Maximize The Yield and Water Productivity by Investigating The Most Appropriate Rice Transplanting Methods under Saline and Non Saline Soils in North Delta of Egypt

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ABSTRACT

A field experiments was conducted at Sakha Agricultural Research Station, Kafr El-Sheikh Governorate in two soils (saline and non saline) during 2009 / 2010 rice growing season. The present study was designed to determine the most appropriate rice (*Oryza sativa* L.) transplanting methods to maximize the productivity of rice grain yield, net profit and water productivity of rice crop in North Delta, Egypt.

The experimental design was a randomized complete block with four replications. Eight treatments were established in the permanent field, as follows:

T1 (random transplanting),

T2 (regular transplanting 20 x 20 cm),

T3 (transplanting on beds 80 cm wide), seedlings were transplanting in hills (4-5 plants) on two sides,

T4 (transplanting on beds 80 cm wide), seedlings were transplanted in hills (4-5 plants) on bottom,

T5 (transplanting on beds 80 cm wide), seedlings were transplanted in hills (4-5 plants) on top and bottom,

T6 (transplanting of furrows 60 cm wide), seedlings were transplanted in hills (4-5 plants) on two sides,

T7 (transplanting of furrow 60 cm wide), seedlings were transplanted in hills (4-5 plants) on bottom.

T8 (transplanting of furrows 60cm wide), seedlings were transplanted in hills (4-5 plants) on top and bottom.

The following results could be summarized as follows:

Data showed that the traditional method of transplanting received the highest amount of irrigation water. While, the transplanting on beds and furrow used less amount of irrigation water compared to traditional method of transplanting and regular transplanting method.

Data revealed that the irrigation water can be saved by 0.336, 1.204, 1.277, 1.108, 1.025, 1.066 and 0.932 m^3/fed. With T2, T3, T4, T5, T6, T7 and T8 compared to conventional transplanting method. This quantity of water saving could be enough to cultivate rice area; 51.43, 185.6, 196.84, 170.66, 158.07, 164.36 and 143.68 thousands feddans under Kafr El-Sheikh governorate condition.

Data indicated that the highest values of field water use efficiency was obtained from T3 (transplanting on beds 80 cm wide), seedlings were transplanted in hills (4-5 plants) on two sides in normal and saline soils. While, the lowest value was resulted from T1 (traditional method of transplanting) under normal and saline soils conditions. Data showed that the maximum rice grain and straw yield were produced by the treatment of T2 compared to T1 in both seasons. The lowest grain and straw yield were recorded with T7 and T8 transplanting method. The highest mean values of 1000-grain weight were obtained by T7 treatment in normal and saline soils, respectively. While, the lowest values were resulted from T1 in normal soil and T4 in saline soil.

Data indicated that the highest values of total income, net profit, water productivity and economic efficiency were realized when using regular transplanting of rice at North Delta. While, the lowest values were recorded with transplanting rice on beds and bottom of furrows with 60 cm wide.

INTRODUCTION

Rice is one of the most important crops in Egypt providing a high source of income. It is a main stable food for the majority of the population and has become a cash crop. All the rice cultivated in Egypt is low-land rice. So, despite of the free cropping pattern policy which has been adopted in the 1980, rice remains an exception such that the areas entitled to cultivate rice are defined by the Ministry of Water Resources and Irrigation (MWRI) to about 1.1 million fed. /year. Regarding the Egyptian conditions, rice is one of the major water consuming crops and continuous flooding is the only method used for irrigation by the farmers. The limitation of water resources and the remarkable increase in population should be forced research workers to find ways for saving some of this water without significant reduction in yield. Thus, saving the water is becoming decisive factor for agricultural expansion. Great efforts should be done through improving the agronomic practices, such as planting methods and water management to finding ways for saving more irrigation water.

Egypt is becoming more and more a water poor country. The per capita share of water is now 780 m^3/person/year, which is below the so-called poverty line and expected to go further down with time. Irrigation is generally defined as the application of water to soil for the purpose of supplying the moisture essential for plant

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growth. However, efficient use of irrigation water is an obligation of each user. However, efficiency of water use will vary from method to another. In areas where water is scarce and costly, available water should be used carefully.

