

## RICE YIELD AND YIELD COMPONENTS AS AFFECTED BY IRRIGATION INTERVAL, CULTIVARE, TRANS PLANT SPACING AND THEIR INTERACTIONS

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### *Abstract*

A two-year experiment was carried out on rice (*Dryza sativa* L.), during 2006 (S1) and 2007 (S2), at the Rice Research and Training Center (RRTC) at Sakha, Kafr El-Sheikh Governorate, Egypt. The trail included three factors, viz. irrigation intervals (6 "1-6", 9 "1-9" and 12 "1-12" days), three rice cultivars (Sakha 101 "Sk-101", Sakha 103 "Sk-103" and sakha 104 "Sk-104") and three plant trans spacing (15x 15 "PS1", 15x20 "PS2" and 15x25 "PS3" cm). A split-split plot design was used. Experimental plot area was 15 m<sup>2</sup>. Eight traits were studied. Water use efficiency was estimated. Simple correlation coefficients were calculated. Curve estimation was performed too. The obtained results in both seasons showed the following: Significant differences were detected on all traits as respects the studied three factors. Concerning irrigation effect, a general trend was observed in most traits, where the 1-6 significantly exceeded 1-9 which surpassed 1-12. An opposite trend was observed with sterility% and 1000 grain weight. The highest grain yield/fed. was 4.52 in S1 and 4.17 ton in S2. Among cultivars, Sk-101 was the superior one in most cases followed by Sk-103 then Sk-104, such superior cultivar yielded 4.27 and 4.23 ton grain/fed. in S1 and S2, respectively.

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Sakha-104 gave the pronounced straw yield/fed., viz 9.85 ton in S1 and 9.04 ton in S2. According to spacing, the narrowest one 15x15 cm "PSI" out yielded the other two spacings. Such superior spacing treatment produced 4.49 and 4.12 ton/fed. in S1 and S2, respectively. The 1000 grain weight was the highest when planting was done at wider spacing (15x25 cm).

For first order interactions, significance was shown with irrigation x cultivar in four traits including grain yield/fed. The combination 1-6xSk-IOI yielded 5.31 in S1 and 4.74 ton/fed in S2. For irrigation x spacing interaction, significant differences were obtained also in the same four traits previously mentioned, with minor deviation. The (1-6xPSI) yielded the pronounced grain yield/fed., viz 5.59 in S1 and 4.62 ton in S2. The first order interaction showed its highest significant grain yield by Sk-101xPSI which yielded. 5.28 in S1 and 4.69 ton/fed. in S2. The second order interaction showed insignificant effects with all aspects.

Water use efficiency was significantly affected by the three main factors and the first order interaction irrigation x cultivar only. The pronounced treatments previously mentioned produced the highest WUE. Correlation was highly significant in all aspects. It was positive in most cases. However, the correlation of sterility % and 1000 grain weight with other traits was negative. Curve estimation illustrated that the relation between grain yield and total applied water was a quadratic one in both seasons.

**Key words:** Rice , Irrigation Cultivars, Plant Spacing, Yield and Yield Components.

## INTRODUCTION

In Egypt, conventional irrigation method of rice consumes greater water, putting rice in the first demand among summer crops, sugar cane, maize and cotton. The high demand by rice lies in high water applying/fed.,

i.e. more than 6000 m<sup>3</sup> as well as the increased rice cultivated area which exceeded 2.0 million fed., in the last few years .

The total high water use by rice causes certain difficulties which negatively affect yields of summer thirsty crops. FAO STAT, (2005) stated that the Egyptian total consumption, production and export of milled rice were 3.28, 3.74 and 1.07 million ton, respectively. Egypt is mainly depending on water from River Nile (55.5 Milliard m<sup>3</sup> yearly). Rice alone consumes about 25% of such water. No doubt, the Government lightly intends to reduce rice growing areas by almost 50% of its current area, as a wise step to achieve better water management .

The successful fit policy of water saving depends on some factors, including lengthening irrigation interval, use of early rice cultivars and good weed control. Several researchers showed that rice can normally grow with high yield under shallow water depth than under deep one, In this respect, Mosalem et al, (1998) Abou Khalifa, (2001) and EI-Sharkawy et al. (2006) reported that continuous flooding irrigation every three days resulted in highest grain yield without significant *difference* with irrigation every 6 days. Egyptian rice cultivars produced higher yield when water control of soil is kept near saturation throughout the growing season (2005).

Irrigation interval was prolonged in the assay of Abou Khalifa et al, (2001) to 4:7 days. They concluded that such interval surpassed the others in the term of grain yield production. The interval of 6-days gave reasonable production of rice grain and most of its components. as mentioned by Ibrahim *et al*, (1988 and 1995) Mosalem et al, (1998) EI-Kalla *et al*, (2006) as well as EI-Bably *et al*, (2000). On the other hand. lengthening irrigation interval over 6 days considerably reduced grain yield and most of yield components. Prolonging irrigation interval causes a degree of water stress. which is considered, in studies of Vivekanandan *et al*, (2005) and Sarvestani

*et al*, (2005), as negative effects on grain yield. Water stress begins through 8-12 days. However, some investigators estimated water stress after 8 days. El-Refaee *et al*, (2005) 9 and 12 days. Mosalem *et al*, (1998) and 10 days. In addition. Nour *et al*, (1994) considered 12-day interval as the successful procedure to save water without remarkable reduction in grain yield .

