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Effect of Organic and Inorganic Fertilizers on Rice and Some Nutrients Availability under Different Water Regimes

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Abstract

Water and fertilizer management are essential to achieve high yield potential in irrigated rice soils. The effect of inorganic, organic fertilizers and their combinations under different irrigation intervals on yield and its attributes of Sakha 106 rice cultivar as well as, the availability of some nutrients (ammonium, nitrate, phosphorus and potassium) in the soil were investigated. A field experiment was conducted at the Experimental Farm Sakha Agriculture Research Station, Kafr El-Sheikh, Egypt, during 2016 and 2017 rice growing seasons. Five rates of fertilizers; control without any fertilizer application (T1), 4.76 tons farm yard manure (FYM) /ha (T2), 4.76 tons of composted rice straw (CRS)/ha (T3), 4.76 tons FYM +110 N kg/ha (T4), 4.76 tons CRS +110 kg N/ha (T5) and the recommended dose of nitrogen, 165 kg N/ha (T6) were used under five irrigation treatments namely; continuous flooding (W1), continuous saturation (W2), irrigation every 6 days (W3), irrigation every 9 days (W4) and irrigation every 12 days (W5). The results indicated that W1 and W2 caused an increase in chlorophyll content, number of tillers/m^2, number of panicles/m^2, panicle weight (g), number of filled grains/panicle, panicle weight, straw yield (t/ha) and grain yield (t/ha) without any significant difference among them. The greatest values of all studied characters were observed with fertilizer treatments T5 and T6 under the irrigation treatments W1, W2, W3 and W4. The highest amounts of nutrients (NH_4^+ and P) availability were found under flooded condition (W1) followed by W2, W3 and W4 especially with T5 treatment. Whereas, the maximum values of nitrate (NO_3^-) availability were found under W5 followed by W4. Potassium was mostly available under W2 followed by W1 in 2016 and 2017 seasons.

Keywords: Rice; Water regime; Organic and inorganic fertilizer; Nutrient availability

Introduction

In Egypt, rice is one of the major water consuming crops and most of Egyptian rice genotypes are grown under continuous flooding with about 5 cm depth of standing water throughout the growing season [1]. Most of Egyptian rice genotypes show better growth and higher productivity under continuous flooding conditions than under water deficit at certain growth stages [2]. Water resources in Egypt are limited to 55.5×10^9 m^3/ year, with tremendous increase in the population, production has to be increased and irrigation water should be well managed for increasing water use efficiency [3]. In near future it is expected that, less water will be available for rice growing [4]. Some rice planted areas, especially at the end of the terminal irrigation channels in the northern part of the Nile Delta, suffer from irrigation water shortage during different growth stages [5]. Therefore, water input can be reduced by; reducing water depth to soil saturation and using different irrigation intervals [6]. Recently, the term "water-saving irrigation techniques" has been introduced, which recommends, (i) reducing the depth of ponded water from 5-7 cm to 2-3 cm height to reduce the amount of water used for irrigation (ii) keeping the soil just saturated by irrigation until the soil is wet [5,7].

It is important to understand the properties of flooded soils in order to manage soil, fertilizer, and moisture regimes and to maximize rice production in a given environment. The application of the organic fertilizers such as the farmyard manure and composted rice straw could increase the soil organic matter contents which serve several advantages like conservation and slow release of nutrients, improve of soil chemical and physical conditions and preservation of soil moisture that help for high production. These advantages lead to increasing the fertility and productivity of the soil [8]. Alternate flooding and dry, gave highest rice grain yield and nitrogen uptake than continuous flooding. In flooded and saturated anaerobic soils, ammonium is the dominant form of available N. Most of the losses of nitrogen fertilizer (N) occur immediately after application into the floodwater through ammonia volatilization [9]. Some of the ammonia is nitrified in oxidized soil zones and in the floodwater [10]. Due to the difference in behavior of nutrients under flooded soil compared to irrigation intervals so, we need to know the best recommendation of fertilizers under irrigation intervals. A study was, therefore, carried out with water and fertilizer management to investigate the yield potential with following objectives 1) to find out the suitable irrigation practice, 2) to determine the suitable fertilizer package and 3) to study the combine effects of irrigation and fertilizer on growth, yield 4) discuss the chemistry of nutrients availability under water stress which may help in better nutrient management and consequently greater yields.

Materials and Methods

Field experiment was conducted at the Experimental Farm Sakha Agriculture Research Station, Kafr El-Sheikh, Egypt, during 2016 and 2017 rice growing season's (Figure 1). To study the impact of different water regimes and fertilizer treatments on yield and its attributes of Sakha 106 rice cultivar as well as the availability of NH_4^+, NO_3^+, P and K at different periods (30, 60 and 90 days after transplanting) and the best combination among studied factors. Five water treatments were used; continuous flooding (W1), continuous saturation (W2), irrigation every 6 days (W3), irrigation every 9 days (W4) and irrigation every 12 days (W5). The fertilizer treatments were, control without any fertilizer application (T1), 4.76 tons of farm yard manure (FYM) /ha (T2), 4.76 tons of composted rice straw (CRS)/ha (T3), 4.76 tons FYM +110 kg N /ha (T4), 4.76 tons CRS +110 kg N /ha (T5) and recommended dose of nitrogen, 165 kg N /ha (T6). Full dose of phosphorus 36.89 kg P_2O_5 ha^{-1} as a superphosphate (15%) was applied as a basal dose during land preparation and incorporated well into the dry soil, while, zinc as zinc sulphate at the rate of 23.8 kg/ha was applied in the nursery after wet leveling. The experiment was laid out in a strip plot design with four replications; irrigation treatments were located in the main plots, while the fertilizers treatments were placed in the sub-plots. After 30 days from nursery, the seedlings were pulled and transferred to the permanent field and transplanted at the spacing 20 × 20 cm between rows and hills. The FYM and CRS treatments were applied during the land preparation. While nitrogen fertilizer was added as urea form (46.5% N) according to the experimental treatment. Two third of N was applied as basal application, and the other third was top dressed at 30 days after transplanting (DAT).

The studied characters

Chlorophyll content of flag leaf (SPAD), number of tillers/m^2, number of panicles/m^2, panicle weight (g), number of filled grains/panicle, straw yield (t/ha) and grain yield (t/ha). Plant sample were collected from each plot for collection of data on plant characters and yield components. The straw yield was estimated while; grain yield was adjusted at 14% moisture. All traits were measured according to the standard's evaluation system used by the International Rice Research Institute (IRRI, Manila, Philippines) [11].

Some chemical analyses of soil used in this study before the experiments were presented in Table 1-3. Total soluble cations and anions, pH and E_c in soil paste extract were determined according to [12]. Soil samples were taken from each plot for all replications at 30, 60 and 90 days after transplanting (DAT), all samples were subjected to determination of available NH_4^+, NO_3^-, P and K according to the methods of [13]. Collected data were subjected to statistical analysis according to procedure describe by [14]. Means were compared at p<0.05 Duncan's multiple test (MRT), which was adapted by [15]. Water use efficiency (WUE) was calculated as following equation:

WUE (kg ha^{-1} m^{-3})=Crop yield (kg ha^{-1})/Water supply (mm or m^3).

Soil chemical properties	**2016 season**	**2017 season**
pH (1:2.5)	8.2	8.3
Ec (ds.m-1)	3.2	3.39
Organic matter%	1.22	1.35
Total nitrogen mg/kg	435	515
Available P, mg/kg (0.5 M $NaHCO_3$)	5.8	6.3
Available Ammonium (ppm)	16	17.3
Available Nitrate (ppm)	13.5	14.6
Available Potassium (ppm)	215	240.8
Anions(meq/l)		
CO_3^-	--	--
HCO_3	5.56	5.4
Cl^-	9	10.2
SO_4^{--}	18.33	18.3
Cations (meq/L)		
Ca^{++}	10.01	11.38
Mg^+	5	6.2
Na^+	1.88	2
K^+	16	14.8

Table 1: Chemical analyses of the experimental soil before planting in 2016 and 2017 seasons.

Analysis	**C%**	**N%**	**C:N ratio**	**P%**	**K %**
Farm yard manure	23.5	1.5	15.66	0.45	0.48
Composted rice straw	31.2	1.75	17.82	0.86	1.95

Table 2: Some chemical analysis of the organic materials (farm yard manure and composted rice straw) used.

	2016 season					**2017 season**				
Months	**Air temperature (Co)**		**RH %**		**Evaporation**	**Air temperature (Co)**		**RH %**		**Evaporation**
	Max.	**Min.**	**0.3125**	**0.5625**	**Max.**	**Min.**	**0.3125**	**0.5625**		
			A.M	**P.M**			**(mm/day)**	**A.M**	**P.M**	**(mm/day)**
April	30.03	18.62	81.6	41.8	593.8	25.4	16.6	82.3	48.3	550.9
May	30.4	22.81	71	45.8	647.03	31.2	23.8	75.6	43.9	633.8
June	33.6	26.3	75.7	46.6	806.8	32.6	25.3	75	48.7	770.9
July	33.7	26.1	82.7	56.8	783.5	34.2	25.3	75.5	48	736.9
August	33.6	26	84.3	56.3	773.6	34.2	26.5	83.5	57	780
Sep.	32.6	24.3	81.3	51.8	590.5	31.9	23.5	82	50.3	585

Oct.	29.8	21.7	82.4	55.3	356.9	29.5	22	82	56	360.5

Table 3: Monthly temperature means (c°), relative humidity (RH %) and evaporation (mmd^{-1}) at study area in 2016 and 2017 seasons.

