J. Soil Sci. and Agric. Eng., Mansoura Univ., Vol. 3 (10): 985 - 1000, 2012

IMPACT OF INTERMITTENT IRRIGATION AND NITROGEN FERTILIZATION ON YIELD OF RICE (*Orayza sativa* L.) AND SOME WATER RELATIONS

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ABSTRACT

Two field experiments were conducted at Sakha Agricultural Research Station farm, Kafr Elshiekh Governorate during the two successive seasons 2005 and 2006 to study the effect of intermittent irrigation water and nitrogen fertilizer levels on rice yield and water requirements. The experiments were arranged in split plot design with four replicates where the intermittent irrigation treatments represent the main plots; (I_1) soil saturation along the growing season, (I_2) soil submergence with 2.5 cm depth in first half of growing season, then irrigation at soil saturation in the second half of the growing season, (I_3) soil submergence with 2.5 cm depth along growing season, (I_4) soil submergence with 5 cm depth in the first half of season, then irrigation at saturation in the second half of the growing season and (I_5) soil submergence with 5 cm depth along the growing season. In this concern nitrogen fertilizer levels represent the sub main plots; where N_1,N_2, N_3 and N_4 were the application of nitrogen at 50%, 75%, 100% and 150% from the recommended dose, respectively.

The maximum rice yields of both grain and straw and its components were obtained with irrigation water depth of 5 cm.(I_5) and nitrogen fertilizer of N_4 (69 kg N/fed) as well as their interaction. This was true for both growing seasons. The highest 1000- grain weight, and panicle length were recorded with above mentioned treatment, while the lowest values, were recorded with irrigation at saturation treatment (I_1) and nitrogen rate of 23 kg N/fed (N_1) in both growing seasons. The highest amount of water applied for permanent field was recorded with 5 cm irrigation water depth along the season, in the two growing seasons, while the lowest value was recorded with irrigation at saturation treatment. The highest mean value of crop water use efficiency (CWUE)was recorded at 5 cm submergence depth along the season (I_5), while the lowest mean value was obtained at saturation treatments along growing seasons (I_1). The values of field water use efficiency (FWUE) had the opposite trend of (CWUE).

INTRODUCTION

The main problem which faces Egyptian agriculture is the limitation of irrigation water because of scarcity of water resources and limitation of Egyptian water budget which is 55.5 milliard cubic metre. Agricultural sector requires more than 85% from this amount. Rice is grown in an area of 1.2 million feddans, having an annual production of about 6.1 million ton. The national average rice yield was gradually increased from 2.40 tons /fed. (1984-1986) to 4.3 tons /fed in 2007. However, there is a good chance to rise rice production in Egypt by improving rice cultivation techniques (RRTC, 2007). So, it can improve the irrigation techniques and find out the possible ways for saving irrigation water, particularly with highly water consuming crops such as rice. In Egypt, however, irrigation water is not sufficient for irrigation and some other purposes, so one way to save water is to decrease submerged irrigation heads without any drastic effects on the yield. The shallow water depth causes rising of water temperature during the day time but decreasing the temperature during the night time that allow more tillering and better growth. One of the method to save irrigation of water for rice cultivation is the intermittent drying of the rice fields instead of keeping them continuously flooded. Most of Egyptian rice varieties produced higher grain yield when water content of the soil was kept near saturation throughout the season and this was comparable to that of continuous flooding. Mishra *et al.*,(2001) found that grain yield significantly affected by water submergence depths from saturation to 2.5, 5.0 and 7.5 cm. depth, respectively.

Moursi (2001) found the increase of submergence depth from 2.5 cm up to 7.5 cm achieved the highest values of rice plant height, leaf area, panicle length, 1000- grain weight, grain yield and straw yield, while the lowest values of these parameters were recorded with 2.5 cm water depth.

El-Hadidi, *et al.*,(2002) illustrated that the mean values of rice grain and straw yields were increased with increasing irrigation water depth from 2.5 cm up to 7.5 cm. due to increasing the availability of nutrients in soil and hence, increasing plant uptake of both water and nutrients.

El-Bably *et al.*, (2007) showed that increasing the submergence depth from 4 to 7 or 10 cm. both significantly increased plant height, number of tillers/m^2, panicle weight, 1000-grain weight, and grain yield in North Delta. Also they found that the submergence depth of 4 cm increased field water use efficiency by 16.6% and 49.7% more than 7 and 10 cm depth, respectively. It was evident that irrigation every six days intervals with submerged depth of 10cm received the highest amount of irrigation water followed by submerged depths of 7 and 4 cm, 196.38, 152.05 and 118.21 cm,.

El-Saiad (2008) found that the highest crop water use efficiency and the lowest field water use efficiency was achieved under submergence head of 6 cm.. Consequently, continuous submerged water head up to 3 cm could be recommended for rice crop watering to produce an economical production with less water consumption. The main objectives of this investigation were to study the effect of intermittent irrigation on some water relations of cultivated rice in North Delta. Identification the best suitability of water depth for rice cultivates was also taken into consideration. .

