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Original Research Article

Performance assessment of the new rice cultivar Sakha108 cultivated using broadcasting method under different seeding rates and nitrogen fertilization levels

Mousa A. M. M.[1], E. A. Rashwan.[2] and A. Abu El-Ezz.[1]
[1]Rice Research Department, Field Crops Research Institute, ARC, Egypt.
[2]Agronomy Department, Faculty of Agriculture, Tanta University, Egypt.

*Corresponding Author
E. A. Rashwan.

Abstract: In Egypt, transplantation is the main followed method of rice cultivation but recently a new trend of rice cultivation was appeared depending on broadcasting seeds directly in the permanent field, so it is pivotal to evaluate new cultivars under that new cultivation method especially seeding rates and the other highly important agronomical practices. In order to assess growth, productivity and nitrogen use efficiency for the newly released rice cultivar Sakha 108 cultivated using broadcasting method under different seeding rates and levels of nitrogen fertilizer, two field experiments were carried out at the experimental farm of Zarzoura, Itay EL- Baroud Agricultural Research Station, El-Behaira Governorate, Egypt, using a split plot design with three replications in the summer seasons of 2016 and 2017. Three seeding rates (70, 95 and 120 kg ha^{-1}) were arranged randomly in main plots, whereas four levels of nitrogen fertilizer (0, 110, 165 and 220 kg ha^{-1}) were plotted randomly in the sub-plots. Results could be summarized as follows; the seeding rate of 120 kg ha^{-1} realized the best plant density that produced the highest values of no. of productive tillers m^{-2}, biomass yield t ha^{-1}, grain yield t ha^{-1}and nitrogen use efficiency in both seasons. On the other hand, highest means of days to heading, plant height, panicle length, 1000 grain weight and no. of filled grains were recorded by the seeding rate of 70 kg ha^{-1}. Regarding nitrogen fertilizer levels, raising nitrogen level up to 220 kg ha^{-1} increased days to heading, flag leaf area, plant height, no. of productive tillers m^{-2}, no. of filled and unfilled grains panicle^{-1}, sterility percentage, biomass and grain yield traits. Meanwhile, the highest values of panicle length and nitrogen use efficiency were scored by 110 kg N ha^{-1}, while the highest harvest index was obtained by 165 kg N ha^{-1}.
Keywords: *Rice, Seeding rates, Nitrogen use efficiency, Oryza sativa, Grain yield*.

INTRODUCTION

More than half of world's people are depending on rice as a primary food considering it the most pivotal source of dietary energy for the people of many countries especially in South East Asia (FAOSTAT 2016). In Egypt, most of the rice cultivars released for farmers belong to japonica sub-species of "*Oryza sativa* L." and planted under irrigated conditions. Nationally, there is an urgent demand to increase rice production to meet the requirements of the population and maintain the self-sufficiency especially after the decision of the Egyptian Ministry of Water Resources and Irrigation to reduce the allotted rice cultivated area starting from 2018/19 (USDA 2018).

Transplanting is the most popular method of rice cultivation, accompanied with application of moderate to high rate of mineral fertilizers, but recently the direct seeding cultivation method appeared and spreaded in some areas due to labors scarcity, under direct seeding method, seeding rate is considered the main factor responsible for adjusting the optimum plant density, which realize a compatible rice growth and high grain yield (Abou Khalifa *et al.*, , 2005; Haque and Haque, 2016; El-Dalil, *et al.*, 2017).

Efficient nutrient management in rice considered one of the necessary factors that control production levels of rice; it ensures minimal leakage of applied nutrients to the environment. Moreover, the recent rice cultivars inserted in intensive rice production

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regimes require knowledge of strategies for the efficient use of all inputs, including fertilizer nutrients. Also, it demands determining the adequate amounts of essential nutrients that enough to produce high grain yield levels (Singh and Singh 2017).

Among the nutrient management practices, judicious application of nitrogen (N) fertilizer is paramount important for yield enhancement of rice. The efficient use of nitrogen is recognized as an important production factor for rice but the problem of raising the utilization rate of the rice plant and increasing efficiency of absorbed nitrogen for grain production is still unsolved. Nitrogen fertilizer (N) is costly input and its utilization varies from cultivar (cv.) to other. So, it is important to determine physiological responses and yield traits of new cultivars under variable nitrogen levels especially that many studies emphasized that the response of rice plants to nitrogen differed among cultivars (Gewaily *et al.,* 2018).

Considering the above facts, the present study was carried out to evaluate the performance of the new released rice cultivar Sakha 108 cultivated using broadcasting method under different seeding rates and nitrogen fertilizer levels.

MATERIAL AND METHODS

Two field experiments were conducted at the experimental farm of Zarzoura, Itay EL- Baroud Agricultural Research Station, El-Behaira Governorate, Egypt, during the two successive seasons 2016 and 2017. Evaluation new rice cultivar Sakha 108 cultivated using broadcasting method under different seeding rates and nitrogen levels was the main objective of this study. The statistical design of these experiments was a split plot design in a randomized complete block design (RCBD) arrangement with three replications; where, the main plots were designated for the three seeding rates (70, 95 and 120 kg ha^{-1}), while sub-plots were designated for the four nitrogen levels (control "0", 110, 165 and 220 kg ha^{-1}).

Soil samples were taken from different sites of the experimental site at 0-30 cm depth from the soil surface, samples were dried (air drying) and grounded to pass through 2 mm sieve, then well mixed. The procedure of preparation and measurements of the soil extract was done according to Black, *et al.,* , (1965). The mechanical and chemical analysis of the soil in 2016 and 2017 seasons are shown in Table1.

TABLE 1. Physical and chemical properties in the experimental soil in 2016 and 2017 seasons.

