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PERFORMANCE OF HYBRID AND INBRED RICE CULTIVARS UNDER DIFFERENT PLANTING GEOMETRY AND NUMBER OF SEEDLINGS PER HILL

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ABSTRACT

Two field experiments were conducted at the Rice Research and Training Center (RRTC), Sakha, Kafr El-Sheikh, Egypt in 2004 and 2005 growing seasons. The present attempt aimed to study the effect of three different spacings (20 x 15, 20 x 20 and 20 x 30 cm) and three number of seedlings/hill (2, 4 and 6 seedling/hill) on growth, grain yield and its components of two rice cultivars (hybrid rice SK2047H and Giza 178, inbred rice). The most important findings of this research could be summarized as follows:

Significant differences were detected between the two rice cultivars in growth, grain yield and its components in the two seasons. The hybrid rice cultivar, SK2047H significantly exceeded the inbred rice cultivar, Giza 178 in growth characters, grain yield and most of its components. Hybrid SK2047H recorded the highest plant height, dry matter production, crop growth rate, leaf area index, chlorophyll content, biomass production, number of panicles/hill, panicles weight, 1000-grain weight, number of filled grains/panicle, grain yield as well as harvest index.

Seedling planted at a sparse spacing (20 x 20 and 20 x 30 cm) produced higher leaf area index (LAI), highest value of light penetration, panicle weight, number of filled grains/panicle, grain filling period than seedling planted at a dense spacing (20 x 15 cm). Closer spacing (20 x 15 cm) gave higher dry weight, crop growth rate (CGR), plant height, sterility percentage than wider spacing. In the same time seedlings plant at 20 x 20 cm was benefit for rice growth and grain yield where, produced the highest number of panicles/hill, biomass, yield, grain yield (t/ha) and harvest index.

Crops planted at two seedlings per hill gave significantly higher panicle weight, 1000-grain weight, grains filling period and harvest index (HI). While, six seedlings/hill resulted in lower in panicle weight, 1000-grain weight, number of filled grains/panicle, number of panicle/hill, biomass yield, harvest index and grain yield. In the same time, gave higher dry weight, leaf area index and sterility % compared with two seedlings/hill. Two or four seedlings/hill recorded the highest value of light penetration, number of filled grains/panicle, number of panicles/hill, 1000-grain weight, biomass and grain yield but, crop growth rate (CGR) and chlorophyll content were not affected.

The interaction between rice cultivars and plant spacings was significant for DM, CGR and light penetration. Also, statistical analysis revealed significant interaction effect between cultivars and no. of seedlings per hill for 1000-grain weight, sterility %, number of panicles/hill and grain yield. In addition, this effect between spacing and number of seedlings/hill was significant for light penetration.

For getting high yield, the hybrid rice (SK2047H) should be transplanted as two seedlings per hill in a 20 x 20 cm spacing. As for the inbred rice (Giz 178), it should be transplanted as four seedlings per hill at the same aforementioned spacing.

INTRODUCTION

Rice is one of the premier food grain crops in Egypt, so its production has to be increased at a much faster rate to feed the burgeoning population.

Hybrid rice technology is one such innovate break through that can further increase rice production lead to food security in Egypt. Gu *et al.* (1991) reported that in general hybrid rice had strong tillering ability, high harvest index, short vegetative growth period, long grain-filling period, high yield potential and bigger sink size as compared to inbred rice. Hybrid rice varieties can out yield conventional varieties 15-20% under the same input levels (Lin, 1994; Virmani, 1996 and Yuan *et al.*, 1996). From 1995 to 2001 many hybrids showed standard heterosis ranging from 15-30% and most of these hybrids have short growth duration, (Bastawisi *et al.,* 2002). No hybrid combination can express its maximum productivity, unless it is grown under package of cultural practices.

Plant spacing is an important production factor in transplanted rice because there are no single spacing practices for all varieties. Mohapatra *et al.* (1989) found that plant spacing of 20 x 20 cm was better than those of 15 x 15 or 15 x 20 cm under normal soil for rice productivity. Maske *et al.* (1997) found that plant height, LAI, number of tellers/m^2, dry matter production, grain yield and yield components were higher with 15 x1 0 cm than that of 15 x 15 or 15 x 20 cm. El-Hawary and Gabra (1998) reported that increasing space between hills significantly increased panicle grains weight. Patel (1999) observed that hill spacing of 20 x 20 cm recorded perceptible increase in number of panicles/m^2, straw yield and grain yield compared to plant density obtained with 20 x 15 and 20 x 10 cm hill spacings but, number of grains/panicle and 100-grain weight were not affect by spacings. Shrirame *et al.* (2000) noticed that hybrid rice recorded higher maximum leaf area/hill and total number of tillers/hill and dry matter/hill at 20 x 15 cm as compared to 20 x 10 cm. Verma *et al.* (2002) found that planted hybrid rice at 20 x 20 and 20 x 15 cm produced higher number of productive tillers, grain yield and harvest index than seedlings planted at 20 x 10 cm and closer spacing 20 x 10 cm gave higher sterility % than wider spacing. Omnia El-Shayieb (2003) confirmed that narrow spacing of 10 x 20 cm gave the highest grain yield and yield components of Giza 177 rice cultivar (inbred rice) as compared with 20 x 20 or 30 x 20 cm. Zayed *et al.* (2005) came to the similar results.

