Ameliorative Effect of Organic and Inorganic Fertilizers under Soil Moisture Regimes on Growth Parameters and Yield of Rice Plants

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Abstract: ***A pot experiment was conducted at the greenhouse of NRC, DOkki, Giza, Egypt, using clay loam soil to study the effect of different moisture regimes (M_1. M_2 and M_3) and fertilizer treatment (F_0, F_1, F_2, F_3 and F_4)on growth parameters and yield of rice plants (variety Sakha 102 and Giza 0176). The important results could be summarized in the follows:***

- **Growth parameters (plant height and number of tillers per plant) and yield of rice plants were highly significantly increased by using soil moisture regime of (M1) followed by M2 and M3 in decreasing order of the tow rice varieties (Giza 176 and Sakha 102).**
- **Results indicated that all the used fertilizer treatments i.e. inorganic fertilizer (F1 and F2), organic fertilizer (F4) and their combination (F3) significantly increased the growth parameters, straw and Grain yields of both rice varieties compared with those obtained under non fertilizer treatment (F0).**
- **Inorganic fertilizers (F1 and F2) treatment significantly increased the growth parameters and yield of rice as compared with those obtained by using the organic fertilizer treatment (F4).**
- **The highest values of the growth parameters and yield were obtained by using the fertilizer treatment of F_3 (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 all that studies the growth and yield of two varieties. The highest values of the growth parameters, straw and grain yields of rice plants were obtained under soil moisture regime of M1 and using fertilizer treatment of F3 (M1 F3) , while the lowest values were obtained under soil moisture régimes of M3 and without fertilizers (M3).**
- **Results show that shakha 102 out yielded Giza 176 variety in straw and grains yields.**

Keywords: Moisture, organic and inorganic fertilizers, soil texture, fertility levels, rice varieties.

1. Introduction

Rice is the second cash crop in Egypt. More than million feddans are cultivated annually with rice.

The production of rice consumes much more water than that of other crops. Flooding conditions require large quantities of water, which is used not only for growth of rice plants but also as a management tool during cultivation McCanley (1990).

Soil, water and fertilizer management are considered the moist important factors in rice production. Nitrogen is frequently the most limiting nutrient in rice production. It is usually low in most arias under arid conditions CaiXiaoHong Yang et al., (2008).

Optimizing soil conditions for plant growth would comprise water regime to more aeration and water requirements, and fertilization to meat nutrient requirements. Rice growing under different soil water levels prevailing under rain fed condition have largely been ignored Mukherjee and Mandal (1995).

Beside the applied fertilizer, particularly nitrogen, may also diffr. Rice growing under different soil water level prevailing under rain fed conditions have largely been ignored (Mukherjee and mandal, 1995, Michel, et al., 2004 and Sangita, et al., 2013) The benefits of organic amendments for rice production is well known. There is however, lack of sufficient information the effect of various organic materials, on the changes in the composition of soil solution nutrients in rice soil. The supplementary and complementary use of organic manures and chemical fertilizers will augment the efficiency of both substances to maintain a high level of soil productivity and rice production Lian (1994) and Yang et al., (2004).

The supplementary an complementary use of organic manure and chemical fertilizers will augment the efficiency of both substances to maintain a high level of soil productivity and rice production (Peng, et al., 2002). The benefits of organic amendments for rice production have been reported by many workers (Jun, et al., 2013). There is however, lake of knowledge on the effect of various organic amendments on the growth and yield of rice.

This research was conducted to study the effects of organic and inorganic nitrogen fertilizers as well as soil moisture regimes on yield by rice plants grown under grain house conditions.

2. 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 growth parameters (plant height and number of tillers per plant and roots volume), yield of rice plants.

Soil samples at a depth of (0-03cm) from the surface layer of clay loam soil has a pH of 7.9; 1.9% O.M; 2.61% $CaCo_3$; 26.7% sand, 35.8% silt and 37.5% clay. A total of 45 plastic post, containg air dried soil were arranged in a complete randomize design.

