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IRRIGATION WATER DEPTHS AND NITROGEN FERTILIZER LEVELS FOR RICE PRODUCTION UNDER TWO WATER TABLE LEVELS

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ABSTRACT

Field experiment was conducted at El-Serw Agricultural Research Station (North of Delta, Egypt) during the 2004 and 2005 summer season. The study is concerned with the effect of water table levels (40 to 50 cm and 70 to 80 cm), irrigation water depths (4.5, 9 and 12 cm) and nitrogen fertilizer levels 30, 60 and 90 k N $fed.^{-1}$) on rice yield, yield components, amount of applied water, actual evapotranspiration (ETa), seepage, percolation losses, and water use efficiency. The early maturing rice cultivar Giza 178 was used in this experiment. A split-split- plot design with four replicates was used. The results indicated that the highest value of water use efficiency (WUE) is 0.76 kg grain/ m^3 for deep water table (70-80 cm), irrigation water depth 9 cm with nitrogen fertilizer 60 kg $fed.^{-1}$.

INTRODUCTION

Rice is the main cereal summer crop. It is a semi-aquatic plant and needs large quantity of water compared to the other field crops. It needs careful water and nitrogen fertilization management in order to obtain the high efficiency use of water and nitrogen. Percolation losses are a function of the local soil and topographic conditions. Irrigation water entering a soil becomes greater than its water-holding capacity, loss by the downward movement of free water will occur. Seepage normally flows onto the soil surface or into streams, rivers, or drainage waterways, while percolation flow usually moves to the water table, because it occurs simultaneously and are difficult to separate in the field, seepage and percolation are usually considered together, De Deatta (1981).

Awad *et al.* (1995) concluded that the irrigation depth of 9 cm with the nitrogen fertilizer level of 60g kg $Nfed.^{-1}$ could be recommended to obtain the best results from rice crop grown under El-Serw area conditions.

Anbumozhi *et al.* (1998) indicated that high values of water productivity were found at 9 cm ponding water depth under different water regimes and fertilization levels. Zeng *et al.* (2003) found that plants performed better with respect to seeding establishment and grain yield in shallow water (i.e. <10cm) than in deep water (i.e.>10cm).Under salt stress, the effect of water depth was significant for panicle number but not significant for panicle weight. El-Kholy *et al.* (1999) indicated that the application of nitrogen fertilization at the rate of 60kg N $fed.^{-1}$ produced the highest yield. De Datta (1981) concluded that a percolation rate of 10-15 mm / day was favorable for supply of dissolved oxygen. The removal of harmful substances, and the maintenance of root activity. In fact, with some situations, the loss of plant nutrients may be serious if the percolation rate is high.

The object of this work is studying the effect of irrigation water depth, nitrogen levels and water table levels on Rice yield, yield components, amount of applied irrigation water and water use efficiency under the North of Delta conditions.

MATERIALS AND METHODS

Field experiment was conducted at EL-Serw Agricultural Research Station Farm (North of Delta, Egypt) during the 2004 and 2005 summer seasons. Soil texture of the experimental site is classified as clayey soil and mainly characterized by pH= 8.05, $CaCO_3$ content 2.5%, organic matter content= 0.87% exchangeable sodium percentage (E.S.P.) = 8.3 and the average electrical conductivity value of soil extract (E.C.) = 4.6 dSm^{-1}. Rice, variety Giza 178, was planted in this experiment. Dates of the main cultural practices during the two growing seasons are presented in Table 1. Nitrogen fertilizer in the form of urea (46%N) was applied in two equal doses the first was applied 14 days after transplanting and the second was added at panicle initiation. A split-split plot experimental design with four replications was used to conduct this experiment. The main plots were assigned for two water table levels. The sub plots were assigned for irrigation water depth treatments, while the sub-sub plots were assigned for the nitrogen level treatments.

Table 1: Date of the main cultural practices for rice during the 2004 and 2005 growing seasons.

Cultural practice	Season 2004	Season 2005
Sowing	May 3rd	May 1st
Transplanting	June 13th	June 11th
N-application		
1st dose	June 27th	June 25th
2nd dose	July 17th	July 15th
Harvesting	September 17th	September 15th

The experimental area was 42 m^2 the tested variables were;

Water table levels:

1. Shallow water table (S) (average 40 to 50 cm)
2. Deep water table (D) (average 70 to 80 cm)

These values were measured before growing seasons.