MATERIALS AND METHODS

Two field experiments were carried out in Sakha Agricultural Research Station Farm at North Delta region, Kafr El-Sheikh Governorate during the two growing seasons 2005 and 2006to study the effect of intermittent irrigation water and nitrogen fertilizer levels on rice yield and water requirements. The experimental field located at 31^0 07^- latitude and 30^0 52^- longitude with 6 m altitude. The design of the experiment was split- plot design with four replicates (40 m^2 For each). Irrigation treatments represent the main plots: The irrigation treatments represent the main plots as :-

- (**I_1**): Soil saturation along the growing season.,
- (**I_2**): Soil submergence with 2.5cm depth in the first half of season then soil saturation in the second half of growing season.,
- (**I_3**): Soil submergence with 2.5 cm depth along growing season,
- (**I_4**): Soil submergence with 5 cm depth in the first half of season then soil saturation in the second half of growing season. And
- (**I_5**): Soil submergence with 5 cm depth along growing season.

Nitrogen fertilizers treatments as sub main plots were as follows :-

N1: Application 50% of nitrogen recommended dose (23 Kg N/ fed.).,
N2: Application 75 % of nitrogen recommended dose (34.5 Kg N/ fed.).,
N3: Application 100% of nitrogen recommended dose (46 Kg N/fed.).
And **N4:** Application 150% of nitrogen recommended dose (69 Kg N/ fed.).

The nitrogen was applied (as urea 46% N) in two equal doses the first dose was applied before transplanting and the second dose was added after 25 days from transplanting .

The experimental field was tilled leveled and rice (Sakha 104) was transplanted at 12 and 15 June 2005 and 2006 growing seasons, respectively. Seedlings were transplanted in hills (four to five plants per each hill) with spacing of 20 x 20 cm (hills x rows). The ordinary super phosphorus fertilizer (15.5 % P_2O_5 /fed). was added during the preparation of land for cultivation. The end of experiments was took place at 24 and 27 September in the two growing seasons, respectively, then the plants were harvested and prepared for plant analysis

Soil analysis:

Soil samples were collected from the experimental plots before planting and after the harvesting of rice at depths of 0-15, 15-30, 30-45 and 45-60 cm. to determine some soil physical and chemical properties.

Soil Physical analysis:

Mechanical soil analysis was determined by the International pipette method according to Klute (1986).

Soil chemical analysis :

- Soluble cation and anions were determined according to Page (1982).
- Soil reaction (pH): was measured in (1:2.5) soil water suspension according to Cottenie et al (1982)
- Electrical conductivity (EC_e) was measured by electrical conductivity meter model Jenway, 4320 as dS/m at 25^0C in soil paste extract according to Page (1982).

Some physical and chemical analyses of soil are shown in Tables (1,2,3, and 4)

Table (1): Some physical analysis of soil of the experimental field before transplanting of rice in seasons (2005) and (2006) ,

Soil depth (cm)	2005				2006			
	Particle size distribution			Texture class	Particle size distribution			Texture class
	Sand %	Silt %	Clay %		Sand %	Silt %	Clay %	
0-15	24.49	23.07	52.44	Clayey	24.37	23.15	52.48	Clayey
15-30	25.58	25.00	49.42	Clayey	25.70	25.00	49.30	Clayey
30-45	26.73	20.45	52.82	Clayey	26.57	20.63	52.80	Clayey
45-60	26.32	24.75	48.93	Clayey	26.28	24.86	48.86	Clayey
Mean	25.78	23.32	50.90	-------	25.73	23.41	50.86	-------

Table (2): Some chemical analysis of soil paste extract of the experimental field before transplanting of rice in the first growing season,2005.

Soil depth (cm)	pH 1:2.5 Soil: water	EC_e dS/m at 25 C°	Cations meq/l				anions meq/l				SAR	O.M %	CaCO3 %	C.E.C meq / 100gm soil
			Na^+	K^+	Ca^{++}	Mg^{++}	CO3=	HCO3-	Cl-	SO4=				
0-15	7.80	2.76	19.40	0.30	4.60	6.30	0.00	3.35	15.50	11.80	8.31	0.72	1.10	36.95
15-30	7.91	2.85	20.70	0.20	4.90	6.70	0.00	3.38	16.10	13.02	8.60	0.61	1.24	32.52
30-45	7.98	3.01	20.90	0.30	4.90	6.80	0.00	3.43	16.60	12.90	8.64	0.53	1.52	32.02
45-60	8.20	3.10	21.40	0.30	5.10	7.00	0.00	3.45	17.00	13.35	8.70	0.50	1.81	29.00
Mean	7.97	2.93	20.60	0.28	4.88	7.70	0.00	3.40	16.30	12.93	8.21	0.59	1.42	32.62

Table (3): Some chemical analysis of soil paste extract of the experimental field before transplanting of rice in the second growing season, 2006.

Soil depth (cm)	pH 1:2.5 Soil: water	EC_e dS/m at 25 C°	Cations meq/l				anions meq/l				SAR	O.M %	CaCO3 %	C.E.C meq / 100gm soil
			Na^+	K^+	Ca^{++}	Mg^{++}	CO3=	HCO3-	Cl-	SO4=				
0-15	**7.78**	**2.70**	**19.00**	**0.30**	**4.50**	**6.20**	**0.00**	**3.30**	**15.30**	**11.40**	**8.21**	**0.71**	**1.08**	**36.43**
15-30	**7.92**	**2.79**	**20.10**	**0.30**	**4.80**	**6.60**	**0.00**	**3.33**	**15.90**	**12.57**	**8.42**	**0.60**	**1.22**	**32.06**
30-45	**8.03**	**2.94**	**20.40**	**0.30**	**4.80**	**6.70**	**0.00**	**3.38**	**16.40**	**12.42**	**8.51**	**0.52**	**1.50**	**31.57**
45-60	**8.15**	**3.02**	**20.90**	**0.30**	**5.00**	**6.90**	**0.00**	**3.40**	**16.80**	**12.90**	**8.57**	**0.49**	**1.78**	**28.56**
Mean	**7.97**	**2.86**	**20.10**	**0.30**	**4.78**	**6.60**	**0.00**	**3.35**	**16.10**	**12.32**	**8.43**	**0.58**	**1.40**	**32.16**

Table (4): Elemental content of soil (ppm).

