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Efficacy of weed control and irrigation intervals on productivity of rice and water under direct seeding on furrows

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ABSTRACT

A field study was conducted at Rice Department Experimental Farm, Sakha Agricultural Research Station, ARC, Egypt during 2020 and 2021 summer seasons, to investigate the best chemical weed control treatment of direct seeded-rice on furrows as innovative method under different irrigation intervals. A strip plot design with three replications was used. Irrigation intervals every 4 (I_1), 8 (I_2) and 12 days (I_3) were assigned in horizontal plots and six weed control treatments were allocated in the vertical plots which contained (W_1): Saturn 50% EC (thiobencarb) at 3.57 kg ai ha^{-1} at 4 days after seeding (DAS), (W_2): Stomp 50% EC (pendimethalin) at 2.023 kg ai ha^{-1} at 4 DAS. (W_3): Saturn followed by Repair 18% TB as a ready-made of quinclorac 16.5% + bensulfuron-methyl 1.5% at rate of 0.491 + 0.0446 kg ai ha^{-1} at 25 DAS. (W_4): Stomp followed by Repair 18% at 0.536 kg ai ha^{-1} (W_5): weed free and weedy check (W_6). The obtained results showed that I_1 treatment exceeded the other irrigation intervals and recorded the lowest dry weights of grassy weeds as well as total weeds, in spite of gave the highest dry weights of broad leaf weed, in addition to the highest rice dry weight, grain yield and its attributes in the two seasons. Irrigation every 8 and 12 days saved about 17.95 and 23.1% of applied irrigation water as compared to irrigation every 4-day. W_4 treatment achieved the best weed control as well as improved water productivity and rice vegetative growth which produced grain yield of 8.14 and 8.58 t ha^{-1} in 2020 and 2021 seasons, respectively, in addition to reduced yield losses to 4.1% as an average of the two seasons. While weeds caused 93.2% losses in rice grain yield in weedy check plots. The combination of irrigation every 4-days with pendimethalin at 4 DAS followed by ready-made of Repair18% at 25 DAS achieved the best chemical weed control treatment and increased rice vegetative growth and yield as well as minimize yield losses of Sakha super 300 as new released Egyptian rice cultivar. While under water scarcity, the interaction of irrigation intervals every I_2 and W_4 that recorded water productivity (0.79 kg m^{-3}), grain yield (8.89 tons ha^{-1}) and saved 17.95% of applied water as an average of the two seasons. The highest water productivity was recorded by I_2 x W_5 (0.81 kgm^{-3}) with no significant differences with I_2 x W_4 (0.79 kgm^{-3}).

Keywords: Rice, furrow, weeds, weed control, irrigation, and water productivity.

INTRODUCTION

Rice (*Oryza sativa* L.) is one of the main essential crops for food security, it provides food for around 50% of world population and over 21% of human caloric requirements (Zhao *et al*., 2020**;** Mohidem *et al*., 2022). Rice is cultivated in about 160 million hectares over in the entire world and consumes 35-45% of irrigation water in the world (Bouman, 2012). Whereas the global paddy rice production raised significantly from 1994 to 2019 (FAOSTAT, 2021). In Egypt, rice is the second vital cereal crop and represents an essential part of plays an important role in food security. Rice importance increased and will show significant rise in the coming years because of the projected impacts of climate change projected effects and drought. Rice grains is rich in a numerous useful and essential elements for human health such as vitamins, proteins, minerals and fibers as well as low content of fats, calories and salt. FAOSTAT, (2021), stated that rice cultivated area in Egypt was 474,494 ha with total production of 4,841,327 tons of paddy rice by an average yield of 10.2 t ha^{-1}. This cultivation area concentrated mainly in eight costal governorates in North Nile-Delta due to its importance as land reclamation crop and to reduce sea water intrusion.

Egyptian farmers prefer rice cultivation because of its high net income beside its role to reduce soil salinity. But the expansion of its cultivation hindering with the limitation of water resources (Mona Hussein, 2021). Tantawi and Ghanem, **(**1999) showed that rice short-duration cultivars as Giza 177 (120-days from seed to seed) saved about 20% of irrigation water when compared to long-duration varieties such as Giza 171 (155-days). In addition, rice cultivation strategies which adapted to long irrigation intervals to maximize water productivity under direct seeded rice.

Rice cultivation by traditional transplanting with continuous flooding along growing season need a huge amount of irrigation water may be double or more of other summer crops, but direct seeded rice planting method decreased water consumption and increase water productivity. Bed-planting as an innovative planting method for rice face many challenges such as high weed population and flora accompanied to aerobic and semi aerobic conditions. Direct dry seeding on furrows as a renew cultivation method basically aims to reduce applied irrigation water in rice fields and increase water productivity by adding water at the bottom of furrow, while rice plants cultivate in two rows at the highest 2/3 of the furrow. Generally, over the entire world 1.4 m^3 of irrigation water uses to produce one kg of rice grains with water productivity of 0.71 kgm^{-3}, while in direct seeded-rice water productivity could be increased to one or more (Soomro *et al*., 2015).

The conventional flooded irrigation for rice results in a huge amounts of water loss. Food security and scarcity of water availability for rice production led global and local scientists to adopt alternative water-saving methods, such as dry and wet thin depth, controlled and intermittent irrigation, that achieved better results in saving irrigation water and enhanced yield or no yield loss **(**Hoang *et al*., 2019; Zeng *et al*., 2019). As well as aerobic rice and furrow irrigation to meet the feeding challenge for billions of people mainly relying and living on rice (Fanish and Ragavan, 2018). Aerobic rice, where plants are seeded directly with no need for continuous puddling, this system without flooded is one of the promising approaches to save a marked quantity of irrigation water. This system is applicable to reduce by the reduction of percolation, evaporative and seepage losses, that can reduce the applied water by 44% compared to traditional transplanted systems, while it keeps acceptable level of the yield (Fukai and Mitchell, 2022).

Furrow irrigation was better than conventional flooded irrigation as regards rice yield, water conservation in addition to water productivity (Carroll *et al.*, 2020; Lunga *et al*., 2020). It could conserve about 20–50% of water used for irrigation (Zhang *et al*., 2011), since water is only applied to furrows, absence of a surface layer of floodwater reduces surface water area, evaporation, seepage and deep percolation, compared to conventional flooded irrigation (Rai *et al*., 2017). Whereas, rapid root development, deeper - higher volume of the root in addition to its distribution, larger capacity and absorption area for the nutrients were obtained of furrow irrigation compared to conventional flooded irrigation, which led to good and effective tillering and panicle for each square meter to get better production (Mitchell *et al*., 2013). Grain yield under furrow irrigation was increased by 11.3-17.6% compared to the conventional flooded irrigation (Zeng and Li, 2020),

Alternative wetting and drying (AWD), the field is irrigated and then left to dry alternatively during all growing season. This technique saved about 15-30% of water use without any yield reduction (Runkle *et al*., 2019). But this technique impact on grain yield depends on its level, mild AWD decreased use of water by about 23.4% with no decrease in yield, where severe AWD significantly reduce rice grain yield in comparison with continued flooding (Kumar *et al*., 2017). Severe AWD resulted in saved water use by 44%, but yield reduced by 12.6% comparing to continuous flooding (Nalley *et al*., 2015). In addition AWD enhanced water productivity up to 5-35% comparing to continued flooding (Romeo *et al*., 2004). Irrigation intervals have a main impact on grain productivity, where the maximum grain yield was obtained under irrigation intervals 5-6 days compared to the rest intervals 8-9, 11-12, 13-14 and 16-17 days, respectively(Murali, 2009). Grain yield of 8 days irrigation intervals did not greatly differ than continued flooding , while water productivity decreased by 18% under 8 days interval, while grain yield decreased under 11 day intervals compared to continued flooding (Ashouri, 2014).

