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RESPONSE OF SAKHA 105 RICE CULTIVAR TO NITROGEN LEVELS UNDER DIFFERENT TIME AND METHODS OF APPLICTION

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ABSTRACT: *To study the response of Sakha 105 rice cultivar to nitrogen levels, i.e., without (control) , 110, 165 and 220 kg N/ha. under different time and methods of its application, viz., T_1: 100% basal, T_2: ½ basal + ½ mid of tillering, T_3: ⅓ basal + ⅓ mid of tillering + ⅓ panicle initiation and T_4: ⅔ basal + ⅓ mid of tillering, two field experimental carried out in 2011 and 2012 seasons at the Experimental Farm of Rice Research and Training Center, Sakha, Kafr El-Sheikh governorate, Egypt.*

The results revealed that raising nitrogen rate up to 220 kg N/ha. gradually increased plant height, flag leaf area, chlorophyll content, number of tillers/m^2, number of days to heading, as well as number of grains/panicle and straw yield. However, moderate N rate (165 kg N/ha.) is considered the suitable dose which not only improved vegetative growth but, also produced maximum number of panicles/m^2, filled grains percentage, as well as 1000-grain weight and grain yield. The highest harvest index was recorded with 110 kg N/ha. Adding nitrogen fertilizer into three equal splits at basal, mid of tillering and panicle initiation gave the maximum values of studied growth patterns and grain yield components, as well as, grain yield and harvest index. Tow equal splits of nitrogen fertilizer at basal and mid of tillering recorded the maximum number of tillers/m^2, while, 100% of nitrogen basal application gave the highest straw yield. So, this investigation conduced that rice growers were advised to fertilize Sakha 105 rice cultivar with 165 kg N/ha. into three equal splits at basal, mid of tillering and panicle initiation for improving vegetative growth and achieving the maximum grain yield.

***Key words**: Rice, cultivar, Nitrogen fertilizer and grain yield components.*

INTRODUCTION

Rice (*Oryza sativa* L.) is an important food crop in the diet of the world population because of its nutritional features and low price. In the last decade, the cultivated area worldwide for rice was around 147.5 million ha (FAO, 2004). In Egypt, rice area was about 0.66 million hectares (1.57 million feddans), and total rice production reached about 6 million tons with national yield average of 9.10 t/ha. This average ranked the highest among all rice cultivating countries throughout the world (Economic Sector, Ministry of Agriculture and Land Reclamation, 2010).

Rice production depends on several factors: climate, physical conditions of the soil, soil fertility, water management, sowing date, cultivar, seed rate, weed control and fertilization (Jing *et al*., 2008). For fertilization, N is the main nutrient associated with yield (Sahrawat 2006, Bouman *et al*., 2007, De-Xi *et al*., 2007 and Jing *et al*., 2008). Its availability promotes crop growth and tillering, finally determining the number of panicles and spikelets during the early panicle formation stage. This nutrient also provides sink during the late panicle formation stage (Artacho *et al*., 2009). Raising rice production can be achieved through optimizing the agricultural practices such as nitrogen fertilization levels and splitting of nitrogen fertilizer. In this regard, many researchers have shown that rice cultivars differ in their growth, grain yield and grain yield components. These views were reported by El-Hosary *et al*. (2000), El-Rewainy *et al*. (2003) they reported that, increasing N-levels up to 60 kg N/fed significantly increased panicle length, panicle grain weight number of field grains/panicle 1000-grain weight, grain yield and straw yield T/fed. Several results were obtained by Sallam (2005) who stated that increasing N-levels from 0, 20, 40 to 60 kg N/fed significantly increased plant height, panicle length, panicle grain weight, 1000-grain weight, grain and straw yields per fad of Gz 1368 cultivar. The same results were reported by El Rewainy *et al*. (2003) who reported that increasing N-levels up to 60 kg N/fed significantly increased panicle length, panicle grain weight, number of field grains/panicle, 1000-grain weight, grain yield and straw yield t/fed. Yield of the newly recommended rice cultivars is not only influenced by nitrogen fertilizer but also by splitting of nitrogen. In this respect, Sallam (2005) stated that adding nitrogen fertilizer in two equal doses significantly increased grain yield and most of its components compared with one or three doses. El-Hosary *et al*. (2000) mentioned that growth, grain yield and its components of rice cultivars responded to splitting nitrogen fertilizer. El-Rewainy *et al.*(2003), Ebaid and Ghanem (2001) and Sallam (2005). Therefore, this investigation was carried out in order to study the effect of nitrogen fertilizer levels, as well as nitrogen split application on growth and productivity of Sakha 105 cultivar.