Number of seedlings per hill, one of the important factors affecting rice growth, depends on plant spacing and tillering capacity of the variety. Rajarathinan and Balasubramaniyan (1999) observed that planting one seedling/hill gave similar results to planting two seedlings/hill. Srinivasulu *et al.* (1999) reported that planting one seedling/hill gave comparable grain yield to two seedlings/hill for hybrids, but two seedlings/hill gave significantly higher grain yield of the conventional cultivar. Shrirame *et al.* (2000) stated that two seedlings/hill gave significantly higher no. of tillers/hill and straw yield than three seedlings/hill and one seedling/ hill gave significantly higher harvest index. In the same time, plant height and grain yield were not affected by seedlings number/hill. Verma *et al.* (2002) reported that crops planted at three seedlings/hill produced higher no. of productive tillers, grain yield and harvest

index than those planted at one or two seedlings/hill when rice hybrid Proagro 620 was transplanted. One seedling/hill recorded the highest grain yield and CGR while three seedlings/hill had the highest dry matter production, leaf area index and leaf area density when rice hybrids DRRH-1 and APHR-2 were evaluated (Obulamm *et al.,* 2002). Ebaid and Abo-Yousef (2006) found that two seedlings/hill significantly increased 1000-grain weight, plant height and number of filled grains/panicle when they transplanted SK2034 hybrid rice.

This investigation aimed to study the performance of hybrid and inbred rice cultivars under different planting geometry and number of seedlings per hill.

MATERIALS AND METHODS

Two field experiments were conducted at the Experimental Farm of Rice Research and Training Center (RRTC), Sakha, Kafr El-Sheikh, Egypt in 2004 and 2005 summer seasons to study the performance of two rice cultivars i.e. (hybrid rice) medium duration (SK2047H) and (inbred rice) medium duration (Giza 178) under different plant spacings i.e. 20 x 15, 20 x 20 and 20 x 30 cm distance between hills and rows and crop density (2, 4, and 6 seedlings per hill). The preceding winter crop was Egyptian clover in both seasons. Some physical and chemical properties of representative soil samples (0-30 cm) of the experimental site are shown in Table 1.

Table 1: Soil characteristics of experimental sites.

Season	pH	EC mmhos/cm^2	O.M (%)	Total N ppm	$CaCO_3$ (%)	P (ppm)	K (ppm)	Zn (ppm)	Tex. class
2004	7.60	1.68	1.62	327	2.90	11.00	420	2.41	Clay
2005	7.56	1.67	1.78	480	2.84	11.20	435	1.97	Clay

The current study was performed in a split-split plot design with four replications. The main plots were occupied by the two rice cultivars; SK2047H and Giza 178, the three different spacings were arranged in the sub-plots and the three number of seedlings (2, 4 and 6 seedling per hill) were allocated in the sub-sub plots (12 m^2 each). Nitrogen fertilizer as urea form (46%N) was applied as recommended by rate of 165 kg N/ha in two doses (2/3 of the total dose was applied and incorporated into the dry soil before flooding and one third was added top dressed before panicle initiation (PI). Phosphorus fertilizer was applied at the rate of 36 kg P_2O_5/ha in the form of super phosphate (15.5% P_2O_5) added during land preparation. All plots were given 50 kg K_2O/ha in dry soil basally. While zinc sulfate was added after puddling in the nursery as recommended. All cultural practices were done up to harvesting as recommended.

1. Growth characters:

Parameters were studied at three successive growth stages (70, 85 and 100 days after sowing), plant samples were collected from each sub-sub plot to determine:

- Dry matter content (g/m^2): Five hills were taken and were dried in the oven at 70^{o}C for 72 hr, and then the total dry matter was determined.
- Crop growth rate (CGR):

The increase of plant material per unit of ground area per unit of time (Radford, 1967)

CGR = $(W_2-W_1)/(t_2-t_1)$ g/m^2/week.

- Number of days from sowing to 50% heading.
- Leaf area index (LAI):
  Leaf area at heading was measured using leaf area meter (Model II. 3000 A). Then the ratio between leaf area/hill divided by ground area.
- Chlorophyll content (SPADE value):
  At panicle initiation, chlorophyll content was estimated by using chlorophyll meter SPAD-502, Minolta corp.
- Light penetration (LUX):
  At complete heading, light penetration was measured by LUX/meter Pu 150 (K-PU).
- Plant height (cm):
  At harvesting, plant height were measured from soil surface up to the top of main panicle.

