RICE AND WATER PRODUCTIVITY AS AFFECTED BY IRRIGATION INTERVALS AND POTASSIUM SPLITTING UNDER NEWLY RECLAIMED SALINE SOIL.

Zayed[1], B.A., S.M.Shehata[1], W.M. Elkhoby and E.E.E.Khafaga[2]

1- Rice Research and Training Center, Sakha, Field Crop Res., Inst Agric, Res., Cent. Egypt

2- Soil, Water and Environ .Res .Inst., Agric. Res. Center, Egypt .

ABSTRACT

Two field experiments were conducted at El-Sirw Agricultural Research Station Farm at Dammietta (North of Delta, Egypt) during the summer seasons of 2005 and 2006 .Soil texture of the experimental sites is classified as clay soil and the electrical conductivity values of soil extraction (Ece) were 6.0 and 5.53 dSm^{-1} in the first and second seasons, respectively . Giza 178 Rice variety (Egyptian salt -tolerant variety) was used in this study. The current study aimed to find out the effect of three irrigation intervals; viz., 3, 6 and 9 days and four potassium splitting treatments; namely, all recommended K^+ applied basally (B), 1/2 B+1/2 maximum tillering stage (MT), 1/2 dressing at tillering stage (T)+1/2 at panicle initiation (PI) and 1/3 B+1/3 MT+ 1/3 dressing at panicle initiation (PI) on rice growth and grain yield and its components beside water productivity under newly reclaimed soil. The main results of this study could be summarized as follows;

Prolonging irrigation intervals from three to nine days significantly decreased rice growth, leaf area index (LAI), chlorophyll content, dry matter (g/m^2),plant height (cm) ,panicle length (cm) ,main grain yield components and grain yield as well as nitrogen and potassium leaf contents at heading . The irrigation intervals of 3 and 6 days were at par in grain yield and most of grain yield components. The irrigation interval of nine days sharply decreased all studied traits. Regarding the water productivity measurements, the irrigation interval of six days gave the highest values of physical (Kg grain /m^3 water) and economic (L.I/m^3 water) water productivities for evapotranspiration (ETa), water requirements (WR) and total applied water (I).The irrigation interval of nine days gave the lowest values of water productivity measurements, as well as

ETa, WR and total applied water amounts (I). These results confirmed the superiority of irrigation interval of six days.

Potassium splitting application significantly affected the aforementioned traits and showed the superiority of potassium splitting against the one dose as basal application .The triple splitting of potassium, 1/3 B+1/3MT+1/3PI, gave the highest values of studied parameters. The triple splitting of potassium and double splits of 1/2 T +1/2 PI were comparable in most of the studied traits but under severe water stress, the triple splitting surpassed it.

The interaction effect had a significant effect on leaf area index (LAI) and panicle numbers in 2005 season, while chlorophyll leaf content , filled grains and unfilled grains /panicle in 2006 season. Also, in both seasons, the interaction between irrigation intervals and potassium splitting treatments exerted a significant effect on dry matter, grain yield, nitrogen leaf content and potassium content .Generally, the result of interaction came to confirm that the triple splitting of potassium application was much needed under severe water stress.

INTRODUCTION

Irrigated rice crop is increasingly facing water scarcity and salt stress in Egypt and over the entire world. More progress has been made for water saving with more rice production and the alleviation of salt stress for rice crop grown under such conditions. Furthermore, water efficient irrigation regimes for rice have been tested, advanced, applied and distributed in different regions in Egypt, particularly, under newly reclaimed saline soil. Because of continued population growth and economic developments, the demand for fresh water to meet industrial and domestic needs has increased in Egypt. Therefore, it is expected that, in the near future, less water will be available for rice growing.

Tabbal *et al.,* (2002) reported that reduced water inputs and increased water productivity of rice grown just under saturated soil conditions were compared with traditional flooding rice. Under saline soil, El-Mowelhi *et al.* (1995) and Zayed (1997) reported that prolonging the irrigation intervals beyond four days significantly reduced rice growth , grain yield components and grain yield ,Khafaga *et al.,(* 2006) and Zayed *et al.,* (2006a) stated that under, saline soil, watering at 9 cm irrigation depth increased rice growth ,yield attributing traits and grain yield, as well as water use efficiency and water productivity over 3 , and 12 cm irrigation depths . Moreover, Anbumozhi *et al., (*1998) and El –Kholy *et al., (*1999) came to similar results .However, under normal soil , El Refaee *et al*., (2005) . found that rice growth and grain yield and its components were significantly affected by irrigation intervals .They pointed out that continuous saturation irrigations gave almost a grain yield similar to that of continuous flooding while, saturation treatments induced 3-5% reduction in grain yield and it gave higher water productivity . Khafaga *et al.,* (2006) found that the percolation losses and evapotranspiration (ETa) were increased by increasing ponding water depth.