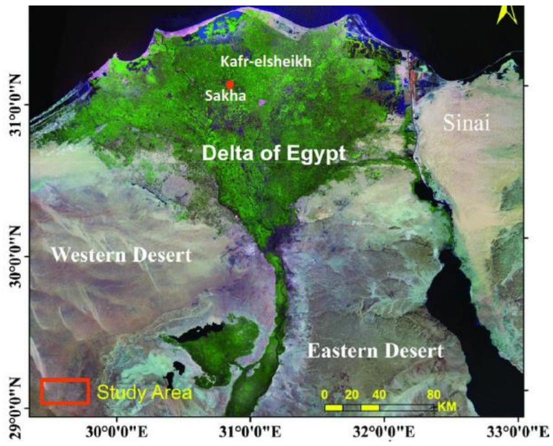

Figure 1: Map showing study area in Kafr El- Sheikh Governorate (Sakha region), North Egypt. It is part of the Egyptian Nile delta that is characterized by extensive rice cultivation. It is located between 31°06 0 40 00 and 31°06 0 0 00 North and 30°54 0 30 00 and 30°55 0 60 00 East.

Results and Discussion

Chlorophyll content of flag leaf, number of tillers/m^2 and number of panicles/m^2, panicle weight (g), number of filled grains/panicle, straw and grain yield (t/ha) of Sakha 106 rice cultivar influenced by water regime and fertilizers treatments are presented in Table 4. Data demonstrated that the continuous flooding (W1) and saturation (W2) treatments gave the greatest values for all studied characters as compared with the other irrigation treatments. On the other hand, the irrigation every 12 days (W5) treatment significantly reduced the values of all the studied characters. The shortage of water might have caused a decrease in the activity of nodes and buds that reduces the emergence of tillers especially the effective tillers and number and area of leaves due to the decrease in cell division and elongation these results are harmony with those obtained [16].

Data also, indicated that irrigation every 12 days decreased the chlorophyll content of flag leaf. Water stress leads to a reduction in the efficiency of physiological processes, including protein synthesis, photosynthesis which causes inhibition of the activities of many enzymes and leads to early senescence in leaves especially flag leaf. Consequently, decrease grain filling rate, panicle weight, number of filled grains and grain yield. These results agreed with those obtained [16-19]. As for the effect of fertilizer treatments, data in Table 4A and 4B revealed that the application of fertilizers treatments increased all the studied characters as compared with the control. The highest values of the most studied characters were obtained with T5 treatment without any significant difference with the application of T6 during the two growing seasons. It can be observed that the organic fertilizers and the composted rice straw combined with urea performed better than the application of organic fertilizers alone. It might be due to the role of nitrogen for improving the growth of plant, physiological process consequently yields and its component found that the decomposition of organic fertilizers improves the soil fertility and keep the water in the soil more time that increase the availability of nutrients [18]. It is clear from the result, the application of T5 treatment produced higher grain yield without any significant difference with T6 and save about one third of inorganic nitrogen as well as, improving soil fertility.

The interaction between irrigation intervals and fertilizers treatments on the chlorophyll content (SPAD) of the flag leaf of sakha 106 rice cultivar is presented in Table 5. The highest values of chlorophyll content were obtained with T5 and T6 fertilizer treatments when combined with W1 and W2 irrigation treatments without any significant differences among them in the two seasons. In contrast, the lowest value in chlorophyll content was observed when T1 was combined with W5. It could be attributed to the inadequate amount of both water and nitrogen fertilizer which led to the decrease in the availability and uptake of nitrogen.

Irrigation interval (A)	2016 Season						
	Chlorophyll content (SPAD)	Number of tillers/m2	Number of panicles/m2	Panicle weight (g)	Number of filled grain/panicle	Straw (t/ha)	Grain (t/ha)
W1	46.96a	499.68a	475.80a	3.30a	110.00a	9.77a	7.94a
W2	45.89ab	492.11b	471.40a	3.27a	106.86b	9.51a	7.75ab
W3	44.34bc	478.37c	458.00b	3.12b	105.05c	9.38a	7.38b
W4	42.81c	451.57d	444.50c	2.95c	100.22d	8.79b	6.90c
W5	36.16d	372.23e	377.40d	2.67d	82.89e	8.27c	5.23d
F Test	**	**	**	**	**	**	**
Treatments (B)							
T1	33.88d	347.54f	288.50f	2.42d	70.53f	5.74f	4.06e

T2	41.17c	416.20e	394.20e	2.92c	82.80e	7.65e	5.16d
T3	41.86c	434.94d	426.10d	3.09b	98.67d	8.70d	6.24c
T4	45.14b	478.94c	475.50c	3.21ab	109.43c	9.88c	7.62b
T5	48.01a	540.38a	551.10a	3.38a	123.93a	11.73a	9.82a
T6	49.33a	534.76b	537.10b	3.37a	120.67b	11.16b	9.33a
F Test	**	**	**	**	**	**	**
Interaction A x B	*	*	*	*	*	*	*

Table 4A: Chlorophyll content of flag leaf, number of tillers/m^2, number of panicles/m^2 and panicle weight (g) of Sakha 106 rice cultivar as affected by the irrigation intervals and fertilizer treatments in 2016. T1=control (without any fertilizer applications); T2=4.76 tons farm yard manure (FYM) /ha T3=4.76 tons composted rice straw (CRS)/ha; T4=4.76 tons FYM +110 N/ha; T5=4.76 tons CRS +110 N/ha; T6=and recommended dose of Nitrogen, 165 kg N/ha W1=Continuous flooding; W2=continuous saturation; W3=irrigation every 6 days; W4=irrigation every 9 days; W5=irrigation every 12 days; *=significant **=highly significant a, b and c are the letter are significant or not significant by different according to DMRT.

Irrigation interval (A)	2017 Season						
	Chlorophyll content (SPAD)	Number of tillers/m2	Number of panicles/m2	Panicle weight (g)	Number of filled grains	Straw (t/ha)	Grain (t/ha)
W1	48.30a	507.55a	483.10a	3.55a	112.22a	10.01a	8.17a
W2	46.39ab	502.93b	476.30b	3.46b	109.15b	9.63b	7.83ab
W3	44.35b	492.55c	466.40c	3.36c	106.72c	9.54b	7.53b
W4	42.83c	473.47d	458.70d	3.25d	103.00d	8.98c	7.05c
W5	36.28d	392.25e	359.80e	2.82e	91.39e	8.19d	5.60d
F Test	**	**	**	**	**	**	**
Treatments (B)							
T1	33.37d	355.44d	290.10e	2.60e	71.60f	5.70f	4.12e
T2	41.63c	423.80c	403.60d	3.15d	58.20e	7.82e	5.29d
T3	41.91c	449.62c	443.20c	3.21d	101.33d	8.86d	6.46c
T4	46.20b	489.00b	484.50b	3.28c	112.33c	10.04a	7.78b
T5	48.60a	564.12a	535.50a	3.91a	130.67a	11.85a	10.18a
T6	50.07a	560.53a	536.40a	3.60b	125.84b	11.36b	9.65a
F Test	**	**	**	**	**	**	**
Interaction A x B	*	*	*	*	*	*	*

Table 4B: Chlorophyll content of flag leaf, number of tillers/m^2, number of panicles/m^2 and panicle weight (g) of Sakha 106 rice cultivar as affected by the irrigation intervals and fertilizer treatments in 2017. T1=control (without any fertilizer applications); T2=4.76 tons farm yard manure (FYM) /ha T3=4.76 tons composted rice straw (CRS)/ha; T4=4.76 tons FYM +110 N/ha; T5=4.76 tons CRS +110 N/ha; T6=and recommended dose of Nitrogen, 165 kg N/ha W1=Continuous flooding; W2=continuous saturation; W3=irrigation every 6 days; W4=irrigation every 9 days; W5=irrigation every 12 days; *=significant **=highly significant a, b and c are the letter are significant or not significant by different according to DMRT.

Nitrogen is one of constituent of chlorophyll and improves the activity of synthetase enzyme that increases the biosynthesis of chlorophyll. The decomposition of organic fertilizers gradually makes continuous supply of nitrogen and other nutrients to the plant during all growth stages and consequently increases the chlorophyll content of flag leaf. These results are in harmony the importance of N from the N-fertilizer application, as the main constituent of the chlorophyll and the enzymes that have direct impact on vegetative and reproductive phases of plants [20].

