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Role of Irrigation Intervals and Plant Spacing on Growth, Yield and its Components for some Rice Cultivated Varieties

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ABSTRACT

Irrigation water is considering important single attributes of sustainable rice production; more effectiveness water management system is required for agriculture. So, the management of water Utilizing in rice producing systems is necessary to increased productivity. Current study was carried out in the trial farm of Rice Research and Training Center (RRTC), Sakha, Kafr El-Sheikh, Egypt, in the summers of 2019 and 2020, to determine the outcome of plant spacing (15x20, 20x20 and 25x20 cm) on growth, grain yield and water use efficiency of two inbred rice cultivated variety (Giza 179 and Sakha 106) under varying times between irrigations namely, continuous flooding (CF), six-day irrigation intervals (6D) and 12-day irrigation intervals (12 D). A strip - split plot design was applied, with four replications. Obtained results revealed that as irrigation intervals increased to as many as twelve days, there were considerable decline in growth characteristics, grain yield and its traits without any significant variations between Cf and 6D in grain production in both seasons. Giza 179 rice variety significantly surpassed Sakha 106 rice variety for growth (Dry matter content and leaf area index "LAI") and grain characteristics (No. of panicles per m^2 as well as total grains per panicle, panicle length, panicle weight, grain yield and straw yield per ha), excluding the 1000 grains weight, which was the greatest values with Sakha 106. Grain yield was significantly larger at closer plant spacing of 15x20 cm than at wider plant spacing of 25x20 cm.

Keywords: Rice varieties; plant spacing; irrigation intervals; Water use efficiency

INTRODUCTION

Rice (*Oryza sativa* L.) is one of the principal crops for food in the world for most people around the world. Rice is a staple item that they eat every day. It also forms the foundation of many enterprises and is a significant source of national income. For the purpose of feeding the world's rapidly expanding population, efforts must be made to enhance the production of rice grains per unit area.

Improving irrigation management is essential for increasing grain yield. Farmers in Egypt employ flooding on a regular basis, which leads to massive water waste and reduced water usage efficiency. Therefore, it is essential to think about and employ water-saving techniques when producing rice. Several irrigation techniques exist to minimize the amount of water entering rice fields (Dong *et al*., 2004), wet and dry watering in alternation, and using irrigation time (El-Refaee *et al*., 2008). The findings demonstrated that flooding rice plants at every stage of development was not necessary; instead, it was possible to achieve the same goals by decreasing the water depth and changing from flooding to non-flooding irrigation techniques (Rahman *et al*., 2002).

Rice varieties are likely to grow differently when exposed to water stress. Moreover, may vary depending on the water supply quantity. Grain yields may increase with varieties that can sustain a water uptake at decreased soil water contents; these varieties may become more significant when the water supply diminishes. Under various water regimes, variations in plant features, such as tillering, panicle size and phenology, may result in variations in dry matter content (Kato *et al*., 2006a) and grain yield formation (Katoo *et al*., 2006b). To get the highest yields possible, the ideal plant density per unit area must be found. Optimal plant spacing is crucial for proper growth, utilizing solar radiation and nutrients and depends on factors like varietal type, plant characteristics, planting time and method, growth period, soil fertility, plant size and planting pattern.

Therefore, the current study aims to examine the consequences of different plant spacing under different irrigation treatments on growth, yield its traits, water use efficient (WUE) on some Egyptian rice varieties.

MATERIALS AND METHODS

The field experiment was carried out in the summers of 2019 and 2020 at the Experimental Farm of Rice Research and Training Center (RRTC), Sakha, Kafr El-Sheikh, Egypt, to investigate the impact of plant distance on growth, grain yield and water use efficient of two rice varieties under various irrigation intervals.

The experimental site's soil has a clayey texture, a pH between 8.11 and 8.19, and an organic matter was 1.65 and 1.60%. The available K was 310 and 300 ppm, the available P was 13 and 15 ppm, and the total N was 520 and 500 ppm for both seasons.

A strip – split plot design, with 4 replicates, was applied. The vertical plots were dedicated to 3 irrigation treatments; namely, continuous flooding (CF), six-day irrigation intervals (6D) and 12-day irrigation intervals (12 D), with 4-5 cm water head at the time of water addition. The horizontal plots were assigned to two rice varieties; i.e., two

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inbreeds (Sakha106) and Giza179). However, the sub sub-plots were occupied by three plant spacings viz., 15x20, 20x20 and25x20cm distance among hills and rows. Some of the rice varieties characters are shown in Table 1.