The irrigation treatments were used as follow: M_1, M_2 and M_3, watering at every 4, 6 and 8 days irrigation interval respectively, and the fertilizer treatment were:
F_0: control (11. 56kg N+ 3.75 kg P_2O_5 + 13 kg K_2O/fed).
F_1: (46 kg N+ 15 kg P_2O_5 + 52 kg k_2O/fed).
F_2: (69kg N+ 15 kg P_2O_5 + 52 kg K_2O/fed).
F_3: (23 kg N+ 15 kg P_0O_5 + 52 kg K_2O/fed + 1.5 ton chicken manure).
F_4: (3 ton chicken manure.

Table 1: some properties of the organic composts used in 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% P_2O_5) and potassium sulphate (48% K_2O) were the sources of nitrogen, phosphorus and potassium, respectively. 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 granis were oven dried at 70°C and ground samples of straw and grains were digested. with concentrated sulphuric acid and hydrogen peroxide.

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 Jackson (1982) and Cottenie et al. (1982).

Statistical analysis were performed using the least significant difference L.S.D) method at 1% and 5% according to stell and Torrie (1980).

3. Results and Discussion

Effect on the growth and yield of rice plants

Effect of soil moisture regimes

Data of plant growth (plant height, number of tellers, roots volume, and roots dry matter at harvest time as affected by soil moisture regimes are presented in Tables (2-5)As can be seen, irrespective of fertilizer treatments, plant height and number of tellers per plant Tables(2&3) were highly significantly increased by the soil moisture regimes (M_1) followed by M_2 and M_3 in decreasing order. These results indicate that a prolonged period of loss of soil water saturation even without causing water stress can markedly depress the growth of rice. In practice, prolonged loss of saturation is likely to be associated with water stress and this may overshadows the decreased P absorption. In addition, by inducing a temporary P deficiency, prolonged loss of water saturation may delay plant phonological development and so expose them to drought at later growth stages. The effect of loss soil-water saturation (M_3) on growth reduction of rice plants will apparently be some times related to the decreased of nutrients availability for plant, at other times to a direct effect of water stress as reported by Wonprasaid et al., (1996).

These results were true for both rice varieties Giza 176 and Sakha 102, and confirmed the findings of Vang et al., (1999) who stated that growth of rice plants was strongly affected by soil water regimes and was more vigorous under continuously flooded conditions than in non flooded and intermittently flooded conditions. They added that the heights of plants grown on soil at submergence were much higher than those grown at field capacity. Similarly, rice plant grown at submerged condition tallied better compared to those of field capacity.

Data in Tables (4 &5) reveal that the dry matter of rice roots and roots volume were significantly affected by soil moisture regimes. The highest values were obtained by using the soil moisture regime of M_1 followed by M_2 and M_3 in decreasing order. These results mean that root growth and its morphology was substantially altered by moisture regimes. Under the continuous submergence where the soil mechanical resistance was lowest, roots grow freely without any waviness. The roots volume values were 86.8, 74.4 and 53.2 cm^3/pot for the variety Giza 176 and 102.2, 88.2 and 67.2 cm^3/pot for the variety Sahka 102 under soil moisture regimes of M_1, M_2 and M_3, respectively. The reduction of roots dry matter and roots volume under the soil moisture regimes of M_2 and M_3 might be due to higher soil mechanical density under those regimes as compared with M_1. Confirm these results Sing et al. (1987) who stated that rooting density and root weight were higher with submergence than that obtained with soil moisture of field capacity. Also Yellamanda and Kuladaivelu (1992) added that root length and root volume were negatively related with soil mechanical resistance. Higher resistance offered by soil due to drying and soil moisture stress was the possible reason for lower root volume. Soil strength was 0.2 kg/cm^2 with submergence and 20.0 kg/cm^2 with moisture level ranging from field capacity to 50% depletion of available-soil moisture.