Qadar (1995) and Zayed (2002) found that potassium application for rice crop under saline soil, with water stress, significantly alleviated the stresses of salts and water withholding .However, potassium significantly improved rice growth, grain yield components and grain yield. Thereby, increasing the efficiency of potassium mode of action under stresses could be achieved by potassium splitting .Velayauthan *et al.,* (1992) Poonam *et al.,* (1993) , Ghoshi *et al* ., (1995) ,Devasenapathy (1997) ,Thakur *et al.,(*1999, Meena *et al.,* (2003) ,Natarajan *et al.,* (2004) ,Ramteke *et al.,*(2004) and Zayed *et al.,(*2006b) reported that rice crop performed better when splitting application of potassium was followed over one dose as basal application .Also, they reported that potassium splitting either as 50% basal +25% at tillering stage +25% at panicle initiation (PI) or 1/3 basal +1/3 tillering stage (T) + 1/3 panicle initiation (PI) were the most effective splits . Whereas , they significantly increased rice growth , all yield attributing traits and grain yield, as well as nutrient contents leaf, such as N,P,K and S. Cao *et al.,* (2004) stated that potassium application as 70 % basal + 30% panicle dressing significantly increased seed setting ,number of filled grains ,1000 – grain weight ,N and K uptake at heading and grain yield of rice crop . Pillal and Anasuya (1997) claimed that the maintenance of K^+ concentration in the three leaves at the level higher than 2.76 at the maximum tillering stage was too much essential for achieving maximum grain yield.

The present study aimed to test rice and water productivity as affected by irrigation and potassium treatments under newly reclaimed saline soil in the Northern part of Delta.

MATERIAL AND METHODS

Two field experiments were conducted at El-Sirw Agricultural Research Station Farm (North of Delta ,Egypt) during the summer seasons of 2005 and 2006 .Soil texture of the experimental sites is classified as clay soil and its chemical analysis was , 8.15 and 8.07 pH , 2.3% and 2.35% CaCo3, 0.85% and 0.89% organic matter, exchangeable sodium percentage 8.96 and 8.73 and the electrical conductivity values of soil extraction(Ece) were 6.0 and 5.53 dSm^{-1} in the first and second seasons, respectively Giza 178 rice variety (Egyptian salt- tolerant variety) was used in this study . The experiments were laid out in a split plot design, with four replications .The main plots were devoted to three irrigation intervals; viz., 3, 6 and 9 days . Meanwhile, potassium splitting treatments; namely, all recommended K applied basally (B), 1/2 B+1/2 maximum tillering stage (MT), 1/2 dressing at tillering stage (T)+ -1/2 panicle initiation (PI) and 1/3 B+1/3 MT+ 1/3 dressing at panicle initiation (PI), were distributed form of potassium sulphate in the sub-plots. The recommended potassium rate of 57 kg k_2o/ ha was used in the 48% K2O) .The recommended nitrogen and phosphorus of 165 Kg N and 50 Kg P_2O_4 /ha in the form of urea and calcium super phosphate, respectively. The nitrogen and phosphorous were applied as recommended under saline soil .Thirty day old seedlings were transplanted at 15x15 cm spacing with four seedlings /hill . The rest of recommendation package of rice under saline soil was applied.

Measurements of growth characters:

For measuring the leaf area index and dry matter accumulation, five hills were randomly cut just at the soil surface at 85 days after transplanting (DAT). The plants were transferred to lab, carefully washed and dry matter of stems and leaves were measured. Leaf area was measured with a leaf area meter. The chlorophyll leaf content was estimated by a SPAD meter.

Estimation of mineral concentrations:

Oven dry samples of 85-day old plants were digested by Hno3-Hclo4 and N and K+ were precisely analyzed by Colorimeter and atomic absorption spectrometry (Mitusui *et al.,* 1999).

Measurements of grain yield and its attributing traits:

Five plants were randomly cut at soil level at harvest, from each sub plot to determine the following traits; plant height, tiller numbers, panicle numbers per hill, panicle length, field grains per panicle, sterility % and 1000- grain weight. Grain yield (t ha^{-1}) was estimated from the collected plants (5 m^2) at 14 % moisture content.

Irrigation water measurements:

Applied water:

In the two experiments, irrigation water was measured by using a cut throat flume of 20 X 90 cm .The total applied water was determined.