MATERIALS AND METHODS

The present study was carried out during two successive rice seasons; 2011 and 2012 at Rice Research and Training Center Experimental Farm, Sakha, Kafr El-Sheikh governorate, Egypt to study the impact of various nitrogen levels, i.e. control (without nitrogen fertilization), 110, 165 and 220 kg N/ha. in the form of urea (46.5% N) and different times and methods of nitrogen application; viz. once basaly, two equal splits at basal and mid of tillering, three equal splits at basal, mid of tillering and panicle initiation and two/thirds basaly and one/third at mid of tillering on Sakha 105 rice cultivar (GZ5581-46-3/GZ4316-7-1-1) growth and productivity. Growth stages of Sakha 105 rice cultivar used in this study are shown in Table (1)

The experiments were laid out in a randomized complete block design, with four replications. The main plots were assigned to nitrogen rates, while, the sub-plots were devoted to time and methods of nitrogen application. The sub-plot size was 4 x 4m (16m^2). The preceding winter crop was wheat in both seasons of study. Soil samples were taken from the experimental site at the depth of 0-30 cm from the soil surface, air-dried, then ground to pass through a two mm sieve and well mixed soil samples were physically analyzed according to Piper (1950) and chemically analyzed according to Black *et al.* (1965) (Table 2).

The nursery area was fertilized with 4 kg/175 m^2 of calcium super phosphate (15.5% P_2O_5) incorporated into dry soil before ploughing and 3 kg/175 m^2 urea (46.5% N) added after ploughing, as well as one kg/175 m^2 of Zinc sulphate (40% Zn) immediately before sowing, then rice grains with the rate of 120 kg/ha. was soaked in water for 24 hour and incubated for 48 hour. At 2-3 cm nursery water depth, rice grains were handly broadcasted on mid May of both seasons. During permanent field preparation, phosphorus fertilizer was added once at the rate of 40 kg P_2O_5/ha. in the form of super phosphate (15.5% P_2O_5), moreover, all sub-plots received 48 kg K_2O/ha. in the form of potassium sulphate (48% K_2O). Thirty day old seedlings of Sakha 105 rice cultivar were handly transplanted with three seedlings/hill, spaced at 20 x 20 cm. The other cultural practices were applied, according to the recommendations of Rice Research and Training Center, for inbred rice cultivation. Tiller number/m^2, chlorophyll content, using chlorophyll meter (Model SPAD-502) and leaf area, using leaf area meter (Model LI 3000A) were estimated at heading stage. Number of days from sowing to 50% heading of each sub-plot was recorded.

Table (1): Growth stages of Sakha 105 rice cultivar (days after sowing).

Growth stage	Mid of tillering	Panicle initiation	Booting	Complete heading	Maturity
Days after sowing	55	65	75	85	120

Table (2): Physical and chemical analyses of the experimental soil sites in 2011 and 2012 seasons.

Character	2011	2012
Physical analysis:		
Soil texture	14.5	12.8
Sand %	30.2	31.6
Silt %	56.8	54.3
Clay %	clay	clay
Chemical analysis:		
pH	7.9	8.1
Electric conductivity Ec (dS/m)	1.8	2.2
Organic matter %	1.6	1.8
Total N ppm	18.4	18.9
Total P ppm	16.3	17.5
Total K ppm	317	324
Total Zn ppm	0.8	0.9

At harvesting time, height of ten random plants from each sub-plots were recorded and panicles number of the central square meter from each sub-plot was counted, then, ten main panicles from each sub-plot were randomly taken for determining its total number of grains, filled grains percentage and 1000-grain weight(g). An area of 6 square meters in the center of each sub-plot was handly harvested, air dried and threshed to estimate grain and straw yields, then adjusted into t/ha. and harvest index was calculated as ratio between grain yield and biological yield (grain yield and straw yield). Thereby, nitrogen use efficiency and partical factor productivity was calculated as follows:

- **Efficiency of nitrogen fertilizer:** It is defined as the increase in grain yield per unit applied of nitrogen fertilizer (Youshida, 1981).

Efficiency of nitrogen fertilizer =

$$\frac{\text{Grain yield of treatment (kg/ha.) – grain yield of control (kg/ha.)}}{\text{Kg applied nitrogen}}$$

- **Partical factor productivity:** Partial factor productivity from applied nitrogen is defined as the ratio of total grain output to applied nitrogen inputs (Peng *et al.,* 1996).

Partical factor productivity =

$$\frac{\text{Grain yield (t/ha.)}}{\text{Kg applied nitrogen}} \times 100$$

All collected data were statically analyzed, according to Gomez and Gomez, (1984), using IRRISTAT Computer program. Treatment means were compared using Duncan's multiple range test (Duncan, 1955).

RESULTS AND DISCUSSION

I- Growth patterns:

The effect of nitrogen levels, time and methods of nitrogen application and their interaction on vegetative growth parameters of Sakha 105 rice cultivar in 2011 and 2012 seasons are presented in Table (3). Data indicated that increasing nitrogen level up to 220kg N/ha. significantly increased plant height, flag leaf area, chlorophyll content, number of tillers/m^2 and number of days to heading. This improvement in vegetative growth could be attributed to the fact that nitrogen application plays a prominent role in building of new meristematic cells, cell elongation and, hence, increased photosynthetic activity. The abovementioned results are in accordance with those obtained by Islam *et al.* (2008), Kandil *et al.* (2010) and Haque *et al.* (2012).

