EFFECT OF NUMBER OF SEEDLINGS/HILL AND NITROGEN FERTILIZATION ON PRODUCTIVITY OF RICE (*ORYZA SATIVA L.*) PLANT

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ABSTRACT

Two field experiments were carried out at the Experimental Farm of Rice Research and Training Center (RRTC), Sakha, Kafr El-Sheikh, Egypt, during two consecutive summer seasons of 2003 and 2004. The study aimed to evaluate the effect of three numbers of seedlings per hill (4, 8 and 12) and four nitrogen levels (0, 96, 144 and 192 kg N/ha) on initial vegetative growth and grain yield and its attributes of Sakha 101 and Sakha 102 rice cultivars in two separated experiments, each included one cultivar. A split plot design, with four replications, was used, keeping the number of seedlings/hill in the main plots and the nitrogen levels in the sub-plots.

The main results indicated that plant height and dry matter accumulation were gradually increased from panicle initiation (PI) to complete heading (CH) stages. However, number of tillers was decreased. At PI stage, increased number of seedlings than four seedlings/hill significantly decreased plant height (of both cultivars) and dry matter accumulation of Sakha 102 rice cultivar, while, the dry matter accumulation was increased for Sakha 101 rice cultivar. At complete heading stage, four and eight seedlings per hill gave the highest values of plant height, number of tillers and dry matter yield of Sakha 101 and Sakha 102 rice cultivars, respectively. The results, also, indicated that four seedlings of Sakha 101 and eight seedlings per hill of Sakha 102 rice cultivars gave the highest values of grain yield and its attributes. Regarding nitrogen levels, both cultivars responded to the higher nitrogen levels. Application of nitrogen fertilizer up to 192 Kg N/ha caused a significant increase for all growth characters at PI and CH stages, as well as grain yield and its attribution. On the other hand, there was no significant difference in grain yield between 144 and 192 kg N/ha for both cultivars.

***Key words**: Rice, number of seedlings, nitrogen fertilization and productivity.*

INTRODUCTION

To improve the productivity of rice plants under transplanted conditions, the optimum population per unit area is very important. Crop density is a major factor contributing to higher crop production. The grain yield and its attributes are considerably influenced by the plant population per unit area and the number of seedlings per hill should be very important to be taken into consideration, because of the damage that might happen to some seedlings after pulling and transplanting. Katanyukul and Chantarsa-ard (1977) reported that rice planted at five and seven seedlings per hill produced more tillers and panicles than rice planted at three seedlings per hill. Abd El-Rahman *et. al.* (1990) pointed out that plant height, number of grains/panicle and panicle weight were decreased as number of seedlings per plant increased. Four seedlings per hill recorded the highest grain yield (Abd El-Rahman *et al.*, 1990 and Banik *et al.*, 1997). On the other hand, Chandrakar and Chandaranshi (1998) reported that there was no grain yield difference between two and four seedlings per hill.

Nitrogen is one of the expensive, and perhaps the most crucial nutrient, limiting rice grain yield, since the response of cultivars to applied fertilizer depends on the genetic potential of different genotypes and plant density. It is essential to work out the optimum dose of N for rice cultivars under different plant densities.

Since information is meager, this work was conducted to optimize the number of seedlings per hill requirement for Sakha 101 and Sakha 102 rice cultivars under different nitrogen levels.

MATERIALS AND METHODS

Two field experiments were conducted for two consecutive summer seasons (2003 and 2004) at the Experimental Farm of Rice Research and Training Center (RRTC), Sakha, Kafr El-Sheikh, Egypt, on a clay soil with pH value of 8.2, containing 1.7% organic matter, 45 ppm available N, 260 ppm available K, 12 ppm available P, 0.90 ppm available Zn, 6.10 ppm available Fe and 3.40 ppm available Mn. The objective of the study was to determine the proper number of seedlings per hill under different levels of nitrogen fertilization for the two rice cultivars, Sakha 101, a high yielding and medium duration cultivar (145 days), and Sakha 102, a high yielding and short duration cultivar (125 days). Pre-germinated grains of the rice cultivars, at the rate of 120 kg seeds/ha, were broadcasted in the nursery on 8th and 10th of May in 2003 and 2004 summer seasons, respectively. The two experiments were preceded by Egyptian clover in both seasons. Twenty-five day-old seedlings of each cultivar was transplanted in a 20 x 20 cm spacing among hills and rows in a well leveled and puddled soil. Each experiment was laid out in a split-plot design, with four replications, for each cultivar, where, three numbers of seedlings/hill (4, 8 and 12) were allocated in the main plots, whereas, the four nitrogen levels (0, 20, 40 and kg /ha) were assigned to the sub-