The cultivars are the pass word of pronounced crop production. expressing different phenotypes. Such differences characterize the cultivar to be more suitable for certain purpose than other one. Several rice cultivars. with different ideal types spread all over the world. Thereafter, it could be expected that the rice varietal variation was detected in many studies. Generally such variation is attributed to the different genetic structure, however the hybrids vary than inbreds, (Gautam *et al*, 2005 and Mishra *et al*, 2005) . Some authors attributed varietals variation to crop duration, Nayak and patra, 2000. In contrast, varietals' variation was absent in the assay of Kadum *et al*, (2008) and Sarvestani *et al*, (2008). Some studies confirmed the superiority of Sk-IOI over Giza 177. In addition, Abd El-Maksoud, (2008) pointed out that Sk-103 and Sk-104 RRTC (2000) out yielded Sk-104 in respect of yield and most yield components. Oppositely. Sk-104 exceeded Sk-103 in its yield, El-Refaee *et al*(2004) as well as Fawzi and Badawi (2006) .

Plant spacing had a significant role on irrigation regime. Wider spacing increases the evaporation from the soil surface and consequently increases evapotranspiration. It may also enhances the growth of accompanied weeds which consume water as or higher than rice itself. Varying reports on the effect of spacing show its dependence on some factors including cultivar (tillering ability) and soil fertility. The wider spacing, (20x20 cm) and more were recommendable in many studies. of them Gupta and Sharma, (1999), Mishra *et al*, (2005) as well as Sultan and

Kaleem (2008). Oppositely. many investigators believed in the value of narrower spacing (15x15 cm) and less. The list of such believers includes Zayed et al (2005) and Salem (2006) .

The interaction between irrigation and varieties is a good establishment as was observed in the studies of Singh and Choudhury (2007). In Egypt. Abou EI-Hassan *et al*, (2006) found insignificant interaction between irrigation and cultivars. Oppositely. EI-Refaei *et al*, (2004) found positive interaction between 3-day interval and both Sk-101 and Sk-104. Abou EI-Hassan et al, (2006) found similar interaction between 6 days interval and Sk-101 cv. He added that such effect saved 8.6% of irrigation water. EI-Kalla *et al*, (2006) pointed out that Sk-104 cultivar was more tolerant to prolonging irrigation interval .

As regards the interaction between cultivar and spacing. Lourduraj, (1999) reported that the yield of low tillering cultivar declined as plant spacing increased from (15x15 to 25x25 cm) and in reverse. He added that medium duration cultivars achieve maximum yield by (20x10 cm) spacing. With this point, Nayak and Patra. (2000) found that a cultivar with 100 days duration requires (10x10 cm) spacing. While a cultivar with 135 days duration needs a spacing of (15x10 cm). khawshi *et al*, (2009) concluded similar trends. Also, Badawi and Ghanem. (2004) reported that plant spacing depended upon the variety and its tillering ability. However a variety with low ability can grow in narrow spacing and inverse. In addition. Guatam et al. (2005) and Mishra et al, (2005) reported that a certain variety needs certain spacing .

The current study aimed to investigate the effect of irrigation intervals, spacing of transplanting on the yield and some yield components of three newly rice cultivars. The final target was to develop a combination among the three factors giving good features and high rice yield .

## MATERIAL AND METHODS

A two-year experiment was running in Rice Research and Training center (RRTC) Sakha, Kafr El-Sheikh Governorate. Egypt in 2006 (S I) and 2007 (S2). The study involved three rice cultivars, three irrigation intervals and three trans plant spacing .

In both seasons, samples for soil analyses were taken from the layer 0.0-30.0 cm depth. Such samples were tested in the laboratory, according to Black, (1965). The chemical and physical properties of the soil are presented in (Table. 1).

Table 1: Some chemical and physical properties of soil, average over the two seasons.

Chemical analysis				Physical analysis	
pH	8.1	Available K (ppm).	412.50	Sand %	12.95
EC ds/m	2.0	Available Zn (ppm).	0.85	Silt %	32.90
Organic matter%	1.9	Available Fe (ppm).	2.45	Clay %	54.15
Available N (ppm).	17.0	Available Mn (ppm).	3.35	Soil Texture	Clay
Available P (ppm).	16.5				

Treatments : Three irrigation intervals, three cultivars and three plant spacing were tested as follows :

A- Irrigation intervals:	B- Cultivars :	C- Plant spacing :
1- Irrigation every 6 days, 1-6	1- Sakha 101, SK-101.	1- (15 x 15 cm). PS1.
2- Irrigation every 9 days, 1-9	2- Sakha 103, SK-103.	2- (15 x 15 cm). PS2.
2- Irrigation every 12 days, 1-12	3- Sakha 104, SK-104.	3- (15 x 15 cm). PS3.

**Experimental Design:** A split-split plot design with three replicates was used. The main plots were devoted to irrigation intervals. the sub-ones were

occupied by cultivars. while spacing were distributed at the sub-sub plots. Randomization was considered in all cases, Plot area was  $15.0 \text{ m}^3$  (3x5) m .

