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Effect of Irrigation Intervals and Submergence Head on Rice Yield and Soil Quality under Salinity of Soil and Water

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ABSTRACT

Two field trials were performed in 2015 and 2016 seasons at the Experimental Farm of El Sirw Agricultural Research Station, Damietta province, Egypt. The trial aims to study the effect of irrigation intervals and submergence head on growth, productivity and water use efficiency of Sakha 104 rice cultivar, as well as, soil characteristics under salinity of soil and water. Strip plot design was assigned as the experimental design with three replicates. The vertical plots were denoted for irrigation intervals namely; (3, 6 and 9 days). The horizontal plots were arranged for submergence head namely;(3 and 6 cm). Salinity levels of soil were 7.68 and 7.45 dSm^{-1} in the first and second seasons, respectively. Results showed that prolonging irrigation intervals markedly reduced growth characteristics such as flag leaf area, leaf area index (LAI), dry matter production, stomatal conductance, number of tillers $hill^{-1}$, chlorophyll content and plant height, as well as, grain yield, yield components and total water applied. The prolonging irrigation interval significantly increased salinity levels, sodium content of soil, bulk density and decreased potassium content of soil. The submergence head of 6 cm increased all measured growth parameters, yield, yield components and enhancing soil characteristics as compared with 3 cm of submergence head except heading date and number of unfilled grains $panicle^{-1}$. The irrigation interval of 3 days with submerged head of 3 cm gave the highest value of water use efficiency followed by 6 days with 6 cm. Generally, under this study and similar conditions, irrigation interval every 3 days with submergence head of 6 cm are suitable to enhance growth, productivity of sakha 104 rice cultivar and effective to improve soil quality. However, the irrigation interval of 3 days with submergence head of 3 cm are suitable to enhance water use efficiency.

Keywords: Saline soil, rice, irrigation and soil properties.

INTRODUCTION

Rice is a major staple food for much of the world's population, as well as, rice plant is the largest water consumer in the agricultural sector (Thakur *et al.*, 2014). Rice crop is very important cereal and beneficial crop to Egyptian's economy. It is cultivated for consumption, export and as a reclamation crop for saline soils. There is an indicator that rice crop has apparently improved the quality of salt affected soil in northern part of Delta in Egypt (Zayed *et al.* 2013). Thereby, rice planting showed vital role in soil fertility, maintenance and declining salinity harmfulness in some areas like northern part of Delta. The problem of soil salinization represents wide spectrum challenge globally and it is blooming year after year because climate change and incorrect soil managements resulted in crop production restriction (FAO, 2006). It is a major constrain for agricultural production for about 20 % of the planted and irrigated area in all over the world.

Egypt share of fresh water is stable and limited to be 55.5 billion m^3 a year despite of continuous of population raising and progress of industry and agriculture. Furthermore, production of agriculture has to be increased with more water need to meet population increasing so, water management has to be developed (Tantawi and Ghanem, 1999).

Agricultural water productivity certainly related to crop productivity, therefore, difference of water saving systems and means have been released to rice growers to reduce water need and keep reasonable yield (Pascual and Wang, 2016). Kima *et al.* (2015) assessed many submergence heads for achieving the highest value of water use efficiency in irrigated lowland rice. Findings indicated that acceptable grain yield and water saving could be achieved by using water holding at insensitive growth stages. The main grand challenge for rice yielding sustainability was found to decrease the quantity of applied water, while, keeping or raising rice grain yield to meet the needs of continued population increase by increasing productivity of water (Yang and Zhang, 2010) . A common finding has been indicated that the amount of irrigation water can be reduced without decreasing grain yield (Zhang *et al.*, 2009). The trail aims to study the effect of irrigation intervals and submergence head on growth, productivity and water use efficiency of Sakha 104 rice cultivar, as well as, soil characteristics under salinity of soil and water irrigation.

MATERIALS AND METHODS

Two field experiments were laid out in 2015 and 2016 seasons at the farm of El Sirw Agricultural Research Station, Damietta province, Egypt. The trial aims to study the effect of irrigation intervals and submergence head on growth, productivity and water use efficiency of Sakha 104 rice cultivar, as well as, soil characteristics. The design of experiment was strip plot design with three replicates. The vertical plots were denoted for irrigation intervals 3, 6 and 9 days, while the horizontal plots were arranged for water depths viz; 3 and 6 cm. The soil was clayey and its chemical properties in 2015 and 2016 seasons are shown in Table1. Soil were chemically analyzed according to Piper (1950).

Table 1. Chemical properties of experimental soil during the two seasons of study.

Chemical properties	seasons	
	2015	2016
pH	8.32	8.18
ECe dS m^{-1}	7.68	7.75
ECw dS m^{-1}	1.89	1.85
Cations $meql^{-1}$		
Ca^{++}	20.1	21.2
Mg^{++}	18.6	19.2
K^+	0.31	0.32
Na^+	37.0	36.0
Anions $meql^{-1}$		
SO_4^{--}	29.0	28.0
HCO^{---}	10.0	11.0
Cl^-	37.0	38.0

ECe and ECw = salinity of soil and water, respectively.