Table 1. Attributes of the studied rice varieties

Varieties	Pedigree	Type	Duration (day)	Grain type
Sakha 106	Gz177&Heix30	Japonica	120	Short
Giza 179	Gz 6296&Gz1368	Indica-Japonica	120	Medium

Nursery region was well-prepared. Seeds (144 kg/ha) were soaked for 24 hr then incubated 48 hr. Pre-germinated seeds were broadcasted in nurseries on May 3 and May 5, respectively, for the 2019 and 2020 growing seasons. In both seasons, Egyptian clover was the previous crop. During field preparation, phosphorus fertilizer was applied as a basal dose at a rate of 36 kg P_2O_5 ha in the form of single super phosphate (15% P_2O_5) and 48 kg K_2O ha^{-1}, was applied as the basal dose to each plot. The nitrogen fertilizer was applied in two splits at a rate of 165 kg N/ha in the form of urea (46.5% N), with two thirds of the dose baseline treatment applied before transplantation and the remaining portion applied 30 days after transplantation. Every variety`s thirty-day-old seedlings were individually uprooted, moved from the nursery to the permanent field and manually transplanted using three seedling hills according to spacing treatments. The sub subplot measured 15 m^2 (3 x 5 m). The recommendations of the Rice Research and Training Center (2018) were followed for all other agronomic techniques. Trenches two meters wide were used to divide each main plot in order to prevent lateral irrigation water movement and provide greater water control. Water pump with a calibrated water meter, was utilized for water measurement. The water usage efficiency (WUE) was calculated using the weight of the grains for each water unit consumed (kg grains/m^3 water).

Each sub-plot's number of days to the 50% heading was noted. At the heading stage, plant samples were randomly selected from each treatment to calculate the leaf area index (LAI) and dry matter accumulation. Plant height (cm) and the total number of panicles per square meter were determined at harvest. Ten panicles were selected randomly to determine the panicle length (cm), panicle weight (g), number of both unfilled and filled grains per panicle, and 1000-grain weight (g). Each plot's core 10 m^2 was collected independently at full maturity, dried, and threshed. The yields of grain and straw were subsequently determined and translated into t/ha. The grain yield was modified to 14% moisture content.

According to Gomez and Gomez (1984), analyses of variance were completed on the obtained data. Duncan's Multiple Rang Test was employed to compare the treatment means (Duncan, 1955). The COSTAT software application was utilized for doing statistical analysis of variance.

RESULTS AND DISCUSSION

1.Growth characteristic.

Results in Table 2 indicated that the period needed to 50% heading was considerably increased by elongate irrigation intervals where the highest values of period needed to 50% heading were gotten under 12D treatment. The results are in balance with those stated by Wopereis *et al*., (1996) and El-Refaee (2002) who found that flowering and maturity of stressed plants were delayed.

Results also showed that dry matter content (DM), LAI and plant length at harvest stage were significantly higher under both continuous flooding (CF) and irrigation every six days (6D) treatments while, the lowest values of these traits were obtained under irrigation every 12 days (12D) treatment. The reduction in growth characteristic, under prolonged irrigation was relative to the total amount of water stress in plants subjected to water stress through early stages of tiller development and cell elongation, which led to reduction in plant height, number of tillers and photosynthetic area. Due to the death of the lower leaves and the overall effects of water stress on plant growth, there may be a deficit of plant height, tillers No. and leaf area, which would explain the decrease in LAI with longer irrigation intervals. These findings are in concord with those of EL- Refaee *et al.* (2012), Sheta (2017) and Ghazy (2019).