Water is considered the major constraint for any policy to increase agriculture productivity. Since the present water supply is limited, water demand is augmenting to face the incessant increase in population. Thus, it was necessary to control and manage the available water supply to face overuse problem and minimize water losses from water courses to improve irrigation efficiency. Sufficient water should be applied to the plant to obtain the highest possible yields with less losses of water over irrigation pushes water beyond the root zone or be accumulated at tail end of the field causing excessive run off and plant health degradation.

To mitigate the increasing water scarcity in Egypt, new ways of growing rice need to be developed that use less water than conventional low land rice.

The present study is designed to determine the most appropriate planting method of rice which can maximize yield and net profit in North Delta, Egypt. It may be interested to evaluate these planting methods together through their impacts on water use efficiency and rice crop production. So, the objectives of this research are to study the effect of different planting methods on irrigation efficiencies, calculating the amount of water saving and effect of different planting methods on the yield of rice crop as well as water use efficiency.

MATERIALIS AND METHODS

One field experiment was conducted during 2009/2010 rice seasons in two soils (saline and non saline) at Sakha Agriculture Research station, Kafr El-Sheikh Governorate. The present study was designed to determine the most appropriate planting method and water productivity of rice to maximize the rice grain yield in North Delta, Egypt.

The experimental design was randomized complete block with four replicates. The experiment consists of 32 plots and each plot was 10.5 m^2 (3 x 3.5 m). Eight treatments were established in the permanent field, as follows:

T1= (random transplanting) random transplanting of rice seedlings on flat soil.

T2= Regular transplanting on flat soil 20 x 20 cm.

T3= Transplanting on beds 80 cm wide, seedlings were transplanted in hills (4-5 plants) on two sides.

T4= Transplanting on beds 80 cm, wide, seedlings were transplanted in hills (4-5 plants) on bottom.

T5= Transplanting on beds 80 cm wide, seedlings were transplanted in hills (4-5 plants) on top and bottom.

T6= Transplanting of furrows 60 cm wide, seedlings were transplanted in hills (4-5 plants) on two sides.

T7= Transplanting of furrows 60 cm wide, seedlings were transplanted in hills (4-5 plants) on bottom.

T8= Transplanting of furrow 60 cm wide, seedling were transplanted in hills (4-5 plants) on top and bottom.

The plant density on all above mentioned planting methods has been adjusted to be 25 hills / m^2.

The amount of irrigation water delivered to the plots of the different treatments was measured and recorded using the cut-throat flumes (30-90 cm). The amount of water used was calculated for both land preparation and nurseries (30 days seedling age) and permanent field. Plots were continuously flooded to a depth of 7 cm as a static head above soil surface every six days for the traditional planting and 7 cm from the bottom to the top of furrows and beds. The amount of irrigation water delivered to each treatment was also recorded and added to get the total used. Irrigation of the permanent field started after six days from transplanting process and stopped at 25 days after complete heading (one week before harvesting) in both seasons. Field water use efficiency (FWUE) was calculated according to Michael (1978).

$$\text{FWUE (kg/m}^3\text{)} = \frac{\text{Rice grain yield (kg/fed.)}}{\text{Total amount of water applied (m}^3\text{/fed.)}}$$

Rice cultivars Sakha 104 was sown in the nursery on June 1st and 5th in 2009 and 2010, respectively. Thirty days old seedlings were transplanted in hills at spacing 20 by 20 cm to give 25 hills/m^2 for random transplanting and spaced (13 by 13 cm) in the two rows in bottom of furrows to keep population on 25 hills/m2 for furrows, and spaced (10 by 10 cm) in the two rows in bottom of bed to keep population on 25 hills/m2 for beds. Cultural practices were similar to those used in the area. Rice plants were harvested at 135 days from sowing. Rice yield was determined by crop-cut sampling in two diagonally opposite corners of each plot using a 1 m x 1 m sampling frame in the experiment. Ten plants were chosen at random from this frame to determine: Plant height (cm), Spike length (cm),No. of tillers/plant, No. of grains/spike, Rice grain and straw yield (ton/fed.), Spike weight (gm),1000 grain weight (gm)

Soil samples were compared before planting from different soil layers, air dried, ground, sieved and stored for physical and chemical analysis were presented in Table (1). Particle size distribution for soil was carried out using the pipette method, as described by (Dewis and Farias, 1970).

