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Response of Two Rice Cultivars to Blue Green Algae, A-Mycorrhizae Inoculation and Mineral Nitrogen Fertilizer

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ABSTRACT

Two field experiments were carried out at the experimental farm of the faculty of Agriculture (Saba Basha) Alexandria University, during 2006 and 2007 summer seasons. This study was conducted to investigate the effect of blue green algae (BGA) and A-mycorrhizal fungi (AMF) inoculation (biofertilization) and nitrogen application on growth yield and its components of some rice cultivars, namely 'Sakha 101' and 'Giza 178'. The experimental design used was a split plot with four replicates. Both cultivars were randomly distributed in the main plots. The sub-plots were assigned to four fertilization treatments: 1) 44 kg N/fed (control); 2) BGA [2 packages of 500 g of mixed Cyanobacteria groups/fed.; a commercial product] + 22 kg N/fed; 3) AMF inoculation [100 ml/plant of infected roots] + 22 kg N/fed; 4) BGA + AMF + 22 kg N/fed. 'Sakha 101' had the highest values for all studied characters in both seasons. Treatment 4, followed by treatment 3, had the highest significant effects on all the studied characters in both rice cultivars during both seasons; treatment 4 resulted in the highest growth, yield and yield components of 'Sakha 101'.

Keywords: mycorrhizal fungi, nitrogen application

INTRODUCTION

Rice (*Oryza sativa* L.) is one of the most important cereal crops in the world, including Egypt, where it ranks second in export after cotton. As a food crop, it contributes over 20% to per capita cereal consumption. The need to raise its productivity per unit land area is a national goal to meet the consistent demands from this crop. Improvement of rice production can be achieved by supplying the field with commercially available nutrient fertilizers. Unfortunately, a substantial amount of fertilizers is lost through different mechanisms, causing environmental pollution. Utilization of biological N_2 fixation (BNF) can decrease the application of N fertilizers, reducing environmental risks (Raimam *et al*. 2007). Also, mycorrhizal fungi play a role in whole plant nutrient balance by aiding in the uptake of limiting nutrients and maintaining the nutrient balance (Ning and Cumming 2001). Use of biofertilization or microbial inoculants to replace or increase the efficiency of chemical fertilizers partially or totally is effective in reducing the cost of crop production and maintaining the natural fertility of the soil.

Previous studies have shown different effects of blue green algae (BGA) on the yield and its components in rice. Yanni *et al*. (1982) found that inoculation with BGA and increasing the nitrogen fertilizer rates increased plant N-content at the booting stage and plant height, the effective tillers and panicle weight of rice. Ashoub *et al*. (1993) found the highest yield/fed (1 fed = 4200 m^2) in rice (*Oryza sativa* L.) with 20 kg N + 10 kg *Nostoc commune* (biofertilization) or 40 kg N + 5 kg *N. commune*. Protein concentration in rice grains increased by increasing the rate of N and *Nostoc*. Abd El-Fattah *et al*. (1994) concluded that inoculation with BGA significantly increased rice grain yield and its components. The highest values of N content of rice grains was obtained from 30 kg N/fed farm yard manure (FYM) + 30 kg N/fed urea + BGA treatments. Amin *et al*. (2000) stated that algalization treatment with NPK (60 – 15 – 24) resulted in higher grain yield of rice, while N and P percentages in rice grains were not significantly different in different treatments. Similarly, Tripathi *et al*. (2008) showed that the use of BGA improved growth, yield and mineral composition of rice plants while reducing the high demand of N fertilizers.