Number of tillers/m^2 as affected by the interaction between irrigation intervals and fertilizer treatments during the 2016 and 2017 seasons are presented in Table 6. The highest number of tillers/m^2 were found when W1, W2 and W3 were combined with T5 and T6 treatments in 2016 and 2017 seasons, followed by W4 when combined with the same two fertilizer treatments. While the lowest values were obtained from T1 combined with W5 treatments. The high performance of number of tillers might be due to adequate amounts of water and nutrients uptake especially nitrogen. The absorption of nitrogen always increases the uptake of both phosphorus and potassium that enhance the nods and buds to emerge more tillers as a result to increase in cell division and elongation. These results are in harmony with those obtained who found that the highest values of number of tillers/m^2 was achieved by using 165 kg N ha^{-1} under flooded conditions and continuous saturations without any significant differences with 5 tons ha^{-1} of composted rice straw +110 kg N ha^{-1}, while using 5 tons composted rice straw ha^{-1} alone gave the lowest values of number of tillers/m^2 in both seasons [18].

Regarding to number of panicles/m^2, panicle weight (g) and number of filled grain as affected by the interaction between irrigation intervals and fertilizer treatments are presented in Tables 7-9. Data indicated that the greatest values of the number of panicles/m^2, panicle weight (g) and filled grain/panicle were obtained when T5 and T6 combined with most of the irrigation treatments except W5. On the other hand, the lowest number of panicles/m^2, panicle weight (g) and filed grain/panicle were found when T1 was combined with W5 treatment.

Treatments	Irrigation intervals									
	2016 season					2017 season				
Fertilizer	W1	W2	W3	W4	W5	W1	W2	W3	W4	W5
T1	38.38m-o	36.77n-p	35.10op	33.17p	26.00q	38.83k-n	37.00l-o	33.33op	32.67p	25.00q
T2	43.40i-l	43.60h-l	42.67i-l	41.50k-m	34.67op	44.83f-i	43.67g-i	42.33h-k	42.33h-k	35.00n-p
T3	45.51f-j	43.9j-l	43.10i-l	41.23k-m	35.50op	46.33e-h	44.33g-i	43.43g-j	39.33j-m	36.00m-p
T4	48.67c-f	47.60d-g	46.47e-i	44.63g-k	38.33m-o	51.00a-d	49.67b-e	47.00d-g	44.67f-i	38.67k-n
T5	52.60ab	51.03a-d	48.93b-f	47.33d-h	40.17l-n	53.67ab	51.00a-d	49.00c-e	48.67c-f	40.67i-l
T6	53.23a	52.40a-c	49.77a-e	49.00b-f	42.27j-l	55.00a	52.67a-d	51.00c-e	49.33c-e	42.33h-k

Table 5: Chlorophyll content of flag leaf (SPAD) of Sakha 106 rice cultivar as affected by the interaction between irrigation intervals and fertilizer treatments in 2016 and 2017 seasons. T1=control (without any fertilizer applications); T2=4.76 tons farm yard manure (FYM) /ha T3=4.76 tons composted rice straw (CRS)/ha; T4=4.76 tons FYM +110 N/ha; T5=4.76 tons, CRS +110 N/ha; T6=and recommended dose of nitrogen, 165 kg N/ha W1=Continuous flooding; W2=continuous saturation; W3=irrigation every 6 days; W4=irrigation every 9 days; W5=irrigation every 12 days a, b and c are the letter are significant or not significant by different according to DMRT.

Treatments	Irrigation intervals									
	2016 season					2017 season				
Fertilizer	W1	W2	W3	W4	W5	W1	W2	W3	W4	W5
T1	380.00i-k	381.70i-l	363.30jk	326.00kl	286.70l	383.30ij	390.00h-j	373.30j	337.30jk	293.30k
T2	476.70c-f	450.00d-i	4.33.30e-j	395.00h-k	326.00m	466.00d-g	458.30d-h	445.00e-i	402.00g-j	347.70jk
T3	471.70c-g	466.70d-h	450.00d-i	416.30f-j	370.00jk	479.70d-f	476.70d-f	460.00d-h	448.00d-i	383.70ij
T4	509.70b-d	506.70b-d	503.30b-e	475.00c-f	400.00g-j	520.70b-d	514.30c-e	507.00de	494.70de	408.30f-j
T5	585.00a	574.55ab	560.30ab	556.33ab	425.00f-j	600.30a	590.00ab	585.00ab	580.00a-c	465.32d-g
T6	575.00ab	573.00ab	560.30ab	540.80ab	425.70f-h	595.30a	588.30ab	585.00ab	578.83a-c	455.23d-h

Table 6: Number of tillers/m^2 of Sakha 106 rice cultivar as affected by the interaction between irrigation intervals and fertilizer treatments in 2016 and 2017 seasons. T1=control (without any fertilizer applications); T2=4.76 tons farm yard manure (FYM) /ha T3=4.76 tons composted rice

straw (CRS)/ha; T4=4.76 tons FYM +110 N/ha; T5=4.76 tons CRS +110 N/ha; T6=and recommended dose of nitrogen, 165 kg N/ha W1=Continuous flooding; W2=continuous saturation; W3=irrigation every 6 days; W4=irrigation every 9 days; W5=irrigation every 12 days a, b and c are the letter are significant or not significant by different according to DMRT.

The increases in number of panicles/m^2, panicle weight (g) and filled grains/panicle could be attributed to the presence of required amount of water with adequate amount of nitrogen whether added to the soil inorganic (urea) or combined with organic fertilizers (farmyard manure or composted rice straw) that cause an increase in nutrients availability and uptake, which led to improve the viability of leaves and late its senescence resulted in increase in photosynthesis and its products (assimilates). These assimilates translocate from source to the sink of plant, consequently increase the filling and percentage. These results are in harmony with those obtained [21].

It can be easily observed that the application of T5 and T6 caused a relief of the harmful of water stress and improved the crop growth. These results are in harmony with those obtained by who found that the application of 5 tons ha^{-1} of rice straw +110 kg N ha^{-1} recorded the maximum value of number of panicles/m^2, panicle weight (g) and filled grains/panicle and mitigation the hazard effect of water stress [22].

Straw yield (t/ha) as affected by the interaction between irrigation intervals and fertilizer treatments are presented in Table 10. Data demonstrated that the highest straw yield was found when T5 and T6 combined with most of irrigation treatments. The highest straw biomass might be due to the presence of adequate amount of both nitrogen fertilizer and water which led to increase the availability of $NH_4^+$and its uptake. The increase in N absorption always increase the absorption of both phosphors and potassium, which increase both of number of tillers and leaves that significantly increase in straw yield. The tested fertilizer treatments with W5 reduced the hazard effect of water stress and increased straw yield and reach to the maximum value when each of T5 and T6 was combined with W4. These results agreed with those reported by who found that there are significant differences among fertilizer treatments on straw yield [23]. Data in Table 11 revealed that rice grain yield was significantly affected by the interaction between irrigation and fertilizer treatments in both seasons. The maximum grain yield was obtained when T5 and T6 fertilizer treatments were integrated with the first four irrigation treatments (W1, W2, W3 and W4) without any significant differences among them. This means that the application of both organic and inorganic fertilizers either individual or combination minimized the hazard effect of water stress up to irrigation every 12 days.

The increase in grain yield might be due to the presence of the required amount of both water and nitrogen fertilizer especially under W1 and W2 treatments. The gradual decomposition of compost rice straw released nitrogen and other nutrients which make continuous supply to the plant at different stages of growth. Moreover, the organic fertilizers kept water in the soil longer as shown in W3 and W4 irrigation treatments [18]. These results are similar to those obtained by who found that irrigation intervals under fertilizer treatments had a highly significant effect on grain yield. He found that under continuous flooding, using 165 kg N ha^{-1} produced the highest grain yield without any significant differences with using 5 tons composted rice straw ha^{-1} +110 kg N ha under irrigation every 9 and 12 days. It could be concluded that using 4.76 tons CRS+110 kg N/ha (T5) combined with irrigation every 9 days (W4) is the best treatment because it well be saved about one third of inorganic fertilizer (urea) as well as, reasonable amount of irrigation water.

Treatments	Irrigation intervals									
	2016 season					2017 season				
Fertilizer	W1	W2	W3	W4	W5	W1	W2	W3	W4	W5
T1	314.30o	309.70o	299.30o	294.70o	224.70p	319.30jk	308.30k	297.70k	290.70k	234.30l
T2	422.70l	425.00k-m	405.00m	395.00m	323.30o	428.0fg	430.00fg	414.00gh	401.70g-i	344.30j
T3	460.00h-j	453.30i-k	440.00j-l	414.0lm	363.30n	467.00de	467.30de	454.70ef	448.00ef	379.00i
T4	507.30de	500.70ef	494.70j-l	475.00f-i	400.00m	513.00c	506.00c	500.30c	494.70cd	408.30ghi
T5	580.00a	571.70ab	562.50abc	553.40a-c	488.00e-h	587.70a	576.00ab	566.00ab	562.00ab	385.70hi
T6	570.70ab	568.30ab	546.50bc	535.00cd	465.00g-j	583.30ab	570.30ab	566.00ab	555.00b	407.30g-i

Table 7: Number of panicles /m^2 of Sakha 106 rice cultivar as affected by the interaction between irrigation intervals and fertilizer treatments in 2016 and 2017 seasons. T1=control (without any fertilizer applications); T2=4.76 tons farm yard manure (FYM) /ha T3=4.76 tons composted rice straw (CRS)/ha; T4=4.76 tons FYM +110 N/ha; T5=4.76 tons CRS +110 N/ha; T6 =and recommended dose of nitrogen, 165 kg N/ha W1=Continuous flooding; W2=continuous saturation; W3=irrigation every 6 days; W4=irrigation every 9 days W5=irrigation every 12 days. a, b and c are the letter are significant or not significant by different according to DMRT.