Percolation measurements and actual evapotranspiration (ETa):

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

Physical and economic water productivities were estimated according to Dang *et al.,* (2001) and Molden *et al.,* (2001). Net return of rice crop was determined according to RRTC (2005 and 2006)

Statistical analysis:

The MSTAT statistical analysis program (1998) was used for data analysis. The data were analyzed and the mean differences were compared, using LSD test, according to Gomez and Gomez, (1984).

RESULTS AND DISCUSSIONS

Irrigation intervals effect:

Irrigation intervals significantly affected all studied parameters, namely, growth, chemical analysis, grain yield attributes and grain yield in the two seasons of study (Tables 1, 2and 3). Prolonging irrigation intervals up to nine days significantly and sharply decreased leaf area index (LAI), dry matter (g /m^2)(DM) ,chlorophyll content , nitrogen and potassium leaf contents, panicle length , plant height , panicle number /m^2 ,field grains /panicle , panicle weight ,1000- grain weight and grain yield. On the contrary, watering every nine days significantly increased the unfilled grains /panicle in the terms of sterility. Irrigating every six days induced a reduction for some extent .By the way, the combination of irrigation intervals of three and six days were comparable in several parameters, such as; LAI, chlorophyll content, panicle length, plant height, panicle weight, 1000-grain weight and nitrogen leaf content in 2006 season, while, panicle numbers and grain yield in the two seasons study. The grain yield of Giza 178 rice variety was low in the first season in comparison with that obtained in the second season because of salinity level .The soil under such condition, might keep water for a long time because its bad drainage resulted from high sodium content .That might be resulted in insignificant effect between three and six days intervals on most studied parameters and grain yield. Watering every nine days might be insufficient to leach salts around the root growth zones under these circumstances plus the water stress resulted in great harmful effect on rice growth, rice photosynthesis, rice photosynthesis pigments, rice metabolism and ion imbalance, which induced more spikelets sterility leading to lower grain yield.

Furthermore, water stress and salt hazardous increased the ABA in the rice plants, which affected the peduncle of panicle and restricted the translocation of carbohydrates to grains resulted in more short panicle and higher rate of panicle sterility leading to lower grain yield. With insignificant sacrificing in the grain yield the irrigation interval of six days could be recommended in the soil similar to the current experimental soil. In addition, under the present conditions with continuous flooding, the soil might be suffering from unaerion (bad drainage) in which using watering every six days interval might improve this problem. The obtained data are in agreement with those reported by Zayed (1997) Anbumozhi *et al* .,(1998) , El –Kholy *et al.*,(1999) ,Khafaga *et al.*,(2006) and Zayed *et al.,* (2006a) .

Table (1): Leaf area index (LAI) , dry matter g/m^2 (DM), chlorophyll content (SPAD value) and plant height cm of rice as affected by Irrigation intervals and potassium splitting during 2005 and 2006 seasons

Treatments	LAI		DM		Ch. content		Plant height	
	2005	2006	2005	2006	2005	2006	2005	2006
Irrig. Intervals(days):								
3	6.28	5.98	1185	1165	41.4	41.9	102.4	103.7
6	5.90	5.60	927	939	40.6	41.9	101.0	99.1
9	4.73	4.59	553	739	38.6	37.7	95.8	94.5
LSD (0.05)	0.34	0.16	34	42	0.5	0.7	2.1	1.2
K^+ splitting treatments								
All basal (B)	5.28	5.12	825	868	38.8	39.6	98.9	98.6
1/2 B -1/2 MT	5.57	5.22	860	917	40.0	40.3	99.1	98.7
1/2 T + 1/2 PI	5.68	5.40	921	981	40.6	40.7	100.1	99.5
1/3 B + 1/3 MT +1/3 PI	6.03	5.82	947	1024	41.4	41.3	100.8	99.7
LSD (0.05)	0.13	0.09	24	32	0.9	0.4	1.3	NS
Interactions	NS	**	**	**	NS	**	NS	NS

T = Tillering stage, MT = Maximum tillering PI = Panicle initiation Ch.=chlorophyll
**=Significant at 0.01 level NS =Not significant

Table (2): Panicle length (cm), panicle number /m^2, filled grains /panicle and unfilled grains /panicle as affected by irrigation intervals and potassium splitting in 2005 and 2006 seasons.