Table 2. Days to 50% heading, dry matter contents, LAI, and plant height of the two used rice varieties as influenced by varying times between irrigations and plant spacing and their interactions

Treatment	Day to 50% heading		Dry matter (g/m^2)		LAI		Plant height (cm)	
	2019	2020	2019	2020	2019	2020	2019	2020
Irrigation (I)								
CF	99.16 c	99.16 c	1230 a	1233.75a	6.97a	6.9a	98 a	98.33a
6D	100.5 b	100.16b	1218.33a	1221.25a	6.82a	6.82a	97.25b	97.83a
12D	101.66a	101.66a	1140.41b	1143.95b	6.2 b	5.95b	94.62c	94.79b
F.test	**	**	**	**	**	**	**	**
Varieties (V)								
Giza 179	99.94b	99.58 b	1213.88a	1217.22a	6.7 a	6.65a	94.80b	94.91b
Sakha 106	100.94a	101.08a	1178.61b	1182.08b	6.62b	6.47b	99.44a	99.05a
F.test	**	**	**	**	**	**	**	**
Spacing (S)								
15×20 cm	100.12	100.41	1204.58a	1208.54a	6.71a	6.63a	97.25a	97.58a
20×20 cm	100.58	99.91	1198.95a	1202.70a	6.67a	6.60a	97.5a	97.91a
25×20 cm	100.62	100.66	1185.20b	1187.70b	6.59b	6.44b	95.12b	95.45b
F.test	-	-	*	*	**	**	**	**
Interaction (I)								
V×C	-	-	-	-	-	-	-	-
V×S	-	-	-	-	-	-	-	-
V×S	-	-	-	-	-	-	**	**
I×V×S	-	-	-	-	-	-	-	-

****= Highly significant at 0.01,*= significant at 0.05 levels and - = not significant. The means of each factors with the same letter assigned to them do not differ significantly at the 5% probability level.**

Rice varieties significantly varied in Days to 50 % heading, DM, LAI and plant height (Table2) in both seasons. Giza 179 rice variety significantly exceeded Sakha 106 in dry matter contents and LAI in both seasons. However, Sakha

106 gave significantly the maximum number of days to 50% heading and produced the tallest plants in both seasons. Similar results were stated by Sheta (2010) and El-Rafaee (2012).

Among the plant spacings, narrow spacing (15x20 cm) recorded the maximum DM, LAI and the tallest plants, on the other hand the wider spacing (25x20 cm) recorded the minimum values of DM, LAI and plant height in two seasons. This could be because there is more competitiveness for solar radiation absorption when there are more plants in close spacing than in a wider one. These findings correspond with that attained by Ghazy (2019).

Table 3. Plant height (cm) as influenced by the interaction between rice varieties and plant spacing

Treatments		Plant height (cm)	
Varieties	**Plant spacing**	**2019 season**	**2020 season**
	15x20 cm	94.75c	95.25d
Giza 179	20x20 cm	96.66b	96.50c
	25x20 cm	93.00d	93.00e
	15x20 cm	99.75a	99.91a
Sakha 106	20x20 cm	98.33b	99.33a
	25x20 cm	97.25b	97.91b
F-Test		**	**

****= Highly significant at 0.01. The means of each factors with the same letter assigned to them do not differ significantly at the 5% probability level.**

Interaction between varieties and plant spacing had the significantly influence on plant length in both seasons. Sakha 106 rice varieties at spacing of 15x20cm produced the tallest plants (99.75 and 99.91 cm), while the shortest plants (93.00 cm) was produced by Giza 179 rice varieties at spacing of 25x20 cm in both seasons (Table3). Similar findings were reported by Uddin *et al*. (2010).

2- Grain yield and its traits:

The results in Table 4 reveled that the irrigation practice of CF registered the greatest values of number of panicles/m^2, panicle length and total number of grains/ panicle in two seasons. While D12 treatment gave the minimum values of panicles No./m^2, panicle length and total number of grains /panicles and registered the maximum values of number of unfilled grains percentage in two seasons.

These results are in concur with those reported by Gewaily *et al*., (2019) who declared that availability of water may have facilitated physiological and biological processes that raise the dry matter content's production and translocation from source to sink, leading to an increase in tillers, panicles, grain filling, and weight. This could explain the observed increase in yield traits under non-stressful conditions.

Data presented in Table 4, further shown that there were notable variations between rice varieties for every studied characters in two seasons.

In both seasons, Giza 179 rice variety gave the greatest number of panicles/m^2, panicle length and total number of grains/panicle. While, Sakha106 rice variety noted the least values of this characters. These results were mentioned by Gewaily *et al*., (2019) who declared that genetic background differences may account for variations in agronomical properties among rice varieties.