**Agricultural Practices:** In both seasons. preceded crop was Egyptian clover. Seedbed of the nursery. area of  $350 \text{ m}^2$  for 1 fed. (1 fed. =  $4200.78 \text{ m}^2$ ) was well prepared and fertilized with calcium super phosphate (15.5%  $\text{P}_2\text{O}_5$ ) at 100 kg/fed. before ploughing. Rice commercial grains of the three cultivars were soaked in running water for 48 hr., then incubated for another 48 hr. Before seeding, 10 kg/fed. of zinc sulphate were added. Seeds were handly broadcasted in the nursery on April 20<sup>th</sup>. at 60 kg/nursery. At 7 days age, weeds were chemicalty controlled by Saturn 50% (Thiobencarb) at 2 litres dissolved in 100 litres of water/fed. and sprayed by a knapsack sprayer. Two weeks after sowing, a rate of 40 kg N/fed. was added at once as urea (46% N). Before transplanting, permanent field was well prepared. calcium super phosphae 15.5% P<sub>2</sub>O<sub>5</sub> at rate 100 kg/fed. was added to the soil before ploughing. Flushing irrigation was done. Nitrogen as urea (46% N) was applied in two rates, two-thirds in dry soil before transplanting and the remainder third at panicle initiation. Transplanting of seedlings from nursery to permanent field was done 25 days after sowing. Planting was spaced at the tested spacing. as three plants/hill, After four days, weeds were controlled by Saturn 50% as previously mentioned. Irrigation was withheld 15 days before harvest. Harvest was carried out according to each cultivar duration. All remainder agricultural practices were carried out as usual .

The tested three cultivars are characterized as short grain, resistant to blight disease and 72% milling. Such cultivars differ in grain yield (more than 5.0. 4.0-4.5 and 4.0-5.0 ton/fed.) and to maturity time (135. 125 and 135 days), for Sk-101. Sk-I03 and Sk-104, respectively .

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Irrigation discharge was adjusted by using triangular weirs (V notch). The height of flowing water was fixed at 30 cm. Water discharge was counted according to the equation of Hansen et al (1980) as follows :

$$Q = 0.0138 \times h^{2.5} \times 3.6 \text{ where :}$$

Q = Water discharge. m<sup>3</sup>/hr .

0.0138 and 3.6 = constant values, where 3.6 was added for obtaining Q in m<sup>3</sup>/hr .

h= Water height or pressure head (cm).

The used irrigation regime is illustrated in (Table, 2).

Table 2: Irrigation intervals (days) , total applied (m<sup>3</sup>/fed.), number of irrigation (m<sup>3</sup>/fed.).

Irrigation interval (days)	Total applied water (TAW) (M <sup>3</sup> /fed.)	Number of irrigation	Quantity of one irrigation (M <sup>3</sup> /fed.)
1-6	500**	16	312.5
1-9	4500**	10	45.0
1-12	4000	8	500.0

• Without nushing irrigation .

•• The quantities were reduced by 312.5 and 450.0 m<sup>3</sup>/fed. with respect to Sk-103 cv. for its short duration. i.e. 125 days .

## Studied Topics :

### A-plant Traits:

At the end of the season. a random sample from the inner part of each experimental plot was taken. Eight traits were studied on that sample as follows :

1- No. of panicles/m<sup>2</sup>.

2- Sterility .%

3- No. of spikelets x10<sup>3</sup>/m<sup>3</sup>.



4- No. of grains/panicle.

5- 1000-grain weight (gm).

6- Straw yield (ST) (ton/fed.) was calculated on the base of yield/plot then per fed.

7- Grain yield (G.Y) (ton/fed.) was calculated on the base of yield/plot then per fed.

8- Harvest index %, (H. I %), according to Wilox (1974), as follows :

$$(H. I \%) = \frac{\text{Grain yield (ton/fed), Gy}}{\text{Grain yield (ton/fed.), Gy + Straw yield (ton/fed.), (St.)}} \times 100$$

**B- Water Relationship:**

Water use efficiency (W.U.E. Kg/m<sup>3</sup>) was calculated according to Vites, (1965) as follows .

$$W.U.E (Kg/m^3) = \left( \frac{\text{Grain yield, Ks/fed.} \quad GY}{\text{Total applied water, m}^3/\text{fed.} \quad TAW} \right) = \text{-----}$$

**Statistical Analysis:** In both seasons, data were subjected to analysis of variance. Means were compared by Duncan's, (1955) multiple range test at a 0.05 level of significance. Simple correlation coefficients were estimated among every trait and all the remainder seven ones. Coefficients of correlation were tested at 0.01 level of significance. All statistical procedures were performed as described by Snedecor and Cochran, (1981) as well as Gomez and Gomez (1984) .

