The Mutual Effect of Irrigation Intervals and Weed Control for Enhancing Yield and Productivity of Irrigation Water for Two Rice Cultivars

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Abstract: Two field experiments were conducted through 2018 and 2019 summer growing seasons at Sakha Agricultural Research Station, Kafrelsheikh, Egypt to study effect of irrigation intervals and weed control for maximizing yield and productivity of irrigation water on Sakha 107 and Giza 179 rice cultivars. A strip split-plot experimental design, with three replications was used in both seasons. Three irrigation intervals *i.e;* irrigation every three days, every six days and every nine days were assigned in horizontal plots. Two rice cultivars viz; Sakha 107 and Giza 179 were randomly distributed in vertical plots. Six weed control treatments i.e., Saturn 50% EC (thiobencarb), Ronstar 25% EC (oxadiazon), Saturn followed by (*fb*) Granite 24% SC (penoxsulam), Ronstar *fb* Granite, hand weeding and weedy check were allocated in the sub-plots. The results of both seasons showed that, irrigation every 3-days recorded the lowest dry weights of *E crus-galli* and total weeds while, irrigation every 9-days recorded the lowest dry weights of *A. baccifera* and *C. difformis*. The highest rice dry weight, number of panicle m^{-2}, number of filled grain $panicle^{-1}$, panicle weight and rice grain yield were recorded by irrigation every 3-days as compared to 6 and 9 days. Rice cultivar Giza 179 exceeded Sakha 107, it recorded the lowest dry weights of *A. baccifera, E crus-galli* and total weeds in addition, increased number of panicle m^{-2}, number of filled grain $panicle^{-1}$ and rice grain yield while, the highest panicle weight was recorded by Sakha 107. Application of Ronstar *fb* Granite at recommended doses achieved the best weed management, the highest weed control efficiency (%), rice grain yield and its attributes as well as productivity of irrigation water (PIW) compared to other treatments. The amount of irrigation water applied was decreased by 15% and 31% for six and nine days compared to three days, while productivity of irrigation water was taken the descending order six > three > nine days. To achieve the best weed control efficiency (%), yield and its attributes as well as save irrigation water and promote PIW, it could be apply irrigation every 6-days with Giza 179 cv treated by Ronstar *fb* Granite at recommended doses. But in case of water shortage, it could be apply irrigation every 9-days with Sakha 107 cv treated by Ronstar *fb* Granite at recommended doses.

Keywords: Rice yield, Irrigation, Weeds, Weed control and Productivity of irrigation water

INTRODUCTION

Rice (*Oryza sativa* L.) is one of the most essential cereal crops not only in Egypt but also overall the world, it is considered the main food for about the half of world population, contributing about 20% of cereal consumption. Moreover, it is the principle food of the majority of Egyptians. According to FAOSTAT the harvested rice area in Egypt was 685.908 hectares (1.632.461 feddan) in 2017 with total production of 6.380.000 million tons with an average productivity 9.30 t ha^{-1} (3.908 t fed^{-1}). In Egypt, water resources are limited, however there is a rapidly population increasing. So, maximizing rice productivity is a main strategy to cope with the continuous increasing of rice consumers needs. To increase rice yield in the future, management strategies that facilitate continued production of rice using less water must be developed (Gealy *et al.,* 2014) Scheduling irrigation through applying irrigation intervals is one of the most effective and applicable on-farm practices to rationalize irrigation water and enhancing rice productivity. Alternate wetting and drying in rice fields is one of on-farm practices that saved about 15% - 50% of applied water (Naresh *et al.,* 2014) and enhanced productivity of irrigation water by 5-35% compared to traditional continuous flooding (Romeo *et al.,* 2004). There was no significant difference between continuous flooding and alternate wetting and drying on rice grain yield (Liang *et al.,* 2016). Number of productive tillers and rice grain yield were significantly recorded higher under alternate wetting and drying compared to continuous flooding (Norton *et al.,* 2017). On the other hand, there was significant reduction of rice grain yield when apply severe alternate wetting and drying compared to continuous flooded (Kumar *et al.,* 2017). But the saved amount of irrigation water and water productivity increased when using alternate wetting and drying (kar *et al.,* 2017). Maintaining the soil moisture content at saturation and then reflooding was the optimal water management practice for growing rice in the swelling clay soil, achieved significant increase in the dry mass production (Alhaj *et al.,* 2019). There was no significant differences of rice grain yield between irrigation intervals every 4 and 6 days (Mahmoud, 2015). Rice varieties are another important factor to define the suitable irrigation intervals, because they show significant variations in physiological response to water stress (Abbasi and Sepaskhah, 2011). The growth of rice cultivars is likely to show different response under water stress conditions and the amounts of irrigation water applied. Some rice cultivars can maintain its water uptake under lower soil water content, so these cultivars may be become important under water shortage to produce large amounts of grain yield (Kato *et al.,* 2006). Weeds are one of the most important limiting factors in rice

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production, as they contribute to great yield losses, if no weed control measures were applied. Weeds cause great reduction in crop yield because of its growth faster and absorption the available water and nutrients earlier than rice plant and this affect the growth and yield of rice (Islam *et al.,* 2015). Furthermore, any delay in weed control will lead to increase weed biomass which has a negative correlation with yield (Manhanas *et al.,* 2012). Weeds are the considerable problem under aerobic rice system whereas, the aerobic soil dry-tillage and alternate wetting and drying conditions are conducive to the germination and growth of weeds causing grain yield losses about 30 to 98% (Ramana *et al.*, 2014). Under aerobic soil conditions, weed diversity is much higher compared to that under saturated or flooded conditions (Anwar *et al.,* 2010). So, successful of aerobic rice culture will largely depend on effective weed control. In rice cultivation systems, weed species has different response to changing water regimes, Bajavathinnan *et al.* (2011) found that broad-leaves and sedges grow rapidly when soil was submerged with water, whereas grassy weeds were favored unsaturated conditions. However, wide irrigation intervals were given a great chance of weed seeds germination and growth to compete with the crop on water, nutrients, place and light resulting in undesirable growth conditions for rice, so a great economic loss of rice yield were happened (Abd El-Naby *et al.*, 2017). In this concern, Abd El-Naby and Mahmoud (2018) found irrigation interval every 3 days was the best treatment in weed management, rice dry weight, number of panicles/m^2, number of filled grain/panicle and grain yield. While irrigation every 6 days and 9 days saved about 20.7% and 29.9% of irrigation water compared to irrigation every 3 days. Weed management through hand weeding is effective to weed control but it is very difficult, time consuming, uneconomical and expensive to control of weeds. Therefore, herbicides can be used to replace manual weeding (Munda *et al.,* 2017). Chemical weed control method is becoming popular among the farmers because it is the most efficient means, easy to apply, economically available method for controlling different weed species at the same time, it reduce weeds competition, allowing better growth and high grain production of rice (Bajavathinnan *et al.,* 2011). The integration between irrigation intervals and weed management is very important issue for rice production and taken more and more attention nowadays. So, the present work aimed to enhance productivity of irrigation water and rice yield using irrigation intervals and weed control treatments for two rice cultivars.

MATERIALS AND METHODS

Site Experiment:

Two field experiments were conducted through 2018 and 2019 summer growing seasons at Sakha Agricultural Research Station, Kafrelsheikh, Egypt to study the effect of irrigation intervals and weed management on rice and weeds under transplanted rice method.

The weather data were taken from Sakha agro-meteorological station during 2018 and 2019 seasons as shown in Table (1).