Arbuscular mycorrhizal fungi (AMF), which form symbiotic associations with most economically important crop plants, can improved plant growth under low fertility conditions and have attracted a considerable research due to their agricultural potential use (Simpson and Daft 1990). On the other hand, Arbuscular mycorrhizal fungi (AMF) are aerobic (Sylvia and Williams 1992; reviewed by Vosátka and Albrechtová 2008); therefore, soil water and aeration have considerable impact on their distribution and effectiveness. Saif (1981, 1983, 1984) found that plant response to AMF colonization was sensitive to the O_2 and CO_2 levels in the soil. Nonetheless, AMF have been found in aquatic plants (Bagyaraj *et al*. 1979; Chaubal *et al*. 1982; Clayton and Bagyaraj 1984) although the role of mycorrhizae in these environments has yet to be elucidated. There is very little information on crop responses to AMF inoculations under field conditions. Some studies under pot culture conditions revealed that AMF increased grain and straw yields of wetland rice (Sivaprasad *et al*. 1990) and increased the grain yield and P and Zn content in plants (Secilia and Bagyaraj 1994a). Also, Gupta and Ali (1993) reported a significant increase in the grain yield by AMF colonization in wetland rice under both pot and field conditions. Secilia and Bagyaraj (1994b) also reported a positive response of wetland rice to AMF under field conditions. Similarly, Solaiman and Hirata (1997) reported that mycorrhizal seedlings had higher shoot biomass 5 weeks after sowing. Inoculated plants produced higher biomass at maturity under field conditions, and the grain yield was 21% higher than those not inoculated. N and P concentrations of field-grown plants at harvest were significantly higher following preinoculation with AMF than those left uninoculated.

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Original Research Paper

Table 1 Physical and chemical properties of the soil.

Sand %	Silt %	Clay %	Soil texture	pH	EC dSm^{-1} (1:1)	OM %	$CaCO_3$ %	Total N %	P[(1)] mg/kg
38.0	19.5	42.5	clay	7.9	2.3	0.75	7.44	0.08	7.25

(1) Available P

Regarding the effect of N, Abd El-Hafez (1982) reported that the concentration of N, P, and K in rice grains increased gradually with an increase in N levels. Abd El-Rahman *et al*. (1986) found that by raising N fertilizer level up to 150 kg N/ha was associated with a marked increase in plant height, number of panicles/m^2, number of filled grains/panicle, panicle weight as well as grain and straw yields/ha of rice. El Kalla *et al*. (1988a) reported that raising N levels up to 60 kg N/fed significantly increased flag leaf area, number of panicle/m^2, panicle length and weight of 1000 grain as well as grain and straw yields/fed of rice. Bassal *et al*. (1996) and Sharief *et al*. (1998) stated that raising N fertilizer rate up to 60 kg N/fed significantly increased grain yield of rice and its attributing variables.

This investigation was carried out to study the effect of biological nitrogen fixation (BGA), A-mycorrhizal fungi inoculation, soil N application on yield and yield components of two rice (*Oryza sativa* L.) cultivars under field conditions.

MATERIALS AND METHODS

Two field experiments were carried out on a farm of the Faculty of Agriculture, Saba Basha, Alexandria University, during the summer seasons of 2006 and 2007. Soil physical and chemical analysis of the experimental site (average of two seasons) is given in **Table 1**.

The experimental design used was a split plot with four replicates. The two rice cultivars used were 'Sakha 101' and 'Giza 178' which were randomly distributed in the main plots. The subplots were assigned to four fertilization treatments: 1) 44 kg N/fed (control); 2) BGA [2 packages of 500 g of mixed Cyanobacteria groups/fed.; a commercial product] + 22 kg N/fed; 3) AMF inoculation [100 ml/plant of infected roots] + 22 kg N/fed; 4) BGA + AMF + 22 kg N/fed.

BGA, a commercial product, was obtained from the Agriculture Research Center, Ministry of Agriculture, and was added at 2 packages (500 g each) per fed. The package contains several cyanobacteria like *Oscillatoria*, *Leptolyngbya*, *Chroococcales*, *Spirulina*, and *Anabaena*. A-mycorrhizal fungi (*Glomus macrocarpium*) strain from Göttingen University, Germany, at a rate 100 ml/plant of infected roots and was mixed with the soil. The nursery land was well prepared after two ploughings, harrowing and leveling.

Rice gains at a rate of 60 kg/fed were soaked in water for about 36 h and lifted for 24 h. Thereafter, it was sprinkled by hand with 2-3 cm of standing water in the nursery land on 22nd May in both seasons. The preceding winter crop was barseem (*Trifolium alexandrium*) and wheat (*Triticum aestivum*) in both seasons. The permanent field was well prepared and calcium superphosphate (15.5% P_2O_5) at a rate of 100 kg/fed was added on the dry soil before ploughings. Thirty days-old seedlings were transplanted to the permanent field. The other usual agricultural practices of growing rice were conducted as recommended by the Ministry of Agriculture. The size of each sub-plot was 3 × 3.5 m occupying an area of 10.5 m^2 (1/400 fed).