Treatments	Irrigation intervals	
	2016 season	2017 season

Fertilizer	W1	W2	W3	W4	W5	W1	W2	W3	W4	W5
T1	2.50j	2.40k-m	2.26lm	2.16m	2.76h-k	2.86j-l	2.73kl	2.65l	2.58l	2.18m
T2	3.20b-g	3.13c-h	3.00e-i	2.86g-j	2.40k-m	3.43e-h	3.36f-g	3.23g-j	3.08h-k	2.63l
T3	3.33a-e	3.36a-e	3.16c-h	3.03d-i	2.56j-m	3.40e-h	3.36f-g	3.30f-i	3.21g-j	2.78kl
T4	3.45a-d	3.53a-c	3.36a-e	3.06d-h	2.63i-l	3.60c-g	3.46f-g	3.30f-i	3.13h-k	2.93i-l
T5	3.73a	3.56a-c	3.40a-e	3.30a-f	2.90f-j	4.20a	4.08ab	4.00a-c	3.91a-c	3.36f-h
T6	3.63ab	3.63ab	3.53abc	3.30a-f	2.76h-k	3.85a-d	3.78b-e	3.68e-f	3.61c-g	3.06h-k

Table 8: panicle weight (g) of Sakha 106 rice cultivar as affected by the interaction between irrigation intervals and fertilizer treatments In 2016 and 2017 seasons. T1=control (without any fertilizer applications); T2=4.76 tons farm yard manure (FYM) /ha T3=4.76 tons composted rice straw (CRS)/ha; T4=4.76 tons FYM+110 N/ha; T5=4.76 tons CRS+110 N/ha; T6=a and recommended dose of nitrogen, 165 kg N/ha W1=Continuous flooding; W2=continuous saturation; W3=irrigation every 6 days; W4=irrigation every 9 days; W5=irrigation every 12 days. a, b and c are the letter are signficant or not significant by different according to DMRT.

Treatments	Irrigation intervals									
	2016 season					2017 season				
Fertilizer	W1	W2	W3	W4	W5	W1	W2	W3	W4	W5
T1	76.00no	74.67op	71.67op	69.33p	61.00q	76.00nl	73.67l	73.00l	71.33l	64.00m
T2	88.00l	86.67l	85.00lm	80.33mn	74.00op	92.00i	89.33ij	86.67i-k	82.00k	76.00l
T3	107.33gh	104.33hi	101.33ij	97.33jk	83.00lm	109.00fg	106.33f-h	103.67gh	102.00h	85.67jk
T4	123.00cd	112.80fg	116.00ef	107.67gh	87.67l	125.67cd	121.67de	117.67e	106.00f-h	90.67
T5	134.32a	132.00ab	128.33bc	126.66bc	98.33jk	136.67a	133.67ab	130.67bc	130.00bc	122.33de
T6	131.33ab	130.67ab	128.00bc	120.00de	93.33k	134.00ab	130.22bc	128.67bc	126.66cd	109.66f

Table 9: Number of filled grains of Sakha 106 rice cultivar as affected by the interaction between irrigation intervals and fertilizer treatment in 2016 and 2017 seasons. T1=control (without any fertilizer applications); T2=4.76 tons farm yard manure (FYM) /ha T3=4.76 tons composted rice straw (CRS)/ha; T4=4.76 tons FYM+110 N/ha; T5=4.76 CRS+110 N/ha; T6=and Recommended dose of nitrogen, 165 kg N/ha W1=Continuous flooding; W2=continuous saturation; W3=irrigation every 6 days; W4=irrigation every 9 days; W5=irrigation every 12 days. a, b and c are the letter are significant or not significant by different according to DMRT.

Treatments	Irrigation intervals									
	2016 season					2017 season				
Fertilizer	W1	W2	W3	W4	W5	W1	W2	W3	W4	W5
T1	6.50lm	6.06mn	5.76mo	5.30no	5.10o	6.60lm	5.86mn	5.60mn	5.33n	5.13n
T2	7.76jk	7.90i-k	8.26ij	7.26kl	7.06kl	8.10i-k	7.96i-k	8.43h-j	7.43j-l	7.16kl
T3	9.46f-h	8.80h-l	8.70h-l	8.16ij	8.36ij	9.60fg	8.96g-i	8.96g-i	8.36h-j	8.43h-j
T4	10.80c-e	10.50de	10.13d-f	9.26gh	8.72hi	10.90c-e	10.83c-e	10.40d-f	9.36f-h	8.70g-i
T5	12.26a	12.16a	12.00a	11.83a	10.42de	12.60a	12.36ab	12.16ab	12.03ab	10.10ef
T6	11.87a	11.66ab	11.42a-c	10.93b-d	9.96e-g	12.30ab	12.80a-c	11.70a-c	11.40b-d	9.63fg

Table 10: straw yield (t/ha) of Sakha 106 rice cultivar as affected by the interaction between irrigation intervals and fertilizer treatments in 2016 and 2017 Seasons. T1=control (without any fertilizer applications); T2=4.76 tons farm yard manure (FYM) /ha T3=4.76 tons composted rice straw (CRS)/ha; T4=4.76 tons FYM +110 N/ha; T5=4.76 tons CRS +110 N/ha; T6=and recommended dose of 165 kg N/ha, W1=Continuous

flooding; W2=continuous saturation; W3=irrigation every 6 days; W4=irrigation every 9 days; W5=irrigation every 12 days. a, b and c are the letter are significant or not significant by different according to DMRT.

Treatments	Irrigation intervals				
	2016 season				
Fertilizer	W1	W2	W3	W4	W5
T1	4.76k-m	4.66lm	4.10l-n	4.30l-n	2.50n
T2	5.90h-l	5.86h-l	5.50i-l	5.16j-m	3.36mn
T3	7.16e-j	6.83e-k	6.76f-k	6.03h-l	4.43l-n
T4	8.53b-f	8.20c-g	7.70d-h	7.56d-i	6.13g-i
T5	10.59a	10.76a	10.26ab	9.86a-d	7.66d-h
T6	10.33ab	10.20a-c	9.96abc	9.35bcd	7.30e-i
2017 season					
T1	4.83k-n	4.80l-n	4.43l-o	3.86m-o	2.66o
T2	6.06h-l	5.76h-m	5.73i-m	5.33j-n	3.56no
T3	7.26e-j	7.03e-j	6.90f-k	6.43j-l	4.70l-n
T4	8.60c-f	8.46c-g	7.86d-h	7.73e-i	6.26h-l
T5	11.36a	10.86ab	10.26abc	9.88a-d	8.56c-f
T6	10.90ab	10.43a-c	10.03a-c	9.40bcd	7.86d-h

Table 11: Grain yield (t/ha) of Sakha 106 rice cultivar as affected by the interaction between irrigation intervals and fertilizer treatments in 2016 and 2017 seasons. T1=control (without any fertilizer applications); T2=4.76 tons farm yard manure (FYM) /ha T3=4.76 tons composted rice straw (CRS)/ha; T4=4.76 tons FYM +110 N/ha; T5=4.76 tons CRS +110 N/ha; T6 and recommended dose of nitrogen, 165 kg N/ha W1=Continuous flooding; W2=continuous saturation; W3=irrigation every 6 days; W4=irrigation every 9 days; W5=irrigation every 12 days. a, b and c are the letter are significant or not significant by different according to DMRT.

Water relations

Grain yield (t/ha), total water input (m^3/ha), water saved (%) and water use efficiency (kg/m^3) as affected by irrigation intervals and fertilizer treatments in 2016 and 2017 seasons are shown in Table 12. Data indicated that the highest grain yield was found under continuous flooding (W1) followed by W2 with all fertilizer treatments in both seasons. In the same time the total water input was so high and reach 15425.90 and 15632.00 m^3/ha under W1 followed by 12560.36 and 12650.55 m^3/ha under W2 in both seasons, respectively. The water use efficiency (WUE) was very low (0.51 and 0.52 kg/m^3) and (0.62 and 0.63) with the same irrigation treatments in both seasons respectively.

The fertilizer 4.76 tons CRS +110 N/ha (T5) with irrigation treatments W3 or W4 gave the highest values of grain yield without any significant differences with W1T5 and saved water about (23.64 and 24.76%) and (30.40 and 30.23%) for both season respectively. The same treatments (W3T5 and W4T5) recorded the highest value of WUE (0.90 and 0.91) and ((0.95 and 0.94 kg/m^3) and lowest yield reduction (6.38 and 9.68%) and (10.03 and 13.02%) in 2016 and 2017 seasons respectively. These results are harmony with those obtained with [19, 24] who reported that the alternating wet and dry irrigation increasing water use efficiency. Data in the same table also, indicated that irrigation every 12 days caused strongly decreased grain yield and WUE under all fertilizer treatments in both seasons (Table 12).

