J.Soil Sci. and Agric. Eng., Mansoura Univ., Vol. 8(2): 67 - 72, 2017

Intermittent Irrigation in Rice Production as a Tool to Mitigate the Expected Water Scarcity

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ABSTRACT

The objective of this study was to evaluate the effects of different irrigation regimes on yield, yield attributes and water productivity. The adopted irrigation regimes were classified as follows: (oncontinuous flooding treatments (irrigation every 6 days with 7 cm depth (I1) and irrigation every 6 days with 5 cm depth (I2)) and intermittent irrigation treatments (irrigation every 6 days with 3 cm depth (I3), irrigation every 12 days with 7 cm depth (I4), irrigation every 12 days with 5 cm depth (I5) and irrigation every 12 days with 3 cm depth (I6)) on the yield and yield attributes of two rice cultivars (Giza178) and (Oraby2), in addition to its effect on water productivity.The results showed that there were significant differences between continuous flooding treatments and intermittent irrigation treatments on all the studied traits and there were no significant differences between the cultivars. Under I1, highest rice yield and water productivity for both cultivars were attained. Application of I2 or I3 caused 7 or 11% yield losses averaged over cultivars and seasons and saved 8 or 13% of the applied water.The highest water productivity (WP) was attained by Giza178 under I2 for both cultivars. The results also showed that application of I6 resulted in similar water productivity value as I1 for both cultivars and seasons.Thus, under expected water scarcity, Giza178 can be cultivated using I6 to attain the highest WP under intermittent irrigation treatments. Furthermore, legume crop need to cultivate it before rice to improve soil quality and increase yield.

Keywords: *Irrigation water saving; water productivity; local rice cultivars: Giza178 and Oraby2.*

INTRODUCTION

Cultivation of rice exists in the Nile Delta, especially in the northern part to reduce sea water intrusion and prevent salinity hazards (El-Hadidi *et al.,* 2002). Rice cultivationin helps in the leaching process of the salts from upper soil layers, which help the reclamation of these lands for other agricultural activities (Arafat *et al.,* 2010).The common irrigation practice for rice cultivation in Egypt is continuous flooding method, which endures high water losses (Mahmoud *et al.,* 2016). Moursi (2001) and El-Hadidi et al. (2002) found that the lowest rice yield values was found with water depth equal to 2.5 cm, whereas 7.5 cm water depth obatined the highest values of rice grain and straw yields under EC value of 8.0 dSm^{-1}. However, according to Sharma (1989), the continuous flooding method is very inefficient because large amounts of the total applied water is wasted. Furthermore,this method results in high leaching rate of soluble nutrients (FAO, 2010).Uphoff and Randriamiharisoa (2002) stated that continuous flooding minimized soil microbial activities and reduced mineralization and nutrient release from the soil complexes (Wassmann, 2010). Morsi and Abdelkhalek (2015) found that gross applied water for Giza 178, Sakha 102 and Sakha 104 rice varieties were1208.4, 1176.1 and 1233.6 mm, respectively.

Water deficiency conditions are prevailing around the world, which poseas a challenge to researchers to develop innovative water saving practices and to study its effect on productivity of high water consuming crops, such as rice. These practices include reduction in applied water depth, saturated soil conditions and intermittent irrigation (Arora, 2006). Intermittent irrigation is a method of alternately irrigating and drying the field for several days (Keiser *et al.,* 2002). Fonteh *et al.,* (2013) stated that in intermittent irrigation, water is applied in certain intervals leading to episodes of non-flooded soil conditions in the fields. The intervals of non-flooded periods can vary between 1 day only to more than 10 days depending on a specific management regime and the conditions of soil and climate. This practice can save an amount of irrigation water to be used in irrigating new areas to reduce food insecurity.

Although, in Egypt, land resources are abundant, water resources became limited. Egypt has reached a state, where the quantity of available water is imposing limits on its national economic development because water scarcity threshold had passed (Ministry of Irrigation and Water Resources, 2014) .On the other hand, water management on field level is poor, with low application efficiency, which endures large water losses to the ground water and runoff. Therefore, intermittent irrigation for rice can be a suitable solution under water scarcity in Egypt. Internationally,the performance of this approach was evaluated and compared to continuous flooding method (Van der Hoek *et al.,* 2001; Ndenecho, 2009; Mostafazadeh-Fard *et al.,* 2010). However, little research was done in Egypt on intermittent irrigation of rice.

