: 0.01	
L.S.D. for (M × F) at	5% : 0.013		1%: 0.02		5%: 0.080		1%: 0.11		5%: 0.016		1%: 0.02	
L.S.D. for (1st × 2nd) varieties at	**5%: 0.003**		**1%: 0.004**		**5%: 0.018**		**1%: 0.024**		**5%: 0.003**		**1%: 0.004**	

Table (7): Potassium uptake (mg/pot) by different rice parts of two varieties at harvest as affected by different fertilizer treatments and soil moisture regimes.

Treatments	**Roots**			**Mean of fertilizer**	**Straw**			**Mean of fertilizer**	**Grains**			**Mean of fertilizer**
	Soil moisture regimes				**Soil moisture regimes**				**Soil moisture regimes**			
	M_1	**M_2**	**M_3**		**M_1**	**M_2**	**M_3**		**M_1**	**M_2**	**M_3**	
First variety (Giza 176)												
F_0	46.13	39.20	34.57	**39.97**	1107.80	899.60	700.90	**902.77**	177.60	154.39	111.97	**147.99**
F_1	84.36	79.93	70.30	**78.20**	2059.18	1798.14	1481.55	**1779.62**	260.40	232.00	182.26	**224.89**
F_2	141.27	136.97	120.83	**133.02**	2727.14	2398.24	2056.20	**2393.86**	331.66	299.86	232.00	**287.84**
F_3	181.80	173.80	167.44	**174.35**	3212.00	287.00	2496.00	**2859.33**	396.25	350.93	264.00	**337.06**
F_4	65.15	61.71	54.40	**60.42**	1384.83	1183.00	1019.72	**1195.85**	218.40	187.20	152.72	**186.11**
Mean of S.M.R.	**103.74**	**98.32**	**89.51**	**97.19**	**2098.19**	**1829.80**	**1550.87**	**1826.29**	**276.86**	**244.88**	**1188.59**	**236.78**
L.S.D. for S.M.R. at	5% : 2.297		1%: 3.10		5%: 15.502		1%: 20.91		5% 4.497		1% 6.07	
L.S.D. for fertilizer at	5%: 1.779		1%: 2.40		5%: 12.008		1%: 16.20		5%: 3.483		1%: 4.70	
L.S.D. for (M × F) at	5% : 3.978		1%: 5.37		5%: 26.850		1%: 36.22		5% 7.788		1% 10.51	
Second variety (Sakha 102)												
F_0	62.08	53.01	43.23	**52.77**	1377.00	1103.60	792.00	**1090.87**	231.61	177.41	125.73	**172.25**
F_1	105.98	104.16	84.60	**98.25**	2376.00	2077.05	1655.64	**2036.23**	306.53	268.97	213.20	**262.9**
F_2	172.82	159.62	147.74	**160.06**	3041.18	2733.09	2253.31	**2675.86**	402.80	360.00	291.40	**351.4**
F_3	217.03	208.42	194.79	**206.75**	3594.50	3250.80	2774.33	**3206.54**	490.29	434.00	362.45	**428.91**
F_4	89.69	78.95	70.30	**79.65**	1675.00	1472.00	1197.00	**1448.00**	260.04	215.20	182.00	**219.08**
Mean of S.M.R.	**129.52**	**120.83**	**108.13**	**119.49**	**2412.74**	**2127.31**	**1734.46**	**2091.5**	**334.65**	**291.12**	**234.96**	**286.91**
L.S.D. for S.M.R. at	5% : 5.736		1%: 7.740		5%: 70.701		1%: 95.38		5%: 25.494		1%: 34.39	
L.S.D. for fertilizer at	5%: 4.443		1%: 5.99		5%: 54.765		1%: 73.88		5%: 19.747		1%: 26.64	
L.S.D. for (M × F) at	5% : 9.935		1%: 13.40		5%: 122.458		1%: 165.21		5%: 44.156		1%: 59.57	
L.S.D. for ($1^{st} \times 2^{nd}$) varieties at	**5%: 1.904**		**1%: 2.539**		**5%: 22.359**		**1%: 29.828**		**5%: 7.256**		**1%: 9.680**	

