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Original Research

Nutritional Value and Grain Quality Characteristics of Different Improved Egyptian Rice Genotypes Under Nitrogen Fertilizer Levels

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Abstract

A two-year field experiment was conducted to study the behavior of three improved Egyptian rice varieties under different rates of nitrogen fertilizer. The selected tested varieties were Sakha109 (Japonica type), Giza179 (Indica/Japonica Type), and Giza182 (Indica type). Giza179 was treated with the highest nitrogen rate and recorded the highest grain yield values. The studied varieties showed different behavior under the various nitrogen levels. Giza182 recorded a high grain yield with better nutritional value. Higher grain quality characteristics were obtained from Sakha109. Generally, increasing the nitrogen level up to 200 kg N/ha increased rice grain yield, hulling (%), milling (%), and head rice (%) as well as carbohydrate %, oil %, ash amylose %, nitrogen %, phosphorus %, potassium %, and protein % in milled rice grains.

Keywords: Indica/Japonica rice, milling recovery, nutritional value, protein content

Introduction

The major cereal crops in Egypt are wheat and rice, and they are directly associated with Egyptian food security. Both of these are considered main stable foods for the Egyptians. Rice is an important cereal crop, so several experiments were carried out to increase the yield production of rice [1-7]. NPK are the main nutrients for growth and limiting factors under flooding conditions. Nitrogen is required in large quantities, and it has a positive effect on the tiller number and yield components of many plants [8-10]. The appropriate level of NPK fertilizer is very important for the better growth and yield of rice [11-14]. Due to population growth, climate change, and urbanization, the demand for wheat and rice has increased year after year, so Egyptian rice breeders have improved high-yielding rice varieties that have adapted to biotic and abiotic stresses. The importance of N fertilizer was studied in many plants,

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such as wheat [15, 16], cowpea, sunflower [17], and sugar beet [18]. The improved varieties should have high nutritional value and good grain quality characteristics to meet Egyptian consumers' needs. The genotypic variations in grain quality and nutritional value of milled rice are predominantly driven by the genetic and environmental aspects, which have been notified by several investigations. Singh et al. [19] indicated genotypic differences in the physicochemical, cooking, and textural properties of milled grains of rice cultivars (Japonica type). Metwally et al. [20] found wide variations among rice varieties in terms of physical grain characteristics. Metwally et al. [21] indicated that the Egyptian rice varieties have different nutritional values and grain quality characteristics. They found that hulling, milling, head rice, gelatinous temperature, kernel elongation, amylose content, protein content, carbohydrate content, lipid content, ash, phosphorus, potassium, and energy composition are varied among the rice varieties. Application of an optimum agronomic package of recommendations for each variety is important to obtain a high yield with acceptable grain quality characteristics. Nitrogen fertilization is one of the most important factors that control rice grain quality and quantity. Zhou et al. [22] noted that rising nitrogen fertilizer rates from 0 to 220 kg N/ha boosted the percentages of brown rice, head rice, chalky-kernel percentage, setback, and peak time values, but reduced the length/width ratio, chalkiness, apparent amylose content, gel consistency, and peak-, trough-, and final-viscosity values. These outcomes suggest that nitrogen fertilizer has a useful influence on milling and nutritional quality, but a detrimental effect on appearance, cooking, and eating quality. So, the objective of the current investigation was to determine the effect of nitrogen fertilizer rates on the nutritional value and grain quality characteristics of three Egyptian improved rice varieties.

Experimental

Materials and Methods

A two-year field experiment was conducted to study the behavior of three improved Egyptian rice varieties under different rates of nitrogen fertilizer. The experiment was located at the Experimental Farm of RRTC (Rice Research & Training Center), Sakha, Kafrelsheikh Governorate, Egypt (31°5′17″N, 30°56′44″E altitude). The selected tested varieties were Sakha109, Giza179, and Giza182. Sakha109 is a recently registered Japonica variety, Giza179 is a newly Indica/Japonica variety, and Giza182 is an Indica variety (Fig. 1.). The parentage, type, and origin of the studied genotypes are presented in Table 1.

Soil representative samples were collected from the experimental sites at a depth of 0-30 cm from the soil surface, then air-dried, ground to pass through a 2mm sieve, and well mixed. The technique of soil analysis was followed by the procedure of Black et al. [23]. Soil chemical analysis in the two studied seasons is presented in Table 2.