Seeds of Sakha 104 rice cultivar at the rate of 140 kg ha^{-1} were prepared for the nursery. Sowing dates were 25 April, in 2015 and 2016 seasons. The permanent field was well prepared as the following; calcium super phosphate (15.5% P_2O_5) was applied in the rate of 238 kg ha^{-1} during tillage of soil. Seedling aged 25 days were planted at space of 20×20 cm with 4-5 seedlings $hill^{-1}$. Potassium sulphate (48% K_2O) was added at the rate of 58 kg K_2O ha^{-1} into two equal splits as basal application and at 45 days from transplanting. The nitrogen in the form of urea (46%N) at the rate of 165 kg ha^{-1} was added into three equal doses at 15, 35 and 55 days after transplanting. Rice agricultural practices under salinity of soil and water were achieved according to the recommendation of Ministry of Agriculture.

At heading stage, the following characteristics were measured: Flag leaf area, LAI, dry matter production, stomatal conductance was measured by leaf porometer Model SC-1, chlorophyll content (SPAD value), heading date, number of tillers $hill^{-1}$, and plant height.

At harvest time, ten main panicles were randomly collected from rice plants to determined the following characteristics; number of panicles $hill^{-1}$, panicle length, panicle weight (g), 1000-grain weight (g), number of filled grains $panicle^{-1}$, number of unfilled grains $panicle^{-1}$ and fertility %. Grain yield (t ha^{-1}), straw yield (t ha^{-1}) and harvest index (HI) were estimated.

The total applied water of varying treatments were assessed by a calibrated water meter. water use efficiency of sakha 104 rice cultivar was determined by Jensen (1983).

After harvest, soil was sampled for chemical and physical analysis according to Piper (1950).

All collected data were statistically analyzed according to Gomez and Gomez (1984) using IRRISTAT program. The obtained means were compared using Duncan's multiple range test (Duncan, 1955).

RESULTS AND DISCUSSION

A-Growth behaviors at heading stage:

Results in Table 2 showed that irrigation interval had a significant effect on flag leaf area, leaf area index (LAI), dry matter production and stomatal conductance in 2015 and 2016 seasons. The maximized values of previous characteristics were obtained by irrigation interval every 3 days followed by irrigation interval every 6 days. The minimized values of them were obtained by irrigation interval every 9 days. With respect to submergence head, the submergence head treatments greatly influenced growth characteristics in 2015 and 2016 seasons (Table 2). The submergence head of 6 cm exerted the maximum values of studied growth characteristics of Sakha 104 rice cultivar. At the same time, the submergence head of 3 cm significantly produced the minimum values of growth characteristics in 2015 and 2016 seasons. The interaction between irrigation intervals and submergence head was insignificant regarding previous growth parameters, except LAI (Table 2). The irrigation interval of 3 days with submergence head of 6 cm recorded the largest LAI in 2015 and 2016 seasons, while the lowest value of LAI was observed by the combination of irrigation interval of 9 days with water depth of 3 cm (Table 3). Prolonging irrigation interval reduces nutrients uptake and photosynthesis, causes reduction in number of tiller, leaf surface, LAI and redistribution of dry matter production (Pirmoradian *et al.*, 2004 and Rezaei and Nahvi, 2008). The previous results are in similarity with those reported by Zumber *et al.* (2007) and Zayed *et al.* (2013).

Table 2. Effect of irrigation intervals and submergence head on some growth characteristics of rice under salinity of soil and water in 2015 and 2016 seasons.

Characters	Flag leaf Area (cm)		LAI		Dry matter production (g $hill^{-1}$)		Stomatal conductance (mmol $m^{-2}s^{-1}$)	
Treatments	**2015**	**2016**	**2015**	**2016**	**2015**	**2016**	**2015**	**2016**
Irrigation interval:								
3 days	43.57a	43.77a	5.62a	5.72a	17.29a	16.92a	1116.8a	1158.4a
6 days	40.22b	41.00b	4.95b	5.80b	14.91b	15.32b	959.5a	986.4b
9 days	32.57c	33.27c	3.72c	3.87c	10.28c	10.73c	560.5b	644.0c
F. Test	**	**	**	**	**	**	**	**
Submergence head:								
3 cm	36.83b	37.36b	4.47b	4.61b	13.20b	13.30b	804.1b	871.2b
6 cm	40.73a	41.33a	5.06a	5.17a	15.12a	15.34a	953.8a	988.1a
F. Test	**	**	**	**	**	**	*	**
Interaction	NS	NS	**	**	NS	NS	NS	NS

***,** and NS indicate P ≤ 0.05, P ≤ 0.01 and insignificant, respectively. Means of each column followed by the same letters in a column are insignificantly different at 0.05 level using DMRT.**

Table 3. Leaf area index of rice as affected by the interaction between irrigation intervals and submergence head in 2015 and 2016 seasons.