Table1. Chemical properties of the soil samples taken from Sakha Agricultural Research station, in the normal and saline soils

Depth (cm)	EC ds/m	PH	SAR	Soluble cations (meq/L)				Soluble anions (meg/L)			
				Na^+	K^+	Ca^{++}	Mg^{++}	$CO_3^=$	HCO_3^-	Cl^-	$SO_4^=$
Normal soil											
0-30	3.82	7.96	10.79	27.10	0.6	7.60	5.00	0.0	4.50	19.0	11.4
30-60	3.62	8.05	10.54	25.70	0.5	7.20	4.70	0.0	4.00	18.0	11.1
Saline soil											
0-30	7.50	8.1	13.51	51.0	0.8	12.0	16.5	0.0	9	35.7	35.6
30-60	7.65	8.09	13.64	52.0	0.8	12.2	16.8	0.0	9.5	36.4	35.9

All the obtained data were statistically analyzed using analysis of variance technique and significant means were separated using least significant difference test (LSD) for comparing the treatment means Snedecor and Cochran (1980).

Bulk density was determined using cylindrical sharp edged as described by Vomocil (1957). Soil chemical analysis was determined according to Jackson (1967). Sodium adsorption ration (SAR) was calculated in soil paste extract as follows:

$$SAR = \frac{Na}{\sqrt{(Ca^{++} + Mg^{++})/2}}$$

Where: SAR= Sodium adsorption ratio. Field capacity (FC) and permanent wilting point (PWP) were determined by using pressure membrane at 1/3 and 15 bar, respectively (Black, 1965).Available water (AW) was calculated as a difference between field capacity and wilting point values (James, 1988).

RESULTS AND DISCUSSION

Effect of different planting methods on some water relations:

The amount of irrigation water applied is presented in Table (2). The total amount of applied water for each season during rice growth stages was varied according to the differences between planting methods. All tests of transplanting on beds and furrows methods used less amount of water compared to traditional transplanting and regular transplanting methods.

Average volumes of applied water for traditional transplanting were 6485 and 6675 m^3/fed for seasons 2009 and 2010, respectively. The average volumes of applied water for regular transplanting method on flat soil were 5831, 5978 m^3/fed. for normal and saline soils, respectively.

Data obtained showed that, the total amount of water applied were 4125, 3982, 4315, 4475, 4395 and 4658 m^3/fed., and 4245, 4193, 4445, 4567, 4643 and 4813 m^3/fed. For T3, T4, T5, T6, T7 and T8 treatments over both normal and saline soils, respectively.

It was evident that T1 (traditional transplanting) transplanting of rice seedlings on flat soil received the highest amount of irrigation water for normal and saline soils, respectively. While T4 (transplanting on beds 80 cm wide, which seedlings were transplanted in hills (4-5 plants) on bottom received the lowest amount of irrigation water for normal and saline soils, respectively. This difference between the tested planting methods could be attributed to shortening the time of applying irrigation water where the water was added by the required depth only beneath the furrows or beds in case of T4 treatment while in case of T1 treatment the whole field is inundated with irrigation water which most of it may be lost due to seepage and deep percolation.

The irrigation water applied was 9028.6, 10047.6 and 15628.6 m^3/ha for planting in strips of furrows 80 cm wide, planting in strips of furrows 60 cm wide and traditional planting (Atta et al., 2006), respectively.Meleha et al. (2008) showed that the means of irrigation water applied were 1480 mm, 1013 mm, and 919 mm for traditional planting, planting in bottom of furrows and beds, respectively. Methods of planting in bottom of furrows and beds saved 31.06% and 37.9% of irrigation water compared to traditional planting method, respectively.

Saving Water:

Table (2) indicated that the amount of water saving compared to T1 in the treatments of T2, T3, T4, T5, T6, T7 and T8 were 654 (10.08%), 2360 (36.39%), 2503 (38.59%), 2170 (33.46%),2010 (31.0%), 2090 (32.23%) and 1827 (28.17%) m^3/ fed. in the normal soil and 697 (10.44%), 2430 (36.40%), 2482 (37.18%), 2230 (33.41%), 2108 (31.58%), 2212 (33.14%) and 1862(27.89%) m^3/fed. in the saline soil, respectively, as compared to traditional method.