Table (1): Sakha agro-meteorological data, (31° 07' N Latitude, 30° 05' E Longitude), during 2018 and 2019 seasons

Season	Months	Air temperature			Relative humidity			Wind speed	Pan evaporation
		Max. °C	Min. °C	Mean °C	Max. %	Min. %	Mean %	Mean (km d^{-1})	Mean (mm d^{-1})
2018	May	31.2	23.8	27.5	75.6	43.9	35.8	95.8	6.33
	June	32.6	25.3	29.0	75.5	48.0	61.8	98.6	7.71
	July	34.2	25.4	29.8	82.6	51.0	66.8	89.5	7.37
	Aug.	33.9	25.2	29.6	82.4	51.8	67.1	76.0	6.42
	Sept.	32.8	23.5	28.2	83.1	48.3	65.7	68.7	4.98
2019	May	31.9	25.4	28.7	76.4	37.9	57.2	68.4	6.83
	June	33.0	28.0	30.5	81.5	50.0	65.8	103.0	8.46
	July	33.5	28.4	31.0	85.2	54.4	69.8	83.8	8.08
	Aug.	34.2	28.9	31.6	89.7	55.6	72.7	68.7	6.82
	Sept.	32.4	27.9	30.2	83.4	52.9	68.2	76.9	5.90

Some soil properties of the experiments site were determined before cultivation. Soil chemical properties were determined according to Page *et al.* (1982). Soil physical properties *i.e.* particle-size distribution, bulk density, total porosity, field capacity and permanent wilting point were determined according to Klute (1986). The mean values of the two growing seasons as shown in Table (2).

Table (2): Some soil physical and chemical properties of the experimental site as mean values of the two growth seasons

Soil depth (cm)	Field capacity (%)	Wilting point (%)	Bulk density (Mg m^{-3})	Total porosity (%)	Sand (%)	Silt (%)	Clay (%)	Texture class	EC_e (dS m^{-1})	pH
0-15	47.12	26.28	1.19	55.09	20.79	25.01	54.20	Clayey	1.93	7.90
15-30	42.31	21.63	1.27	52.07	22.06	26.92	51.02	Clayey	2.51	8.03
30-45	39.89	20.97	1.40	47.17	21.85	27.44	50.71	Clayey	2.96	8.26
45-60	39.54	21.46	1.46	44.90	21.72	27.03	51.25	Clayey	3.70	8.53
Mean	42.22	22.59	1.33	49.81	21.60	26.60	51.80	Clay	2.78	

Experimental design and treatments:

A strip split-plot design, with three replications was used in both seasons. The horizontal plots were devoted to three irrigation intervals. Vertical plots were assigned to two rice cultivars (cv), while weed control treatments were distributed in sub-plots in both seasons. The two rice cultivars were transplanting on 3rd and 5th of May in 2018 and 2019 seasons respectively. Pre-germinated seeds were broadcasted in the presence of water after puddling the nursery. 25-days old plants were transplanted at 2-3 seedlings per hill. Agricultural practices were applied as recommended in transplanted rice. The studies treatments as following:

A-Irrigation intervals:

1- Three days (3-days).
2- Six days (6-days).
3- Nine days (9-days).

B-Rice cultivars (cv):

1- Sakha 107.
2- Giza 179.

C-Weed control treatments:

1- Saturn 50% EC (thiobencarb) at 4.76 L ha^{-1}.
2- Ronstar 25% EC (oxadiazon) at 1.79 L ha^{-1}.
3- Saturn 50% EC followed by (*fb*) Granite 24% SC (penoxsulam) at 83.3 ml ha^{-1}.
4- Ronstar 25% EC *fb* Granite 24% SC.
5- Hand weeding twice.
6- Unweeded (Weedy check).

Saturn 50% EC (thiobencarb) and Ronstar 25% EC (oxadiazon) as pre-emergence herbicides were applied mixed with sand on flooded land at 4 days after transplanting (DAT) then, kept field flooded for 4 days after herbicidal application. Granite 24% SC (penoxsulam) as post-emergence herbicide was applied at 20 DAT after Saturn and Ronstar herbicide treatment. Granite herbicide was sprayed using Gloria sprayer as 5 liters capacity with rate of water as 300 liter ha^{-1} on drained plots then, irrigation was introduced after 24 hours from herbicidal application. Hand weeding was done at 20 and 40 DAT.

The plots were isolated by ditches of 1.5 m in width to avoid any lateral movement of water. Irrigation treatments were applied after 35 days from transplanting. During irrigation time, plots were submerged to depth of 7 cm. The applied irrigation water to each experimental plot was measured using one spile (PVC tubes) of 5 cm inner diameter and 80 cm length, which used to let water from field ditches into each plot. The effective head of water above the cross section center of irrigation spile was measured several times during irrigation and the average value was 10 cm. The water in the canal of the field was controlled to maintain a constant head by means of fixed sliding type gates. Stage gauges were placed in each plot to measure water depth flowing through the spile. The amount of water in each application was added until it reaches the required submerged depth (7 cm), and the time of the water applied was monitored using a stop watch.

The amount of water delivered through the spile tube was calculated according to Majumdar (2002) by the equation;

$$q = CA\sqrt{2gh} \qquad (1)$$

Where:

q = discharge of irrigation water (cm^3/s).
C = a discharge coefficient equal 0.62 (determined by experiment).
A = the inner cross section area of the irrigation spile (cm^2).
g = a gravity acceleration (cm/s^2).
h = the average effective head (cm).

The volume of water delivered for each plot (6 ×7 = 42 m^2) was calculated by substituting Q in the following equation**:**

$$Q = q \times T \times n \qquad (2)$$

Where:

Q = the volume of water m^3/ plot.
q = the discharge (m^3/min).
T = total irrigation time (min).
n = the number of spiles tube per each plot

Sampling data recorded and calculations:

A-Weed data:

At 50 DAT, weeds were sampled by 50 x 50 cm quadrate replicated four times for each plot. Weeds were cleaned, classified into species, weed plants were obtained and weighed as fresh weight then, air dried for two days then, the air dried samples were oven dried at 70^0C up for 48 hours to weight constant, dry weight as g m^{-2} was determined. Weed control efficiency (WCE %) was calculated with the following formula (Drost and Moody, 1982):

$$\textbf{WCE (\%)} = \frac{\text{DMC - DMT}}{\text{DMC}} \times 100$$

Where:

DMC = Weed dry matter in un-weeded treatment.

DMT = Weed dry matter in weed control treatment.

B-Rice data:

Rice dry weight also, was evaluated at the same time of sampling by the same method of weed dry weight. Before harvest, panicles were counted in two random quadrate of 0.50 m (50 x 50 cm) and number of panicles per square meter was calculated as a mean. After rice maturity, panicle weight (g) was estimated by weighing ten random panicles per plot and their average was recorded. Ten random panicles were collected from plot to estimate number of filled grain per panicle. Rice grain yield as ton ha^{-1} was recorded by manually harvesting of the central 5 m^2 from each plot then, air dried, threshed and cleaned then adjusted at 14% moisture content.

C-Productivity of irrigation water (PIW)

The Productivity of irrigation water in kg grains m^{-3} was calculated according to (Ali *et al.,* 2007), as follow:

$$\textbf{PIW (kg m}^{-3}\textbf{)} = \frac{\text{Grain yield in kg ha}^{-1}}{\text{Amount of applied water in m}^3\text{ ha}^{-1}}$$

D-Statistical analysis:

Data of the experiment were subjected to proper statistical analysis of variance, according to Snedecor and Cochran (1971). Weed data were statistically analyzed by MSTATC program after transformed according to square-root transformation ($\sqrt{[x+0.5]}$). Rice collected data were directly analyzed by MSTATC program then the means both of weeds and rice studied traits were compared by using Duncan´s Multiple Range Test (Duncan, 1955).

Table (3): Some characteristics of studied herbicide, trade name, active ingredient, chemical group, mode of action, rate per hectare, time of application and target weeds

Character \ Herbicide	Saturn 50% EC	Ronstar 25% EC	Granite 24% SC
Active ingredient	Thiobencarb	Oxadiazon	Penoxsulam
Chemical group	Thiocarbamate	Oxadiazolnoe	Sulfonamide or Triazolopyrimidine
Mode of action	Systemic-photosynthesis inhibitors	Systemic-photosynthesis inhibitors	Systemic-ALS inhibitors
Rate (ha^{-1})	4.76 L	1.79 L	83.3 ml
Time of application (DAT)	4	4	20
Target weeds	Grasses + sedges	Grasses + sedges	Grasses + broadleaves + sedges

ALS = acetolactate synthase L = Liters.

RESULTS AND DISCUSSION

The major weed species associated in this study during the two growing seasons were: a- Broadleaves including; *Ammannia baccifera* (Red stem), b- Sedges including; *Cyperus difformis* (small flower) and c- Grassy weeds including; *Echinochloa crus-galli* (barnyardgrass).