Cultural Practices

Seed Bed Preparation and Raising Nurseries

The seedbed had been established and sufficiently plowed, dry-grounded, irrigated by water, then wet-leveled. Calcium monophosphate (15.5% P_2O_5) was added to dry soil at a rate of 37 kg P_2O_5/ha just before plowing. Nitrogen in the form of urea (46.5% N) was applied and incorporated into the soil just before flooding. All seeds of the three rice genotypes were submerged in

Fig. 1. Rice grain shape of the studied rice varieties.

Table 1. Name, origin and Subspecies group of the studied rice genotypes.

Genotype	Parentage	Origin	Subspecies group
Sakha109	Sakha101/Sakha105	Egypt	Japonica
Giza179	GZ1368/IRAT112 GZ1368/GZ6296	Egypt	Japonica/Indica
Giza182	Giza181/IR39422//Giza181	Egypt	Indica

Table 2. Some chemical analyses of the experimental sites before planting in 2020 and 2021 seasons.

Soil chemical properties	2020 season	2021 season
Ph (1:2.5)	8.12	8.35
Ec (ds.m^{-1})	3.09	2.90
Total N (ppm)	585.60	593.50
Available P (ppm)	5.70	6.00
Available K (ppm)	440.50	455.10
Anions (meq.L^{-1})		
CO_3^{--}	--	--
HCO_3^-	6.50	5.77
Cl^-	8.80	8.30
SO_4^{--}	15.63	14.90
Cations (meq.L^{-1})		
Ca^{++}	5.95	5.80
Mg^{++}	4.10	3.70
Na^{++}	19.13	17.70
K^+	1.40	1.70
Available micronutrients (ppm)		
Fe	6.00	6.50
Mn	3.70	3.60
Zn	1.00	1.12

fresh water for one day and then incubated for two days in order to accelerate germination. Germinated seeds had been uniformly planted in the recommended area of 624.8 m^2/ha for all rice genotypes. The nursery sowing dates were the 6th and 8th of May for 2020 and 2021, respectively.

The Permanent Field

The permanent plots were sufficiently set as plowing two times, harrowing one time, removing the crop residues of the previous crop, and dry leveling using a laser device. All plots received the optimum phosphorus and potassium fertilizer doses. Phosphorus was applied just before the second plowing at 36.9 kg P_2O_5kg/ha in the form of super-monophosphate $Ca(H_2PO_4)_2$ which contains 15.5% P_2O_5. The recommended dose of 57 kg K_2O/ha as potassium sulfate (48% K_2O) was used in the permanent field and incorporated into the soil before the second plowing. Regarding nitrogen fertilization, urea (46.5% N) as a recommended source of nitrogen has been used and added according to the treatment schedule (0, 50, 100, 150, and 200 kg N ha^{-1}) as two splits. The first split equaled two-thirds of the total amount and was applied and incorporated into the soil just before the first irrigation. The second split equaled one-third and was top-dressed 30 days after the application of the first split. 30-day-old seedlings had been uprooted from the seedbed and sufficiently spread via the experimental units. The transplanting operation was done manually at a planting density of 20 X 20 cm to maintain 25 hills per meter square. Three seedlings per hill were used for transplanting all rice varieties.

Grain Quality Characteristics

The milling recovery, gelatinization temperature, kernel elongation, and amylose content were estimated according to Cruz and Khush [24]. 150 (g) of cleaned rough rice at 14% moisture content was dehulled using an Experimental Huller Machine (Satake - Japan). The brown rice was separated and weighed, then the hulling percentage was calculated. The brown rice was milled using MC GILL Rice Miller No.2. (S.K. Appliances – India). The total milled rice (whole milled grains + broken milled grains) was weighed, and the milled rice percentage was calculated. Whole milled grains were separated from the total milled rice using a rice sizing device SKU: 61-220-50 (Seedburo – USA). The percentage of head rice (whole grains) was calculated.

Six grains of whole milled rice were placed in boxes containing 1.7% KOH and arranged so that the kernels did not touch each other. The boxes were covered and incubated for 23 h at 30 °C. The appearance and disintegration of endosperm were graded visually according to the numerical scale of the gelatinization temperature. Kernel elongation was measured using the Micrometer: the length of five milled grains was measured (mm), and their average was determined for each treatment (before cooking). Grains were left in a test tube filled with 30 ml of distilled water for 30 min, then for another 10 min in a 98 °C water tub. After that, the tubes were placed in cold water until reaching room temperature. Grains were lifted from the distilled water, dried (by filter paper), and measured again by graph paper (after cooking). Kernel elongation percentage was calculated as the percentage of grain expanding before and after cooking. Amylose content was determined by accurately weighing 100 mg of sample into a 100 ml volumetric flask, then carefully adding 1 ml of 95% ethanol and 9 ml 1 N NaOH. The mixture was heated for 10 min in a boiling water bath to gelatinize the starch, then cooled, and the content made up to a volume of 100 ml with water. A 5 ml pipette portion of the gelatinization starch solution, 1 ml of 1 N acetic acid, and 2 ml of iodine solution were added and made up to a volume of 100 ml with distilled water. The content was shaken and stood for 20 min before reading the transmission at 620 nm by the Spectronic 1201 Spectrophotometer (Milton Roy, USA).

