

# Effect of Nitrogen Fertilizer Sources on Grain Yield, Yield Components and Grain Quality of Rice

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## ABSTRACT

Two field experiments were conducted at the Experimental Farm of Etai El- Baroud Agricultural Research Station, Behaira Governorate, Agriculture Research Center (ARC), during 2012 and 2013 summer seasons to evaluate the response of three rice cultivars (Giza 178, Sakha 104 and Sakha 106) to nine different nitrogen sources i.e., (T1) Control, (T2) 75 % of the recommended mineral nitrogen, (T3) 50 % mineral + 25 % blue green algae (BGA), (T4) 50 % mineral + 25 % organic manure (OM), (T5) 25 % mineral + 25 % BGA + 25 % OM, (T6) 100 % of the recommended mineral N, (T7) 75 % mineral + 25 % BGA, (T8) 75 % mineral + 25 % OM and (T9) 50 % mineral + 25 % BGA + 25 % OM. A split plot design with three replications was used. The main plots were devoted to the three rice cultivars while mineral nitrogen, blue green algae (BGA) and organic manure (OM) combinations were arranged in the sub plots. The most important results are summarized as follows: (1) Varieties were highly significantly varied in all studied characters except leaf area index (LAI), number of filled grains and protein % in both seasons. (2) Applying 50 % mineral nitrogen combined with 25 % blue green algae and 25 % organic fertilizer showed the highest values for most studied characters in both seasons. (3) Grain yield was highly significant and positive correlated with LAI, number of panicles/m<sup>2</sup>, number of filled grains/panicle and 1000-grain weight with r- values of 0.90, 0.88, 0.90 and 0.94, respectively as averages of the two seasons.

**Keywords:** rice, nitrogen fertilizers, organic manure, blue green algae, yield, quality.

## INTRODUCTION

Rice is one of the most important crops in Egypt and the world in addition to wheat and maize as cereal crops. In Egypt, the total cultivated area is about 1.40 million feddan (2011 season), which produces about 5.66 million tons (R.N.C., 2012). Yield per unit area increased during the last decade, from 3.83 tons/fed in 2000 to 4.02 in 2012 season. This increase may be attributed to the newly released high yielding varieties in addition to improving cultural practices especially nitrogen fertilization.

Nitrogen is considered the key element that manipulates the performance of the plants to some extent, especially cereal crops. The amount of (N) required and management are varied depending on

variety, soil conditions, cultural practices and crop rotation. Nitrogen is applied to meet the needs of the crop during the early growth stages and accumulate in the vegetative part to be utilized for grain formation (Salem *et al.* 2005). Also, nitrogen fertilizer has a vital role in the contents of nitrogen % in rice grains and nitrogen uptake by rice plants (Ebaid and Ghanem, 2000).

Organic farming is a system which primarily aim to eliminate the environmental pollution and develop a more profitable and sustainable farming. Application of organic manure could increase the soil organic carbon (SOC) and that will increase soil particles aggregation, water holding capacity, infiltration rate, hydraulic conductivity and decrease bulk density. Furthermore, organic matter content serves several advantages such as conservation and slow release of nutrients, providing micronutrients and other growth factors not normally applied by inorganic fertilizers, and may also enhance microbial activity and nutrient turnover in soil.

Application of organic manure could improve the nutrient absorption, soil fertility, and reduce of fertilizer loss. Also, it is more profitable for environment protection compared with application of mineral fertilizer alone (Reganold 1995, Conacher 1998 and Liu *et al.* 1996). The soil with organic manure continually applied had lower bulk density and higher porosity values, porous and buffering capacity (Edmeades 2003). However, the use value of organic matter decreased along with the organic resources continually increasing under the background of agriculture with high input, high output and high efficiency (Xi *et al.* 2004).

Yang *et al.*, 2004 studied the application effect of chemical fertilizer combined with farmyard manure on rice dry matter accumulation and nutrients distribution, and reported that application of organic manure combined with chemical fertilizer was propitious to the transferability and distribution of nutrients from shoot to rice grains, in addition to increase in dry matter accumulation. Also, Zhou *et al.* (2002, 2003) reported that the nitrogen uptake by rice and system productivity increased with the long-term combination between organic manure and chemical NPK fertilizer. Moreover, utilization of biological N<sub>2</sub> fixation (BNF) can decrease the application of mineral N fertilizers, thus reducing

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environmental risks (Raimam *et al.*, 2007 and Radwan *et al.* 2008). Using bio-fertilizer or microbial inoculates to replace or increase the efficiency of chemical fertilizer, partially or totally, is effective in reducing the cost of crop production and maintaining the natural fertility of soil (Bassal *et al.*, 1996).