Weeds dramatically plays the main limiting factor for rice production under direct seeded rice method (DSR) because of large weed flora and huge density of both grassy weeds and broadleaves which appear in the field in successive generations as a result of aerobic conditions/alternate wetting and drying (Bajavathiannan *et al*., 2011). Weeds caused 93% reduction in direct seeded-rice yield (Abd El-Naby and El-Ghandor, 2022), while the reduction was from 17 to 47% in transplanted rice method (Ranjit, 1997). Aerobic rice and furrow irrigation practices are at the forefront of water conservation and enhancing water productivity in rice fields, but little research has been done to evaluate they risks on weed managements and yield loss. The chief object of the present study is to investigate the best chemical weed control treatment under irrigation intervals for direct-seeded rice Sakha Super 300 on furrows.

MATERIALS AND METHODS

A field trail was performed in summer season of 2020 and 2021 at the Farm of Rice Research Department, Sakha, Kafrelsheikh, Egypt to manage weeds in new innovated planting method of rice (dry seeding on furrows) under three irrigation intervals for new Egyptian released rice cultivar Sakha Super 300. Data of weather was obtained from the nearby agro-meteorological Station of Sakha as illustrated in Table (1).

Table 1: The agro-meteorological parameters of Sakha (31° 07' N Latitude, 30° 57' E Longitude).

Seasons	Parameters		May	June	July	August	September	October
2020	Air temperature	Max. (°C)	31.90	31.10	33.70	34.60	34.60	31.50
		Min. (°C)	23.80	25.20	27.30	28.20	27.10	24.60
		Mean (°C)	27.85	28.15	30.50	31.40	30.85	28.05
	Relative humidity	Max. (%)	68.90	78.00	84.20	85.30	86.70	84.80
		Min. (%)	38.40	42.60	51.10	49.60	47.70	47.10
		Mean (%)	53.65	60.30	67.65	67.45	67.20	65.95
	Wind speed	Mean (km d^{-1})	114.40	111.80	101.70	92.40	93.30	72.70
	Pan evaporation	Mean (mm d^{-1})	7.70	8.44	8.79	8.03	6.24	4.12
	Rain	(mm)	0.00	0.00	0.00	0.00	0.00	0.00
2021	Air temperature	Max. (°C)	32.54	32.04	34.69	35.66	32.51	28.50
		Min. (°C)	24.72	25.52	27.00	27.99	25.10	22.3
		Mean (°C)	28.63	28.78	30.85	31.83	28.81	25.4
	Relative humidity	Max. (%)	74.18	80.27	84.77	85.32	83.97	76.50
		Min. (%)	42.64	50.23	50.62	46.72	49.5	61.20
		Mean (%)	58.41	65.25	67.70	66.02	66.74	68.85
	Wind speed	Mean (km d^{-1})	81.1	106.7	99.2	83.18	96.70	80.49
	Pan evaporation	Mean (mm d^{-1})	8.63	8.92	8.60	7.53	7.58	5.03
	Rain	(mm)	0.00	0.00	0.00	0.00	0.00	0.00

Samples from the soil were obtained from the experiment location before cultivation, Physical properties i.e., bulk density, total porosity, particle-size distribution, permanent wilting point in addition to field capacity were determined as cited by Klute (1986) as demonstrated in Table (2). Soil pH in addition to electrical conductivity were determined on the word of Page *et al*. (1982).

Table 2: Mean values of soil properties at the experiment location in 2020 and 2021 seasons.

Soil depth (cm)	EC_e (dS m^{-1})	pH	Particle-size distribution			Texture class	Field capacity (%)	Wilting point (%)	Bulk density (g cm^{-3})	Total porosity (%)
			Sand (%)	Silt (%)	Clay (%)					
0-15	1.93	7.58	19.78	24.33	55.89	Clayey	45.65	24.82	1.18	55.47
15-30	2.07	7.85	20.37	25.61	54.02	Clayey	41.34	19.70	1.31	50.57
30-45	2.34	8.12	20.72	25.89	53.39	Clayey	39.51	19.38	1.39	47.55
45-60	2.86	8.47	21.24	24.95	53.81	Clayey	38.02	18.91	1.45	45.28
Mean	2.30		20.53	25.19	54.28	Clay	41.13	20.70	1.33	49.81

Experiment design and treatments:

By the usage of a strip plot design consisting of three replicates, three irrigation intervals were settled in horizontal plots, whereas six treatments of weed control were located in vertical plots as presented in Fig (1).

- Description of direct dry seeding on furrow planting method:

Rice was cultivated in two rows on the furrow by a distance of 30 cm between the rows, while the distance inside the row among rice hills was 10 cm and 12 cm of the furrow depth. Seed rate was 150 kg ha^{-1} and planting depth was 2-3 cm. Irrigation water depth in the bottom of furrow was 7 cm in each irrigation as presented in Fig. (2).

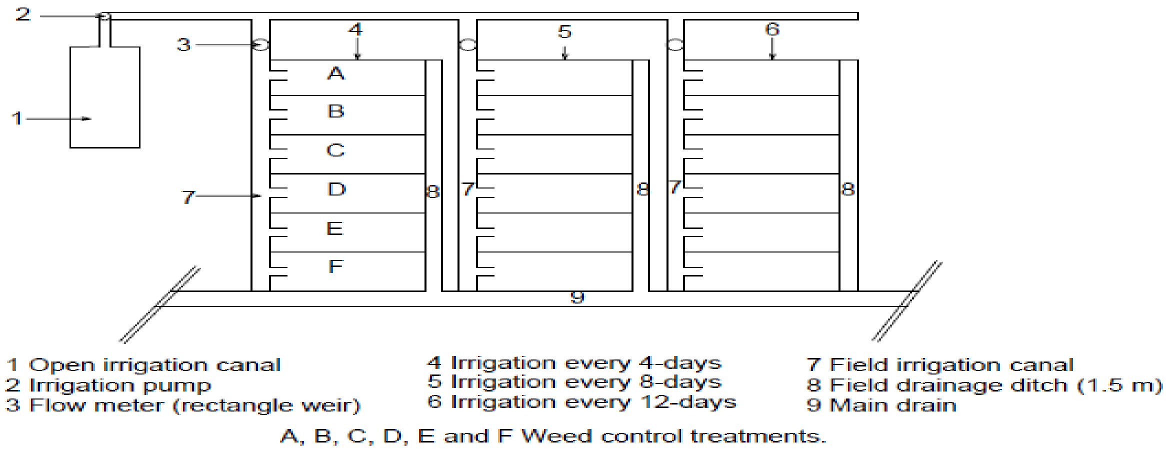

Fig. 1. Experiment design for one replication contain irrigation, drainage systems and weed control treatments.

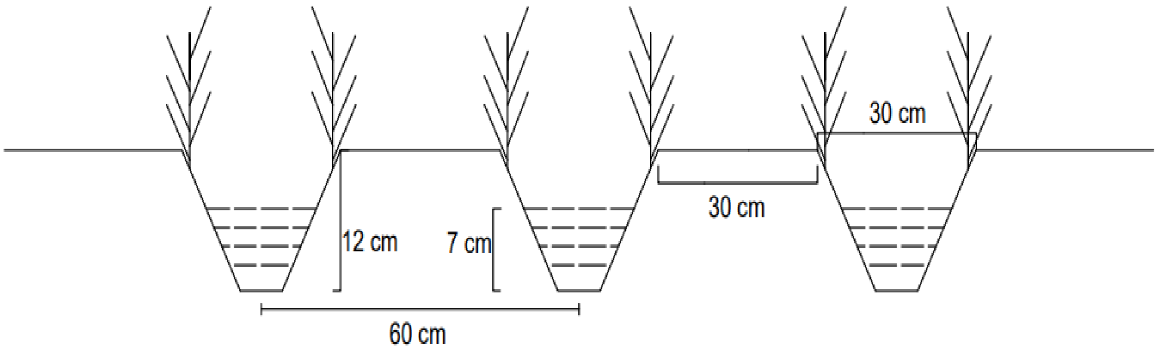

Fig. 2. Schematic diagram of furrows design

- Studied factors:

A- Irrigation intervals:

Three irrigation intervals; every 4 (I_1), 8 (I_2) and 12 (I_3) days were studied. Irrigation plots were well isolated to avoid any lateral water movement with two ditches of 1.5 m for each, the first one was in front for irrigation and the second for drainage next to plots. Irrigation water from the branch canal nearby the experiment field was pumped, water in the field canal was controlled to sustain a constant height of water over the crest of rectangular weir through fixed sliding type gates.