The studied characters

At harvest 10 guarded hills were taken at random from the inner area of each experimental plot to estimate the following characters: 1) Plant height (cm). The average height of 10 randomly chosen plants from each plot was measured from the ground level to the panicle. 2) Flag leaf area (cm^2). The flag leaf area was calculated using the equation of Palaniswomy and Gomez (1974). 3) Number of panicles/m^2 counted in randomly chosen/m^2 in each plot. 4) Panicle length (cm). Average length of 10 randomly chosen panicles. 5) Number of filled grains/panicle. Average number of filled grains from 10 randomly chosen panicles. 6) Grain weight/panicle (g). It was estimated from 10 randomly chosen main panicles from each plot. 7) 1000-grain weight (g). Average weight of 1000-grain randomly taken from each plot. 8) Grain and straw yields (ton/ha). The plants in the inner six square meters of each experiment were harvested, collected together and tied. Plants were transferred to thresh and the grains were separated. The grain and straw yields were recorded in Kg/m^2, which was converted to estimate grain and straw yields in ton/ha. 9) Biological yield (kg/ha). 10) Harvest index = grain yield/biological yield.

Chemical analysis

For determination of N and P content in plants, plant material was digested with H_2SO_4 – H_2O_2 (Lowther 1980). Total N content in both rice grain and straw was determined calorimetrically by the Nessler method (Chapman and Pratt 1978). Total P content in rice grain was estimated by the vanadomolybdophosphoric method (Jackson 1967).

All collected data were subjected to ANOVA for a split plot design according to Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Effect of rice cultivars

The results presented in **Table 2** indicated that rice cultivars significantly varied in their studied characters. 'Sakha 101' exceeded 'Giza 178' in plant height, flag leaf area, number of penicles/m^2, panicle length, number of filled grains/panicles, grain weight/panicle, 1000-grain weight, grain yield/ha, straw yield, biological yield and harvest index% during both seasons. Similar results were obtained by Mahrous *et al*. (1985), Shaalan *et al*. (1986), El-Hissewy and El-Kady (1990), Abd El-Wahab (1998a) and Badawi (2002), who found clear differences between two rice cultivars.

'Sakha 101' surpassed 'Giza 178' in grain yield (t/ha) by 20 and 17.5% in both seasons, respectively. 'Giza 178' showed the lowest values for all characters compared to 'Sakha 101'. These results are in partial agreement with those obtained by Hamissa *et al*. (1987b), El-Kalla *et al*. (1992), Gorgy (1995), El-Kady and Abd El-Wahab (1999) and Badawi (2002) who found that grain yield was higher in 'Sakha 101', 'Giza 182' and 'Sakha 102' than in 'Giza 178'.

Table 3 shows clearly that N content% of grain and straw of 'Sakha 101' increased significantly compared to 'Giza 178' in both seasons. The total N uptake (kg/ha) of 'Sakha 101' was increased by about 79 and 62% compared with 'Giza 178' in both seasons, respectively. On the other hand, P content% of 'Sakha 101' grain was significantly higher than 'Giza 178' in both seasons. The grain P uptake (kg/ha) of 'Sakha 101' was higher than 'Giza 178' by about 75 and 67% in both seasons, respectively.

Effect of fertilization

The application of the combined treatment (biofertilization (BGA + AMF) + 22 kg N/fed) gave higher yields and showed a positive effect on all studied characters, compared with controls (**Tables 2, 3**). The respective percentage increases as an average of both seasons, due to such treatment over the uninoculated control (44 kg N/fed) were 8.87% for plant height, 16.36% for flag leaf area, 6.36% for number of filled grains/panicle, 51.78% for grain yield/ha, 27.14% for biological yield t/fed, 61.10% for nitrogen uptake (kg/fed) and 62.03% for phosphorus uptake (kg/fed) by grains. These increases of grain and straw yields/ha due to biological nitrogen fixation by BGA and AMF inoculation improves soil structure, increases the availability of nutrients and enhances reclamation of alkali soils. Such results are in

Table 2 Effect of biofertilization (BGA + AM fungi) and nitrogen application on plant growth and yield of two rice cultivars during 2006 and 2007 seasons.