This study aimed to investigate the performance of some rice varieties under different nitrogen application sources, including mineral, organic and bio sources of nitrogen and their combinations, regarding some agronomic, yield and yield components and grain quality characters.

#### MATERIALS AND METHODS

Two field experiments were conducted at the Experimental Farm of Etai El- Baroud Agricultural Research Station, Behaira Governorate, Agriculture Research Center (ARC), during 2012 and 2013 summer seasons to evaluate the response of three rice cultivars (Giza 178, Sakha 104 and Sakha 106) to different nitrogen application sources as follow: (T<sub>1</sub>) Control, without nitrogen application, (T<sub>2</sub>) 75 % of the recommended mineral nitrogen (45 kg N/fed as urea 46.5 % N), (T<sub>3</sub>) 50 % mineral (30 kg N/fed) + 25 % blue green algae (BGA), (T<sub>4</sub>) 50 % mineral + 25 % of nitrogen added in the form of organic manure (OM), (T<sub>5</sub>) 25 % mineral (15 kg N/fed) + 25 % BGA + 25 % OM, (T<sub>6</sub>) 100 % of the recommended mineral nitrogen (60 Kg N/fed), (T<sub>7</sub>) 75 % mineral (45 kg N/fed) + 25 % BGA, (T<sub>8</sub>) 75 % mineral (45 kg N/fed) + 25 % OM and (T<sub>9</sub>) 50 % mineral (30 kg N/fed) + 25 % BGA + 25 % OM.

Blue green algae was provided by Agriculture Research Center (ARC), Giza, with the recommendation of application of 2 packages/fed to replace 25 % of the added mineral nitrogen fertilization. Regarding organic manure, samples were analyzed to determine the nitrogen content and a quantity of 1330 kg/fed of OM were added to replace 25 % of mineral N fertilizer. The experimental site soil had the following properties as an average of the two seasons: PH = 7.8, total organic matter = 2.3 %, total nitrogen = 0.20, available P = 18.3 ppm and available K = 640.0 ppm. In addition the chemical composition of cow dung was as follow: nitrogen = 11.3 (g/ Kg), Phosphors = 4.5 (g/Kg), Potassium = 15.3 (g/Kg), Sulfur = 1.9 (g/Kg) and Zinc = 123 (mg/Kg).

A split plot design with three replicates was used in both season. The main plots were devoted to three rice cultivars; namely, Giza 178, Sakha 104 and Sakha 106 while, the different nitrogen application sources were applied in the sub-plots. The previous crop was wheat in two seasons. Sub-plot size was 10 m<sup>2</sup> and the sowing date in nursery was 10 May and plant were

transplanted after 30 days after sowing to permanent field, in both seasons.

Random samples, each of 10 plants were taken from each sub plot to determine root growth rate (RGR) and shoot growth rate (SGR) between 15 and 30 days after transplanting on dry weight basis. Thirty days after transplanting, plant samples (five hills) were taken randomly from each plot to estimate leaf area index (LAI) and was calculated using the following equation: LAI = (leaf area of fixed number of hills/ ground area occupied by these hills). At harvest, one meter square was harvested for determination of grain yield (GY) per plot then it was converted to tons/fed. Also, number of panicles/m<sup>2</sup>, number of filled grains/panicle and 1000-grain weight (g) were determined. Furthermore, grain quality characters such as hulling, milling, broken, protein and amylose percentages were recorded according to International Rice Research Institute (IRRI 1996). Analysis of variance and correlation were carried out according to Gomez and Gomez (1984) using SAS program, version 8.0.

#### RESULTS AND DISCUSSION

##### 1- Effect of rice cultivars:

Performance of the studied rice cultivars, in both seasons, are presented in tables (1, 2 and 4). Data revealed that there were significant differences between rice cultivars for all studied characters except for LAI, number of filled grains/panicle and protein % in the two seasons.