Such results indicate that the planting of rice in beds (T4) and furrows (T7) saved 38.59%, 37.18% and 32.23%, 33.14% of irrigation water compared to traditional planting method over the two seasons, respectively. The results are in accordance with those reported by Atta et al. (2006), Jagroop et al. (2007), and Meleha et al. (2008).

Table 2.Amount of water saving (m^3/fed.) due to different planting methods for rice crop in normal soil and saline soil

Treatments		Total water applied (m^3 /fed)	Water saving	
			m^3/fed	%
Normal soil	T2	5831	654	10.08
	T3	4125	2360	36.39
	T4	3982	2503	38.59
	T5	4315	2170	33.46
	T6	4475	2010	31.00
	T7	4395	2090	32.23
	T8	4658	1827	28.17
Saline soil	T2	5978	697	10.44
	T3	4245	2430	36.40
	T4	4193	2482	37.18
	T5	4445	2230	33.41
	T6	4567	2108	31.58
	T7	4463	2212	33.14
	T8	5978	697	10.44

In general, it can be concluded that water is becoming an economically scarce resource in many areas in the world. So, the use of transplanting of beds (T4, T3 and T5) or furrows (T7) becomes very important to save and optimize use of water, estimating economic of irrigation water becomes very important for planning irrigation management.

Table (2) showed that the irrigation water can be saved by 0.336, 1.204, 1.277, 1.108, 1.025, 1.066 and 0.932 m^3/fed., with T2, T3, T4, T5, T6, T7 and T8 compared to conventional transplanting method which represents the farmers practices in the studied area under Kafr El-Sheikh conditions in the normal soil.

In the Saline soil, the irrigation water can be saved by 0.418, 1.458, 1.489, 1.338, 1.242, 1.327 and 1.117 m^3/fed with T2, T3, T4, T5, T6, T7 and T8 treatments methods compared to conventional transplanting method which represents the farmer practices in the studied area under Kafr El-Sheikh conditions.

Therefore, it can be concluded that the area cultivated by rice may be increased in the future if the farmers apply these techniques of planting methods.

Field water use efficiency (FWUE):

Table (3) showed that the highest value of field water use efficiency (0.697 kg/m3) was obtained from T3 (transplanting on beds 80 cm, wide) and seedlings were transplanted in hills (4-5 plants) on two sides. While, the lowest value of field water use efficiency (0.395 kg/m3) was resulted from the T8 (transplanting of furrows 60 cm wide, seedling were transplanted in hills (4-5 plants) on top and bottom under normal soil conditions. While, under saline soil conditions, the highest value of (0.664 kg/fed.) was obtained by the treatment of T3 and the lowest value (0.420 kg/m^3) is resulted from T1 (traditional transplanting) of rice seedlings on flat soil.

It could be noticed that field water use efficiency values were higher for treatments having higher rice yield (grain and straw) and less water applied. Depending on the intended purpose and the domain of interest, many efficiency concepts are involved such as crop water-use efficiency, water application efficiency, and others (Israelsen, 1962; Jensen, 1980). Such finding could be ascribed to the marked reduction in the amount of water used with a significant increase in grain yield. Similar results were obtained by Atta (2005), Atta et al. (2006) and Meleha et al. (2008).

Effect of transplanting methods on yield and yield components of rice under normal soil condition:

Table (4) showed that the maximum rice grain yield (3.445 ton/fed) was produced by the treatment T2. Results indicated that the maximum values of relative change ± % was increased by 3.13% with the treatment of T2 as compared with traditional transplanting method (T1) on the other hand grain yield decreased by the rest treatments as compared with traditional transplanting method (T1) under normal soil condition. These results are in agreement with those obtained by Ockerby and Fukaib (2001) who pointed out that the rice grain yield ranged from 710 to 1250 g/m^2 and was slightly greater in paddy than raised beds.

Data in Table (4) showed that the maximum paddy straw yield (3.963 ton /fed) was produced by the treatment of T2. The relative increase was about

(8.52%) by T2 treatment, but it was decreased by the other transplanting methods, as compared with the normal transplanting. The lowest straw yield is obtained by T7and T8 transplanting methods since it produced grain and straw yield lower than that produced by T2 transplanting method.