Characters	Values	
	2016	**2017**
A. Physical properties		
1. Clayey %	52.7	52.8
2. Silt %	25.8	25.1
3. Sand %	21.5	22.1
Soil texture class	Clayey	Clayey
B. Chemical properties		
1. pH	7.8	7.7
2. EC dS/m*	1.8	1.7
3. Organic matter %	0.50	0.43
4. Available (N) ppm	59	56
5. Available (P) ppm	23	27
6. Available (K) ppm	238	216
7. Available (Zn) ppm	2.2	1.7

***EC: Electrical conductivity**

The area of sub-plot was 15 m^2 (3 m wide and 5 m long). The preceding crop was wheat in both seasons. The evaluated seeds in these experiments were used under the name of "SP70 promising line with type (J)" that resulted from backcross of the excellent Egyptian rice cultivar Sakha 101 with HR 5824, and obtained from Rice Research Sections, Sakha, Kafr El-Sheikh, Field Crops Research Institute, Agricultural Research Center. The promising line SP70 was certified as a cultivar in 2018 and named "Sakha 108".

Seeds were broadcasting directly in the permanent field at the first of May in both seasons. Nitrogen fertilizer was applied in the form of Urea (46.5 % N) in three equal doses; first dose (one-third) was applied as a basal dose (mixed in dry soil before its flooded by irrigation water), the second dose (one-third) was added as a top-dressing application after 30 days from cultivation, whereas the third dose (one-third) was added as a top-dressing application at panicle initiation stage. Phosphorous in the form of calcium super phosphate (15.5% P_2O_5) at the rate of 37 kg P_2O_5 ha^{-1} and potassium in the form of potassium sulfate (48% K_2o) at the rate of 57 kg k_2O ha^{-1} were applied as a basal application. Moreover, Zinc was applied in the form of Zinc sulphate (22% Zn) at the rate of 24 kg Zn ha^{-1} just before broadcasting. Flood irrigation was performed frequently at 6 days intervals to maintain at least 5 cm water depth in each sub-plot, whereas all sub-plots were drained 10 days before harvest to ease handling crop harvest. Weeds were chemically eradicated using Saturn 50% Ec (Thiobencarb) at the rate of 4.75 liters ha^{-1} mixed with 240 - 285 liters of water and applied on the wet soil after 2 - 3 days from planting. Insects and diseases were intensively controlled as per recommendation through the whole season to avoid any yield loss. Other normal agronomical practices for rice growing in the permanent field were performed according the recommendations of Rice Research and Training Centre (RRTC).

The studied characters

- Days to heading (day): Determined as number of days from sowing up to 50% of head emerged from sheath.
- Flag leaf area (cm^2): five hills were randomly taken from each sub-plot at heading stage, transferred to lab and flag leaf area was estimated as follows :
  Flag leaf area (cm^2) = the maximum length (cm) X the maximum wide (cm) X 0.75.
- Plant height (cm): the height of the main culm was measured at harvesting from the soil surface up to the top of the tallest culm.
- Number of productive tillers m^{-2}: was counted from an average of five hills from each sup-plot when all panicles were at full ripe stage.
- Panicle length (cm): the main panicle length of plant was measured from the base of panicle up to its tip.
- 1000-grains weight (g): a random sample of one thousand paddy rice grains were weighted to the nearest 0.01g.
- Number of filled and unfilled grains panicle $^{-1}$: ten main panicles were randomly collected from each sub-plot and the average of grain and unfilled grain numbers panicle^{-1} were calculated.
- Sterility percentage: was calculated as follows:
  Sterility percentage = (number of unfilled grains panicle $^{-1}$/ total spikelets panicle $^{-1}$) X 100
- Biomass yield: were determined from harvested 10 m^2 of each sub-plot and then converted into ton ha^{-1}.
- Grain yield were determined at 14 % moisture content from harvested 10 m^2 of each sub-plot and then converted into ton ha^{-1}.
- Harvest index was determined using **Yoshida (1981)** method according to the following equation:

$$\text{Harvest index} = \frac{\text{Grain yield ton ha}^{-1}}{\text{Total biomass ton ha}^{-1}}$$

- Nitrogen use efficiency (NUE) was determined using **Miyoshi (1991)** equation as follows:

$$\text{NUE} = \frac{\text{Rice grain yield kg ha}^{-1}}{\text{Total applied nitrogen kg ha}^{-1}}$$

Statistical analysis

All data collected were subjected to standard statistical analysis of variance following the method described by Gomez and Gomez (1984) using Michigan State University Computer Statistical Package (MSTAT-C). Different Means were compared using (Duncan, 1955), when the ANOVA showed significant differences ($P<0.05$) or highly significant differences ($P<0.01$).

RESULTS AND DISCUSSION

Mean values of number of days to heading, flag leaf area (cm^2), plant height (cm) and number of productive tillers m^{-2} as affected by different seeding rates and nitrogen fertilizer levels during 2016 and 2017 seasons are listed in Table (2). The analysis of variance showed that, the effect of different seeding rates on number of days to heading and plant height was highly significant in the first season and not significant in the second one. However, it was highly significant regarding number of productive tillers and not significant regarding flag leaf area in both seasons.

In the first season, the earliest flowering date at 98.87 and 99.66 days were recorded under 95 kg ha^{-1} and 120 kg ha^{-1} seeding rates respectively, also the same seeding rates recorded the highest values of plant height (86.85 and 87.75 cm, respectively) with insignificant differences between them. Meanwhile the lowest seeding rate 70 kg ha^{-1} recorded the latest flowering date (101.2 days) and the shortest plant height (85.65 cm). These results indicated that, under high seeding rates conditions, spaces among plants became closer, plants competed severely and tended to grow taller in order to search for light. This high competition among rice plants under dense planting delayed the panicle initiation and consequently increased the vegetative period resulted in delaying heading date. These results are in agreement with those obtained by Dongarwar *et al.,* (2018) where they revealed that, increasing seeding rates increased significantly number of days to heading and plant height.