1. Effect of irrigation intervals (days) on:

1.1. Weeds:

Dry weights of *A. baccifera*, *C. difformis*, *E. crus-galli* and their total weeds were significantly affected by irrigation intervals during two seasons (Table 4). The plots which irrigated every 9-days recorded the lowest dry matter of *A. baccifera* and *C. difformis* compared to irrigated every 3-days which gave the highest values of abovementioned weeds species in 2018 and 2019 seasons. These results are agreeing with those obtained by Bajavathinnan *et al.* (2011) they found that continuous high moisture content of soil allow increased germination of broadleaves seeds and sedges compared to wide irrigation interval. For *E. crus-galli* and total weeds, the lowest dry matter were observed under irrigation every 3-days, while the highest dry weights of both weeds were obtained by irrigation every 9-days in both seasons. It might be due to lack of oxygen under unaerobic condition, whereas grassy weeds good growth under aerobic conditions. These results are confirmed with those cited by Abou El-Darag *et al.* (2017).

1.2. Rice:

Rice dry weight at 50 DAT, number of panicles m^{-2}, panicle weight, number of filled grains panicle^{-1} and grain yield were significantly affected by irrigation intervals during the two seasons (Table 5). The highest values of abovementioned traits were obtained by irrigation every 3-days compared to 9-days which achieved the lowest values of all rice studied characters in 2018 and 2019 seasons. That might be due to plants exposure to water stress during its growth and development processes in early growth stages, which cause imbalance of the vital processes inside the plant, water shortage zone, a reduction of nutrients uptake from soil and decreased plant growth, consequently a decrease in photosynthesis products, resulted that cause a decrease in grain yield and most of its components. Similar results were reported by Bozorgi *et al.* (2011).

Table (4): Dry weights (g m^{-2}) of weed species and their total weeds as influenced by irrigation intervals in 2018 and 2019 seasons

Irrigation intervals (days)	*A. baccifera*	*C. difformis*	*E. crus-galli*	Total weeds
		2018 season		
3	16.3 (3.5 a)	30.0 (4.7 a)	80.1 (7.7 c)	120.7 (9.5 c)
6	11.1 (3.1 b)	20.6 (3.9 b)	117.1 (9.5 b)	148.8 (10.7 b)
9	8.2 (2.8 c)	14.5 (3.5 c)	221.8 (14.6 a)	250.1 (15.5 a)
F test	**	**	**	**
		2019 season		
3	9.4 (2.6 a)	18.0 (3.6 a)	60.6 (6.5 c)	88.1 (7.7 c)
6	6.4 (2.4 b)	13.8 (3.3 b)	85.1 (8.1 b)	105.4 (9.0 b)
9	4.5 (2.1 c)	9.4 (2.9 c)	160.4 (12.2 a)	174.3 (12.7 a)
F test	**	**	**	**

** indicates P< 0.01 and. Means of transformed data *fb* the same letter are not significantly differed at 5% level, using Duncan's Multiple Range Test (DMRT). Weed data were subjected to square-root (√[x+0.5]) transformation before analysis; Values within parentheses are transformed.

Table (5): Rice dry weight (g m^{-2}), number of panicles m^{-2}, panicle weight (g), number of filled grains $panicle^{-1}$ and grain yield (t ha^{-1}) as influenced by irrigation intervals in 2018 and 2019 seasons

Irrigation intervals (days)	Rice dry weight (g m^{-2})	Number of panicles m^{-2}	Panicle weight (g)	Number of filled grains $panicle^{-1}$	Grain yield (t ha^{-1})
			2018 season		
3	940.9 a	456.9 a	2.3 a	99.1 a	8.61 a
6	834.3 b	428.5 b	2.1 b	95.4 b	8.17 b
9	504.7 c	344.4 c	1.8 c	78.7 c	5.34 c
F test	**	**	**	**	**
			2019 season		
3	1014.1a	483.3 a	2.4 a	102.9 a	8.94 a
6	905.0 b	456.9 b	2.2 b	99.1 b	8.53 b
9	588.1 c	370.8 c	1.9 c	82.5 c	5.70 c
F test	**	**	**	**	**

** indicates P< 0.01. Means of each factor within each column, values *fb* the same letters are not significantly different at 5% level, using DMRT.

2. Effect of rice cultivars on:

2.1. Weeds:

In 2018 and 2019 seasons, both of two rice cultivars (Sakha 107 and Giza 179) were significantly influenced on dry matter of *A. baccifera*, *E. crus-galli* and total weeds except for *C. difformis* (Table 6). Rice cultivar Giza 179 produced the lowest dry weights of all studied weeds compared to Sakha 107 which recorded the heaviest dry matter of *A. baccifera*, *E. crus-galli* and total weeds. The same trend was obtained in 2018 and 2019 seasons.

The reduction in dry weight of these weed species in Giza 179 plots may be due to the high tillering and competiveness ability of this cultivar against weeds. These results are confirmed with those obtained by Ghalwash *et al*. (2018).

Table (6): Dry weights (g m^{-2}) of weed species and their total weeds as influenced by rice cultivars in 2018 and 2019 seasons

Rice cultivars	*A. baccifera*	*C. Difformis*	*E. crus-galli*	Total weeds
		2018 season		
Sakha 107	13.6 (3.3 a)	23.0 (4.1 a)	145.8 (11.0 a)	179.8 (12.3 a)
Giza 179	10.1 (2.9 b)	20.4 (4.0 a)	33.5 (10.2 b)	166.6 (11.5 b)
F test	**	NS	**	**
		2019 seasons		
Sakha 107	8.0 (2.5 a)	14.3 (3.3 a)	105.7 (9.2 a)	128.0 (10.2 a)
Giza 179	5.6 (2.2 b)	13.2 (3.2 a)	98.4 (8.6 b)	117.2 (9.5 b)
F test	**	NS	**	**

** and NS indicates P< 0.01 and not significant, respectively. Means of transformed data *fb* the same letter are not significantly differed at 5% level, using DMRT. Weed data were subjected to square-root (√[x+0.5]) transformation before analysis; Values within parentheses are transformed.

2.2. Rice:

Generally, all studied characteristics of rice were significantly affected by the two rice cultivars (Sakha 107 and Giza 179) during both seasons except for rice dry weight in 2018 and 2019 seasons as well as number of filled grains panicle^{-1} in 2019 season (Table 7). Rice cultivar Giza 179 produced the highest number of panicles m^{-2} and rice grain yield in the first and second seasons as well as number of filled grains panicle^{-1} in the first season compared to Sakha 107. The superiority of Giza 179 cv in these parameters might be due to characteristics of different genotypes. These finding are confirmed by El-Namaky (2007). On the other hand, rice cultivar Sakha 107 significantly exceeded Giza 179 in panicle weight during two seasons of study.

Table (7): Rice dry weight (g m^{-2}), number of panicles m^{-2}, panicle weight (g), number of filled grains panicle^{-1} and grain yield (t ha^{-1}) as influenced by irrigation intervals in 2018 and 2019 seasons

Rice cultivars	Rice dry weight (g m^{-2})	Number of panicles m^{-2}	Panicle weight (g)	Number of filled grains panicle^{-1}	Grain yield (t ha^{-1})
			2018 season		
Sakha 107	754.7 a	406.1 b	2.2 a	90.5 b	7.15 b
Giza 179	765.2 a	413.9 a	2.0 b	91.7 a	7.60 a
F test	NS	*	*	*	**
			2019 season		
Sakha 107	826.0 a	429.2 b	2.2 a	94.7 a	7.46 b
Giza 179	845.5 a	444.9 a	2.1 b	95.0 a	7.99 a
F test	NS	**	*	NS	**

*, ** and NS indicates P< 0.05, P< 0.01 and not significant, respectively. Means of each factor within each column, values *fb* the same letters are not significantly different at 5% level, using DMRT.