Data in Table (5) indicated that the 1000 grain weights of the rice have been highly significantly affected by transplanting methods. The highest mean value was 5.77 by T7 treatment and the lowest value 5.14g was recorded by T1 treatment, under normal soil condition.

Table (5) results pointed out that the panicle weight (g) of the rice had been highly significantly affected by transplanting methods. The highest mean obtained value was 3.98 g by T6 while, the lowest value was recorded by transplanting methods (T7), respectively. Results show highly significant differences existed due to transplanting methods. Where transplanting method (T4) gave the highest number of grains/panicle (133.5), as compared with transplanting methods (T8) which recorded (111) grains/panicle, respectively. Table (6) revealed that the No. of tillers/plant of the rice, have been highly significantly affected by transplanting methods. The highest mean value (15.8) were achieved by transplanting method (T6) while the lowest value was recorded by transplanting method of (T8) as compared with traditional irrigation transplanting.

Table 3. Field water use efficiency (kg /m^3) as affected by different planting methods under normal and saline soil conditions

Treatment	Rice grain yield (ton/fed)	Rice straw yield (ton/fed)	Total water applied (m^3/ fed)	Field water use efficiency (kg/ m^3)	
				Grain (kg/m^3)	Straw (kg/m^3)
			Normal soil		
T1	3.337a	3.652b	6485	0.515	0.563
T2	3.445 a	3.963a	5831	0.590	0.679
T3	2.875b	3.411c	4125	0.697	0.827
T4	2.583c	2.913d	3982	0.649	0.731
T5	2.347d	2.699e	4315	0.544	0.626
T6	2.572c	2.948d	4475	0.575	0.659
T7	1.969e	2.221f	4395	0.448	0.505
T8	1.843f	2.141g	4658	0.395	0.459
			Saline soil		
T1	2.805bc	4.212a	6675	0.420	0.547
T2	3.23a	4.132a	5978	0.540	0.663
T3	2.821b	3.213b	4245	0.664	0.804
T4	2.570bcd	2.814c	4193	0.613	0.695
T5	2.483 d	2.745c	4445	0.559	0.607
T6	2.526cd	2.907c	4567	0.553	0.646
T7	2.197e	2.452 d	4463	0.492	0.498
T8	2.037 e	2.272 d	4813	0.423	0.445

Table 4. Effect of transplanting methods on grain and straw yield of Rice *(Oryza sativa* L.*)* under normal soil conditions

Treatments	Grain yield (ton/fed*)*	Relative Change ± % compared to T1	Straw yield (ton/fed)	Relative change % (±) compared to T1
		Irrigation system (I)		
T1	3.337a	00.0	3.652b	00.0
T2	3.445 a	3.13	3.963a	8.52
T3	2.875b	-13.84	3.411c	-6.60
T4	2.583c	-22.60	2.913d	-20.24
T5	2.347d	-29.67	2.699e	-26.10
T6	2.572c	-22.92	2.948d	-19.28
T7	1.969e	-40.99	2.221f	-39.18
T8	1.843f	-44.77	2.141g	-41.37
F-test	* *	-	* *	-

** Highly significant at 0.01 probability level.

Table 5. Effect of transplanting methods on yield and yield components of rice (Oryza sativa L.) under normal soil conditions

Treatments	1000 grain weight (g)	Panicle weight (g)	No. of grains/ panicle	No. of tillers/ hill	Panicle length (cm)	Plant height (cm)
T1	20.56 b	3.03 de	132.5 a	14.75 c	21.25 be	79.0 c
T2	21.96 a	3.76 a	119.7 b	20.25 a	21.75 ab	90.0 a
T3	22.28 a	3.3 cd	95.5d	18.5 b	17.75 d	81.5bc
T4	22.00 a	3.49 be	133.5 a	15.0 c	21.25 be	83.5 b
T5	22.76 a	3.27 cd	132.5 a	16.0 c	22.75 a	88.5 a
T6	22.24 a	3.98 a	121.7 b	18.25 b	21.5 ab	80 be
T7	23.08a	2.65 e	95.5 d	10.0 d	21.25 be	83.25b
T8	22.68 a	3.26 cd	111.0 c	9.25 d	20.0 c	83.25 b
F-test	**	**	**	**	**	**

** Highly significant at 0.01 probability level.

Table (6) revealed that the panicle length (cm) of the rice has been highly significantly increased by transplanting methods and the highest value was obtained with transplanting method (T5). And plant height (cm) has been highly significantly increased by transplanting methods. The highest mean value (96.2 cm) was obtained by treatment (T2).