Table 2: Plant height of rice plants (cm/pot) as affected by different levels of fertilizers, duration of irrigation and varieties.

Fertilizer Treatments	*1st variety (Giza 176)*			*Mean of fertilizer*	*2nd variety (Sakha 102)*			*Mean of fertilizer*
	Soil moisture regimes				*Soil moisture regimes*			
	M_1	*M_2*	*M_3*		*M_1*	*M_2*	*M_3*	
F_0	37	35	32	34.67	38.10	36.15	33.18	35.81
F_1	42.12	39.23	37.11	39.49	44.13	41.15	39.00	41.43
F_2	48.15	46.20	42.10	45.48	49.28	47.15	44.10	46.84
F_3	53.22	51.28	48.15	50.88	55.28	53.22	50.10	52.87
F_4	39.14	38.00	35.00	37.38	43.00	40.00	36.00	39.67
Mean of S.M.R.	43.93	41.94	38.87	41.58	45.96	43.53	40.48	43.32
L.S.D. for S.M.R. at	5% : 0.844 1 % : 1.14				5%: 0.965 1 % : 1.30			
L.S.D. for Fertilizer at	5%: 1.654 1% : 0.88				5%: 0.747 1% : 1.01			
L.S.D. for (M × F) at	5%: 1.463 1% : 1.97				5%: 1.671 1% : 2.25			
L.S.D. for ($1^{st} \times 2^{nd}$) varieties at	5% : 0.394				1% : 0.526			

Table 3: Number of tillers of rice plants (per pot) as affected by different levels of fertilizers, duration of irrigation and varieties.

Fertilizer Treatments	*1st variety (Giza 176)*			*Mean of fertilizer*	*2nd variety (Sakha 102)*			*Mean of fertilizer*
	I_4	*I_6*	*I_8*		*I_4*	*I_6*	*I_8*	
F_1	14	11	8	11.00	17	14	11	14.00
F_2	20	17	14	17.00	25	22	18	21.67
F_3	28	24	20	24.00	33	30	25	29.33
F_4	34	31	26	30.33	39	36	29	34.67
F_5	20	17	12	16.33	23	21	15	19.67
Mean of irrigation	23.20	20.00	16.00	19.73	27.40	24.60	19.60	23.87
L.S.D. for Irrigation at	5% : 1.239 1 % : 1.67				5%: 1.324 1 % : 1.79			
L.S.D. for Fertilizer at	5%: 0.959 1% : 1.29				5%: 1.024 1% : 1.38			
L.S.D. for (I × F) at	5%: 2.145 1% : 2.89				5%: 2.292 1% : 3.09			
L.S.D. for ($1^{st} \times 2^{nd}$) varieties at	5% : 0.560				1% : 0.747			

Table 4: Roots volumes of rice plants (cm/pot) as affected by different levels of fertilizers, duration of irrigation and varieties.

Fertilizer Treatments	1st variety (Giza 176)			Mean of fertilizer	2nd variety (Sakha 102)			Mean of fertilizer
	I_4	I_6	I_8		I_4	I_6	I_8	
F_1	20.18	17.00	14.25	17.14	25.90	23.00	20.10	23.00
F_2	32.28	29.12	25.12	28.84	35.38	32.15	30.00	32.51
F_3	43.00	40.00	34.15	39.05	46.00	43.08	37.10	42.06
F_4	48.12	45.10	39.22	44.15	50.15	47.12	41.35	46.21
F_5	25.00	22.10	18.15	21.75	28.90	26.00	23.00	25.97
Mean of irrigation	33.72	30.66	26.18	30.19	37.27	34.27	30.31	33.95
L.S.D. for Irrigation at	5% : 1.538 1 % : 2.07				5%: 1.657 1 % : 2.24			
L.S.D. for Fertilizer at	5%: 1.191 1% : 1.61				5%: 1.284 1% : 1.73			
L.S.D. for (I × F) at	5%: 2.663 1% : 3.59				5%: 2.870 1% : 3.87			
L.S.D. for ($1^{st} \times 2^{nd}$) varieties at	5% : 0.688				1% : 0.918			