3. Effect of weed control treatments on:

3.1. Weeds:

Generally, all chemical weed control treatments as well as hand weeding significantly reduced dry weights of *A. baccifera*, *C. difformis*, *E. crus-galli* and total weeds compared to the weedy check plots in 2018 and 2019 seasons (Table 8). Better weed control was observed in plots treated by herbicide of Ronstar 25% at 4 DAT *fb* Granite 24% at 20 DAT (1.79 L *fb* 83.3 ml ha^{-1}) respectively that leads to reduced dry weight of all tested weeds compared to weedy check plots which gave the highest values of abovementioned weed species in both two seasons. These results may be due to the efficiency of herbicide which decrease weed population and its growth. These results are confirmed with those obtained by Hassan *et al.* (2010).

As shown in Table (8), all herbicides treatments and hand weeding were higher weed control efficiency (WCE) compared to unweeded plots in both seasons. The better WCE (%) was observed with the application of Ronstar 25% EC *fb* Granite 24% SC at recommended doses (88 and 93%) in the 2018 and 2019 respectively. On the other side, the lower WCE (%) was obtained in weedy check plots during two seasons of study. It may be due to high efficiency of herbicide treatment that lead to lower weeds dry matter accumulation as compared to other herbicide. These results are confirmed with those cited by Paramita *et al.* (2005).

Table (8): Dry weights (g m^{-2}) of weed species, their total weeds and weed control efficiency (%) as influenced by weed control treatments in 2018 and 2019 seasons

Weed control treatments	*A. baccifera*	*C. Difformis*	*E. crus-galli*	Total weeds	Weed control efficiency (%)
2018 season					
Saturn 50% EC	12.0 (3.5 b)	21.9 (4.6 b)	158.2 (12.4 b)	199.9 (14.0 b)	53
Ronstar 25% EC	9.2 (3.0 c)	17.7 (4.1 c)	135.1 (11.4 c)	165.6 (12.7 c)	61
Saturn *fb* Granite 24% SC	5.0 (2.3 e)	6.4 (2.6 e)	66.6 (7.3 e)	77.9 (8.2 e)	82
Ronstar *fb* Granite	1.4 (1.2 f)	1.4 (1.4 f)	48.6 (5.2 f)	51.6 (5.4 f)	88
Hand weeding	7.2 (2.7 d)	9.8 (3.2 d)	98.0 (9.3 d)	115.0 (10.3 d)	73
Weedy check	36.3 (5.9 a)	72.9 (8.5 a)	331.4 (18.1 a)	429.2 (20.7 a)	--
F test	**	**	**	**	
2019 season					
Saturn 50% EC	7.6 (2.8 b)	13.4 (3.6 b)	121.3 (10.8 b)	142.3 (11.8 b)	56
Ronstar 25% EC	4.7 (2.2 c)	10.6 (3.3 c)	110.2 (10.3 c)	125.4 (11.0 c)	61
Saturn *fb* Granite 24% SC	2.3 (1.6 e)	3.4 (1.9 e)	40.2 (5.6 e)	45.9 (6.1 e)	86
Ronstar *fb* Granite	0.6 (1.0 f)	1.3 (1.2 f)	22.4 (3.6 f)	24.3 (3.7 f)	93
Hand weeding	3.2 (1.9 d)	7.4 (2.8 d)	64.7 (7.5 d)	75.2 (8.3 d)	77
Weedy check	22.4 (4.6 a)	46.5 (6.8 a)	253.4 (15.8 a)	322.3 (17.9 a)	--
F test	**	**	**	**	

** indicates P< 0.01. Means of transformed data *fb* the same letter are not significantly differed at 5% level, using DMRT. Weed data were subjected to square-root ($\sqrt{[x+0.5]}$) transformation before analysis; Values within parentheses are transformed.

3.2. Rice:

All chemical weed control treatments and hand weeding significantly increased rice dry weight, number of panicles m^{-2}, panicle weight, number of filled grains $panicle^{-1}$ and grain yield of compared to the untreated plots during two seasons (Table 9). Application of Ronstar at 1.79 L ha^{-1} *fb* Granite at 83.3 ml ha^{-1} respectively recorded the highest values of all studies rice characteristics as compared to unweeded plots in both seasons.

This increase may be due to the high efficiency of chemical control in reducing weed competiveness ability, which lead to more absorption of nutrients and water by rice plant, enhanced metabolites synthesized processes and produced more grain yield of rice as reported by Shebl *et al*. (2009).

Table (9): Rice dry weight (g m^{-2}), number of panicles m^{-2}, panicle weight (g), number of filled grains $panicle^{-1}$ and grain yield (t ha^{-1}) as influenced by weed control treatments in 2018 and 2019 seasons

Weed control Treatments	Rice dry weight (g m^{-2})	Number of panicles m^{-2}	Panicle weight (g)	Number of filled grains $panicle^{-1}$	Grain yield (t ha^{-1})
2018 season					
Saturn 50% EC	612.3 e	398.6 e	2.0 d	85.4 e	7.17 e
Ronstar 25% EC	784.3 d	406.9 d	2.1 c	89.2 d	7.47 d
Saturn *fb* Granite 24% SC	975.4 b	463.9 b	2.2 b	100.3 b	8.81 b
Ronstar *fb* Granite	1059.1 a	494.4 a	2.3 a	105.1 a	9.51 a
Hand weeding	862.4 c	425.0 c	2.2 b	95.3 c	8.10 c
Weedy check	266.1 f	270.8 f	1.6 e	70.2 f	3.18 f
F test	**	**	**	**	**
2019 season					
Saturn 50% EC	733.4 e	413.9 d	2.1 d	88.4 e	7.58 e
Ronstar 25% EC	832.9 d	436.1 c	2.2 c	93.6 d	7.82 d
Saturn *fb* Granite 24% SC	1038.6 b	490.3 b	2.3 b	103.9 b	9.26 b
Ronstar *fb* Granite	1141.6 a	518.1 a	2.4 a	109.0 a	9.85 a
Hand weeding	924.1 c	450.0 c	2.2 c	98.9 c	8.33 c
Weedy check	343.8 f	313.9 f	1.7 e	75.0 f	3.50 f
F test	**	**	**	**	**

** indicates P< 0.01. Means of each factor within each column, values *fb* the same letters are not significantly different at 5% level, using DMRT.

4. Effect of the interactions on:

4.1. Weeds:

4.1.1. Effect of the interaction between irrigation intervals and weed control treatments

Generally, all chemical and manual control caused a significant reduction in dry weights of *C. difformis*, *E. crus-galli* and total weeds under all irrigation intervals compared to weedy check during the two seasons of study (Table 10). Plots which were irrigated every 3-days treated by Ronstar *fb* Granite at recommended doses achieved the best weed control and recorded the lowest dry weights of all studied weed species and total weeds as well as every 6-days under the same of herbicide treatment for *C. difformis* during both seasons. These results may be due to important role of water in raising herbicide absorption and efficiency which leads to more suppression for weed seeds germination and kill germinated weeds. These results are confirmed with those cited by Abou EL-Darag *et al.* (2017), Abd El-Naby and Mahmoud (2018). On the other hand, the heaviest dry weight of *C. difformis* was observed at the combined effect of irrigation interval every 3-day under weedy check plots. While, irrigation interval every 9-days under weedy check plots recorded the highest dry weights of *E. crus-galli* and total weeds in 2018 and 2019 seasons.

4.1.2. Effect of the interaction between rice cultivars and weed control treatments

All chemical and manual weed control caused a significant reduction in dry weights of *E. crus-galli* and total weeds under two rice cultivars during two seasons (Table 11). Application of per-emergence herbicide (Ronstar) *fb* post-emergence herbicide (Granite) at recommended doses with Giza 179 cv recorded the lowest dry weights of *E. crus-galli* and total weeds in 2018 and 2019 seasons as well as the same treatment of herbicide in Sakha 107 plots for *E. crus-galli* in 2018 season. On the other hand, Sakha 107 cv under weedy check plots recorded the highest dry weight of abovementioned traits in the first and second seasons as well as with Giza 179 cv in unweeded plots for *E. crus-galli* in the first season. It may be due to the high efficacy of herbicide application in controlling weeds and high competitive ability for rice cultivar 179 against weeds. These results are confirmed with those cited by Shebl *et al.* (2009).