Table 4. Panicles No./m^2, panicle length (cm), total grains/panicle and unfilled grains % of the two used rice varieties as influenced by varying times between irrigations and plant spacing and their interactions

Treatment	Panicles No. / m^2		Panicle length (cm)		Total grains/panicle		Unfilled grains%	
	2019	2020	2019	2020	2019	2020	2019	2020
Irrigation (I)								
CF	534.91a	538.20a	24.43a	24.5a	164.62a	165.75a	11.70b	12.00b
6 D	524.58a	531.54a	24.33a	24.42a	161.70a	164.20a	12.00b	12.12b
12 D	469.75b	469.37b	24.18b	24.00 b	156.33b	156.41b	13.50a	14.12a
F.test	**	**	**	**	**	**	**	**
Cultivars(C)								
Giza 179	514.72a	516.16a	24.40a	24.38a	161.80a	163.38a	12.44	12.80
Sakha106	504.77b	509.91b	24.22b	24.23b	159.97b	160.86b	12.36	12.69
F.test	**	**	**	**	**	**	-	-
Spacing (S)								
15x20 cm	531.91a	534.79a	24.10b	24.14b	158.70b	159.37b	13.58a	13.62a
20x20 cm	524.04b	525.00b	24.04b	24.10b	160.54b	161.87b	12.25b	12.58b
25x20 cm	473.29c	479.33c	24.78a	24.67a	163.41a	165.12a	11.37c	12.04b
F.test	**	**	**	**	**	**	_**	**
Interaction (I)								
IxC	-	-	-	-	-	-	-	-
IXS	-	-	-	-	-	-	**	**
CXS	-	-	-	-	-	-	-	-
IXCXS	-	-	-	-	-	-	-	-

****= Highly significant at 0.01 and - = not significant.**
The means of each factors with the same letter assigned to them do not differ significantly at the 5% probability level.

In both seasons, different plant spacing had marked influence on grain yield and its attributing characters, rice planted at narrow plant spacing of 15x20 cm listed the highest values of panicles No./m^2 and number of unfilled grains percentage compared with other plant spacing. While, plant spacing of 25x20 cm listed the maximum panicle length and the highest number of total grains /panicles in both season compared with other planting spacing. These conclusions are in harmonization with the results acquired by Munyithya *et al*., (2017) and Ghazy, *et al*., (2019) who reported that, narrow plant spacing showed the greatest values of unfilled grain % and panicles No. /m^2 among all plant spacing, these were mostly caused by higher plant populations and more No. of hills, despite fewer tillers per hill. In the meantime, maximal values for the total number of grains/panicles and panicle length were recorded with a wider space. It has indicated that plant physiological activity is impacted by spacing through intra-specific competition. Interaction between varying times of irrigations and plant spacing in 2019 limited the greatest significant number of unfilled grains percentage (14.5 %) in the combination of D12 treatment, at the spacing of 15x20 cm, but the significant lowest number of unfilled grains percentage (10.37 %) which produced under CF treatment at the spacing of 20x20 cm in both seasons (Table 5).

Table 5. Unfilled grain % as influenced by the interaction between varying times between irrigations and plant spacing

Treatments		Unfilled grain %	
Irrigation	Plant spacing	2019 season	2020 season
C.F	15x20 cm	13.75b	13.62bc
	20x20 cm	10.37d	10.75g
	25x20 cm	11.00cd	11.62efg
6 D	15x20 cm	12.50bc	12.12def
	20x20 cm	12.50bc	12.75cde
	25x20 cm	11.00cd	11.50fg
12 D	15x20 cm	14.50a	15.12a
	20x20 cm	13.87b	14.25b
	25x20 cm	12.12bcd	13.00cd
F-Test		**	**

****= Highly significant at 0.01.**
The means of each factors with the same letter assigned to them do not differ significantly at the 5% probability level.

Results in Table 6 revealed that the varying times between irrigations were significantly affected on grain yield and its traits in both seasons. The irrigation practice CF and irrigation every 6 days produced the highest values of most grain yield and its traits such as 1000 grain weight (g), panicle weight (g), grain and straw yield t/ha in two seasons without significant variation between them. Irrigate every 12 days presented the lowest values of yield and it attributes in two seasons. The greatest grain yield (10.48 and 10.57 t/ha) were achieved due to continuous flooding along the two seasons without significant variations with 6D in both seasons. Bozorgi *et al.* (2011) observed that flooding irrigation produced the greatest grain yield. Furthermore, using the six-day intervals between irrigations was statistically distribution in the same level with the flooded method. This could be the result of improved growth traits (dry matter, chlorophyll content, leaf area, and plant height) linked to increased inorganic N mobility and absorption in soil solution, which enhanced nutrient uptake and contributed to favorable growth traits, which in turn produced higher yield attributes. This agrees with the findings of Gewaily *et al.* (2019) and Ghazy *et al.* (2019) who reported that drought condition significantly reduced grain output from rice plants, since all yield components were affected by prolonging irrigation intervals up to nine days. In addition to decreasing the number of panicles per square meter and the overall number of grains/panicles, the absence of water hinders the formation and movement of dry matter in the various plant organs.