Concerning to number of productive tillers m^{-2}, it was obvious that, increasing seeding rates increased number of productive tillers m^{-2}, where the largest number of productive tillers m^{-2} (308.23 and 346.33 in 2016 and 2017 seasons, respectively) were produced under 120 kg ha^{-1} seeding rate. On contrast, 70 kg ha^{-1} seeding rate scored the lowest number of productive tillers m^{-2} (262.6 and 291.8 in 2016 and 2017 seasons, respectively). That may be due to the high number of main plants, which are mostly fertile tillers resulted from the large number of seeds sowed under the highest seeding rates. These results are in accordance with those obtained by Abou Khalifa *et al.*, (2014), where they revealed that, the number of productive tillers m^{-2} increased with increasing seeding rates. Moreover, Angassa (2017) found that, 125 kg ha^{-1} seeding rate recorded the greater number of productive tillers m^{-2} and added that, although the growth, size and number of productive tillers per each plant decreased under dense planting, the total number per unit area increased due to large number of plants per unit area.

With respect to nitrogen levels, data showed highly significant effect for nitrogen levels on all previous mentioned traits in both seasons. The trend of data was clear and unified, whereas means of these traits were gradually increased with increasing level of nitrogen from 0 up to 220 kg N ha^{-1}. In other words, the highest values of these traits were obtained when 220 kg N ha^{-1} was applied with insignificant differences with values obtained with application of 165 kg N ha^{-1} level regarding flag leaf area and number of productive tillers m^{-2}. On the other hand, the lowest values were scored under control treatment.

It is clear that, heading date was delayed and plant height increased as the applied nitrogen increased up to the highest level 220 kg N ha^{-1}. However, flag leaf area and number of productive tillers m^{-2} increased significantly with raising the applied nitrogen up to 165 kg ha^{-1}, while no significant response could be noticed with increasing applied nitrogen to 220 kg ha^{-1}compared to 165 kg ha^{-1}.

The availability of nitrogen increased vegetative growth due to its pivotal role in cell division, multiplication and root development which enhanced more leaf area resulting in higher photosynthesis rate, higher translocation of carbohydrates from source to growing points and thereby resulted in more dry matter accumulation, higher number of tillers m^{-2} and taller plants. Similar trends were also obtained by Chaturvedi (2005) when he determined the effect of different (N) fertilizers on growth, yield and quality of hybrid rice, Djaman *et al.*, (2016) when they aimed to optimize nitrogen fertilizer for higher yield and nitrogen use efficiency of four rice cultivars, Noor (2017) and Gewaily *et al.*, (2018) and all agreed that, days to heading significantly increased, augmented plant height for rice cultivars, increment in number of tillers and more flag leaf area were noticed with increasing nitrogen rate due to the role of nitrogen in enhancing rice growth, internode elongation, photosynthesis and metabolism.

The interaction between seeding rates and nitrogen fertilization had highly significant effect on plant height and number of productive tillers m^{-2} (Fig. 1 and 2, resp.). However, the highest nitrogen fertilizer level 220 kg N ha^{-1} recorded the tallest plants and the highest number of productive tillers m^{-2} under 120 kg ha^{-1} seeding rate with insignificant differences with the values recorded by nitrogen fertilizer level 165 kg N ha^{-1} under 95 and120 kg ha^{-1} seeding rates regarding number of productive tillers m^{-2}, which may be due to high tillering capacity of new cultivar Sakha 108 that compensated seeding rate reduction to 95 kg ha^{-1}.

Table 2. Means of no. of days to heading (days), flag leaf area (cm^2), plant height (cm) and no. of productive tillers m^{-2} for Sakha 108 cultivar as affected by seeding rates and nitrogen fertilizer levels in the two seasons:

Main effect	Days to heading (day)		Flag leaf area (cm^2)		Plant height (cm)		No. of productive tillers m^{-2}	
	2016	2017	2016	2017	2016	2017	2016	2017
Seeding rates (S)								
70 kg ha^{-1}	101.2a	102.00	23.49	25.43	85.65b	97.50	262.6c	291.8c
95 kg ha^{-1}	98.87b	101.67	22.34	24.70	86.85a	97.33	291.9b	331.8b
120 kg ha^{-1}	99.66b	101.42	24.06	26.36	87.75a	97.58	308.2a	346.3a
F_{test}	**	N.S.	N.S.	N.S.	**	N.S.	**	**
Nitrogen levels (N)								
Control 0 kg N ha^{-1}	98.10d	99.67d	18.76c	20.40c	76.05d	85.44d	201.9c	227.0c
110 kg N ha^{-1}	99.19c	100.9c	21.72bc	23.73bc	83.26c	93.56c	298.1b	335.1b
165 kg N ha^{-1}	100.7b	102.6b	24.51ab	26.87ab	91.67b	103.0b	324.1a	364.3a
220 kg N ha^{-1}	101.7a	103.7a	28.21a	31.02a	96.02a	107.9a	326.2a	366.7a
F_{test}	**	**	**	**	**	**	**	**
Interaction (S×N)	N.S.	N.S.	N.S.	N.S.	**	**	**	**

Means designated by the same letter in the same column are not significantly different a according to Duncan's Multiple Range Test.
*, ** and N.S. indicate P < 0.05, P < 0.01 and not significant, respectively.