Irrigation water depth:

1_1: Ponding water depth 4.5 cm. all season.
1_2: Ponding water depth 9 cm. all season.
1_3: Ponding water depth 12 cm. all season.

Nitrogen fertilizer levels:

N_1: Applying 30 kg $Nfed.^{-1}$.
N_2: Applying 60 kg $Nfed.^{-1}$.
N_3: Applying 90 kg $Nfed.^{-1}$.

Plant growth and yield determination:

Just before harvest, ten guarded plants were selected from each plot to determine plant height, panicle length and 1000-grain weight. Number of panicles per square meter was also determined. At harvest time one square meter from each plot was harvested by hand for grain and straw yields determination.

Water parameters:

Applied water:

The amount of applied irrigation water delivered to each experimental plot was measured by using the cut-throat flume. The dimensions of the used flume were 20 x 90 cm.

Seepage, percolation measurements and actual evapotranspiration (ETa):

The seepage and percolation measurements were calculated from data obtained from sets of tanks installed in one plots of each irrigation water depth treatments and two water table levels. Each set consists of two tanks. The first an open tanks at the top and the bottom (95 cm in diameter and 100 cm long) which was used to determined the total amount of applied irrigation water needed to replenish losses through evapotranspiration, seepage and percolation. The second is a closed tank at the bottom only to determine the actual evapotranspiration (ETa) values. Rice plants were transplanted into the tanks and were treated similar to the plants grown in the open field.

3- Water Utilization Efficiency (WUE).

Water utilization efficiency values for the two growing seasons were calculated according to the following equation:

$$WUE = \frac{\text{Rice grain yield (kg)}}{\text{Amount of applied water (m}^3\text{)}}$$

Statistical analysis:

Data collected from each plot were analyzed using the Co-Hort Software (1986) statistical package. Average grain and straw yields from the four replicates of each treatment were interpreted using the analysis of variance (ANOVA). The Student – Newman – Keuls Test (SNK) was used for comparisons between the different sources of variation.

RESULTS AND DISCUSSION

Rice grain yield:

The effects of water table, irrigation water depth and nitrogen fertilizer levels on rice grain yield (kg fed.$^{-1}$) for the two growing seasons are shown in Table 2. Results indicate that, the grain yield obtained from deep water table, irrigation water depth I_2 (9 cm) and nitrogen fertilizer level N_2 (60 kg N fed^{-1}) was higher than the other treatments. These results are in agreement with those reported by Awad *et al.* (1995), Anbumozhi *et al.*

(1998), *Zeng et al.* (2003) and El-Kholy *et al.* (1999). The interaction between nitrogen levels, irrigation depths and water table levels is presented in Table 2. There were a significant effects in some cases W. D. and W.T.

Table 2: Effect of water table levels, irrigation water depth and nitrogen fertilizer levels on rice grain and straw yield (kg fed^{-1})

Treatment	Grain yield (kg fed^{-1})		Straw yield (kg fed^{-1})	
	2004	2005	2004	2005
Nitrogen fertilizer levels.				
N_1	2831 c	2677 c	3275 c	3241 c
N_2	3290 a	3143 a	3732 b	3520 b
N_3	3033 b	2841 b	3876 a	3811 a
L.S.D. 0.05	88.28	162.89	8.26	11.83
Irrigation water depth.				
I_1	2979 b	2815 b	3544 c	3396 c
I_2	3277 a	3065 a	3736 a	3691 a
I_3	2899 b	2780 b	3603 b	3486 b
L.S.D. 0.05	97.04	135.57	9.81	12.66
Water table levels.				
Shallow	2725 b	2541 b	3587 b	3474 b
Deep	3378 a	3232 a	3669 a	3574 a
L.S.D. 0.05	274.33	212.73	11.15	10.34
Interactions				
N. f.	***	***	***	***
W. d	***	**	***	***
W. t.	**	**	***	**
N. f. x W. d.	N.S	N.S	***	***
N. f. x W. t.	*	N.S	***	***
W. d. x W. t.	***	**	**	***
N. f. x W. d. x W. t.	*	N.S	***	***

Rice straw yield:

The effect of tested variables on rice straw yield for the two growing seasons is presented in Table 2. Results reveal that there was a significant effect of the N- fertilizer levels, irrigation water depth and water table levels. Results showed that, there was a significant increase in the straw yield with increase in N- fertilizer level from N_1 to N_3 (30 to 90 kg N fed.$^{-1}$).but the highest straw yield obtained from I_2 ponding water depth 9 cm and deep water table are 70 to 80 cm. These results are in agreement with those reported by Anbumozhi *et al.* (1998) and Zeng *et al.* (2003).

