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RESPONSE OF SOME RICE CULTIVARS TO IRRIGATION INTERVALS AND POTASSIUM LEVELS UNDER BROADCASTING METHOD

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Abstract: *The investigation aimed to study the response of three rice cultivars; namely, Sakha 104, Sakha 105 and Giza 179 rice cultivars to three irrigation intervals, i.e., continuous flooding (CF), irrigation ever six (6 days) and every nine days (9 days) and four potassium fertilizer levels; viz, 0 (control), 29, 57 and 86 kg K_2O/ha., the field experiments were carried out during 2013 and 2014 growing seasons using broadcast method at the Experimental Farm of Rice Research and Training Center, Sakha, Kafr El-Sheik, Egypt. The experimental design was a strip-split plot, with three replications. The tested rice cultivars were allocate in the horizontal plots and the irrigation intervals were arranged in the vertical plots. However, the potassium levels were assigned in the sub-plots. The sub-plot size was 15 m^2 (3x5 m). The obtained main results showed that the maximum values of plant height, number of tillers/m^2, number of days to 50% heading and number of panicles/m^2, as well as, hilling, milling and head rice percentages were produced by Sakha 104 rice cultivar. In addition, Giza 179 rice cultivar gave the highest harvest index and the lowest unfield grain percentage. Giza 179 followed by Sakha 104 rice cultivars recorded the maximum and significant grain yield. However, the maximum straw yields were obtained by both Sakha 104 and Sakha 105 rice cultivars with no significant differenced each either in both seasons. The tallest plants and the highest number of tillers/m^2, as well as, the highest percentages of hulling and head rice were belonged with CF (continuous flooding). Furthermore, CF and 6 days significantly gave the maximum values of number of panicles/m^2, number of grains/panicle, 1000-grain weight, grain and straw yields and harvest index. On the other side, irrigation every 9 days recorded the longest period to 50% heading and the highest unfield grains percentage. Data, also, cleared that adding either 57 or 86 kg K_2O/ha. gave the highest values of number of grains/panicle, 1000-grain weight, grain yield and milling percentage without any significant differences between them. Harvest index was not significantly affected by Potassium applications. CF received the highest amount of irrigation water, however, the lowest amount was received by 9 days. 6 days treatment gave a similar grain yield to that of CF, with less amount of irrigation water and increased water use efficiency up to a maximum value.*

Key words: *Direct-seeded, broadcast, rice cultivars, irrigation intervals, potassium levels.*

INTRODUCTION

Rice (*Oryza satival* L.) is one of the agronomically and nutritionally major cereal crops, and considered as one of the most important source for human food.

Egypt is self-sufficient in rice, but, water scarcity will reduce rice production due to decreasing rice cultivated area to save water to be used for other crops. (Soliman, 2012). Rice growth, productivity and grain quality are affected by genetic structure of growing rice varieties and various environmental conditions, especially irrigation water supply, fertilizer use efficiency anth others. Water deficit is one of the most constraints to rice production, particularly at the ends of the irrigation canals of Nile Delta (Adbulmajid, Dina, 2010). Cultivate the early maturity and water shortage tolerant rice varieties, decrease rice vegetative period through direct-sown methods, enhance water absorption and reduce transpiration via potassium application and improve irrigation regime could be contributed in solving water deficit problem. (El-Refaee, 2006; Bernier *et*

al., 2007; Zayed *et al.,* 2012 ; Abdel-Hafez *et al.,* 2013 and El-Ekhtyar, 2014a).

Potassium has essential functions in osmoregulation, enzyme activation, regulation of cellular pH, cellular cation-anion balance, regulation of transpiration by stomata and transport of assimilates, also, it increases leaf area and leaf chlorophyll content, delays leaf senescence and therefore contributes to greater rice canopy photosynthesis. Also, K increases number of grains/panicle, percentage of filled grains and 1000-grain weight. Interestingly, K deficiency in rice is more common under direct-sown rice, especially during early growth stages, when the plant population is large and root system is shallow (Szczerba *et al.,* 2009).

Thus, this investigation was conducted in order to fined out the sutible rice cultivar for broadcast seeding method, as well as, the adequate irrigation interval and the optimum potassium level to maximize rice productivity.

MATERIALS AND METHODS

Two field experiments were conducted to study the performance of three rice cultivars; namely, Sakha 104, Sakha 105 and Giza 179 as affected by three irrigation intervals; viz, continuous flooding (CF), irrigation every six days (6D) and irrigation every nine days (9D) and four potassium levels; i.e., control (without potassium fertilizer application), 29, 57 and 86 kg K_2O/ha. under broadcast seeding method. This investigation was carried out at the Experimental Farm of Rice Research and Training Center, Sakha, Kafr El-Sheikh governorate, Egypt, during 2013 and 2014 growing seasons. The preceding crop was wheat in both studied seasons.

Soil representative samples were taken from the experimental sites at (0-30 cm) depth from soil surface, then, air-dried, ground to pass through a 2 mm sieve and well mixed. The fine soil samples were mechanically analyzed, according to Piper (1950) and chemically analyzed, according to Black *et al.,* (1965). The mechanical and chemical analysis of the experimental sites were presented in Table (1).

The experimental design was a strip-split plot, with three replications. The tested rice cultivars were allocate in the horizontal plots and the irrigation intervals were arranged in the vertical plots. However, the potassium levels were assigned in the sub-plots. The sub-plot size was 15 m^2 (3 x 5 m).

Table (1): Mechanical and chemical properties the experimental soil sites.