Table 5: Dry matter of roots of rice plants (gm / pot) as affected by different levels of fertilizers, duration of irrigation and varieties

Fertilizer Treatments	*1st variety (Giza 176)*			*Mean of fertilizer*	*2nd variety (Sakha 102)*			*Mean of fertilizer*
	Soil moisture regimes				*Soil moisture regimes*			
	M_1	*M_2*	*M_3*		*M_1*	*M_2*	*M_3*	
F_0	19.22	14.00	11.15	14.79	22.17	17.10	12.35	17.21
F_1	28.12	24.22	19.00	23.78	30.98	28.15	21.15	26.76
F_2	38.18	35.12	28.10	33.80	42.15	37.12	30.15	36.47
F_3	45.45	41.38	36.40	41.08	47.18	43.42	37.46	42.69
F_4	24.13	21.28	16.00	20.47	27.18	23.22	19.00	23.13
Mean of S.M.R.	31.02	27.20	22.11	26.78	3.93	29.80	24.02	29.25
L.S.D. for S.M.R. at	5% : 1.241 1 % : 1.67				5%: 1.566 1 % : 2.11			
L.S.D. for Fertilizer at	5%: 0.961 1% : 1.30				5%: 1.213 1% : 1.64			
L.S.D. for (M × F) at	5%: 2.15 1% : 2.90				5%: 2.713 1% : 3.66			
L.S.D. for ($1^{st} \times 2^{nd}$) varieties at	5% : 0.632				1% : 0.843			

Data in Tables (6&7) show that straw and grain yield of the two rice varieties took the same trend of the previous growth parameters (Table 2-4). Generally the M_1 moisture regime gave the highest grain and straw yield followed by those obtained under M_2 and M_3 in decreasing order. M_1 soil moisture regime was found to be beneficial for better initial drop stand and subsequent vigor. This means that M_1 facilitated the more efficient translocation of stored dry matter ensuring adequate grain-filling and earlier crop maturity. From the obtained results it could be established the superiority of variety Sakha 102 over variety Giza 176 under indentical conditions. In this connection, Suratno et al., (1998) stated that rice varieties and varietal characteristics affecting yield stability. Among these latter are agronomic and morphological characters such as well as pest resistance and tolerance of dough, flooding adverse soils and adverse temperatures.

Results show almost exactly the same trend mentioned in the case of growth parameters, plant height, number .of tillers, roots volume and root dry matter (Table 2-5). This is logical because the dry matter yield is more or less just another expression of the plant growth parameters at least in the case of this experiment. These results are in good agreement with those of Singandhupe and Rajput (1990) who stated that maintenance of 7 cm irrigation head and 1 day drainage, increased grain yield by 11.5% and straw by 8.6% compared with 6 days drainage. Moreover, Woperies et al. (1994) showed that growth and yield of rice were substantially depressed by water stress occurring throughout the whole vegetative phase. However, the authors were primarily interested in the direct effects of water stress rather than water-induced nutritional problems, while Brahmanad et al., (2000), Rao et al., (2000) and Siam et al., (2014) stated that grain and straw yields were significantly improved due to continuous submergence as compared to the soil at field capacity, and the growth reductions were attributed to reduced shoot P levels resulting from the decline in P availability during the loss of soil-water saturation. They concluded that continuous flooding gave a higher grain yield and higher values of yield components and grain quality than intermittent flooding.

Effect of Fertilizer Treatments

Data presented in tables (2-5) indicate that irrespective of soil moisture regimes all the fertilizer treatments. Significantly increased rice growth parameters and rice straw and grain yield as they compared with the control treatment (F_0). These results agree well with those obtained by Pande et al. (1993) who found that all of the fertilizer treatments gave significantly higher grain and straw yield over the control (treatment).