Treatments	Panicle length		Panicle no/m^2		Filled grains		Unfilled grains	
	2005	2006	2005	2006	2005	2006	2005	2006
Irrig. Intervals (day):								
3	21.6	21.8	441	459	130.5	132.0	5.9	5.0
6	21.0	21.4	402	441	125.0	128.4	11.8	12.2
9	19.9	20.9	312	366	117.8	120.4	21.8	21.8
LSD (0.05)	0.7	0.6	42	36	2.0	2.4	2.1	1.04
K^+ splitting treatments								
All basal (B)	20.1	21.1	340	378	120.1	123.1	17.7	17.0
1/2 B -1/2 MT	20.7	21.1	376	414	124.3	126.6	13.5	14.3
1/2 T + 1/2 PI	21.2	21.8	399	432	125.0	127.3	11.1	11.9
1/3 B + 1/3 MT +1/3 PI	21.4	22.0	429	462	128.7	130.9	9.8	9.0
LSD (0.05)	0.6	0.2	21	22	1.6	2.55	1.4	0.98
Interactions	NS	NS	NS	**	**	NS	NS	**

T = Tillering stage, MT = Maximum tillering PI = Panicle initiation
**=Significant at 0.01 level NS =Not significant

Potassium splitting effect:

Potassium splitting significantly improved LAI, DM ,chlorophyll content , N and K^+ leaf contents at heading, grain yield attributing characters and grain yield in both seasons of study

(Tables1,2and 3). Interestingly, potassium application in one dose, as basal, significantly failed to exert any improvement in rice growth or enhancing its withstanding to water and salinity stresses. The splitting, including dressing at panicle initiation, showed its superiority in enhancing tolerance rice to both water and salinity stresses and, subsequently, improved rice growth and grain yield. Also, the potassium application at the maximum tillering or tillering stages, with panicle initiation encouraged rice plant to grow healthy under such stresses. The triple potassium splitting as following: 1/3 basal +1/3 maximum tillering (MT) +1/3 panicle initiation (PI) gave the significantly gave the highest values of all studied traits .On the contrary, the triple potassium splitting was found to be efficient to reduce the spiklelets sterility and it gave the lowest value of unfilled grains panicle^{-1} in terms of sterility. The one dose of potassium application significantly gave the lowest values of all studied traits, except for the unfilled grains whereas; it gave its highest value. Split application of potassium, as triple equal doses, might encourage early and fast rice growth, which was more convenient under either water or salinity stresses. Also, the triple split of potassium might increase rice tolerance to salinity and water stresses, especially at sensitive growth stage, such as panicle initiation, enhanced photosynthesis rate, kept the normal osmotic of plant cell and its turgid pressure, increased stored carbohydrate at pre-heading and boosted more reproductive tillers formation. Moreover, triple split application of potassium significantly increased nitrogen, potassium and chlorophyll leaf contents at heading, resulted in delaying leaf senescence occurred under water and salt stresses during grain filling. Furthermore, triple application of potassium leaf content resulted in more translocation of carbohydrates from stem leaf sheathes and other storage organs to grains, leading to high sink capacity and, subsequently, more potassium leaf content, enhancing the efficiency of photosynthesis of the three active leaves after heading and obviously improving grain filling .In addition, triple application of potassium in this study greatly increased potassium leaf content resulted in more translocation of carbohydrates from stems , leaf sheathes and other storage organs to grains, leading to high sink capacity and, subsequently, higher grain yield .More potassium leaf content supported rice plants to be more salinity and water stresses tolerance by suppressing Na^+ uptake or organizing stomatal conductance (Qader, 1995 and Zayed, 2002) .Similar data have been reported by Velayutham *et al.*, (1992) Poonam *et al.*, (1993) , Ghoshi *et al* ., (1995), Devasenapathy (1997)

,Thakur *et al.*,(1999) ,Kanti and Chauhan (2000), Meena *et al.*, (2003) ,Natarajan *et al.*, (2004) ,Ramteke *et al.*,(2004) and Zayed *et al.*,(2006b).

Table (3): Panicle weight (g),1000- grain weight (g) ,grain yield (t/ha) ,N% and K^+ content (mmol /kg dry leaf)as affected by irrigation intervals and potassium splitting treatments in 2005 and 2006 seasons.

Traits	Panicle wt		1000-grain wt		Grain yield		N%		K^+ content	
Treatments	2005	2006	2005	2006	2005	2006	2005	2006	2005	2006
Irri .intervals days:										
3	2.96	2.97	20.0	20.2	7.37	7.37	2.483	2.496	562	573
6	2.81	2.86	19.9	20.3	6.90	7.19	2.413	2.428	543	549
9	2.71	2.76	18.5	18.7	5.31	5.75	2.195	2.127	473	477
LSD(0.05)	0.1	0.12	1.2	1.05	0.17	0.19	0.094	0.03	18	13
K^+ Splitting treatments:										
All basal (B)	2.64	2.66	18.5	18.6	5.46	5.71	2.234	2.211	476	481
1/2 B -1/2 MT	2.79	2.83	19.2	19.4	6.19	6.61	2.337	2.327	513	518
1/2 T + 1/2 PI	2.91	2.92	20.1	20.4	6.90	7.22	2.396	2.403	539	547
1/3 B + 1/3 Mt +1/3 PI	2.97	3.04	20.2	20.6	7.25	7.57	2.487	2.461	576	584
LSD(0.05)	0.08	0.11	0.8	0.6	0.18	0.16	0.35	0.03	8	12
Interaction	NS	NS	NS	NS	**	**	**	**	**	**