2. Grain yield and its components:

At harvest, ten random hills from sub-sub-plot were collected to determine the number of panicles/hill, and ten panicles characters estimate (number of filed grains/panicle, panicle weight, 1000-grain weight and sterility %). Ten square meter of each sub-sub-plot was harvested, dried and threshed to estimate the grain yield. The grain yield was adjusted to 14% moisture content and converted into ton/ha. Harvest index was estimated according to the following equation:

HI = Economic yield (t/ha)/biological yield (t/ha)

Where economic yield is the actual grain yield and biological yield is the total yield of grain plus straw yield.

All the collected data was conducted with IRRISTAT and the difference among the treatments mean were computerized by M-STAT (Duncan, 1955 multiple range test at 5% level) (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

1. Growth characters:

1.1. Dry matter content, crop growth rate and plant height :

Means of dry matter content, crop growth rate and plant height as affected by cultivars, plant spacings, and number of seedlings/hill as well as their interactions in 2004 and 2005 seasons are presented in Table 2.

In both seasons, the data in Table 2 indicated that significant differences existed between hybrid and inbred rice cultivars in dry matter content at all growth stages, except at the first stage (70 days), where hybrid rice SK2047H surpassed inbred rice (Giza 178). In general, (CGR) for SK2047H was significantly higher than Giza 178 at the second growth period (85-100 days) in both seasons. Also, hybrid rice SK2047H plants were taller than Giza 178.

The current results are in a complete conformity with those of Cheng *et al.* (1989), Blanco *et al.* (1990), Yamauchi (1994) and Padmavathi (1997). They reported higher dry matter and crop growth rate in hybrid rice as compared to inbred rice variety.

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Results in Table 2 for the effect of plant spacings on dry matter content, CGR and plant height revealed that close spacing of 20 x 15 cm produced the highest dry matter and CGR in all growth stages and ranked first followed by 20 x 20 cm spacing and ranked second, while 20 x 30. cm spacing ranked third and gave the lowest values at all growth stages in both seasons. The effect of plant spacing on plant height revealed that close spacing of 20 x 15 cm gave the highest value of plant height. Similar findings were obtained by Padmavathi (1997), Kumar and Subbaiah (2001) and Zayed *et al.* (2005).

The effect of number of seedlings/hill on dry matter was significant at all growth stages except at the third stage in both seasons (Table 2). where, six and four seedlings/hill gave higher (DM) compared with the two seedlings/hill. From the same table it can show that four seedlings/hill treatment did not differ significantly with six seedlings/hill treatment in this trait. Similar results were reported by Obulamma *et al.* (2002). Also, results showed insignificant differences in (CGR) values due to different no. of seedlings/hill at the two growth periods, in both seasons.

The effect of number of seedlings/hill on plant height at harvest was significant in both seasons, where transplant two seedlings/hill gave the tallest plants and increasing no. of seedlings/hill decreased plant height. Similar findings were obtained by Abd El-Rahman *et al.* (1990) and Ebaid, and Abo-Yousef (2006).

None of the interactions among the three factors has significant effect on these traits except, those between varieties and plant spacings on (DM) at 70, 85 and 100 days in both seasons (Table 3) and (CGR) in the first period (70-85) in 2004 season (Table 4).

Table 3: Dry matter weight (g/m^2) as affected by the interaction between varieties and plant spacings during 2004 and 2005 seasons.

	Plant spacings (cm)					
Varieties	**20 x 15**	**20 x 20**	**20 x 30**	**20 x 15**	**20 x 20**	**20 x 30**
	2004			**2005**		
	At 70 days					
SK2047H	830.90 a	590.50 c	306.9 f	900.17 a	643.06 c	344.72 f
Giza 178	788.60 b	562.20 d	337.31 e	858.00 b	616.67 d	377.78 e
	At 85 days					
SK2047H	1400.0 a	1017.7 c	600.0 e	1446.5 a	1059.7 c	613.9 e
Giza 178	1225.2 b	930.0 d	580.4 f	1290.70 b	941.70 d	589.30 f
	At 100 days					
SK2047H	2063.0 a	1444.0 c	873.3 e	2137.6 a	1490.5 c	890.97 e
Giza 178	1748.8 b	1292.0 d	781.0 f	1824.17 b	1335.0 d	816.00 f

Means followed by a common letter are not significantly different at 5% level according to DMRT

Regarding dry matter, the best combination was transplant SK2047H and 20 x 15 cm spacing in all stages in both seasons. Meanwhile, the lower (DM) when Giza 178 transplanted at wider spacing of (20 x 30 cm). These results are in agreement with Zayet *et al.* (2005) The previous finding was true with (CGR) too in Table 4.

Table 4: Crop growth rate (g/m^2/week) as affected by the interaction between varieties and plant spacings during 2004 season.