Irrigation interval × Submergence head	Leaf area index (LAI) 2015 3 cm	2015 6 cm	2016 3 cm	2016 6 cm
3 days	5.47b	5.77a	5.60b	5.83a
6 days	4.63c	5.27b	4.77d	5.40c
9 days	3.30e	4.13d	3.47f	4.27e

Means followed by the same letters are insignificantly different at 5% level using DMRT.

Results in Table 4 revealed that irrigation intervals; 3, 6 and 9 days markedly affected rice growth performance in both seasons. Irrigation every 3 days exerted the maximum values of chlorophyll content, number of tillers and plant height (Table 4). The irrigation interval of 6 days came in the second arrangement after irrigation interval of 3 days. Elongation of irrigation interval to 9 days was found to be bad option, since it gave the minimum values of above mentioned growth characteristics, (chlorophyll content, number of tillers and plant height). Regarding heading date, it was observed great variation in this traits due to irrigation intervals and head of submergence. Heading date was early pushed when rice plants were irrigated every 3 days. On the other side, prolonging irrigation intervals from 6 to 9 days gradually prolonged the period from sowing to heading. It is clear that water deficit significantly delayed heading date (Table 4).The reduction in chlorophyll content, number of tillers and plant height are owing to water deficit happened at tillering phase as a result of lowering leaf water content and diminishing photosynthesis (Sokoto and Muhammad, 2014). These present findings were in a similarity with those indicated by Tantawi and Ghanem (2001) and Tuong *et al*. (2005).

Table 4. Effect of irrigation intervals and submergence head on some growth characteristics of rice under salinity of soil and water in 2015 and 2016 seasons.

Characters	Chlorophyll content (SPAD value)		Heading date (day)		Number of tillers hill^{-1}		Plant height (cm)	
Treatments	**2015**	**2016**	**2015**	**2016**	**2015**	**2016**	**2015**	**2016**
Irrigation interval:								
3 days	42.30a	41.85a	105.4c	104.0b	19.44a	20.38a	96.44a	94.60a
6 days	40.60b	40.20b	106.5b	104.5b	16.66b	17.38b	80.25b	80.60b
9 days	36.50c	35.84c	109.0a	108.3a	12.59c	13.75c	67.88c	64.85c
F. Test	**	**	**	**	**	**	**	**
Submergence head:								
3 cm	38.93b	38.49b	107.5a	106.0a	15.27b	16.08b	78.65b	76.90b
6 cm	40.67a	40.10a	106.4b	105.2b	17.19a	18.25a	84.40a	83.13a
F. Test	**	**	**	**	**	**	**	**
Interaction	NS	NS	NS	NS	NS	NS	**	**

** and NS indicate P ≤ 0.01 and insignificant, respectively. Means of each column followed by the same letters in a column are insignificantly different at 0.05 level using DMRT.

The interaction between irrigation intervals and head of submergence significantly affected the plant height in both seasons (Table 4). By the way, the combination of 3 days irrigation intervals with submergence head of 6 cm apparently produced the highest plants in both seasons. On the other hand, the shortest plants were observed when rice plants were watered every 9 days at 3 cm depth (Table 5). The current data are in agreement with those reported by Sarvestani *et al*. (2008), Wan (2009), Hafez *et al*. (2015) and Refaie *et al*. (2017).

Table 5. Plant height of rice as affected by the interaction between irrigation intervals and submergence head in the two seasons of study.

Irrigation interval × Submergence head	Plant height (cm) 2015 3 cm	2015 6 cm	2016 3 cm	2016 6 cm
3 days	94.75b	98.13a	93.50b	95.70a
6 days	75.00d	85.50c	75.00d	86.20c
9 days	66.19f	69.56e	62.20f	67.50e

Means followed by the same letters are insignificantly different at 5% level using DMRT.

B-Grain yield and yield Components:

Apparently irrigation intervals markedly affected all yield components; number of panicles hill^{-1}, panicle length cm^{-1}, panicle weight g^{-1} and 1000 grains weight g^{-1} (Table 6). The 3 days irrigation interval gave the highest values of abovementioned characteristics followed by the irrigation interval of 6 days in 2015 and 2016 seasons. The minimum values of studied yield components were produced when rice plants were subjected to water prolonging up to 9 days in both seasons of study. With respect to head of submergence, the submergence head treatments greatly influenced the yield components parameters in both season of study (Table 6). The submergence head of 6 cm exerted the maximum values of studied yield components of Sakha 104 rice cultivar. At the same time, the submergence head of 3 cm significantly produced the minimum values of yield components in the two seasons of study. Reduction in characters of yield caused by prolonging irrigation interval not only affects the amount of used water but also reducing absorption of nutrients by plant and reduction of photosynthesis (Zumber *et al*., 2007). Pirmoradian *et al*.(2004) and Rezaei and Nahvi (2008) showed similar pattern of current findings.