Treatm ents	Grain yield (t/ha)	Yield reduction %	Total water input m^3/ha	Water saved %	water use efficiency (WUE) kg/m^3	Grain yield (t/ha)	Yield reduction %	Total water input m^3/ha in	Water saved %	water use efficiency (WUE) kg/m^3
	2016 season					2017 season				
W1T1	4.76	-	16200.5	-	0.29	4.83	-	16500	-	0.29
W1T2	5.9	-	15700.5	3.08	0.37	6.06	-	15850.9	3.39	0.38

W1T3	7.16	-	15402.9	4.92	0.46	7.26	-	15650	5.15	0.46
W1T4	8.53	-	15150.5	6.48	0.56	8.6	-	15300.6	7.27	0.56
W1T5	10.96	-	14800.8	8.63	0.74	11.36	-	14950.5	9.39	0.75
W1T6	10.33	-	15300.2	5.55	0.67	10.9	-	15540	5.81	0.7
Mean	7.94	-	15425.9	5.73	0.51	8.16	-	15632	6.2	0.52
W2T1	4.66	2.1	14200.2	12.3	0.33	4.8	0.62	14400.9	12.72	0.33
W2T2	5.86	0.67	12750.6	18.78	0.46	5.76	4.95	12700.5	19.87	0.45
W2T3	6.83	4.6	12233.5	20.57	0.56	7.03	3.16	12450.5	20.44	0.56
W2T4	8.2	3.86	12050.9	20.45	0.68	8.46	1.62	12120.6	20.8	0.69
W2T5	10.76	1.82	11676.5	21.1	0.92	10.86	4.4	11730.3	21.53	0.92
W2T6	10.2	1.25	12450.5	18.62	0.82	10.43	4.3	12500.5	19.55	0.83
Mean	7.75	2.38	12560.36	18.63	0.62	7.89	3.71	12650.55	19.15	0.63
W3T1	4.1	13.85	13550.6	16.35	0.3	4.43	7.71	13620.6	17.45	0.32
W3T2	5.5	6.77	12500.5	20.38	0.44	5.73	5.4	12630.5	20.31	0.45
W3T3	6.76	5.58	12000.7	22.08	0.57	6.9	4.95	12400.5	20.76	0.55
W3T4	7.7	9.7	11850.6	21.78	0.65	7.86	8.6	12050.9	21.23	0.65
W3T5	10.26	6.38	11300.3	23.65	0.9	10.26	9.68	11250.4	24.74	0.91
W3T6	9.96	4	12330.4	19.41	0.81	10.03	8.53	12500.5	19.55	0.8
Mean	7.38	7.71	12255.51	20.6	0.61	7.53	7.47	12408.9	20.67	0.61
W4T1	4.3	9.66	13100.7	19.13	0.32	3.86	20.08	13350.5	19.1	0.28
W4T2	5.16	12.54	12150.5	22.61	0.42	5.33	12.05	12450.5	21.45	0.42
W4T3	6.03	15.78	11700.6	24.03	0.52	6.43	11.43	11800.9	24.6	0.54
W4T4	7.56	11.37	11200.5	26.07	0.67	7.73	10.11	11505.6	24.8	0.67
W4T5	9.8	10.03	10300.6	30.4	0.95	9.88	13.02	10430.3	30.23	0.94
W4T6	8.9	13.85	11600.5	24.2	0.77	9.06	16.88	11750.5	24.38	0.77
Mean	6.95	12.2	11675.53	24.4	0.6	7.04	13.92	11881.38	24.09	0.6
W5T1	2.5	47.5	11850.8	26.84	0.21	2.66	44.92	11900.9	27.87	0.22
W5T2	3.36	43.05	10800.9	31.2	0.31	3.56	41.25	11000.5	30.6	0.32
W5T3	4.43	38.12	10500.5	31.82	0.42	4.7	35.26	10750.6	31.3	0.43
W5T4	6.13	27.74	10200.3	32.67	0.6	6.26	27.2	10350	32.35	0.6
W5T5	7.66	30.1	9800.9	33.78	0.78	8.56	24.64	9700.5	35.11	0.88
W5T6	7.3	29.5	10100.5	34	0.72	7.86	27.88	10250.6	34.04	0.76
Mean	5.23	36	10542.31	31.71	0.5	5.6	33.52	10658.85	31.87	0.53

Table 12: Grain yield (t/ha), grain yield reduction %, total water input (m^3/ha), water saved (%) and water use efficiency as affected by irrigation intervals and fertilizer treatments in 2016 and 2017 seasons. T1=control (without any fertilizer applications); T2=4.76 tons farm yard manure (FYM)/ha T3=4.76 tons composted rice straw (CRS)/ha; T4=4.76 tons FYM +110 N/ha; T5=4.7 tons CRS +110 N/ha; T6=and recommended dose of nitrogen, 165 kg N/h W1=Continuous flooding; W2=continuous saturation; W3=Irrigation every 6 days; W4=irrigation 9 days; W5=irrigation every 12 days.

Form these results and previous studies we can observed that there are different irrigation regimes for reduction of entering water to rice field, and increase WUE, such as soil saturation, and, alternating wet and dry irrigation (irrigation every 6 and 9 days) instead of a layer with deep 3-5 cm water. Also using mixed between organic and inorganic fertilizer with irrigation interval (9 days) significantly improves grain yield and WUE.

Nutrients availability in the soil

Concentration of NH_4^+ available (ppm): The availability of ammonium (NH_4^+) in the soil at 30, 60 and 90 days after transplanting (DAT) as affected by irrigation and fertilizer treatments are presented in Table 13. Data clarified that the highest available concentration of NH_4^+ were recorded with W1 and W2 during all period of rice plant (30, 60 and 90 DAT) followed by W3 compared with W4 and W5 in 2016 and 2017 seasons. It could attribute to the fact that the presence of adequate amount of the water in the soil enhances nutrients availability and improved nutrients uptake by plants.

Data also, revealed that the available concentration of NH_4^+ was higher at 30 DAT and 60 DAT, compared with availability of NH_4^+ at 90 DAT during the two seasons. The highest value of NH_4+ available was observed at 30 DAT with W1 and W2 without any significant differences between them followed by W3. The same trend of NH_4^+ availability was found at 60 and 90 DAT. The increase in NH_4^+ availability under the first three irrigation treatments (W1, W2 and W3). It could be attributed to the adequate amount of water in the soil increase the availability of NH_4^+ and improved NH_4^+ absorption by plants because at the 30 DAT the rice canopy of plant still small, while at 60 DAT the rice canopy of plant reach the maximum growth consequently, the absorption of NH_4^+ by plant dramatically increased so, the amount of NH_4^+ in the soil solution tended to decrease. It can be easily notice that when the water cut off before harvesting the soil conditions transferred from anaerobic to aerobic that cause a conversion of NH_4^+ into NO_3^-. These findings are in harmony with those reported by [25,26]. The T5 and T6 recorded the highest value of available NH_4+ followed by T4 in both seasons. This might be due to that incorporation of CRS or FYM with urea in the soil reduced the N losses beside stimulated both heterotrophic and phototrophic N fixation in flooded soil [27]. The lower N immobilization after incorporating composted in anaerobic system compared with aerobic system which increases inorganic N and also microbial N was replenished by N contained in root exudates and decomposing root debris [28].

Irrigation interval (A)	30 DAT		60 DAT		90 DAT	
	2016	2017	2016	2017	2016	2017
W1	55.97a	56.20a	46.83a	47.40a	28.07a	28.90a
W2	53.23ab	54.20ab	45.06a	46.50a	26.41ab	27.80a
W3	50.18b	50.69b	42.53b	41.53b	23.85b	24.82b
W4	44.40c	45.07c	38.75c	38.95b	20.35c	20.78c
W5	38.05d	38.85d	33.93d	34.72c	13.91d	13.75d
F Test	**	**	**	**	**	**
Treatments (B)						
T1	35.60d	36.80d	30.96d	30.65c	16.80d	16.58c
T2	46.32c	48.00c	38.80c	40.04b	19.98cd	21.74b
T3	49.20bc	49.59bc	41.53b	43.10ab	22.02bc	22.98b
T4	50.93b	50.04bc	44.46a	44.52ab	23.28a-c	23.84ab
T5	55.47a	56.76a	47.07a	47.57a	27.56a	28.82a
T6	52.68a	53.20b	45.76a	45.06ab	25.49ab	25.84ab
F Test	**	**	**	**	**	**
Interaction A x B	*	*	*	*	*	*

Table 13: Availability of $NH4^+$ concentration (ppm) in the soil at 30, 60 and 90 days after transplanting (DAT) as affected by irrigation intervals and fertilizer treatments in 2016 and 2017 seasons. T1=l control (without any fertilizer applications); T2=4.76 tons farm yard manure (FYM) /ha T3=4.76 tons composted rice straw (CRS)/ha; T4=4.76 tons FYM+110 N/ha; T5=4.7 tons CRS+110 N/ha; T6=and recommended dose of nitrogen, 165 kg N/ha W1= Continuous flooding; W2=continuous saturation; W3=irrigation every 6 days; W4=irrigation 9 days; W5=irrigation every 12 days. a, b and c are the letter are significant or not significant by different according to DMRT.