## RESULTS AND DISCUSSION

### I-Analysis of Variance :

#### A: Main Effects :

**1- irrigation Effect:** Table (3) gives the means of all studied traits as affected by irrigation intervals. In the two seasons, it is clear that all traits were significantly affected by irrigation treatments. A certain tendency was detected. However, the highest values were recorded on 1-6 followed by 1-9 then 1-12 days. This means that the most abundant irrigation, i.e. 5000 m<sup>3</sup>/fed. promoted the growth and yield of rice. While lengthening irrigation interval to 12 days gave the poorest products. Okasha *et al*, (2009) that enough watering enhanced growth features such as plant height, leaf area index, chlorophyll content, No. of panicles/plant and panicle length. Such positive effects were turned in No. of panicles/m<sup>2</sup> and produced its highest value, viz. 458.12 in S1 and 439.16 in S2. Moreover, abundant watering reduced sterility %, through enhancing pollination. Thereafter, it was shown that the lowest sterilities, viz 10.39 in S1 and 10.84 in S2 were produced by 1-6. While the highest ones were recorded on 1-12 treatment (14.26 and 13.90% in S1 and S2, respectively). In addition, it seemed that abundant moisture within the rice plant (self pollinated crop) during heading phase supported successful pollination and consequently reduced sterility % Abd Allah *et al* (2009) reported that sterility is greatly affected by revealing environments. It is matter of fact that abundant water promotes and secures fertilization and hence increase the No of spikelets/m<sup>3</sup>. Pronounced values of such trait were 84.89x10<sup>3</sup> in S1 and 77.71 x 10<sup>3</sup> in S2. The present results did not differ from those found by El Bably *et al* (2007). Enough watering as a reducer of sterility and raising pollination in spikelets completed its positive role on No. of grains/panicle. Such latter trait increased by 1-6 to

193.96 in SI and 188.67 in S2. The present findings are in good convenient with Abou Khalifa *et al*, (2007). Such progressive effects may encourage panicles formation, with higher numbers of spikelets and grains/panicle. The 1000 grain weight is negatively correlated with No. of grains/panicle. Thereafter, the former trait increase on the expanse of the latter one and in reverse. Thus, the heaviest grains were recorded when lengthening irrigation interval because of their good filling .

Such heaviest grains were formed without competition to each other. In addition, the irrigation intervals 1-6, 1-9 and I 12 yielded grain as 22.35, 23.87 and 25.25 gm in SI and 21.75, 23.47 and 24.65 gm in S2, respectively. Mosalem *et al*, (1998) as well as Abou Khalifa et al (2007) approached similar results. As regards straw yield/fed., it was observed that 1-6, 1-9 and 1-12 intervals produced 9.37, 9.13 and 8.35 ton/fed. in SI and 9.03, 8.29 and 7.51 ton/fed. in S2, respectively. This means that highest irrigation amount of 5000 m<sup>3</sup>/fed.(1-6) gave the highest straw yield. No. of panicles/plant and panicle length are makers. of straw yield. Such makers were found in positive relation with increasing watering quantity. Consequently, no surprising herein that higher water supplies promoted straw yield/fed. The present results confirmed those reported by many authors of them El-Rafae et al (2005) .

Table (4) gives the obtained means of the studied traits as affected by irrigation intervals in the two seasons. In the first season, 1-6, 1-9 and 1-12 days yielded 4.52, 3.90 and 2.48 ton/fed. and 4.17, 3.74 and 3.25 ton/fed: in S2, respectively. It seemed that short interval (1-6) secured the required water for good growth. Moreover such positive progressive value were turn in yield component which provided them to grain yield/fed. Abou Khalifa *et al*, (2007) found similar results. In contrast, Kadum et al, (2008) found insignificant effect due to watering on rice grain yield .

**2- Cultivars Effect:** Table (3,4) includes the means of the studied traits of the three cultivars in S1 and S2. It is obvious that significant responses were observed with all aspects. Mostly, Sk-101 cultivar significantly surpassed the other two cultivars, except with sterility%, 1000 grain weight and straw yield, where the lowest values were observed on such cultivar sterility % where Sk-101 expressed the lowest sterility %, i.e. 11.61 % in S1 and 11.34% in S2. The results confirmed the findings of Abou Khalifa *et al*, (2009). It is well known that Sk-101 is the superior cultivar over the Egyptian ones. In the previous part of the present study, Okasha *et al*, (2009) named the growth features enhancing grain yield/plant in leaf area index, total chlorophyll, No. of panicle and panicle length. Hence, no surprise herein that yield components were better with Sk-101 too. Thus, it seemed that yield components benefited the positive effects of growth traits and turned them into grain yield/fed. of Sk-101 viz., 4.27 and 4.23 ton/fed. in S1 and S2, respectively. In addition, superiority in favour to Sk-103 over Sk-104 was measured on some components including grain yield itself. However, grain yields of Sk-103 were 3.56 in S1 and 3.70 ton/fed. in S2. While those of Sk-104 were 3.07 in S1 and 3.23 ton/fed in S2. In addition, Sk-104 significantly exceeded Sk-103 with most yield components; including straw yield, viz in S1 (9.85) and S2 (9.04) ton/fed. Many researchers reported the superiority of Sk-101, of them El-Khoby *et al* (2008). The excess of Sk-104 over Sk-103 was found by different authors of them, Fawzi and Badawi (2006). But Abd El-Maksoud, (2008) found superiority in favour to Sk-103 over Sk-104 .

Table 3: No. of panicles/m<sup>2</sup>, sterility %, No. of spikelets x 10<sup>-3</sup>/m<sup>2</sup> and No. of grains/panicle IS affected by irrigation intervals, cultivars and plant spacings and their interactions in the two seasons.