Soil depth (cm)	N	P	K
0-15	**29.75**	**9.94**	**333**
15-30	**31.4**	**9.61**	**329**
30-45	**31.73**	**9.55**	**317**
45-60	**33.12**	**9.30**	**301**
Mean	**31.50**	**9.6**	**320**

- Rice grain yield (ton/fed), straw yield (ton/fed), panicle length (cm) , 1000-grain weight (g) were determined for each treatments. and subjected to statistical analysis according to Snedecor and cochran (1967).
- Water requirement (= evaporation +transpiration + deep percolation) was determined according to Israelsen and Hansen, (1962), usign four groups of tanks. Each group consists of three similar tanks filled with soil. These tanks consist of three types with four replicates. The first type with bottom to estimate the evaporation + transpiration, the second type without bottom to estimate evaporation + transpiration and percolation. While the third type without bottom and device to estimate the evaporation as show in Fig (1).

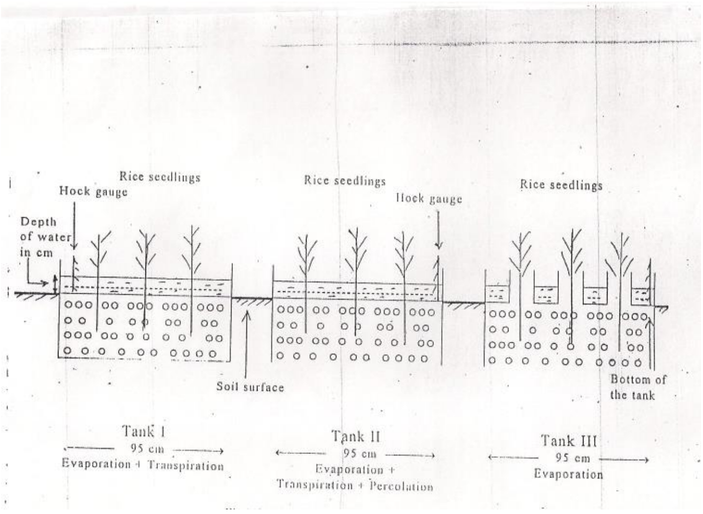

Fig (1): Experiment system

- Irrigation water applied under the different treatments was measured by using a cutthroat flume of (20 x 90 cm) according to Early(1975) and Walker and Skogerboe (1987).
- The crop water use efficiency was calculated for the different irrigation treatments by dividing the rice grain yield (Kg/fed.) on the total amount of consumed water (evapotranspiration) expressed as cubic meter/fed (Abdel-Rassol *et al.*, 1971).
- Field water use efficiency is the weight of marketable crops produced per volume unit of applied water expressed as cubic meters of water (Michaele, 1978).

RESULTS AND DISCUSSION

1. Effect of intermittent irrigation treatments and nitrogen fertilizer levels on the growth of rice plant.

1. Rice grain and straw yields (ton /fed) :-

Data illustrated in Table (5) show that the intermittent irrigation levels exhibited highly significant effect on rice grain and straw yields in both seasons. It was observed that soil submergence with 5 cm depth along the growing season (I_5) produced the highest yield of both grain and straw, while with soil saturation along the growing season (I_1) produced the lowest values of rice yield of both grain and straw. This was true in the two growing seasons. The obtained values of rice grain yield were 2.784 , 2.913 , 3.188 , 3.481 and 3.991 ton/ fed for I_1 , I_2 , I_3 , I_4 , and I_5, respectively in the first season, while in the 2 nd season the corresponding values were 2.765 , 2.907 , 3.186 , 3.503 and 4.008 ton/fed, respectively. The values of rice straw yield are 4.16 , 4.23, 4.89 , 5.05 and 5.98 ton/fed for I_1 , I_2 , I_3 , I_4 and I_5, respectively in the first season . while the corresponding values for the same treatments are 4.2 , 4.33 , 4.97 , 4.997 and 6.053 ton/fed, respectively. In this respect, the rate of nitrogen fertilization have highly significant effect on rice yields of both grain and straw in both growing seasons.

Table (5): Effect of intermittent irrigation and nitrogen fertilizer levels on rice yield and yield components in growing season,2005 and 2006 .