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plots. The net sub-plot size was 15 m^2 (2 x 3 m). The nitrogen fertilizer, in the form of urea (46.5 % N), was applied at the assigned levels in two splits; i.e., 2/3 as a basal application and 1/3 as topdressing at panicle initiation stage. The recommended doses of the other fertilizers; i.e., phosphorus (P_2O_5) and zinc (Zn So_4) were applied at the proper time and the rest of cultural practices were followed as recommended. Random plant samples from the third row in each sub-plot (three hills each) were collected at panicle initiation and complete heading stages to estimate plant height, number of tillers per hill and dry matter yield. Crop growth rate (CGR) was recorded by applying the formula, as described by Radford (1967).

At harvest time, the total number of panicles per hill were counted. Ten panicles from each sub-plot were randomly collected and number of filled grains per panicle and 1000-grain weight were estimated. A guarded area of 10 m^2 from each sub-plot was manually harvested to estimate the grain yield and its moisture content was adjusted to 14% basis.

Data collected were statistically analyzed, according to Gomez and Gomez (1984), using IRRISTAT computer program. The homogeneity test was conducted of error mean squares and, accordingly, the combined analysis was carried out because such errors were homogeneous.

RESULTS AND DISCUSSION

1- Growth characters:

a- Panicle initiation stage:

Data in Table (1) showed that both plant height and dry matter yield (g/hill) of Sakha 101 were significantly affected by the number of seedlings per hill. The tallest plants (72.4 cm) and the highest dry matter yield (122.3 g/hill) were obtained when four and twelve seedlings/hill were transplanted, respectively, over the two seasons. On the other hand, number of tillers/hill did not show any significant differences among the three numbers of seedlings/hill. For Sakha 102, data revealed that plant height (cm) and dry matter yield (g/hill) decreased as the number of seedlings/hill increased up to twelve seedlings per hill, without significant differences between four and eight seedlings/hill in both traits. However, dry matter yield and the number of tillers/hill were not significantly affected by the number of seedlings/hill.

Regarding nitrogen fertilizer, data in Table (1) showed that increasing nitrogen level up to 192 kg N/ha resulted in a significant increase in plant height, number of tillers per hill and dry matter yield of both Sakha 101 and Sakha 102 rice cultivars. The lowest and the highest significant values for these characters were obtained from zero and 192 kg N/ha, respectively.

Concerning the interaction effect (over the two seasons) between number of seedlings and nitrogen levels, data did not show any significant effect on either plant height or the number of tillers per hill for both cultivars. While, it showed a significant effect on dry matter production for both cultivars. The highest value of dry matter production (142.9 g/hill) was found when twelve seedlings per hill were transplanted and received 192 kg N/ha for Sakha 101 (Table 2). While, eight seedlings per hill with, the same level of nitrogen fertilizer, gave the highest value of dry matter production for Sakha 102 (125.7 g/hill) (Table 2).

Table (1): Mean values for some growth characters of Sakha 101 and Sakha 102 at panicle initiation stage as affected by number of seedlings/hill and N levels (combined data of the two seasons).

Main effects	Sakha 101			Sakha 102		
	Plant height (cm)	No. of tillers/ hill	Dry matter yield (g/hill)	Plant height (cm)	No. of tillers/ hill	Dry matter yield (g/hill)
No. of seedlings/ hill:						
4	72.4	20.6	103.2	102.2	23.7	117.2
8	67.4	21.3	113.6	102.4	23.3	116.0
12	69.2	20.9	122.3	98.3	23.0	109.6
L.S.D (5%)	1.6	N.S	7.71	4.0	N.S	N.S
Nitrogen levels (kg/ha):						
0	63.0	14.6	90.8	86.1	18.2	99.7
96	70.8	22.3	108.7	103.9	23.7	113.7
144	75.3	25.9	123..2	112.9	28.1	120.4
192	78.6	27.0	130.4	115.6	27.7	124.1
L.S.D (5%)	1.5	1.6	7.1	3.6	1.9	7.1
Interaction	N.S	N.S	*	N.S	N.S	*

N.S = Not significant and * = Significant at 5 % level.

Table (2): Dry matter yield (g/hill) of Sakha 101 and Sakha 102 as affected by the interaction between number of seedlings/hill and N levels at panicle initiation stage (over both seasons).