Treatments	Plant height (cm)		Flag leaf area $(cm)^2$		№ of panicles/ m^2		Panicle length (cm)		№ filled grains/ panicles		Grain weight/ panicle (g)	
	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007
Cultivar (C)												
Sakha 101	89.1 a	91.7 a	18.2 a	18.6 a	298 a	300 a	21.7 a	22.3 a	115 a	117 a	3.13 a	3.19 a
Giza 178	81.9 b	83.9 b	15.7 b	16.9 b	286 b	287 b	20.5 b	21.1 b	110 b	114 b	2.96 b	2.83 b
Fertilization (F)												
Cont + 44 kg N/fed	82.5 d	83.3 d	16.2 d	16.8 c	290 d	291 d	20.1 d	20.6 d	109 d	111 d	2.39 d	2.28 d
BGA + 22 kg N/fed	84.8 c	86.6 c	16.7 c	17.5 b	292 c	293 c	20.9 c	21.4 c	112 c	115 c	2.87 c	2.84 c
AMF + 22 kg N/fed	85.6 b	89.9 b	17.2 b	18.2 a	293 b	294 b	21.5 b	22.1 b	114 b	117 b	3.21 b	3.24 b
BGA + AMF + 22 kg N/fed	89.1 a	91.4 a	17.9 a	18.5 a	294 a	296 a	22.0 a	22.7 a	115 a	119 a	3.71 a	3.67 a
Interaction:			ns		ns							
C x F	**	**		**		**	**	**	**	**	**	**

Table 2 (Cont.)

Treatments	1000-grain weight (g)		Grain yield t/ha		Straw yield t/ha		Biological yield t/ha		Harvest index %	
	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007
Cultivar (C)										
Sakha 101	20.6 a	21.0 a	5.04 a	5.23 a	10.8 a	11.3 a	15.9 a	16.5 a	0.39 a	0.39 a
Giza 178	20.2 b	20.4 b	4.20 b	4.45 b	7.7 b	8.6 b	11.9 b	13.0 b	0.35 b	0.34 b
Fertilization (F)										
Cont + 44 kg N/fed	19.8 d	20.1 d	3.64 d	5.05 d	8.2 d	9.0 d	12.8 d	14.1 d	0.36 a	0.36 c
BGA + 22 kg N/fed	20.2 c	20.3 c	5.29 c	5.45 c	8.9 c	9.6 c	14.2 c	15.1 c	0.37 a	0.36 c
AMF + 22 kg N/fed	20.6 b	20.9 b	6.01 b	6.20 b	9.7 b	10.3 b	15.7 b	16.5 b	0.38 a	0.37 b
BGA + AMF + 22 kg N/fed	21.1 a	21.4 a	6.53 a	6.66 a	10.2 a	10.8 a	16.8 a	17.4 a	0.38 a	0.38 a
Interaction:										
C x F	**	**	**	**	**	**	**	**	ns	**

Table 3 Effect of biofertilization (BGA + AM fungi) and nitrogen application on nitrogen and phosphorus contents (%) of two rice cultivars during 2006 and 2007 seasons.

Treatments	N content % Grain		N content % Straw		N uptake (kg/ha) Grain		N uptake (kg/ha) straw	
	2006	2007	2006	2007	2006	2007	2006	2007
Cultivar (C)								
Sakha 101	1.26 a	1.23 a	0.24 a	0.24 a	89.12 a	89.40 a	25.60 a	27.84 a
Giza 178	1.23 b	1.20 b	0.16 b	0.22 b	51.69 b	53.60 b	12.39 b	18.67 b
Fertilization (F)								
Cont + 44 kg N/fed	1.15 d	1.12 d	0.16 d	0.16 d	53.68 d	56.96 d	13.68 c	14.66 c
BGA + 22 kg N/fed	1.28 b	1.26 b	0.21 b	0.25 b	54.10 c	68.74 c	19.53 b	24.60 b
AMF + 22 kg N/fed	1.25 c	1.21 c	0.19 c	0.23 c	75.10 b	75.01 b	19.25 b	23.88 b
BGA + AMF + 22 kg N/fed	1.30 a	1.28 a	0.22 a	0.28 a	85.17 a	85.42 a	23.52 a	29.86 a
Interaction:								
C x F	**	**	**	**	**	**	**	**

Table 3 (Cont.)