Varieties	Plant spacings (cm)		
	20 x 15	20 x 20	20 x 30
	At (70-85)		
SK2047H	284.40 a	213.30 b	146.60 d
Giza 178	218.00 b	184.10 c	121.50 e

Means followed by a common letter are not significantly different at 5% level according to DMRT

1.2. Days to heading, leaf area index (LAI), light penetration (LUX) and chlorophyll content:

Data presented in Table 5 indicated that there were highly significant differences in days to heading, LAI and chlorophyll content between the two rice varieties in both seasons. Giza 178 was earlier in heading than SK2047H. The values of chlorophyll content and LAI were higher for hybrid rice SK2047H than for inbreed rice (Giza 178) in both seasons. These results are in agreement with those reported by Cheng *et al.* (1989), Murthy *et al.* (1991) and Abou Kalifa *et al.* (2005). Meanwhile, varieties had significant effect on light penetration. Results showed that more light penetrated through Giza 178 (inbred rice variety) than hybrid rice (SK2047H) in both seasons. Results indicate that penetrating through rice canopy decreased as LAI increased, however light penetration decreased. These results are in agreement with those obtained by Virmani (1996) and Abd El-Wahab (1998).

Concerning plant spacings, (Table 5) wider plant spacing of 20 x 20 cm and 20 x 30 cm gave the highest values of LAI and light penetration while, the number of day from sowing till 50% heading decreased under narrow spacing of 20 x15 cm. In both seasons, data show insignificant differences existed between 20 x 20 or 20 x 30 cm spacing for light penetration and LAI. The largest LAI under wider spacing of 20 x 20 or 20 x 30 cm might be due to more tillers/hill than narrow spacing of 20 x 15 cm and also, consequently trapped more light. Obtained results are in good accordance with those previously reported by Shin *et al.* (1998) and Zayed *et al.* (2005). Light penetration increased with increasing space between hills. This increment may be attributed to shading of leaves under dense plant population. Also, high plant density might have reduce light intensity between row of transplanting (Abd El-Wahab, 1998).

Data in Table 5 showed that, transplanting of two seedlings/hill significantly decreased the period from sowing to 50% heading, also, decreased LAI compared with four or six seedlings/hill. Moreover, the differences in LAI between four or six seedlings/hill were statistically insignificant. In the same time, six seedlings/hill reduce light penetration. These results are in good agreement with the findings of Obulamma *et al.* (2002). Also, results showed insignificant differences in chlorophyll content values due to crop density in both seasons.

Table 5:Number of days to heading, leaf area index (LAI), light penetration (LUX), chlorophyll content of hybrid (SK2047H) and inbred (Giza 178) rice varieties as affected by plant spacing and number of seedlings per hill during 2004 and 2005 seasons..

Characters / Treatments	Days to heading		Leaf area index (LAI)		Light penetration		Chlorophyll content	
	2004	2005	2004	2005	2004	2005	2004	2005
Varieties (V):								
SK2047H	108.35a	106.7a	7.71a	8.03a	1425.9b	1382.5b	38.86a	37.82a
Giza 178	103.65b	102.07b	5.72b	6.04b	1474.0a	1431.5a	36.29b	35.22b
Plant spacing (S):								
20 x 15 cm	105.57	103.89b	6.52b	6.84b	1376.7b	1333.3b	37.69a	36.95a
20 x 20 cm	106.02	104.33b	6.79a	7.12a	1478.38a	1435.0a	37.65a	36.8a
20 x 30 cm	106.41	104.94a	6.84a	7.16a	1495.00a	1452.8a	37.39b	36.60b
Number of seedlings (N):								
2 seedlings/hill	105.46b	104.0b	6.54b	6.86b	1488.48a	1446.2a	37.80	36.60
4 seedlings/hill	106.02a	104.3ab	6.76a	7.08a	1454.66a	1411.3a	37.86	36.61
6 seedlings/hill	106.52a	104.83a	6.85a	7.17a	1406.96b	1363.6b	37.70	36.30
Interaction effect:								
V X S	NS	NS	NS	NS	*	**	NS	NS
V x N	NS	NS	NS	NS	NS	NS	NS	NS
S x N	NS	NS	NS	NS	*	*	NS	NS
V x S x N	NS	NS	NS	NS	NS	NS	NS	NS

In each column, means followed by a common letter are not significantly different at 5% level according to DMRT

The interaction between varieties and plant spacings had a significant effect on light penetration in both seasons (Table 6). The highest values of light penetration was produced when Giza 178 was planted at 20 x 30 cm while, the lowest value was produced when SK2047H transplanted at the high plant density i.e. 20 x 15 cm. The lowest value of light penetration under the narrow spacing might mainly due to more higher tillers number/unit area, more LAI and dry matter for hybrid rice as compared to inbred rice variety (Padmavathi, 1997). Also, the interaction between plant spacings and no. of seedlings/hill had a significant effect on light penetration in both seasons (Table 7). Results showed that the highest values of light penetration was obtained when two seedlings/hill was planted at 20 x 30 cm space. While, the lowest value was produced when six seedlings, per hill was planted under narrow spacing of 20 x 15 cm.