Table (3): Growth patterns of Sakha 105 Rice cultivar as affected by levels and split applications of nitrogen fertilizer in 2011 and 2012 seasons.

Treatment	Plant height (cm)		Flag leaf area (Cm^2)		Chlorophyll content (SPAD value)		Number of tillers/m^2		Days to heading (Day after sowing)	
	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012
Nitrogen level (kg N/ha.):										
Without (Control)	8068d	78.47d	26.82d	24.56d	33.38d	32.82d	365.09d	340.49d	89.87d	90.76d
110	92.13c	90.09c	29.47c	28.29c	38.39c	37.36c	462.75c	449.07c	93.38c	93.64c
165	96.99b	95.21b	33.34b	31.72b	41.73b	40.95b	521.89b	510.51b	95.27b	95.83b
220	101.24a	98.98a	34.68a	32.91a	43.62a	43.23a	543.59a	534.96a	98.63a	99.72a
F. Test	**	**	**	**	**	**	**	**	**	**
Nitrogen split applications (T):										
T_1	88.09c	85.34d	29.85c	28.60b	37.01c	36.28c	477.59b	459.92b	92.58c	93.22c
T_2	93.62b	91.75b	30.63c	28.96b	39.03b	38.81b	496.13a	480.04a	94.39b	95.13b
T_3	96.95a	95.42a	32.22a	30.55a	42.31a	41.20a	451.06d	439.23d	96.23a	96.84a
T_4	92.38b	90.23c	31.61b	29.37b	38.77b	38.06b	468.54c	455.81c	93.95b	94.76b
F. Test	**	**	*	*	**	**	**	**	**	**
N X T Interaction:	**	**	N.S	N.S	**	**	**	**	N.S	N.S

T_1: 100% basal (B) T_2: ½ B + ½ mid of tillering (MT).
T_3: ⅓ B + ⅓ MT + ⅓ Panicle initiation (PI). T_4: ⅔ B + ⅓ MT.
* Significant at 0.05 level. ** Significant at 0.01 level. N.S: Not significant.
Means followed by the same letter are not significantly different, according to DMRT.

Concerning the effect of nitrogen split application, data in Table (3) showed that vegetative growth characters were significantly affected by time and methods of nitrogen application. Partitioning of nitrogen fertilizer as follows: ⅓ basally + ⅓ at mid of tillering + ⅓ at panicle initiation (T_3) produced the tallest plants, largest area of flag leaf, highest chlorophyll content and the maximum number of days to heading compared with adding all amount of nitrogen fertilizer once at basal (T_1) which gave the lowest values of the abovementioned traits. Moreover, both of ½ basally + ½ at mid of tillering (T_2) and ⅔ basaly + ⅓ at mid of tillering (T_4) recorded intermediate values. On the other side, number of tillers/m^2 was significantly higher with (T_2), designedly followed by (T_1), (T_3) and (T_4). The superiority of (T_3) might be due to increase nitrogen efficiency by rice plants and reduction nitrogen loss by volatilization and leaching resulted in better growth and development (Manzoor *et al.,* 2006). In addition, Tahir *et al.* (2008) reported that adequate and balance supply of nitrogen promotes vigorous vegetative growth and chlorophyll content as well as influences utilization of P, K and other nutrient which results better growth of rice plants. Such effects of nitrogen split application on vegetative growth patterns were observed by Islam *et al.* (2009), Sathiya and Ramesh (2009), Kaushal *et al.* (2010) and Tabar *et al.* (2012).

In regard to the interaction effect, it is evident from Table (3) that there was no significant effect of the interaction between nitrogen level and its split application on flag leaf area or number of days to heading, on the other hand the interaction had a significant effect on plant height, chlorophyll content and tiller number/m^2. It could be easily observed from data presented in Tables (4, 5 and 6) that adding 220 kg N/ha. as three equal split at basal, mid of tillering and panicle initiation gave the tallest plants, and the highest chlorophyll content, while, the maximum number of tillers/m^2 was obtained when the highest nitrogen level (220 kg N/ha.) was applied equally at basal and mid of tillering. However the lowest values in this respect were recorded with control (without nitrogen fertilizer application).

Table (4): Effect of interaction between nitrogen level and time and methods of its application on plant height (cm) of Sakha 105 rice cultivar in 2011 and 2012 seasons.

Time and methods of N application (T)	2011				2012			
	Nitrogen level (kg N/ha.)				Nitrogen level (kg N/ha.)			
	Without (control)	110	165	220	Without (control)	110	165	220
T_1	80.82i	86.15h	90.26g	95.14de	78.35j	83.39i	87.37h	92.25g
T_2	81.76i	93.38ef	98.37c	100.96b	77.42j	92.09g	97.46de	100.02bc
T_3	79.91i	97.10cd	103.48b	107.32a	79.27j	95.37ef	102.08b	104.97a
T_4	80.23i	91.89fg	95.85cde	101.54b	78.84j	89.51h	93.91fg	98.66cd

T_1: 100% basal (B) T_2: ½ B + ½ mid of tillering (MT).
T_3: ⅓ B + ⅓ MT + ⅓ Panicle initiation (PI). T_4: ⅔B + ⅓ MT.
Means followed by the same letter(s) are not significantly different, according to DMRT.