Treatments	Total N kg/ha		P content % Grain		P uptake (kg/ha) Grain		Average P uptake (kg/ha) Grain
	2006	2007	2006	2007	2006	2007	
Cultivar (C)							
Sakha 101	114.70 a	117.20 a	0.208 a	0.210 a	14.75 a	15.33 a	15.04 a
Giza 178	64.08 b	72.27 b	0.199 b	0.205 a	8.42 b	9.18 b	8.80 b
Fertilization (F)							
Cont + 44 kg N/fed	67.36 d	71.62 d	0.184 d	0.188 d	8.58 d	9.54 d	9.06 d
BGA + 22 kg N/fed	87.20 c	93.35 c	0.201 c	0.203 c	10.63 c	11.11 c	10.87 c
AMF + 22 kg N/fed	94.35 b	98.89 b	0.209 b	0.217 b	12.67 b	13.48 b	13.08 b
BGA + AMF + 22 kg N/fed	108.70 a	115.20 a	0.221 a	0.223 a	14.46 a	14.90 a	14.68 a
Interaction:							
C x F	**	**	ns	*	**	**	**

accordance with whose obtained by Bagyarai and Menge (1978), Sakthiviel (1990), Kerni (1991), Hassouna and Aboul-Nasr (1992), who reported that the use of biofertilization lead to increase in nutrient bioavailability and reducing environmental risks. Several studies (i.e. Subba Rao *et al*. 1985; Sainz and Arines 1988; Raju *et al*. 1990), exhibited some increases in colonization levels and, in some cases, synergistic or additive effects of dual inoculation on plant growth and nutrition. Besada *et al*. (1991) illustrated that inoculation with AMF, either singly or with N_2-fixing bacteria improved barley growth and yield when compared with the control treatment. The increase in yield was mostly due to plant growth regulators produced by mycorrhizal fungi and due to less extent to N-fixation. Increasing nitrogen and P percentages and uptake of rice plants were generally recorded for the combined treatment i.e. BGA with mycorrhizal inoculation in addition to 22 kg N/fed (**Table 3**). These data are in agreement with the results obtained by Besada (1987) and Medina *et al*. (1987) who reported that inoculation with AMF and N-fixers significantly increased N content and percentage protein of plants compared with the untreated control. These results are in agreement with those obtained by Kucey and Janzen (1983), Radwan and El-Nimer (1996) on barley, and Bassal and Zahran (2002) on rice.

Data in **Tables 2** and **3** show that the yields obtained by

AMF treatment (A-mycorrhizal inoculation + 22 kg N/fed) were higher than those of control (44 kg N/fed) which, in turn, were higher than those of BGA + 22 kg N/fed treatment. The AMF + 22 kg N/fed treatment was higher than the control treatment (44 kg N/fed) on average of both seasons by about 5.85% for plant height, 7.13% for panicle length, 38.12% for grain weight/panicle, 40.51% for grain yield, 16.28% for straw yield, 19.7% for biological yield, 39.04% for total N uptake and 44.37% for P uptake of grain. That could be due to increase acquisition of nutrients by increasing the extension of the depletion zone around the root. The mycorrhizal fungi extend a network of hyphae several centimeters out into the surrounding soil, thereby expanding the effective volume of soil that a plant can exploit (Smith 2002). The hyphal mycelium increases the total absorption surface of infected plants and this improves its access to elements in areas beyond the roots' depletion zone (Douds *et al*. 2005; Grant *et al*. 2005). In addition, in alkaline soils, mycorrhizal hyphae lead to a decrease in alkalinity of the rhizosphere soil from 8.5 to 7.4 by exudation of organic acids, which solubilize immobile elements such as P (Giri *et al*. 2005). Similarly, Soliman and Hirata (1997) showed that N and P concentrations of field-grown rice plants at harvest were significantly increased by preinoculation with AMF over those left uninoculated. In contrast, Raimam *et al*. (2007) reported that, the presence of *Glomus clarum* decreased or did not significantly affect plant growth under different culture conditions. Also, Herdler *et al*. (2008) found that rice biomass did not increase in the presence of mycorrhizae (*Glomus intraradices*).