Treatments	No. of panicles/m <sup>2</sup>		Sterility %		No. of spikelets x 10 <sup>-3</sup> /m <sup>2</sup>		No. of grains/panicle	
	S1	S2	S1	S2	S1	S2	S1	S2
I-6	458.12 a	439.16 a	10.39 c	10.84 c	84.98 a	77.71 a	193.96 a	188.67 a
I-9	401.40 b	418.25 b	12.17 b	12.46 b	70.55 b	69.90 b	174.68 b	168.64 b
I-12	335.50 c	338.91 c	14.26 a	13.90 a	52.24 c	49.80 c	146.87 c	140.18 c
Sk-101	492.24 a	488.22 a	11.60 c	11.34 c	87.22 a	79.32 a	184.17 a	177.52 a
Sk-103	329.39 c	342.48 c	12.19 b	12.12 b	57.21 c	57.02 c	172.38 b	166.05 b
Sk-104	373.40 b	365.63 b	13.03 a	13.74 a	63.34 b	61.06 b	158.97 c	153.92 c
Pa1	475.86 a	489.80 a	10.73 b	11.06 c	85.72 a	84.14 a	187.29 a	180.62 a
Pa2	383.32 b	369.30 b	12.95 a	12.42 b	65.11 b	59.59 b	169.30 b	163.97 b
Pa3	335.84 c	337.23 c	13.15 a	13.73 a	56.94 c	53.68 c	158.92 c	152.90 c
I-6xSk-101	566.11 a	537.67 a	9.82	9.92	107.02 a	93.68 a	207.88	201.97
I-6xSk-103	378.82 c	377.17 d	10.32	10.60	70.20 d	67.34 d	194.56	188.91
I-6xSk-104	429.44 c	402.66 c	11.03	12.01	77.72 c	72.11 c	179.43	175.12
I-9xSk-101	496.02 b	512.06 b	11.51	11.40	88.86 b	84.26 b	187.22	180.53
I-9xSk-103	331.92 f	359.21 e	12.09	12.18	58.28 f	60.57 f	175.23	168.86
I-9xSk-104	376.27 e	383.48 d	12.93	13.81	64.52 e	64.86 e	161.60	156.53
I-12xSk-101	414.58 d	414.92 c	13.47	12.72	65.79 c	60.04 f	157.41	150.06
I-12xSk-103	277.42 h	291.06 g	14.16	13.59	43.16 h	43.16 h	147.33	140.37
I-12xSk-104	314.49 g	310.73 f	15.14	15.40	47.78 g	46.21 g	135.87	130.11
I-6xPa1	547.28 a	539.41 a	9.08	9.67	105.18 a	99.36 a	211.40	203.49
I-6xPa2	440.83 c	406.70 c	10.96	10.86	79.88 c	70.37 c	191.09	186.55
I-6xPa3	386.25 d	371.38 de	11.13	12.00	69.87 d	63.39 d	179.38	173.96

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Table 3: Continue

I-9xPs1	479.52	b	513.72	b	10.64	11.11	87.33	b	89.37	b	190.39	183.68
I-9xPs2	386.27	d	387.33	d	12.84	12.48	66.33	e	63.29	d	172.10	166.75
I-9xPs3	338.42	e	353.70	e	13.04	13.79	58.01	f	57.02	e	161.55	155.49
I-12xPs1	400.79	d	416.27	c	12.47	12.40	64.66	e	63.68	d	160.08	152.68
I-12xPs2	322.84	e	313.85	f	15.04	13.92	49.11	g	45.10	f	144.70	138.61
I-12xPs3	282.86	f	286.60	g	15.27	15.39	42.95	h	40.63	g	135.83	129.25
Sk-101xPs1	588.03	a	599.66	a	10.14	10.12	107.96		101.43	a	200.73	193.35
Sk-101xPs2	473.67	b	452.13	b	12.23	11.36	81.99		71.83	c	181.45	175.53
Sk-101xPs3	415.01	d	412.86	c	12.42	12.56	71.71		64.71	d	170.33	163.68
Sk-103xPs1	393.49	e	420.66	c	10.66	10.81	70.82		72.91	c	187.88	180.85
Sk-103xPs2	316.97	g	317.16	e	12.86	12.13	53.78		51.64	f	169.83	164.18
Sk-103xPs3	277.71	h	289.62	f	13.06	13.42	47.04		46.52	g	159.42	153.10
Sk-104xPs1	446.06	c	449.09	b	11.40	12.25	78.40		78.07	b	173.26	167.65
Sk-104xPs2	359.32	f	338.60	d	13.75	13.76	59.54		55.29	e	156.62	152.19
Sk-104xPs3	314.81	g	309.19	e	13.96	15.21	52.08		49.81	f	147.02	141.92

Table 4: 1000-grain weight (g). straw yield (ton/fed.). grain yield (Ton/fed.), har.est index. and W.U.6 Kg/m' as affected by irrigation inter.als. culli.a., and plant spaecinc and their interactions in the two seasons .