Effect of transplanting methods on yield and yield components of rice under saline soil condition:

Table (6) the results indicated that the maximum rice grain yield (3.23 ton/fed) was produced by the treatment of T2 while, the other treatments (T1, T3, T4, T5, T6 and T7) produced comparatively lower paddy grain yield each of (2.805, 2.821, 2.570, 2.483, 2.526 2.197, and 2.037 ton /fed). Results indicated that the maximum values of relative change ± % was increased by 15.15% with the treatment of T2 as compared with traditional irrigation method (T1) on the other hand, grain yield was decreased by 27.38% with the treatment T8 compared with traditional irrigation method (T1).

Data in table (6) showed that, the maximum rice straw yield (4.212, 4.132 ton fed^{-1}) was produced by the treatment of T1 and T2 with no significant difference between them while, the other treatments (T3, T4, T5, T6, T7and T8) produced comparatively lower paddy straw yield each of (3.213, 2.814, 2.745, 2.907 2.452 and 2.272 ton fed^{-1}), respectively, under saline soil condition.

Data in Table (7) indicated that the 1000 grain weights, panicle weight (g), no. of grains/panicle, no. of tillers/plant, panicle length (cm) and plant height (cm) of the rice, have been highly significantly affected by transplanting methods.

The highest mean values of 1000 grain weight and no. of tillers/plant was recorded by transplanting methods (T7) as compared with traditional transplanting methods, (T4) and (T3) recorded the highest numerical values for panicle weight and panicle length , respectively. The transplanting method (T4) recorded the highest mean value for no. of grains/panicle and plant height.

Economic evaluation:

Table (8) the results show that the values of variable, fixed and total costs (LE/fed.) as affected by treatments applied in normal and saline soils indicated that the total costs were 3510, 3430 and 3410 LE/fed for the T1, T2 and T3, respectively. While, the total costs for the other treatments are similar (3360 LE/fed.). Also, the same tables illustrated the values of grain yield, total income (LE/fed.) and net profit. The highest values of total income (6890 and 6460 LE/fed.) were obtained from T2 treatment, while the lowest values (3686 and 4074 LE/fed.) were recorded with T8 treatment. This increase of total income could be attributed to highest grain yield achieved by T2.

Water productivity and economic efficiency:

Table (9) illustrated that the maximum values of water productivity (0.59 and 0.53 LE/m3) were obtained from the treatment of T2 and under normal and saline soil conditions, respectively. However, the differences between T2 and T3 were very small. While, the lowest one (0.07 and 0.15 LE/m3) for T8 under normal and saline soil conditions, respectively.

It was observed that the regular transplanting achieved higher grain yield and water productivity than the transplanting rice on beds and furrows.

Concerning the economic efficiency, the increasing net return or profit for crops refers to the decreasing of production costs or increasing the crop production. So, economic efficiency index refers to the agricultural and irrigation activities which can give the highest return from each Egyptian pound unit which can spend on crop production.

Table 6. Effect of transplanting methods on grain and straw yield of rice (Oryza sativa L.) under saline soil condition

Treatments	Grain yield (ton/ fed)	Relative Change ± %	Straw yield (ton /fed)	Relative change % (±)
		Transplanting methods		
T1	2.805bc	00.0	4.212a	00.0
T2	3.23a	15.15	4.132a	-1.90
T3	2.821b	0.57	3.213b	-23.72
T4	2.570bcd	-8.38	2.814c	-33.19
T5	2.483 d	-11.48	2.745c	-34.83
T6	2.526cd	-9.95	2.907c	-30.98
T7	2.197e	-21.68	2.452 d	-41.79
T8	2.037 e	-27.38	2.272 d	-46.06
F-test	**	-	* *	-

** Highly significant at 0.01 probability level.

Table7. Effect of transplanting methods on yield and yield components of rice (*Oryza sativa* L.) under saline soil condition