Table (5): Effect of interaction between nitrogen level and time and methods of its application on chlorophyll content (SPAD value) of Sakha 105 rice cultivar in 2011 and 2012 seasons.

Time and methods of N application (T)	2011				2012			
	Nitrogen level (kg N/ha.)				Nitrogen level (kg N/ha.)			
	Without (control)	110	165	220	Without (control)	110	165	220
T_1	34.40gh	35.86fg	37.74ef	40.05d	33.89fgh	34.84efg	36.80de	39.61c
T_2	33.87hi	38.13e	40.82cd	43.28b	33.54fgh	38.72cd	40.06c	42.93b
T_3	32.09i	42.64bc	46.71a	47.80a	31.46h	39.95c	45.93a	47.47a
T_4	33.15hi	36.92ef	41.66bc	43.35b	32.39gh	35.92ef	41.02bc	42.90b

T_1: 100% basal (B) T_2: ½ B + ½ mid of tillering (MT).
T_3: ⅓ B + ⅓ MT + ⅓ Panicle initiation (PI). T_4: ⅔B + ⅓ MT.
Means followed by the same letter(s) are not significantly different, according to DMRT.

Table (6): Effect of interaction between nitrogen level and time and methods of its application on number of tillers/m^2 of Sakha 105 rice cultivar in 2011 and 2012 seasons.

Time and methods of N application (T)	2011				2012			
	Nitrogen level (kg N/ha.)				Nitrogen level (kg N/ha.)			
	Without (control)	110	165	220	Without (control)	110	165	220
T_1	363.12j	476.34g	512.47d	558.42b	341.74j	455.16g	496.43e	546.36b
T_2	364.39j	487.63f	549.82b	582.67a	339.78j	471.87f	536.29c	572.23a
T_3	367.18j	434.84i	498.69e	503.54de	338.41j	427.49i	492.35e	498.77e
T_4	365.67j	452.19h	526.58c	529.73c	342.03j	441.76h	516.97d	522.48d

T_1: 100% basal (B) T_2: ½ B + ½ mid of tillering (MT).
T_3: ⅓ B + ⅓ MT + ⅓ Panicle initiation (PI). T_4: ⅔ B + ⅓ MT.
Means followed by the same letter(s) are not significantly different, according to DMRT.

II: Grain yield components:

Adding 165 or 220 kg N/ha. produced the maximum number of panicles/m^2 without any significant deference between them, while, total number of grains/panicle significantly increased by increasing nitrogen level up to 220 kg N/ha. Moreover, the highest percentage of filled grains and the heaviest weight of 1000-grain were obtained when 165 kg N/ha. was added and significantly decreased with 220 kg N/ha. (high N level). The lowest values of abovementioned grain yield components were always belonging to control (without nitrogen fertilizer application) during 2011 and 2012 seasons (Table 7). The reduction of 1000-grain weight and filled grains percentage with the highest N level might be attributed to enhancing vegetative growth and delayed heading, as well as, decreasing grain filling (Poussin *et al.* 2005). Additionally, Matushima (1966) noticed the reduction in 1000-grain weight and filled grains percentage due to ashortage of charbohydrates supplied per grain, which was directly caused by an excessive number of grains produced by heavy nitrogen fertilization. Meanwhile, Ebaid and Ghanem (2001) reported that, the positive effect of nitrogen application in increasing number of total grains/panicle might be due to the role of nitrogen in promoting vegetative growth and increasing panicle length and number of branches/panicle. a similar trend was found in a good harmony with those reported by Nawaz *et al* (2001), Hach and Hongnam (2006) and Kandil *et al.* (2010).

With respect to time and methods of nitrogen application effect, data of both 1st and 2nd seasons illustrated in Table (7) indicated that split application of nitrogen fertilizer significantly affected grain yield components of Sakha 105 rice cultivar. The highest values were obtained by adding nitrogen into three equal splits at basal, mid of tillering and panicle initiation. On the other and 100% basal application of nitrogen gave the lowest values in this respect. In addition, the other two nitrogen splits either ½ basally + ½ at mid of tillering nor ⅔ basaly + ⅓ at mid of tillering produced intermediate values of grain yield components. These findings could be mainly attributed to the continuous supply of N application until panicle initiation, which improved vegetative growth, delayed leaf senescence and increased grain filling (Dingkuhan *et al.*, 1992). This improvement in grain yield components with partitioning nitrogen fertilizer might be, also, due to the utilization of N at critical growth stages (Peng *et al.*, 2003). These results are in a parallel line with the findings of Sallam (2005), Tahir *et al.* (2008) and Abd El-Maksoud (2008).