Comparison between means showed that rice cultivar Sakha 106 gave the highest values for most studied characters (Tables 1, 2 and 4). The average values for the two seasons were 0.35 g/day, 0.71g/day, 285.44, 25.61 g and 3.68 t/fed for RGR, SGR, number of panicles/m<sup>2</sup>, 1000-grain weight and grain yield, respectively. Furthermore, for grain quality characters, Sakha 106 rice cultivar gave acceptable values for grain quality characters reaching were 80.81, 70.97, 5.69 and 19.39 for hulling, milling, broken and amylose percentages, as averages over the two seasons, respectively. These findings are similar to those reported by El-Kholy (2004), El-Feky (2006), El-Kalla *et al.* (2006), El-Sherif *et al.* (2007), El-Nory (2008) and Radwan *et al.* (2008), who recorded variations between rice cultivars for agronomic and quality characters, and that could be attributed to genetic variations, between cultivars and their response to environmental conditions.

##### 2- Effect of nitrogen sources:

The primary goal of the present study was to reduce the application of mineral nitrogen in rice growing to lower production costs and reduce the adverse effects of

chemical fertilizers on the environment. However, the data presented in tables (1 and 2) showed that application of 75 % mineral nitrogen gave significantly lower values for all studied growth characters, yield components and grain yield compared to 100 % mineral nitrogen application. Abdel-Hamed (2005), Abdel-Salam (2006), Gorgy (2007) and El-Refae *et al.* (2008) found that increasing mineral N application level led to increase in vegetative growth, grain yield and yield components of rice. However, replacing 25 % of the applied mineral nitrogen with its equivalent of either blue green algae or organic manure gave a slight improvement in studied characters, but still were inferior to 100 % mineral N application. The combination of 25 % mineral N + 25 % BGA + 25 % OM (T<sub>5</sub>) gave comparable values for the studied traits, in both seasons, to application of 100 % mineral N. These findings may be attributed to the role of BGA and/or OM in improving soil fertility and stimulating healthy root development in plants. Besides, organic matter application provides food for microorganism which keeps the soil in balanced conditions. As a result, nitrogen, potassium and phosphorus will be produced naturally by feeding of microorganisms (Khatab 2010). Furthermore, the data revealed that replacement of 25 % of added mineral N by both BGA and OM gave the highest grain yield of rice and high values for growth characters and yield components. The average values for the two seasons were 0.39, 0.84, 6.87, 311.7, 120.36, 25.35 and 4.57 for RGR, SGR, LAI, number of panicles/m<sup>2</sup>, number of filled grains/panicle, 1000-grain weight, and GY, respectively. These values were superior, significantly or insignificantly than the application of 100 % mineral nitrogen.

The data, also, indicated that application of 100 % mineral nitrogen, in the second season, gave more rapid growth in early stages (as RGR and SGR) compared to application of N from organic or bio-sources. This may be explained by the greater availability of mineral N to the plant for uptake and use compared to the slow transformation of N from organic or bio-sources, through soil microbial activity, into a form that could be absorbed and used by the rice plant. However, N from organic and bio-sources was beneficial to rice plants at the end of season as indicated by the values of studied characters. Application of chemical fertilizer with organic manure was propitious to coordinate the balance of carbon and nitrogen pools, which then increased system productivity (Kaur *et al.* 2007). It is, also, a simple and feasible environment protection. Application of organic manure is an important approach in soil fertility improvement (Han *et al.* 2004). The soil organic matter would preserve nutrients balance under long term application of chemical fertilizer only, and

that will increase significantly under long term application of organic manure or organic manure combined with chemical fertilizer (Wang *et al.* 2000; Sui *et al.* 2005). Organic manure application with chemical fertilizers increased the yield and nitrogen use efficiency of rice, reduced the risk of environmental pollution and improved soil fertility (Gang *et al.* 2008). Similar findings have been reported by Pramanik *et al.* (2004), Yadav (2004), Gewaily (2006) and Tabl (2008).