Yield components:

The effect of water table, irrigation water depth and nitrogen fertilizer levels on the yield components are presented in Table 3. Shows that plant height (cm) increased significantly with increased N- fertilizer, water depth and water table level. Also the highest values for the panicle length (cm), average number of panicles/ m^2 and 1000 grain weight values were at N_2. There was no a significant difference between ingestion water depths for average number of panicle /m^2 and 1000 grains weight (g).Also the Highest values for these parameters were obtained from deep water table level. The obtained results agree with the result of El-Kholy *et al.* (1999) and De Datta (1981).

Applied water:

The amount of applied water to each plot is presented in Table 4. The table result shows that, applied water was increased by the increasing irrigation depth. Irrigation water was increased by increasing the nitrogen fertilizer from N_1 to N_3. Also irrigation water was increased by increasing water table levels from average 50 to average 80 cm under soil surface, this is depth increasing in the percolation losses. These results are in agreement with those obtained with De Datta (1981), Awad *et al.* (1995) and Zeng *et al.* (2003).

Actual evapotranspiration (ETa) and average seepage and percolation measurements:

An average values of actual evapotranspiration (ETa) and average seepage and percolation losses (cm) for treatments for two growing seasons. Results indicate that (ETa) values for N_1, N_2 and N_3 treatments were 77.5, 79.2 and 83.5 cm respectively for I_1, I_2 and I_3 treatments. Also results indicated that the average seepage and percolation losses for water table levels for two growing seasons were 14.1, 20.4 and 26.9 cm for 50 cm water table and 19.8, 37.2 and 54.6 cm for 80 cm water table for 4.5, 9 and 12 cm ponding water depth respectively.

Table 3: Effect of water table levels, irrigation water depth and nitrogen fertilizer levels on yield components.

Treatments.	Plant height (cm)		Panicle length (cm)		Average Number of panicles/ m^2		1000 grain weight (g)	
	2004	2005	2004	2005	2004	2005	2004	2005
Nitrogen fertilizer levels.								
N_1	69.3 c	68.1 c	17.7 c	17.0 b	432.3 b	429.3 b	19.8 c	19.3 c
N_2	74.9 b	73.3 b	20.5 a	19.8 a	592.8 a	627.5 a	22.2 a	22.0 a
N_3	81.3 a	77.9 a	19.7 b	19.5 a	596.2 a	610.6 a	20.5 b	20.0 b
L.S.D. 0.05	0.87	1.1	0.31	0.45	29.7	41.37	0.17	0.11
Irrigation depth.								
I_1	74.26 b	70.8 c	19.2 b	19.2 a	521.6 b	543.0 a	20.7 b	20.5 a
I_2	75.8 a	73.1 b	20.1 a	19.3 a	570.0 a	576.4 a	21.0 a	20.5 a
I_3	75.5 a	75.3 a	19.0 b	17.8 b	529.7 b	547.9 a	20.8 a	20.4 a
L.S.D. 0.05	0.77	1.41	0.32	0.62	29.21	41.37	0.17	0.11
Water table levels.								
Shallow	74.3 b	72.4 b	19.0 b	18.7 a	521.6 b	535.8 b	20.6 b	20.3 b
Deep	76.0 a	73.8 a	19.7 a	18.7 a	559.3 a	575.7 a	21.1 a	20.6 a
L.S.D. 0.05	0.94	0.42	0.65	0.46	23.85	33.7	0.15	0.11
Interactions								
N. f.	***	***	***	***	***	***	***	***
W. d	**	***	***	***	*	N.S	*	N.S
W. t.	*	**	*	N.S	N.S	N.S	**	**
N. f. x W. d.	*	**	N.S	*	***	***	***	***
N. f. x W. t.	***	***	N.S	**	N.S	N.S	***	***
W. d. x W. t.	***	**	*	N.S	N.S	N.S	*	***
N. f. x W. d. x W. t.	***	*	***	***	***	N.S	***	***

Table 4: The amount of applied irrigation water (m^3 $fed.^{-1}$) as the effect of water table levels, irrigation water depth and nitrogen fertilizer levels.