Table (7): Grain yield components of Sakha 105 rice cultivar as affected by levels and split applications of nitrogen fertilizer in 2011 and 2012 seasons.

Treatment	Number of panicles/M^2		Total numbers of grains/panicle		Field grains percentage		1000-grain weight (g)	
	2011	2012	2011	2012	2011	2012	2011	2012
Nitrogen level (kg N/ha.):								
Without (control)	339.18c	320.64c	107.26d	103.35d	92.90d	94.11b	25.02d	25.30d
110	404.35b	391.92b	122.51c	118.84c	93.13c	95.26a	25.81c	26.27c
165	467.47a	457.71a	127.90b	126.73b	95.04a	95.63a	27.75a	28.38a
220	472.63a	466.43a	133.47a	130.96a	94.58b	94.37b	26.54b	26.88b
F. Test	**	**	**	**	**	**	**	**
Nitrogen split applications (T):								
T_1	401.91d	386.78d	114.97d	112.66d	93.32c	94.48b	25.68c	26.11d
T_2	427.03b	414.10b	125.28b	121.98b	94.29b	94.95a	26.33b	26.78b
T_3	438.58a	430.33a	131.01a	128.17a	95.06a	95.38a	26.96a	27.40a
T_4	416.11c	405.48c	119.89c	117.08c	93.99b	94.57b	26.15b	26.53c
F. Test	**	**	**	**	*	*	**	**
N X T Interaction:	**	**	**	**	N.S	N.S	**	**

T_1: 100% basal (B) T_2: ½ B + ½ mid of tillering (MT).
T_3: ⅓ B + ⅓ MT + ⅓ Panicle initiation (PI). T_4: ⅔ B + ⅓ MT.
* Significant at 0.05 level. ** Significant at 0.01 level. N.S: Not significant.
Means followed by the same letter are not significantly different, according to DMRT.

Table (8 , 9 and 10) Shows a significant effect of the interaction between nitrogen levels and it's split application on grain yield components except for filled grains percentage. The highest number of panicles/m^2 and grains/panicle were obtained with the application of 220 kg N/ha. In three equal splits at basal, mid of tillering and panicle initiation without significant differences with adding 165 kg N/ha. Equally at basal, mid of tillering and panicle initiation for number of panicles/m^2 in 2011 season and number of grains/panicle in 2012 season. Also, the maximum weight of the 1000-grain was observed when 165 kg N/ha. Was applied as ⅓ basally, ⅓ at mid of tillering, and ⅓ at panicle initiation , the lowest number of panicles/m^2, grains/panicle and 1000-grain weight were beloved to control (without any nitrogen fertilizer application).

Table (8): Effect of interaction between nitrogen level and time and methods of its application on number of panicles/m of Sakha 105 rice cultivar in 2011 and 2012 seasons.

Time and methods of N application (T)	2011				2012			
	Nitrogen level (kg N/ha.)				Nitrogen level (kg N/ha.)			
	Without (control)	110	165	220	Without (control)	110	165	220
T_1	340.56h	387.82g	436.50d	442.77d	321.20k	370.39j	423.28g	432.25f
T_2	339.90h	406.79f	477.68b	483.74b	322.07k	391.27h	466.61d	476.46c
T_3	337.24h	429.37e	491.27a	496.43a	318.45k	422.76g	486.53b	493.59a
T_4	339.02h	393.42g	464.43c	467.58c	320.83k	383.83k	454.42e	463.41d

T_1: 100% basal (B) T_2: ½ B + ½ mid of tillering (MT).
T_3: ⅓ B + ⅓ MT + ⅓ Panicle initiation (PI). T_4: ⅔ B + ⅓ MT.
Means followed by the same letter(s) are not significantly different, according to DMRT.

Table (9): Effect of interaction between nitrogen level and time and methods of its application on number of grains/Panicl of Sakha 105 rice cultivar in 2011 and 2012 seasons.

Time and methods of N application (T)	2011				2012			
	Nitrogen level (kg N/ha.)				Nitrogen level (kg N/ha.)			
	Without (control)	110	165	220	Without (control)	110	165	220
T_1	106.73g	115.05f	117.26ef	120.82de	102.48g	112.57f	116.21ef	119.39de
T_2	107.68g	123.81d	132.19c	137.43b	104.74g	120.34de	127.99c	134.84b
T_3	107.97g	132.42c	138.97b	144.68a	103.25g	127.61c	139.57ab	142.25a
T_4	106.66g	118.76def	123.19d	130.95c	102.93g	114.85ef	123.16cd	127.36c

T_1: 100% basal (B) T_2: ½ B + ½ mid of tillering (MT).
T_3: ⅓ B + ⅓ MT + ⅓ Panicle initiation (PI). T_4: ⅔ B + ⅓ MT.
Means followed by the same letter(s) are not significantly different, according to DMRT.

Table (10): Effect of interaction between nitrogen level and time and methods of its application on 1000 grain weight of Sakha 105 rice cultivar in 2011 and 2012 seasons.