Protein, Carbohydrate, Lipids, Ash, Phosphorus, and Potassium Determination in Rice Grain

Plant samples were taken from the grain after milling (50 g of milled rice). All plant samples were placed in paper bags and oven-dried at 70 °C for 48 h. Grain samples were ground to powder and digested according to the method of Chapman and Pratt [25] before chemical analysis as follows: The nitrogen content of milled grains was determined by using the Microkieldahl method [26] to calculate protein content. Total carbohydrate was calculated by difference, as mentioned by Fraser and Holmes [27]. Lipids were determined according to A.O.A.C. [28]. The phosphorus content of milled grain was determined using the Spectronic 1201 Spectrophotometer (Milton Roy, USA) following the procedures of Watanabe and Olsen [29]. The potassium content of grain was determined using an Elico CL378 Flame Photometer (RHYS international LTD, India) according to the Peterpurgski method [30]. The data was subjected to analysis of variance (ANOVA), and the differences among treatments' means were compared by Duncan's Multiple Range Test ($P < 0.05$) and multiple F. test according to Duncan [31].

Results and Discussion

The grain yields of studied varieties, as affected by various nitrogen levels and their interaction in the 2019 and 2020 rice seasons, are presented in Tables 3 and 4. There are highly meaningful variations among various varieties in terms of grain yield in both seasons of investigation. Giza182 delivered the most elevated grain yield, followed by Giza179 without any significant differences between both of them in the second season only, while Sakha109 presented the lowest grain yield. Boosting nitrogen rates up to the highest rate caused a significant increase in grain yield.

The data in Table 4 asserts that highly significant variations in grain yield were due to the interaction between the variety and nitrogen level in both seasons. Giza179, treated with the highest nitrogen rate, recorded the highest grain yield values. While the lowest grain yield had been achieved at zero nitrogen with Sakha109. These results suggested that the studied cultivars were positively efficacious in nitrogen use at the highest rate, causing a relative boost in vegetative growth characteristics as well as yield attributes. The expansion in grain productivity at a higher nitrogen rate may also be attributed to the accumulation of more dry matter and translocation from source to sink. Moreover, Chu et al. [32] noted that the increase in sink ability is a fundamental way for plant breeders to improve rice productivity. They also reported that the number of unproductive tillers declined with increasing nitrogen application, and the highest weight of 100-grain was obtained from the lowest rate of nitrogen. Zhou et al. [33] suggested that under the application of a high dose of nitrogen fertilizer, a higher post-anthesis biomass could be gained and greater advantages from heading to maturity than the low nitrogen in the aspects of more dry matter accumulation at the late growth stage, a coordinated organ growth ratio, and a higher matter translocation rate from the stem and leaf to the panicle, thus benefiting yield formation.

Milling recovery characteristics were significantly affected by the studied treatments. Generally, Sakha109 produced the highest percentage of hulling, milling, and head rice. The varietal distinctions in hulling recovery could be attributed to their genetically inherited variants. Zhao et al. [34] reported that rice grain milling and physical characteristics are commanded by the genetic backdrop of rice genotypes. They also reported that gene GS9 regulates grain shape and hull thickness by altering cell division. It means rice grain milling recovery characteristics are mainly controlled by the genetic background.

Increasing the nitrogen level to the highest parameter gradually increased the milling recovery characteristics. The boost in milling recovery by raising nitrogen levels could be associated with the enlargement in assimilates translocation to the rice spikelets at the filling stage. The highest percentages of those characteristics were recorded when the Sakha109 rice variety was fertilized with the highest rate of nitrogen fertilizer.

Data in Tables 5 and 6 revealed significant differences due to nitrogen fertilizer application among rice varieties for carbohydrate, oil, ash, and amylose percentages in milled grains. Carbohydrate, oil, ash, and amylose percentages were significantly higher in the milled grains

Table 3. Grain yield and milling recovery characteristics of studied rice varieties under different levels of nitrogen fertilizers in 2020 and 2021.