Soil analysis	2013	2014
Mechanical analysis:		
Clay %	55.7	56.4
Silt %	29.8	31.2
Sand %	13.5	12.4
Texture class	clayey	clayey
Chemical analysis:		
E.C. dS/m	1.48	1.53
pH	8.06	7.94
Total N ppm	16.79	18.69
Available P ppm	12.91	14.17
Available K ppm	309	314
Available Zn ppm	0.91	0.93

The experimental field was prepared and well ploughed twice, then, dry leveled and submerged by water, then, water leveled. Seeds of rice cultivars were soaked in sufficient water for 24 hours and, then, incubated for 48 hours to enhance germination. Pre-germinated grains, of each tested rice cultivar at the rate of 120 kg/ha., were handily broadcasted on 15th and 19th of May in 2013 and 2014, respectively. Calcium super phosphate (15.5% P_2O_5) was added at the rate of 37 kg P_2O_5/ha. during dry land preparation, while, 165 kg N/ha. in the form of urea (46.5% N) was added into two splits (⅓ basaly + ⅓ at tillering stage and ⅓ at panicle initiation). However, potassium sulfate (48% K_2O) at each tested level was basaly applied and incorporated into dry soil. All other cultural practices for broadcast seeded rice during the growing season was applied as recommendations of Rice Research and Training Center.

Number of days from sowing up to 50 % heading of each sub-plot was recorded. At harvesting, ten main panicles from each sub-plot were randomly collected to determine average total number of grains/panicle, 1000-grain weight and unfield grains percentage. Moreover, number of tillers and panicles of 0.25 m^2 were counted and adjusted into square mater. Grain and straw yields in the inner 10 m^2 of each sub-plot were recorded and adjusted into tons/ha. at 14 % moisture content. Harvest index was determined by dividing weight of grain yield on the weight of biological yield. The percentages of hulling, milling and head rice were estimated, according to Juliano (1971) and Khush *et al.,* (1979). The volume or irrigation water applied in each irrigation treatment block was measured by a calibrated water meter with water pump. The amount water used before treatment was recorded, as well as, water required for irrigation treatments of all experiments. Water use efficiency was calculated as the weight of grains per unit of irrigation water received during crop growth (kg grains/m^3 water input), according to Michael (1978).

Data were subjected to analysis of variance, as described by Gomez and Gomez (1984), using IRRISTAT computer program. Treatment means were compared by Duncun's Multiple Range Test (DMRT), according to Duncan (1955).

RESULTS AND DISCUSSION

I. Vegetative growth parameters:

Rice cultivars performance:

Data in Table (2) indicated that significant variation among the three testes rice cultivars in their growth characters. Sakha 104 rice cultivar gave the tallest plants, the highest number of tillers/m^2 and the longest period to 50 % heading during both seasons. On the other side, the shortest plants and earliest heading were obtained by Giza 179 rice cultivar. Sakha 105 rice cultivar recorded the lowest number of tillers/m^2 and intermediate values of plant height and number of days to heading. The detected variation among the tested rice cultivars in studied growth characters could mainly be attributed to their genetic background. Similar differences among rice cultivars in growth patterns were obtained by El-Rewainy (2006) and Sheta (2010).

Influence of irrigation intervals:

Continuous flooding recorded the tallest plants, the maximum number of tillers/m^2 and reduced days to heading. While, irrigation every 9 days treatment gave the shortest plants, the lowest number of tillers/m^2 and delayed heading. Irrigation every 6 days came in between in both investigation seasons (Table 2).

The superiority of CF in inhancing rice growth might be due to water availability commensurable with vegetative growth stages. While, water shortage (irrigation every 9 days) might be affect cell elongation and division, resulted in short plants. Also, water stress might affect plant phonology due to the recovery period after each cycle of stress and watering which delaying or accelerating panicle exertion and heading stage (El-Ekhtyar, 2014a). These results are

in conformity with the findings of El-Refaee (2006) and Majid (2012).

Table (2): Effect of irrigation intervals and potassium levels on plant height, number of tillers/m^2 and days to 50% heading of some broadcast-seeding rice cultivars.

Treatments	Plant height (cm)		Number of tillers/m^2		Days to 50% heading	
	2013	2014	2013	2014	2013	2014
Rice cultivars (C):						
Sakha 104	105.1a	103.6a	467a	482a	104.8a	105.6a
Sakha 105	99.8b	98.9b	419c	446c	95.9b	96.8b
Giza 179	96.1c	94.8c	445b	459b	90.5c	91.2c
F-test	**	**	**	**	**	**
Irrigation intervals (I):						
Continuous flooding.	105.3a	102.7a	464a	488a	95.7c	96.5c
Irrigation every 6days.	102.1b	100.1b	456b	481b	97.4b	98.0b
Irrigation every 9 days.	93.6c	94.5c	411c	417c	98.1a	99.1a
F-test	**	**	**	**	**	**
Potassium levels (kg K_2O/ha):						
0 (control)	95.8d	94.2d	390d	399d	95.2d	95.7d
24	99.3c	98.4c	426c	442c	96.7c	97.5c
57	102.1b	101.0b	473b	497b	97.8b	98.6b
86	104.2a	102.8a	485a	511a	98.6a	99.7a
F-test	**	**	**	**	**	**
Interaction:						
C x I	**	**	**	**	N.S	N.S
C x K	N.S	N.S	N.S	N.S	N.S	N.S
I x K	N.S	N.S	**	**	N.S	N.S
C x I x K	N.S	N.S	N.S	N.S	N.S	N.S

* Significant at 0.05 level, ** Significant at 0.01 and N.S Not significant.
Means followed by the same letter are not significantly different, according to DMRT.

Impact of potassium levels:

Increasing potassium level up to 86 kg K_2O/ha., significantly increased plant height, number of tillers/m^2 and number of days to heading. Enhancing growth characters with increasing potassium level could be attributed to the role of potassium as activator of enzymes specific for a modifying internal hormone balancing (reducing ABA and increasing gibberellins and other activators concentrations) which, intern, delaying leaf senescence and increasing cell elongation. In addition, K may be relatively increases the uptake of nitrogen, consequently improves rice growth (Wang *et al.,* 2013). Such improvement in growth patterns due to potassium application were reported by Gobi *et al.* (2006), Manzoor *et al.* (2008) and El-Habet, Howida (2014).