T = Tillering stage, MT = Maximum tillering, PI = Panicle initiation, wt =weight
**=Significant at 0.01 level NS =Not significant

Interaction effects:

Data documented in Tables 4 and 5 revealed that the interaction between irrigation intervals and potassium splitting treatments had a significant effect on leaf area index (LAI), in 2005, and panicle numbers in 2006 season and chlorophyll leaf content, filled grains and unfilled grains /panicle in 2006 season. Also, in both seasons, the interaction between irrigation intervals and potassium splitting treatments exerted a significant effect on dry matter, grain yield and nitrogen and potassium leaf contents .It was detected that all interaction effects came to confirm the fact that triple split of potassium application could be recommended for rice plant grown under water and salinity stresses. The splitting potassium in two equal doses, at tillering stage + panicle initiation, were comparable to the triple splits under moderate stresses (Qadar, 1995 and Zayed, 2002)

Table (4): Leaf area index (LAI), Chlorophyll content (SPAD value), panicle numbers /m^2 filled grains /panicle and unfilled grains /panicle as affected by the interaction between irrigation intervals and potassium splitting treatments in 2005 and seasons.

Irr. interval days	K^+ splitting treatments	LAI	Chloro. content	Panicle numbers	Filled grains /panicle	Unfilled grains /panicle
		2005	2006	2006	2006	2006
3	All basal (B)	5.81	41.4	405	127.3	7.5
	1/2 B -1/2 MT	5.84	41.9	435	131.3	5.5
	1/2 T + 1/2 PI	6.03	42.1	459	130.8	4.0
	1/3 B + 1/3 Mt +1/3 PI	6.25	42.2	465	132.8	3.5
6	All basal (B)	5.32	40.9	360	121.5	15.8
	1/2 B -1/2 MT	5.47	42.0	390	125.3	13.5
	1/2 T + 1/2 PI	5.62	42.3	414	126.0	11.3
	1/3 B + 1/3 Mt +1/3 PI	5.99	42.3	450	128.3	8.3
9	All basal (B)	4.23	36.5	255	111.5	27.8
	1/2 B -1/2 MT	4.36	37.1	300	116.3	23.8
	1/2 T + 1/2 PI	4.54	37.7	330	118.3	20.5
	1/3 B + 1/3 Mt +1/3 PI	5.23	39.4	369	125.0	15.3
	LSD(0.05)	0.15	0.7	38	2.8	1.0

T = Tillering stage, MT = Maximum tillering PI = Panicle initiation, Chloro.=Chlorophyll
**=Significant at 0.01 level NS =Not significant

Table (5): Dry matter (g/m^2),grain yield (t/ha), N% and K^+ leaf content as affected by the interaction between irrigation intervals and potassium splitting treatments during 2005 and 2006 seasons.

Irri. Intervals (days)	Potassium splitting treatments	Dry matter		Grain yield t/ha		N%		K^+ content	
		2005	2006	2005	2006	2005	2006	2005	2006
3	All basal (B)	1070	1043	6.46	6.72	2.406	2.431	503	515
	1/2 B -1/2 MT	1117	1104	6.83	7.10	2.440	2.444	552	563
	1/2 T + 1/2 PI	1262	1243	7.44	7.75	2.527	2.530	581	590
	1/3 B + 1/3 Mt +1/3 PI	1290	1270	7.62	7.92	2.559	2.585	613	623
6	All basal (B)	891	895	6.16	6.38	2.345	2.365	502	513
	1/2 B -1/2 MT	925	915	6.70	7.07	2.398	2.413	538	544
	1/2 T + 1/2 PI	944	950	7.15	7.51	2.438	2.448	551	556
	1/3 B + 1/3 Mt +1/3 PI	950	999	7.60	7.85	2.470	2.488	581	582
9	All basal (B)	515	668	3.77	4.04	1.95	1.838	425	417
	1/2 B -1/2 MT	537	733	5.06	5.66	2.173	2.125	448	449
	1/2 T + 1/2 PI	559	753	6.14	6.41	2.225	2.235	484	495
	1/3 B + 1/3 Mt +1/3 PI	600	804	6.55	6.94	2.433	2.310	535	547
	LSD(0.05)	41	55	0.43	0.28	0.061	0.059	13.5	21