Table 6. Effect of irrigation intervals and submergence head on some yield components of rice under salinity of soil and water in 2015 and 2016 seasons.

Characters	No. of panicles hill^{-1}		Panicle length (cm)		Panicle weight (g)		1000-grain weight (g)	
Treatments	**2015**	**2016**	**2015**	**2016**	**2015**	**2016**	**2015**	**2016**
Irrigation interval:								
3 days	17.09a	17.88a	17.30a	17.65a	2.84a	2.86a	25.22a	25.17a
6 days	14.28b	15.63b	16.06b	16.55b	2.63b	2.70b	24.52b	24.55b
9 days	10.97c	11.38c	14.16c	14.60c	2.33c	2.33c	19.94c	20.15c
F. Test	**	**	**	**	**	**	**	**
Submergence head:								
3 cm	12.81b	13.67b	15.42b	15.83b	2.51b	2.52b	22.57b	22.72b
6 cm	15.42a	16.25a	16.27a	16.70a	2.70a	2.73a	23.88a	23.87a
F. Test	**	**	**	**	**	**	**	**
Interaction	*	*	NS	NS	*	**	**	**

*,** and NS indicate P ≤ 0.05, P ≤ 0.01 and insignificant, respectively. Means of each column followed by the same letters in a column are insignificantly different at 0.05 level using DMRT.

The interaction between irrigation intervals and submergence head significantly influenced number of panicles hill^{-1}, panicle weight and 1000-grain weight in 2015 and 2016 seasons (Table 6). The highest values of panicles number, the heaviest panicles and 1000- grain weight were obtained when rice plants were irrigated every 3 days with 6 cm depth in 2015 and 2016 seasons. The combination of 9 days irrigation intervals and 3 cm submergence head gave the lowest values of previous mentioned yield components. The submergence heads of 3 and 6 cm with irrigation interval of 3 days were at a par regarding yield components characters that mentioned above (Table 7).

Table 7. Some rice yield components as affected by the interaction between irrigation intervals and submergence head in 2015 and 2016 seasons.

Irrigation interval × Submergence head	No. of panicle hill^{-1}		Panicle weight (g)		1000-grain weight (g)	
	3 cm	6 cm	3 cm	6cm	3 cm	6cm
			2015			
3 days	16.44a	17.75a	2.79a	2.89a	25.07a	25.37a
6 days	12.31b	16.25a	2.47b	2.79a	23.67b	25.37a
9 days	9.69c	12.25b	2.25c	2.42b	18.97d	20.90c
			2016			
3days	17.25ab	18.50a	2.82b	2.90a	25.25a	25.10a
6 days	13.75c	17.50b	2.55c	2.85ab	23.80b	25.30a
9 days	10.00d	12.75b	2.20e	2.45d	19.10d	21.20c

Means followed by the same letters are insignificantly different at 5% level using DMRT.

Results in Table 8 revealed that irrigation intervals and submergence head had a significant effect on number of filled grains panicle^{-1}, number of unfilled grains panicle^{-1} and fertility % in 2015 and 2016 seasons. The maximum number of filled grains panicle^{-1} and fertility % were obtained when sakha 104 rice cultivar irrigated every 3 days followed by irrigation interval of 6 days, while the lowest values of them were observed by irrigation interval of 9 days. Regarding submergence head, the 6 cm of submergence head had a significant effect on number of unfilled grains per panicle and fertility % as compared with 3 cm of submergence head. However, the lowest number of unfilled grains panicle^{-1} were obtained by irrigation interval of 3 days and submergence head of 6 cm in both seasons of study. The interaction between irrigation intervals and submergence head was insignificant on above mentioned characters. These results are agreement with those obtained by Boonjung and Fukai (1996) and Zayed (1997).

Table 8. Effect of irrigation intervals and submergence head on some yield components of rice under salinity of soil and water in 2015 and 2016 seasons.

Characters / Treatments	No. of filled grains panicle^{-1} 2015	2016	No. of unfilled grains panicle^{-1} 2015	2016	Fertility % 2015	2016
Irrigation interval:						
3 days	96.64a	99.35a	20.82c	19.10c	82.3a	83.8a
6 days	91.15b	94.10b	26.20b	24.04b	77.5b	79.5b
9 days	72.46c	72.00c	35.50a	35.50a	67.1c	66.8c
F. Test	**	**	**	**	**	**
Submergence head:						
3 cm	81.08b	82.07b	30.45a	28.17a	72.6b	74.0b
6 cm	92.42a	94.90a	24.57b	24.26b	78.7a	79.0a
F. Test	**	**	**	**	**	**
Interaction	NS	NS	NS	NS	NS	NS

**** and NS indicate P ≤ 0.01 and insignificant, respectively. Means of each column followed by the same letters in a column are insignificantly different at 0.05 level using DMRT.**