Effect of the interactions:

It is clear from data presented in Table (2) that the interaction between rice cultivars and irrigation intervals had a significant effect on both plant height and number of tillers/m^2 in both seasons. The tallest plant and the maximum tillers number/m^2 were produced by Sakha 104 rice cultivar with continuous flooding, while, the shortest plants were recorded with Giza 179 rice cultivar when it irrigation every 9 days and the lowest number of tillers/m^2 was obtained

by Sakha 105 rice cultivar with irrigation every 9 days (Tables 3 and 4).

Table (3): Plant height (cm) as influenced by the interaction between rice cultivars and irrigation intervals under broadcast-seeded method.

Irrigation intervals	Rice cultivars					
	2013			2014		
	Sakha 104	Sakha 105	Giza 179	Sakha 104	Sakha 105	Giza 179
Continuous flooding	111.3a	104.9c	99.7d	108.1a	102.6c	97.4e
Irrigation every 6 days	107.9b	101.4d	970e	105.4b	100.2d	94.7f
Irrigation every 9 days	96.1e	93.1f	91.6f	97.2e	93.9f	92.3g

Means followed by the same letter are not significantly different, according to DMRT.

Table (4): Number of tillers/m^2 as influenced by the interaction between rice cultivars and irrigation intervals under broadcast-seeded method.

Irrigation intervals	Rice cultivars					
	2013			2014		
	Sakha 104	Sakha 105	Giza 179	Sakha 104	Sakha 105	Giza 179
Continuous flooding	486a	453c	454c	503a	475e	486c
Irrigation every 6 days	483a	414e	471b	497b	466f	481d
Irrigation every 9 days	433d	390f	409e	445g	397i	410h

Means followed by the same letter are not significantly different, according to DMRT.

With respect to the effect of the interaction between irrigation intervals and potassium levels on number of tillers/m^2, data in Table (5) indicated that, at the same irrigation regime, number of tillers/m^2 was significantly increased due to increasing potassium level up to 86 kg K_2O/ha. Moreover, at the same K level number of tillers/m^2 was significantly decreased due to increasing irrigation intervals up to 9 days.

II. Grain yield components:

Rice cultivars performance:

Data in Table (6) cleared that Sakha 104 rice cultivar gave the maximum number of panicles/m^2 and the highest unfield grains percentage. However, the highest total number of grains/panicle and the lowest unfield grains percentage were obtained by Giza 179 rice cultivar. The heaviest 1000-grain weight was recorded with Sakha 105 rice cultivar in both seasons. These varietal variations could mainly be due to genetic make up. The present findings are harmony with those reported by Saito *et al.* (2006) and Abou Khalifa (2014).

Influence of irrigation intervals:

The maximum number of panicles/m^2 and total grains/panicle, as well as, the heaviest 1000-grain weight were obtained continuous flooding by followed by irrigation every 6 days without any significant differences between them. Moreover, the lowest values of the above mentioned traits and the highest unfield grains percentage were belonged with irrigation every 9 days (Table 6). The reduction in grain yield components with irrigation every 9 days as compared to continuous flooding or irrigation every 6 days could be mainly attributed to the shortage of available water during critical growth stages of rice plants which, intern, decrease dry matter production and grain filling processes (Kamoshita *et al.,* 2008). Similar findings were obtained in this respect

by El-Refaee *et al.* (2008) and El-Ekhtyar (2014b).

Table (5): Number of tillers/m^2 as influenced by the interaction between irrigation intervals and potassium levels under broadcast-seeded method.

Potassium levels (kg K_2O/ha.)	Irrigation intervals					
	2013			2014		
	continuous flooding	6 days	9 days	continuous flooding	6 days	9 days
0 (control)	424e	400f	346g	429e	421f	348h
24	450cd	440d	389f	469c	459d	397g
57	484b	485b	450cd	520b	514b	457d
86	498a	500a	458c	534a	530a	468c

Means followed by the same letter(s) are not significantly different, according to DMRT.

Table (6): Effect of irrigation intervals and potassium levels on number of panicles/m^2, total number of grains/panicle, unfield grains percentage and 1000-grain weight of some broadcast-seeding rice cultivars.

Treatments	Number of panicles/m^2		Total number of grains/panicle		unfield grains (%)		1000-grain weight (g)	
	2013	2014	2013	2014	2013	2014	2013	2014
Rice cultivars (C):								
Sakha 104	450a	461a	146.4b	148.2b	12.47a	10.68a	27.34b	27.28b
Sakha 105	414c	432c	141.6c	143.2c	9.41b	8.16b	27.90a	27.56a
Giza 179	434b	444b	153.1a	155.2a	6.55c	6.96c	26.77c	26.63c
F-test	**	**	**	**	**	**	**	**
Irrigation intervals (I):								
Continuous flooding	459a	475a	155.2a	156.2a	6.98c	6.11c	28.08a	27.84a
Irrigation every 6days	447a	464a	152.4a	154.8a	8.63b	7.89b	27.70a	27.65a
Irrigation every 9 days	391b	398b	133.5b	135.7b	12.82a	11.80a	26.24b	26.01b
F-test	**	**	**	**	**	**	**	**
Potassium levels (kg K_2O/ha):								
0 (control)	374d	376d	138.0c	139.9c	12.54a	11.18a	26.00c	25.81c
24	419c	429c	145.1b	148.0b	9.94b	9.11b	27.16b	26.93b
57	459b	483b	151.2a	153.1a	8.36c	7.51c	27.89a	27.79a
86	478a	496a	153.9a	154.5a	7.06d	6.60d	28.30a	28.06a
F-test	**	**	**	**	**	**	**	**
Interaction:								
C x I	**	**	N.S	N.S	**	**	**	**
C x K	**	**	N.S	N.S	*	*	N.S	N.S
I x K	**	**	**	**	**	**	N.S	N.S
C x I x K	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S

* Significant at 0.05 level, ** Significant at 0.01 and N.S Not significant.
Means followed by the same letter are not significantly different, according to DMRT.