B- Weed control treatments:

1- Saturn 50% EC (thiobencarb) at rate of 3.57 kg ai ha^{-1} at 4 days after sowing (DAS) (W_1).
2- Stomp 50% EC (pendimethalin) at rate of 2.023 kg ai ha^{-1} at 4 DAS (W_2).
3- Saturn 50% at rate of 3.57 kg ai ha^{-1} at 4 DAS followed by (fb) Repair 18% TB (quinclorac 16.5% + bensulfuron-methyl 1.5%) at rate of 0.491 + 0.0446 kg ai ha^{-1} at 25 DAS (W_3)
4- Stomp 50% at rate of 2.023 kg ai ha^{-1} at 4 DAS followed by Repair 18% TB at rate of 0.536 kg ai ha^{-1} at 25 DAS (W_4).
5- Weed free (weeds were removed by hand every two weeks along the season) (W_5).
6- Weedy check (un-treated plots) (W_6).

Saturn and Stomp as were applied as spraying then the land were flush irrigated at 24 hours after treatment. While Repair 18% TB was sprayed at 25 DAS using CP3 knapsack sprayer on dry land then the land was irrigated at 24 hours after herbicide spraying. Sowing date was 10th and 4th of June during the two seasons and seeding rate was 150 kg/ha. Other agricultural practices were done as recommended by **RRTC, 2019** for Sakha super 300 as new released Egyptian rice cultivar.

- Studied characteristics:

A- Weed traits:

Weed flora contained grasses included *Echinochloa crus-galli* and *Echinochloa colonum / colona* and *Ammannia baccifera* as broadleaf weed. After 80 days from seeding, weed samples were taken four times by area of 0.5 m x 0.5 m quadrate from each plot. After weeds classification, weeds dried by air then put in the oven at 70 °C for 48 hours or to stable weight then dry weight as g m^{-2} for individual weeds was recorded, total weeds dry weight was calculated as summation of studied weeds, Weed control efficiency percent (WCE %) was estimated as said by Drost and Moody (1982).

B- Rice characteristics:

Rice vegetative samples were taken at 80 DAS by the previous methods of weed sampling to determine dry weight of rice (g m^{-2}). Before rice harvest, panicles were counted three replicates by area of 0.5 x 0.5 m for each plot then calculated converted to number per m^2. Ten panicles of rice were randomly sampled before harvest from every plot to asses panicle weight, 1000-grain weight and filled grains per panicle. The central area of four-square meters was harvested; grain yield was adjusted at moisture content of 14% then converted to t ha^{-1}. Yield losses percentages were calculated by using the subsequent equation:

$$\textbf{Yield losses (\%)} = \frac{Y_{\text{weed free}} - Y_{\text{treatment}}}{Y_{\text{weed free}}} \times 100$$

C- Applied water and water productivity

By the use of a fixed rectangular weir, the applied water per irrigation treatment in every irrigation was measured and the underlying equation was also used:

$Q = 1.84LH^{1.5}$

Where,

Q =discharge rate, m^3/min., L = weir length edge, cm

H = Height of water column above weir edge, cm

The seasonal applied water was calculated through the assumption of the applied quantity in all irrigation during the season. Water productivity in kg grain per m^3 was calculated as said by Ali *et al*. (2007), as follows:

$$\text{Water productivity (kg m}^{-3}\text{)} = \frac{\text{Grain yield (kg/ ha)}}{\text{Applied water (m}^3\text{/ ha)}}$$

Statistical analysis:

Attained results were subjected to appropriate statistical analysis of variance as said by Snedecor and Cochran (1971). After transformation according to square-root ($\sqrt{[x + 0.5]}$), MSTATC program was used to analyze weed data. Rice results were directly analyzed by same program. Duncan´s Multiple Range Test (Duncan, 1955) was used to compare means of weeds and rice traits.

RESULTS

- Water measurements:

- Applied water

Data in Fig (3) and Fig (4) are present the applied water per month and season, respectively, as influenced by irrigation intervals. The peak value of monthly applied water was 3875 m^3 ha^{-1} in August for 4-days intervals, while it was 3725 m^3 ha^{-1} in July for both 8 and 12-days intervals in the1st season. In the 2nd season, the maximum value was 4351 m^3 ha^{-1} in August for 4-days irrigation intervals, but it was 2992 m^3 ha^{-1} in July for 8 and 12-day intervals as shown in Fig (3). When increasing irrigation intervals, the applied water was reduced. The amount of applied water was 13273 and 13844 m^3 ha^{-1} of 4-days, 10974 and 11265 m^3 ha^{-1} of 8-days and 10239 and 10602 m^3 ha^{-1} for 12-days irrigation intervals for 2020 and 2021 growing seasons, respectively. Applied water decreased by 17.3% and 18.6% for 8-days and 22.9% and 23.4% of 12-days intervals in 2020 and 2021 seasons, respectively, in comparison with 4-days irrigation intervals as shown in Fig (4). These results match with those gained by Ashouri (2014), who found that water use decreased by 18% under 8 days interval compared to continuous flooding. Irrigation intervals and alternative wetting and drying can markedly decrease applied irrigation when comparing to continuous flooding (Basha and Sarma, 2017). Alternative wetting and drying saved about 15-30% of water use without any yield reduction (Runkle *et al*., 2019).

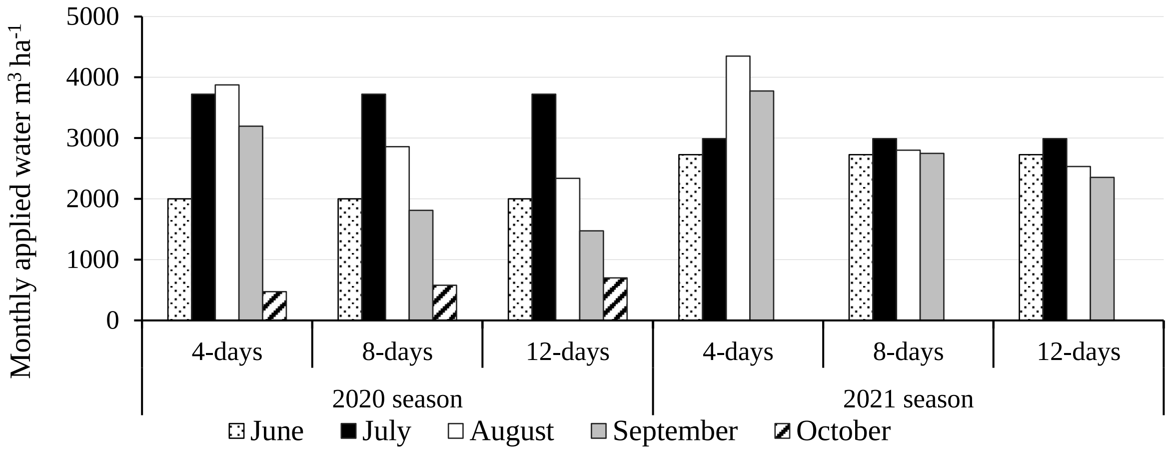

Fig. 3. Monthly applied water (m^3 ha^{-1}) as affected by irrigation intervals and weed control treatment