Table 6:Light penetration (LUX) as affected by the interaction between plant spacings and varieties during 2004 and 2005 seasons.

	Plant spacings (cm)					
Varieties	**20 x 15**	**20 x 20**	**20 x 30**	**20 x 15**	**20 x 20**	**20 x 30**
	2004			2005		
SK2047H	1315.86 d	1480.67 b	1481.2 b	1272.5 d	1437.3 b	1437.8 b
Giza 178	1437.5 c	1476.1 b	1508.82 a	1394.1 c	1432.7 b	1467.7 a

Means followed by a common letter are not significantly different at 5% level according to DMRT

Table 7:Light penetration (LUX) as affected by the interaction between plant spacings and number of seedlings/hill during 2004 and 2005 seasons.

Number of seedlings	Plant spacings (cm)					
	20 x 15	20 x 20	20 x 30	20 x 15	20 x 20	20 x 30
	2004			2005		
2	1435.23 d	1496.6 b	1533.6 a	1391.9 d	1453.2 b	1493.5 a
4	1388.52 e	1486.6 b	1488.85 b	1345.1 e	1443.3 b	1445.5 b
6	1306.35 f	1451.9 cd	1462.58 c	1263.0 f	1408.5 cd	1419.3 c

Means followed by a common letter are not significantly different at 5% level according to DMRT

2. Yield and its components:

2.1. Panicle weight, 1000-grain weight, number of filled grains/panicle, grain filling period and sterility %:

Data in Table 8 presented the effect of rice varieties, plant spacings, number of seedlings/hill and their interaction on panicle weight, 1000-grain weight, number of filled grains/panicle, grain filling period and sterility % in 2004 and 2005 seasons.

Data showed that significant differences were observed between the two tested rice cultivars, where hybrid rice SK2047H surpassed inbred rice (Giza 178) in panicle weight, 1000-grain weight number of filled grains/panicle, long grain-filling period and high percentage of spikelet sterility. Similar findings were obtained by Gu *et al.* (1991), Abou Kalifa (2005) and Ebaid and El-Mowafy (2005).

The analysis of variance in Table 8 confirmed significant variations by plant spacings in all these traits in both seasons, except 1000-grain weight in the two seasons. These results are in harmony with those Patel (1999) and Chopra and Chopra (2000).

The wider spacings of 20 x 20 and 20 x 30 cm gave the heaviest panicle weight, maximum number of filled grains/panicle, long-grain-filling period and lowest sterility %. The inferiority of 20 x 15 cm hill spacing may be due to reducing the rate of photosynthesis because of the competition between plants for light within the dense plants. These results are in agreement with those obtained by Ma-Jun *et al.* (1997), El-Hawary and Gabr (1998), Verma *et al.* (2002), Shivoy and Singh (2003) and Zayed *et al.* (2005).

Regarding number of seedlings/hill, the results showed that highly significant effect, on panicle weight, 1000-grain weight, number of filled grains/panicle, grain-filling period and sterility % in both seasons (Table 8). Two seedlings/hill gave the heaviest panicle weight and the longest grain filling period, while six number of seedlings/hill significantly decreased panicle weight, and number of filled grains/panicle. This could be attributed to the competition on nutrients and light which in turn affected the translocation of carbohydrates and nutrients to the panicles, so less number of filled grains, produced low weight of the panicle. Also, six seedlings/hill gave the highest sterility %. Two and four number of seedlings/hill gave the heaviest 1000-grain weight and number of filled grains/panicle, without any significant difference between them. The current results are in a good harmony with those reported by Abd El-Rahman (1990) and Ebaid and Abo Yousef (2006).

Table 8: Panicle weight (g), 1000-grain weight (g), No of filled grains/panicle, grain filling period and sterility (%) as affected by hybrid and inbred rice cultivars, plant spacings and number of seedlings/hill during 2004 and 2005 seasons.

Characters	Panicle weight (g)		1000 grain weight (g)		No. of filled grains/panicle		Grain filling period (day)		Sterility (%)	
Treatments	**2004**	**2005**	**2004**	**2005**	**2004**	**2005**	**2004**	**2005**	**2004**	**2005**
Varieties (V):										
SK2047H	4.59a	4.63a	26.27a	26.45a	155.04a	162.93a	28.38a	28.79a	7.49a	8.11a
Giza 178	3.56b	3.62b	20.98b	21.17b	129.50b	136.88b	24.074b	24.56b	5.32b	5.53b
Plant spacing (S):										
20 x 15 cm	3.83b	3.89b	23.4	23.59	134.71b	141.52b	25.64b	25.9b	7.17a	7.82a
20 x 20 cm	4.29a	4.33a	23.86	24.05	148.25a	155.38a	26.41a	27.0a	6.27b	6.49b
20 x 30 cm	4.11a	4.16a	23.61	23.79	143.86a	152.82a	26.62a	27.12a	5.76c	6.14c
Number of seedlings (N):										
2 seedlings/hill	4.34a	4.38a	24.10a	24.28a	153.58a	161.08a	26.7a	27.26a	5.38c	5.77c
4 seedlings/hill	4.16b	4.21b	23.91ab	24.09a	146.63a	155.21a	26.38b	26.8b	6.21b	6.85b
6 seedlings/hill	3.72c	3.79c	22.86b	23.06b	126.61b	133.42b	25.6c	26.0b	7.61a	7.84a
Interaction effect:										
V X S	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
V x N	NS	NS	**	**	NS	NS	NS	NS	**	*
S x N	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
V x S x N	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