Thus, the objective of this investigation was to evaluate the effect of continuous flooding (common irrigation practice) and intermittent irrigation on two paddy rice cultivars with respect to its yield and yield attributes, in addition to water productivity under salt-affected soil at the North Nile Delta, Egypt.

MATERIALS AND METHODS

A field experiments was carried out at the El-Serw Agricultural Research Station, Demiatte Governorate (31°07 N, 30°57 E and elevation of 6.0 m above sea level), Egypt during the two sucssieve seasons of 2013 and 2014. Soil mechanical analysis and some chemical analyses of the experimental site are shown in Table 1. In addition, some soil hydrodynamic constants and bulk density in 2013 and 2014 growing seasons are presented in Tables 2 and 3, respectively.

The climate of the experimental site is characterized by a cool winters with low rain fall and hot summers. Recorded weather data, as well as reference evapotranspiration in the experimental site for both rice growing seasons are presented in Table 3.

Table 1. Mechanical soil analysis and some chemical properties of the experimental sites (average of soil depth 0-60 cm) during both growing seasons.

Years	Sand (%)	Silt (%)	Clay (%)	$CaCO_3$ (%)	EC (dSm^{-1})	pH	Total N (%)	OM (%)
2013	11.79	22.26	65.95	1.34	7.71	8.00	0.84	0.86
2014	12.23	21.67	66.10	1.41	5.70	7.89	0.95	0.75

Table 2. Some soil hydrodynamic constants and bulk density at different soil depth of the experimental sites (averages of the two seasons).

Soil depth (cm)	Field capacity (% mass)	Wilting point (% mass)	Available water (% mass)	Bulk density (gcm^{-3})
00-15	48.43	26.31	22.12	1.11
15-30	45.58	24.77	20.21	1.20
30-45	46.99	25.53	21.46	1.23
45-60	42.86	23.29	19.57	1.11
Average	45.96	24.97	20.84	1.16

Table 3. Weather data and reference evapotranspiration in 2013 and 2014 growing seasons

Month	2013 growing season					2014 growing season				
	SR	TX	TN	WS	ETo	SR	TX	TN	WS	ETo
May	25.4	31.1	19.3	3.3	6.4	24.8	30.0	19.0	3.4	6.2
Jun	28.1	33.0	21.7	3.5	7.3	27.9	32.8	21.6	3.4	7.2
Jul	27.7	33.1	22.8	3.7	7.2	27.7	34.5	23.3	3.4	7.3
Aug	25.8	33.6	23.8	3.1	6.9	25.4	34.6	24.4	3.3	7.0
Sep	21.9	32.0	22.8	3.3	5.9	21.5	32.5	23.4	3.0	5.8

SR : solar radiation ($MJm^{-2}day^{-1}$), TX and TN:maximum and minimum temperatures(°C), WS:wind speed (ms^{-1}) and ETo:reference evapotranspiration ($mmday^{-1}$),respectively.

The preceding crop was wheat in the first growing season and clover in second one.The experiment was laid out in a split - plot design with 3 replicates , where the main plots were assigned for irrigation management regimes and in the rice cultivars (Giza178 and Oraby2) were presented in split -plots. The adopted irrigation management regimes were classified as follows:

Continuous flooding:

- I_1: irrigation every 6 days with 7 cm depth.
- I_2: irrigation every 6 days with 5 cm depth.

Intermittent irrigation treatments:

- I_3: irrigation every 6 days with 3 cm depth.
- I_4: irrigation every 12 days with 7 cm depth.
- I_5: irrigation every 12 days with 5 cm depth.
- I_6:irrigation every 12 days with 3 cm depth.

The area of the experiment was chisel ploughed 3-passes, to a depth of 15 cm, and then laser land leveling was applied. Rice seedlings (25 old days) were transplanted on the 8th and 9th of May in the 2013 and 2014 growing seasons, respectively. The irrigation treatments were applied30 days post transplanting and were stopped 2 weeks before harvest. Each plot area was 42 m^2 (6 X 7 m) and isolated from the others by ditches of 2.5 min width to avoid lateral movement of water.

The amount of the applied water was measured using tube spiles. Two PVC tube spiles of 5 cm inner diameter and 80 cm length were used to convey irrigation water from field ditches into each plot. Stage gauges were placed in each plot to measure the depth of applied water. Water was added at each application until it reached the required submerged depth and was calculated according to James (1988). Agronomic practices e.g. N fertilization, weeds and pests control …..etc were similar to those used in the studied area. Rice plants were harvested 110 days from transplanting.