Results in Table 9 clarified that irrigation intervals significantly induced great variation in grain yield and straw yield, as well as, HI in both season of study. Interestingly, the irrigation interval of 3 days significantly produced the maximum values of grain and straw yields, and harvest index. The minimum values of abovementioned yields in both seasons of study were recorded at the irrigation interval of 9 days. Regarding the impact of submergence head, the couple submergence heads showed certain variation in rice yields, and harvest index. The submergence head of 6 cm gave the highest mean of yields in the two seasons of current study. The minimum values of yields were obtained by the submergence head of 3 cm in 2015 and 2016 seasons. Yield decreasing happened by water deficit might be contributed to diminishing of metabolism and photosynthesis as well as, assimilation translocation. Clearly, water scarcity in plant restricted plant evapotranspiration and finally yield (Shani and Dudley, 2001). The grain yield reduction mainly developed from sever fertile panicle reduction and partially grain filling. The means of total biomass, harvest index, plant height, filling grains and 1000-grain weight were decreased under increasing irrigation interval resulted in reduction of grain yield (Zeinolabedin, 2012 and Sokoto and Muhammed, 2014). The reduction in rice grain yield could be attributed to the reduction in number of tillers hill^{-1}, number of filled grains panicle^{-1}, panicle weight and increase in number of unfilled grains panicle^{-1} as well as the decrease in 1000-grain weight (Refaie *et al*., 2017). Reaults are in a good agreement with those discriminated by Shani and Dudley (2001) and Zayed *et al*. (2017).

Table 9. Effect of irrigation intervals and submergence head on grain yield and straw yield, as well as HI of rice under salinity of soil and water in 2015 and 2016 seasons.

Characters / Treatments	Grain yield (t ha^{-1}) 2015	Grain yield (t ha^{-1}) 2016	Straw yield (t ha^{-1}) 2015	Straw yield (t ha^{-1}) 2016	HI 2015	HI 2016
Irrigation interval:						
3 days	5.374a	5.500a	9.19a	9.33a	0.37a	0.37a
6 days	4.470b	4.600b	8.56b	8.18b	0.34b	0.36ab
9 days	2.555c	2.630c	5.23c	4.75c	0.33b	0.35b
F. Test	**	**	**	**	**	*
Submergence head:						
3 cm	3.768b	3.817b	7.05b	6.97b	0.34	0.35b
6 cm	4.498a	4.667a	8.27a	7.87a	0.35	0.37a
F. Test	**	**	**	**	NS	**
Interaction	*	**	NS	NS	NS	NS

*,** and NS indicate $P \leq 0.05$, $P \leq 0.01$ and insignificant, respectively. Means of each column followed by the same letters in a column are insignificantly different at 0.05 level using DMRT.

The interaction between irrigation intervals and flooding head had a significant effect on yield in 2015 and 2016 seasons (Table 9). The highest values of yields were given by the combination of 3 days irrigation interval and submergence head of 6 cm. The combination of 9 days irrigation interval and 3 cm submergence head exerted the lowest means of grain yield in 2015 and 2016 seasons (Table 10).

Table 10. Grain yield of rice as affected by the interaction between irrigation intervals and submergence head on in 2015 and 2016 seasons.

Irrigation interval × Submergence head	2015 3 cm	2015 6 cm	2016 3 cm	2016 6 cm
3 days	5.17b	5.58a	5.35b	5.65a
6 days	3.89c	5.05b	4.00c	5.20b
9 days	2.25e	2.86d	2.10e	3.15d

Grain yield (t ha^{-1}). Means followed by the same letters are insignificantly different at 5% level using DMRT.

C- Total applied water and water use efficiency:

Table 11 showed the studied water relations such as total applied water and water use efficiency in both growing seasons. The highest mean of total applied water was recorded when rice plants were irrigated every 3 days. The lowest total water applied was recorded by irrigation interval of 9 days in both seasons. At the same time, the couple submergence head distinctly developed significant influence on water relates mentioned above. The interaction between irrigation intervals and submergence head showed significant effect on total water applied and water use efficiency in 2015 and 2016 seasons (Table 11). The same results were reported by Pirmoradian *et al.* (2004) and Mojtaba *et al.* (2009).

The interaction results indicated that the amount of total water applied had be increased by reducing of irrigation interval to 3 days with submergence head of 6 cm. The irrigation interval of 3 days with submergence head of 3 cm recorded the maximum value of water use efficiency followed by irrigation interval of 6 days with 6 cm of submergence head in 2015 and 2016 seasons (table 12). The lowest value of water use efficiency was obtained with the irrigation interval of 9 days with 3 cm of water depth in 2015 and 2016 seasons.

Table 11. Total applied water and water use efficiency of rice under salinity of soil and water in 2015 and 2016 seasons.