Impact of potassium levels:

Increasing potassium level up to 86 kg K_2O/ha significantly increased number of panicles/m^2. However, adding either 57 or 86 kg K_2O/ha. recorded the maximum and significant values of total number of grains/panicle and 1000-grain weight. Unfield grains percentage was significantly decline with increasing potassium level during both investigation seasons (Table 6). These results might be due to the positive effect of potassium in encouraging faster and earlier growth and improving the photosynthesis rate, which, consequently increased storage carbohydrates at pre-heading, which relatively translocated to the panicles, consequently increased filling of spikelets. These findings are in agreement with those reported by Kavitha *et al.* (2009) and Mashmann *et al.* (2010).

Effect of the interactions:

Data in Table (6) cleared that the interactions among the study factors were significant on number of panicles/m^2 in both seasons accept for the three diminution interaction. At the same irrigation interval, Sakha 104 rice cultivar recorded the maximum number of panicles/m^2, while, the lowest values were obtained by Sakha 105 rice cultivar (Table 7). In addition, at the same potassium level, Sakha 104 rice cultivar gave the maximum number of panicles/m^2 and the highest values in this respect were found when Sakha 104 rice cultivars was fertilized with 86 kg K_2O/ha., during both seasons (Table 8).

Data in Table (9) cleared that the maximum number of panicles/m^2 was obtained with continuous flooding and 86 kg K_2O/ha. Meanwhile, the lowest number of panicles/m^2 was recorded by irrigation every 9 days without potassium fertilization.

Table (7): Number of panicles/m^2 as influenced by the interaction between rice cultivars and irrigation intervals under broadcast-seeded method.

Irrigation intervals	Rice cultivars					
	2013			2014		
	Sakha 104	Sakha 105	Giza 179	Sakha 104	Sakha 105	Giza 179
Continuous flooding	471a	448c	458bc	488a	463c	474b
Irrigation every 6 days	467ab	419d	456c	479b	448d	465c
Irrigation every 9 days	412d	375f	387e	416e	385f	393f

Means followed by the same letter(s) are not significantly different, according to DMRT.

Table (8): Number of panicles/m^2 as influenced by the interaction between rice cultivars and potassium levels under broadcast-seeded method.

Potassium levels (kg K_2O/ha.)	Rice cultivars					
	2013			2014		
	Sakha 104	Sakha 105	Giza 179	Sakha 104	Sakha 105	Giza 179
0 (control)	394f	355h	372g	383i	367k	376j
24	439d	400f	417e	441f	416h	428g
57	479b	439d	460c	504b	463e	482d

86	489a	461c	485ab	515a	481d	491c

Means followed by the same letter(s) are not significantly different, according to DMRT.

Table (9): Number of panicles/m^2 as influenced by the interaction between irrigation intervals and potassium levels under broadcast-seeded method.

Potassium levels (kg K_2O/ha.)	Irrigation intervals					
	2013			2014		
	continuous flooding	6 days	9 days	continuous flooding	6 days	9 days
0 (control)	413f	388g	319i	414g	392h	320j
24	448d	432e	376h	460de	454e	372i
57	474c	477c	427e	510ab	501c	438f
86	501a	492b	442d	517a	509b	462d

Means followed by the same letter(s) are not significantly different, according to DMRT.

Among all possible interactions, the interaction between irrigation intervals and potassium levels had a significant effect on total number of grains/panicle. The maximum value was recorded by continuous flooding or irrigation every 6 days, when 57 or 86 kg K_2O/ha. was applied (Table 10).

Data in Table (11) revealed that at the same irrigation interval, Giza 179 rice cultivar recorded the lowest unfield grains percentage, while, the highest values were obtained by Sakha 104 rice cultivar. On the contrary, at the same rice cultivars unfield grains percentage was increased by increasing irrigation intervals up to 9 days.

As for the effect of the interaction between rice cultivars and potassium levels on unfield grains percentage, data illustrated in Table (12) shown that at the same rice cultivar, unfield grains percentage was significantly decreased by increasing potassium level up to 86 kg K_2O/ha. On the other side at, the same potassium level, Giza 179 rice cultivar gave the lowest unfield grains percentage.

Continuous flooding with 86 kg K_2O/ha. recorded the lowest unfield grains percentage (Table 13).

Data in Table (14) indicated that Sakha 105 rice cultivar produced the heaviest 1000-grain weight at any irrigation regime.

III. Grain yield, straw yield and harvest index:

Rice cultivars performance:

Result in Table (15) shows that Giza 179 following by Sakha 104 rice cultivars recorded the highest grain yield without any significant differences between each other. In addition, Sakha 104 and Sakha 105 rice cultivar gave the maximum straw yield without significant differences between them. The highest harvest index was obtained by Giza 179 rice cultivar and the lowest ones was produced by Sakha 105 rice cultivar. The superiority of Giza 179 and Sakha 104 rice cultivars in grain yield could be attributed mainly to high values of grain yield components and genetic background. Such varietal variation were recorded by El-Refaee *et al.* (2005) and El-Refaee *et al.* (2012).

Influence of irrigation intervals:

Either continuous flooding or irrigation every 6 days recorded the maximum and significant grain and straw yields, as well as, harvest index during both seasons (Table 15). The superiority in improving rice productivity may be attributed to increased yield attributes, also, the available water enhanced the production and exporting the dry matter content to panicle, resulting more grain filling and weight, as well as, grain yield (El-Refaee, 2006). Similar findings were reported by Zayed *et al.* (2007), Ali *et*

al. (2012), El-Habet, Howida (2014) and Babaeian *et al.* (2015).