Number of tillers per hill, 1000-grain weight (g), grain and straw yields ($tonha^{-1}$) of rice were measured at harvesting from a central area (20 m^2) of each split - plot to avoid any border effect. Statistical analyses were performed according to Gomez and Gomez (1984) using MSTAT statistical package (MSTAT- C). Least Significant Difference (LSD, at 5% level of probability) was used to test the differences between treatments mean as described by Waller and Duncan (1969).

Water Productivity (WP)

Water productivity describes the relationship between crop produced from a unit of applied irrigation water. Furthermore, it is a useful indicator for quantifying the impact of management on final crop yield (FAO, 2003).Rice water productivity (kgm^{-3}) was calculated by dividing the obtained yield by the amount of applied irrigation water for each split - plot.

RESULTS AND DISCUSSION

Amounts of applied irrigation water

Application of continuous irrigation, namely I_1or I_2 maintained 2.8-3.5 cm or1.0 -1.7 cm of water depth, respectively,before the application of the following irrigation. Whereas, application of intermittent treatments, namely I_3, I_4, I_5 or I_6 resulted in 1, 2, 5 or 7 days of dry soil before the application of the following irrigation, respectively averaged over the two cultivars and growing seasons.

Data in Table 4 indicte that changing irrigation practice from continuous irrigation every 6 days and 7 cm irrigation depth to 5 cm irrigation depth under the same interval resulted in reduction in the applied water by 8 and 9% depending on the growing season, for Giza178 and Oraby2, respectively. Regarding intermittent irrigation treatments, the applied water decreased as irrigation interval increase or irrigation depth decrease for both cultivars and seasons. Furthermore, the applied irrigation water to Oraby2 was higher than Giza178 cultivarin continuous and intermittent irrigation treatments. The results in Table 4 also indicated that the applied irrigation water to both cultivars was lower in the second growing season, compared to the first season. This result can be attributed to reduction in EC value from 7.71 dSm^{-1} in the first growing season to 5.70 dSm^{-1} in the second growing season, which reduce salinity stress and consequently reduce leaching requirements.

Table 4. Applied irrigation water amounts (m^3ha^{-1})* for the two rice cultivars under different Irrigation management regimes and percentage of reduction in the applied water (PR%) in 2013 and 2014.

Irrigation management regime**	2013				2014			
	Sakha178		Oraby1		Sakha178		Oraby1	
	Irrigation	PR	Irrigation	PR	Irrigation	PR	Irrigation	PR
Continuous flooding								
I_1	10200	---	10392	---	10000	---	10200	---
I_2	9410	8	9420	9	9210	8	9314	9
Intermittent irrigation regime								
I_3	8860	13	8896	14	8690	13	8700	15
I_4	8510	17	8630	17	8370	16	8595	16
I_5	8472	17	8564	18	8292	17	8300	19
I_6	7625	25	7664	26	7475	25	7500	26

*Composed of applied irrigation water plus 1400 m^3ha^{-1} applied during nursery

** I_1: irrigation every 6 days with 7 cm depth; I_2: irrigation every 6 days with 5 cm depth; I_3: irrigation every 6 days with 3 cm depth; I_4: irrigation every 12 days with 7 cm depth; I_5: irrigation every 12 days with 5 cm depth; I_6: irrigation every 12 days with 3 cm depth.

Effect of irrigation treatments on rice yield attributes

Table 5 show that there was no significant difference between I1 and I2, as well as I3 on number of tillers per hill for both cultivars in both growing seasons. Similar trend was found for the rest of intermittent treatments, where no significant differences between them were found. The table also indicated that there is a significant difference (*P<0.05*) between irrigation every 6 days and every 12 days for all studied depth on number of tillers per hill. These results were true for both cultivars in both growing seasons. The results also showed that the highest number of tillers per hill was found for Giza178 cultivar in both growing seasons under both continues flooding and intermitted treatments.

Regarding to 1000-grain weight (Table 5), there was a significant difference (*P<0.05*) between the two cultivars under I1and I2, where Giza178 had higher value in both growing seasons. Furthermore, it can be notice from Table 5 that there were significant differences between continues flooding and intermittent treatments on 1000-grain weight (*P<0.05*).The results also showed that the highest values of 1000-grain weight were found for Giza178 cultivar in both growing seasons under both continues flooding and intermitted treatments.

Table 5. Effect of irrigation treatments on number of tillers per hill and 1000-grain weight in two rice cultivars in 2013 and 2014.