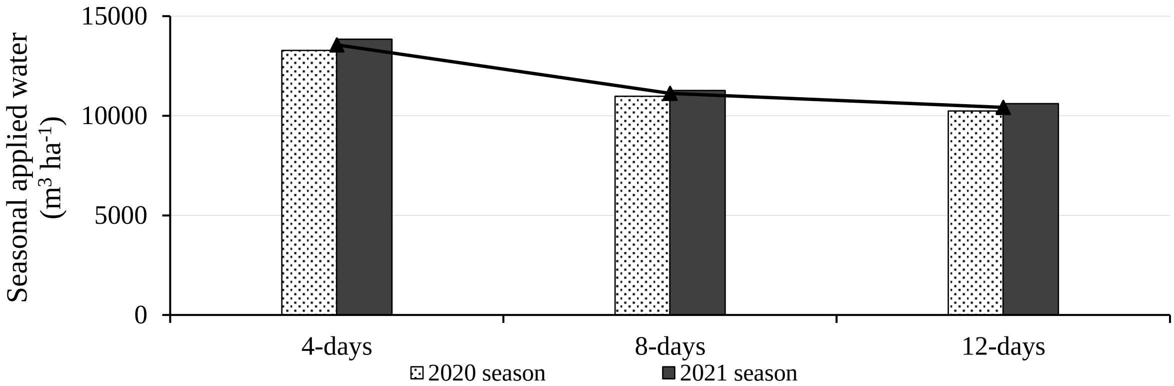

Fig. 4. Seasonal applied water (m^3 ha^{-1}) as affected by irrigation intervals and weed control treatment.

- Weed measurements:

- Effect of irrigation intervals and weed control treatments on studied traits of weeds.

Data in Table (3) summarized various effects of irrigation intervals on dry weights of grasses and broadleaf weeds, short irrigation interval encourage the appearance of broadleaf weeds such as *Ammannia baccifera*, while long irrigation interval every 12 days induce grassy weeds seeds germination in consecutive generations as a result of alternative wetting and drying which cause soil cracks and light penetration to weed seeds and start to break the dormancy then begin to germinate along rice growing season. Irrigation every 4 days achieved the least dry weights of *Echinochloa cru-galli, E. colona* in addition to dry weights of total weeds in both seasons. While long irrigation interval every 12 days significantly reduced dry matter of *Ammannia baccifera* as broadleaf weed in 2020 and 2021 seasons. Irrigation every 12 days increased total weeds dry weights by 50.3 and 34.3% as compared to irrigation every 4 and 8 days, respectively. Similar results were obtained by Abou El-Darag *et al*. (2017) and Abd El-Naby and El-Ghandor (2022).

Data presented in Table (3) indicated that all tested chemical weed control treatments significantly decreased dry weights of both grassy and broadleaf weeds in 2020 and 2021 seasons as compared to weedy check. Sequential application of pre followed by post-emergence herbicides exceeded single application of pendimethalin or thiobencarb as pre-emergence. Pendimethalin application at 4 DAS fb ready-made of quinclorac + bensulfuron-methyl as recommended dose at 25 DAS superior rest tested chemical weed control treatments in reducing dry weights of *E. crus-galli, E. colona* and *A. baccifera* as well as total weeds during the two seasons. While sequential application of thiobencarb at 4 DAS fb ready-made of quinclorac + bensulfuron at 25 DAS ranked second in this respect. While, weedy check recorded the maximum values of dry weights for studied weeds in 2020 and 2021 seasons.

For weed control efficiency percent (WCE), sequential application of pre followed by post-emergence herbicides achieved 91.4% WCE and exceeded single herbicidal treatment which achieved 65% WCE as an average of both seasons.

Table 3: Dry weights of *A. baccifera, E. colonum*, *E. crus-galli* and their total weeds as influenced by irrigation intervals and weed control treatments.

Factors	Broadleaf weeds		Grassy weeds				Total weeds dry weight (g m^{-2})		Weed control efficiency (%)	
A-Irrigation intervals	***A. baccifera*** **dry weight (g m^{-2})**		***E. colonum*** **dry weight (g m^{-2})**		***E. grus-galli*** **dry weight (g m^{-2})**					
	2020 season	2021 season	2020 season	2021 season	2020 season	2021 season	2020 season	2021 season	2020 season	2021 season
Every 4 days	65.3 (6.2 a)	53.2 (5.4 a)	100.8 (8.3 c)	76.4 (6.9 c)	109.1 (8.4 c)	89.2 (7.4 c)	275.2 (13.2 c)	218.8 (11.4 c)	--	--
Every 8 days	32.0 (5.0 b)	26.7 (4.5 b)	139.3 (9.9 b)	124.5 (8.9 b)	181.4 (10.9 b)	149.2 (9.6 b)	352.7 (15.5 b)	300.3 (13.8 b)	--	--
Every 12 days	20.9 (4.1 c)	15.9 (3.6 c)	234.7 (13.5 a)	181.2 (11.6 a)	284.4 (14.3 a)	257.1 (13.6 a)	540.0 (20.1 a)	454.2 (18.2 a)	--	--
F test	**	**	**	**	**	**	**	**	--	--
B-Weed control treatment										
Thiobencarb 50% EC	38.9 (6.2 b)	31.9 (5.6 b)	200.0 (13.8 b)	165.4 (12.6 b)	216.4 (14.3 b)	197.5 (13.6 b)	455.3 (20.9 b)	394.8 (19.5 b)	63.0	62.5
Pendimethalin 50% EC	33.5 (5.7 c)	26.8 (5.1 c)	173.6 (12.8 c)	146.6 (11.9 c)	188.3 (13.4 c)	179.7 (13.0 c)	395.4 (19.5 c)	353.1 (18.4 c)	67.9	66.4
Thiob. *fb* ready-made (quinclorac 16.5%+bensulfuran-methyl 1.5%)	12.4 (3.6 d)	7.3 (2.7 d)	68.6 (7.8 d)	31.6 (5.2 d)	58.9 (7.2 d)	39.7 (5.7 d)	139.9 (11.2 d)	78.6 (8.2 d)	88.6	92.5
Pendi.*fb* ready-made (quinclorac 16.5% +bensulfuran-methyl 1.5%)	9.3 (3.1 e)	5.3 (2.4 e)	55.8 (7.1 e)	28.1 (4.8 d)	48.5 (6.7 d)	34.9 (5.4 d)	113.6 (10.2 e)	68.4 (7.5 e)	90.8	93.5
Weed free	0.0 (0.7 f)	0.0 (0.7 f)	0.0 (0.7 f)	0.0 (0.7 e)	0.0 (0.7 e)	0.0 (0.7 e)	0.0 (0.7 f)	0.0 (0.7 f)	100	100
Weedy check	142.4 (11.3 a)	120.4 (10.4 a)	451.5 (21.2 a)	392.4 (19.7 a)	637.7 (24.9 a)	539.1 (22.9 a)	1231.6 (35.0 a)	1051.9 (32.3 a)	--	--
F test	**	**	**	**	**	**	**	**	--	--
F. test of the interaction: A x B	**	**	**	**	**	**	**	**	--	--

Transformed values are shown in parentheses. In a column, means of transformed data followed by the same letter are not significantly different at 5% level, using Duncan's Multiple Range Test

- Effect of the interaction on dry weights of studied weeds.