Table (10): Effect of the interaction between irrigation intervals and weed control treatments on dry weights (g m^{-2}) of *C. difformis*, *E. crus-galli* and total weeds in 2018 and 2019 season**s**

Irrigation intervals (days)	Weed control treatments					
	Saturn	**Ronstar**	**Saturn *fb* Granite**	**Ronstar *fb* Granite**	**Hand weeding**	**Weedy check**
			C. difformis **2018 season**			
3	34.8 (5.9 d)	30.4 (5.5 d)	7.5 (2.8 h)	0.5 (0.9 k)	11.4 (3.4 fg)	95.6 (9.8 a)
6	19.6 (4.5 e)	13.8 (3.8 f)	4.7 (2.3 ij)	0.9 (1.2 k)	9.9 (3.2 gh)	75.0 (8.7 b)
9	11.5 (3.4 fg)	9.0 (3.0 gh)	7.0 (2.7 hi)	3.5 (2.0 j)	8.1 (2.9 gh)	48.0 (7.0 c)
			2019 season			
3	18.0 (4.3 d)	13.9 (3.8 ef)	1.1 (1.2 j)	0.1 (0.8 k)	9.7 (3.2 g)	65.3 (8.1 a)
6	15.8 (4.0 de)	12.6 (3.6 f)	3.5 (2.0 i)	0.1 (0.8 k)	6.7 (2.7 h)	44.3 (6.7 b)
9	6.4 (2.6 h)	5.3 (2.4 h)	5.5 (2.4 h)	3.6 (2.0 i)	5.6 (2.4 h)	29.9 (5.5 c)
			E. crus-galli **2018 season**			
3	95.8 (9.8 i)	74.8 (8.6 j)	16.2 (4.0 m)	1.7 (1.5 o)	43.4 (6.6 k)	248.5 (15.8 c)
6	162.9 (12.7 f)	131.3 (11.4 h)	31.6 (5.5 c)	5.0 (2.3 n)	51.2 (7.1 k)	320.5 (17.9 b)
9	216.0 (14.7 d)	199.1 (14.1 e)	151.9 (12.3 fg)	139.0 (11.8 gh)	199.3 (14.1 e)	425.3 (20.6 a)
			2019 season			
3	69.5 (8.2 i)	62.6 (7.8 i)	8.7 (3.0 m)	0.2 (0.8 o)	23.2 (4.9 k)	199.4 (14.1 c)
6	113.4 (10.6 g)	103.4 (10.1 h)	17.9 (4.2 l)	4.0 (1.9 n)	39.1 (6.3 j)	233.2 (15.2 d)
9	181.1 (13.5 b)	164.4 (12.8 e)	94.2 (9.7 h)	63.1 (7.9 i)	131.8 (11.4 f)	327.8 (18.1 a
			Total weeds			
			2018 season			
3	147.9 (12.1 h)	119.0 (10.9 i)	27.5 (5.2 l)	2.3 (1.6 n)	63.5 (8.0 j)	364.0 (19.1 c)
6	194.5 (13.9 f)	153.4 (12.3 gh)	42.4 (6.5 k)	6.4 (2.5 m)	68.7 (8.3 j)	427.6 (20.7 b)
9	257.4 (16.0 d)	224.3 (15.0 e)	163.8 (12.8 g)	146.3 (12.1 h)	212.7 (14.6 e)	496.0 (22.3 a)
			2019 season			
3	96.0 (7.9 g)	81.6 (8.9 h)	11.4 (3.4 m)	0.3 (0.9 o)	36.2 (6.0 k)	302.8 (17.4 b)
6	139.0 (11.8 e)	122.0 (11.0 f)	24.1 (4.9 l)	4.1 (2.o n)	48.8 (48.8 j)	294.0 (17.1 b)
9	192.0 (13.9 c)	172.6 (13.1 d)	102.1 (10.1 g)	68.4 (8.3)i	140.6 (11.8 e)	370.1 (19.2 a)

Means *fb* a common letter within a season are not significantly differed at 5% level, using DMRT. Values within parentheses are transformed

Table (11): Effect of the interaction between rice cultivars and weed control treatments on dry weights (g m^{-2}) of *E. crus-galli* and total weeds m^{-2} in 2018 and 2019 seasons

Weed control treatments	*E. crus-galli*		Total weeds	
	Rice cultivars			
	Sakha 107	Giza 179	Sakha 107	Giza 179
2018 season				
Saturn 50% EC	170.7 (13.0 b)	145.7 (11.8 c)	206.9 (14.4 c)	193.0 (13.7 d)
Ronstar 25% EC	148.8 (12.1 c)	121.4 (10.7 d)	178.9 (13.4 d)	152.2 (12.1 e)
Saturn *fb* Granite 24% SC	68.1 (7.7 g)	65.0 (6.9 h)	80.2 (8.5 h)	75.6 (7.8 i)
Ronstar *fb* Granite	48.3 (5.4 i)	48.9 (5.0 i)	51.6 (5.7 j)	51.7 (5.2 k)
Hand weeding	103.0 (9.7 e)	92.9 (8.8 f)	121.7 (10.8 f)	108.2 (9.8 g)
Weedy check	335.9 (18.3 a	326.9 (17.9 a)	439.7 (21.0 a)	418.7 (20.4 b)
2019 season				
Saturn 50% EC	132.1 (11.4 c)	110.6 (10.1 e)	155.1(12.4 c)	129.6 (11.1 e)
Ronstar 25% EC	118.2 (10.8 d)	102.3 (9.7 f)	135.3 (11.6 d)	115.5 (10.4 f)
Saturn *fb* Granite 24% SC	36.5 (5.7 h)	44.0 (5.5 h)	42.6 (6.2 h)	49.1 (6.0 h)
Ronstar *fb* Granite	23.2 (3.8 i)	21.6 (3.3 j)	25.1 (4.0 i)	23.5 (3.4 j)
Hand weeding	58.9 (7.4 g)	70.4 (7.6 g)	70.1 (8.2 g)	80.3 (8.4 c)
Weedy check	265.3 (16.3 a)	241.6 (15.4 b)	339.5 (18.4 a)	305.1(17.4)

Means *fb* a common letter within a season are not significantly differed at 5% level, using DMRT. Values within parentheses are transformed

4.1.3 Effect of the interaction among irrigation intervals, rice cultivars and weed control treatments

Total weeds dry weight was greatly influenced by the interaction among irrigation intervals, rice cultivars and weed control treatments during the two seasons (Table 12). Irrigation interval every 3-days with two rice cultivars treated by Ronstar *fb* Granite at recommended doses as well as irrigation every 6-days with Giza 179 under the same herbicide treatment achieved the best weed control and recorded the lowest total weeds dry weight. While, the highest dry weight of total weeds was observed in plots which irrigated every 9-days with Giza 179 cv under weedy check plots in 2018 and 2019 seasons. This may be due to the important role of water in increasing herbicide efficiency as well as inhibition and kill weeds and highly ability competitiveness for Giza 179 cv against weeds, lead to good growth for rice plants. These results are confirmed with those cited by Abd El- Naby and Mahmoud (2018).

Table (12): Effect of the interaction among irrigation intervals (days), rice cultivars and weed control treatments on total weeds dry weight (g m^{-2}) in 2018 and 2019 seasons