Impact of potassium levels:

Increasing potassium level up to 86 kg K_2O/ha. significantly increased both grain and straw yields. However, the differences between 57 and 86 kg K_2O/ha. in grain yield were not significant in both seasons. On the other side, harvest index was not significantly affected by potassium application rates (Table 15). The positive effect of potassium in improving rice productivity might be due to that K increases number of grains/panicle, percentage of filled grains and 1000-grain weight, also, K increases photosynthesis rate which increase stored carbohydrates and grain filling processes (Szczerba *et al.,* 2009). Such effects of potassium levels on rice productivity were, also, recorded by Pillal and Anasuya (1997), Li (2014) and Javad *et al.* (2015).

Table (10): Total number of grains/panicle as influenced by the interaction between irrigation intervals and potassium levels under broadcast-seeded method.

Potassium levels (kg K_2O/ha.)	Irrigation intervals					
	2013			2014		
	continuous flooding	6 days	9 days	continuous flooding	6 days	9 days
0(control)	147.0de	144.1e	122.9h	148.6d	146.0de	25.0h
24	452.9c	149.5d	132.7g	156.1b	153.6c	134.2g
57	159.1ab	156.7b	137.9f	160.6a	158.8ab	140.0f
86	161.7a	159.3ab	150.5f	159.4ab	160.7a	143.4ef

Means followed by the same letter(s) are not significantly different, according to DMRT.

Table (11): Unfield grains percentage as influenced by the interaction between rice cultivars and irrigation intervals under broadcast-seeded method.

Irrigation intervals	Rice cultivars					
	2013			2014		
	Sakha 104	Sakha 105	Giza 179	Sakha 104	Sakha 105	Giza 179
Continuous flooding	9.21d	6.46g	5.27i	7.92d	5.76f	4.64g
Irrigation every 6 days	12.19c	7.78f	5.92h	9.74c	7.44d	6.50e
Irrigation every 9 days	16.00a	14.00b	8.46e	14.38a	11.28b	9.73c

Means followed by the same letter are not significantly different, according to DMRT.

Table (12): Unfield grains percentage as influenced by the interaction between rice cultivars and potassium levels under broadcast-seeded method.

Potassium levels (kg K_2O/ha.)	Rice cultivars					
	2013			2014		
	Sakha 104	Sakha 105	Giza 179	Sakha 104	Sakha 105	Giza 179

0 (control)	16.11a	12.67b	8.83e	13.28a	10.97b	9.28cd
24	12.69b	10.33d	6.80g	11.16b	8.93d	7.24e
57	11.18c	8.23f	5.68h	9.55c	6.98e	6.01f
86	9.88d	6.41g	4.89i	8.73d	5.77fg	5.29g

Means followed by the same letter(s) are not significantly different, according to DMRT.

Table (13): Unfield grains percentage as influenced by the interaction between irrigation intervals and potassium levels under broadcast-seeded method.

Potassium levels (kg K_2O/ha.)	Irrigation intervals					
	2013			2014		
	continuous flooding	6 days	9 days	continuous flooding	6 days	9 days
0 (control)	9.69d	11.43c	16.50a	7.88e	10.12c	15.53a
24	7.15e	9.27d	13.41b	6.32fg	8.59d	12.43b
57	5.79g	7.29e	12.00c	5.44h	6.84f	10.26c
86	5.28g	6.53f	9.37d	4.81i	6.02g	8.96d

Means followed by the same letter(s) are not significantly different, according to DMRT.

Table (14): 1000-grain weight (g) as influenced by the interaction between rice cultivars and irrigation intervals under broadcast-seeded method.

Irrigation intervals	Rice cultivars					
	2013			2014		
	Sakha 104	Sakha 105	Giza 179	Sakha 104	Sakha 105	Giza 179
Continuous flooding	28.11b	28.81a	27.31d	27.92ab	28.28a	27.23c
Irrigation every 6 days	27.63c	28.34b	27.13d	27.74b	28.16a	27.05c
Irrigation every 9 days	26.29f	26.57e	25.86g	26.8d	26.18d	25.60e

Means followed by the same letter(s) are not significantly different, according to DMRT.

Table (15): Effect of irrigation intervals and potassium levels on grain yield, straw yield and harvest index of some broadcast-seeding rice cultivars.

Treatments	Grain yield (t/ha.)		Straw yield (t/ha.)		Harvest index	
	2013	2014	2013	2014	2013	2014
Rice cultivars (C):						
Sakha 104	9.61a	9.73a	13.62a	13.59a	40.97b	41.20b
Sakha 105	8.95b	8.88b	13.35a	13.38a	40.38c	40.14c
Giza 179	9.92a	10.07a	12.80b	12.67b	43.55a	44.46a
F-test	**	**	*	*	**	**
Irrigation intervals(I):						
Continuous flooding	10.21a	10.14a	13.77a	13.89a	42.56a	42.19a
Irrigation every 6days	9.98a	9.86a	13.57a	13.52a	42.35a	42.13a
Irrigation every 9 days	8.29b	8.68b	12.43b	12.24b	39.99b	41.48b
F-test	**	**	**	**	*	*
Potassium levels (kg K_2O/ha.):						
0 (control)	8.62c	8.75c	12.21d	12.26d	41.29	41.65
24	9.30b	9.46b	13.15c	13.07c	41.37	41.90
57	9.77a	9.90a	13.66b	13.56b	41.92	42.17
86	10.15a	10.13a	14.01a	13.97a	41.96	42.01

F-test	**	**	**	**	N.S	N.S
Interaction:						
C x I	N.S	N.S	**	**	N.S	N.S
C x K	**	**	N.S	N.S	N.S	N.S
I x K	**	**	N.S	N.S	N.S	N.S
C x I x K	N.S	N.S	N.S	N.S	N.S	N.S

* Significant at 0.05 level, ** Significant at 0.01 and N.S Not significant.
Means followed by the same letter(s) are not significantly different, according to DMRT.