Data in Table (4) presented the major impact of the interaction between irrigation intervals and weed control treatments on dry matter of studied weed species in addition to total weeds in 2020 and 2021 seasons. The combination of irrigation every 4 days treated by sequential application of pendimethalin fb ready mix of quinclorac + bensulfuron recorded the best control of *A. baccifera, E. crus-galli and E. colona* and total weeds during this study. Whereas the heaviest dry weights of all studied weeds were recorded by weedy check plots irrigated every 12 days except for *A. baccifera* dry matter in un-treated plots irrigated every 4 days in 2020 and 2021 seasons. These results reflect the superiority of sequential application of pre fb post-emergence herbicides in controlling weeds under short, medium and long irrigation intervals in direct seeding on furrows because of high efficiency of certain combination to minimize/free of weeds in rice fields at least for 8-10 weeks after seeding and give chance for rice to occupy land spaces and cover the soil consequently reduce weed competition to minimum limits through growing season of rice. These consequences match with the consequences gained by Abd El-Naby and Mahmoud (2018) and Kumar *et al*. (2020).

Table 4: Effect of the interaction between irrigation intervals and weed control treatments on dry weights of *A. baccifera, E. colona, E. crus-galli* and total weeds.

Weed control treatment	Irrigation intervals (days)					
	4	8	12	4	8	12
	A. baccifera **dry weight (g m^{-2})**					
	2020 season			**2021 season**		
Thiobencarb 50% EC	50.3 (7.1 cd)	46.3 (6.8 de)	20.2 (4.5 f)	43.5 (6.6 d)	37.9 (6.2 de)	14.3 (3.8 f)
Pendimethalin 50% EC	45.6 (6.8 de)	35.5 (6.0 e)	19.3 (4.5 f)	37.3 (6.1 de)	32.3 (5.7 e)	10.7 (3.3 fg)
Thiobencarb *fb* ready-made (quinclorac 16.5%+bensulfuron-methyl 1.5%)	10.1 (3.3 gh)	12.5 (3.6 fgh)	14.5 (3.9 fg)	3.8 (2.1 ij)	7.7 (2.9 gh)	10.3 (3.3 fg)
Pendimethalin *fb* ready-made (quinclorac 16.5%+bensulfuron-methyl 1.5%)	7.4 (2.7 h)	10.6 (3.3 gh)	10.0 (3.2 gh)	2.7 (1.8 j)	5.3 (2.4 hi)	8.0 (2.9 gh)
Weed free	0.0 (0.7 i)	0.0 (0.7 i)	0.0 (0.7 i)	0.0 (0.7 k)	0.0 (0.7 k)	0.0 (0.7 k)
Weedy check	278.4 (16.7 a)	87.3 (9.4 b)	61.4 (7.9 c)	231.9 (15.2 a)	77.1 (8.8 b)	52.4 (7.3 c)
	E. colona **dry weight (g m^{-2})**					
	2020 season			**2021 season**		
Thiobencarb 50% EC	97.7 (9.9 hi)	183.7 (13.6 f)	318.5 (17.9 d)	80.5 (9.0 g)	179.7 (13.4 e)	235.9 (15.4 d)
Pendimethalin 50% EC	86.6 (9.3 i)	149.8 (12.3 g)	284.5 (16.8 e)	75.7 (8.7 gh)	144.1 (12.0 f)	220.1 (14.9 d)
Thiobencarb *fb* ready-made (quinclorac 16.5%+bensulfuron-methyl 1.5%)	29.0 (5.4 jk)	38.1 (6.2 j)	138.6 (11.8 g)	10.1 (3.2 ij)	14.3 (3.8 i)	70.5 (8.4 gh)
Pendimethalin *fb* ready-made (quinclorac 16.5%+bensulfuron-methyl 1.5%)	25.7 (5.1 k)	34.0 (5.9 jk)	107.5 (10.4 h)	7.2 (2.8 j)	11.6 (3.5 ij)	65.6 (8.1 h)
Weed free	0.0 (0.7 l)	0.0 (0.7 l)	0.0 (0.7 l)	0.0 (0.7 k)	0.0 (0.7 k)	0.0 (0.7 k)
Weedy check	365.6 (19.1 c)	429.9 (20.7 b)	558.9 (23.6 a)	285.1 (16.9 c)	397.0 (19.9 b)	495.2 (22.3 a)
	E. crus-galli **dry weight (g m^{-2})**					
	2020 season			**2021 season**		
Thiobencarb 50% EC	91.5 (9.6 i)	233.5 (15.3 f)	324.1 (18.0 d)	81.9 (9.1 g)	198.8 (14.1 e)	311.9 (17.7 d)
Pendimethalin 50% EC	87.1 (9.4 i)	196.2 (14.0 g)	281.6 (16.8 e)	76.7 (8.8 g)	170.1 (13.1 f)	292.2 (17.1 d)
Thiobencarb *fb* ready-made (quinclorac 16.5%+bensulfuron-methyl 1.5%)	26.0 (5.2 j)	31.3 (5.6 j)	119.4 (10.9 h)	13.7 (3.8 h)	15.2 (3.9 h)	90.3 (9.5 g)
Pendimethalin *fb* ready-made (quinclorac 16.5%+bensulfuron-methyl 1.5%)	25.2 (5.1 j)	27.4 (5.3 j)	92.9 (9.7 i)	11.7 (3.5 h)	13.4 (3.7 h)	79.6 (9.0 g)
Weed free	0.0 (0.7 k)	0.0 (0.7 k)	0.0 (0.7 k)	0.0 (0.7 i)	0.0 (0.7 i)	0.0 (0.7 i)
Weedy check	424.7 (20.6 c)	600.0 (24.5 b)	888.2 (29.8 a)	351.2 (18.8 c)	497.6 (22.3 b)	768.3 (27.7 a)
	Total weeds dry weight (g m^{-2})					
	2020 season			**2021 season**		

Thiobencarb 50% EC	139.5 (15.5 gh)	463.5 (21.5 e)	662.8 (25.7 c)	205.9 (14.4 h)	416.4 (20.4 f)	562.1 (23.7 d)
Pendimethalin 50% EC	219.2 (14.8 h)	381.6 (19.5 f)	585.5 (24.2 d)	189.7 (13.8 h)	346.5 (18.6 g)	423.0 (22.9 e)
Thiobencarb *fb* ready-made (quinclorac 16.5%+bensulfuron-methyl 1.5%)	65.2 (8.1 ij)	81.9 (9.1 i)	272.5 (16.5 g)	27.8 (5.3 lm)	37.2 (6.1 k)	171.1 (13.1 ij)
Pendimethalin *fb* ready-made (quinclorac 16.5%+bensulfuron-methyl 1.5%)	58.3 (7.7 j)	71.9 (8.5 ij)	210.5 (14.5 h)	21.6 (4.7 m)	30.2 (5.5 kl)	153.2 (12.4 j)
Weed free	0.0 (0.7 k)	0.0 (0.7 k)	0.0 (0.7 k)	0.0 (0.7 n)	0.0 (0.7 n)	0.0 (0.7 n)
Weedy check	1068.8 (32.7 b)	1117.4 (33.4 b)	1508.6 (38.8 a)	868.2 (29.5 c)	971.7 (31.2 b)	1315.9 (36.3 a)

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

- Rice measurements:

- Effect of the interaction between irrigation intervals and weed management on rice characteristics.