Treatments	2005					2006				
	Grain (ton /fed)	Straw (ton/fed)	Rough rice 1000-grain weight (g)	Plant height (cm)	Panicle length (cm)	Grain (ton /fed)	Straw (ton/fed)	Rough rice 1000-grain weight (g)	Plant height (cm)	Panicle length (cm)
Water Management (W)										
I_1	2.7840	4.1598	25.530	85.908	17.050	2.7655	4.2017	25.663	86.093	17.375
I_2	2.9130	4.2258	26.297	88.995	18.812	2.9075	4.3250	26.268	89.285	18.905
I_3	3.1878	4.8940	26.503	91.868	19.283	3.1860	4.9675	26.650	92.373	19.124
I_4	3.4805	5.0545	27.833	94.662	19.775	3.5033	4.9965	27.978	95.375	20.113
I_5	3.9913	5.9854	28.470	97.765	21.095	4.0083	6.0530	28.615	98.713	21.215
F-test	**	**	**	**	**	**	**	**	**	**
LSD 0.05	0.0720	0.0782	0.777	1.101	0.992	0.0893	0.1012	1.293	2.541	0.808
LSD 0.01	0.1009	0.1096	1.090	1.544	1.391	0.1252	0.1419	1.813	3.561	1.133
Nitrogen fertilizer levels (N)										
N_1	2.9626	4.2906	25.794	88.540	17.310	2.9872	4.2772	25.922	89.068	17.580
N_2	3.0922	4.5375	26.480	90.442	17.870	3.0836	4.5666	26.640	90.960	18.112
N_3	3.4040	5.0924	27.254	92.942	19.662	3.4052	5.0980	27.378	93.332	19.985
N_4	3.6264	5.5350	28.178	95.434	21.970	3.6204	5.5836	28.198	96.110	21.709
F-test	**	**	**	**	**	**	**	**	**	**
LSD 0.05	0.0806	0.0811	0.611	0.932	0.447	0.0697	0.0846	1.236	2.277	0.740
LSD 0.01	0.1108	0.1114	0.877	1.276	1.100	0.0941	0.1136	1.680	3.092	1.008
Interaction										
I* N	**	**	Ns	**	*	**	**	< 1	**	< 1

The highest values of rice grain and straw yields in the 1st season (4.385 and 5.986 ton/ fed, respectively) and in the 2nd season (4.008 and 6.053 ton/fed, respectively) were obtained at the rate of 69 Kg nitrogen /fed (N_4). While the lowest values of rice grain and straw yields in 1st (2.567 and 3.650 ton / fed, respectively.) and in the 2nd season (2.575 and 3.689 ton/fed, respectively) were recorded at rate of 23Kg N/fed.(N_1) in the first and second seasons, respectively. Also, data in Table (5) reveal that the interaction between irrigation and nitrogen fertilizer levels have highly significantly effects on rice yields of both grain and straw in both growing seasons. The highest grain and straw yield are given with interaction between (I_5 and N_4) in both seasons. While the lowest values are recorded with (I_1 and N_1). These findings are in agreement with those obtained by Moursi (2001) and EL-Bably *et al.*, (2007).

2- 1000 – grain weight (gm):

Irrigation treatments show a high significant effect on seed index (1000 – grain weight) in both growing seasons as shown in Tables (5). In the first season o , the treatments of I_1 , I_2 , I_3 , I_4 and I_5 gave seed index of 25.53 , 26.3 , 26.5, 27.83 and 28.47 gm., respectively, while in the second seasons, the corresponding values reached to 25.66 , 26.27 , 26.65 , 27.89 and 28.62 gm,. Data in Table (5) also indicate that the increase of nitrogen rate up to 69 Kg N/fed.(N_4) gave a significant increment in 1000 grain weight. The greatest values of 1000 – grain weight in the 1st and 2nd seasons (28.18 and 28.2 gm., respectively) are achieved with application the rate of 69 Kg N/fed.(N_4). However, no significant effect was found due to the interaction between irrigation treatments and nitrogen fertilizer levels on 1000 – grain weight in both seasons . These results are in great agreement with those obtained by Moursi (2001), and El-Bably *et al.*,(2007).

3. Panicle length (cm):

Panicle length as influenced by intermittent irrigation and nitrogen fertilizer levels and their interactions in the first and second seasons are presented in Table (5). The obtained data show a significant increase in panicle length due to raising submerged head of water up to 5cm. The panicle length values in the first season are 17.05, 18.81, 19.28,19.70 and 21.10 cm for I_1 , I_2 , I_3 , I_4 and I_5, respectively, while in the second season, the corresponding values are 17.38 ,18.91,19.21,20.11 and 21.22 for the stated treatments.

Concerning the effect of nitrogen levels on panicle length, it can be observed that the panicle lengths reaches to the highest values (21.97 and 21.71cm) with nitrogen application rate of 69 kg N/fed (N_4) in 2005 and 2006, respectively while the lowest length (17.31 and 17.58 cm) were recorded at nitrogen rate of application rate of 23 Kg N/fed (N_1) in both seasons, respectively. There is a significant interaction effect between the irrigation treatments and nitrogen fertilizer levels on panicle length in the first season as shown in Table (5). These results are in agreement with those obtained by Moursi (2001),El- Hadidi *et al.*,(2002), and El- Saiad (2008).

Water consumptive use (ETa) and water requirements (W.R) of the rice crop as affected by irrigation treatments.

Data in Tables (6 and 7) and Figs (2 &3) indicate that the evaporation (E) is the major cause of actual evapotranspiration at the beginning of the growing season. The highest rate of evaporation was recorded in July, while the lowest values of evaporation were in August at the maturity stage for the both growing seasons. The evaporation rates are decreased with increasing plant ages as a result of the accumulated vegetation parts (shoots) and consequently shading effect. With regard to transpiration data indicate that (T) values are increased by the time during growing season and the maximum of values are found in July and August for the both growing seasons. It can be observed that total transpiration values throughout the season are 302.02 mm and 271.45 mm in the first and second growing season, respectively**.** The data also reveal that actual evapotranspiration (ETa) values are 243.48 and 243.28 mm/ month at the end of July and the beginning of August in the first and second growing seasons, respectively. The respective values of actual evapotranspiration of both growing season were 600.7 and 623.0 mm,. The data in Tables (6 & 7) show that percolation (P) values throughout the two growing season,s reached to 212.96 mm and 237.02 mm, respectively. Water requirements (W.R.) of rice crop are found to be 813.62 and 859.90 mm / season in the first and second growing seasons respectively. On the other hand, at reproductive and ripening stages, the evapotranspiration was higher than percolation. It could be due to much water needed at growth stage. These data are in agreement with those obtained by Moursi (2001)

Table (6): Components of rice water requirements during 2005 growing season .