Irrigation intervals (days)	Rice cultivars	Weed control treatments					
		Saturn	Ronstar	Saturn *fb* Granite	Ronstar *fb* Granite	Hand weeding	Weedy check
2018 seasons							
3	**Sakha 107**	173.6 (13.2 ij)	142.2 (11.9 l)	33.3 (5.7 q)	3.0 (1.9 t)	76.8 (8.8 o)	402.5 (20.1 c)
	Giza 179	122.3 (11.1 m)	95.7 9.8 n)	21.7 (4.7 r)	1.5 (1.4 t)	50.3 (7.1 p)	325.5 (18.1 d)
6	**Sakha 107**	225.9 (15.1 fg)	188.3 (13.7 hi)	56.9 (7.6 p)	9.6 (3.2 s)	84.0 (9.2 no)	455.6 (21.4 b)
	Giza 179	163.1 (12.8 jk)	118.6 (10.9 m)	27.9 (5.3 qr)	3.1 (1.9 t)	53.3 (7.3 p)	399.5 (20.0 c)
9	**Sakha 107**	221.1 (14.9 fg)	206.3 (14.4 gh)	150.5 (12.3 kl)	142.1 (11.9 l)	204.4 (14.3 gh)	461.1 (21.5 b)
	Giza 179	293.7 (17.2 e)	242.2 (15.6 f)	177.1 (13.3 ij)	150.1 (12.3 kl)	220.9 (14.9 fg)	530.9 (23.1 a)
2019 seasons							
3	**Sakha 107**	124.6 (11.2 i)	106.8 (10.4 jk)	15.8 (4.0 q)	0.4 (0.9 s)	40.7 (6.4 no)	328.4 (18.3 b)
	Giza 179	67.4 (8.2 l)	56.4 (7.5 m)	7.0 (2.7 r)	0.2 (0.9 s)	31.7 (5.7 p)	277.1 (16.7 c)
6	**Sakha 107**	162.2 (12.8 gh)	148.6 (12.2 h)	33.0 (5.8 op)	7.5 (2.8 r)	55.0 (7.4 m)	341.5 (18.5 b)
	Giza 179	115.9 (10.8 ij)	95.4 (9.8 k)	15.1 (3.9 l)	0.8 (1.1 s)	42.6 (6.5 n)	246.6 (15.7 d)
9	**Sakha 107**	178.5 (13.4 fg)	150.5 (12.3 h)	79.0 (8.9 l)	67.4 (8.2 l)	114.7 (10.7 ij)	348.7 (18.7 b)
	Giza 179	205.8 (14.4 e)	194.8 (14.0 ef)	125.2 (11.2 i)	69.4 (8.3 l)	166.4 (12.9 gh)	391.4 (19.8 a)

Means *fb* a common letter within a season are not significantly differed at 5% level, using DMRT. Values within parentheses are transformed.

4.2. Rice:

4.2.1. Effect of the interaction between irrigation intervals and rice cultivars

Rice dry weight, number of panicles m^{-2}, panicle weight, number of filled grains panicle^{-1} and grain yield were significantly affected by the interaction between irrigation intervals and rice cultivars during two seasons (Table 13). Irrigation interval every 3-days with Giza 179 cv recorded the highest rice dry weight, number of panicles m^{-2}, number of filled grains panicle^{-1} and grain yield while, the highest panicle weight was detected from the combined effect of the same irrigation interval with Sakha 107 cv in 2018 and 2019 season. On the other hand, weedy check plots cultivated with Giza 179 and irrigated every 9-days gave the lowest values of all rice studied traits in the two growing seasons as mentioned by Abou El-Hassan *et al*. (2006).

Table (13): Effect of the interaction between irrigation intervals and rice cultivars on rice dry weight (g m^{-2}), number of panicles m^{-2}, panicle weight (g), number of filled grains panicle^{-1} and grain yield (t ha^{-1}) in 2018 and 2019 seasons

Irrigation intervals (days)	Rice dry weight (g m^{-2})		Number of panicles m^{-2}		Panicle weight (g)		Number of filled grains panicle^{-1}		Grain yield (t ha^{-1})	
	Rice cultivars									
	Sakha 107	**Giza 179**	**Sakha 107**	**Giza 179**	**Sakha 107**	**Giza 179**	**Sakha 107**	**Giza 179**	**Sakha 107**	**Giza 179**
	2018 season									
3	890.0 b	991.8 a	437.5 c	476.4 a	2.4 a	2.2 b	95.5 c	102.8 a	7.96 c	9.27 a
6	780.4 c	888.2 b	408.3 d	448.6 b	2.1 c	2.0 d	93.3 d	97.6 b	7.59 d	8.75b
9	593.8 d	415.5 e	372.2 e	316.7 f	1.9 e	1.8 f	82.7 e	74.8 f	5.90 e	4.78 f
	2019 season									
3	953.9 b	1074.3a	459.7 c	506.9 a	2.5 a	2.3 b	100.0 b	105.7 a	8.28 c	9.61 a
6	834.7 c	975.3 b	430.6 d	483.3 b	2.2 b	2.1 c	97.9 c	100.3 b	7.95 d	9.11 b
9	689.4 d	486.8 e	397.2 e	344.4 f	2.0 d	1.8 e	86.1 d	78.9 e	6.16 e	5.24 f

Means *fb* a common letter within a season are not significantly differed at 5% level, using DMRT

4.2.2. Effect of the interaction between irrigation intervals and weed control treatments

Rice number of panicles m^{-2} and grain yield were significantly influenced by the interaction between irrigation intervals and weed control treatments during two seasons (Table 14). The highest number of panicles m^{-2} and grain yield of rice were obtained when weeds were controlled by herbicide of Ronstar *fb* Granite at (1.79 L *fb* 83.3 ml ha^{-1}) respectively with irrigation interval every 3-days in the first and second seasons as well as rice grain yield under irrigation interval every 6-days at the same herbicide treatment in the first season only. While, the lowest values of these traits were observed in weedy check plots under irrigation every 9-days during two growing seasons. This may be due to the high efficiency of herbicide application under irrigation every 3 and 6 days to reduced weed competition, weakness its growth consequently allowed to good growth for rice plants that lead to increasing yield and its attributes. Similar results were reported by Sarkar *et al*. (2017).

4.2.3. Effect of the interaction among irrigation intervals, rice cultivars and weed control treatments

Rice number of panicles m^{-2} and grain yield were significantly affected by the interaction among irrigation intervals, rice cultivars and weed control treatment during two seasons (Table 15). The high number of panicle m^{-2} and rice grain yield achieved by irrigation every 3- days with Giza 179 cv treated by Ronstar 25% EC at 1.79 L ha^{-1} *fb* Granite 24% SC at 83.3 ml ha^{-1} without significant differences with irrigation every 6-days for Giza 179 cv under the same herbicide treatment in 2018 and 2019 seasons. The superiority Giza 179 cv in this characteristics under two irrigation intervals (3 and 6-days) when treated by herbicide may be due to the high efficiency of herbicide in controlling of dominant weeds that lead to reduced weeds competition, give a good chance for rice growth, increasing yield and its components. These results are in agreement by Abd El-Naby and Mahmoud (2018). On the other hand, the lowest number of panicles m^{-2} and rice grain yield were found at irrigation every 9- days with Giza 179 cv under weedy check plots during two growing seasons. It might be due to higher weed-crop competition with limited resources under these conditions as reported by Abou El-Darag *et al*. (2017). In case of water shortage (irrigation every 9-days), the highest number of panicle m^{-2} and rice grain yield were recorded by Sakha 107 treated with Ronstar *fb* Granite at recommended doses in 2018 and 2019 seasons.

Table (14): Effect of the interaction between irrigation intervals and weed control treatments on rice number of panicles m^{-2} and grain yield (t ha^{-1}) in 2018 and 2019 seasons

Weed control treatments	Number of panicles m^{-2}			Grain yield (t ha^{-1})		
	Irrigation intervals (days)					
	3	6	9	3	6	9
			2018 season			
Saturn 50% EC	437.4 e	416.7 f	341.7 i	8.41 g	7.93 h	5.17 l
Ronstar 25% EC	437.5 e	433.3 e	350.0 hi	8.66 f	8.38 g	5.37 l
Saturn *fb* Granite 24% SC	512.5 b	487.5 c	391.7 g	10.14 b	9.87 c	6.43 j
Ronstar *fb* Granite	545.8 a	520.8 b	416.7 f	10.65 a	10.45 a	7.42 i
Hand weeding	470.8 d	441.7 e	362.5 h	9.49 d	9.10 e	5.70 k
Weedy check	337.5 i	270.8 j	204.2 k	4.32 m	3.29 n	1.94 o
			2019 season			
Saturn 50% EC	454.2 h	433.3 j	354.2 o	8.80 fg	8.42 h	5.53 l
Ronstar 25% EC	479.2 f	450.0 h	379.2 m	8.98 f	8.70 g	5.78 k
Saturn *fb* Granite 24% SC	537.5 c	520.8 d	412.5 k	10.44 c	10.37 c	6.97 j
Ronstar *fb* Granite	566.7 a	545.8 b	441.7 i	11.02 a	10.77 b	7.75 i
Hand weeding	500.0 e	462.5 g	387.5 l	9.72 d	9.30 e	5.98 k
Weedy check	362.5 n	329.2 p	250.0 q	4.68 m	3.63 n	2.19 o