Time and methods of N application (T)	2011				2012			
	Nitrogen level (kg N/ha.)				Nitrogen level (kg N/ha.)			
	With out (control)	110	165	220	Without (control)	110	165	220
T_1	25.05g	24.82g	27.14c	25.72f	25.32h	25.25h	27.79c	26.06g
T_2	24.94g	26.08ef	27.86b	26.43de	25.22h	26.57ef	28.46b	26.87de
T_3	25.00g	26.59d	28.37a	27.86b	25.39h	26.94d	29.09a	28.16b
T_4	25.09g	25.75f	27.63b	26.14e	25.27h	26.32fg	28.17b	26.35fg

T_1: 100% basal (B) T_2: ½ B + ½ mid of tillering (MT).
T_3: ⅓ B + ⅓ MT + ⅓ Panicle initiation (PI). T_4: ⅔ B + ⅓ MT.
Means followed by the same letter(s) are not significantly different, according to DMRT.

III: Grain yield, straw yield and harvest index:

Data presented in Table (11) revealed a significant increase in grain yield by increasing nitrogen rate up to 165 kg N/ha. and slightly reduced with the highest nitrogen level (220 kg N/ha.), while, straw yield gradually increased by increasing nitrogen level until 220kg N/ha. In addition, adding 110 kg N/ha. significantly increased harvest index, then, it decreased by increasing the rate of nitrogen fertilizer above this rate. The results were similar in both seasons. The positive effect of nitrogen in increasing grain yield might be due to improvement photosynthesis and accumulated more photosynthetic production, such effects were caused by increasing yield components; i.e. number of panicles/m^2, number of grains/panicle, filled grains percentage and 1000-grain weight. Mean while, the reduction in grain yield in response to high N level (220 kg N/ha.) was mainly due to encourage foliage growth against reproductive growth resulted in reducing grain filling (Koutroubas and Ntanos, 2003). Similar results were found by Saito *et al.* (2006), Baba *et al.* (2010) and Gorgy (2010).

Regarding the effect of nitrogen split application, data of Table (11), also clarified that, adding nitrogen fertilizer in three equal splits at basal, mid of tillering and panicle initiation (T_3) produced the highest significant grain yield and harvest index, as well as, the lowest straw yield. In contrary, applying 100% of nitrogen fertilizer as basal (T_1) gave the minimum grain yield and harvest index, as well as, the maximum straw yield. Increasing grain yield and harvest index with (T_3) might be due to keeping high amount of available nitrogen at critical growth. stages of rice plants, which, delayed leaf senescence and prolonging active grain filling period (Ten-Berge *et al.,* 1997). Such results are going in agreement with those of Manzoor *et al.* (2006), El-Rewainy *et al.* (2007) and Tabar *et al.* (2012).

The Interaction between nitrogen level and its split application had only a significant effect on grain and straw yields of Sakha 105 rice cultivar (Table 11). Tables (12 and 13) revealed that the maximum grain yield was recorded when 165 kg N/ha. was added equally at basal, mid of tillering and panicle initiation, while, adding 220 kg N/ha. basally gave the highest straw yield. In general, without nitrogen application (control) produced the lowest grain and straw yields.

Table (11): Grain yield, straw yield and harvest index of Sakha 105 rice cultivar as affected by levels and split applications of nitrogen fertilizer in 2011 and 2012 seasons

Treatment	Grain yield (t/ha.)		Straw yeidl (t/ha.)		Harvest index (HI)	
	2011	2012	2011	2012	2011	2012
Nitrogen level (kg N/ha.):						
Without (control)	6.557c	6.203c	8.699d	8.258d	42.98d	42.90d
110	10.463b	10.278b	12.024c	11.623c	46.47a	46.96a
165	11.679a	11.512a	13.780b	13.461b	45.99b	45.87b
220	11.481a	11.374a	14.828a	14.625a	43.56c	43.94c
F. Test	**	**	**	**	**	**
Nitrogen split applications (T):						
T_1	9.569c	9.308c	12.913a	12.532a	42.65d	42.64c
T_2	10.126b	9.926b	12.184c	11.829c	45.31b	45.68b
T_3	10.454a	10.272a	11.702d	11.371d	46.67a	46.81a
T_4	10.031b	9.861b	12.533b	12.236b	44.36c	44.52c
F. Test	**	**	**	**	**	**
N X T Interaction:	**	**	**	**	N.S	N.S

T_1: 100% basal (B) T_2: ½ B + ½ mid of tillering (MT).
T_3: ⅓ B + ⅓ MT + ⅓ Panicle initiation (PI). T_4: ⅔ B + ⅓ MT.
* Significant at 0.05 level. ** Significant at 0.01 level. N.S: Not significant.
Means followed by the same letter(s) are not significantly different, according to DMRT.

Table (12): Effect of interaction between nitrogen level and time and methods of its application on grain yield (t/ha.) of Sakha 105 rice cultivar in 2011 and 2012 seasons.