Characters / Treatment	Total applied water ($m^3 ha^{-1}$) 2015	Total applied water ($m^3 ha^{-1}$) 2016	Water use efficiency (kg m^{-3}) 2015	Water use efficiency (kg m^{-3}) 2016
Irrigation interval:				
3 days	14788 a	14882 a	0.363 a	0.370 a
6 days	12667 b	13023 b	0.353 a	0.353 b
9 days	9987 c	10135 c	0.256 b	0.260 c
F. Test	**	**	**	**
Submergence head:				
3 cm	11010 b	11017 b	0.333	0.335
6 cm	13951 a	14343 a	0.320	0.325
F. Test	**	**	NS	NS
Interaction	**	**	*	*

*,** and NS indicate $P \leq 0.05$, $P \leq 0.01$ and insignificant, respectively. Means of each column followed by the same letters in a column are insignificantly different at 0.05 level using DMRT.

Table 12. Total water applied and water use efficiency of rice as affected by the interaction between irrigation intervals and submergence head in 2015 and 2016 seasons.

Irrigation interval × Submergence head	Total water applied (m^3 ha^{-1}) 3 cm	Total water applied (m^3 ha^{-1}) 6 cm	Water use efficiency (kg m^3) 3 cm	Water use efficiency (kg m^3) 6 cm
2015				
3 days	12900c	16676a	0.400a	0.335b
6 days	11410d	13924b	0.341b	0.363b
9 days	8720e	11254d	0.258c	0.254c
2016				
3 days	12970c	16794a	0.413a	0.336b
6 days	11540d	14506b	0.347b	0.358b
9 days	8540e	11730d	0.246d	0.269c

Means followed by the same letters are insignificantly different at 5% level using DMRT.

D-Soil properties:

The analysis variance of data showed that the studied irrigation intervals significantly released variation in soil properties. The statically analysis of data clarified that irrigation intervals greatly affected pH value in the second season, salinity level of soil, bulk density, sodium and potassium contents in both seasons after harvest (Table 13). The pH value didn't significantly response to irrigation intervals in the first seasons. The prolonging irrigation interval significantly increased salinity level, bulk density and sodium content of soil even more than the initial salinity level. On the other hand, narrowing the irrigation interval to 3 days was found to be more efficient to leach salt to drainage water resulted in reducing soil salinity level (Ec) and sodium content of soil. However, potassium content was significantly reduced by strengthening irrigation interval. The data indicated that reducing sodium soil content had positive effective in enhancing potassium soil content. The value of pH was slightly decreased by prolonging irrigation interval. The pH soil reaction showed the opposite pattern of salinity level under irrigation intervals. Reducing Na^+ in soil encourage soil aggregates formations resulted in low bulk density and improving drainage system of soil. Similar results were obtained by Hafez *et al.* (2015) and Zayed *et al.* (2017).

With respect to submergence head, the pH soil values, soil salinity level, bulk density, sodium and potassium soil contents were greatly varied by submergence head in both seasons (Table 13). The pH values were reached its maximum value under 6 cm submergence head. The potassium soil content had same pattern of pH value in both seasons of study. Couple traits of soil salinity level and sodium soil content had the same trend under studied submergence head. The latter traits recorded its maximum values under submergence head of 3 cm. The 6 cm head was found to be more efficient to leach more salt to drainage channel resulted in the lowest value of sodium soil content. Increasing submergence head ensured enough water for soil reclamation that induced low salinity level, sodium content and bulk density resulted in improving soil properties and productivity of rice crop. The current findings are in a good confirming with those reported byEl-Sharkawy *et al.* (2006) and Abu and Malgwi (2012).

The interaction between irrigation interval and submergence head had significant effect on salinity level of soil in both seasons (Table 13). The interaction results confirmed that the prolonging irrigation interval and reducing head of submergence is not recommended under saline or saline sodic soils. Increasing water irrigation under saline soil and water to get rid of salt accumulation is much needed that was hold true with the current attempt (Table 14).

Table 13. Effect of irrigation intervals and submergence head on some soil properties of experimental site in 2015 and 2016 seasons.

Characters	pH		Ec (dSm^{-1})		Bulk density ($g\ cm^{-3}$)		$Na^+ meq\ l^{-1}$		$K^+ meq\ l^{-1}$	
Treatments	**2015**	**2016**	**2015**	**2016**	**2015**	**2016**	**2015**	**2016**	**2015**	**2016**
Irrigation interval:										
3 days	8.32	8.41 a	6.40 c	6.46 c	1.66c	1.64c	32.79 c	31.64 b	0.384 a	0.402 a
6 days	8.22	8.35ab	7.06 b	6.90 b	1.70b	1.69b	35.63 b	34.36 a	0.366 b	0.381 b
9 days	8.28	8.30 b	8.01 a	7.85 a	1.74a	1.73a	37.82 a	35.59 a	0.351 c	0.360 c
F test	NS	*	**	**	**	**	**	**	**	**
Submergence head:										
3 cm	8.23 b	8.29 b	7.65 a	7.53 a	1.73a	1.72a	36.65 a	35.41 a	0.349 b	0.368 b
6 cm	8.32 a	8.42 a	6.66 b	6.61 b	1.67b	1.66b	34.18 b	32.32 b	0.385 a	0.393 a
F. Test	*	*	**	**	**	**	**	*	**	**
Interaction	NS	NS	**	**	NS	NS	NS	NS	NS	NS

***,** and NS indicate P ≤ 0.05, P ≤ 0.01 and insignificant, respectively. Means of each column followed by the same letters in a column are insignificantly different at 0.05 level using DMRT.**

Table 14. Ec of soil as affected by the interaction between irrigation intervals and water submergence head under salinity of soil and water.