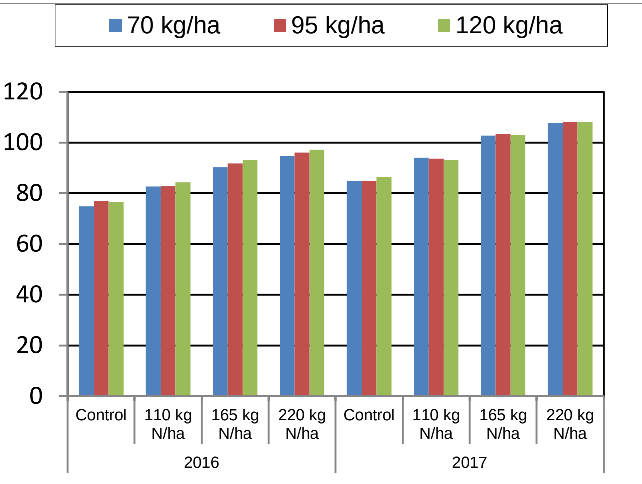

Fig. 1. Effect of interaction between seeding rates and N fertilizer levels on plant height during the two seasons

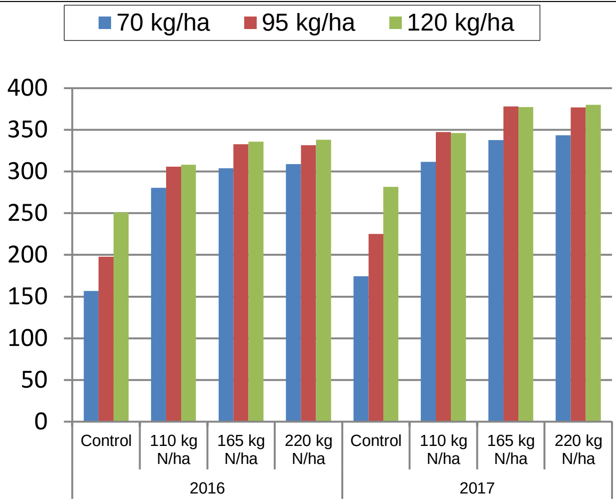

Fig. 2. Effect of interaction between seeding rates and N fertilizer levels on no. of productive tillers/m2 during the two seasons.

Mean values of panicle length, 1000-grains weight, number of filled grains panicle^{-1}, number of unfilled grains panicle^{-1} and sterility percentage as affected by different seeding rates and nitrogen fertilizer levels during 2016 and 2017 seasons are presented in Table (3). The analysis of variance showed highly significant differences among seeding rates in both seasons for all previous mentioned traits except for panicle length in the second season while it was only significant.

Increasing seeding rates from 70 to 120 kg ha^{-1} gradually decreased panicle length, 1000-grain weight and number of filled grains panicle^{-1}, where the highest values of panicle length (20.42 and 22.69), 1000-grain weight (21.30 and 23.67) and number of filled grains panicle^{-1}(106.58 and 118.41) were recorded under the lowest seeding rate (70 kg ha^{-1}) in 2016 and 2017 seasons, respectively. However, the lowest values for these traits were obtained from the highest seeding rate (120 kg ha^{-1}) with insignificant differences with (95 kg ha^{-1}) seeding rate regarding to panicle length in both seasons and 1000-grain weight in the first season only. That may be due to the large number of productive tillers m^{-2} under high seeding rate, which produce large number of spikelets which means high sink capacity as compared to limited source capacity, which negatively affects grain filling. Similar findings were obtained by Balock*et al.*, (2002) who reported that, under low seeding rate the plant spacing increased and considerably resulted in vigorous plant growth and caused a significant increase in number of panicles hill^{-1}, grain yield hill^{-1}, filled grain panicle^{-1} and 1000 grain weights. Furthermore, Mosalem *et al.*, (2002) revealed that, increasing seeding rates decreased the number of spikelets panicle^{-1}, spike length, number and weight of grains spike^{-1} in wheat.

In contrary, increasing seeding rates from 70 to 120 kg ha^{-1} gradually increased number of unfilled grains panicle^{-1} and sterility percentage, where the highest values of number of unfilled grains panicle^{-1}(7.862 and 8.833) and sterility percentage (8.077 and 7.404) were recorded under the highest seeding rate (120 kg ha^{-1}) in 2016 and 2017 seasons, respectively. However, the lowest values for these two traits were scored by the lowest seeding rate (70 kg ha^{-1}) in both seasons. it could be explained as a result of low grains filling rate due to insufficient carbohydrates remobilization rate from leaves sheaths to a large number of grains. Consequently, number of unfilled grains panicle^{-1} and sterility percentage were significantly increased and 1000-grain weight was decreased with increasing seeding rates (Rahman, *et al.*, 2007). These results are in the same trend with those found by Saphi and Yadav (2016), who found that, number of filled grains panicle^{-1} decreased and number of unfilled grains panicle^{-1} increased under high seeding rates due to increase in competition among rice plants for growth limiting factors like water, nutrients, light and space etc…

The analysis of variance showed highly significant effect for nitrogen levels on all previous mentioned traits in both seasons. Application of 110 kg N ha^{-1} recorded the tallest panicle length (20.23 and 22.73) without significant variation with application of 165 kg N ha^{-1} regarding this trait, while the control treatment (0 kg N ha^{-1}) ranked the last and gave the shortest panicles(18.5 and 20.78), in 2016 and 2017 seasons, respectively. On contrast, the control treatment (0 kg N ha^{-1}) ranked first and recorded the heaviest 1000-grains weight (22.06 and 24.78 in both seasons, respectively) with a gradual reduction with increasing the level of applied nitrogen. In addition, application of the highest level of nitrogen fertilizer (220 kg N ha^{-1}) recorded the highest number of filled grains panicle^{-1}

(110.1 and 123.7), number of unfilled grains panicle^{-1} (10.67 and 12.00) and sterility percentage (9.84 and 8.90 in 2016 and 2017, respectively) with insignificant differences with the nitrogen level (165 kg N ha^{-1}) concerning number of filled grains panicle^{-1}, however the lowest values were scored under control treatment without significant variation with (110 and 165 kg N ha^{-1}) regarding sterility percentage trait, in both seasons.