Table 6. 1000 - grain weight (g), panicle weight (g), grain yield t/ha and straw yield t/ha of the two used rice varieties as influenced by varying times between irrigations and plant spacing and their interactions

Treatments	1000-grain weight (g)		Panicle weight (g)		Grain yield (t/ha)		Straw yield (t/ha)	
	2019	2020	2019	2020	2019	2020	2019	2020
Irrigation (I)								
CF	29.29a	29.35a	3.82a	39.10a	10.48a	10.57a	13.59a	13.68a
6D	29.20a	29.22a	3.77a	3.88a	10.37a	10.46a	13.48 a	13.54a
12D	28.07b	27.81b	3.56b	3.61b	8.73b	8.57b	10.85b	10.81b
F-test	**	**	**	**	**	**	**	**
Varieties (C)								
Giza 179	28.83	28.64b	3.78a	3.87a	10.06a	10.03a	12.72a	12.76 a
Sakha 106	28.88	28.95a	3.66b	3.73b	9.66b	9.71b	12.56b	12.59 b
F-test	-	**	**	**	**	**	**	**
Spacing (S)								
15×20 cm	28.17b	28.63b	3.70b	3.76b	10.20a	10.24a	13.03a	13.04a
20×20 cm	28.76b	28.66b	3.70b	3.77b	10.10a	10.13a	12.65b	12.71b
25×20 cm	29.17a	29.09a	3.77a	3.87a	9.29b	9.25b	12.25c	12.27c
F-test	**	**	**	**	**	**	**	**
Interaction (I)								
V×C	-	-	-	-	-	-	-	-
V×S	-	-	**	**	**	**	**	**
V×S	-	-	-	-	**	**	-	-
I×V×S	-	-	-	-	-	-	-	-

****= Highly significant at 0.01 and - = not significant. The means of each factors with the same letter assigned to them do not differ significantly at the 5% probability level**

From statistics displayed in Table 6 demonstrated that significant variation was achieved between used rice varieties for grain yield and its traits. Giza 179 rice variety resulted in the maximal values of panicle weight, grain and straw yield t/ha, except 1000-grain weight in the second season. Conversely, Sakha 106 rice variety noted the minimum values of most grain yield and its traits and give the heaviest 1000-grain weight in the second season. The diversity among the rice varieties in grain yield and its traits is possibly because of the genetic background differences. This finding hold fairly true for the first season and second one. Similarly, results were reported by Sheta (2010) and El-Refaee (2012) and Gewaily *et al*., (2019).

The characteristics of grain output were significantly impacted by different plant spacing in both seasons, the wider plant spacing 25x20 cm recorded the heaviest 1000-grain weight and panicle weight (g) in both seasons, also the wider plant spacing 25x20 cm listed the minimum values of grain yield t/ha, straw yield t/ha compared with other plant spacing in both seasons. While, the narrow spacing of 15 x 20 cm followed by plant spacing 20x 20 cm showed the highest values of grain and straw yield t/ha in two seasons. These outcomes concur with the results obtained by El- Refaee (2012), Ram *et al*. (2014) and Ghazy (2019), who reported that neighbor competition frequently amplifies the physiological competition within the hill that is a fundamental component of the physical environment, and both factors influence on yield. Studies have indicated that plant spacing affects physiological activities of plants through intra-specific competition. (Moro *et al*., 2016; Munyithya *et al*., 2017). Closer spacing may result in a larger grain production than wider spacing because of the ideal plant population, improved yield parameters, delayed leaf senescence caused by increased pre-heading, current photosynthesis, and higher assimilation rate.