Effect of the interactions:

It could be easily observed from data presented in Table (16) that, the highest grain yield was produced by Giza 179 rice cultivar when fertilized with either 57 or 86 kg K_2O/ha.

The effect of the interaction between irrigation intervals and potassium levels on grain yield presented in Table (17). Its clear that the maximum and significant grain yield was obtained with continuous flooding when 57 or 86 kg K_2O/ha. was added without any significant differences between them, while, under irrigation every 6 days grain yield was significantly increased due to increasing potassium level up to 86 kg K_2O/ha.

The maximum straw yield was produced by Sakha 104 and Sakha 105 rice cultivars with continuous flooding. On the other hand, Giza 179 rice cultivar recorded the lowest straw yield when it irrigated every 9 days in the first and the second seasons (Table 18).

Harvest index was not significantly affected by all possible interactions during both seasons (Table 15).

Table (16): Grain yield (t/ha) as influenced by the interaction between rice cultivars and potassium levels under broadcast-seeded method.

Irrigation intervals	Rice cultivars					
	2013			2014		
	Sakha 104	Sakha 105	Giza 179	Sakha 104	Sakha 105	Giza 179
0 (control)	8.58g	8.35g	8.96ef	8.93de	8.10f	9.22cd
24	9.41cd	8.65fg	9.86b	9.55c	8.76e	10. 8b
57	10.01b	9.27de	10.37a	10.07b	9.21cd	10.42ab
86	10.45a	9.53bc	10.50a	10.37ab	9.46c	10.56a

Means followed by the same letter(s) are not significantly different, according to DMRT.

Table (17): Grain yield (t/ha.) as influenced by the interaction between irrigation intervals and potassium levels under broad cast-seeded method.

Potassium levels (kg K_2O/ha.)	Irrigation intervals					
	2013			2014		
	continuous flooding	6 days	9 days	continuous flooding	6 days	9 days
0 (control)	9.40ef	9.29f	7.20i	9.46e	8.99f	7.81h
24	9.98cd	9.70de	8.24h	10.09cd	9.82d	8.48g
57	10.58ab	10.29bc	8.78g	10.42ab	10.15bc	9.12f
86	10.89a	10.64a	8.95g	10.59a	10.48a	9.31ef

Means followed by the same letter(s) are not significantly different, according to DMRT.

Table (18): Straw yield (t/ha) as influenced by the interaction between rice cultivars and irrigation intervals under broadcast-seeded method.

Irrigation intervals	Rice cultivars

	2013			2014		
	Sakha 104	Sakha 105	Giza 179	Sakha 104	Sakha 105	Giza 179
Continuous flooding	14.07a	13.95a	13.26c	14.19a	14.04ab	13.43d
Irrigation every 6 days	13.91ab	13.64b	13.16cd	13.86bc	13.71c	12.99e
Irrigation every 9 days	12.89d	12.43e	11.97f	12.73e	12.39f	11.60g

Means followed by the same letter(s) are not significantly different, according to DMRT.

IV: Some of grain quality characters:

Rice cultivars performance:

Data in Table (19) indicated that the three tested rice cultivars were significantly varied in their studied grain quality characters. The maximum hulling, milling and head rice percentages were obtained by Sakha 104 rice cultivar. On the other side, Giza 179 rice cultivar gave the lowest percentages of the above mentioned grain quality characters. Sakha 105 rice cultivar recorded intermediate values in this respect. Such variation probably due to genetic variability among the tested rice cultivar. Similar outcomes were obtained by El-Sheref *et al.* (2004) and El-Refaee *et al.* (2006).

Influence of irrigation intervals:

Data in Table (19) clarified that irrigation treatments had highly significant effect on hulling, milling and head rice percentages during both investigation seasons, where, increasing irrigation intervals from CF up to 9 days significantly decreased the percentages of hulling, milling and head rice. However, the difference between continuous flooding and irrigation every 6 days treatments in milling percentage was not significant. The obtained results are in accordance with the findings of Lee *et al.* (1996).

Table (19): Effect of irrigation intervals and potassium levels on hulling, milling and head rice percentages of some broadcast-seeding rice cultivars.

Treatments	Hulling (%)		Milling (%)		Head rice (%)	
	2013	2014	2013	2014	2013	2014
Rice cultivars (C):						
Sakha 104	82.12a	82.45a	72.67a	72.33a	61.55a	62.21a
Sakha 105	80.83b	81.24b	70.89b	71.26b	60.69b	61.07b
Giza 179	79.71c	79.65c	69.91c	69.85c	59.48c	60.12c
F-test	**	**	**	**	**	**
Irrigation intervals (I):						
Continuous flooding	82.03a	82.22a	72.28a	71.87a	62.14a	62.52a
Irrigation every 6days	80.96b	81.33b	71.87a	71.61a	60.36b	61.14b
Irrigation every 9 days	79.67c	79.79c	69.32b	69.96b	59.23c	59.74c
F-test	**	**	**	**	**	**
Potassium levels (kg K_2O/ha.):						
0 (control)	79.44d	79.79c	69.22c	70.05c	59.02d	59.57c
24	80.32c	80.77b	70.88b	70.95b	60.28c	60.86b
57	81.49b	81.84a	71.98a	71.59a	61.29b	61.79a
86	82.31a	82.04a	72.54a	71.99a	61.71a	62.31a
F-test	**	**	**	**	**	**
Interaction:						

C x I	**	**	**	**	**	**
C x K	**	**	*	*	N.S	N.S
I x K	*	*	N.S	N.S	N.S	N.S
C x I x K	N.S	N.S	N.S	N.S	N.S	N.S

* Significant at 0.05 level, ** Significant at 0.01 and N.S Not significant.
Means followed by the same letter are not significantly different, according to DMRT.