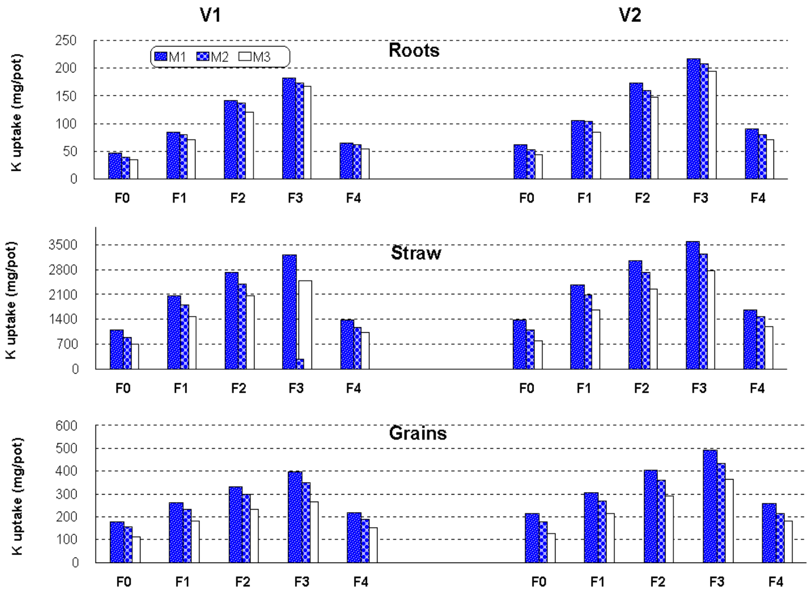

Fig. (6) : Potassium uptake (mg/pot) by different rice parts of two varieties at harvest as affected by different fertilizer treatments and soil moisture regimes (M1, M2 and M3).

Effect of fertilizer treatments:

Data of K content and uptake in different parts of the two rice varieties show that all the used fertilizer treatments significant increased the K content and uptake as compared with the control treatment. The inorganic fertilizer treatments (F1 and F2) significant increased K content and uptake in the different rice parts. (roots, straw and grains) as compared with organic fertilizer treatment (F4). Also, data show that increasing the rate of inorganic fertilizer (F2) increased significantly K content and uptake as compared with lowest inorganic fertilizer treatment (F1). These results are confirmed with those obtained by [25,33]who stated that the uptake of K by rice was increased by application of organic matter and by increasing N-rates. The highest values of K content and uptake by the different parts of the two rice varieties were obtained by using the fertilizer treatment F3 (inorganic and organic fertilizer in combination) followed by F2, F1, F4 and F0 in descending order. In this connection [34]stated that the increase in K uptake with organic matter addition alone in clay soil was nearly equivalent to the amount of K supplied by the organic matter, indicating that K supply to plants was enriched directly by organic matter addition. The increase in K uptake from organic matter addition would not explain the observed growth increases. They added that, in sandy soil the increase in K uptake with organic matter addition was much higher than the amount added from organic matter, suggesting the addition of organic matter not only enriched the soil with K but also it increased the availability of K from added fertilizer and native soil K. Data, also show that the maximum K content and uptake were obtained in straw followed by grains and roots in decreasing order.

Interaction: MX F

The interaction between the soil moisture regimes and fertilizer treatments tables (6&7) significantly affected K concentration and uptake by the different parts of the two rice varieties. Data show that the highest values of K content and uptake by straw and grains were obtained by growing rice plants under soil moisture regime of M1 and fertilized by the fertilizer treatment of F3 (organic + inorganic fertilizer), while the lowest values were obtained under soil moisture of M3 and unfertilizer treatment F0. These results were true for the two rice varieties. On the other hand, K. content in the two rice varieties roots were higher under M3F3 than those obtained under M1F0. In straw of the two varieties M3F1 increased significantly K-uptake as compared with M1F0, while M1F0 did not exert any effect in straw of variety Giza 176 as compared with M3F4 whereas K uptake of variety Sakha 102 straw M1F0 significantly increased by using M1F0 than M3F4. Concerning the k uptake by the roots of the two varieties, M3F1 and M3F4 significantly increased K uptake as compared with M1F0.

Generally, [35,36]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[37].

The better results of the submergence without fertilizer (M1F0) than those of fertilized with F4 treatment at soil moisture regime of M3 (M3F4) conditions was due to higher assimilation of N, P, K, Ca, Mg and Mn which were released more in the soil solution under the submergence (M1F0) more than M3 treatment.

Conclusion

- Soil moisture regimes and different fertilizer treatments cause a marked effect on the yield and the behavior of different nutrients in rice plants.
- The obtained information on fertilizer treatments may lead to more rational basis for the selection of the fertilizer sorts and levels to suit particular combination of soil, water management and rice varieties.
- In conclusion, we feel it is worthy to recommend for further studies of soil moisture regimes and different fertilizers (organic and inorganic) to get the best soil moisture level and fertilizers to obtain the best and the highest economically yield of rice.
- We must recommended that it is better to give rice plants organic and inorganic fertilizer in combination, and use the submergence treatment as the best soil moisture regime to obtain the highest yield of rice.