Irrigation interval × Submergence head	Ec (dSm^{-1}) 2015		2016	
	3 cm	**6 cm**	**3 cm**	**6 cm**
3 days	6.99 c	5.82 e	7.00 c	5.93 d
6 days	7.74 b	6.38 d	7.53 b	6.28 d
9 days	8.23 a	7.78 d	8.08 a	7.62 ab

Means followed by the same letters are insignificantly different at 5% level using DMRT.

CONCLUSION

Under this study and similar conditions. The water management in the form of irrigation interval every 3 days with submergence head of 6 cm is recommended to enhance growth, productivity of Sakha 104 rice cultivar and effective to improve soil quality. However, the irrigation interval of 3 days with submergence head of 3 cm are suitable to enhance water use efficiency.

REFERENCES

Abu, S.T. and W.B. Malgwi (2012). Effects of irrigation regime and frequency on soil physical quality, water use efficiency, water productivity and economic returns of paddy rice. ARPN J. of Agric. and Biol. Sci., 7(2):86-99.

Boonjung, H. and S. Fukai (1996). Effects of soil water deficit at different growth stages on rice growth and yield under upland conditions. Field Crops Research, 48: 47-55.

Duncan, B.D. (1955). Multiple ranges and multiple F-test. Biometrics, 11:1-42.

El-Sharkawy, H. M.; B. Zayed; T. Honna and S. Yamamoto (2006). Chemical compositions and salinity development in paddy soil as affected by irrigation intervals of mixed water under saline soil. Pakistan J. Biol. Sci., 9(4):741-745.

FAO, (2006). Species description. Oryza sativa L. www. fao.org.

Gomez, K.A. and A. A. Gomez (1984). Statistical Procedures for Agricultural Research. 2nd Edition. A Wiley Interscience Pub., John Wiley and Sons, New York. USA. Pp.628.

Hafez, E. M.; W. H. Abou El Hassan; I. A. Gaafar and M. F. Seleiman (2015). Effect of gypsum application and irrigation intervals on clay saline-sodic soil characterization, rice water use efficiency, growth, and yield. J. of Agri. Sci., 7 (12):1916-1926.

Jensen, M. E. (1983). Design and operation of farm irrigation systems. Monograph, Amer. Soc. Agric. Eng.

Kima, A.S.; W.G. Chung; Y.M. Wang and S. Traore (2015). Evaluating water depths for high water productivity in irrigated lowland rice field by employing alternate wetting and drying technique under tropical climate conditions, southern Taiwan. Paddy Water Environ., 13: 379–389.

Mojtaba, R.; H.S. Vahed; M.K. Motamed and E. Azarpour (2009). The effects of irrigation and nitrogen management on yield and water productivity of rice. World Applied Sci. J., 7(2):203-210.

Pascual, V.J. and Y.M. Wang (2016). Utilizing rainfall and alternate wetting and drying irrigation for high water productivity in irrigated lowland paddy rice in southern Taiwan. Plant Prod. Sci., 19: 1–12.

Piper, C.S. (1950). Soil and plant analysis. Inter science Publisher. Inc. New York., USA.

Pirmoradian, N.; A.L. Sepaskhah and M. Mafton (2004). The effects of deficit irrigation and different levels of nitrogen on yield and water productivity of rice. Proceeding of the 11th Seminar of Iranian National Committee on Irrigation and Drainage. Dec. 2004. Tehran, Iran.

Refaie, K.M.; H.M. El Sharkawi; A.A. Khalil; T.F. Metwally; S.M. Abolmaty; B.A. Ali and M.K. Hassanein (2017). Smart control of water flow and depth within rice field for improving irrigation management and mitigating methane emission. Int. J. Adv. Res., 5(1):2904-2910.

Rezaei, M. and M. Nahvi (2008). Effect of different irrigation management methods on water use efficiency and some characters of two native rice cultivars in Guilan. J. Agric. Sci., 1(9):15-26.

Sarvestani, Z.T.; H. Pirdashti; S.A. Sanavy and H. Balouchi (2008). Study of water stress effects of different growth stages on yield and yield components of different rice (oryza sativa L.) cultivars. Pakistan. J. Biol. Sci., 11(1);1303-1309.

Shani, U. and L.M. Dudley (2001). Field studies of crop response to water and salt stress. Soil Science. Society of America J., 65: 1522-1528.

Sokoto, M.B. and A. Muhammad (2014). Response of rice varieties to water stress in Sokoto, Sudan savanna, Nigeria. J. of Bioscience and Medicines, 2:68-74.