Influence of irrigation intervals and weed control treatments on rice dry weight, number of panicles m^{-2}, panicle weight (g), 1000-grain weight (g), number of filled grains per panicle, grain yield (t ha^{-1}) and yield losses percent are presented in Tables (5 and 6). Irrigation every 4-days documented the peak values of abovementioned rice traits during 2020 and 2021 seasons followed by every 8 days while long irrigation interval every 12 days produced the least values as regard this respect. Irrigation every 8 days reduced grain yield of Sakha super 300 by 21.7%, while grain yield was decreased by 47.2% under long irrigation interval every 12 days as compared to irrigation every 4 days in direct seeding on furrows. These results agreed with which obtained by Kumar *et al*. (2017), they showed that severe alternative wetting and drying significantly reduce rice grain yield in comparison with continuous flooding. This reduction reached 12.6% comparing to continuous flooding (Nalley *et al*. 2015).

Table 5: Dry weight, number of panicles per square meter and panicle weight of rice as influenced by irrigation intervals and weed control treatments.

A-Irrigation intervals	**Rice dry Weight (g m^{-2})**		**Number of panicle m^{-2}**		**Panicle weight (g)**	
	2020 season	2021 season	2020 season	2021 season	2020 season	2021 season
Every 4 days	1067.2 a	1307.8 a	413.3 a	441.8 a	1.95 a	2.30 a
Every 8 days	664.5 b	814.0 b	360.0 b	381.3 b	1.53 b	1.99 b
Every 12 days	445.6 c	542.1 c	279.1 c	296.0 c	1.35 c	1.49 c
F test	**	**	**	**	**	**
B-Weed control treatment						
Thiobencarb 50% EC	478.3 e	633.1 e	309.3 d	325.3 c	1.19 d	1.43 c
Pendimethalin 50% EC	573.0 d	701.8 d	332.4 c	350.2 c	1.25 c	1.52 c
Thiobencarb *fb* ready-made (quinclorac 16.5%+bensulfuron-methyl 1.5%)	953.1 c	1147.6 c	446.2 b	474.7 b	2.04 b	2.52 b
Pendimethalin *fb* ready-made (quinclorac 16.5%+bensulfuron-methyl 1.5%)	1012.1 b	1199.5 b	462.2 b	490.7 ab	2.16 b	2.59 ab
Weed free	1214.7 a	1375.7 a	488.9 a	515.6 a	2.35 a	2.71 a
Weedy check	123.4 f	260.1 f	65.8 e	81.8 d	0.67 e	0.77 d
F test	**	**	**	**	**	**
F. test for the interaction**:** A x B	**	**	**	**	**	**

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

Data in Tables (5 and 6) showed markedly the impact of weed control treatments upon rice dry weight, yield and its attributes as well as yield losses percent in 2020 and 2021 seasons. Pendimethalin at 4 DAS followed by ready-made of quinclorac + bensulfuron at recommended doses applied at 25 DAS surpassed all tested chemical weed control and produced the peak rice biomass, effective tillers, panicle weight, 1000-grain weight, filled grains per panicle and grain yield in both seasons of study. Whereas, the least values of rice studied traits were attained by un-treated plots. The superiority of sequential herbicidal application may be due to create optimum conditions for rice plants with no or minimum weed competition on basic demands of rice growth (water, space, sun light and nutrients) consequently increased rice vegetative growth and improve grain yield as demonstrated by Singh *et al*. (2017) and Sen *et al*. (2020). While the least values of all studies rice characteristics were recorded by un-treated plots in 2020 and 2021 seasons. This might be due to full season weed competition in weedy check plots (Chongtham *et al.,* 2016).

Depending on weed free plots, yield losses percent were estimated for all tested weed control treatments. In weedy check plots, yield losses was 93.2% which explains the negative effect of weeds on yield reduction under direct seeding on furrows, so that it must be have a very strong chemical weed control program depending on using sequential application of herbicides (pre fb post-emergence) to reduce or minimize yield losses (pendimethalin at 4 DAS fb ready-made of quinclorac + bensulfuron at 25 DAS decreased yield losses to 4.1%). While single application of pre-emergence herbicide caused yield losses ranged from 57.7 to 61.5% under this study.

Table 6: Effect of irrigation intervals and weed control treatments on 1000-grain weight, number of filled grains per panicle, grain yield and yield losses of rice.

A-Irrigation intervals	**1000-grian weight (g)**		**Number of filled grains per panicle**		**Grain yield (t ha^{-1})**		**Yield losses (%)**	
	2020 season	2021 season	2020 season	2021 season	2020 season	2021 season	2020 season	2021 season
Every 4 days	22.24 a	23.68 a	85.9 a	94.3 a	6.873 a	7.288 a	--	--
Every 8 days	18.84 b	21.12 b	73.1 b	79.3 b	5.378 b	5.704 b	--	--
Every 12 days	17.67 c	18.44 c	56.8 c	64.2 c	3.561 c	3.921 c	--	--
F test	**	**	**	**	**	**	--	--
B-Weed control treatments								
Thiobencarb 50% EC	16.74 d	19.17 c	47.6 c	56.6 c	3.162 e	3.561 e	62.8	60.2
Pendimethalin 50% EC	17.94 c	19.60 c	51.3 c	60.0 c	3.573 d	3.854 d	58.1	56.9
Thiobencarb *fb* ready-made (quinclorac 16.5%+bensulfuron-methyl 1.5%)	23.2 b	24.32 b	96.9 b	102.8 b	7.726 c	8.214 c	9.1	8.2
Pendimethalin *fb* ready-made (quinclorac 16.5%+bensulfuron-methyl 1.5%)	24.00 b	25.19 ab	100.2 b	110.0 ab	8.141 b	8.583 b	4.2	4.0
Weed free	25.29 a	26.22 a	108.2 a	114.9 a	8.497 a	8.945 a	--	--
Weedy check	10.29 e	12.00 d	27.4 d	31.3 d	0.525 f	0.668 f	93.8	92.5
F test	**	**	**	**	**	**	--	--
F. test of the interaction: A x B	Ns	Ns	**	**	**	**	--	--

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

- Rice dry weight, yield and its attributes as affected by the interaction.

Data in Tables (7 and 8) showed the significant impact of the interaction between irrigation intervals and weed control treatments on rice dry matter, panicles m^{-2}, panicle weight, filled grains per panicle and grain yield in 2020 and 2021 seasons. Plots were irrigated every 4 days and treated with sequential application of pre-emergence herbicide (pendimethalin or thiobencarb) at 4 DAS fb recommended dose of ready-made (quinclorac + bensulfuron-methyl) at 25 DAS showed the peak values of abovementioned rice traits during 2020 and 2021 seasons. Weed free plots achieved 10.74 t ha^{-1}, while pendimethalin at 4 DAS fb ready-made of quinclorac + bensulfuron at 25 DAS produced 10.148 t ha^{-1} rice grain yield by reduction percent of 5.51% under irrigation every 4 days which reflex high efficiency of such chemical weed control in weed control and improve grain yield of Sakha Super 300 rice cultivar under direct seeding on furrows. The least values of rice dry matter, grain yield and its attributes were recorded by weedy check plots which irrigated every 12 days in 2020 and 2021 growing seasons. These results agreed with those obtained by Murali (2009) who found irrigation intervals has main impact upon grain productivity, the maximum grain yield was obtained under irrigation intervals 5-6 days compared to the rest intervals 8-9, 11-12, 13-14 and 16-17 days, respectively. Grain yield was decreased under 11 day intervals compared to continue flooding (Ashouri, 2014). Abadulrazak *et. al.* (2017) found that, the best weed control treatment and lowest dry weight of *E. colona* and *D. retroflexa* as well as *A. baccifera* achieved by adding sequential application of pre-emergence (pretilachlor 50% EC at 0.50 kg a.i. ha^{-1}) fb post-emergence (bispyribac-sodium 10% SC at 35 g a.i. ha^{-1}). Analogous consequences were concluded by Sarkar *et al*. (2017).

Table 7: Effect of the interaction between irrigation intervals and weed control treatments on rice dry weight, number of panicles m^{-2} and panicle weight.