Period	Date	E mm/month	T mm/month	P mm/month	ET mm/month	W.R mm/month
1	15/6-30/6 2005	73.50	25.94	97.65	99.44	197.09
2	1/7-31/7 2005	127.98	115.5	69.09	243.48	312.57
3	1/8—31/8 2005	89.53	139.02	39.78	228.55	268.33
4	1/9—7/9/2005	7.63	21.56	6.44	29.19	35.63
Seasonal water consumed mm		298.64	302.02	212.96	600.66	813.62

Table (7): Components of rice water requirements during 2006 growing season .

Period	Date	E mm/month	T mm/month	P mm/month	ET mm/month	W.R mm/month
1	17/6-30/6 2006	69.44	20.65	102.41	90.09	192.50
2	1/7-31/7 2006	187.91	55.37	84.80	243.28	328.08
3	1/8—31/8 2006	85.19	154.33	41.15	239.52	280.67
4	1/9—8/9/2006	8.89	41.10	8.66	49.99	58.65
Seasonal water consumed mm		351.43	271.45	237.02	623.02	859.90

ET = Evapotranspiration E = Evaporation
T = Transpiration P = Percolation
W.R = Water requirements

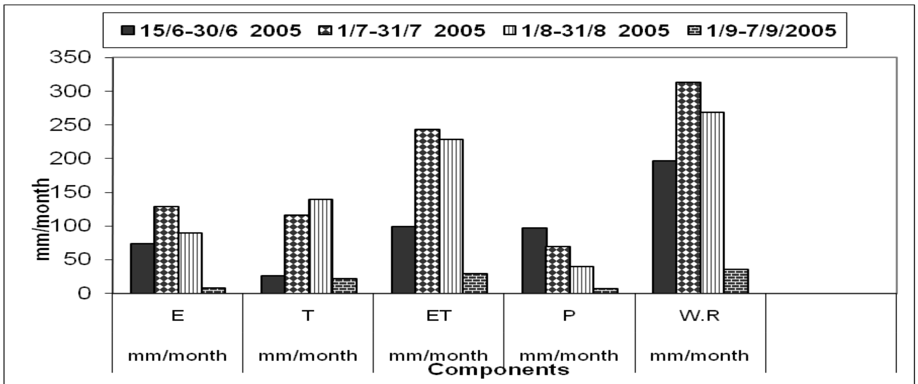

Fig (2): Components of rice water requirements during 2005 growing season

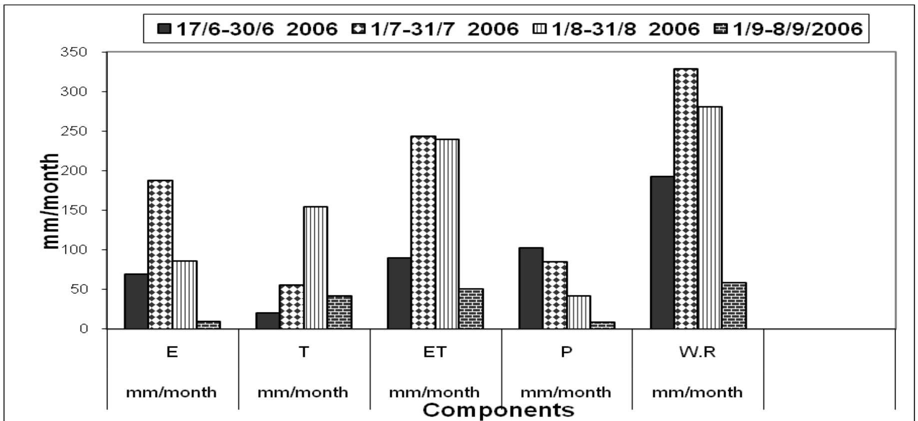

Fig (3): Components of rice water requirements during 2006 growing season

ET = Evapotranspiration **E = Evaporation**
T = Transpiration **P = Percolation**
W.R = Water requirement

Effect of intermittent irrigation and nitrogen fertilizer levels on water applied and water use efficiency:-

1. water applied :

The obtained data in Table (8) and Fig.(4). show that the values of total water applied corresponding to all treatments (I_1, I_2, I_3, I_4 and I_5) were 3235, 3635 , 4093, 4633 and 5722 m^3/ fed in the first season, and 3313, 3649 , 4168 , 4799 and 5855 m^3 /fed. In the second growing season. The highest amount of water applied in both seasons are recorded at I_5 (5722 and 5855 m^3/fed., respectively) while I_1 treatment gave the lowest amount of irrigation water (3235 and 3313 m^3 /fed., respectively). The wide range in water applied with different treatments is due to the differences in the period of the crop in the permanent field. Similar results of water requirements were reported by Moursi (2001), and El-Bably *et al.* (2007).