### 3- The interaction between Cultivars and N sources:

The interaction between cultivars and nitrogen application treatments was not significant for all studied characters except for 1000-grain weight and grain yield in both seasons. The interaction between cultivars and nitrogen sources for 1000-grain weight and grain yield/fed could be attributed to the differential response of studied cultivars to the different nitrogen application treatments. Increasing mineral nitrogen levels from 75 to 100 % increased 1000-grain weight and grain yield by 5.5 and 14.0 %, 6.8 and 22.1 % and 5.5 and 30.2 % for Giza 178, Sakha 104 and Sakha 106, respectively in 2012 season. The comparable values in 2013 season were 4.4 and 13.2 %, 3.2 and 20.9 % and 0.4 and 27.4 % for the respective cultivars. However, application of the two nitrogen levels from different sources (25 % mineral + 25 % BGA + 25 % OM or 50 % mineral + 25 % BGA + 25 % OM) revealed that 1000-grain weight and grain yield increased by 3.9 and 41.6 %, 7.5 and 22.2 % and 6.5 and 29.2 % for Giza 178, Sakha 104 and Sakha 106, respectively in 2012 season. Respective percentages in the second season were 8.3 and 39.1 %, 0.8 and 20.4 % and 0.8 and 21.3 % for the respective cultivars.

Concerning grain quality characters, means presented in (table 4) revealed significant differences due to applied nitrogen sources and quantities, except for milling percentage in both seasons. Application of 100 % N as a combination 50 % mineral N + 25 % BGA + 25 % OM was superior, either significantly or insignificantly, to 100 % N as mineral nitrogen for all studied grain quality characters. That treatment gave higher values for hulling, protein and amylose percentages, and lower percentage of broken grain compared to 100 % mineral nitrogen. The average values of both seasons were 80.83, 5.54, 8.79 and 19.81 % for hulling, broken, protein and amylose percentages, respectively. However, reducing nitrogen application to 75 % as combination of 25 % mineral + 25 % BGA + 25% OM gave statistically similar values, for those characters, to 100 % N in the same combination of N sources. These findings emphasize the role of organic and bio-sources of N in increasing nutrient availability

and balancing nutrient uptake by the rice plant which led to better quality characters.







**Table 5. Correlation between grain yield, its component and some agronomic characteristics**

Characters	RGR	SGR	LAI	No. panicles/m <sup>2</sup>	No. Filled grains/ panicle	1000-grain weight	GY
RGR		0.934**	0.600	0.689*	0.699*	0.842**	0.733*
SGR			0.709*	0.749*	0.773*	0.836**	0.797*
LAI				0.745*	0.786*	0.796*	0.861**
No. panicles/m <sup>2</sup>					0.991**	0.801**	0.866**
No. filled grains						0.844**	0.901**
1000-grain weight							0.963**
GY							

**Table 6. Correlation between grain yield, its component and some agronomic characteristics**

Characters	RG R	SGR	LAI	No. panicles/m <sup>2</sup>	No. Filled grains/ panicle	1000-grain weight	GY
RGR		0.855**	0.847**	0.882**	0.755*	0.691*	0.775*
SGR			0.873**	0.824**	0.656	0.828**	0.848**
LAI				0.844**	0.812**	0.951**	0.931**
No. panicles/m <sup>2</sup>					0.925**	0.795*	0.888**
No. filled grains						0.759*	0.897**
1000-grain weight							0.907**
GY							

#### 4- Correlation analysis of grain yield, its components and some agronomic characteristics:

Data presented in tables (5 and 6) revealed that grain yield was significantly, or highly significantly, and positively correlated to yield components, i.e., number of panicles/m<sup>2</sup>, number of filled grains/ panicle and 1000-grain weight, in addition to growth characters, i.e. RGR, SGR and LAI, in both seasons of study. These results indicate the favorable effect of enhanced growth, in early stages (30 days after transplanting), in increasing yield components which, in turn, result in higher grain yield. The present results were in a general agreement with those reported by El-Hity and El-Keredy (1992), Ganesan (2001) and Satyavathi *et al.* (2001).

In conclusion, the results of the present study revealed the possibility of replacing about 25 % to 50 % of the mineral N applied to rice crop by organic and/or bio BGA sources and still maintain a comparable yield to 100 % mineral N. In addition, such applications may be a necessary approach in developing sustainable agriculture by keeping the balance of microelements and decreasing the risk of heavy metal pollution (Kong and Ni 2006). Application of chemical fertilizer combined with organic manure may play an important role in decreasing the soil nitrate content, increasing the soil buffering capacity and soil organic matter, improving the soil function and continually increasing yield of crops (Yang *et al.* 2005).

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