In each column, means followed by a common letter are not significantly different at 5% level according to DMRT

The interaction between rice varieties and number of seedlings/hill had a significant effect on 1000-grain weight and sterility % in both seasons (Table 9). Data showed that the highest 1000-grain weight was recorded when hybrid SK2047H was planted with two seedling/hill. On the other hand, Giza 178 (inbred) under six seedlings/hill recorded the lowest values of 1000-grain weight in both seasons.

Table 9:1000-grain weight (g) and sterility (%) as affected by the interaction between rice cultivars and number of seedlings per hill during 2004 and 2005 seasons.

Varieties	No. of seedlings/hill	1000-grain weight (g)		Sterility (%)	
		2004	**2005**	**2004**	**2005**
SK2047H	2	27.01 a	27.21 a	6.07 c	6.69 c
	4	26.11 b	26.29 b	7.19 b	8.19 b
	6	25.67 c	25.86 c	9.19 a	9.43 a
Giza 178	2	21.18 e	21.36 e	4.70 e	4.84 f
	4	21.70 d	21.89 d	5.22 d	5.50 e
	6	20.05 f	20.25 f	6.03 c	6.24 d

Means followed by a common letter are not significantly different at 5% level according to DMRT

Furthermore, the interaction between rice varieties and number of seedlings/hill had a significant effect on sterility % in both seasons (Table 9). The highest sterility % was obtained when hybrid SK2047H was planted with six seedlings/hill. The lowest combination in this concern was two

seedlings/hill with Giza 178. Similar results are reported by Gu *et al.* (1991) and Ebadi & Abo-Yousef (2006).

2.2. Number of panicles/hill, biomass yield, grain yield and harvest index:

The performance of the rice varieties in 2004 and 2005 seasons is summarized in Table 10. Data clearly indicated that hybrid SK2047H produced significant higher number of panicles/hill, biomass yield, grain yield and harvest index compared with Giza 178 (inbred rice). These results were expected and could be explained on the basis that hybrids have stronger and more active root system at early and middle growth stages having 21-34% higher root ability at seedling stage (Cheng *et al.,* 1989). Also, Song *et al.* (1990), Yamauchi (1994) and Virmani (1996) reported that more dry matter accumulation, more leaf area index (LAI) and higher crop growth rate (CGR) in hybrid rice as compared to conventional rice.

Seedling spacings proved to be one of the most significant factors affecting rice production (Table 10). Seedlings planted at 20 x 20 cm produced higher number of panicles/hill, biomass yield and grain yield than seedlings planted 20 x 30 or 20 x 15 cm in both seasons. Plant spacing of 20 x 20 and 20 x 15 cm were a par in their harvest index value. These results are in agreement with the findings of Verma *et al.* (2002).

Table 10 : Number of panicles/hill, biomass yield (t/ha), grain yield (t/ha) and harvest index of hybrid (SK2047H) and inbred (Giza 178) rice cultivars as affected by plant spacing and number of seedlings/hill uring 2004 and 2005 seasons.

Characters / Treatments	No. of panicles/hill		Biomass yield (t/ha)		Grain Yield (t/ha)		Harvest index	
	2004	2005	2004	2005	2004	2005	2004	2005
Varieties (V):								
SK2047H	24.76 a	22.63 a	26.34 a	27.65 a	12.12 a	12.72 a	0.46 a	0.46 a
Giza 178	21.31 b	19.94 b	24.38 b	24.69 b	10.73 b	11.11 b	0.44 b	0.45 b
Plant spacing (S):								
20 x 15 cm	21.38 c	19.43 c	24.15 c	24.85 c	11.10 b	11.68 b	0.46 a	0.47 a
20 x 20 cm	25.16 a	23.41 a	26.71 a	27.0 a	12.02 a	12.42 a	0.46 a	0.46 a
20 x 30 cm	22.56 b	21.03 b	25.34 b	26.48 b	11.15 b	11.65 b	0.43 b	0.44 b
Number of seedlings (N):								
2 seedlings/hill	23.70 a	22.11 a	25.50 a	25.91 a	11.73 a	12.18 a	0.47 a	0.47 a
4 seedlings/hill	24.36 a	22.44 a	25.63a	26.61 a	11.79 a	12.24 a	0.45 b	0.46 a
6 seedlings/hill	21.01 b	19.32 b	25.02 b	25.75 b	10.76 b	11.33 b	0.44 c	0.44 b
Interaction effect:								
V X S	NS	NS	NS	NS	NS	NS	NS	NS
V x N	**	**	NS	NS	**	**	NS	NS
S x N	NS	NS	NS	NS	NS	NS	NS	NS
V x S x N	NS	NS	NS	NS	NS	NS	NS	NS