Treatments	**Grain yield**		**Hulling (%)**		**Milling (%)**		**Head rice (%)**	
	2019	**2020**	**2019**	2019	2020	**2020**	**2019**	**2020**
Variety								
Giza 179	10.74b	10.61a	76.76b	76.08b	70.49 b	70.11b	62.65b	**58.54c**
Sakha 109	10.17c	10.25b	78.83a	77.97a	72.69 a	72.49a	64.79a	**64.55a**
Giza 182	10.93a	10.70a	76.7b	74.92c	72.69 a	69.08c	59.13c	**59.16b**
Nitrogen kg/ha								
0	7.89e	7.59e	75.42e	74.45e	69.7 e	69.28d	59.09e	**57.71e**
50	9.99d	10.06d	76.79d	75.87d	71.17 d	69.92c	61.19d	**59.82d**
100	10.86c	10.77c	77.6c	76.46c	72.05 c	70.11c	62.66c	**61.09c**
150	11.77b	11.60b	78.21b	77.1b	72.94 b	71.02b	63.49b	**62.05b**
200	**12.55a**	**12.56a**	**79.13a**	**77.73a**	**73.92 a**	**72.46a**	**64.54a**	**63.08a**

Table 4. Grain yield and milling recovery characteristics as affected by the interaction between rice variety and nitrogen level in 2020 and 2021.

Treatments		Grain yield		Hulling (%)		Milling (%)		Head rice (%)	
Variety	**Kg N /ha**	**2019**	**2020**	**2019**	2019	2020	**2020**	**2019**	**2020**
Giza 179	0	7.73i	7.24i	74.41j	73.75h	67.74l	68.04k	60.19h	**53.42j**
	50	9.81g	9.63g	76.63h	75.91f	69.71k	68.99i	61.82fg	**56.93i**
	100	10.82e	10.49e	77.1fg	76.4e	70.81j	69.63gh	63.01e	**59.91f**
	150	12.35bc	12.11b	77.42f	76.81d	71.55i	70.93f	63.61de	**60.76e**
	200	13.00a	13.55a	78.23de	77.54c	72.67ef	72.96c	64.64c	**61.67d**
Sakha 109	0	6.65j	6.77j	77.26fg	76.78d	70.80j	69.94g	63.07e	**62.26d**
	50	9.89g	10.13f	77.97de	77.72c	72.03gh	71.54e	64.22cd	**63.65c**
	100	10.80e	10.9d	78.71c	77.78c	72.37fg	72.15d	64.47c	**64.22c**
	150	11.38d	11.42c	79.37b	78.44b	73.46d	73.8b	65.50b	**65.78b**
	200	12.13c	12b	80.86a	79.14a	74.81a	75.02a	66.70a	**66.86a**
Giza 182	0	9.30h	8.76h	74.59j	72.81i	70.59j	69.86g	54.01j	**57.46i**
	50	10.26f	10.42ef	75.77i	73.99h	71.77hi	69.24hi	57.52i	**58.88h**
	100	10.97e	10.92d	76.98gh	75.2g	72.98e	68.56j	60.51h	**59.14gh**
	150	11.59d	11.25c	77.85e	76.07f	73.85c	68.34jk	61.36g	**59.6fg**
	200	**12.53b**	**12.14b**	**78.29d**	**76.51de**	**74.29b**	**69.39h**	**62.28f**	**60.72e**

Table 5. Carbohydrate, oil, ash and amylose percentages in milled rice grains of studied varieties under different levels of nitrogen fertilizers in 2020 and 2021.

Treatments	Carbohydrate		Oil		Ash		amylose	
	2019	**2020**	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**
Variety								
Giza 179	76.77b	77.91b	0.423b	0.428b	0.598b	0.622b	18.82b	**18.03b**
Sakha 109	76.05c	77.17c	0.416c	0.422c	0.574c	0.603c	17.22c	**16.5c**
Giza 182	77.69a	78.9a	0.440a	0.448a	0.626a	0.635a	19.84a	**19.05a**
Nitrogen kg/ha								
0	75.72e	77.04e	0.399e	0.406e	0.584e	0.611e	17.84e	**17.08e**
50	76.66d	77.75d	0.415d	0.421d	0.596d	0.617d	18.34d	**17.59d**
100	76.96c	78.06c	0.429c	0.435c	0.601c	0.621c	18.72c	**17.94c**
150	77.21b	78.33b	0.436b	0.443b	0.605b	0.623b	18.98b	**18.22b**
200	77.63a	78.77a	0.452a	0.459a	0.611a	0.63a	19.27a	**18.47a**

of Giza182 than the other varieties. Singh and Singh [35] found genotypic variation in carbohydrate, oil, ash, and amylose percentages among different rice varieties. The application of nitrogen fertilizer significantly increased the contents of carbohydrate, oil, ash, and amylose in milled grains. Liao et al. [36] concluded that nitrogen application regulated the grain yield, nitrogen metabolism, and antioxidant responses of different rice genotypes.