N-level (kg/ha)	Sakha 101			Sakha 102		
	Number of seedlings/hill					
	4	8	12	4	8	12
0	92.2	94.1	86.2	106.8	101.3	91.0
96	97.8	108.3	120.0	114.4	117.5	108.2
144	109.2	120.3	140.1	122.9	121.5	115.9
192	115.6	132.7	142.9	124.4	125.7	123.4
L.S.D (5%)	5.2			5.1		

b- Complete heading stage:

Data in Table (3) revealed that plant height of both cultivars was not significantly affected by the different numbers of seedlings per hill over both seasons. While, the number of tillers per hill and dry matter production of Sakha 101 significantly decreased from 21.8 to 19.0 tillers/ hill and from 177.8 to 152.4 g/hill with increasing seedling number from eight to twelve seedlings per hill, respectively, with no significant differences between eight and twelve seedlings per hill for both traits.

For Sakha 102, either eight or twelve seedlings per hill recorded reasonable and optimum numbers of tillers for good growth of rice plants, which, in turn, might positively affect the production of dry matter.

Regarding N fertilizer application, data in Table (3) showed that increasing N level up to 192 Kg N/ha caused a significant increase and the highest values of plant height (96.2 cm), number of tillers per hill (26.8 tiller/hill) and dry matter production (190.7 g/hill) for Sakha 101. The respective values were 112.0, 26.2 and 185.4 for Sakha 102. However, zero nitrogen level recorded the lowest values of all traits under study. This means that Sakha 101 and Sakha 102 rice cultivars similarly responded to N application up to 192 kg/ha. These results are in close conformity with those of Singh *et al.* (1990), Assey *et al.* (1992) and Singh and Sharma (1993).

Table (3): Mean values for some growth characters of Sakha 101 and Sakha 102 as affected by number of seedlings/hill and N levels at heading stage (combined data of the two seasons).

Main effects	Sakha 101			Sakha 102		
	Plant height (cm)	No. of tillers/ hill	Dry matter yield (g/hill)	Plant height (cm)	No. of tillers/ hill	Dry matter yield (g/hill)
No. of seedlings/ hill:						
4	84.4	21.8	177.8	94.0	18.8	149.0
8	84.0	19.2	176.6	96.6	22.1	168.2
12	82.8	19.0	152.4	94.7	22.0	166.4
L.S.D (5%)	N.S	2.1	7.6	N.S	1.4	8.1
Nitrogen levels (kg/ha):						
0	75.1	14.7	132.0	83.0	16.0	123.3
96	84.2	20.9	170.4	97.4	21.6	157.5
144	91.9	24.7	183.3	104.0	25.3	178.4
192	96.2	26.8	190.7	112.0	26.2	185.4
L.S.D (5%)	3.0	2.8	6.4	2.4	1.4	7.3
Interaction	N.S	N.S	*	N.S	N.S	*

N.S = Not significant and * = Significant at 5 % level.

Concerning the interaction effect (over the two seasons) between seedling numbers and N levels on growth characters, data in Table (3) indicated that there was no significant effect on any of these traits, except for dry matter yield for the two rice cultivars. It was clearly indicated that the promising combination was transplanting eight seedlings/hill and applying 192 Kg N/ha for both rice cultivars under study (Table 4), as an average of the two seasons.

Table (4): Dry matter yield (g/hill) of Sakha 101 and Sakha 102 as affected by the interaction between number of seedlings/hill and N levels at heading stage (over both seasons).

N-level (kg/ha)	Sakha 101			Sakha 102		
	Number of seedlings/hill					
	4	8	12	4	8	12
0	132.3	133.6	130.1	120.6	124.6	124.7
96	187.8	184.3	139.1	142.2	161.8	169.1
144	194.4	189.1	166.4	162.8	191.4	181.1
192	196.7	199.4	176	170.4	195.2	190.7
L.S.D (5%)	6.1			5.8		

Data in Fig. (1) showed the crop growth rate (CGR) (g/week/hill) of Sakha 101 and Sakha 102 as affected by the number of seedlings/hill and N levels. Data showed that the highest CGR was obtained when Sakha 101 was transplanted with four seedlings/hill. However, twelve seedlings/hill gave the highest value for Sakha 102. On the other hand, 144 and 192 kg N/ha resulted in an increase of these growth attribute in Sakha 102, compared with the other N levels. While, 96 kg N/ha recorded almost similar values of CGR for both cultivars. In fact, the increased CGR value was associated with an increase in plant height and dry matter accumulation.