Table 7. Panicle weight (g) and grain yield (t/ha) as influenced by the interaction between varying times between irrigations and plant spacing

Treatments		Panicle weight (g)		Grain yield (t/ha)	
Irrigation	Plant spacing	2019	2020	2019	2020
	15x20 cm	3.78b	3.87b	10.68a	10.76a
C.F	20x20 cm	3.81b	3.88b	10.61a	10.77a
	25x20 cm	3.88a	3.97a	10.15b	10.20 b
	15x20 cm	3.76b	3.89b	10.71a	10.81a
6 D	20x20 cm	3.77b	3.87b	10.62a	10.75 a
	25x20 cm	3.78b	3.91b	9.80 c	9.86 c
	15x20 cm	3.48e	3.52e	9.20d	915d
12 D	20x20 cm	3.57d	3.60d	9.07d	8.88 e
	25x20 cm	3.63c	3.72c	7.92e	7.70 f
F-Test		**	**	**	**

****= Highly significant at 0.01. The means of each factors with the same letter assigned to them do not differ significantly at the 5% probability level.**

Interaction between varying times between irrigations and plant spacing significantly affected the panicle weight and grain yield Table (7). The heaviest panicle weight (3.88 and 3.97 g) were obtained under the combination between CF treatment and the spacing of 25x20cm, while, the lowest panicle weight (3.48 and 3.52 g) was recorded with irrigation every 12 days at spacing of 15x20 cm in both seasons (Table7).

Results in Table 7 also demonstrated that the maximum grain yield (t/ha) were produced under CF and irrigation of 6 days at both spacing of 15x20 cm and 20x20 cm. The minimum grain yield (t/ha) was produced under irrigation 12 days at the spacing of 25x20 cm. These outcomes correspond with those attained by El- Refaee (2012) and Ghazy (2019), who stated that closer spacing and longer irrigation intervals produced a significant response. Water stress reduced the number of panicles m^{-2} when the irrigation interval was extended. Thus, in order to obtain a significant grain yield, high plant density was required.

Table 8. Grain yield (t/ha) as influenced by the interaction between rice varieties and plant spacing

Treatments		Grain yield (t/ha)	
Varieties	Plant spacing	2019 season	2020 season
	15x20 cm	10.33a	10.35a
Giza 179	20x20 cm	10.25a	10.13bc
	25x20 cm	9.60c	9.50d
	15x20 cm	10.07b	10.25a
Sakha 106	20x20 cm	9.75b	10.02c
	25x20 cm	8.98d	8.99e
F-Test		**	**

****= Highly significant at 0.01. The means of each factors with the same letter assigned to them do not differ significantly at the 5% probability level.**

The interaction between plant spacing and rice varieties recorded considerable impact on grain yield t/ha in both seasons. Data in Table 8 indicated that the maximum value of grain yield was acquired with Giza 179 rice variety at the spacing of 15x20 followed by spacing of 20x20 cm without significant variations between them. While, the minimum value of grain yield was obtained by Sakha 106 rice variety at the spacing of 25x20 cm in the two seasons.

Table 9. Straw yield (t ha^{-1}) as influenced by interaction between varying times between irrigations and plant spacing

Treatments		Straw yield (t ha^{-1})	
Irrigation	Plant spacing	2019 season	2020 season
	15x20 cm	13.86a	13..96a
C.F	20x20 cm	13.50b	13.58bc
	25x20 cm	13.42 b	13.50c
	15x20 cm	13.85a	13.87a
6 D	20x20 cm	13.60b	13.72b
	25x20 cm	12.93c	13.03d
	15x20 cm	11.38d	11.31e
12 D	20x20 cm	10.76e	10.83f
	25x20 cm	10.41f	10.30g
F-Test		**	**

****= Highly significant at 0.01. The means of each factors with the same letter assigned to them do not differ significantly at the 5% probability level.**

The interaction between varying times between irrigations and plant spacing had a marked impact on straw yield (Table 9) in the two seasons. Close spacing of 15x20 cm recorded the maximum straw yield under CF and irrigation every 6 days, it was 13.86 and 13.96 t/ha for CF, 13.85 and 13.87 t/ha under 6 days. However, wider spacing 25x20 cm with 12 days gave the lowest straw yields of 10.41 and 10.3 t/ha in 2019 and 2020 seasons, respectively.