Nitrogen, phosphorus, and potassium concentrations in milled rice grains of the studied varieties under different levels of nitrogen fertilizer varied significantly in both seasons. Giza179 and Sakha109 recorded the highest percentage of nitrogen content in both seasons. Giza182 recorded the highest percentage of phosphorus content in the first season and for potassium content in the second season, while Sakha109 recorded the highest percentage of phosphorus content in the second season and for potassium content in the first season. Application of nitrogen fertilizer significantly increased the NPK content in milled rice grains of all varieties, up to the highest level. Gosal et al. [37] found a positive effect of increasing the dose of inorganic N on NPK uptake by rice plants that might be

Table 6. Carbohydrate, oil, ash and amylose percentages in milled rice grains as affected by the interaction between rice variety and nitrogen level in 2020 and 2021.

Treatments		Carbohydrate		Oil		Ash		amylose	
Variety	**Kg N /ha**	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**
Giza 179	0	76.04i	77.07i	0.41hi	0.41h	0.59gh	0.62h	18.49hi	**17.70gh**
	50	76.79efg	77.84f	0.42fg	0.42g	0.59fg	0.62gh	18.77gh	**17.93fg**
	100	76.89ef	77.94f	0.42ef	0.43ef	0.60f	0.62fg	18.83fg	**18.08f**
	150	76.99de	78.12e	0.43de	0.44d	0.60ef	0.62f	18.9fg	**18.16f**
	200	77.14d	78.56d	0.44cd	0.45cd	0.61e	0.63ef	19.12ef	**18.28ef**
Sakha 109	0	74.47j	76.08k	0.39j	0.40i	0.55k	0.59l	15.65m	**14.99l**
	50	75.97i	76.89j	0.41gh	0.41g	0.57j	0.60k	16.77l	**16.15k**
	100	76.35h	77.32h	0.42fg	0.42f	0.58i	0.61j	17.56k	**16.76j**
	150	76.61g	77.62g	0.42f	0.43ef	0.59h	0.61j	17.89j	**17.16i**
	200	76.85efg	77.92f	0.44cd	0.45c	0.59h	0.61i	18.21i	**17.45hi**
Giza 182	0	76.66fg	77.96f	0.40ij	0.42g	0.61d	0.63de	19.37de	**18.54de**
	50	77.21d	78.51d	0.42f	0.43e	0.62c	0.63cd	19.47cd	**18.69cd**
	100	77.65c	78.93c	0.45c	0.45c	0.63bc	0.63c	19.76c	**18.99c**
	150	78.04b	79.25b	0.46b	0.46b	0.63b	0.64b	20.13b	**19.34b**
	200	**78.90a**	**79.84a**	**0.48a**	**0.48a**	**0.64a**	**0.65a**	**20.47a**	**19.69a**

Table 7. Nitrogen, phosphorus, potassium, and protein concentrations in milled rice grains of studied varieties under different levels of nitrogen fertilizers in 2020 and 2021.

Treatments	N %		P%		K%		Protein	
	2019	**2020**	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**
Variety								
Giza 179	1.54a	1.41a	0.28c	0.28c	0.19c	0.19c	8.83a	**8.09a**
Sakha 109	1.57a	1.43a	0.32b	0.33a	0.23a	0.2b	9.05a	**8.22a**
Giza 182	1.41b	1.29b	0.34a	0.3b	0.21b	0.22a	8.12b	**7.39b**
Nitrogen kg/ha								
0	1.19e	1.06e	0.21e	0.21e	0.14e	0.13e	6.84e	**6.12e**
50	1.43d	1.29d	0.29d	0.28d	0.19d	0.18d	8.20d	**7.42d**
100	1.53c	1.39c	0.33c	0.31c	0.22c	0.21c	8.77c	**8.00c**
150	1.62b	1.48b	0.35b	0.35b	0.24b	0.24b	9.32b	**8.53b**
200	**1.78a**	**1.64a**	**0.37a**	**0.37a**	**0.26a**	**0.26a**	**10.21a**	**9.44a**

due to its direct contribution towards the available N pool and the enhancement of the decomposition of the organic nitrogenous material.