Means *fb* a common letter within a season are not significantly differed at 5% level, using DMRT

Table (15): Effect of the interaction among irrigation intervals (days), rice cultivars and weed control treatments on rice number of panicles m^{-2} and rice grain yield (t ha^{-1}) in 2018 and 2019 seasons

Irrigation intervals (days)	Rice cultivars	Weed control treatments					
		Saturn	Ronstar	Saturn *fb* Granite	Ronstar *fb* Granite	Hand weeding	Weedy check
				2018 season			
3	Sakha 107	425.0 f-i	433.3 e-h	483.3 d	516.7 c	458.3 e	308.3 n
	Giza 179	450.0 ef	441.7 efg	541.7 b	575.0 a	483.3 d	366.7 l
6	Sakha 107	400.0 ijk	416.7 ghi	458.3 e	483.3 d	425.0 f-i	266.7 op
	Giza 179	433.3 e-h	450.0 ef	516.7 c	558.3 ab	458.3 e	275.0 o
9	Sakha 107	375.0 l	375.0 l	408.3 hij	441.7 efg	383.3 kl	250.0 p
	Giza 179	308.3 n	325.0 mn	375.0 l	391.7 jkl	341.7 m	158.3 q
				2019 season			
3	Sakha 107	441.7 k	458.3 ij	500.0 de	525.0 c	491.7 ef	341.7 q
	Giza 179	466.7 hi	500.0 de	575.0 b	608.3 a	508.3 d	383.3 no
6	Sakha 107	416.7 l	425,0 l	475.0 gh	491.7 ef	441.7 k	333.3 qr
	Giza 179	450.0 jk	475.0 gh	566.7 b	600.0 a	483.3 fg	325.0 rs
9	Sakha 107	383.3 no	391.7 mn	425.0 l	466.7 hi	400.0 m	316.7 s
	Giza 179	325.0 rs	366.7 p	400.0 m	416.7 l	375.0 op	183.3 t
				Rice grain yield (t ha^{-1})			
				2018 season			
3	Sakha 107	7.70 lm	7.93 l	9.37 fgh	9.90 de	8.80 ij	4.03 s
	Giza 179	9.12 ght	9.38 fg	10.91 bc	11.40 a	10.19 d	4.60 r
6	Sakha 107	7.39 m	7.70 lm	9.03 hi	9.70 ef	8.57 jk	3.13 u
	Giza 179	8.47 k	9.07 ghi	10.70 c	11.20 ab	9.63 ef	3.45 t
9	Sakha 107	5.90 p	6.03 op	6.99 n	7.96 l	6.29 o	2.20 v
	Giza 179	4.43 r	4.70 r	5.87 p	6.88 n	5.10 q	1.68 w
				2019 season			
3	Sakha 107	8.10 lm	8.23 l	9.52 gh	10.23 de	9.10 ij	4.47 t
	Giza 179	9.51 gh	9.73 fg	11.37 bc	11.81 a	10.35 d	4.90 s
6	Sakha 107	7.87 m	8.03 lm	9.57 gh	10.00 ef	8.70 k	3.52 u
	Giza 179	8.97 jk	9.37 hi	11.17 c	11.54 ab	9.89 f	3.74 u
9	Sakha 107	6.05 p	6.35 o	7.41 n	8.14 lm	6.50 o	2.51 v
	Giza 179	5.00 rs	5.23 qr	6.53 o	7.37 n	5.47 q	1.87 w

Means *fb* a common letter within a season are not significantly differed at 5% level, using DMRT.

5. Irrigation Water Indicators:

5.1. Irrigation water applied (IWA)

The highest values of irrigation water applied were observed from irrigation interval every 3-days (16127 m^3 ha^{-1}), while the lowest values were recorded from irrigation every 9-days (11035 m^3 ha^{-1}) as mean of both growing seasons. Irrigation intervals every 6 and 9 days saved irrigation water by 15 % and 31% compared to 3-days as a mean of the two growing seasons, with increasing irrigation intervals the amount of irrigation water applied decreased. This results are consistent with those obtained by Abd El-Naby and Mahmoud (2018) they found irrigation every six and nine days saved about 21% and 30 % of irrigation water applied, respectively compared to irrigation every three days. Also, with those obtained by Naresh *et al.* (2014) and Sriphirom *et al.* (2019) they found irrigation water applied could be reduced when applying irrigation intervals, alternate wetting and drying (AWD) and intermittent irrigation compared to continuous flooding of rice. Maneepitak *et al.* (2019) reported that the irrigation water applied was decreased by 29% under AWD compared to conventional flooding, these results may be due to the reduction of flooded length time and therefore decreases the amount of evaporation Deelstra *et al.* (2018), seepage Adhya *et al.* (2014) and percolation Xu *et al.* (2017). A slight difference of applied irrigation water were observed between different weed control treatments, as well as between the two varieties during both growing seasons as shown in Table (16).

Table (16): The seasonal irrigation water applied (m^3 ha^{-1}) as related to irrigation intervals, rice cultivars and weed control treatments in 2018 and 2019 seasons

Irrigation intervals (days)	Rice cultivars	Weed control treatments					
		Saturn	Ronstar	Saturn *fb* Granite	Ronstar *fb* Granite	Hand weeding	Weedy check
		2018 season					
3	Sakha 107	16280	16303	16371	16309	16403	16363
	Giza 179	16450	16355	16355	16425	16492	16410
6	Sakha 107	13878	13899	13802	13884	13921	13914
	Giza 179	13935	13945	13850	13896	13879	14034
9	Sakha 107	11281	11253	11329	11328	11354	11273
	Giza 179	11337	11402	11379	11356	11291	11379
Mean		13896	13890	13866	13860	13860	13848
Mean		**3-days = 16376**		**6-days = 13903**		**9-days = 11330**	
		Sakha 107 = 13850			**Giza 179 = 13941**		
		2019 season					
3	Sakha 107	15897	15887	15912	15752	15797	15894
	Giza 179	15941	15915	15978	15824	15831	15892
6	Sakha 107	13351	13401	13392	13406	13372	13354
	Giza 179	13375	13436	13381	13428	13681	13656
9	Sakha 107	10664	10665	10688	10711	10705	10752
	Giza 179	10766	10769	10841	10784	10746	10785
Mean		13389	13365	13355	13345	13332	13317
Mean		**3-days = 15877**		**6-days = 13436**		**9-days = 10740**	
		Sakha 107 = 13333			**Giza 179 = 13445**		

5.2. Productivity of irrigation water (PIW):

As shown in Table (17), irrigation every 6-days recorded the highest values of PIW compared to the other irrigation intervals in the two growing seasons. Irrigation interval every 6-days increased PIW by 13%, compared to 3-days as a mean of the two growing seasons. This result agreed with those obtained by Deelstra *et al.* (2018) they found the productivity of irrigation water increased from 26% to 168% under AWD compared to continuous flooded. This may be due to the reduction of irrigation water applied and higher grain yield production under AWD compared to continuous flooded Deelstra *et al.* (2018) and Maneepitak *et al.* (2019). While, PIW decreased by 9% under irrigation interval every 9-days compared to 3-days, this may be due to grain yield reduction as a result of excessive water stress. Water stress at critical growth stages reduced rice growth, yield and its attributed Maneepitak *et al.* (2019). Productivity of irrigation water of weed control treatments had the descending order Ronstar *fb* Granite > Saturn *fb* Granite > hand weeding > Ronstar > Saturn > weedy check in the two growing seasons. Its increased by 125%, 138%, 175%, 200% and 150% for Saturn, Ronstar, Saturn *fb* Granite, Ronstar *fb* Granite and hand weeding compared to weedy check as a mean of the two growing seasons.