On the other hand, rice plants treated with BGA and 22 kg N/fed showed a significant increase of all studied characters in both seasons compared to untreated plants (control) (**Tables 2, 3**). The BGA that grow with rice plants contribute a substantial amount of nitrogen to the crop. Therefore blue green algae have been used as a source of fertilizer nitrogen in rice production (Sylvia *et al*. 1998). In addition, BGA can produce plant growth regulators, natural toxins and other antibiotics. Also, BGA participate in the formation of soil organic matter through both the exudation of organic compounds and upon their death. In the same line, Watanabe (1962) showed that BGA contributed as much as 50 kg N/ha yr in tropical rice paddies. Also, El-Kholy *et al*. (1999) found that BGA inoculation with the addition of 20 kg N/fed and organic manure at 20 m^3/fed, produced the highest increase of rice yield and soil fertility while the highest N content in grains of rice was obtained from the treatment of BGA inoculation with addition of 40 kg N/fed and organic manure at the rate of 20 m^3/fed. Following a similar trend, Tripathi *et al*. (2008) reported that use of BGA improved growth, yield, and mineral composition of rice plants besides reducing the high demand of N fertilizers.

Effect of interactions

Data in **Tables 4** and **5** show that in both seasons the two cultivars showed the same trend for all studied characters. In other words, the studied characters increased significantly when the plants were grown under BGA and/or AMF treatments, compared to the control. However, the highest rice yield for any of the studied cultivars was attained with the combined treatments, i.e. BGA + AMF + 22 kg N/fed. These results are in agreement with those obtained by Ishac (1986a). On the other hand, it was clear that for all studied characters 'Sakha 101' was superior to 'Giza 178' for all treatments, in particular for the two treatments in which AMF was applied in both seasons (**Tables 4, 5**). For example, in treatment BGA + AMF + 22 kg N/fed, the respective percentage increases as an average of both seasons, due to difference in cultivars were 13.89% for plant height, 76.8% for grain yield, 37.11% for straw yield, 78.47% for total N uptake, and 80.74% for grain P uptake. These results are in accord with several authors (Fageria and da Costa 2000; Bhadoria *et al*. 2002) who stated that plant species or even genotypes of the same species varied in their ability to grow on the same soil. The difference between the two cultivars could be due to an increase in their ability to acquire nutrients from the soil (nutrient uptake efficiency) and/or to utilize nutrients for the production of total biomass or utilizable plant material (nutrient use efficiency) (Marschner 1995). Various root characteristics like nutrient acquisition

Table 4 Plant growth and rice yield as affected by the interaction between biofertilization (BGA + AM fungi) and nitrogen application of two rice cultivars during 2006 and 2007 seasons.

Treatments	Plant height (cm)		Flag leaf area $(cm)^2$	№ of panicle /m^2	Panicle length (cm)		№ filled grains/ panicle		Grain weight/ panicle (g)	
Fertilization	**2006**	**2007**	**2007**	**2007**	**2006**	**2007**	**2006**	**2007**	**2006**	**2007**
Sakha 101										
Cont + 44 kg N/fed	84.45	84.78	18.08	296.50	20.35	20.83	110.85	111.60	2.30	2.14
BGA + 22 kg N/fed	88.15	90.00	18.28	298.65	21.60	21.95	114.65	117.33	2.88	2.92
AMF + 22 kg N/fed	89.48	95.08	18.83	300.75	22.18	22.80	116.58	118.68	3.30	3.48
BGA + AMF + 22 kg N/fed	94.33	96.98	19.05	302.60	22.78	23.60	119.63	120.63	4.03	4.23
Giza 178										
Cont + 44 kg N/fed	80.50	81.75	15.58	284.65	19.93	20.38	107.95	110.20	2.47	2.43
BGA + 22 kg N/fed	81.43	83.25	16.63	286.83	20.25	20.88	110.05	112.60	2.86	2.75
AMF + 22 kg N/fed	81.85	84.83	17.55	287.78	20.88	21.35	110.53	114.48	3.13	3.01
BGA + AMF + 22 kg N/fed	83.90	85.83	17.90	288.58	21.13	21.85	111.63	116.70	3.39	3.11
$LSD_{0.05}$	0.16	0.48	0.18	0.18	0.11	0.11	0.47	0.38	0.08	0.06

Table 4 (Cont.)