Data in Tables 7 and 8 revealed significant differences among rice varieties, nitrogen levels, and their interactions with protein content percentage in both seasons. Sakha109 and Giza179 recorded higher values of protein content than Giza182, which came in the last rank and recorded the lowest value of protein content. Zhao et al. [34] indicated that the GS9 gene on Chromosome 9 acts as a transcriptional activator to regulate rice grain protein content and appearance quality. Singh and Singh [35] found genotypic variation in protein content percentage among different rice varieties. The application of nitrogen fertilizer significantly increased the contents of protein over the control treatment. Also, increasing the level of nitrogen fertilizer increased the available ammonium concentration in rice soil, which might enhance the uptake of nitrogen by rice plants, as well as increase the protein content. Moreover, Liao et al. [36] found that N fertilizer application regulates rice yield by affecting yield formation and biomass accumulation and modulating the activities of enzymes involved in N metabolism, the antioxidant enzyme activity, and the content of malondialdehyde.

Table 8. Nitrogen, phosphorus, potassium, and protein concentrations in milled rice grains as affected by the interaction between rice variety and nitrogen level in 2020 and 2021.

Treatments		N %		Pv%		K%		Protein	
Variety	Kg N /ha	2019	2020	2019	2020	2019	2020	2019	2020
Giza 179	0	1.24g	1.13e	0.21k	0.20k	0.13l	0.13l	7.13g	**6.47j**
	50	1.46de	1.33d	0.27i	0.26i	0.18j	0.17i	8.4de	**7.64g**
	100	1.54cd	1.41c	0.29h	0.28g	0.2h	0.2h	8.86c	**8.13e**
	150	1.65b	1.51b	0.3g	0.31e	0.22f	0.22f	9.46b	**8.71c**
	200	1.79a	1.65a	0.33f	0.33d	0.23e	0.23d	10.3a	**9.51a**
Sakha 109	0	1.34f	1.20e	0.23j	0.21j	0.14l	0.13k	7.73f	**6.90h**
	50	1.52cd	1.37cd	0.30g	0.30f	0.20h	0.17i	8.75cd	**7.89f**
	100	1.6bc	1.45bc	0.32f	0.35c	0.24d	0.2g	9.19bc	**8.33d**
	150	1.65b	1.50b	0.34e	0.38b	0.26b	0.24d	9.46b	**8.63c**
	200	1.76a	1.63a	0.38c	0.42a	0.29a	0.25c	10.12a	**9.34b**
Giza 182	0	0.98h	0.87f	0.21k	0.21j	0.15k	0.14j	5.65h	**4.99k**
	50	1.29fg	1.17e	0.31g	0.27h	0.19i	0.19h	7.43fg	**6.74i**
	100	1.44e	1.31d	0.36d	0.30f	0.21g	0.23e	8.28e	**7.54g**
	150	1.57bc	1.43bc	0.39b	0.35c	0.24e	0.27b	9.03bc	**8.24de**
	200	**1.78a**	**1.64a**	**0.42a**	**0.37b**	**0.26c**	**0.29a**	**10.22a**	**9.45ab**

Conclusions

The studied varieties showed different behavior under the various nitrogen levels. Giza182 (Indica Type) recorded a high grain yield with better nutritional value (protein, carbohydrate, lipids, ash, phosphorus, and potassium contents). Higher grain quality characteristics (milling recovery, gelatinization temperature, kernel elongation, and amylose) were obtained from Sakha 109. Generally, increasing the nitrogen level up to 200 kg N/ha increased rice grain yield, hulling %, milling %, and head rice % as well as carbohydrate %, oil %, ash %, amylose %, nitrogen %, phosphorus %, potassium %, and protein % in milled rice grains.