The trend of these results regarding number of filled grains panicle^{-1}, number of unfilled grains panicle^{-1} and sterility percentage was completely in agreement with those found by Metwally *et al.,* (2010) and Gewaily *et al.,* (2018), where they stated that, with increasing rate of nitrogen application, a significant increase in number of filled, unfilled grains panicle^{-1} and hence sterility percentage was observed due to high increment in total number of grains panicle^{-1} as a result to higher nitrogen absorption which encouraged formation of higher number of branches panicle^{-1}. Meanwhile, the stated results concerning to panicle length are partially in accordance with those obtained by Metwally *et al.,* (2017) and Gewaily *et al.,* (2018) where they recognized the positive effect of nitrogen on panicle length and noted that, panicle length increased significantly with increased levels of applied nitrogen, but under the study in concern, the tallest panicles were scored by 165 kg N ha^{-1} which may be due to the high nutrients' contribution from the experimental fertile soil as shown in (Table 1). Also, the negative effect of increasing nitrogen fertilizer on 1000-grains weight was an interesting data and in contradictory with the results obtained by Sorour *et al.,* (2016) and Gewaily *et al.,* (2018) where they found a promoting effect of nitrogen on 1000-grain weight; but this contradictory may be interpreted due to carbohydrates migration to few grains panicle $^{-1}$ which improve grain weight under control in comparison with many grains panicle $^{-1}$ in case of high levels of nitrogen, especially under fertile soil as shown in soil analysis report (Table 1) .

The interaction between seeding rates and nitrogen fertilization had highly significant effect on 1000-grains weight, number of filled grains panicle^{-1}, number of unfilled grains panicle^{-1} and sterility percentage (Fig. 3, 4, 5 and 6, resp.). However, the control treatment 0 kg N ha^{-1} recorded the heaviest 1000-grains weight under 70 kg ha^{-1} seeding rate. On the other hand, 220 kg N ha^{-1} recorded the highest number of filled grains panicle^{-1} under seeding rate 70 kg ha^{-1} and also recorded the highest number of unfilled grains panicle^{-1} and sterility percentage under seeding rate 120 kg ha^{1}.

Table 3. Means of panicle length, 1000-grains weight, number of filled grains panicle^{-1}, number of unfilled grains panicle^{-1} and sterility percentage for Sakha 108 cultivar as affected by seeding rates and nitrogen fertilizer levels in the two seasons:

Main effect	Panicle length cm		1000-grain weight g.		No. of filled grains/ panicle		No. of unfilled grains/ panicle		Sterility %	
	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
Seeding rates (S)										
70 kg ha^{-1}	20.42 a	22.69 a	21.30 a	23.67 a	106.6 a	118.4 a	5.175 c	5.750 c	4.766 c	4.534 c
95 kg ha^{-1}	19.24 b	21.86 b	20.17 b	22.92 b	97.17 b	110.4 b	6.527 b	7.417 b	6.608 b	6.180 b
120 kg ha^{-1}	18.76 b	21.08 b	19.94 b	22.41 c	95.53 c	107.3 c	7.862 a	8.833 a	8.077 a	7.404 a
F_{test}	**	*	**	**	**	**	**	**	**	**
Nitrogen levels (N)										
Control 0 kg N ha^{-1}	18.50 c	20.78 c	22.06 a	24.78 a	80.13 c	90.00 c	4.25 d	4.778 d	5.338 b	5.067 b
110 kg N ha^{-1}	20.23 a	22.73 a	20.65 b	23.20 b	98.91 b	111.1 b	5.132 c	5.778 c	5.231 b	4.957 b
165 kg N ha^{-1}	19.91 a	22.37 a	20.05 c	22.52 c	109.9 a	123.4 a	6.030 b	6.778 b	5.529 b	5.229 b
220 kg N ha^{-1}	19.26 b	21.63 b	19.13 d	21.49 d	110.1 a	123.7 a	10.67 a	12.00 a	9.837 a	8.903 a
F_{test}	**	**	**	**	**	**	**	**	**	**
Interaction (S×N)	N.S.	N.S.	**	**	**	**	**	**	**	**

Means designated by the same letter in the same column are not significantly different a according to Duncan's Multiple Range Test.
*, ** and N.S. indicate $P < 0.05$, $P < 0.01$ and not significant, respectively.

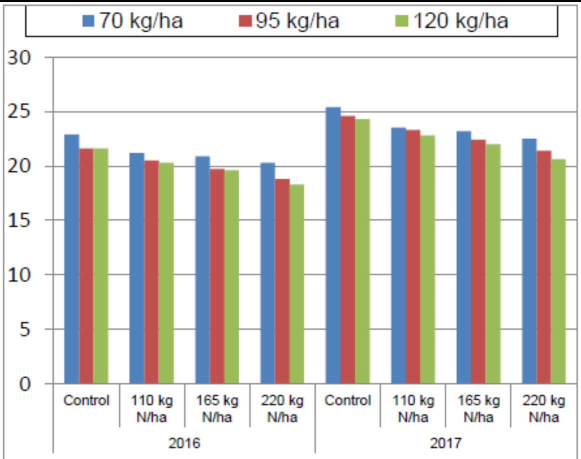

Fig. 3. Effect of interaction between seeding rates and N fertilizer levels on 1000- grains weight during the two seasons