Irrigation interval (A)	30 DAT	60 DAT	90 DAT

	2016	2017	2016	2017	2016	2017
W1	17.04d	17.00e	14.94d	14.62e	15.37d	15.38e
W2	21.43c	21.70d	19.70c	20.08d	20.31c	20.20d
W3	25.03bc	25.17c	22.52b	23.07c	23.05bc	23.50c
W4	27.24ab	28.30b	24.27b	25.53b	24.91b	26.35b
W5	31.09a	31.19a	27.48a	27.97a	28.30a	28.95a
F Test	**	**	**	**	**	**
Treatments (B)						
T1	18.08c	18.54c	17.20c	17.12c	17.54d	17.34c
T2	21.63bc	21.91bc	19.18bc	19.52bc	19.88cd	19.92bc
T3	24.12a-c	24.86ab	21.15a-c	21.60a-c	21.72b-d	22.34ab
T4	25.66ab	25.94ab	23.28a-c	23.60ab	23.80a-c	24.40ab
T5	28.52a	29.44a	25.70a	26.10a	26.68a	26.80a
T6	27.48ab	28.00a	24.18ab	25.58a	24.66ab	26.46
F Test	*	*	*	*	*	*

Table 14: Availability of NO_3^- concentration (ppm) in the soil at 30, 60 and 90 days after transplanting (DAT) as affected by irrigation intervals and fertilizer treatments in 2016 and 2017 seasons.

The concentrations of NH_4^+ available (ppm) at 30, 60 and 90 DAT as affected by the interaction between irrigation intervals and fertilizer treatments are illustrated in Figure 1. Data indicated that the application of fertilizer treatments (organic or inorganic form) under all irrigation treatments increased the available concentrations of NH_4^+ compared with the control. The greatest value of concentrations of $NH4^+$available was observed when both T5 and T6 combined with either W1 or W2 at the period of 30 DAT which reached to about 60 to 70 ppm, while the lowest value was obtained when T1 was combined with W5 treatment. It could be attributed under non-flooded conditions, rapid nitrification of the added fertilizer led to a rapid decrease in NH_4^+ and a simultaneous increase in NO_3^- concentrations within the first 30 days [29]. Also, under flooded conditions, NH_4^+ was the principal inorganic N form, as all NO_3^- originally present in the soils was rapidly lost, with time, NH_4^+ concentrations tended to decrease under non-flooding conditions and increase in the presence straw under flooding conditions.

Concentration of NO_3^- available (ppm): The availability of nitrate (NO_3^-) in the soil at 30, 60 and 90 days after transplanting (DAT) as affected by irrigation intervals and fertilizer treatments are presented in Table 14. Data showed that the highest available concentration of NO_3^- was found with W5 followed by W4 at 30, 60 and 90 days from transplanting. This is mainly due to prolonging irrigation intervals up to 12 days which increased the aerobic conditions and higher amount of oxygen that lead to more nitrification producing plenty of NO_3^- beside its effect on increasing nitrate-N immobilization, also the reduction of NO_3^- to NH_4^+ by microorganism [28]. Under aerobic conditions, a large part of immobilized N was released to the exchangeable and soluble phase within the first 10 days of incubation and rapidly converted into nitrate [30-32]. The largest concentration of NO_3^- available in soil was obtained at 30 DAT then decreased to the minimum at 60 DAT, followed with a slight increase at 90 DAT. This is due to the improving the aeration in the soil layers at 90 DAT and therefore nitrification process take place. These results are in agreed with those obtained [26,33]. It is clear from the data that utilization of T5 and T6 gave the maximum NO_3^- concentration without any significant differences with T3 and T4 treatments compared to the other treatments. These results agreed with the findings [21].

Significant interaction between irrigation intervals and fertilizer treatments were observed for available concentration of NO_3^- (ppm) during 2016 and 2017 seasons is illustrated in Figure 2. Results showed that the application of nitrogen fertilizers whether organic or inorganic increased concentration available of NO_3^- under all irrigation treatments compared with the control. The highest concentration available of NO_3^- were observed with T5 and T6 under W5 followed by the same fertilizer treatments under W4 in both seasons. Similar results were obtained by who found that application of composted rice straw and cellulose enhances nitrate immobilization under anaerobic conditions [34].

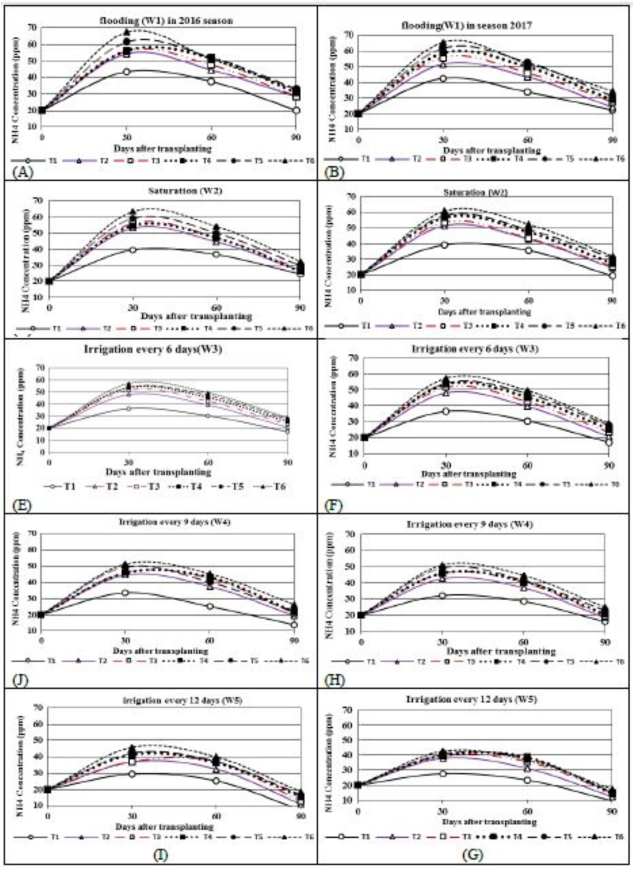

Figure 2: (A, B, C, D, E, F, J, H, I and g): Concentrations of NH_4^+ available (ppm) in the soil at 30, 60 and 90 days after transplanting (DAT) as affected by the interaction between irrigation intervals and fertilizer treatments in 2016 and 2017 seasons.

Concentration of P available (ppm): Concentration of P available (ppm) as affected by the irrigation intervals and fertilizer treatments in 2016 and 2017 seasons are presented in Table 15. Generally, the available concentration of P was highest under continuous flooding than the other irrigation treatments in both seasons under study. The increase in phosphorus due to flooding conditions is attributed mainly to the reduction of iron, manganese and aluminum since their solubility increased with flooding and changing the soil condition from oxidation (before flooding) to reduction conditions (after flooding) [35]. The desorption of P held by Fe_3^+ oxides and release of occluded P [8]. Data in the same table revealed that the application of any fertilizer treatments whether, organic or inorganic fertilizers increased phosphorus availability compared with the control. The highest phosphorus availability was observed with (T5) followed by T4. It could be attributed to the decomposition of compost and farm yard manure as organic fertilizers which release N, P, K and other nutrients. Data also, indicated that the P availability increased up to 30 DAT then decreased afterward (Figures 3 and 4). It could be attributed to fewer uptakes by plant because of the small growth at 30 DAT. The concentration of P available in the soil sharply decreased up to 90 DAT. This mainly due to the absorption of plant beside subsequent precipitation and desorption by soil minerals, also before harvesting the soil transferred from anaerobic to aerobic conditions caused a decline in the availability of P [36].