In each column, means followed by a common letter are not significantly different at 5% level according to DMRT

Results in Table 10 revealed that crops planted at 2 or 4 seedlings/hill had a highly significant effect on number of panicles/hill, biomass yield, grain yield and harvest index in both seasons and there was no significant difference between 2 and 4 seedlings/hill, but, 6 seedlings/hill gave the lowest

value of harvest index. These results could be attributed to the absence of competition between two or four seedlings/hill for nutrients and light, which gave the rice plant a good chance for producing more panicles and grain yield. These results are in harmony with those reported by Bisht *et al.* (1999). Shrirame *et al.* (2000) and Verma *et al.* (2002).

The interactions between cultivars and number of seedlings/hill were highly significant on number of panicles/hill and Grain yield (ton/ha) during 2004 and 2005 summer seasons (Table 11).

In general, planted hybrid rice (SK2047H) at two seedlings/hill produced the highest number of panicles/hill (27.19 and 24.98) and grain yield (13.1 and 13.6 t/ha). While, four seedlings/hill gave the highest number of panicle (23.93 and 22.11) and grain yield (11.27 and 11.67 t/ha) for inbred rice (Giza 178), in both seasons respectively.

Table 11:Number of panicles/hill and grain yield (t/ha) as affected by the interaction between rice varieties and number of seedlings per hill during 2004 and 2005 seasons.

Varieties	No. of	No. of panicles/hill		Grain yield (t/ha)	
	seedlings/hill	2004	2005	2004	2005
SK2047H	2	27.19 a	24.98 a	13.10 a	13.60 a
	4	24.79 b	22.77 b	12.30 b	12.81 b
	6	22.29 c	20.15 c	10.96 cd	11.76 c
Giza 178	2	20.28 d	19.24 cd	10.36 d	10.75 d
	4	23.93 b	22.11 b	11.27 c	11.67 c
	6	19.72 d	18.48 d	10.56 d	10.90 d

Means followed by a common letter are not significantly different at 5% level according to DMRT

Generally, the present study indicated that hybrid rice (SK2047H) requires planting two seedlings/hill at (20 x 20 cm) space, while, inbred rice (Giza 178) requires planting four seedlings/hill at the same space to obtain higher grain yield and improve its components, especially the number of filled grains per panicle and number of panicles per hill. Moreover, these results emphasized the importance of different planting geometry and number of seedlings/hill in increasing grain yield in rice because there are no single spacing practices for all varieties. Also, number of seedlings/hill, one of the important factor affecting rice growth specially in hybrid rice.

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سلوك الأرز الهجين والأصناف المرباة داخليا تحت طرق مختلفة من مسافات الزراعة وعدد البادرات بالجورة

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مركز البحوث الزراعية ، مركز البحوث والتدريب فى الأرز سخا - كفرالشيخ - مصر

أقيمت تجربتان حقليتان فى المزرعة البحثية لمركز البحوث والتدريب فى الأرز بسخا كفرالشيخ موسمى صيف ٢٠٠٤ , ٢٠٠٥م بهدف دراسة تأثير ثلاث مسافات من الزراعة (٢٠ × ١٥سم , ٢٠ × ٢٠سم , ٢٠ × ٣٠سم) وثلاث معدلات من البادرات (٢ ، ٤ ، ٦ بادرات فى الجورة) لصنفين من أصناف الأرز هما: الصنف الهجين SK2047H- والصنف المرباة داخليا Giza 178 وكانت أهم النتائج المتحصل عليها كما يلى:

- وجود فروق معنوية بين أصناف الأرز فى معظم صفات النمو ومكونات المحصول ومحصول الحبوب خلال موسمى الزراعة حيث تفوق الصنف الهجين SK2047H معنويا على الصنف Giza 178 (المرباة داخليا) من حيث طول النبات - إنتاج المادة الجافة - معدل الزيادة فى النمو - دليل مساحة الأوراق - محتوى الكلورفيل - عدد الداليات/جورة - وزن حبوب الدالية - وزن الـ ١٠٠٠ حبة - عدد الحبوب الممتلئة/دالية ، فترة إمتلاء الحبوب ، % للحبوب العقيمة بالإضافة إلى محصول الحبوب والقش معا ومحصول الحبوب (طن/هكتار) ودليل الحصاد.
- أعطت مسافات الزراعة الواسعة (٢٠× ٢٠سم , ٢٠ × ٣٠سم) زيادة معنوية فى دليل مساحة الأوراق ، نفاذية الضوء للنبات ، وزن حبوب الدالية ، عدد الحبوب الممتلئة/دالية ، زيادة فترة إمتلاء الحبوب وذلك بالمقارنة بالزراعة الكثيفة (٢٠ × ١٥سم) التى أعطت أعلى القيم فى إنتاج المادة الجافة ، ومعدل الزيادة فى النمو ، وطول النبات ، والنسبة المئوية للحبوب العقيمة.
- بالنسبه لعدد البادرات بالجودة وجد أن شتل بادرتين/بالجورة أدى إلى زيادة معنوية فى وزن الدالية ، وزن الألف حبة ، زيادة فترة إمتلاء الحبوب ، ودليل الحصاد ، أما شتل ستة بادرات/بالجورة فنتج عنها انخفاض وزن الدالية - ووزن الألف حبة - والحبوب الممتلئة/الدالية - عدد الداليات/جورة - ودليل الحصاد - ونقص فى محصول الحبوب والقش معا ومحصول الحبوب فى حين زاد إنتاج المادة الجافة ، ودليل مساحة الأوراق ، % للحبوب العقيمة. لم تظهر فروق معنوية واضحة بين شتل بادرتين أو أربع بادرات/بالجورة فى قيم نفاذية الضوء للنبات ، عدد الحبوب الممتلئة/الدالية ، عدد الداليات/الجورة ، وزن الألف حبة ومحصول الحبوب والقش معا ومحصول الحبوب.
- أظهرت النتائج أن هناك تأثيرا معنويا نتيجة للتفاعل بين الأصناف ومسافات الزراعة فى تكوين المادة الجافة - معدل الزيادة فى النمو - نفاذية الضوء للنبات. كذلك تفاعل بين الأصناف وعدد البادرات بالجورة فى وزن الألف حبة - % النسبة المئوية للحبوب العقيمة - عدد السنابل/الجورة ومحصول الحبوب. وأيضا بين مسافات الزراعة وعدد البادرات بالنسبه لنفاذية الضوء للنبات.
- توصى الدراسة بأنه للحصول على أعلى إنتاجية من صنف الأرز الهجين SK2047H يجب شتله بمعدل بادرتين/بالجورة وعلى أبعاد ٢٠ × ٢٠سم بينما الصنف Giza 178 (المرباة داخليا) يفضل شتله بمعدل أربع بادرات/بالجورة وعلى نفس المسافة ويرجع ذلك لطبيعة النمو القوى والسريع لأصناف الأرز الهجين عن الأصناف العادية.

Table (2):Dry matter weight (g/m^2), crop growth rate (g/m^2/week) and plant height (cm) of hybrid (SK2047H) and inbred (Giza 178) rice varieties as affected by plant spacing and number of seedlings/hill and their interactions during 2004 and 2005 seasons.

Characters	2004			2005			2004		2005		2004	2005
	Dry weight (g/m^2) (sampling days after sowing)						Crop growth rate (g/m^2/week)				Plant height (cm)	
Treatments	**70**	**85**	**100**	**70**	**85**	**100**	**(70-85)**	**(85-100**	**(70-85)**	**(85-100)**	**at harvest**	
Varieties (V):												
SK2047H	576.10	1006.0 a	1460.2 a	629.31	1040.0 a	1506.4 a	214.8	227.2 a	205.2	235.04 a	103.4 a	101.62 a
Giza 178	562.72	912.0 b	1274.0 b	671.5	940.6 b	1325.06 b	174.5	181.0 b	161.5	192.25 b	94.5 b	93.10 b
Plant spacing (S):												
20 x 15 cm	809.7 a	1312.0 a	1905.0 a	879.1 a	1368.6 a	1980.9 a	251.2 a	296.8 a	244.8 a	306.2 a	100.7 a	99.2 a
20 x 20 cm	576.4 b	974.4 b	1368.0 b	629.9 b	1000.7 b	1412.85 b	198.7 b	197.1 b	185.4 b	206.0 b	98.81 b	97.3 ab
20 x 30 cm	322.1 c	590.0 c	827.2 c	361.3 c	601.6 c	853.5 c	134.1 c	118.6 c	119.9 c	128.7 c	97.3 c	95.6 b
Number of seedlings (N):												
2 seedlings/hill	528.11 b	921.0 b	1338.3	581.9 b	958.0 b	1387.4	196.6	208.3	188.0	217.5	100.81 a	99.52 a
4 seedlings/hill	577.2 ab	965.0 a	1372.0	630.6 a	996.9 a	1422.7	193.77	203.8	182.9	212.9	98.61 b	97.2 b
6 seedlings/hill	602.9 a	990.0 a	1391.0	657.7 a	1015.9 a	1437.1	192.7	200.3	179.1	210.6	97.4 b	95.4 c
Interaction effect:												
V X S	*	**	**	*	**	**	*	NS	NS	NS	NS	NS
V x N	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
S x N	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
V x S x N	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

In each column, means followed by a common letter are not significantly different at 5% level according to DMRT