T = Tillering stage, MT = Maximum tillering PI = Panicle initiation
**=Significant at 0.01 level NS =Not significant

Water productivity:

Data in Tables 6and 7 showed that the irrigation interval of three days gave the highest values of evapotranspiration (ETa) mm, percolation, water requirement and total applied water in the two seasons of study. On the contrary, watering every nine days gave the lowest values of such water measurements. Interestingly, the medium irrigation interval of six days resulted in moderate values of these water assessments As for physical water productivity, data in Table 7 revealed that a combination of three and six irrigation intervals days gave similar values of physical water productivity assessed, on the basis of ETa (PWP_{ETa}) in 2005 and 2006 seasons. Hence, such two irrigation intervals gave the highest values of PWP_{ETa} (0.85 and 0.88) in the first and second seasons, respectively. The irrigation interval of six days surpassed the rest irrigation intervals of three and nine days regarding physical water productivity measured on the basis of water requirement (PWP_{WR}) and physical water productivity based on total applied water (i) (PWPi). Thereby, irrigation every six day gave the maximum values of (PWP_{wr}) and (PWP_i),being 0.63and 65 ;and 0.50and 0.52 for PWP_{Wr} and PWP_i in the first and seasons, respectively .Meanwhile, the lowest values of the aforementioned water productivity parameters were obtained by the irrigation interval of nine days (Table7) . The PWP measurements were decreased in an ascending order of PWPETa > PWP_{WR} > PWP_i under the studied irrigation intervals in both seasons. From data here and results of grain yield the watering every six days was found to be efficient and it was the best.

Regarding economic water productivity (EWP L.E/ m^3 water) ,data shown in Table 8 clarified that irrigation every six days gave the highest values of EWPs (,0.55,0.63,0.41,0.42 and 0.32 ,0.37 L.E /m^3 water) for EWP_{ETa} ,EWP_{WR} and EWP_i in the first and second seasons ,respectively. The irrigation every nine days gave the lowest values of EWPs, while, the irrigation interval of three days came in the second rank after six day interval. Again, such result regarding EWPs, came to prove the superiority of six day interval. The obtained finding are in a good agreement with those reported by to Dang *et al.*, (2001), Molden *et al.*, (2001) and Khafaga *et al.*,(200

Table (6): Evapotranspiration ETa (mm), percolation (mm) ,water requirement (WR) (mm) and total applied water(I) m^3 /ha as affected by three irrigation intervals during 2005 and 2006 seasons.

Irrigation intervals (days):	Evapotranpiration (ETa)(mm)		Percolation (mm)		Water requirement (WR)(mm)		Total water applied (I) m^3 /ha	
	2005	2006	2005	2006	2005	2006	2005	2006
3	827	836	320	350	1147	1186	15207	15300
6	810	816	280	300	1090	1096	13790	13898
9	777	780	215	215	986	995	10978	11350

Table (7): Physical water productivity for evapotranspiration (ETa), water requirement (WR) and total applied water (I) in 2005 and 2006 seasons.

Irrigation intervals (days):	Physical water productivity ETa Kg grain / m^3 water		Physical water productivity (WR) Kg grain/ m^3 water		Physical water productivity (I) Kg grain/ m^3 water	
	2005	2006	2005	2006	2005	2006
3	0.85	0.88	0.61	0.62	0.47	0.48
6	0.85	0.88	0.63	0.63	0.50	0.52
9	0.69	0.74	0.55	0.58	0.47	0.50

Table (8): Economic water productivity for evapotranspiration (ETa), water requirement (WR) and total applied water (I) in 2005 and 2006 seasons.

Irrigation intervals (days):	Economic water productivity ETa L.E / m^3 water		economic water productivity (WR) L.E/ m^3 water		economic water productivity (I)L.E/ m^3 water	
	2005	2006	2005	2006	2005	2006
3	0.55	0.62	0.39	0.40	0.30	0.34
6	0.55	0.63	0.41	0.42	0.32	0.37
9	0.33	0.33	0.26	0.33	0.23	0.29

REFERENCES

Anbumozhi, V.E.:E.Yamaji and T. Tabuchi. (1998). Rice crop growth and yield as influenced by change in pending water depth, vater regime and fertilization levels .Agriculture and Water Management 37; 241-253.

Cao W., YF.Ding, Ji. ZhiJun, QS. Wang,PS. Huang and RH.Zhen. (2004). Effects of potassium fertilizer application rates on plant potassium accumulation and grain quality of japonica rice. Scientia Agricultura Sinica 37(10) 1444-1450.