2. water saving

Water saving represents the difference between the quantity of water applied with the conventional practice used by farmer or applied with the studied treatment. Data in Tables (9 and 10) and Fig.(5) show that the amount of water saving with I_1, I_2, I_3 and I_4 treatments comparing to I_5 were 2486.82 (43.46%) , 2086.56 (36.47%) , 1628.76 (28.47% and 1089.06 m^3 /fed., (19.03%). respectively in 1st season, while the corresponding values in the 2 nd season were 2541.84 (43.41%), 2205.84 (37.68%) 1686.72 (28.81%)and 1055.46 m^3/ fed.(18.03%). Data show also that the amounts of water saving with I_1 , I_2 , I_3 , I_4 and I_5 comparing to traditional irrigation practice (7500 m^3/ fed) are 56.9 , 51.53 , 45.43 , 38.23 and 23.71 % in the first season, respectively and 55.87 , 51.35 , 44.43 , 36.01 and 21.94 % in the second season, respectively. These results are in accordance with those reported by Zhou Huanl, *et al.*, (2010).

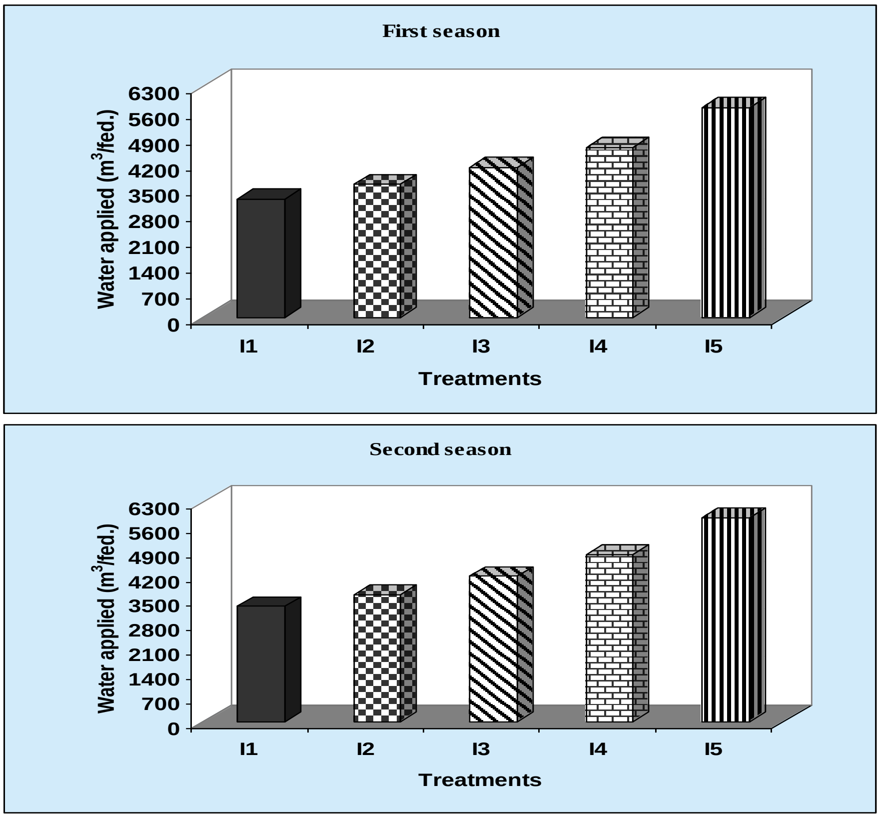

Fig (4): Amount of irrigation water applied under different irrigation levels for the first and second seasons.

Table (8): Amount of irrigation water applied (m^3/fed.) under different intermittent irrigation treatments in the first and second season.

Irrigation treatments	First season (2006) m3 / fed.	Second season (2006) m3 / fed.
I_1	3235	3313
I_2	3635	3649
I_3	4093	4168
I_4	4633	4799
I_5	5722	5855

Table (9): Total water applied and water saving in both 2005 and 2006 seasons as affected by different treatments .

Treat-ments	2005			2006		
	Total water Applied (m^3 fed^{-1})	Water saving m^3 fed^{-1}	Water saving (%)	Total water Applied (m^3 fed^{-1})	Water saving m^3 fed^{-1}	Water saving (%)
I_1	3234.84	2486.82	43.46	3312.96	2541.84	43.41
I_2	3635.10	2086.56	36.47	3648.96	2205.84	37.68
I_3	4092.90	1628.76	28.47	4168.08	1686.72	28.81
I_4	4632.60	1089.06	19.03	4799.34	1055.46	18.03
I_5	5721.66	-	-	5854.8	-	-

Table(10):Water applied to rice field and water saving in the two growing seasons.

Trea-tments	2005			2006		
	Total water Applied (m^3 fed^{-1})	Water saving m^3 fed^{-1}	Water saving (%)	Total water Applied (m^3 fed^{-1}	Water saving m^3 fed^{-1}	Water saving (%)
I_1	3234.84	4265.16	56.87	3312.96	4187.04	55.83
I_2	3635.10	3864.90	51.53	3648.96	3851.04	51.35
I_3	4092.90	3407.10	45.43	4168.08	3331.92	44.43
I_4	4632.60	2867.4	38.23	4799.34	2700.66	36.01
I_5	5721.66	1778.34	32.71	5854.8	1645.2	21.94
I_6	7500	---	---	7500	---	---

I_6 : the conventional irrigation used by farmer .

Table (11): Amount of water saving with I_5 treatment for rice crop during the season of 2005 and 2006.