References:

1. Matsunami, M. Matsunami, T. Kon, K. Ogawa, A.Kodama, I. Kokubun, M. (2013). Genotypic variation in nitrogen uptake during early growth among rice cultivars under different soil moisture regimes. Plant Production Science; 16(3): 238-246
2. Cai X, Yang J., Ma W., Wang Hu, Xu, W. (2008). Effects of nitrogen supply levels and water schemes on rice mizosphere microbial biomass carbon in rice development stage at paddy field. Journal of Zhejiang University (Agriculture and Life Sciences); 34(6): 662-668
3. El-Ashry, S.M., S. Siam Hanan and M.R. Abd El-Moez, (2008). Ameliorative effect of organic fertiizers in the presence of Mineral fertilizers on lettuce and sorghum and their components. Australian Journal of Basic Applied Sciences, 2(4): 1246-1257
4. Pathak, H. Bhatia, A. Jain, N. (2010). Yield and and N-use efficiency in rice-wheat system with different soil moisture regimes and fertilizer management, Current advances in agricultural sciences; 2 (2): 74-76
5. Sheng-mao, Y,; Feng-min, L,.; Dong-rang, S.; Tian-wen, G.; Jian-guol, W.; Bingling, S. and Shao-ling, J. (2006). Effect of long term fertilization on soil productivity and nitrate accumulation in Gansu Oasis. Agric. Sci.In China.5: 57-67
6. Jackson, M.L. (1982). Soil Chemical Analysis. Prentice-Hall, Inc. Englewood cliffs, N.J
7. Cottenie, A., Verloo, M., Velghe, G. and Comerlynk, R. (1982). Chemical Analsysis of plant and Soils. Laboratory of Analytical and Agrochemistry state University Ghent, Belgium
8. Steel, R.G.D. and Torrie, J.H. (1980). Principles and procedures of statistic. Second edition, Mc Graw-Hill, Kogakusha, Japan, PP. 633
9. Osuma, C.F.J., De Datta, S.K. and Bonman, J.M. (1991). Nitrogen form and silicon nutrition effects on resistance to blast disease of rice. Plant and Soil, 135:223-231
10. Negrin, V., Spetter, C., Asteasuain, R. Perillo, G., Marcovecchio, J. (2011). Influence of flooding and vegetation on carbon, nitrogen, and phosphorus dynamics in the pore water of a Spartina alterniflora salt mars, Journal of Enviromental Sciences, 23(2): 212-221
11. Yellamanda, R.T. and R. Kuladaivelu, 1992. Root growth of rice (*Oryza sativa* L) as influenced by soilmoisture regimes and nitrogen. Indian J. Agron. 37 (4): 694-700
12. Tan, X. Shao, D., Gu, W., Liu H., (2015). Field analysis of water and nitrogen fate in lowland paddy fields under different water management using HYDRUS-ID. Agricultural Water Management 150(0), 67-80