Dang, B., R Loeve, Y.H. Li,., C.D. Chen, , L. Deng and D. Molden. (2001). Water productivity in the Zhanghe irrigation system issues of scale. In: Barker, R., Li, Y.H.,Toung, T.P. (eds) Water Saving Irrigation for Rice. International Water Management Institute. Colombo, SriLanka. Pp 97-115.

Devasenapathy, P.(1997). Split application of potassium in rice. Madras Agricultural J. 84(5):265-266.

El-Kholy, M.H.; M.H.Hegazy and F.K.Abdel –Fattah. (1999). Response of rice yield to N-fertilizer ,bio-inoculation and herbicides application .J.Agric. Sci., Mansoura Univ., 24:5165-5173.

El-Refaee, I.S.; M.E. Mosalem and F.A. Sorour. (2005). Effect of irrigation regimes on productivity of Giza 178 and Sakha 102 rice cultivars under broadcasting method. Egypt. J Agric. Res. 83 (5B): 377-391.

El-Mowelhi, N.M.; M. Saied; M.A. Abou El-Soud and S.M. El-Barbary (1995). On farm water management in soils of Kafr El-Sheikh. II- Effect of land leveling and irrigation intervals on the water utilization efficiency and rice productivity under saline soil conditions. Conf. On-Farm Irrigation and Agroclimatology, Giza, Egypt, No. 31:165-173. (2-4) 237(2-4) 22.

Ghoshi, S.K.; S.Pal and A.K. Mukhopad hyay. (1995). Split application of potassium to maximize its efficiency on yield of high yielding rice. Ind. Agriculturist. 39(4): 259-264.

Gomez, K. A. and A.A. Gomez. (1984). Statistical procedures for agricultural research .2nd .ed, John Wiley and Sons, U SA.

Khafaga E.E.E.:M.I.Abdel –Kalek and H.A.Awad. (2006) Irrigation water depth and Nitrogen fertilizer levels for rice production under two water table levels . J.Agric. Sci. Mansoura Univ. 31(6):4041-4047.

MSTAT Development Team. (1989). Microcomputer program for design management. Analysis of Agronomy Research Experiments. Michigan S. University, East Lansing, USA.

Molden, D., H. Murray-Rust, R. Sakthivadivel and I. Makin. (200. A water productivity framework for understanding and action. Workshop on Water Productivity .Wadduwa, Sri Lanka, November 12 and 13, 2001.

Meena,S.; S. Singh and Y.S. Shivary. (2003). Response of hybrid rice (Oryza sativaL.) to nitrogen and potassium application in sandy clay-loam soils. Indian J. of Agric. Sci.,73(1):8-11.

Mitsui, T.; T. Lobada; A. Itoh and T. Tkarashi. (1999). Sugar controlled Ca+2 uptake and amylase secretion in cultured cell of rice (Oryza sativa L.). Plant Cell physiology (40): 884-893.

Natarajan, S., K. Arivazhagan and U. Surendran. (2004). Effect of split application of different potassic fertilizers on yield and nutrient uptake by rice cv PY5. J.of Ecobiology16 (3) 175-180

Pillal, R.N. and P. Anasuya (1997). Effect of graded levels of applied potassium on dry matter production and potassium concentration in leaves of rice. J. of Potassium Res. 13(2):137-142.

Poonam, A.; I.P. Sharma and V.C. Srivastava. (1993). Rate and time of potassium application in transplanted rice. J. of Res. Birsa. Agric. Univ. 5(2): 171-172. (C.F. CD Rom Computer System).

Qadar, A. (1995). Requirement of rice crop for phosphorus and potassium at varying sodicity levels. J. of Plant Nutr. 18(11): 2291-2303.

Ramteke, J. R., , M. S. Powar, , S. L Yadav and V. B. Gedam(2004) Effect of time of application of phosphorus and potassium on the yield and nutrient uptake of rice hybrids. J.of Maharashtra Agric. Univ.29 (2) 242-243.

RRTC(2005). Rice Research and Training Center, Annual Report for 2004 season,Sakha, Kafr El- Shiekh ,Egypt.

RRTC(2006). Rice Research and Training Center ,Annual Report for 2005 season,Sakha Kafr El- Shiekh ,Egypt.

Tabbal DF., BAM. Bouman, SI. Bhuiyan, EB. Sibayan and MA. Sattar. (2002). On-farm strategies for reducing water input in irrigated rice: case studies in the Philippines. Agric. Water Manage. 56(2):93-112.

Thakur, D.S.; S.R. Patel and N.Ageshwarlal (1999). Effect of split application of potassium with FYM on rice (Oryza sativa L.). Indian J. of Agron., 44(2):301-303.

Velayautham, A.; K. Velayudham and R. Balasubramanian. (1992). Effect of split application of potassium to lowland rice on NPK uptake and yield. Orissa J. of Agric. Res. 5(3): 162-165.