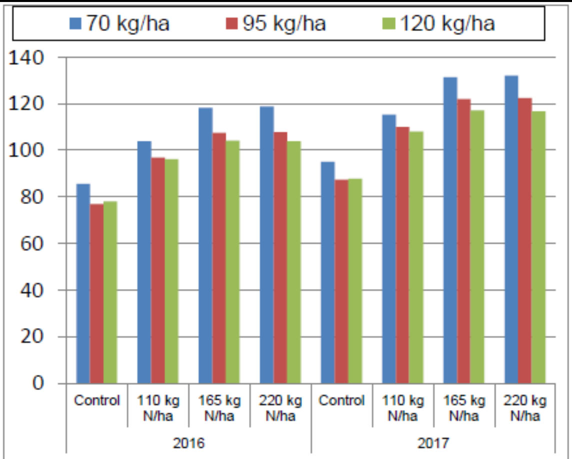

Fig. 4. Effect of interaction between seeding rates and N fertilizer levels on no. of filled grains/panicle during the two seasons

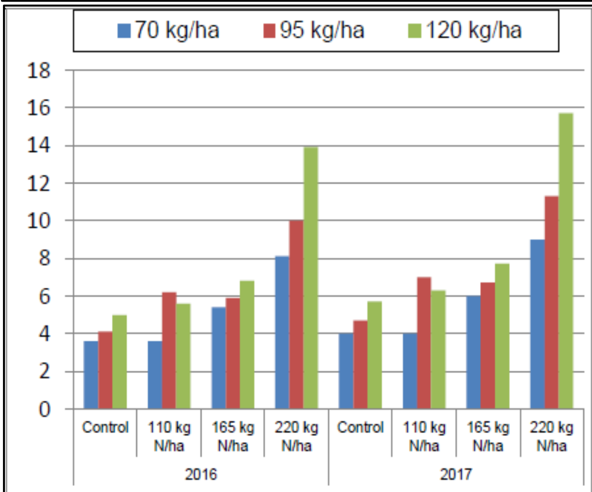

Fig. 5. Effect of interaction between seeding rates and N fertilizer levels on no. of unfilled grains/panicle during the two seasons

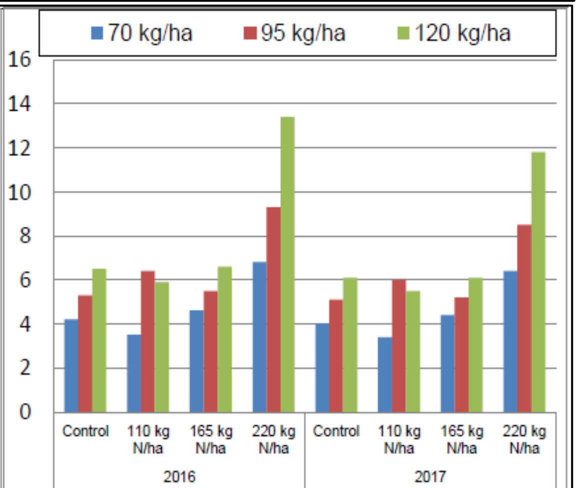

Fig. 6. Effect of interaction between seeding rates and N fertilizer levels on no. of sterility percentage during the two seasons

Results in Table (4) present biomass yield, grain yield, harvest index and nitrogen use efficiency (NUE) values as affected by the tested seeding rates and nitrogen fertilizer levels during 2016 and 2017 seasons.

Statistical analysis showed highly significant differences in biomass yield, grain yield and nitrogen use efficiency (NUE), and only significant differences in harvest index due to the tested seeding rates, in both seasons. It is clear that, increasing seeding rates from 70 to 95 kg ha^{-1} increased significantly all previous mentioned traits except harvest index where the increment didn't reach to the level of significant regarding this trait. Moreover, increasing seeding rates from 95 to 120 kg ha^{-1} significantly decreased harvest index and increased biomass yield, while this increment didn't reach to the level of significance regarding grain yield and nitrogen use efficiency, in both season. In the other words, the highest values of biomass yield (17.78 and 18.41), grain yield (6.82 and 7.66) and nitrogen use efficiency (36.83 and 41.38) were recorded under seeding rate 120 kg ha^{-1} respectively, in both seasons, with insignificant differences with values obtained by seeding rate 95 kg ha^{-1} regarding to grain yield and nitrogen use efficiency traits. Notably, the highest harvest index values (39.00 and 42.31) were scored by seeding rate of 95 kg ha^{-1} without significant variation with values scored by 70 kg ha^{-1} in both seasons.

Under the highest seeding rate, intra competition among plants increased in order to intercept light, which encouraged internodes elongation; that increased plant height. On the other side, total number of tillers per unit area increased (as mentioned before) which finally resulted in more total biomass production. These results are in accordance with those obtained by Ahmed *et al.*, (2014) where they reported, rice biomass increased significantly when seeding rate increased.

The results of the grain yield confirm the results of Angassa (2017) who found that, higher grain yield m^{-2} was obtained under seeding rate 100 Kg ha^{-1} than 125 and 75 Kg ha^{-1} which is completely in agreement with results of this study. It could be interpreted as, wider spacing had linearly increasing effect on the performance of individual plants and the plants grown with wider spacing have more land area around to exploit the nutrition elements and more solar radiation to absorb, resulted in better photosynthetic process and hence better performance as individual plants. Notably, the grain yield does not entirely depend on the performance of individual plants but also on the total number of plants per unit area and yield contributing parameters within the plant. Also, similar findings were obtained by Ahmed *et al.*, (2014).

The results of harvest index are in agreement with those obtained by Angassa (2017) who noticed a trend of increasing harvest index as the seeding rate increased from 75 to 100 kg ha^{-1} but at a seeding rate of 125 kg ha^{-1}, the harvest index was decreased. Also, Zeng and Shannon (2000) reported that under high plant density, carbohydrate supply was limited due to; shading among plants and the competition between shoot growth and panicle growth which resulted in reduction in harvest index under high seeding densities.