Time and methods of N application (T)	2011				2012			
	Nitrogen level (kg N/ha.)				Nitrogen level (kg N/ha.)			
	Without (control)	110	165	220	Without (control)	110	165	220
T_1	6.634h	9.536g	11.113e	10.994e	6.218i	9.347h	10.857f	10.811f
T_2	6.535h	10.529f	11.849ab	11.591cd	6.261i	10.283g	11.665bc	11.493cd
T_3	6.483h	11.396d	12.065a	11.873ab	6.149i	11.204e	11.927a	11.809ab
T_4	6.577h	10.392f	11.689bc	11.466d	6.184i	10.279g	11.598cd	11.383de

T_1: 100% basal (B) T_2: ½ B + ½ mid of tillering (MT).
T_3: ⅓ B + ⅓ MT + ⅓ Panicle initiation (PI). T_4: ⅔ B + ⅓ MT.
Means followed by the same letter(s) are not significantly different, according to DMRT.

Table (13): Effect of interaction between nitrogen level and time and methods of its application on straw yield (t/ha.) of Sakha 105 rice cultivar in 2011 and 2012 seasons.

Time and methods of N application (T)	2011				2012			
	Nitrogen level (kg N/ha.)				Nitrogen level (kg N/ha.)			
	Without (control)	110	165	220	Without (control)	110	165	220
T_1	8.756j	12.461g	14.452cd	15.981a	8.250j	12.035g	14.097c	15.747a
T_2	8.662j	11.879hi	13.617e	14.578c	8.192j	11.471h	13.289e	14.364c
T_3	8.780j	11.552i	12.965f	13.510e	8.354j	11.158i	12.656f	13.316e
T_4	8.598j	12.204gh	14.086d	15.244b	8.236j	11.828j	13.802d	15.078b

T_1: 100% basal (B) T_2: ½ B + ½ mid of tillering (MT).
T_3: ⅓ B + ⅓ MT + ⅓ Panicle initiation (PI). T_4: ⅔ B + ⅓ MT.
Means followed by the same letter(s) are not significantly different, according to DMRT.

IV: Nitrogen use efficiency (NUE) and Partial factor productivity (PFP):

It is obvious from Table (14) that increasing nitrogen fertilizer level significantly decreased the efficiency of nitrogen fertilizer and partial factor productivity. The highest values in both seasons were recorded with 110 kg N/ha. These findings could be mainly attributed to the fact that the first dose of nitrogen fertilizer increased grain yield linearly, while, the other doses caused in grain yield relative to the first dose. The present findings are in agreement with those obtained by Badawi, Shimaa (2002), Hach and Hongnam (2006), Baba *et al.* (2010) and Gorgy (2010).

In connection with the impact of nitrogen application time and methods, data arranged in Table (14) claimed that, during both 2011 and 2012 seasons, the highest values of nitrogen use efficiency and partial factor productivity were recorded with one/third as basal, one/third at mid of tillering and one/third at panicle initiation (T_3), on the other side, adding nitrogen fertilizer as basal application (T_1) gave the lowest efficiency of nitrogen fertilizer and partial factor productivity. The application of half basally and half at mid of tillering (T_2) and two/thirds basally and one/third at panicle initiation (T_4) gave the intermediate values with out significant differences between them only in the second season. These results are in harmony with those found by Angayarkanni and Ravichandran (2001) and El-Kallawy (2008).

As for the interaction effect, the maximum values of nitrogen use efficiency and partial factor productivity in both seasons were obtained when 110 kg. N/ha. was added in three equal splits at basal, mid of tillering and panical initiation. On the contrary, the basal application of 220 kg N/ha. gave the lowest values in this regard (Tables 15 and 16).

Table (14): Nitrogen use efficiency and partial factor productivity of Sakha 105 rice cultivar as affected by levels and split applications of nitrogen fertilizer in 2011 and 2012 seasons

Treatment	Nitrogen use efficiency (NUE)		Partial factor Productivity (PFP)	
	2011	2012	2011	2012
Nitrogen level (kg N/ha.):				
110	35.502a	37.048a	95.121a	93.493a
165	31.046b	32.174b	70.782b	69.768b
220	22.381c	23.503c	52.186c	51.702c
F. Test	**	**	**	**
Nitrogen split applications (T):				
T_1	24.445d	25.811c	68.006d	66.687c
T_2	30.498b	31.032b	73.404b	72.094b
T_3	34.343a	35.566a	76.897a	75.916a
T_4	29.284c	31.224b	72.478c	71.852b
F. Test	**	**	**	**
N X T Interaction:	**	**	**	**

T_1: 100% basal (B) T_2: ½ B + ½ mid of tillering (MT).
T_3: ⅓ B + ⅓ MT + ⅓ Panicle initiation (PI). T_4: ⅔ B + ⅓ MT.
* Significant at 0.05 level. ** Significant at 0.01 level. N.S: Not significant.
Means followed by the same letter are not significantly different, according to DMRT.

Table (15): Effect of interaction between nitrogen level and time and methods of its application on nitrogen use efficiency (ratio) of Sakha 105 rice cultivar in 2011 and 2012 seasons.