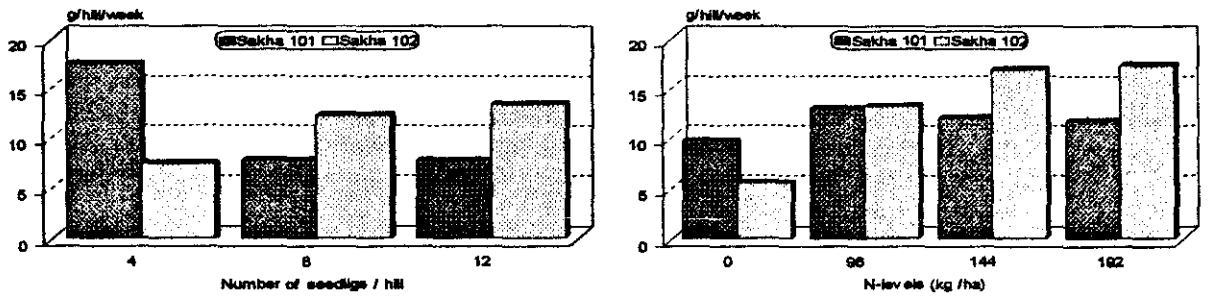

Fig. (1): Crop growth rate (g/week/hill) of Sakha 101 and Sakha 102 as affected by number of seedlings/hill and N levels (over both seasons).

2- Grain yield and its components:

Grain yield and its components of Sakha 101 and Sakha 102 over both seasons, are presented in Table (5). Data showed that there was no significant difference among the three numbers of seedlings/hill for number of panicles of Sakha 101, while, increasing number of seedlings caused a decrease in the number of panicles/hill of Sakha 102. This finding might be due to the greater competition among the large number of seedlings that resulted in more none ear-bearing tillers. Chandrakar and Chandravanshi (1988) and Abd El-Rahman *et. al.* (1990) reported that nine seedlings per hill produced the highest values of this trait under saline soil conditions. On the other hand, Shrirame *et. al.* (2000) found that three seedlings/hill gave more number of panicles/hill for hybrid rice.

For number of filled grains per panicle, data in Table (5) showed that eight seedlings per hill produced the highest values of this trait for both cultivars with no significant difference among the three numbers of seedlings/hill for Sakha 102 rice cultivar. The same trend of this finding was found by Banik *et al.* (1997). Panicle weight was, however, more superior with four seedlings/hill for Sakha 101 and Sakha 102, with no significant difference among three numbers of seedlings for Sakha 102. Increasing the number of seedlings per hill induced a shading effect causing adverse effect on panicle weight. Similar results were reported by Chandrakar and Khan (1981). 1000-grain weight had no significant differences among the number of seedlings for both Sakha 101 and Sakha 102. Such data agreed with those of Chandrakar and Chandravanshi (1988). Grain yield (t/ha) only of Sakha 101 was significantly affected by seedling number/hill over the two seasons. Four and eight seedlings gave the highest significant values of grain yield for such cultivar, compared to the twelve seedlings/hill. However there was no significant difference among the three numbers of seedlings /hill for Sakha 102 ,although the grain yields of four and eight seedlings /hill ,also, were higher than the twelve seedlings. These results might be due to the increase of both panicle and 1000-grain weights of each cultivar. Abd El-Rahman *et al.* (1990) reported that with increasing seedling number, the grain yield was increased up to nine seedlings under saline conditions. Attia *et al.* (1994) found that increasing the number of seedlings from two to three, four and five seedlings/hill increased grain yield. In contrast, Shahi *et al.* (1976), Chandrakar and Chandravanshi (1988) and Shrirame *et al.* (2000) reported that the grain yield was not affected by seedling number/hill.

Table (5): Grain yield and its components of Sakha 102 and Sakha 102 as affected by number of seedlings per hill and N levels (combined data of the two seasons)..

Main effects	Sakha 101					Sakha 102				
	No. of panicles / hill	No. of filled grains/ panicle	Panicle weight (g)	1000-grain weight (g)	Grain yield (t/ha)	No. of panicles / hill	No. of filled grains /panicle	Panicle weight (g)	1000-grain weight (g)	Grain yield (t/ha)
No. of seedlings /hill:										
4	20.8	121.9	4.15	28.7	9.60	21.7	123.9	3.34	28.8	9.12
8	21.0	122.6	3.85	28.2	9.54	20.9	124.1	3.11	28.2	9.22
12	20.9	119.9	3.80	27.6	9.03	20.2	123.4	3.10	29.7	8.91
L.S.D. (5%)	NS	2.5	0.31	NS	0.43	0.4	NS	NS	NS	NS
Nitrogen levels (kg/ha):										
0	19.4	101.7	3.62	28.0	7.59	18.8	105.0	3.15	28.1	6.58
96	20.7	120.0	4.20	28.0	9.59	20.4	125.6	3.11	27.4	8.78
144	22.6	139.7	4.20	28.6	11.09	22.3	140.1	3.14	28.1	10.80
192	23.4	154.4	4.02	28.2	11.56	23.0	145.2	3.43	28.0	10.95
L.S.D. (5%)	1.5	2. 5	0.29	NS	0.50	1.9	11.2	0.25	NS	0.76
Interaction	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

N.S = Not significant.