Concerning biomass yield and grain yield, there was a gradual increment with increasing applied nitrogen levels from control treatment (0 kg N ha^{-1}) up to 220 kg N ha^{-1}, where the highest values of biomass yield (18.87 and 19.55) and grain yield (7.81 and 8.78) were recorded under 220 kg N ha^{-1}, respectively, in both seasons, with insignificant differences with values obtained by 165 kg N ha^{-1} regarding to grain yield trait only. On the other hand, the lowest values of these traits were recorded under control treatments in both seasons. These results are in harmony with those of Djaman *et al.*, (2018) where they reported that, rice biomass and grain yield increased with increasing the applied nitrogen rates up to the recommended dose, while a reduction could be noticed in case of greater applied nitrogen rate than the recommended dose. In addition, Gewaily *et al.*, (2018) found that, increased nitrogen rates from 0 to 220 kg N ha^{-1} significantly enhanced the biomass and grain yield for all tested cultivars including (Sakha 108 cv.), whereas the rate of nitrogen of 220 kg N ha^{-1} showed the highest values of these traits followed by 165 kg N ha^{-1}, while the minimum ones were obtained under application of 0 kg N ha^{-1} being in a complete agreement with results of the study in concern. That increment in biomass and grain yield may be attributed to the pivotal role of nitrogen in enhancing plant height, no. of tillers m^{-2}, dry matter accumulation and grain yield components *i.e.*, no. of panicles hill^{-1}, panicle length, no. of filled grains panicle^{-1} and panicle weight, Gharib *et al.*, (2011). Furthermore, Morteza, *et al.*, (2011) and Haque and Haque (2016), explained that, the increment of grain yield under higher nitrogen levels might be due efficient absorption of nitrogen and other elements which raise the production and translocation of the dry matter from the source to the sink (grains).

The arrangement of the applied nitrogen levels in a descending order with regard to harvest index was as follows; the applied level of 165 kg N ha^{-1} ranked the first and recorded the highest harvest index (42.43 and 46.04 in 2016 and 2017, resp.), followed by 110 kg N ha^{-1}, then 220 kg N ha^{-1} which ranked the third, and the control treatment which ranked the last grade in this concern. This arrangement was attributed to the insignificant variations between grain yield in comparison to the highly significant ones between the biomass yield scored by the nitrogen levels 165 and 220 kg ha^{-1}. Similar results were reported by Djaman *et al.*, (2018).

Nitrogen use efficiency (NEU) is considering an important indicator for adjusting the applied dose of nitrogen fertilizer to rice fields. An inverse relationship could be noticed regarding to nitrogen use efficiency (NUE), whereas the lowest level of the applied nitrogen 110 kg N ha^{-1} scored the highest NUE and the highest level of the applied nitrogen 220 kg N ha^{-1} recorded the lowest NUE, in both seasons. These findings confirmed with those of Peng *et al.*, (2009), Guo *et al.*, (2010) and Djaman *et al.*, (2018), where they recapitulated that, the highest nitrogen level showed the lowest NUE and vise-versa that might be due to nitrogen losses through ammonia volatilization, denitrification and nitrogen leaching, hence causing environmental pollution.

The interaction between seeding rates and nitrogen fertilization had highly significant effect on biomass yield, grain yield, harvest index and nitrogen use efficiency (NUE), (Fig. 7, 8, 9 and 10, resp.). However, the highest level of nitrogen 220 kg N ha^{-1} recorded the highest biomass and grain yields under 120 kg ha^{-1} seeding rate, without significant differences with values recorded by (220 kg N ha^{-1} level under 95 kg ha^{-1} seeding rate and 165 kg N ha^{-1} under 95 and 120 kg ha^{-1} seeding rates) regarding grain yield ha^{-1} trait. On the other hand, 165 kg N ha^{-1} recorded the highest harvest index under all tested seeding rates with insignificant differences with values achieved by 110 kg N ha^{-1} under seeding rate 95 kg ha^{-1} and 220 kg N ha^{-1} under seeding rate 70 kg ha^{-1}.

Concerning nitrogen use efficiency, 110 kg N ha^{-1} under seeding rate 95 and 120 kg ha^{-1} recorded the highest NUE in both seasons. which refers to high nitrogen losses under low seeding rate (70 kg ha^{-1}), as nitrogen is considered a quick leachable and volatilized element especially under high temperature and flooded conditions, making it requires high absorbing rate to meet high available nitrogen, which might be explain the increment of NUE under high seeding rates (95 and 120 kg ha^{-1}) by the lowest nitrogen level (110 kg N ha^{-1}).

Table 4. Means of biomass yield (t ha^{-1}), grain yield (t ha^{-1}), harvest index and NUE for Sakha 108 cultivar as affected by seeding rates and nitrogen fertilizer levels in the two seasons:

Main effect	Biomass yield (t/ha)		Grain yield (t/ha)		Harvest index %		NUE (kg grains/kg urea)	
	2016	2017	2016	2017	2016	2017	2016	2017
Seeding rates (S)								
70 kg ha^{-1}	16.68 c	17.08 c	6.488 b	7.208 b	38.52 ab	41.79 ab	34.91 b	38.79 b
95 kg ha^{-1}	17.28 b	18.09 b	6.798 a	7.725 a	39.00 a	42.31 a	36.97 a	42.01 a
120 kg ha^{-1}	17.78 a	18.41 a	6.816 a	7.658 a	38.04 b	41.27 b	36.83 a	41.38 a
F_{test}	**	**	**	**	*	*	**	**
Nitrogen levels (N)								
Control 0 kg N ha^{-1}	15.47 d	16.03 d	4.380 c	4.922 c	28.31 d	30.72 d	0. 00	0.00
110 kg N ha^{-1}	16.36 c	16.95 c	6.860 b	7.711 b	41.92 b	45.48 b	62.36 a	70.10 a
165 kg N ha^{-1}	18.27 b	18.92 b	7.752 a	8.711 a	42.43 a	46.04 a	47.34 b	53.20 b
220 kg N ha^{-1}	18.87 a	19.55 a	7.810 a	8.778 a	41.39 c	44.90 c	35.23 c	39.60 c
F_{test}	**	**	**	**	**	**	**	**
Interaction (S×N)	**	**	**	**	**	**	**	**

Means designated by the same letter in the same column are not significantly different a according to Duncan's Multiple Range Test.
*, ** and N.S. indicate P < 0.05, P < 0.01 and not significant, respectively.