Treatments	1000 grain weight (g)	Panicle weight (g)	No. of grains/ panicle	No. of tillers/ hill	Panicle length (cm)	Plant height (cm)
T1	19.8 ab	2.47 b	116.0 c	14.8 abc	2.47 b	88 be
T2	19.88 ab	2.80 ab	113.0 c	15.3 ab	2.80 ab	94.25 a
T3	19.28 abc	2.93 a	123.5 b	14.5 be	2.93 a	87.25 c
T4	17.56 c	3.04 a	129.3 a	14 cd	3.04 a	96.2 a
T5	18.12 be	2.76 ab	121.0 b	15.3 ab	2.76 ab	92.5 ab
T6	20.44 a	2.71ab	121.0 b	14 cd	2.71 ab	94.75 a
T7	20.56 a	2.99 a	100.0 d	15.8 a	2.99 a	83.5 cd
T8	19.32 abc	2.02 c	96.0 d	13 d	2.02 c	80.5 d
F. test.	**	**	**	**	**	**

** Highly significant at 0.01 probability level.

Table 8.Values of grain yield (kg/fed.) total income (LE/fed.), total cost (LE/fed.) and net profit (LE/fed.) as affected by different transplanting methods under normal and saline soils conditions

Treatments	Grain yield (kg/fed)	Total income (LE/fed.)	Production cost (LE/fed.)			Net Profit (LE/fed.)
			Variable	Fixed	Total	
			Normal soil			
T1	3337	6674	1560	1950	3510	3164
T2	3445	6890	1480	1950	3430	3460
T3	2875	5750	1460	1590	3410	2340
T4	2583	5166	1410	1950	3360	1806
T5	2347	4694	1410	1950	3360	1334
T6	2572	5144	1410	1950	3360	1754
T7	1969	3938	1410	1950	3360	578
T8	1843	3686	1410	1950	3360	326
			Saline soil			
T1	2805	5610	1560	1950	3510	2100
T2	3230	6460	1480	1950	3430	3030
T3	2821	5642	1460	1950	3410	2232
T4	2570	5140	1410	1950	3360	1780
T5	2483	4966	1410	1950	3360	1606
T6	2526	5052	1410	1950	3360	1692
T7	2147	4394	1410	1950	3360	1034
T8	2037	4074	1410	1950	3360	714

Table 9.Water productivity (LE/m^3) and economic efficiency for rice crop as affected by different transplanting method under normal and saline soils conditions

Treatments	Net profit, LE/fed.	Total water applied, m^3/fed	Water productivity, LE/m^3	Total production cost, LE/fed.	Economic efficiency
			Normal soil		
T1	3164	6485	0.49	3510	0.9
T2	3460	5831	0.59	3430	1.01
T3	2340	4125	0.57	3410	0.69
T4	1806	3982	0.45	3360	0.54
T5	1334	4315	0.31	3360	0.4
T6	1784	4475	0.40	3360	0.53
T7	578	4395	0.13	3360	0.17
T8	326	4658	0.07	3360	0.10
			Saline soil		
T1	2100	6675	0.31	3510	0.60
T2	3030	5978	0.51	3430	0.88
T3	2232	4245	0.53	3410	0.65
T4	1780	4193	0.42	3360	0.53
T5	1606	4445	0.36	3360	0.48
T6	1692	4567	0.37	3360	0.50
T7	1034	4463	0.23	3360	0.31
T8	714	4813	0.15	3360	0.21

$$\text{Water productivity} = \frac{\text{Net profit}}{\text{Amount of water applied}}$$

$$\text{Economic efficiency} = \frac{\text{Net profit}}{\text{Total production cost}}$$

Also the values of economic efficiency were 0.9, 1.01, 0.69, 0.54,, 0.40, 0.53, 0.17 and 0.1 and 0.6, 0.88, 0.65, 0.53, 0.48, 0.5, 0.31 and 0.21 for T1, T2, T3, T4, T5, T6, T7 and T8 treatments under normal and saline soil conditions, respectively.

It was noticed that, the economic efficiency increased in case of regular transplanting treatment (1.01 and 0.88) due to maximum yield in normal and saline soils, respectively. While, the lowest values of economic efficiency (0.1 and 0.21) were obtained in case of transplanting on beds and bottom of furrows with 60 cm wide (T8). These increases in economic efficiency are due to the enhancement of net profit in (T2) treatments compared with the other treatments.