Table 6: Dry matter of straw of rice plants (gm / pot) as affected by different levels of fertilizers, duration of irrigation and varieties

Fertilizer Treatments	1st variety (Giza 176)			Mean of fertilizer	2nd variety (Sakha 102)			Mean of fertilizer
	Soil moisture regimes				Soil moisture regimes			
	M_1	M_2	M_3		M_1	M_2	M_3	
F_0	58.00	52.00	43.00	51.00	61.20	55.18	44.00	53.46
F_1	69.10	65.15	58.10	64.12	72.00	68.10	59.13	66.41
F_2	80.21	75.18	69.00	74.80	83.32	79.22	69.12	77.22
F_3	88.00	82.00	78.00	82.67	91.00	86.00	78.15	85.05
F_4	62.10	59.15	55.12	58.79	67.00	64.00	57.00	62.66
Mean of S.M.R.	71.48	66.70	60.64	66.27	74.90	70.50	61.48	68.96
L.S.D. for S.M.R. at	5% : 1.312 1 % : 1.77				5%: 1.444 1 % : 1.95			
L.S.D. for Fertilizer at	5%: 1.016 1% : 1.37				5%: 1.118 1% : 1.51			
L.S.D. for (M × F) at	5%: 2.273 1% : 3.07				5%: 2.500 1% : 3.37			
L.S.D. for (1st × 2nd) varieties at	5% : 0.819				1% : 1.093			

Table 7: Dry matter of grains yield of rice plants (gm / pot) as affected by different levels of fertilizers, duration of irrigation and varieties

Fertilizer Treatments	1st variety (Giza 176)			Mean of fertilizer	2nd variety (Sakha 102)			Mean of fertilizer
	Soil moisture regimes				Soil moisture regimes			
	M_1	M_2	M_3		M_1	M_2	M_3	
F_0	48.00	44.11	36.12	42.74	52.10	49.28	38.10	46.49
F_1	62.00	58.00	49.26	56.42	65.22	61.13	52.00	59.45
F_2	72.10	68.15	58.00	66.08	76.00	72.00	62.00	70.00
F_3	79.25	73.11	60.00	70.78	83.10	76.15	76.12	78.46
F_4	56.00	52.00	46.28	51.42	59.10	55.18	52.00	55.42
Mean of S.M.R.	63.47	59.07	49.93	57.49	67.10	62.74	56.04	61.96
L.S.D. for S.M.R. at	5% : 1.251 1 % : 1.69				5%: 1.221 1 % : 1.65			
L.S.D. for Fertilizer at	5%: 0.969 1% : 1.31				5%: 0.946 1% : 1.28			
L.S.D. for (M × F) at	5%: 2.167 1% : 2.92				5%: 2.115 1% : 2.85			
L.S.D. for (1st × 2nd) varieties at	5% : 0.541				1% : 0.722			

Data also show that the inorganic fertilizer treatments (F_1 and F_2) significantly increased all the previous parameters as compared with the organic fertilizer treatment alone (F_4). The highest values of plant height, number of tillers, root volume, root dry matter and straw and grain yield were obtained when organic and inorganic fertilizer treatment was used (F_3), followed by F_2, F_1, F_4 and F_0 in decreasing order, this trend may be attributed to increased microbial respiration stimulated by organic matter and this may indicate the complementary effect of organic and inorganic fertilizer in meeting the nutrition requirements of rice plants. Also, data show that increasing the rate of inorganic fertilizer (F_2), the growth parameters as well as straw and yield of rice significantly increased as compared with the fertilizer treatment of F_1. It is evident that variation in either of the rates of N, P, K and organic matter brings proportional changes in the studied parameters. Confirm these results Panda et al., (1986) stated that yield of rice was increased by 521 kg/ha at a N:P:K dose of 60: 30: 30 and by 996kg/ha at 90:45:45 over that of the in fertilized control.