Irrigation management Regime*	Number of tillers per hill				1000-grain weight (g)			
	2013		2014		2013		2014	
	Sakha 178	Oraby 1	Sakha 178	Oraby 1	Sakha 178	Oraby 1	Sakha 178	Oraby 1
Continuous flooding								
I_1	455^{a}	433^{ab}	466^{a}	440^{b}	23.14^{a}	21.98^{b}	22.47^{a}	22.05^{b}
I_2	445^{ab}	430^{ab}	457^{a}	430^{c}	22.40^{ab}	20.35^{c}	21.00^{bc}	19.47^{d}
Intermittent irrigation								
I_3	440^{b}	422^{b}	441^{b}	424^{c}	19.70^{cd}	19.27^{de}	19.25^{d}	19.05^{d}
I_4	358^{c}	352^{cd}	352^{d}	345^{de}	19.38^{de}	17.86^{f}	19.97^{cd}	17.62^{e}
I_5	351^{cd}	334^{cd}	341^{def}	339^{ef}	19.33^{de}	16.46^{g}	19.56^{d}	17.00^{e}
I_6	343^{cd}	326^{d}	334^{fg}	325^{g}	18.69^{g}	16.36^{g}	19.25^{d}	16.84^{e}

* I_1: irrigation every 6 days with 7 cm depth; I_2: irrigation every 6 days with 5 cm depth; I_3: irrigation every 6 days with 3 cm depth; I_4: irrigation every 12 days with 7 cm depth; I_5: irrigation every 12 days with 5 cm depth; I_6: irrigation every 12 days with 3 cm depth.

The above results indicate that numbers of tillers per hill (representative of vegetative growth) and 1000-grain weight (representative of reproductive growth) were reduced as a result of application of intermittent treatments. The reduction in numbers of tillers per hill was 3-25% for Giza178 cultivar and it was 4-26% for Oraby2 cultivar averaged over the two growing seasons, compared to continuous flooding. This result can be explained by what was found by Pantuwan*et al.,* (2002), where they stated that water stress during vegetative growth, especially booting, flowering and terminal period reduce rice yield. Reduction in 1000-grain weight under intermittent treatments for Giza178 was 14-17% and it was 13-25% for Oraby2 cultivar averaged over the two growing seasons, compared to continuous flooding. Kamoshita *et al.,* (2004) reported that water stress during vegetative and reproductive growth reduces floret initiation, which causes spikelet sterility and lower grain weight. Furthermore, Yang *et al*, (2008) indicated that panicle initiation, anthesis and grain filling are three critical growth stages in rice to water stress. Water stress tends to delay flowering and reduced percentages of fertile panicles, as well as filled grains (Pantuwan *et al.,* 2002).

Effect of irrigation treatments on rice grain and straw yields

The highest rice grain and straw yields were obtained in the second growing season for both cultivars (Table 4). Giza178 cultivar produced the highest grain and straw yields under all treatments, compared to Oraby2 cultivar. There were significant differences between I_1 and I_2 treatment (*P<0.05*) on rice grain and straw yields in both growing seasons. Furthermore, there was no significant difference between the studied cultivar on its response to the application of either I_1 or I_2 treatments. Similarly, there were significant differences between rice grain and straw yields under continue flooding and intermittent treatments for both cultivars and growing seasons (*P<0.05*) (Table 6).

Table 6. Effect of irrigation treatments on grain and straw yields of the studied two rice cultivars in 2013 and 2014.

Irrigation management regime	Grain yield (tonha^{-1}) 2013 Sakha 178	Grain yield 2013 Oraby 1	Grain yield 2014 Sakha 178	Grain yield 2014 Oraby 1	Straw yield (tonha^{-1}) 2013 Sakha 178	Straw yield 2013 Oraby 1	Straw yield 2014 Sakha 178	Straw yield 2014 Oraby 1
Continuous flooding								
I_1	7.55^{a}	7.44^{a}	8.61^{a}	8.27^{a}	11.20^{a}	10.85^{ab}	11.57^{a}	11.46^{a}
I_2	7.03^{b}	7.01^{b}	8.05^{bc}	7.61^{cd}	10.10^{c}	9.56^{cde}	10.62^{b}	9.66^{cd}
Intermittent irrigation								
I_3	6.46^{c}	6.39^{cd}	7.02^{def}	6.79^{ef}	8.99^{e}	8.78^{cde}	9.32^{de}	9.10^{e}
I_4	6.40^{c}	5.89^{ef}	6.93^{cde}	6.46^{fgh}	9.67^{bcd}	8.56^{cde}	10.10^{c}	10.00^{c}
I_5	6.16^{cde}	5.81^{ef}	6.53^{ef}	6.25^{ef}	8.79^{cde}	8.57^{cde}	8.88^{ef}	8.79^{fg}
I_6	5.96^{de}	5.54^{f}	6.16^{ef}	6.01^{f}	8.40^{de}	8.10^{e}	8.35^{g}	8.30^{g}