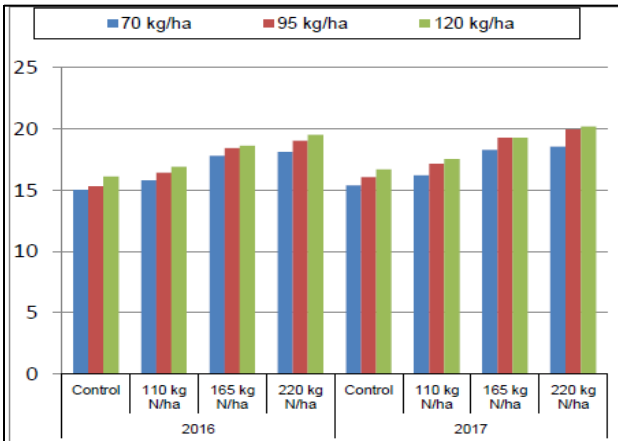

Fig. 7. Effect of interaction between seeding rates and N fertilizer levels on biomass yield during the two seasons

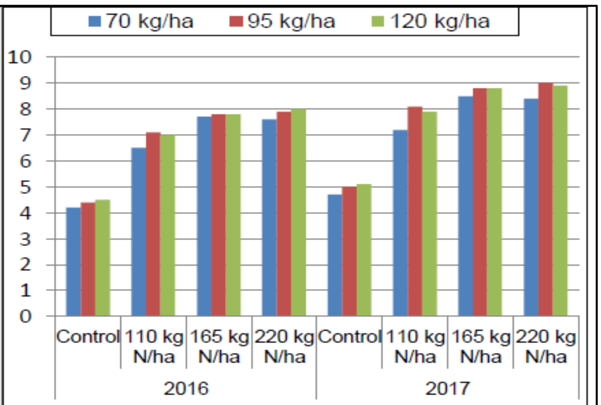

Fig. 8. Effect of interaction between seeding rates and N fertilizer levels on grain yield during the two seasons

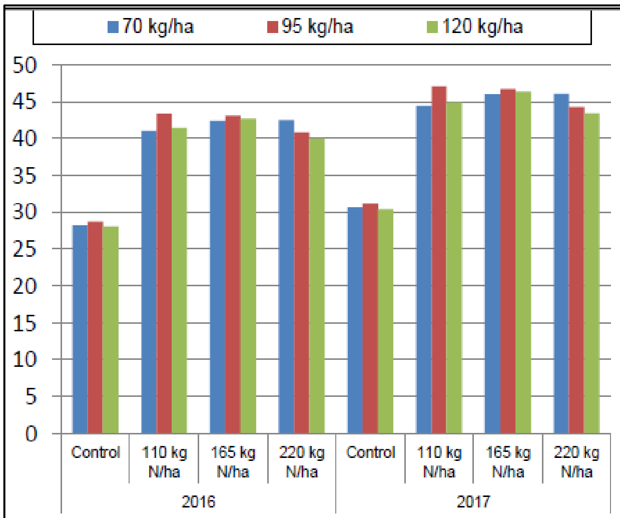

Fig. 9. Effect of interaction between seeding rates and N fertilizer levels on harvest index during the two seasons

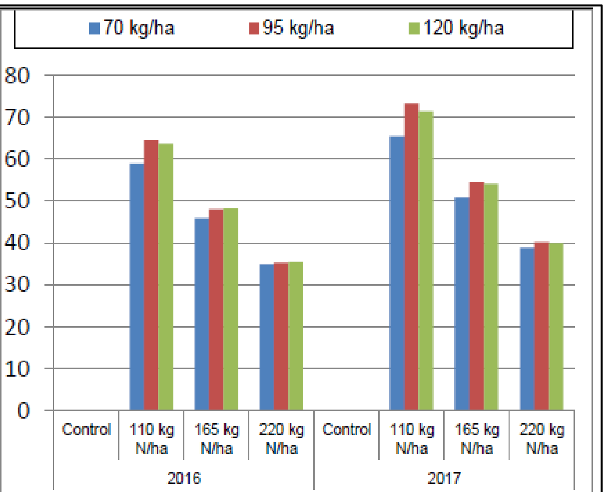

Fig. 10. Effect of interaction between seeding rates and N fertilizer levels on NUE during the two seasons

CONCLUSION

Seeding rate of 120 kg ha^{-1} recorded the highest values of no. of productive tillers m^{-2}, biomass yield t ha^{-1}, grain yield t ha^{-1} and nitrogen use efficiency in both seasons. On contrast, highest means of days to heading, plant height, panicle length, 1000 grain weight and no. of filled grains were recorded by the seeding rate of 70 kg ha^{-1}. Regarding nitrogen fertilizer levels, raising nitrogen level up to 220 kg ha^{-1} increased days to heading, flag leaf area, plant height, no. of productive tillers m^{-2}, no. of filled and unfilled grains $panicle^{-1}$, sterility percentage, biomass and grain yield traits. On the other hand, the highest values of panicle length and NUE were scored by 110 kg N ha^{-1}, while the highest harvest index was obtained by 165 kg N ha^{-1}.

RECOMMENDATION

This study recommended the application of 165 kg N ha^{-1} under the seeding rate of 120 kg ha^{-1} in case of using broadcasting cultivation method to achieve the highest grain yield and its components with avoiding high rate of environmental pollution caused under application of high levels of nitrogen.

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