Treatments	1000-grain weight (g)		Straw yield (ton/fed.)		Grain yield (ton/fed.)		Harvest index %		W.U.E Kg/m <sup>2</sup>	
	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
I-6	22.35 c	21.75 c	9.73 a	9.03 a	4.52 a	4.17 a	31.64 a	31.90 a	0.88 b	0.81 b
I-9	23.87 b	23.47 b	9.13 b	8.29 b	3.90 b	3.74 b	29.89 b	31.38 b	0.90 a	0.86
I-12	25.25 a	24.65 a	8.35 c	7.51 c	2.48 c	3.25 c	22.94 c	30.52 c	0.65 c	0.86 a
Sk-101	22.44 c	22.63 b	8.30 c	7.50 c	4.27 a	4.23 a	33.39 a	36.26 a	0.93 a	0.94 a
Sk-103	23.43 b	22.77 b	9.06 b	8.29 b	3.56 b	3.70 b	27.74 b	31.07 b	0.83 b	0.87 b
Sk-104	25.61 a	24.47 a	9.85 a	9.04 a	3.07 c	3.23 c	23.36 c	26.48 c	0.67 c	0.72 c
Ps1	22.30 c	22.08 c	10.55 a	9.71 a	4.49 a	4.12 a	29.48 a	29.81 c	1.00 a	0.93 a
Ps2	23.74 b	23.26 b	9.41 b	8.57 b	3.53 b	3.73 b	26.97 c	30.34 b	0.79 b	0.84 b
Ps3	25.43 a	24.54 a	7.25 c	6.54 c	2.88 c	3.32 c	28.04 b	33.66 a	0.64 c	0.75 c
I-6xSk-101	21.05	21.13	8.90	8.18	5.31 a	4.74 a	37.25 a	36.95 a	1.01 a	0.90 c
I-6xSk-103	21.98	21.26	9.72	9.04	4.43 c	4.15 c	31.22 c	31.71 d	0.90 c	0.84 d
I-6xSk-104	24.02	22.85	10.57	9.86	3.82 d	3.62 c	26.46 f	27.06 g	0.73 e	0.69 f
I-9xSk-101	22.48	22.81	8.35	7.51	4.58 b	4.25 b	35.33 b	36.38 b	1.02 a	0.95 b
I-9xSk-103	23.48	22.95	9.12	8.30	3.83 d	3.72 d	29.47 d	31.18 e	0.94 b	0.92 c
I-9xSk-104	25.66	24.66	9.91	9.06	3.30 c	3.24 f	24.87 g	26.59 h	0.73 e	0.72 c
I-12xSk-101	23.78	23.96	7.64	6.81	2.92 f	3.70 de	27.57 e	35.44 c	0.77 d	0.97 a
I-12xSk-103	24.83	24.10	8.34	7.52	2.43 g	3.24 f	22.53 h	30.31 f	0.64 f	0.85 d
I-12xSk-104	27.14	25.90	9.07	8.21	2.10 h	2.82 g	18.73 i	25.81 i	0.55 g	0.74 e
I-6xPs1	20.92	20.62	11.32	10.59	5.59 a	4.62	33.06 a	30.43 f	1.09 a	0.90
I-6xPs2	22.27	21.72	10.09	9.35	4.39 c	4.18	30.36 d	30.96 d	0.86 b	0.81
I-6xPs3	23.86	22.92	7.78	7.14	3.58 c	3.72	31.51 b	34.33 a	0.70 d	0.72
I-9xPs1	22.35	22.25	10.62	9.73	4.82 b	4.14	31.26 c	29.93 g	1.11 a	0.96
I-9xPs2	23.79	23.44	9.47	8.59	3.79 d	3.75	28.65 f	30.45 e	0.87 b	0.86
I-9xPs3	25.49	24.73	7.30	6.55	3.09 f	3.33	29.76 e	33.77 b	0.71 d	0.77
I-12xPs1	23.64	23.37	9.71	8.82	3.07 f	3.60	24.10 g	29.08 i	0.81 c	0.95

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Table 4 : Continue

I- 12xPs2	25.16	24.62	8.66	7.78	2.41 g	3.26	21.89 i	29.60 h	0.64 e	0.86
I- 12xPs3	26.95	25.98	6.67	5.94	1.97 h	2.90	22.84 h	32.87 c	0.52 f	0.76
Sk-101x Ps1	21.01	21.45	9.65	8.80	5.28 a	4.69	34.84 a	34.69 c	1.15 a	1.04
Sk-101x Ps2	22.35	22.60	8.61	7.77	4.15 c	4.24	32.07 c	35.26 b	0.91 c	0.94
Sk-101x Ps3	23.95	23.58	6.63	5.93	3.38 e	3.77	33.24 b	38.83 a	0.74 e	0.84
Sk-103x Ps1	21.94	21.58	10.54	9.73	4.41 b	4.10	29.06 d	29.60 f	1.02 b	0.97
Sk-103x Ps2	23.34	22.74	9.40	8.59	3.47 e	3.71	26.54 f	30.13 e	0.81 d	0.87
Sk-103x Ps3	25.01	23.99	7.24	6.55	2.82 f	3.30	27.62 e	33.48 d	0.66 f	0.78
Sk-104x Ps1	23.97	23.20	11.46	10.61	3.80 d	3.57	24.54 g	25.16 i	0.83 d	0.79
Sk-104x Ps2	25.51	24.44	10.22	9.36	2.98 f	3.23	22.28 i	25.62 h	0.65 f	0.72
Sk-104x Ps3	27.34	25.79	7.88	7.15	2.43 g	2.88	23.25 h	28.67 g	0.53 g	0.64

**3-Spacing Effect:** Means of the studied traits as affected by spacing in the two seasons are included in Tables (3 and 4). Significance of the obtained differences were calculated on all aspects. Narrow spacing (15x15 cm) gave the highest significant products with all aspects, except sterility % and 1000 grain weight. The obtained values of 1000 grain weight were 22.30 and 22.08 gm in S1 and S2, respectively. It seemed that the narrow spacing produced higher number of stands and consequently high No. of panicles/m<sup>2</sup>. No doubt that higher stands and panicles give higher straw yield/fed. In addition, No. of panicles/m<sup>2</sup> is a main maker of grain yield/fed., the former could be automatically expected by narrow spacing. Many authors believed in the positive value of narrowing spacing of them Salem (2006). The superiority of 1000 kernel weight in wider spacing may be attributed to the good growth for single plants under wider spacing. The present results are in good convenience with the findings of Intikhab *et al*, (2007) as well as Wilcox (1974).