3- Irrigation Water Used, Water saved (%) and water use efficiency

Data in Table 10 present total applied water, grain yield, water use efficiency, and water save percentage. Data showed marked variations among irrigation treatments regarding previously mentioned traits in both seasons (Table 10). When rice plants were irrigated of CF, they consumed the greatest values of total used water. Meanwhile, higher total used water under the irrigation interval of CF was combined with the greatest values of rice grain yield in two seasons in contrast to other irrigation intervals. Obviously, prolonging irrigations intervals more than CF markedly and significantly reduced the water inputs declined grain yield output, and increased water use efficiency. Continuously, prolonged varying times between irrigations were found to be effective in increasing water save percentage under the current study. The lowest values of total used water (11150 and 11220m^3/ha), the lowest grain yield, and the highest mean of water save (15.53 and 15.63%) were exerted by rice plants when they were 12D in both seasons. The greatest values of water use efficiency (0.853 and 0.857 kg/m^3) in the first and second seasons, respectively, were given by 6D. The lowest values of water use efficiency (0.782 and 0.763kg/m^3) in the 2019 and 2020 seasons, respectively, were recorded when the irrigation schedule 12D was followed in this study. By the way, prolonging irrigation intervals showed a high affinity to produce more grain per water unit resulting in high water use efficiency in both seasons. These outcomes concur with those of Gewaily *et al.* (2019) and Poddar *et al.* (2022).

Table 10. Total used water, water saved and water use efficiency as influenced by varying times between irrigations during 2019 and 2020 seasons.

Irrigation	Total water use (m^3/ha)		Grain yield (t/ha)		Water saved (%)		Water use efficiency (kg/m^3)	
interval	2019	2020	2019	2020	2019	2020	2019	2020
CF	13200	13300	10.48	10.57	-	-	0.793	0.794
6D	12150	12200	10.37	10.46	7.95	8.27	0.853	0.857
12D	11150	11220	8.73	8.57	15.53	15.63	0.782	0.763

CONCLUSION

The role of agronomical strategies (*i.e.,* plant spacing, varieties and irrigation) on yield characteristics of rice was investigated. It could be concluded that irrigation every six day with closer spacing 15x20 gave the highest grain yield and water use efficiency and high production of rice crop in both season of study.

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دور فترات الري ومسافات الزراعة على النمو والمحصول ومكوناته لبعض أصناف الأرز

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الملخص

تعتبر مياه الري من السمات المهمة للإنتاج المستدام للأرز، ويتطلب الأمر نظامًا أكثر فعالية لإدارة المياه في الزراعة. لذا، فإن إدارة استخدام المياه في أنظمة إنتاج الأرز أمر ضروري لتعزيز الإنتاجية. أجريت الدراسة الحالية في المزرعة التجريبية لمركز بحوث وتدريب الأرز (RRTC)، سخا، كفر الشيخ، مصر، في صيف 2019 و2020، لدراسة تأثير مسافات الزراعة (15 x20 – 20 x20 – 25 x20) على النمو وإنتاجية الحبوب وكفاءة استخدام المياه لصنفين من الأرز العادى (جيزة 179 وسخا 106) تحت فترات رى مختلفة (الغمر المستمر (CF)، والري كل ستة أيام والرى كل 12 يوم). نفذت التجربة بتصميم الشرائح المتعامدة بأربعة مكررات. أوضحت النتائج التي تم الحصول عليها أنه مع زيادة فترات الري إلى اثني عشر يوما، حدث انخفاض كبير في صفات النمو وإنتاج الحبوب وخصائصها، دون أي اختلافات معنوية بين الري بالغمر CF والري كل ستة أيام D6 في إنتاج الحبوب في كلا موسمي الزراعة. وقد تفوق الصنف جيزة 179 عن الصنف سخا 106 فى صفات النمو (انتاج المادة الجافة والمساحة الورقية) والمحصول ومكوناته (عدد الفروع للمتر المربع – العدد الكلى للحبوب بالسنبلة وطول السنبلة ووزن السنبلة ومحصول الحبوب والقش بالطن للهكتار فيما عدا وزن 1000 حبة والذي تفوق فيه الصنف سخا 106. وتفوقت المسافات الضيقة 20x15 سم فى محصول الحبوب مقارنة بالمسافات الواسعة 25 x20 فى كلا الموسمين .

الكلمات المفتاحية: أصناف الأرز- مسافات الزراعة - فترات الري - كفاءة استخدام المياه