13. Pande, N.C., Samantary, R.N., Mahapatra, P. and Mohanty, S.K. (1993). Effect of optimal and suboptimal nutrient management on nutrient changes, yield and nutrient uptake by rice in submerged soil. Journal of the Indian Society of Soil Science, vol. 41, No 1, pp 90-95
14. Kaleem, A.M. and K. Almas, (2012). Microbial biomass carbon and nitrogen trnasformations in a loam soil amended with organic-inorgenicNsources and their effect on growth and N-uptake in maize. Ecological Engineering, 39,123-132
15. Abou-Zeid, S.T. (1981). A study on the effect of depth of submergence and nitrogen fertilization on growth, nitrogen content and losses in leachate water in rice cultures. M. Sc. Thesis, Fac. Of Agric. Cairo Univ., Giza
16. Wang, S. Jiao, L.X. Yan, S. Jin, X. Yi, W. (2012). Effect of organic matter and submerged macrophytes on varaiations of alkaline phosphatase activity and phosphorus fractions in lake scdiment J.F. NVI Iron Mange 23:113-365
17. Tiessen, H., Cuevas, E. and Chaeon, P, (1994). The role of soil organic matter in sustaining soil fertility. Nature. 371, 783-785
18. Yao, H., Bowman, D., Rufty, T. Shi, W. (2009). Interactions between N., fertilization, grass clipping addition and pH in turf ecosystems: Implications for soil enzyme activities and organic matter decomposition, Soil Biology and Biochemistry Vol 41(7): 1425-1432
19. Bijay S., Arshujit V., Yadvinder S., Singh K. (2003). Nitrogen mineralization potential of rice-wheat soils amended with organic manures and crop residues. SAARC Journal of Agirculture, 1:117-125
20. Suduan Gao, Kenneth K. Tanji and Steven C. Scardaci (2003). Incorporating straw may induce sulfide toxicity in paddy rice (http://danr.ucop.edu/calag)
21. Bouchard, V. and Cochran, M., (2002). Wetland and carbon sequestration in Encyclopedia of Soil cience (ed. Lal, R.), Marcel Dekker, New York, pp. 1416-1419
22. Lee, C.H. Hong, C.O, Kim, S.Y. Schumacher, T. and Kim, P.J. (2011). Reduction of phosphorus release by liming from temporary flooded rice rotational system in greenhouse upland soil. Ecological Engineering, 37(8) 239: 243
23. Knowles, L. Iles, J. Lu, Y. Kobayashi, T. Wen, L. (2012). Phosphorus dynamics in an ephermeral wetland ecosystem after re-flooding. Environmental Modelling & Software, 35:11-37
24. Bhattacharyya, P. Roy, K.S. Dash, P.K., Neogi, S. Shahid, Md, Nayak, A.K. Raja, R. Karthikeyan, S. Balachandar, D. Rao, K.S. (2014). Effect of elevated carbon dioxde and temperature on phosphorus uptake in (tropical flooded rice (orzya sativa L). European Journal of Agronomy. (53): 28-37
25. Lee, K., Kang, J., Uhm, T.,Kim, J. and Kim, S. (1995). Effect of long term organic matter application on N,P and K uptake by rice in paddy soil. RDA Journal of Agricutlural Science, Soil and Feritlizer, 1995, 37: 1, 291-297
26. Schonbrunner, I.M. Preiner, S. and Hein, T. (2012). Impact of drying and re-flooding of sediment on phosphorus dynamics of river-floodplain systems. Science of the total environment, 432:329-337
27. Mukherjee, P.K. and Mandal, S.R. (1995). Influence of water dress and split application of nitrogen on changes in organic carbon and macronutrients in soils growing rice on Orthent. Journal of the Indian-Society of Soil Science, 43: No., 2, pp. 241-245
28. Narteh, L.T. and Sharawat, KL., (1999). Influence of flooding on electrochemical and chemical properties of West African Soils. Geoderma, 87, 179-207
29. Pierce, S.C., Moore, M.T. Larsen, D. Pezeshki, S.R. (2010). Macronutrient (N,P,K) and redoximorphic metal (Fe, Mn) allocation in Leersia oryzoides (rice cutgrass) grown under different flood regimes. Water, Air, and Soil Polution, 207(1/4): 73-84
30. Fraga, T.I. Genro Junior, S.A. Inda, A.V. Anghinoni, I. (2009). Potasium supply and mineralogy of lowland soils under consective croppings of flooded rice. Revisto Brasilerira de Ciencia do Solo; 3393): 497-506
31. Lu, S.G., C. Tang and Z. Rengel (2004). Combined effect of waterlogging and salinity on electrochemistry, water-soluble cations and water dispersible clay in soils with various salinity levels. Plant and Soil 264:231-245
32. Kundu, D.K., H.U. Neue and S. Ravender, 2000. Iron and potassium availability to rice in tropudalf and sulfa quest as influenced by water regime. Journal of the Indian Society of Soil Science. Vol. 48, No. 4, pp: 130-135
33. Yang C.M., Yang L.Y., Yang O.Z. (2004). Rice root growth and nutrient uptake as influenced by organic manure in continuously and alternately flooded paddy soils. Agricultural Water Management; 7(1): 67-81

34. Vang, S., Bell, R.W., Willett, F.R. and Nesbitt, H.J. (1999). Phosphorus nutrition of rice in relation to flooding and temporary loss of soil-water saturation in two lowland soils of cambodia. Plant and Soil 207: 121-132
35. Surridge, Ben W.J., A. Louis and Bairdi Andy J. (2012). Phosphorus mobilization and transport within a long-restored floodplain wetland, Ecological Engineering 44(0), 348-359
36. Valizadeh Fard, F., A. ReyhaniTabar, N. Najafi and S.H. Oustan, 2012. Effects of combined application of Cd and Zn on the growth characteristics of rice plant and zinc, cadmium, iron and manganese concentration in soil under flooded vs. no flooded conditions. J. Soil Water, 43(3): 195-205
37. Willet, I.R., 1991. Phosphorus dynamics in acid soils that undergo alternate flooding and drying. In: Rice Production acid soils of the Tropics. Eds. P. Deturck and F.N. Ponnamperuma, pp: 43-49. Institute of Fundamental Studies, Kanay, Sirilanka

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