## B- First Order Interaction :

**1- Irrigation x Cultivars:** Table (3-4) present the obtained means of the studied traits as affected by the interaction irrigations x cultivar. It was obtained that highest significant values were detected only with (1-6x Sk-101) on No. of panicles/m<sup>2</sup>, No. of spikelets/m<sup>2</sup>, grain yield/fed. and harvest index, in the two seasons. This means that each level of Sk-IOI significantly interacted with 1-6 as respects the previous four traits. In addition, the treatments 1-12x either with Sk-103 or Sk-104 achieved the lowest values in all traits. Such results confirm the superior value of 1-6 interval and Sk-101 treatments, as previously explained. Abou Khalifa, (2001) reported the value of Sk-101x1-3 interval for producing higher yield and some yield components Vivekanandan *et al*, (2005) stated that adaptability of available soil moisture (ASM) was exhibited by certain cultivars EI-Kalla *et al*, (2006) found significant effect due to the interaction on all trait. Singh and Choudhury, (2007) agreed with similar trends. Kadum *et al*, (2008) reported significancy on No. of tillering/m<sup>2</sup> and sterility %

**2- Irrigation x Spacing:** Means of the studied traits as affected by irrigation x spacing interactions in the two seasons are given in Tables (3 and 4). In the two seasons, only No. of panicles/m<sup>2</sup>, No. of spikelets/m<sup>2</sup> and harvest index were significantly affected by the interaction. Grain yield/fed. was significantly affected only in the first season producing 5.59 ton/fed. by I-6x PS1. Such interaction also achieved the highest values on most traits, especially those which were significantly affected .

**3- Cultivars x Spacing:** Table (3 and 4) declare the obtained means of the studied traits as affected by cultivar x spacing interactions in the two seasons. It is obvious that No. of panicles/m<sup>2</sup> and harvest index in the two seasons, No. of spikelets/m<sup>2</sup> in S2 and grain yield in SI were the only traits which significantly responded to the interactions. The (Sk-101xPSI)

interaction highly yielded the highest values in most of the remainder traits. The highest grain yield/fed. for the mentioned interaction in SI was 5.28 ton, it seemed that such grain yield benefited No. of panicles/m<sup>2</sup>, as well as No. of spikelets/panicle to produce its superior value. Pawar et al, (2005) found no significant effect due to (irrigation x spacing) interaction. Some authors contribute the success of such interaction to the cultivar it self and its tillering ability Badwi et al, (2004). Some pointed to cultivar duration, Guatam *et al*, (2005) and Mishra *et al*, (2005) generalizing that a certain variety needs certain spacing .

**C- Second Order Interaction:** Data did not show any significant differences as a result of the combination among the three factors, in the two seasons, except harvest index in SI. The value herein was 38.79%. Harvest index is a ratio usually does not exceed the unit value, where the numerator is occupied by grain yield, while the denominator is devoted to the summation of grain yield + straw yield. Thereafter, the percentage of harvest index is lesser than 50%. In other words greater harvest index % means greater grain yield versus the straw one. It was observed, in spite of the absence of significance, that the interaction (1-6 x Sk10 x Ps1) gave the highest grain yield, viz 6.57 and 5.25 ton/fed. in SI and S2, respectively .

## **II- Water Relationships :**

### **Water Use Efficiency, WUE:**

Table (4) presents the obtained WUE values for different aspects. Obviously, WUE was the greatest by 1-9 (0.9 - 0.86), Sk-101 (0.93-0.94) and PSI (1.0 - 0.93) kg/m<sup>3</sup> in SI and S2, respectively. The superiority of WUE with 1-9 could be attributed to the middle TAW (4500 m<sup>3</sup>/fed.). While the super WUE of Sk-101 as well as PSI could be attributed to the pronounced grain yield in the numerator in Vites, (1965) equation. Abou Khalifa, (2001) reported that 1-3 produced the highest utilization efficiency,

followed by I-6. El-Khoby *et al.*, (2008) reported that Sk-IOI gave the highest WUE, consuming 1181 mm .

As regards the interactions, it was observed that the cultivars Sk-101 successfully interacted with all irrigation interval to produce remarkable WUE which were ranged between 0.77 to 1.02 kg/m<sup>3</sup>, which were produced from Sk-101xI-12 and I-9, respectively. All estimations in such cases increased because of the pronounced grain yield of such cultivar .

Similarly it was noticed that I-6 or I-9 combined with the closer spacing (15x 15cm) produced the considerable WUE in the two season where the lowest and highest WUE were 1.09 and 1.11 kg/m<sup>3</sup> respectively. Such two limits were produced by I-6x and I-9xPSI, respectively. Such pronounced WUE could be attributed to grain yield/fed. rather than TAW .