Weed control treatment	Irrigation intervals (days)					
	4	8	12	4	8	12
	Rice dry weight (g m^{-2})					
	2020 season			2021 season		
Thiobencarb 50% EC	686.3 fg	458.6 j	290.1 k	879.6 ef	649.9 g	369.8 h
Pendimethalin 50% EC	824.8 e	539.7 i	354.6 k	961.1 de	697.3 g	447.0 h
Thiobencarb *fb* ready-made (quinclorac 16.5%+bensulfuron-methyl 1.5%)	1402.3 b	873.9 de	582.9 hi	1745.1 b	995.4 de	702.4 g
Pendimethalin *fb* ready-made (quinclorac 16.5% + bensulfuron-methyl 1.5%)	1462.9 b	941.3 d	632.1 gh	1840.5 b	1045.4 d	712.5 g
Weed free	1824.9 a	1081.0 c	738.2 f	2065.7 a	1250.1 c	811.2 fg
Weedy check	202.1 l	92.6 m	75.6 m	355.0 h	215.7 i	209.5 i
	Number of panicle m^{-2}					
	2020 season			2021 season		
Thiobencarb 50% EC	373.3de	298.7 gh	256.0 i	389.3 de	314.7 gh	272.0.i
Pendimethalin 50% EC	400.0 d	330.7 fg	266.7 hi	421.3 d	346.7 fg	282.7 hi
Thiobencarb *fb* ready-made (quinclorac 16.5%+bensulfuron-methyl 1.5%)	512.0 b	474.7 c	352.0 ef	549.3 b	490.7 c	378.7 ef
Pendimethalin *fb* ready-made (quinclorac 16.5% + bensulfuron-methyl 1.5%)	517.3 b	496.0 bc	373.3 de	560.0 b	522.7 bc	389.3 de
Weed free	576.0 a	501.3 bc	389.3 de	613.3 a	533.3 bc	400.0 de
Weedy check	101.3 j	58.7 k	37.3 k	117.3 j	74.7 k	53.3 k
	Panicle weight (g)					
	2020 season			2021 season		
Thiobencarb 50% EC	1.45 h	1.12 i	0.99 ij	1.71 ef	1.47 f	1.12 g
Pendimethalin 50% EC	1.58 gh	1.14 i	1.04 ij	1.86 de	1.53 f	1.17 g
Thiobencarb *fb* ready-made (quinclorac 16.5%+bensulfuron-methyl 1.5%)	2.44 b	1.98 de	1.70 fg	2.94 b	2.66 c	1.97 d
Pendimethalin *fb* ready-made (quinclorac 16.5% + bensulfuron-methyl 1.5%)	2.46 b	2.13 cd	1.89 ef	2.93 b	2.83 bc	2.02 d
Weed free	2.91 a	2.22 c	1.91 e	3.32 a	2.77 bc	2.04 d
Weedy check	0.84 j	0.60 k	0.56 k	1.07 g	0.65 h	0.59 h

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

Table 8: Effect of the interaction between irrigation intervals and weed control treatments on number of filled grains per panicle and grain yield.

Weed control treatment	**Irrigation intervals (days)**					
	4	**8**	**12**	**4**	**8**	**12**
	Number of filled grains panicle^{-1}					
	2020 season			**2021 season**		
Thiobencarb 50% EC	57.7 g	46.3 hi	38.7 jk	69.3 g	56.7 h	43.7 ij
Pendimethalin 50% EC	62.7 g	50.3 h	41.0 ij	76.0 fg	58.0 h	46.0 i
Thiobencarb *fb* ready-made (quinclorac 16.5%+bensulfuron-methyl 1.5%)	113.7 bc	103.0 d	74.0 f	123.0 b	103.3 d	82.0 f
Pendimethalin *fb* ready-made (quinclorac 16.5% + bensulfuron-methyl 1.5%)	116.7 b	105.3 d	78.7 f	1250 b	113.7 c	91.3 e
Weed free	131.7 a	107.0 cd	86.0 e	136.0 a	114.3 c	94.3 e
Weedy check	33.0 kl	26.7 lm	22.7 m	36.3 jk	29.7 k	28.0 k
	Grain yield (t ha^{-1})					
	2020 season			**2021 season**		
Thiobencarb 50% EC	4.950 g	2.950 i	1.585 k	5.307 g	3.483 h	1.994 i
Pendimethalin 50% EC	5.397 f	3.290 h	2.033 j	5.651 g	3.734 h	2.177 i
Thiobencarb *fb* ready-made (quinclorac 16.5%+bensulfuron-methyl 1.5%)	9.654 b	8.120 d	5.411 f	10.177 b	8.371 d	6.094 f
Pendimethalin *fb* ready-made (quinclorac 16.5% + bensulfuron-methyl 1.5%)	9.790 b	8.631 c	6.000 e	10.507 b	8.941 c	6.300 ef
Weed free	10.521 a	8.819 c	6.150 e	10.960 a	9.257 c	6.618 e
Weedy check	0.934 l	0.458 m	0.183 m	1.123 j	0.537 k	0.344 k

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

- Water productivity

As shown in Table (9), essential differences were obtained between irrigation intervals, weed control treatments significant and the interaction among them. The highest values of water productivity were found with 4-days interval, while the lowest values were obtained with 12-day interval in both seasons. This might occur owing to the reduction of grain yield as a consequence of sever alternative wetting and drying (Carrijo *et al*., 2017), long irrigation intervals (Murali, 2009) and weeds growth and competition (Abd El-Naby and El-Ghandor, 2022). These results agree with the results attained by Abd El-Naby and Mahmoud (2018) and El-Ghandor *et al*. (2020). The values of water productivity of weed control treatments were taken the descending order: $W_5 > W_4 > W_3 > W_2 > W_1 > W_6$ for 2020 and 2021 seasons. This may be due to the significant reduction in weeds growth and its competition with rice plants for nutrients, water and light as reported by Singh *et al*. (2017) and Abd El-Naby *et al*. (2018).

The peak values of water productivity were obtained of 8-days × W_5 and 4-days × W_5 and 8-Days × W_4 with no significant differences among them, while the lowest values of applied water were found with 12-days × W_6 in the two seasons compared to the others treatments as shown in Table(3).

Table 9: Influence of irrigation intervals, weed control treatments on water productivity.

Treatments	**2020 Season**						
	W_1	**W_2**	**W_3**	**W_4**	**W_5**	**W_6**	**Mean**
4-day	0.373 f	0.407 e	0.727 b	0.738 b	0.794 a	0.070 k	0.518 a
8-day	0.269 h	0.300 g	0.740 b	0.786 a	0.804 a	0.042 l	0.490 b
12-day	0.155 j	0.199 i	0.528 d	0.586 c	0.601 c	0.018 l	0.348 c
Mean	0.266 e	0.302 d	0.665 c	0.703 b	0.732 a	0.043 f	
	2021 season						
4-day	0.383 e	0.408 e	0.735 b	0.759 b	0.792 a	0.081 h	0.526 a
8-day	0.300 f	0.331 f	0.743 b	0.794 a	0.822 a	0.048 i	0.506 a
12-day	0.188 g	0.205 g	0.575 d	0.594 cd	0.624 c	0.032 i	0.370 c
Mean	0.291 e	0.315 d	0.684 c	0.716 b	0.746 a	0.054 f	

Means followed by a common letter within a season are not significantly differed at 5% level, using DMRT.
W_1= Thiobencarb 50% EC **W_2**= Pendimethalin 50% EC **W_3**= Thiobencarb *fb* ready-made (quinclorac 16.5%+bensulfuron-methyl 1.5%) **W_4**= Pendimethalin *fb* ready-made (quinclorac 16.5%+bensulfuron-methyl 1.5%) **W_5**= Weed free **W_5**= Weedy check