Time and methods of N application (T)	2011			2012		
	Nitrogen level (kg N/ha.)			Nitrogen level (kg N/ha.)		
	110	165	220	110	165	220
T_1	26.352fg	27.166f	19.818j	28.446d	28.115d	20.873f
T_2	36.309b	32.206de	22.982hi	36.564b	32.751c	23.782e
T_3	44.699a	33.830cd	24.500gh	45.955a	35.018c	25.726e
T_4	34.648bc	30.982e	22.223i	37.227b	32.813c	23.631e

T_1: 100% basal (B) T_2: ½ B + ½ mid of tillering (MT).
T_3: ⅓ B + ⅓ MT + ⅓ Panicle initiation (PI). T_4: ⅔ B + ⅓ MT.
Means followed by the same letter(s) are not significantly different, according to DMRT.

Table (16): Effect of interaction between nitrogen level and time and methods of its application on partial factor productivity (ratio) of Sakha 105 rice cultivar in 2011 and 2012 seasons.

Time and methods of N application (T)	2011			2012		
	Nitrogen level (kg N/ha.)			Nitrogen level (kg N/ha.)		
	110	165	220	110	165	220
T_1	86.691c	67.352f	49.974i	84.973c	65.800e	49.289f
T_2	95.718b	71.812de	52.683gh	93.482b	70.697cd	52.102f
T_3	103.602a	73.121d	53.968g	101.855a	72.284de	53.609f
T_4	94.473b	70.843e	52.119h	93.446b	70.291e	51.820f

T_1: 100% basal (B) T_2: ½ B + ½ mid of tillering (MT).
T_3: ⅓ B + ⅓ MT + ⅓ Panicle initiation (PI). T_4: ⅔ B + ⅓ MT.
Means followed by the same letter(s) are not significantly different, according to DMRT.

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استجابة صنف الأرز سخا ١٠٥ لمستويات ومواعيد وطرق إضافة السماد الأزوتى

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الملخص العربي

لدراسة استجابة صنف الأرز سخا ١٠٥ لأربعة مستويات من التسميد الأزوتى (بدون إضافة أزوت ، ١١٠كجم أزوت/هكتار ، ١٦٥كجم أزوت/هكتار ، ٢٢٠كجم أزوت/هكتار) والتي أضيفت فى مواعيد مختلفة هي: دفعة واحدة على الشراقى ، دفعتين متساويتين على الشراقى ، وعند منتصف مرحلة التفريع ، ثلاث دفعات متساوية على الشراقى وعند منتصف مرحلة التفريع وعند بدء نشوء الدالية ، وثلثي الكمية على الشراقى والثلث الباقي عند منتصف مرحلة التفريع. أجريت تجربتان حقليتان خلال موسمي ٢٠١١ ، ٢٠١٢م بالمزرعة البحثية لمركز البحوث والتدريب فى الأرز بسخا . كفر الشيخ . مصر.

وفيما يلي أهم النتائج ما يلي: بزيادة مستوى التسميد الأزوتى حتى ٢٢٠كجم أزوت/هكتار حدثت زيادة معنوية فى ارتفاع النبات ، مساحة الورقة العلم ، محتوى الأوراق من الكلوروفيل ، عدد الفروع/م٢ ، عدد الأيام من الزراعة حتى تزهير ٥٠% من النباتات ، عدد الحبوب/دالية ومحصول القش ، بينما كان المعدل ١٦٥ كجم أزوت/هكتار هو المعدل المناسب ليس فقط فى تحسين النمو الخضرى ولكن أيضا فى إنتاج أعلى عدد معنوي من الداليات/م٢ ، أعلى نسبة مئوية من الحبوب الممتلئة وأيضا أعلى وزن للألف حبة. كما بينت نتائج كل من موسمي الدراسة أن أعلى دليل حصاد سجل مع المعدل ١١٠كجم أزوت/هكتار.

كما أظهرت نتائج موسمي الدراسة زيادة معنوية فى مقاييس النمو الخضرى ومحصول الحبوب ومكوناته إلى جانب دليل الحصاد عند إضافة السماد الأزوتى على ثلاث دفعات متساوية على الشراقى وعند منتصف مرحلة التفريع وعند بدء نشوء الدالية.

وعلى صعيد أخر فإن أعلى عدد من الفروع/م٢ تحقق مع إضافة السماد الأزوتى على دفعتين متساويتين على الشراقى وعند منتصف مرحلة التفريع. فى حين أن إضافة السماد الأزوتى دفعة واحدة على الشراقى حقق أعلى محصول من القش.

وعلى ذلك توصى هذه الدراسة مزارعي الأرز بتسميد صنف الأرز سخا ١٠٥ بمعدل ١٦٥كجم أزوت/هكتار تضاف على ثلاث دفعات متساوية على الشراقى وعند منتصف مرحلة التفريع وعند بدء نشوء الدالية وذلك لتحسين النمو الخضرى والحصول على أعلى محصول حبوب.