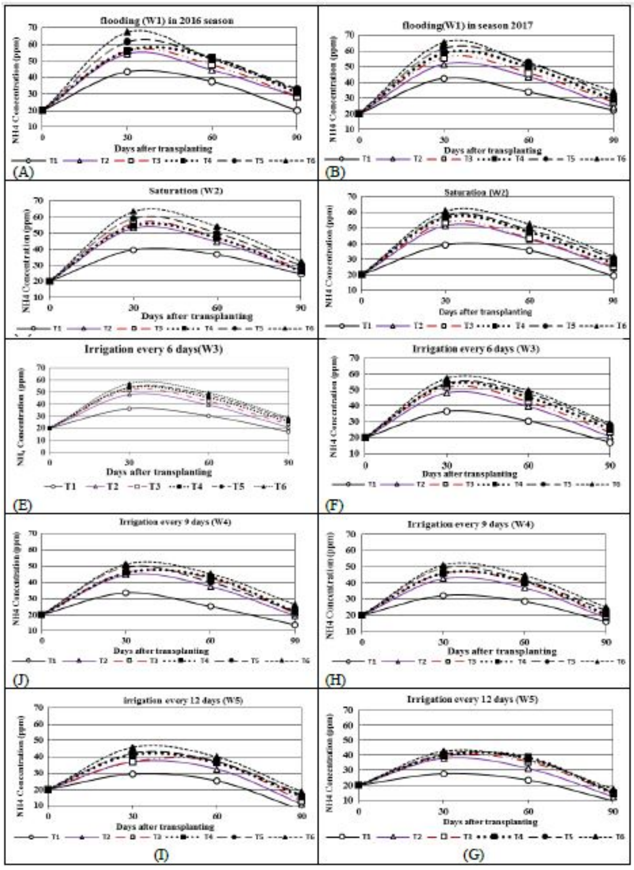

Figure 3: (A, B, C, D, E, F, J, H, I and g): Available NO_3 concentrations (ppm) in the soil at 30, 60 and 90 days after transplanting (DAT) as affected by the interaction between fertilizer treatments and irrigation intervals in 2016 and 2017 seasons.

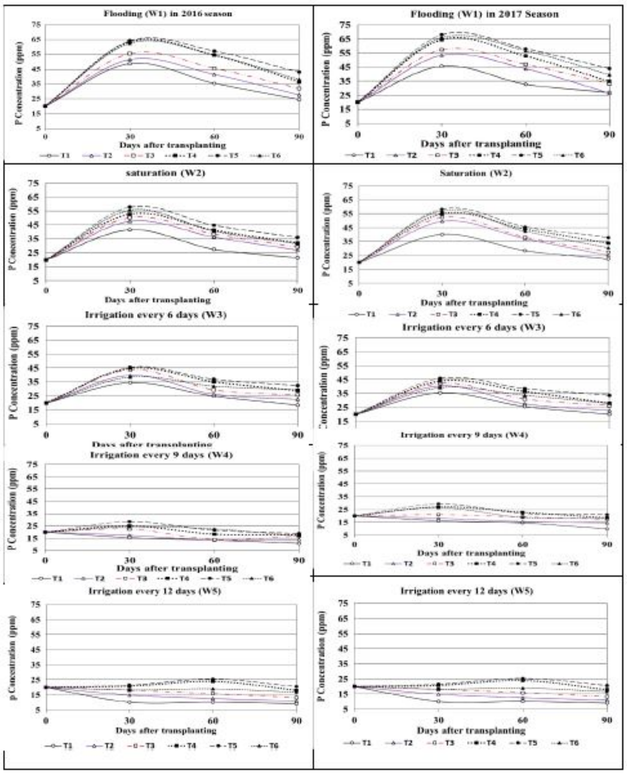

Figure 4: (A, B, C, D, E, F, J, H, I and g): Available P concentrations (ppm) in the soil at 30, 60 and 90 days after transplanting (DAT) as affected by the interaction between irrigation intervals and fertilizer treatments in 2016 and 2017 seasons.

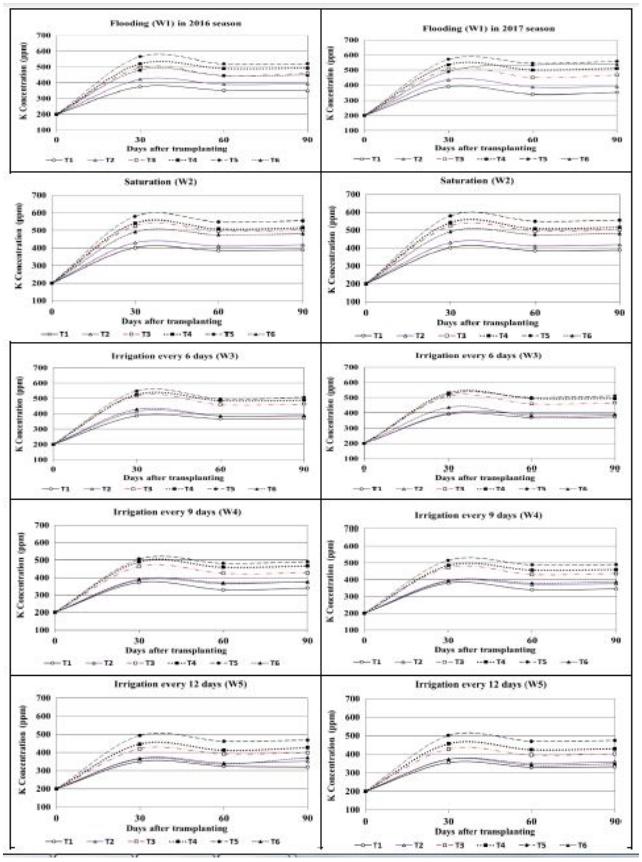

Figure 5: (A, B, C, D, E, F, J, H, I and g): Available K concentrations (ppm) in the soil at 30, 60 and 90 days after transplanting (DAT) as affected by the interaction between irrigation intervals and fertilizer treatments in 2016 and 2017 seasons.

Irrigation interval (A)	30 DAT		60 DAT		90 DAT	
	2016	2017	2016	2017	2016	2017
W1	57.65a	59.07a	48.15a	48.52a	33.60a	34.15a
W2	50.93b	51.98b	38.15b	39.18b	29.57b	29.52b
W3	41.15c	41.23c	30.75c	32.15c	26.25c	26.47c
W4	22.15d	23.05d	17.22d	18.85d	15.90d	16.70d
W5	16.57e	17.33e	16.88e	17.88e	13.58e	14.80e
F Test	**	**	**	**	**	**
Treatments (B)						
T1	30.36f	29.52f	24.12f	22.34f	16.74f	17.74e
T2	33.80e	35.03e	25.44e	27.32e	20.30e	20.00d
T3	37.66d	38.24d	27.88d	30.20d	23.10d	23.54c
T4	41.08b	42.22b	32.74c	36.04b	26.38b	26.64b

T5	43.60a	44.56a	36.56a	37.90a	29.96a	31.40a
T6	39.64c	41.36c	34.64b	34.10c	26.20c	26.64b
F Test	*	*	*	*	*	*

Table 15: Available of phosphorus (P) concentration (ppm) in the soil at 30, 60 and 90 days after transplanting (DAT) as affected by irrigation intervals and fertilizer treatments in 2016 and 2017 seasons. Control (T1), 2 tons FYM (T2), 2 tons CRS (T3), 2 tons FYM+110 N/ha (T4), 2 tons CRS+110 N/ha (T5), recommended dose of N (T6), Continuous flooding=(W1), continuous saturation=(W2), irrigation every 6 days=(W3), irrigation every 9 days=(W4) and irrigation every 12 days=(W5). a, b and c are the letter are significant or not significant by different according to DMRT.

Irrigation intervals (A)	**30 DAT**		**60 DAT**		**90 DAT**	
	2016	**2017**	**2016**	**2017**	**2016**	**2017**
W1	476.30b	488.07b	440.28b	459.50b	444.60b	452.68b
W2	495.38a	501.65a	470.79a	466.52a	493.80a	472.30a
W3	470.88c	464.78c	430.05c	433.67c	434.10bc	437.67c
W4	435.02d	439.83d	405.55d	411.55d	412.00cd	416.30d
W5	407.40e	414.20e	378.36e	385.02e	390.00d	391.03e
F Test	**	**	**	**	**	**
Treatments (B)						
T1	377.34f	385.50f	351.68f	353.94f	353.50e	359.52f
T2	403.96e	404.56e	378.76e	382.48e	384.30d	386.42e
T3	485.16c	490.24c	443.50c	444.90c	450.60c	452.88c
T4	505.46b	511.38b	471.26b	477.60b	478.20b	483.14b
T5	538.42a	539.38a	502.03a	507.08a	509.40a	512.84a
T6	431.80d	439.18d	402.82d	421.50d	433.40c	409.18d
F Test	*	*	*	*	*	*

Table 16: Available of potassium (K) concentration (ppm) in the soil at 30, 60 and 90 days after transplanting (DAT) as affected by irrigation intervals and fertilizer treatments in 2016 and 2017 seasons. Control (T1), 2 tons FYM (T2), 2 tons CRS (T3), 2 tons FYM+46 N/ha (T4) and 2 tons CRS+46 N/ha (T5) and recommended (T6), Continuous flooding=(W1), continuous saturation= (W2), irrigation every 6 days=(W3), irrigation every 9 days=(W4) and irrigation every 12 days=(W5). a, b and c are the letter are significant or not significant by different according to DMRT.

Concentration of P available (ppm) in the soil as affected by the interaction between irrigation intervals and fertilizer treatments in 2016 and 2017 seasons is illustrated in Figure 3. The greatest concentration of P available recorded when T5, T6 and T4 were integrated with either W1 or W2 at 30 DAT, while the lowest value of P available was found when T1 combined with W5 in both seasons. These findings are in harmony with those obtained who found that rice straw incorporated and FYM with higher doses of fertilizer N increased the available P [37].