Similarly, Sk-101 x PSI gave the greatest WUE among the other combinations in the interaction in S1, i.e. 1.15 kg/m<sup>3</sup>. Herein also the numerator played the most important role for increasing WUE. It was expected that water use efficiency could be greater with a combination included I-9xSk-01xPsi .

**III-Correlation:** Table (5) represents simple correlation coefficients among each trait and the other ones in the two seasons. It is clear in the first seasons that all coefficient values were highly significant except that between straw yield and harvest index, i.e. -0.14. Most of simple correlation coefficients were positive. The negative signs were detected on the correlation of sterility% with all traits except 1000 grain weight. The latter trait was negatively correlated with all traits. Such results could understand where sterility % and 1000 grain weight were affected by treatments in different direction to other traits. In the second season, similar results were obtained, with a very minor deviation where the only insignificant correlation coefficient was detected between straw yield/fed. and WUE, i.e. 0.16. These results refer, in general, to the high strong link, regardless the correlation

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sign, among yield and all of its components. Also WUE was shown in strong correlation with most variables .

**Iv-curve Estimation:** Figure (1) illustrate the relation between grain yield (ton/fed.) and total applied water (m<sup>3</sup>/fed.) in the two seasons. It is so clear that grain yield/fed. gradually increased as total applied water increased. But the curve analysis showed that the relation between the two variables was a quadratic one either in the first or the second season. The obtained equation of the first season was  $Y = -37.68+0.0164X-0.0000016X^2$ . In the second season, the equation was  $Y = -2.83+0.002X-0.00000012X^2$ .

Table 5: Simple correlation coefficients (r), among each trait and the other ones in the two seasons.

Traits	Grain yield /plant (g)		Panicle length (cm)/plant		No. of panicles		DAS to 50% heading		Total Chlorophyll content		Light penetration		Leaf area index	
	S 1	S 2	S 1	S 2	S 1	S 2	S 1	S 2	S 1	S 2	S 1	S 2	S 1	S 2
Plant height (cm)	S	0.7	0.5	0.8	0.9	0.6	0.8	0.3	-0.63	0.5				
	S		0.4	0.4	0.6	0.8	0.3	-0.65	0.4					
Leaf area index	S	0.9	0.8	0.9	0.7	0.9	0.9	-0.57						
	S		0.9	0.9	0.7	0.7	0.9	-0.58						
Light penetration	S	-0.58	-0.57	-0.62	-0.57	-0.65	-0.52							
	S		-0.54	-0.62	-0.57	-0.71	-0.41							
Total content	S	0.8	0.8	0.9	0.9									
	S		0.9	0.9	0.8	0.7								
DAS to 50% heading	S	0.9	0.7	0.9										
	S		0.8	0.8	0.8									
No. of /plant	S	0.9	0.8											
	S		0.7	0.7										
Panicle (cm)	S	0.8												
	S		0.9											

All coefficients are significant at a 0.01 level in the two seasons.

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## تأثير الصنف ، الفترة بين الريات ومسافة الشتل والتفاعلات بينها على محصول الأرز ومكوناته

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أجريت تجربتان حقلين على الأرز فى موسمى ٢٠٠٦ و ٢٠٠٧ ، فى المركز الأبحاث والتدريب للأرز بسخا محافظة كفر الشيخ - تضمنت الدراسة فى كل تجربة ثلاثة عوامل ، حيث جرب كل منها فى ثلاثة مستويات ؛ الأول فترة الرى ( ٦ ، ٩ ، ١٢ يوم ) أ الثانى الصنف ( سخا ١٠١ ، سخا ١٠٣ و سخا ١٠٤ ) والثالث مسافة الشتل ( ١٥ x ١٥ ) ، ( ١٥ x ٢٠ ) ، ( ٢٥ x ١٥ ) سم . استخدم تصميم القطع الشقية مرتين فى ثلاثة مكررات . وقد أجريت الدراسة على ثمانى صفات وتلخص أهم النتائج فيما يلى :

- كانت الفروق بين مستويات كل عامل ، تفاعلات الدرجة الأولى والثانية معنوية على جميع الصفات .

- تفوق كل من الرى ٦ أيام والصنف سخا ١٠١ ومسافة الشتل ( ١٥ x ١٥ ) سم على المستويات الأخرى ، كل داخل عاملة ، وذلك بالنسبة لمعظم الصفات - إلا مع النسبة المئوية للقم - وزن الألف حبة فظهر اتجاهاً مخالفاً حيث تفوق الصنف سخا ١٠٣ فى وزن الألف حبة وكذلك تفوق الصنف سخا ١٠٤ فى محصول القش / فدان .

- أعطت المستويات المتفوقة السابقة لكل عامل أفضل التفاعلات الأحادية والثنائية فيما بينها - وكذلك كفاءة استخدام مياه الرى كل ٦ أيام مع شتل سخا ١٠١ وعلى مسافة ( ١٥ x ١٥ ) سم.

- كان معامل الارتباط بين جميع الصفات موجباً ومعنوياً ماعداً مع صفتى النسبة المئوية للقم ووزن الألف حبة فكان سالباً ومعنوياً أيضاً .

- أوضحت دراسة تحليل منحنى الاستجابة بين محصول الحبوب وكمية مياه الرى أن العلاقة بينهما من النوع الثانى Quadratic .

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