Impact of potassium levels:

Increasing potassium level up to 86 kg K_2O/ha. significantly increased hulling, milling and head rice percentages, while, the differences between 86 and 57 kg K_2O/ha in milling percentage during both seasons and head rice percentage in the second season were not significant (Table 19). Improving studied grain quality by potassium application could be mainly attributed to improve grain filling and minimize the thickness of rice hull. Similar results were reported by Bahmanjar and Ranjbar (2007).

Effect of the interactions:

Data in Table (20) clarified that the highest percentage of hulling was obtained by Sakha 104 rice cultivar with continuous flooding during both seasons. However, irrigated Giza 179 rice cultivar every 9 days recorded the lowest hulling percentage.

At the same potassium level, Sakha 104 rice cultivar recorded the maximum hulling percentage followed by Sakha 105 and Giza 179 (Table 21).

As for the effected of the interaction between irrigation intervals and potassium levels, data in Table (22) shows that at the same potassium level hulling percentage was significantly decreased by increasing irrigation intervals up to 9 days.

Table (20): Hulling percentage as influenced by the interaction between rice cultivars and irrigation intervals under broadcast-seeded method.

Irrigation intervals	Rice cultivars					
	2013			2014		
	Sakha 104	Sakha 105	Giza 179	Sakha 104	Sakha 105	Giza 179
Continuous flooding	83.12a	81.96b	81.03c	83.46a	82.26b	80.94d
Irrigation every 6 days	81.95b	81.17c	79.76d	82.62b	81.54c	79.83c
Irrigation every 9 days	81.29c	79.38d	78.34e	81.27cd	79.92e	78.18f

Means followed by the same letter are not significantly different, according to DMRT.

Table (21): Hulling percentage as influenced by the interaction between rice cultivars and potassium levels under broadcast-seeded method.

Potassium levels (kg K_2O/ha.)	Rice cultivars					
	2013			2014		
	Sakha 104	Sakha 105	Giza 179	Sakha 104	Sakha 105	Giza 179
0 (control)	80.91ef	79.36h	78.05i	81.59cd	79.80fg	77.99h
24	81.80cd	80.17g	78.99h	81.87c	80.95de	79.50g
57	82.48b	8.49de	80.50fg	82.93ab	82.01c	80.60ef
86	83.29a	82.33bc	81.30de	83.41a	82.21bc	81.51ef

Means followed by the same letter(s) are not significantly different, according to DMRT.

Table (22): Hulling percentage as influenced by the interaction between irrigation intervals and potassium levels under broadcast-seeded method.

Potassium levels	Irrigation intervals

($kg K_2O$/ha.)	2013			2014		
	continuous flooding	6 days	9 days	continuous flooding	6 days	9 days
0 (control)	80.62de	79.48f	78.21g	80.77e	80.22ef	78.40g
24	81.39c	80.34e	79.23f	81.83ab	81.02de	79.47f
57	82.80ab	81.46c	80.21e	83.05ab	81.78cd	80.71e
86	83.34a	82.56b	81.03cd	83.24a	82.31bc	80.58e

Means followed by the same letter(s) are not significantly different, according to DMRT.

The highest milling percentage was produced by Sakha 104 rice cultivar with either continuous flooding or irrigation every 6 days (Table 23).

Sakha 104 rice cultivar when fertilized with either 57 or 86 kg K_2O/ha. recorded the maximum and significant milling percentage in both seasons, while, the lowest milling percentage was obtained by Giza 179 rice cultivar without potassium fertilization (Table 24).

Data in Table (25) revealed that Sakha 104 rice cultivar with continuous flooding gave the maximum head rice percentage.

V: Water relations:

Data in Table (26) indicated that both water used through irrigation and total water applied were decreased due increasing irrigation intervals from continuous flooding up to irrigation every 9 days.

The highest water use efficiency was recorded with irrigation every 6 days, while, continuous flooding gave the lowest water use efficiency in first and second seasons (Table 27). Interestingly, the irrigation interval of 9 days saved more amount of irrigation water, but, increased the yield reduction to the maximum values. Furthermore, the intermittent irrigation interval of 6 days clearly mediated the two irrigation intervals in amount of irrigation water saved and it recorded the minimum yield reduction. There for irrigation every 6 days interval could be the optimum irrigation regime for obtaining high water use and save some of irrigation water with minimizing grain yield reduction.

At the same potassium level, irrigation every 6D recorded the maximum values of water use efficiency. Moreover, at the same irrigation interval water use efficiency was increased by increasing potassium level (Table 28).

Table (23): Milling percentage as influenced by the interaction between rice cultivars and irrigation intervals under broadcast-seeded method.

Irrigation intervals	Rice cultivars					
	2013			2014		
	Sakha 104	Sakha 105	Giza 179	Sakha 104	Sakha 105	Giza 179
Continuous flooding	73.20ab	72.34dc	71.29cde	73.04a	71.92b	70.65cd
Irrigation every 6 days	73.66a	71.56cd	70.40e	72.68a	71.79b	70.36d
Irrigation every 9 days	71.15de	68.77f	68.02f	71.28bc	70.07d	68.53e

Means followed by the same letter(s) are not significantly different, according to DMRT.

Table (24): Milling percentage as affected by the interaction between rice cultivars and potassium levels under broadcast-seeded method.

Potassium levels ($kg K_2O$/ha.)	Rice cultivars	
	2013	2014

	Sakha 104	Sakha 105	Giza 179	Sakha 104	Sakha 105	Giza 179
0 (control)	70.50cd	68.36e	68.79e	70.96de	70.40e	68.81g
24	72.77ab	70.62cd	69.24de	72.34bc	70.98de	69.55f
57	73.62a	71.84bc	70.47cd	72.84ab	71.59cd	70.33e
86	73.79a	72.73ab	71.12c	73.21a	72.07bc	70.70e

Means followed by the same letter(s) are not significantly different, according to DMRT.