Regarding nitrogen levels effect, the data in Table (5) showed that all traits of both cultivars were significantly affected by N fertilizer levels, except for 1000-grain weight, which had no significant differences among N levels. The grain yield of both cultivars similarly responded to nitrogen fertilizer levels up to 192 Kg N/ha. However, there was no significant diference between the last two levels of N fertilizer on grain yield of Sakha 102 rice cultivar. So, it could be stated that the reasonable rate of N fertilizer might be 144 kg/ha for Sakha 102 rice cultivar under the conditions of the present work. The other studied characters showed the same trend of grain yield over both seasons. Also, the interaction was not significant for all traits (Table 5).

The present study suggested that four seedlings/hill, with application of 192 Kg N/ha, might favorable for good rice plant growth and good grain yield for Sakha 101. While, eight seedlings/hill and 144 Kg N/ha could the promising combination for Sakha 102.

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الملخص العربي

تأثير عدد البادرات بالجورة و التسميد النيتروجيني على إنتاجية نبات الأرز (*Oryza sativa L.*)

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مركز البحوث الزراعية– معهد بحوث المحاصيل الحقلية– مركز البحوث و التدريب في الأرز – سخا–كفر الشيخ

أجريت تجربتان حقليتان بمزرعة مركز البحوث والتدريب في الأرز بسخا – كفر الشيخ – مصر خلال موسمي صيف ٢٠٠٢ و ٢٠٠٣ م لدراسة تأثير عدد البادرات بالجورة (٤ و ٨ و ١٢ بادرة/جورة) و أربع مستويات من التسميد النيتروجيني (بدون سماد و ٩٦ و ١٤٤ و ١٩٢ كجم نيتروجين/هكتار) على النمو و محصول الحبوب و مكوناته لصنفي الأرز "سخا ١٠١ وسخا ١٠٢". أقيمت التجربتان منفصلتان و احتوت كل تجربة على صنف واحد و استخدم فيها تصميم القطع المنشقة مرة واحدة في أربع مكررات بحيث احتوت القطع الرئيسية على عدد البادرات بالجورة ، في حين احتوت القطع الشقية على مستويات التسميد النيتروجيني.

وقد أوضحت أهم النتائج أن ارتفاع النباتات و تراكم المادة الجافة قد زادت تدريجيا من مرحلة بزوغ الداليات و حتى مرحلة تمام الطرد، بينما نقص عدد الأشطاء بكل جورة. و في مرحلة بزوغ الداليات وجد أن زيادة عدد البادرات عن أربعة بالجورة أدى إلى الزيادة المعنوية في ارتفاع النباتات لكلا الصنفين (سخا ١٠١ و سخا ١٠٢)، بينما نقص تراكم المادة الجافة في الصنف "سخا ١٠٢". وفى مرحلة تمام الطرد سجلت كل من أربع و ثمان بادرات بالجورة أعلى القيم لكل من ارتفاع النباتات وعدد الفروع بالجورة و المادة الجافة لصنفي الأرز"سخا ١٠١ و سخا ١٠٢" على التوالي.

وتشير النتائج أيضا إلى أن أربع بادرات بالجورة للصنف "سخا ١٠١" و ثمان بادرات بالجورة للصنف "سخا ١٠٢" قد أعطت أعلى القيم لمحصول الحبوب و مكوناته. و قد استجاب كلا الصنفين للزيادة في مستويات التسميد النيتروجيني المضافة حيث أعطى التسميد بمعدل ١٩٢ كجم نيتروجين/هكتار أعلى القيم لجميع صفات النمو المدروسة في مرحلتي بزوغ الداليات و تمام الطرد، بالإضافة إلى محصول الحبوب و مكوناته. و على الجانب الآخر لم تكن هناك فروق معنوية في محصول الحبوب عند استخدام معدل ١٤٤ أو ١٩٢ كجم نيتروجين/هكتار و ذلك لكلا الصنفين.