Concentration of K available (ppm): The effect of irrigation intervals and fertilizer treatments on K availability in the soil in both seasons is presented in Table 16. Data showed that the highest availability of K was found with W2 followed by W1 at 30, 60 and 90 DTA. Data also, indicated that the availability of K increased up to 30 DAT then decrease to the minimum at 60 DAT, followed by a slight increase at 90 DAT. The increasing in availability of K at the period of 30 DAT could be attributed to decrease in K absorption due to small growth in the canopy of tested rice cultivar, but with the increase the plant canopy the concentration of K gradually decreased. A slight increase in K availability at 90 DAT may be due to at this age the cut off water before harvesting transfer the soil from anaerobic to aerobic conditions moreover, alternate wet and dry under irrigation intervals (W3, W4 and W5). It is clear that all treatments under continuous saturation gave the largest amounts of K availability compared to the treatments under continuous flooding. This mainly due to the effects of leaching on K losses [21,38]. Data also, indicated that all fertilizer treatments increased the availability of K compared with the control at the three periods 30, 60 and 90 DAT. The maximum mean value of K availability was recorded with T5 followed by T4 compared with the other fertilizer treatments in both seasons (Figure 5).

Potassium availability (K) as affected by the interaction between irrigation intervals and fertilizer treatments at different period of tested cultivar (30, 60 and 90 DAT) in both seasons is presented in Figure 4. Data demonstrated that the combination between T3, T4 and T5 with all the irrigation treatments gave the highest availability of K at the three periods 30, 60 and 90 (DAT) compared with other fertilizer treatments. This could due to that the soil solution K is higher in composted rice straw treatments. The other reason could be higher increase in the soil solution Fe_2^+ and Mn_2^+ caused by organic fertilizers which release K from exchange complexes [36].

Conclusion

Soil saturation and alternating wet and dry irrigation (irrigation every 6 and 9 days) are very important for water saving strategy. In this study the fertilizer 4.76 tons CRS+110 N/ha (T5) treatment with irrigation every 6 days or 9 (W3 or W4) gave the highest values of grain yield without any significant differences with continues flooded (W1T5) and saved water about (23.64 and 24.76%) and (30.40 and 30.23%) for both season respectively. The same treatments (W3T5 and W4T5) also recorded the highest value of WUE (0.90 and 0.91) and ((0.95 and 0.94 kg/m^3) and lowest with yield reduction (6.38 and 9.68%) and (10.03 and 13.02%) in 2016 and 2017 seasons respectively. Also this study concluded that using mixed between organic and inorganic fertilizers with irrigation interval (9 days) significantly improve grain yield and WUE. The highest amounts of nutrients (NH_4^+ and P) availability were found under W1 followed by under W2, W3 and W4 especially with T5 fertilizer treatments. Whereas, the maximum values of NO_3^- availability was found under W5 followed by W4.

References

1. Rashid AH, Murshedul MBA, Khan AMH, Ladha JKC (2009) Productivity and resource use of direct seeded (dum) and transplanted rice in puddled soils in rice-rice-wheat ecosystems. Field Crops Res. 113: 274-281.
2. Nile Basin Initiative (2005) Nile Basin National Water Quality Monitoring Baseline. Study Report for Egypt.
3. Naglaa LM (2010) Wastewater treatment and reuse in The Mediterranean Region. Springer, Germany.
4. El-Ekhtyar AM (2014) Response of Egyptian hybrid one rice cultivar to potassium split application under different irrigation intervals. J Plant Prod Mansoura Univ 5: 973-990.
5. Daniela RC, Mark EL, Bruce AL (2017) Rice yields and water use under alternate wetting and drying irrigation: A meta-analysis. Field Crops Res 203: 173-180.
6. Ghanem SA, Badawi AT (1999) Future of water management for rice in Mediterranean climate areas: Proceedings of the Workshop.
7. Yanga CB, Yangb L, Yanga Y, Ouyang Z (2004) Rice root growth and nutrient uptake as influenced by organic manure in continuously and alternately flooded paddy soils. Agricultural Water Management. Agric Water Manage 70: 67-81.
8. Doberman A, Fairhruse TH (2000) Rice nutrient disorder and nutrient management. International Rice Research Institute of Canada.
9. Vlek PLG, Craswell ET (1981) Ammonia volatilization from flooded soils. Fert Res 2: 227-245.
10. Datta SKD (1981) Principles and Practices of Rice Production. IRRI, Los Banos, Philippines.
11. IRRI (2002) Standard Evaluation System for Rice. International Rice Research Institute.
12. Richards LA (1954) Diagnosis and improvement of saline and alkali soils. Soil Sci 78:154.
13. Cottenie A, Verloo M, Kiekens L, Velghe G, Camerlynch C (1982) Chemical Analysis of Plants and Soils. Laboratory of Analytical and Agro.
14. Gomes AK, Gomes AA (1984) Statistical procedures of Agricultural Research. John Wiley Sons, New York.
15. Duncan BD (1995) Multiple range and multiple- F-test. Biometrics 11: 1-42.
16. Awad HA (2001) Rice production at the north of Delta Region in Egypt as affected by irrigation intervals and nitrogen fertilizer levels. J Agric Sci 26: 1151-1159.
17. Mengel K, Kirkby EA, Kosogarten H, Appel T (2002) Principles of Plant Nutrition. IRRI, Manila, Phillippines.
18. El-Refaee IS (2006) The interaction effect between water regimes and potassium levels on growth, grain yield and water productivity in rice. Egypt J Agri Res 85: 1399.
19. El-Refaee IS, Al-Khtyar AM, El-Gohary AA (2008) Improving rice productivity under irrigation intervals and nitrogen fertilizer. Second Field Crops Conference, Egypt.
20. Osman EAM, EL-Masry AA, Khatab KA (2013) Effect of nitrogen fertilizer sources and foliar spray of humic and/or fluvic acids on yield and quality of rice plants. Adv Appl Sci Res 4:174-183.
21. Naeem SS (2006) Availability of Some Nutrient Elements In Flooded Rice Soils Fertilized With Organic And Mineral Nitrogen Fertilizers. Mansoura Univeriesty.
22. Gewaily EE, Naeem ES, Metwally TF, El-Din NIE (2011) Availability of some nutrients and rice yield as affected by rice straw fertilization under continuous flooding and saturation. J Soil Sci Agric Eng Mansoura Univ 2: 379-392.
23. Lakpale R, Pandey N, Tripath RS (1999) Effect of levels of nitrogen and forms of pre-conditioned urea grain yield and N status in plant and soil of rainfed rice. Ind J Agron 44: 89-93.
24. El-habet HBI (2014) Irrigation regime and potassium levels effects on yield of some rice genotypes, water use efficiency (WUE) and economic returns. J Plant Production Mansoura Univ 5: 383-399.
25. Savant NK, Datta SKD (1982) Nitrogen transformation in wetland rice soils. Adv Agron 35: 241-302.
26. Kotb MA, Hammad SA, Mancy MH (1997) Dynamic changes of soil-N as affected by integrated use of mineral N, P and blue green algae. J Agric Sci Mansuora Univ 22: 3039-3051.
27. IRRI (1984) Organic Matter and Rice. International Conference on Organic Matter and Los Banos.
28. Inubushi K, Watanabe I (1996) Dynamics of available nitrogen in paddy soils. II. Mineralized N chloroform-fumigated soil as a nutrient source for rice. Soil Sci Plant Nutr 32: 561-577.
29. Maria AC, Daniel SP, Valter M (2014) Influence of redox conditions and rice straw incorporation on nitrogen availability in fertilized paddy soils. Biol Fertil Soils 50: 755-764.
30. Matsuoka K, Moritsuka N (2011) Dynamics of clay-fixed ammonium as a sink or source of exchangeable ammonium in a paddy soil. Soil Sci Plant Nutr 57: 751-758.
31. Nieder R, Benbi D, Scherer H (2011) Fixation and defixation of ammonium in soils: a review. Biol Fert Soils 47: 1-4.
32. Said-Pullicino D, Cucu MA, Sodano M, Birk JJ, Glaser B, et al. (2013) Nitrogen immobilization in paddy soils as affected by redox conditions and rice straw incorporation. Geoderma 228: 44-53.
33. Gewaily EE (2006) Behavior of some nutrient elements in rice soils under different irrigation intervals. Mansoura University.
34. Gok M, Ottow JCG (1988) Effect of cellulose and straw incorporation in soil on total identification and nitrogen immobilization initially aerobic and permanent anaerobic conditions. Biol Fert Soils 5: 317-322.
35. Datta DSK, Biswas TK, Charoenchamratcheep C (1983) Phosphorus requirements and phosphorus fertilization of lowland rice. International Congress on Phosphorus, Belgium.
36. Ponnamperuma FN (1972) The chemistry of submerged soils. Avd Agron 24: 29-96.

37. Manish Kumar RP, Singh S, Rana NS (2003) Effect of organic and inorganic sources of nutrition on Productivity of rice. Indian J Agron 48: 175-177.

38. Hammad SA (1995) Pollution of leached water and some nutrients available as a parameter of efficiency of biological and inorganic sources under submergence condition. J Agric Sci Mansoura Univ 20: 1915-1931.