Table (25): Head rice percentage as influenced by the interaction between rice cultivars and irrigation intervals under broadcast-seeded method.

Irrigation intervals	Rice cultivars					
	2013			2014		
	Sakha 104	Sakha 105	Giza 179	Sakha 104	Sakha 105	Giza 179
Continuous flooding	63.02a	61.94b	61.46c	63.48a	62.23b	61.85bc
Irrigation every 6 days	61.11cd	60.76de	59.21f	61.97bc	61.36bc	60.09d
Irrigation every 9 days	60.53e	59.38f	57.77g	61.18c	59.61d	58.43e

Means followed by the same letter(s) are not significantly different, according to DMRT.

Table (26): Water use before treatments, water use trough treatments and total water applied as influenced by irrigation intervals under broadcast-seeded method.

Irrigation intervals	Water use before treatments (m^3/ha.)		Water used through irrigation (m^3/ha.)		Total water applied (m^3/ha.)	
	2013	2014	2013	2014	2013	2014
Continuous flooding	4093.6	4217.3	9420.6	9346.8	13514.2	13564.1
Irrigation every 6 days			8262.4	7921.4	12356.0	12138.7
Irrigation every 9 days			6655.0	6806.5	10748.6	11023.8

Table (27): Water saved, yield redaction and water use efficiency as influenced by irrigation intervals under broadcast-seeded method.

Irrigation intervals	Water saved (%)		Grain yield reduction (%)		Water use efficiency (kg/m^3)	
	2013	2014	2013	2014	2013	2014
Continuous flooding	-	-	-	-	0.756	0.748
Irrigation every 6 days	8.57	10.51	2.25	2.76	0.808	0.812
Irrigation every 9 days	20.46	18.73	18.81	14.40	0.771	0.787

Table (28): Water use efficiency (kg/m^3) as influenced by the interaction between irrigation intervals and potassium levels under broad cast-seeded method.

Potassium levels (kg K_2O/ha.)	Irrigation intervals	
	2013	2014

	continuous flooding	6 days	9 days	continuous flooding	6 days	9 days
0 (control)	0.696	0.752	0.669	0.698	0.741	0.709
24	0.739	0.785	0.767	0.744	0.809	0.769
57	0.783	0.833	0.817	0.768	0.836	0.827
86	0.803	0.861	0.833	0.781	0.864	0.845

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استجابة بعض أصناف الأرز لفترات الرى ومستويات البوتاسيوم تحت طريقة الزراعة البدار

بطرس بشرى يوسف ميخائيل

مركز البحوث والتدريب فى الأرز . معهد بحوث المحاصيل الحقلية . مركز البحوث الزراعية . سخا . كفرالشيخ . مصر

الملخص العربى

أجريت تجربتان حقليتان خلال موسمى ٢٠١٣ و ٢٠١٤م باستخدام طريقة الزراعة البدار بالمزرعة البحثية لمركز البحوث والتدريب فى الأرز ، سخا ، كفرالشيخ ، مصر ويهدف هذا البحث إلى دراسة استجابة ثلاثة أصناف من الأرز وهى: سخا ١٠٤ ، سخا ١٠٥ ، جيزه ١٧٩ لفترات الرى وهى: الغمر المستمر ، والرى كل ستة أيام ، الرى كل تسعة أيام وأيضا مستويات التسميد البوتاسى وهى: صفر (بدون إضافة بوتاسيوم) ، ٢٩ ، ٥٧ ، ٨٦ كجم بو$_٢$أ/هكتار. ، وقد أظهرت أهم النتائج المتحصل عليها أن أعلى القيم لصفات ارتفاع النباتات ، وعدد الأشطاء/م^٢ ، وعدد الأيام من الزراعة حتى تزهير ٥٠% من النباتات ، وعدد الداليات/م^٢ وكذلك أقصى نسبة مئوية من التقشير والتبييض والتدريج قد سجلت مع صنف الأرز سخا ١٠٤. علاوة على ذلك ، فقد أعطى صنف الأرز جيزه ١٧٩ القيم لدليل الحصاد وأقل نسبة من الحبوب الفارغة. سجل صنفى الأرز سخا ١٠٤ وجيزه ١٧٩ أعلى القيم لمحصول الحبوب بدون فروق معنوية بينهما ، فى حين سجلت أعلى القيم لمحصول القش مع صنفى الأرز سخا ١٠٤ وسخا ١٠٥ بدون فروق معنوية بينهما. أوضحت النتائج أيضا أن أطول النباتات وأقصى عدد من الأشطاء/م^٢ وأعلى النسب المئوية من التقشير والتدريج قد لوحظت مع الغمر المستمر. سجلت معاملتى الرى الغمر المستمر والرى كل ستة أيام أعلى القيم لعدد الداليات/م^٢ ، وعدد الحبوب/الدالية ، وأثقل وزن للألف حبة ، وأعلى محصول للقش والحبوب وأكبر دليل حصاد بدون فروق معنوية بينهما. فى حين أن الرى كل تسعة أيام أعطى أطول فترة حتى التزهير وأعلى نسبة من الحبوب الفارغة. أظهرت النتائج أيضا أن إضافة السماد البوتاسى بالمعدل ٥٧ أو ٨٦ كجم بو$_٢$أ/هكتار قد سجل أعلى القيم لعدد الحبوب/دالية ووزن الألف حبة ومحصول الحبوب والنسبة المئوية للتبييض دون فروق معنوي بينهما ، فى حين لم يتأثر دليل الحصاد معنويا بمستويات التسميد البوتاسى. سجل الغمر المستمر أعلى كمية من مياه الرى بينما أقل كمية قد لوحظ مع الرى كل تسعة أيام. معاملة الرى كل

ستة أيام أعطت محصول حبوب قريب من الغمر المستمر مع أقل كمية الماء المضاف كما أعطت أعلى القيم لكفاءة الاستهلاك المائى.