DISCUSSION

The applied water of direct seeding on furrows (Figures 3 and 4) was reduced by 16% and 11.4% for irrigation intervals 4-days and 8-day, respectively compared to the conventional rice transplanting. These results show the importance of direct seeding on furrows as a promising method to conserve irrigation water in rice farms. Aerobic rice planting method has essential role to reduce percolation, evaporative and seepage losses, which significantly reduce applied water compared to the traditional transplanted systems (Bhushan *et al*., 2007). Otherwise, furrow irrigation method was superior to conventional irrigation in terms of saving irrigation water (Carroll *et al*., 2020; Lunga *et al*., 2020). The absence of the surface water layer which reduce surface water area, evaporation, seepage, and deep percolation (Rai *et al*., 2017). When comparing results of applied water in direct seeding on furrows planting in the current study with the applied water in conventional rice transplanting which reported by Mahmoud (2015) in the same region,

The reduction in rice grain yield reached 12.6% in alternative wetting and drying comparing to continuous flooding (Nalley *et al*., 2015). The obtained consequences (Tables 5 and 6) on rice grain yield and its attributes might be owing to the importance of optimum soil moisture content to improve both root and shoot systems of rice which increase rice plants potential in water and nutrients absorption from the soil, increase photosynthesis, more tillers, panicles and more grain yield of rice. Analogous consequences were reported by El-Ghandor *et al.,* (2020).

The superiority of sequential application of herbicides (Tables 3 and 4) might be due to high efficacy of certain herbicidal application in suppressing weed seed germination during the first period after planting by pre-emergence herbicide, then post-emergence herbicide which contains two active ingredients (quinclorac against grassy weeds and bensulfuron-methyl which control broad leaf weeds) has high killing ability for young seedlings of weeds with no negative effect on rice plants. It plays an important role to save the field free of weeds during critical period of weed competition until rice plants occupy space and coverage soil surface and maximize benefits of soil, water, nutrients and sun light as cited by Singh *et al*., (2017) and Abd El-Naby *et al.,* (2018). Chongthanm, *et. al.,* (2016) stated that, pendimethalin as pre-emergence fb bispyribac-sodium as post emergence increased WEC (%) by reducing dry weight of weed species as shown in table (3).

Without application of post-emergence herbicides, yield losses of rice were 9-60% (McCauley *et al*., 2005). Farooq *et al*., (2011) stated that single application of pendimethalin is not enough to prevent grasses germination for long time during rice growing season.

CONCLUSION

Under the study conditions, the combination of irrigation every 4-days treated by sequential application of pendimethalin (2.023 kg ai ha^{-1}) as pre-emergence herbicide at 4 DAS followed by ready-made of quinclorac 26.5%+ bensulfuron-methyl 1.5% (0.491+0.0446 kg ai. ha^{-1}) at 25 DAS weed control treatment achieved the highest rice grain yield 10.148 tons ha^{1} as average of 1st and 2nd seasons and water productivity 0.75 kg m^{-3}. While under water scarcity, it could apply the interaction of irrigation intervals every 8-days and W_4 weed treatment which recorded the highest water productivity (0.79 kg m^{-3}), saved 17.95% of applied water and produced a reasonable grain yield (8.89 tons ha^{-1}) as an average of the two seasons. For rice and under arid conditions, rice yield and water productivity as influenced by associated aerobic conditions and furrow irrigation still need further investigation.

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فعالية مكافحة الحشائش وفترات الري على إنتاجية الأرز والمياه تحت الزراعة المباشرة على خطوط

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بريد المؤلف المراسل:

أجريت دراسة حقلية بالمزرعة البحثية بقسم بحوث الارز- محطة البحوث الزراعية – سخا- كفرالشيخ - مصر خلال الموسم الصيفي لعامي 2020 و 2021 لتحقيق أفضل مكافحة كيماوية للحشائش في الأرز المنزرع بالطريقة المباشرة على خطوط كطريقة مبتكرة تحت فترات ري مختلفة. حيث أستخدم تصميم الشرائح المتعامدة في ثلاث مكررات خلال موسمي الدراسة، ثلاث فترات للري تضمنت الري كل أربعة أيام (I_1) كل ثمانية أيام (I_2) وكل اثني عشر يوماً (I_3) وزعت في الشرائح الأفقية، وستة معاملات لمكافحه الحشائش وزعت عشوائياً في الشرائح الرأسية وتضمنت (W_1 ساتيرن 50% EC ثيوبينكارب بمعدل 3,750 كجم مادة فعالة/ هكتار بعد 4 ايام من الزراعة, (W_2) ستومب 50% EC بنديميثالين) بمعدل 2,023 كجم مادة فعالة/ هكتار بعد 4 ايام من الزراعة, (W_3) ساتيرن متبوعاً بمبيد ريبير 18% TB كمخلوط جاهز من مادتي كوينكلوراك 16,5% بينسلفورون- ميثيل 1,5% بمعدل 0,491 0,0446 كجم مادة فعالة/ هكتار بعد 25 يوم من الزراعة, (W_4) ستومب متبوعاً بمبيد ريبير بالمعدل الموصي به مقارنة بالمعاملة الخالية من الحشائش طوال الموسم W_5) وغير المعامل W_6). وقد أظهرت النتائج تفوق معاملة الري كل أربعة ايام عن فترات الري الأخرى و سجلت اقل وزن جاف للحشائش النجيلية و كذلك الحشائش الكلية بالإضافة الي أعلي وزن جاف للأرز, محصول الحبوب ومكوناته خلال موسمي الدراسة. بينما سجلت معاملة الري كل إثني عشر يوماً أقل وزن جاف للحشائش عريضة الأوراق في كل من موسمي الدراسة. كما حققت معاملتي الري كل 8 و 12 يوم توفير في مياه الري بمقدار 17,95 و 23,1% مقارنة بفترة الري كل 4 أيام. حققت معاملة الحشائش W_4 أفضل مكافحة للحشائش وحسنت من إنتاجية مياه الري النمو الخضري للأرز وأنتجت محصول حبوب 8,14 و 8,58 طن/هكتار خلال موسمي 2020 و 2021 علي التوالي, بالإضافة إلي تقليل الفقد في محصول الحبوب الي 4,1% كمتوسط للموسمين في حين كان الفقد في محصول الحبوب في القطع غير المعاملة بمبيدات الحشائش 93,2% حققت معاملة الري كل أربعة أيام مع إضافة مبيد بنديميثالين بعد 4 أيام من الزراعة, متبوعاً بالمخلوط الجاهز من مبيد ريبير 18% بعد 25 يوم من الزراعة أفضل معاملة لمكافحة الحشائش وزيادة النمو الخضري للأرز والمحصول وتقليل الفقد في محصول الصنف سخا سوبر 300 كصنف أرز مصري جديد. بينما تحت ظروف ندرة المياه يمكن إجراء الري كل 8 أيام مع مكافحة الحشائش بالمعاملة W_4 حيث سجلت أعلي انتاجية لمياه الري 0,79 كجم م^3) ومحصول حبوب 8,89 طن/هكتار) وتوفير مياه الري 17,95% كمتوسط للموسمين. كانت أعلي انتاجية لمياه الري 0,81 كجم/م^3) وسجلت بواسطة الري كل 8 أيام والمعاملة الخالية من الحشائش بدون فروق معنوية مع الري كل 8 أيام مستخدماً مبيد الحشائش بنديميثالين بعد 4 ايام من الزراعة متبوعاً بالمخلوط الجاهز من مبيد ريبير 18% 0,79 كجم/م^3) بعد 25 يوم من الزراعة.

الكلمات المفتاحية: الأرز، الخطوط، الحشائش، مكافحة الحشائش، الري وإنتاجية المياه.