**** I_1: irrigation every 6 days with 7 cm depth; I_2: irrigation every 6 days with 5 cm depth; I_3: irrigation every 6 days with 3 cm depth; I_4: irrigation every 12 days with 7 cm depth; I_5: irrigation every 12 days with 5 cm depth; I_6: irrigation every 12 days with 3 cm depth.**

The above results indicated that rice yield was higher in the second growing season, compared to the first season. This can be attributed to clover cultivation before rice in the second growing season, which resulted in improving soil quality. Espinoza *et al.,* (2015) indicated that cultivation of a legume crop before rice can increase available nitrogen. Moreover, McCallum *et al.,* (2004) reported that it can improve soil quality, porosity, and structure. In our experiments, the yield of Giza178 was increased in the second growing season by 14-15% under continues flooding treatments and by 3-9% under intermittent irrigation treatments. With respect to Oraby2, its yield was increased by 9-11% under continues flooding treatments and by 6-10% for intermittent irrigation treatments.

Furthermore, the results in Table 4 indicated that grain and straw yields of rice were the highest under I_1 for both cultivars. Furt hermore, low grain and straw yield of rice were observed under intermittent irrigation treatments, as a result of episodes of soil drying during vegetative and reproductive growth. Sarvestani *et al.,* (2008) stated that water stress during rice vegetative stages reduced grain yield by 21% on average (Botwright *et al.,* 2008). Furthermore, Yang *et al.,* (2008) indicated that water stress during panicle initiation, anthesis and grain filling, reduced final rice yield.Harbir and Ingram (2000) reported that water stress starting from booting to grain filling stage caused greatest rice yield reduction. Our results showe that trend, where the reduction in rice yield under intermittent irrigation treatments were 11-21% averaged over the two cultivars and the two growing seasons, compared to continuous flooding.

Effect of water saving on final yield of rice cultivars and water productivity

Continuous flooding using I_2 treatment for Giza178 cultivar resulted 8% saving in the applied irrigation water and yield losses by7%, compared to using I_1 treatment (Table 7). Intermittent irrigation resulted in 11-20% yield losses, where 1 day of dry soil (I_3) caused 11% yield losses and 7 days of dry soil caused 20% yield losses. Furthermore, higher irrigation water savings can occur under intermittent treatments, namely 8-25% and yield losses will increase to be between 7-20% . The highest water productivity can be obtained I_2 and where water depth was 1.0 - 1.7 cm before the application of the following irrigation, namely 0.81 kgm^{-3}. Furthermore, I_6 achieved a value of water productivity similar to I_1, namely 0.80 kgm^{-3}.

Table 7. Grain yield, irrigation amounts and water productivity for Sakha178 and Oraby1 cultivars averaged on the two growing seasons.

Irrigation management regime	Yield (kgha^{-1})	Change (%)	Irrigation (m^{3}ha^{-1})	Saving (%)	Water productivity (kgm^{-3})
Sakha178 cultivar					
Continuous flooding					
I_1	8.08	--	10,100	--	0.80
I_2	7.54	7	9,310	8	0.81
Intermittent irrigation					
I_3	6.74	11	8,775	13	0.77
I_4	6.67	12	8,415	17	0.79
I_5	6.35	16	8,382	17	0.76
I_6	6.06	20	7,550	25	0.80
Oraby1 cultivar					
Continuous flooding					
I_1	7.86	--	10,100	--	0.76
I_2	7.31	7	9,310	8	0.78
Intermittent irrigation					
I_3	6.59	10	8,775	13	0.75
I_4	6.18	16	8,415	17	0.72
I_5	6.03	18	8,382	17	0.72
I_6	5.78	21	7,550	25	0.76

I_1: irrigation every 6 days with 7 cm depth; I_2: irrigation every 6 days with 5 cm depth;I_3: irrigation every 6 days with 3 cm depth; I_4: irrigation every 12 days with 7 cm depth; I_5: irrigation every 12 days with 5 cm depth; I_6: irrigation every 12 days with 3 cm depth.