Treatments	1000-grain weight (g)		Grain yield t/ha		Straw yield t/ha		Biological yield t/ha		Harvest index %
Fertilization	**2006**	**2007**	**2006**	**2007**	**2006**	**2007**	**2006**	**2007**	**2007**
Sakha 101									
Cont + 44 kg N/fed	19.83	20.23	5.58	6.15	9.63	10.23	15.20	16.38	0.376
BGA + 22 kg N/fed	20.43	20.50	6.60	6.50	10.35	10.90	16.95	17.40	0.374
AMF + 22 kg N/fed	20.73	21.35	7.63	7.78	11.30	11.75	18.93	19.53	0.398
BGA + AMF + 22 kg N/fed	21.33	21.88	8.35	8.50	11.98	12.33	20.33	20.83	0.408
Giza 178									
Cont + 44 kg N/fed	19.69	19.95	3.70	3.95	6.71	7.83	10.41	11.78	0.336
BGA + 22 kg N/fed	19.93	20.14	3.98	4.40	7.45	8.33	11.43	12.73	0.346
AMF + 22 kg N/fed	20.44	20.40	4.40	4.63	8.08	8.83	12.48	13.45	0.344
BGA + AMF + 22 kg N/fed	20.90	20.98	4.70	4.83	8.50	9.23	13.21	14.05	0.344
$LSD_{0.05}$	0.06	0.03	0.07	0.07	0.15	0.09	0.09	0.12	0.008

Table 5 Nitrogen, Phosphorus contents % and uptake in rice grains and straw as affected by the interaction between biofertilization (BGA and AMF) and nitrogen application of two rice cultivars in 2006 and 2007 seasons.

Treatments		**N content % Grain**		**N content % Straw**		**N uptake (kg/ha) Grain**		**N uptake (kg/ha) Straw**	
Cultivar	**Fertilization**	**2006**	**2007**	**2006**	**2007**	**2006**	**2007**	**2006**	**2007**
Sakha 101	Cont + 44 kg N/fed	1.17	1.14	0.19	0.17	65.23	70.27	18.29	17.39
	BGA +22 kg N/fed	1.29	1.28	0.26	0.27	85.15	83.04	26.40	29.43
	AMF + 22 kg N/fed	1.26	1.22	0.23	0.25	96.08	94.86	25.99	28.79
	BGA+AMF+22kg /fed	1.32	1.29	0.27	0.29	110.02	109.44	31.73	35.74
Giza 178	Cont + 44 kg N/fed	1.14	1.11	0.14	0.15	42.14	43.65	9.07	11.94
	BGA +22 kg N/fed	1.26	1.24	0.17	0.24	50.19	54.45	12.67	19.78
	AMF + 22 kg N/fed	1.23	1.19	0.16	0.22	54.12	55.16	12.52	18.98
	BGA+AMF+22kg /fed	1.28	1.27	0.18	0.26	60.32	61.15	15.31	23.98
$LSD_{0.05}$		0.008	0.006	0.007	0.008	0.63	0.92	0.67	0.82

Table 5 (Cont.)

Treatments		**Total N (Kg/ha)**		**P content % Grain**	**P uptake (kg/ha) Grain**	
Cultivar	**Fertilization**	**2006**	**2007**	**2007**	**2006**	**2007**
Sakha 101	Cont + 44 kg N/fed	83.52	87.65	0.191	10.52	11.76
	BGA +22 kg N/fed	111.54	112.47	0.206	13.40	13.38
	AMF + 22 kg N/fed	122.07	123.65	0.219	16.44	17.03
	BGA+AMF+22kg /fed	141.75	145.18	0.225	18.66	19.15
Giza 178	Cont + 44 kg N/fed	51.20	55.59	0.185	6.63	7.31
	BGA +22 kg N/fed	62.85	74.23	0.201	7.87	8.84
	AMF + 22 kg N/fed	66.64	74.13	0.205	8.91	9.92
	BGA+AMF+22kg /fed	75.63	85.14	0.221	10.27	10.65
$LSD_{0.05}$		1.84	2.45	0.002	0.18	0.15

capacity, lifetime of roots, root: shoot ratio, root hair length and root hair density influence the nutrient uptake efficiency of plants. In addition, physiological characteristics such as exudation of organic acids and rhizosphere pH also affect the nutrient uptake efficiency. Cultivating nutrient-efficient cultivars can provide a complementary solution to the problem emanating from low yields due to low nutrient supply in the soil (Lynch 1998).

From our results, it can be concluded that inoculation with AMF in addition to BGA and supported by 22 kg N/fed significantly increased nutrient uptake and improved plant growth and yield and its components. Also, 'Sakha 101' gave higher growth and yield, compared to 'Giza 178'.

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