Treatments	studied Seasons	Grain yield kg fed^{-1}	Total water applied $m^3 fed^{-1}$	Saved water $m^3 fed^{-1}$		Average Area cultivated rice crop in kafer El sheikh governor- ate (1000 fed)	Total water saving milliard m^3/area	The area which can be cultivated as a result of saving water (1000 fed)
I_5 5cm depth irrigation	2005	3991	5721.66	1778.34	23.71%	450	0.800	139.8
water all season	2006	4008	5854.80	1645.2	21.94%	420	0.690	117.85
Mean		4000	5788	1712	22.83 %	435	0.745	128.83

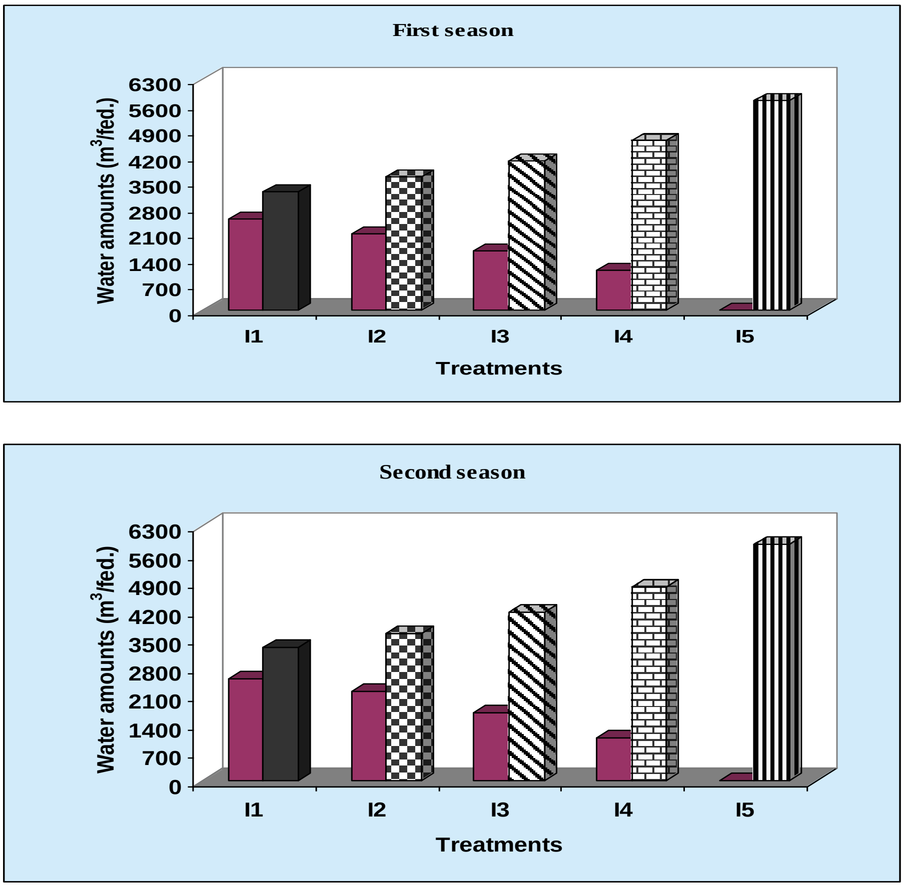

Fig (5): Total water applied and amount of water saving in the first and second seasons.

In general, it can be concluded that water is fast becoming an economically scarce resource in many countries in the world . So the use of I_5 (5cm depth irrigation all season) or I_4 (5cm depth half season) is the most suitable water depth to achieve proper rice yield and to save considerable amounts of irrigation water comparing to the conventional irrigation depth used by the farmers. Similar trend was reported by Won *et al.*,(2005).

Data in Table (11) show also that about 0.745 milliard m^3 of irrigation water can be saved with I_5 (5cm depth irrigation water along season) if it used instead of the tradition method in all area of Kafr El Sheikh (435000 fed.).

3 Crop water use efficiency (CWUE):-

Data presented in Table (12) show that the values of crop water use efficiency for rice grains and straw yield are affected by irrigation water depth. In the 1st and 2 nd season the highest mean values of crop water use efficiency for straw (2.37 and 2.31 kg/m^3 respectively) and for grain (1.58 and 1.53 kg/m^3, respectively) are obtained with I_5 treatment while the lowest values in both seasons for straw (1.65 and 1.61 kg/m^3 , respectively) and for grain (1.10 and 1.06 kg/fed, respectively) are recorded with I_1 treatment. This might be attributed to increasing the yield of rice either grains or straw with I_5 treatment . The value of crop water use efficiency for straw is greater than that obtained for grains due to increasing straw yield in comparison with grain yield. These results are in good agreement with those obtained by Moursi (2001), El-Saiad (2008) and Zhou Huanl, *et al.*, (2010) .

Field water use efficiency (FWUE) .

Data presented in Table (13) show that the field water use efficiency (FWUE) take the opposite trend of (CWUE). The highest mean values of field water use efficiency in the 1st and 2nd seasons for grain (0.86 and 0.84 kg / m^3 respectively) and for straw (1.3 and 1.12 kg/m^3, respectively) are obtained with (I_1) while the lowest values for grain (0.70 and 0.69 kg /m^3, respectively) and for straw (1.04 and 1.04 kg/m^3) are recorded under I_5 treatment. It can be noticed that crop water use efficiency values are high for treatments having higher grain rice yield and less amount of both water consumptive use and water applied and vic versa.. While mean, to maximize the field water use efficiency it must increase the obtained yield from the same area and / or minimize the water losses. Similar trend was reported by Moursi (2001), El-Bably *et al.*,(2007) and EL – Saiad (2008).

Table (12): Effect of intermittent irrigation on crop water use efficiency (CWUE) for rice grain and straw yields in the two growing seasons (2005&2006).