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Conflict of Interest

The authors declare no conflict of interest

References and Notes

1. ABD EL-LATTEF A.S., ELKHOBY W.M., ABDELAAL KH., MOHAMED A. Genetic behavior of morphology yield yield components and grain quality in Rice (*Oryza sativa* L). Journal of Plant Production, **5** (11), 1945, **2014**.
2. EL-HITY M.A., METWALLY T.F., MOHAMMED A.A., ELSAKA M.A.M., HASSAN F., HAFEZ Y.M., ABDELAAL KH. Integrated fertilizer management on growth and nutrient uptake of Egyptian hybrid rice. Fresenius Environmental Bulletin, **29** (12A), 11588, **2020**.
3. HAFEZ Y., ELKOHBY W., MAZROU Y.S.A., GHAZY M., ELGAMAL A., ABDELAAL KH. Alleviating the detrimental impacts of salt stress on morpho-physiological and yield characters of rice plants (*Oryza sativa* L) using actosol Nano-Zn and Nano-Si. Fresenius Environmental Bulletin, **29** (8), 6882, **2020**.
4. OMAR A., ZAYED B., ABDEL SALAM A., HAFEZ Y., ABDELAAL K. Folic acid as foliar application can improve growth and yield characters of rice plants under irrigation with drainage water. Fresenius Environmental Bulletin, **29** (10), 9420, **2020**.
5. MOHAMED A.A., ZAYED B., HAFAZ E., ELTOBGY R., HAFEZ Y., ABDELAAL KH. Effect of Potassium Fertilizer Treatments and Harvest Date on Rice Grain Yield and Quality of Rice Plants (Giza 179 Variety). Fresenius Environmental Bulletin, **30** (2), 1010, **2021**.
6. MOHAMED A.A., MAZROU Y., ELHAG D., SAAD A., HAMDY R., ABDELAAL K.H. Response of some faba bean varieties to amino acids and potassium foliar application under delta soil conditions. Fresenius Environmental Bulletin, **30** (11), 11816, **2021**.
7. ABDELAAL K.H., MAZROU Y., MOHAMED A.A., GHAZY M., BARAKAT M., HAFEZ Y., GABALLAH M. The different responses of rice genotypes to heat stress associated with morphological chlorophyll and yield characteristics Notulae Botanicae Horti Agrobotanici Cluj-Napoca, **49** (4), 12550, **2021.**
8. ELHITY M.A., OMER A.M., ZAYED B.A., ASSRA A.A., HASSAN M.M., HAFEZ Y.M., ABDELAAL KH.

Effect of phosphoric acid spray on rice growth and yield under saline sodic soils. Fresenius Environmental Bulletin, **30** (5), 4935, **2021**.