Tantawi, B.A. and S.A. Ghanem (1999). Water use efficiency in rice culture. In: Chataigner J. (ed.). Future of water management for rice in Mediterranean climate areas: Proceedings of the Workshops. Montpellier: CIHEAM,.39-45.

Tantawi, B.A. and S.A. Ghanem (2001). Water use efficiency in rice culture. Agricultural Research Center, Giza (Egypt). *CIHM-Optin Mediterraneennes*, 40: 39-45.

Thakur, A.K.; R.K. Mohanty; D. Patil; A. Kumar (2014). Impact of water management on yield and water productivity with system of rice intensification (SRI) and conventional transplanting system in rice. Paddy Water Environ., 12: 413–424.

Tuong, T.P.; B.A.M. Bouman and M. Mortimer (2005). More Rice, less water-integrated approaches for increasing water productivity in irrigated rice. Based Systems in Asia. Plant Production Sci., 8: 229-239.

Wan, M. Z. (2009). Rice growth and yield under rain shelter house as influenced by different water regimes. International J. of Agri. and Biological Sci., 11: 556-560.

Yang, J. and J. Zhang (2010). Crop management techniques to enhance harvest index in rice. J. Exp. Bot., 61: 3177–3189.

Zayed, B. A. (1997). Effect of irrigation intervals and nitrogen fertilizer treatments on growth and yield of some rice cultivars under saline soil conditions. M.Sc. Thesis. Agron. Dept. Fac. Agric. Mansoura Univ., Egypt.

Zayed, B. A.; I. A. El-Saiad; S. M. Bassiouni and A. K. Salem (2013). Effect of different planting systems on soil water and rice productivity in the Northern part of Delta in Egypt. J. of Soils Sci. and Agric. Eng., Mansoura Univ., 4(5):453-462.

Zayed, B.A.; W.H. Elkellawy; Amira M. Okasha and M. Abd El-Hamed (2017). Improvement of salinity soil properties and rice productivity under different irrigation intervals and gypsum rates. J. Plant Production, Mansoura Univ., 8(3):361-368.

Zeinolabedin, J. (2012). The Effects of Salt stress on plant growth. Tech. J. Engin. & App. Sci., 2 (1): 7-10.

Zhang, H.; Y. Xue; Z. Wang; J. Yang and J. Zhang (2009). An alternate wetting and moderate soil drying regime improves root and shoot growth in rice. Crop Sci., 49: 2246–2260.

Zumber, M.A.; A.K. Chowdhury; M.Z. Islam; T. Ahmad and M.A. Hasa (2007). Effects of water stress on growth and yield attribute Aman rice genotype. Int. J. Sustain. Crop Prod., 2(6):25-30.

تأثير فترات وارتفاع مياه الرى على محصول الأرز وجودة التربة تحت ظروف ملوحة الأرض والمياه

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أقيمت تجربتان حقليتان خلال موسمى 2015 و 2016 بمحطة بحوث السرو الزراعية بمحافظة دمياط، مصر. وكان الهدف من الدراسة هو معرفة تأثير فترات الرى وارتفاع المياه على نمو وإنتاجية وكفاءة استخدام المياه لصنف الأرز سخا 104 وتأثيرها على جودة التربة. أجريت التجربة فى تصميم الشرائح المتعامدة مع استخدام ثلاث مكررات, حيث وضعت فترات الرى (3 و 6 و9 أيام) فى القطع الرأسية بينما وضع فى القطع الأفقية ارتفاع ماء الرى (3 و 6 سم). كانت مستويات ملوحة التربة 7.68 و7.45 دسيسمينز/م فى كلا موسمى الدراسة على التوالى. أوضحت النتائج أن طول فترة الرى أثرت سلبيا على صفات النمو تحت الدراسة وهى مساحة ورقة العلم , دليل مساحة الأوراق , المادة الجافة المتكونة , التوصيل الثغرى ,عدد الأفرع , محتوى الكلوروفيل , طول النبات والمحصول ومكوناته وأيضا أدت الى زيادة مستوى ملوحة التربة ومحتوى الصوديوم والكثافة الظاهرية وانخفاض محتوى البوتاسيوم . أدى الرى بارتفاع 6 سم إلى تحسين صفات النمو والمحصول ومكوناته وحسن أيضا من خواص التربة مقارنة بالرى بارتفاع 3 سم. أعطى الرى كل 3 أيام بارتفاع 3 سم أعلى كفاءة فى استخدام الماء وجاء الرى كل 6 أيام بارتفاع 6 سم فى المرتبة الثانية. تحت هذه الدراسة نجد أن الرى كل 3 أيام بارتفاع 6 سم يكون مناسب للحصول على إنتاجية مناسبة من صنف الأرز سخا 104 مع تحسين خواص التربة والرى كل 3 ايام بارتفاع 3 سم للحصول على أعلى كفاءة فى استخدام الماء.