Table (17): Influence of irrigation intervals (days), rice cultivars and weed control treatments on productivity of irrigation water (kg m^{-3}) in 2018 and 2019 seasons

Irrigation intervals (days)	Rice cultivars	Weed control treatments						Mean
		Saturn	Ronstar	Saturn *fb* Granite	Ronstar *fb* Granite	Hand weeding	Weedy check	
2018 season								
3	Sakha 107	0.47 ij	0.49 i	0.57 f	0.61 e	0.54 gh	0.25 m	0.49 e
	Giza 179	0.55 fg	0.57 f	0.67 d	0.69 c	0.62 e	0.28 l	0.56 b
6	Sakha 107	0.53 gh	0.55 fg	0.65 d	0.70 c	0.62 e	0.23 m	0.55 c
	Giza 179	0.61 e	0.65 d	0.77 b	0.80 a	0.70 c	0.24 m	0.63 a
9	Sakha 107	0.52 h	0.54 gh	0.61 e	0.70 c	0.55 fg	0.20 n	0.52 d
	Giza 179	0.39 k	0.41 k	0.51 h	0.61 e	0.45 j	0.15 o	0.40 f
Mean		0.51 e	0.54 d	0.63 b	0.69 a	0.58 c	0.23 f	
Mean		**3-days = 0.53 b**		**6-days = 0.59 a**		**9-days = 0.46 c**		
		Sakha 107 = 0.52 b			**Giza 179 = 0.53 a**			
2019 season								
3	Sakha 107	0.51 mn	0.52 m	0.60 jk	0.65 i	0.58 jk	0.28 q	0.52 e
	Giza 179	0.60 jk	0.61 j	0.71 ef	0.75 cd	0.66 i	0.31 p	0.61 b
6	Sakha 107	0.59 jkl	0.60 jk	0.72 ef	0.75 cd	0.65 i	0.26 q	0.60 c
	Giza 179	0.67 hi	0.70 fg	0.83 b	0.86 a	0.73 de	0.27 q	0.68 a
9	Sakha 107	0.57 l	0.60 jk	0.70 fgh	0.76 c	0.61 j	0.23 r	0.58 d
	Giza 179	0.46 o	0.48 no	0.60 jk	0.68 gh	0.51 mn	0.17 s	0.48 f
Mean		0.57 e	0.59 d	0.69 b	0.74 a	0.62 c	0.25 f	
Mean		**3-days = 0.57 b**		**6-days = 0.64 a**		**9-days = 0.53 c**		
		Sakha 107 = 0.57 b			**Giza 179 = 0.59 a**			

The interaction between irrigation intervals, rice cultivars and weed control treatments showed significant differences in PIW between all interactions in the two growing seasons. The highest values of PIW resulted from irrigation interval every 6-days with Giza 179 treated by Ronstar *fb* Granite at recommended doses followed by the same irrigation interval and rice cultivar under Saturn *fb* Granite at recommended doses in the two growing seasons. It increased after these two interactions by 69% and 63% respectively compared to irrigation every 3-days with Sakha 107 treated by Saturn at recommended dose (traditional practices by farmers) also, it increased after the same two interactions by 214% and 202% respectively compared to irrigation every 3-days with Sakha 107 under weedy check as a mean of the two growing seasons. While, the lowest values of PIW resulted from irrigation every 9-days with Sakha 107 under weedy check as well as 9-days with Giza 179 under weedy check to be 0.22 and 0.16 kg m^{-1} as mean during two growing seasons. The increases in PIW values may be due to the enhancement of growth characters, photosynthetic activity and provide adequate nutrition for rice crop plants which play a major role in the efficient use and conservation of water resources. PIW determines the capability of the plants to convert the water applied to yield. The increases in PIW was mainly related to the role of weed control and irrigation intervals to promote and support rice growth which was the result of raising photosynthesis assimilation in building metabolites and consequently yield is enhanced (Abd El-Naby and Mahmoud (2018).

CONCLUSION

Due the limitations of water resources in Egypt and the high abundance of weed in rice fields, from this study it could be concluded that, the best weed control, rice growth, yield and its attributes as well as productivity of irrigation water (0.83 kg m^{-3}) were obtained from irrigation every 6-days with Giza 179 cv treated by Ronstar (1.79 L ha^{-1}) at 4 DAT *fb* Granite (83.3 ml ha^{-1}) at 20 DAT. In case of severe water shortage (irrigation every 9-days) with Sakha 107 cv treated by Ronstar *fb* Granite at recommended doses achieved the best weed control, rice growth, a reasonable yield and its attributes as well as productivity of irrigation water (0.73 kg m^{-3}), moreover saved 31% from irrigation water during two growing seasons compared to traditional farmer practices.

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التأثير المتبادل لفترات الري ومكافحة الحشائش لتحسين المحصول وإنتاجيه مياه الري لصنفين من الأرز

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أقيمت تجربتان حقليتان خلال الموسم الصيفي لعامي ٢٠١٨ و ٢٠١٩ في المزرعة البحثية بمحطة البحوث الزراعية بسخا - كفر الشيخ – مصر بهدف دراسة التأثير المتبادل لفترات الري ومكافحة الحشائش لتعظيم المحصول وإنتاجيه مياه الري على صنفي الأرز سخا ١٠٧ وجيزة ١٧٩. حيث استخدم تصميم الشرائح المنشقة في ثلاث مكررات خلال موسمي الدراسة، ثلاث فترات ري تضمنت الري كل ثلاثة أيام وكل ستة أيام وكل تسعه أيام وزعت عشوائيا في الشرائح الأفقية بينما وزع صنفي الأرز سخا ١٠٧ وجيزة ١٧٩ في الشرائح الرأسية. ستة معاملات لمكافحه الحشائش احتوت علي ساتيرن EC %50 (مبيد ثيوبينكارب)، رونستار EC %25 (اوكساديازون)، ساتيرن متبوعاً بمبيد الجرانيت SC %24 (بينوكسولام)، رونستار متبوع بمبيد الجرانيت والنقاوة اليدوية مقارنه بغير المعامل وزعت عشوائيا في القطع المنشقة الفرعية. وقد أوضحت النتائج خلال الموسيمين أن معاملة الري كل ثلاثة أيام سجلت اقل وزن جاف لحشيشه الدنيبة والحشائش الكلية، بينما سجلت معاملة الري كل تسعه أيام اقل وزن جاف لحشيشتي السويده والعجيره. ولقد سجلت معاملة الري كل ثلاثة أيام اعلي وزن جاف للأرز وعدد السنابل بالمتر المربع وعدد الحبوب الممتلئة بالسنبلة ووزن السنبلة ومحصول حبوب مقارنه بفترتي الري كل ستة وتسعه أيام. وتفوق صنف الأرز جيزة ١٧٩ علي سخا ١٠٧ حيث سجل أقل وزن جاف لحشيشة السويده، الدنيبه والحشائش الكلية بالإضافة إلي زيادة في عدد السنابل بالمتر المربع، عدد الحبوب الممتلئة بالسنبلة ومحصول حبوب، بينما الصنف سخا ١٠٧سجل أعلي وزن للسنبلة. ولقد حققت معاملة رونستار متبوع بمبيد الجرانيت بالمعدلات الموصي بها أفضل مكافحه للحشائش وأعلي نسبه مئوية في كفاءة مكافحة الحشائش ومحصول الحبوب ومكوناته وكذلك إنتاجية مياه الري مقارنه بباقي المعاملات. وقد انخفضت كمية مياه الري المضافة بمعدل ١٥% و ٣١% لمعاملتي الري كل ستة وتسعه أيام مقارنه بمعامله الري كل ثلاثة أيام، في حين أن إنتاجية مياه الري أخذت الترتيب التنازلي التالي معاملة الري الثانية يليها الأولي يليها الثالثة. لتحقيق أفضل نسبة مئوية في كفاءة مكافحه الحشائش, محصول الحبوب ومكوناته وكذلك توفير كمية مياه الري المضافة ورفع إنتاجية مياه الري يمكن تطبيق التفاعل الري كل ٦ أيام مع الصنف جيزة ١٧٩ مستخدماً مبيد الحشائش رونستار متبوع بمبيد الجرانيت بالمعدلات الموصي بها. ولكن في حالة نقص المياه، يمكن تطبيق التفاعل معامله الري كل ٩ أيام مع الصنف جيزة ١٧٩ مستخدماً مبيد الحشائش رونستار متبوع بمبيد الجرانيت بالمعدلات الموصي بها للحصول على قيم معقول من محصول حبوب الأرز وإنتاجية مياه الري حوالي ٨.٠ طن للهكتار و ٠.٧٣ كيلوجرام حبوب لكل متر مكعب علي الترتيب.