9. ABD EL-ATY M., MAZROU Y., ABO-YOUSSEF M., GALAL A., SALAMA A., HAFEZ Y., AABDELAAL KH. Genetic behavior for insect resistance and anthocyanin characters in some rice genotypes (*Oryza sativa* L). Fresenius Environmental Bulletin, **31** (2), 1764, **2022**
10. ABDELAAL K.H., RAGAB A., EL-HAG D., OSMAN M. Effect of nitrogen and potassium fertilization on productivity and quality sugar beet plants at North Delta Region Egypt Fresenius Environmental Bulletin, **28** (11), 7833, **2019**.
11. ELHITY M.A., OMER A.M., ZAYED B.A., ASSRA A.A., HAFEZ Y., EL-SHARNOUBY M., ABDELAAL KH. Improvement of grain quality and nutrition of rice under saline sodic conditions and foliar spray with phosphoric acid. Fresenius Environmental Bulletin, **30** (8), 9814, **2021**.
12. OMAR A., ABOYOUSSEF M., SHOUGHY A., ABD EL-ATY M.S., ABDELAAL KH., HAFEZ Y., KAMARA M. Response of Egyptian Yasmin rice cultivar to different seeding number per hill and different nitrogen levees. Fresenius Environmental Bulletin, **31** (1A), 1258, **2022**.
13. ABDELAAL K.H., BADAWY S.H., NEANA S.H. Effect of foliar application of microelements and potassium on growth physiological and quality characters of sugar beet (*Beta vulgaris* L) under newly reclaimed soils. Journal Plant Production Mansoura University, **6** (1), 123, **2015**.
14. ABOU KHADRAH S., GHARIB H.S., MOHAMED A.A., ELHOSARY M.A., ABDELAAL KH., HAFEZ Y.M. Combination of nitrogen and potassium fertilizers improve physiological and yield characters of two wheat cultivars. Fresenius Environmental Bulletin, **29** (10), 8998, **2020**.
15. MOSALEM M., MAZROU Y., BADAWY SH., ABD ULLAH M.A., MUBARAK M.G.H., HAFEZ Y.M., ABDELAAL KH. Evaluation of sowing methods and nitrogen levels for grain yield and components of durum wheat under arid regions of Egypt. Romanian Biotechnological Letters, **26** (6), 3031, **2021**.
16. GALAL A., BASAHI M., SHABANA M.T., ABDELAAL KH., ABDEL-HAFEZ A.G. Studies on combining ability in triticale under nitrogen levels. Fresenius Environmental Bulletin, **32** (1), 241, **2023**.
17. ALHARBI K., HAROUN S.A., KAZAMEL A.M., ABBAS M.A., AHMAIDA S.M., ALKAHTANI M., ALHUSNAIN L., ATTIA K.A., ABDELAAL KH., GAMEL R.M.E. Physiological Studies and Ultrastructure of *Vigna sinensis* L and *Helianthus annuus* L under Varying Levels of Nitrogen Supply. Plants, **11**, 1884, **2022**.
18. ZALAT S.S., EL-SAYED A.A., ELKHOBY R.A., HAFEZ Y., ALI E., ABDELAAL KH. Effect of method and time of micronutrients application on sugar beet productivity under two nitrogen fertilizer sources. Fresenius Environmental Bulletin, **30** (7A), 9135, **2021**.
19. SINGH N.N., PAL G., MAHAJAN S., SHEVKANI K. Rice grain and starch properties: Effects of nitrogen fertilizer application. Carbohydrate Polymers, **86** (1), 219, **2011**.
20. METWALLY T., AL-DAEJ M., EL-MALKY M., RAGAB A. Genetic analysis for rice seedling vigor and yield characteristics of Hassawi landrace compared with some rice varieties (*Oryza Sativa* L). Fresenius Environmental Bulletin, **31** (03A), 3793, **2022**.
21. METWALLY T.F., MOHAMED A.A.E., SOROUR S.G.R., ELSAYED G A. Stimulating compounds affect the grain quality characteristics and the nutritional value of rice (*Oryza sativa*). Applied Ecology and Environmental Research, **18** (5), 6829, **2020**.
22. ZHOU C., HUANG Y., JIA B., WANG Y., WANG Y., XU Q., LI R., WANG S., DOU F. Effects of Cultivar Nitrogen Rate and Planting Density on Rice-Grain Quality. Agronomy, **8,** 246, **2018**.
23. BLACK C.A., EVANS D.D., ENSMINGHER J.L., ENSMINGER L.E., CLARK F.E. Methods of soil analysis Part 2-Chemical and microbiological properties. American Society of Agronomy, Inc. Publisher Madison Wisconsin USA, **1965**.
24. CRUZ N.D., KHUSH G.S. Rice Grain Quality Evaluation Procedures – In: Primlani M (ed) Aromatic Rices Oxford & IBH Publishing, New Delhi, pp. 15, **2000**.
25. CHAPMAN H.D., PRATT P.F. Method of Analysis for Soils Plant and Water –Citrus Experiment Station Univ of California Division of Agricultural Sciences California USA, pp 150, **1961**.
26. JACKSON M.L. Soil Chemical Analysis – Prentice Hall of India, New Delhi, pp 144, **1967**.
27. FRASER J.R., HOLMES D.C. Proximate analysis of wheat flour carbohydrates IV – Analysis of whole meal flour and some of its fractions. Journal of the Science of Food and Agriculture, **10** (9), 506, **1959**.
28. AOAC. Official Methods of Analysis. 17th Edition, The Association of Official Analytical Chemists, Gaithersburg, MD, USA. Methods 925.10, 65.17, 974.24, 992.16, **2000**.
29. WATANABE F.S., OLSEN S.R. Test of an ascorbic acid method for determining phosphorus in water and $NaHCO_3$ extracts from soils. Environmental Science, Agricultural and Food Sciences, **29**, 677, **1965**.
30. PETERPURGSKI A.V. Handbook of Agronomic Chemistry – Kolos Publishing house, Moscow, pp. 29 **1968** [in Russian].
31. DUNCAN B. Multiple Range and multiple F test. Biometrics, **11**, 1, **1955**
32. CHU G., CHEN S., XU C., WANG D., ZHANG X. Agronomic and physiological performance of indica/japonica hybrid rice cultivar under low nitrogen conditions Field Crops Research, **243**, 107625, **2019**.
33. ZHOU C., JIA B., WANG S., HUANG Y., WANG Y., HAN K., WANG W. Effects of nitrogen fertilizer applications on photosynthetic production and yield of Japonica rice. International Journal of Plant Production, **15** (4), 599, **2021**.
34. ZHAO D.S., QF LI., CQ ZHANG C., ZHANG Q.Q., YANG L.X., PAN X.Y., REN J., LU MH G. GS9 acts as a transcriptional activator to regulate rice grain shape and appearance quality. Nature Communications, **9** (1), 1, **2018**.
35. SINGH N, SINGH D The Nutritional Composition of Local Rice Varieties in Guyana Greener. Journal of Agricultural Sciences, **9** (2), 138, **2019**.
36. LIAO G., YANG Y., XIAO W., MO Z. Nitrogen Modulates Grain Yield Nitrogen Metabolism and Antioxidant Response in Different Rice Genotypes Journal of Plant Growth Regulation, **42** (2), **2022**.
37. GOSAL S.K., GILL G.K., SHARMA S., WALIA S.S. Soil nutrient status and yield of rice as affected by long-term integrated use of organic and inorganic fertilizers. Journal of Plant Nutrition, **41** (4), 539, **2018**.