Regarding to Oraby 2 cultivar (Table 7), 8% water saving can be attained with 7% yield losses, when I_2 treatment was used, compared to I_1. Intermittent irrigation resulted in 10 - 21% yield losses, where 1 day of dry soil (I_3) caused 10% yield losses. Furthermore, I_2 treatment produced the highest water productivity, i.e. 0.78 kg m^{-3}. The highest water saving can occur using I_6 treatment (7 days of dry soil), namely 25%, which cause 21% reduction in the yield and water productivity was 0.76 kg m^{-3}, similar to its counterpart of I_1.

Comparison between Giza178 and Oraby2 cultivars showed that Giza178 have higher number of tillers per hill and 1000-grain weight, as well as higher grain and straw yields. Our results indicated that the highest water productivity value was obtained under I_2, namely 0.81 and 0.78 kg/m^3 for Giza178 and Oraby2 cultivars, respectively. Similarly, higher water productivity values for the rest of the irrigation treatments were obtained for Giza178 cultivar. El-Saiad (2008) found that the highest crop water use efficiency was achieved under submergence head of 6 cm. These results implied that Giza178 can use water more efficiently and attain high water productivity, compared to Oraby2.

CONCLUSION

Our results indicated that irrigation every 6 days with 3 cm depth resulted in 1 day of dry soil before the application of the following irrigation. Furthermore, irrigation every 12 days with 7, 5 and 3 cm depth resulted in 2, 5 and 7 days of dry soil, respectively, before the application of the following irrigation. Furthermore, rice yield losses per day averaged over the two cultivars and seasons were 9, 7, 3 and 3%, respectively. Thus, taking into account the average of these yield losses it could be concluded that 4% rice yield losses can occur for each day of soil drying during intermittent irrigation.

Furthermore, In case of using continuous flooding to irrigate rice, it is recommended to apply irrigation every 6 days with 5 cm depth to attain high rice yield and water productivity.In case of water deficiency conditions, intermittent irrigation can be used, namely application of irrigation every 6 days with 3 cm depth, where yield losses was 11%. In case of water scarcity,application of irrigation every 12 days with 3 cm depth can be recommended because it resulted in similar water productivity value as application of irrigation every 6 days with 7 cm depth for both cultivars.Giza178 can use water more efficiently and attained higher water productivity, compared to Oraby2. Therefore, it can be recommended to be use under water scarcity conditions in Egypt. In all cases, legume crop need to cultivate it before rice to improve soil quality and increase yield.

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تقيم بعض نظم الرى بغرض ترشيد استهلاك المياه.

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يهدف هذا البحث الى تقيم بين تأثيرمعاملات الرى المتواصل (الري كل 6 أيام مع 7 سم عمق (I1) و الري كل 6 أيام مع 5 سم عمق (I2)) ومعاملات الري على فترات متقطعة (الري كل 6 أيام مع 3 سم عمق (I3) والري كل 12 أيام مع 7 سم عمق (I5) ، الري كل 12 يوم مع 5 سم عمق (I6) و الرى كل 12 يوم مع 3 سم عمق (I6)) على المحصول ومكوناته و اوإنتاجية وحدة المياه لصنفين من الأرز و هما جيزه 178 و عرابى2 . و قد أظهرت النتائج وجود فروق معنوية بين معاملات الرى المتواصل و الرى على فترات متقطعه في جميع الصفات المدروسة ولم توجد فروق معنوية بين الاصناف . وتم تحقيق أعلى إنتاجية لوحدة المياه لكلا الصنفين عند تطبيق معاملة (I1). إضافة معاملة (I3) أو (I2) أدى الى نقص المحصول بنسبة 7% أو 8% كما أدى الى توفير 13% او 8 % من كمية المياه المضافه لهم . و كانت اعلى إنتاجية لوحدة المياه تم الحصول عليها من الصنف جيزه 178 تحت معاملة (I2) لكلا من الصنفين . أظهرت النتائج أيضا أن إضافة معاملة (I6) أسفرت عن قيمة إنتاجية وحدة المياه مماثلة للمعامله (I1) لكلا الصنفين . وعلى ذلك ففى ظل ندرة المياه المتوقعة يمكن زراعة الصنف جيزه 178 للحصول على أعلى قيمه لإنتاجية وحدة المياه . كما من المفضل زراعة برسيم قبل محصول الأرز لتحسين التربة وزيادة محصول الأرز.