Results show that application of organic and inorganic fertilizer together (F_3) make the availability of plant nutrients from both sources together proved advantageous as the rice plants could meet their requirements rapidly from inorganic fertilizer and more steadily from the organic source as already explained by Ghosh and Sharma (1999),Ghosh (2000),Sharawat, (2004) and Kaleem and Almas (2012).who stated that application of organic and inorganic fertilizers together had a significantly positive effect on all agronomic parameters (plant height, umber of tillers, and weight of grains) when compared with that of organic and inorganic sources each alone. These increases in growth parameters and rice yield observed from the manuered treatments were directly results of greater nutrient supply from the manure upon fertilization (EgrinyaEneji et al., 2000). Confirm these results Willett (1995) and Siam et al., (2014) reported that organic matter amendment improved the effectiveness of applied fertilizers and increased rice yield.

Interaction between soil moisture regime and fertilizer treatments:

Tables (2-7) showed that all the growth parameters and straw and grain yield of rice plants responded greater to fertilizer treatments under submergence treatment (M_1) than under the other soil moisture regimes (M_2 and M_3). It seems therefore that the efficiency of different fertilizers interns of rice yield may differ according to water regimes. Concerning the effect of interaction between the tested variables and rice dry matter and yield production, it was found that soil moisture regimes, and fertilizer treatments significantly affected the growth and yield of rice plants each alone, yet both variables together significantly affected the previous parameters. Results show that the highest values of studied parameters were obtained under soil moisture regime of submergence (M_1) and fertilizer treatment of organic and inorganic fertilizers together (F_0), while the lowest values were obtained under soil moisture regime of M_3 and unfertilized treatment (F_3). Confirm these results Mohamed et al., (1998) stated that combination of continuous flooding and 120 kg N/ha gave the highest grain yield and a moist soil with no nitrogen application gave the lowest yield of rice and the effect of both variables together on dry matter was significant Singh, et al., (2010). On the other hand, Sahoo et al., (1970) found that heavy application of organic matter in presence of continuous submergence depressed grain yield and nutrients uptake.

Rice straw yield (Table 6), plant height (Table 2) and roots dry matter of rice plants (Table 5) grown under submergence (M_1) without any fertilizer (M_1 F_0) were significantly higher as compared with those grown under soil moisture regime of M_3 and fertilized with F_4 treatment (M_3F_4), however, the previous parameters of rice plants grown under soil moisture regime of M_3 and fertilized with F_1 treatment, were not statistically differ from those grown under submergence and not fertilized ($M1F_0$). The butter results of the submergence without fertilizer (M_1F_0) than those of fertilized with F_4 treatment at soil moisture regime of M3 (M_3F_4) 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 (M_1F_0) more than M_3 treatment.

Grain yield (table 7) and numbers of tillers/plant (Table 3) under submergence (M_1) and without fertilizer (M_1F_0) did not show any significantly differences when compared with those grown under soil moisture regime of M_3 and fertilized with F_1 or F_4 (M_3F_1 and M_3F_4). This mean, that it can be concluded that soil at (M_3) soil moisture can meat the water demands of the most vigorously growing rice plants at (M_1) by supplying extra fertilizers. Came to the same results Vang et al., (1999) stated that the additional application of nutrients in the form of fertilizers at field capacity condition can equate the benefits of submergence. They found that organic matter addition minimized the reduction of growth caused by loss of soil-water saturation by increasing the water holding capacity of soils and reducing the need for irrigation.

The obtained results in this investigation are in good harmony with those obtained by Tano et al., (1995) and Subudhi and Pradhan (1996), who stated that rice biomass and grain yield were positively affected by nitrogen fertilization and 4-day period of drying. The 8-day period of drying reduced rice growth and yield because of lesser availability of nitrogen. They added that continuously submerged and supplying inorganic and organic fertilizer in combination (10:15: 20 NPK + 1.5 kg FYM/m^2) gave the tallest seedlings and the highest yield. Also, Pathak et al., (2010) who stated that urea plus FYM treatment recorded maximum grain yield of when.

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