Irrigation treatments	Crop water use efficiency (kg m3) for rice grain yield.		Crop water use efficiency (kg m3) for rice straw yield.	
	First season (2005)	Second season (2006)	First season (2005)	Second season (2006)
I1	1.10	1.06	1.65	1.61
I2	1.15	1.11	1.68	1.65
I3	1.26	1.22	1.94	1.90
I4	1.38	1.34	2.01	1.91
I5	1.58	1.53	2.37	2.31

Table (13): Effect of intermittent irrigation on field water use efficiency (FWUE) for rice grain and straw yields in the two growing seasons (2005&2006).

Irrigation treatments	Crop water use efficiency (kg/ m3) for rice grain yield.		Crop water use efficiency (kg/ m3) for rice straw yield.	
	First season (2005)	Second season (2006)	First season (2005)	Second season (2006)
I1	0.86	0.84	1.30	1.12
I2	0.80	0.80	1.17	1.19
I3	0.78	0.76	1.20	1.19
I4	0.75	0.73	1.09	1.04
I5	0.70	0.69	1.04	1.04

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تـاثيرالرى المتقطـع والتسـميد النتروجينــى علــى محصـول الارز وبعـض العلاقـات المائية

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****معهد بحوث الاراضى والمياه والبيئة-مركز البحوث الزراعية**

أقيمت تجربتان حقليتان بمزرعة محطة البحوث الزراعية بسخا موسمي 2005 و2006 وذلك لدراسة تأثير معاملات الري المختلفة والتسميد النتروجيني على محصول الأرز وبعض العلاقات المائية وكانت معاملات الري الرئيسية هي كالتالي:--

1-الري حتى حد التشبع طول الموسم.

2- الري حتى عمق 2.5 سم فوق سطح التربة نصف الموسم الأول وحتى حد التشبع في النصف الأخر من الموسم.

3- الري حتى عمق 2.5 سم فوق سطح التربة طول الموسم.

4- الري حتى عمق 5 سم فوق سطح التربة نصف الموسم الأول وحتى حد التشبع في النصف الأخر من الموسم.

5—الري حتى عمق 5 سم فوق سطح التربة نصف الموسم الأول وحتى حد التشبع في النصف الأخر من الموسم.

وكانت معدلات التسميد النتروجينى المضافة من سماد اليوريا كمصدر للنتروجين كالتالي:

1 - 23 كجم نتروجين للفدان تمثل (50% من الموصى بة).

2- 34.5 كجم نتروجين للفدان تمثل (75% من الموصى بة).

3- 46 كجم نتروجين للفدان تمثل (100% من الموصى بة).

4-69 كجم نتروجين للفدان تمثل (150% من الموصى بة).

وكانت أهم النتائج المتحصل عليها كالتالي:-

- أوضحت النتائج أن الري بعمق 5سم طوال الموسم أعطى أعلى القيم لكلا من محصول الحبوب والقش للأرز بينما الري حتى حد التشبع طوال الموسم أعطى اقل القيم لهما وذلك خلال موسمي الدراسة.
- كذلك أوضحت النتائج ان التسميد النتروجينى بمعدل 69 كجم نتروجين للفدان مع الري بعمق 5 سم طوال الموسم أعطى أعلى القيم لمحصولي الحبوب والقش للأرز بينما التسميد النتروجينى بمعدل 23 كجم نتروجين للفدان مع الري حتى حد التشبع طوال الموسم أعطى اقل قيم للمحصول خلال موسمي الزراعة.
- وتوضح النتائج أيضا أن استخدام الري بعمق 5سم طوال الموسم مع التسميد النتروجينى بمعدل 69 كجم ن/ فدان أدى إلى زيادة كلا من وزن الألف حبة, وطول السنبلة, وطول النبات بينما استخدام الري حتى حد التشبع طوال الموسم مع التسميد النتروجينى بمعدل 23 كجم ن/فدان أدت إلى انخفاض تلك القيم خلال موسمي الدراسة.

- أوضحت النتائج ان معاملة الري بعمق 5سم طوال الموسم اخذ ت أعلى كمية من المياه المضافة بينما الري بمعاملة الري حتى حد التشبع طوال الموسم أخذت اقل كمية من المياه المضافة خلال موسمي الزراعة.
- أوضحت النتائج أن معاملة الري عند حد التشبع طوال الموسم سجلت أعلى قيم من المياه المتوفرة من كميات مياه الري المضافة بينما معاملة الري بعمق 5 سم طوال الموسم سجلت اقل قيم من كميات المياه المضافة وذلك مقارنة بكميات مياه الري التقليدي والتي تبلغ حوالي(7500 م3/فدان).
- تبين من النتائج أن معاملة الري بعمق 5سم طوال الموسم سجلت أعلى كفاءة لاستخدام المحصول للمياه مقارنة بباقي المعاملات بينما سجلت معاملة الري عند حد التشبع اقل القيم في كلا موسمي الدراسة.

وتبين من النتائج أن معاملة الري عند حد التشبع طوال الموسم سجلت اعلي كفاءة لاستخدام مياه الحقل بينما سجلت معاملة الري بعمق 5 سم طوال الموسم اقل القيم وذلك خلال موسمي الدراسة.

لذا يوصى بإضافة مياه الري بعمق غمر 5سم فوق سطح التربة طوال الموسم لمحصول الأرز مع إضافة 150% من المعدل الموصى بة من السماد النتروجينى (69 كجم ن / فدان) في منطقة شمال الدلتا.

قام بتحكيم البحث

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