Zayed B. Z. (1997). Effect of irrigation intervals and methods of nitrogen application on growth and yield of some rice cultivars under saline soil conditions. M.Sc. Thesis, Faculty of Agric. Agron. Dept., Mansoura University, Egypt.

Zayed, B.A. (2002). Performance of some rice cultivars as affected by irrigation and potassium fertilizer treatments under saline soil conditions. Ph.D. Thesis, Agronomy Dept., Faculty of Agric., Mansoura University.

Zayed B.A., W.H Abou El Hassan., Y. Kitamura, S.M Shehata Zahor Ahmed and Faridullah. (2006a) Effect of reuse drainage water management on rice growth yield under saline soil s of Egypt. Asian J.of Plant Sci. 5(2):287-295.

Zayed, B.A.; A.A. EL-Gouhary,A.M. El-Ekhtyar and S.E.M. Sedeek. (2006b). Response of Giza 177 and SK2034H hybrid rice to potassium splitting. 1st Crop Conference, 22-24 August, pp406-414.Egypt

انتاجية الأرز والمياة المتأثرة بفترات الري و اضافة البوتاسيوم علي دفعات تحت ظروف الأراضي الملحية المستصلحة حديثا

بسيوني عبد الرازق زايد[١] و سعيد محمد شحاته [١]و ليد محمد الخبي[١] والحسيني السيد المرسي السيد خفاجة[٢]

١-مركز البحوث والتدريب في الأرز – سخا- كفر الشيخ، معهد بحوث المحاصيل الحقلية مركز البحوث الزراعية- مصر.

٢-معهد بحوث الأراضي والمياة والبيئية -مركز البحوث الزراعية -محطة البحوث الزراعية بالسرو.

الملخص العربي

أقيمت تجربتان حقليتان بارض طينية ذات مستوي ملوحة ٦ و٥,٥٣ ملليموز /سم في الموسمين المتتاليين بمزرعة بحوث محطة السرو الزراعية بدمياط(شمال الدلتا بمصر) في موسمي صيف ٢٠٠٥و ٢٠٠٦ . الدراسة هدفت إلي دراسة تأثير فترات الري المختلفةوهي :كل ٣و٦و٩ أيام وكذا اضافة البوتاسيوم علي دفعات وهي: الأضافة دفعة واحدة ارضي والأضافة علي دفعتين ١/٢ علي الشراقي +١/٢ عند أقصي تفريع و ١/٢ عند مرحلة التفريع +١/٢ عند مرحلة بدايةتكوين النورة و ١/٣ علي الشراقي+١/٣ عند مرحلة اقصي تفريع +١/٣ عند مرحلة بداية تكوين النورة علي نمو وانتاجية الأرز(جيزة ١٧٨ وهو متحمل للملوحة والجفاف) و الميا ة تحت ظروف الأراضي الملحية المستصلحة حديثا .وكانت التربة المستخدمة طينية و ومستوي الملوحة بها.

وتتلخص اهم النتائج فيما يلي :

اثرت فترات الري علي دليل مساحة الورقة و المادة الجافة والكلوروفيل وكل مكونات محصول الحبوب ومحصول الحبوب و محتوي الورقة من النتروجين و البوتاسيوم عند مرحلة الطرد، بدون فرق معنوي بين فترتي الري ٣و٦ أيام وقد أدي تطويل فترات الري الي تسعة ايام الي نقص الصفات المذكورة بصورة شديدة تحت فترةالري ٩ ايام .

وقد تحقق اعلي معدل لانتاجية المياة سواء الطبيعي (كجم أرز / م٣مياة) أو الأقتصادي (جنية مصري/ م٣مياة) لكل من النتح بخر (الأستهلاك المائي) و الأحتياجات المائية و كذلك كمية المياة الكلية المضا فة.

بالنسبة لتأثير اضافة البوتاسيوم علي دفعات ، وجد ان الأضافةعلي دفعات تفوقت علي الأضافة علي دفعة واحدة .
ووجد ان تقسيم البوتاسيوم علي ثلاث دفعات كانت هي الأفضل و حققت اعلي انتاجية وتلتها الأضافة علي دفعتين ١/٢ عند التفريع +١/٢ عند بداية تكوين النورة . كما وجد من تأثير التفاعل المعنوي عليمحصول الحبوب وبعض مكوناته ان الأضافة علي ثلاث دفعات متساوية ١/٣ علي الشراقي +١/٣ عند بداية التفريع +١/٣ عند بداية تكوينالنورة لعبت دورا فعالا في زيادة تحمل الأرز للظروف البيئية المعاكسة مثل الملوحة و الجفاف.