Treatment			I_1	I_2	I_3	Ave.
Season 2004	Shallow water table	N_1	3864	4116	4410	4130
		N_2	3927	4221	4464	4204
		N_3	4158	4368	4662	4396
		Ave.	3983	4235	4512	
	Deep water table	N_1	4074	4830	5566	4830
		N_2	4242	4914	5628	4928
		N_3	4368	5082	5817	5089
		Ave.	4228	4942	5677	
Season 2005	Shallow water table	N_1	3822	4095	4368	4095
		N_2	3893	4166	4439	4166
		N_3	4074	4347	4620	4347
		Ave.	3929	4202	4475	
	Deep water table	N_1	4053	4809	5544	4802
		N_2	4116	4880	5615	4870
		N_3	4305	5061	5796	5054
		Ave.	4158	4916	5651	

Those values were measure after transplanting and up to harvesting process.

Water Use Efficiency:

Data in table 5: Show that the highest value of water use efficiency for treatments is 0.76 kg grain/ m^3 for deep water table, irrigation water depth 9 cm and nitrogen fertilizer 60 kg N $fed.^{-1}$ It could be concluded that ponding water depth 9 cm, nitrogen fertilizer 60 kg N $fed.^{-1}$ and 70 to 80 cm water table proved to be the best practices for rice production under North of Delta conditions.

Table 5: Average water use efficiency (WUE) values as affected by water table levels, irrigation water depth and nitrogen fertilizer levels.

Treatment			I_1	I_2	I_3	Ave.
Season 2004	Shallow water table	N_1	0.55	0.72	0.56	0.61
		N_2	0.65	0.73	0.63	0.67
		N_3	0.59	0.70	0.54	0.61
		Ave.	0.59	0.71	0.57	
	Deep water table	N_1	0.66	0.68	0.59	0.64
		N_2	0.72	0.67	0.57	0.68
		N_3	0.66	0.64	0.56	0.62
		Ave.	0.68	0.69	0.56	
Season 2005	Shallow water table	N_1	0.52	0.69	0.51	0.57
		N_2	0.64	0.72	0.59	0.65
		N_3	0.57	0.68	0.51	0.58
		Ave.	0.57	0.69	0.53	
	Deep water table	N_1	0.65	0.67	0.50	0.60
		N_2	0.70	0.76	0.56	0.67
		N_3	0.64	0.65	0.57	0.62
		Ave.	0.66	0.69	0.54	

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أعماق ماء الري ومستويات التسميد النيتروجيني لإنتاج الأرز تحت مستويين مختلفين من الماء الأرضي

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أقيمت تجربتين حقليتين في مزرعة محطة البحوث الزراعية بالسرو شمال الدلتا بمصر خلال صيف ٢٠٠٤و ٢٠٠٥ وذلك لدراسة تأثير مستويين للماء الأرضي من ٤٠ إلي سم٥٠ ومن ٧٠ إلي ٨٠ سم وثلاث أعماق من ماء الري ٤,٥، ٩، ١٢ سم وثلاثة مستويات من التسميد النتروجيني ٣٠، ٦٠، ٩٠ كيلو جرام نتروجين للفدان علي محصول الأرز ومكوناته وكمية الماء المضاف للري والاستهلاك المائي والتسييل والرشح والكفاءة الإستعمالية للماء ولقد استخدم الصنف جيزة ١٧٨ واستخدمت تصميم القطع المنشقة مرتين للتجربة وأربع مكررات وكانت النتائج المتحصل عليها كالتالي:

كانت أعلي كفاءة لاستعمال الماء هي ٠,٧٦ كيلو جرام أرز لكل متر مكعب ماء ري وذلك للمعاملة ذات الماء الأرضي العميق من ٧٠ إلي ٨٠ سم عمق ماء ري ٩ سم وتسميد ٦٠ كيلو جرام للفدان.