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الملخص العربي

تعظيم إنتاجية المياه والمحصول من خلال طرق شتل الأرز تحت ظروف الاراضى الملحية وغير الملحية في شمال الدلتا– مصر

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تم إجراء تجربتين حقليتين بنجاح خلال موسم الزراعة 2009 بمزرعة محطة البحوث الزراعية بسخا– مركز البحوث الزراعية حيث تقع منطقة الدراسة تحت ظروف وسط شمال دلتا النيل.حيث تهدف الدراسة إلى تقدير أفضل طريقة شتل الأرز لتعظيم المحصول وصافى العائد، وإنتاجية الماء لمحصول الأرز فى شمال دلتا مصر. تم تصميم التجربة فى قطاعات كاملة العشوائية فى أربع مكررات، حيث تم دراسة ثمانية معاملات فى الحقل المستديم وهى كالتالي:

ت1: الشتل العادى.

ت2: الشتل المنتظم. (على مسافة 20x20سم).

ت3: الشتل فى جور على مصاطب عرضها 80سم على الجانبين من أسفل(4–5 نبات/جورة).

ت4: الشتل فى جور على مصاطب عرضها 80 سم أعلى المصاطب (4–5 نبات/جورة).

ت5: الشتل فى جور على مصاطب عرضها 80سم أعلى وأسفل المصاطب (4–5 نبات/جورة).

ت6: الشتل فى جور على مصاطب عرضها 60سم الشتل على الجانبين (4–5 نبات/جورة).

ت7: الشتل فى جور على مصاطب عرضها 60سم فى القاع (4–5 نبات/جورة).

ت8: الشتل فى جور على مصاطب عرضها 60سم الزراعة أعلى وأسفل المصطبة (4–5 نبات/جورة).

يمكن تلخيص أهم النتائج المتحصل عليها من فيما يلي:

- تبين من النتائج أن طريقة الزراعة بالشتل العادي (التقليدي) سجلت أعلى كمية من الماء المضاف بينما طريقة الشتل فى خطوط وأعلى الخطوط أقل كمية من الماء المضاف مقارنة بطريقة الشتل التقليدي.
- توضح النتائج أن طريقة الزراعة ت2، ت3، ت4، ت5، ت6، ت7، ت8 وفرت مياه بنسب: 10.08%، 36.39%، 33.46%، 38.59%، 31.58% ، 33.14% ، 27.89% على التوالى مقارنة بطريقة الزراعة التقليدية.
- أيضا تبين من النتائج أنه يمكن توفير مياه ري معدل 0.336، 1.277، 1.204، 1.108، 1.025 ، 1.066، 0.932 م3/فدان مع المعاملات ت2، ت4، ت5، ت6، ت7، ت8 مقارنة بطريقة الشتل التقليدي.
- تبين من النتائج أن أعلى قيم كفاءة استخدام المياه تمت مع المعاملة رقم 3 (ت3) الزراعة على جانبي الخط بعرض 80سم وتم زراعة الشتلات فى جور (4–5 نبات) فى الاراضى الملحية وغير الملحية.

بينما سجلت كفاءة استعمال المياه أقل القيم عند استخدام طريقة الشتل التقليدى (ت1 فى الاراضى الملحية وغير الملحية.

- تبين من النتائج أن أعلى محصول من الحبوب والقش كان نتيجة الشتل المنتظم (ت2) بينما سجلت المعاملتين رقم 7 ، ورقم 8 أقل محصول من الحبوب فى الاراضى الملحية وغير الملحية.
- تشير النتائج إلى أن وزن الألف حبة سجل أعلى القيم فى المعاملة السابعة (ت7) فى الاراضى الملحية وغير الملحية ، بينما سجلت أقل القيم نتيجة المعاملة الأولى (ت1) فى االاراضى غير الملحية، والمعاملة الرابعة (ت4) فى الاراضى الملحية.

التقييم الاقتصادي:

تبين من النتائج أن أعلى قيم من العائد الكلى، وصافى العائد، وإنتاجية المياه، والكفاءة الاقتصادية تم التحصل عليها نتيجة استخدام طريقة الشتل المنتظم للأرز فى شمال الدلتا. بينما سجلت أقل القيم بطريقة الشتل أسفل وأعلى الخط بعرض 60سم.