VARIETAL DIFFERENCES IN PHYSIOLOGICAL EFFICIENCY OF NITROGEN UTILIZATION IN RICE

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Abstract

The present investigation was carried out at the experimental farm of Rice Research and Training Center, Sakha, Kafer El-Sheikh, Egypt during 2008 and 2009 seasons to study the physio-morphological behavior of some rice genotypes under low and high nitrogen application. Twenty one genotypes, 10 japonica/japonica, 6 japonica/indica japonica and five indica japonica/indica japonica were tested under three different nitrogen levels i.e., 0, 75 and 150 kg N ha^{-1} for ten traits: flag leaf area, chlorophyll content, days to heading, panicle weight, no. of filled grains/panicle, no. of panicles/plant, 1000-grain weight, grain yield t/ha, Grain yield efficiency index (GYEI) and nitrogen use efficiency (NUE). The genotypes were divided into three groups i.e., japonica/japonica (J/J), japonica/indica japonica (J/IJ) and indica japonica/indica japonica (IJ/IJ). Genotype No. 17 (GZ6296 x Giza178 (IJ/IJ)) and genotype No. 19 (GZ6296 x Giza 178 (IJ/IJ)) gave the highest values of no. of filled grains/panicle and no. of panicles/hill under low input of nitrogen. Giza177/Sakha101 and Giza176/GZ6944 (J/J) gave the highest grain yield under low input of nitrogen followed by the genotypes derived from Giza178/GZ6296 (IJ/IJ).

Key Words: Rice, nitrogen, physio-morphological traits, low input, NUE, GYEI.

INTRODUCTION

Rice (*Oryza sativa L.*) is one of the important food crops. It is grown in 154 million hectars' world-wide in a wide range of environments. However, rice is the principle food crop for more than half of the world's population. It is staple food in the diet of the population of Asia, Latin America, and Africa. Nitrogen fertilizer is one of the most important agronomic inputs and limiting factors realizing the potential rice grain production in the world. Use of adequate nitrogen rate is important not only for obtaining maximum economic return, but also to reduce environmental pollution. Excessive nitrogen application can result in accumulation of large amounts of post harvest residual soil N. Residual soil N may be available for subsequent crops in the next season, but such N is highly susceptible to leaching during non-crop periods (Fageria and Baligar 2003). It is important to achieve efficient use of nitrogen as chemical fertilizers, not only through cultivation techniques, but also by breeding rice varieties, which are characterized with high nitrogen use efficiency to reduce nitrogen inputs from farming to the environment (Fageria et al. 2008, Sachiko *et. al.* 2009).

The objective of this study was to determine the genotypes which give high yield under low nitrogen application.

MATERIALS AND METHODS

The present investigation was carried out at the farm of Rice Research and Training Center, Sakha, Kafr El-Sheikh, Egypt, during 2008 and 2009 seasons to compare the genetic behavior of twenty one rice genotypes (Table 1) selected from Fn under different nitrogen levels (0, 75 and 150 kg N ha^{-1}). Nitrogen fertilizer was supplied in the form of urea (46.5% N) in two equal splits, i.e., half as basal incorporated into the dry soil immediately before flooding, followed by the second dose 30 days after transplanting. Pre-germinated seeds were uniformly broadcasted in the nursery on 5^{th} and 8^{th} May of the two seasons, respectively. Twenty five day old seedlings of each genotype were transplanted at 20 X 20 cm spacing with two seedlings per hill. Plot size was 15 m^2. All other agronomic practices were followed as recommended during the growing seasons.

The genotypes were divided into three groups i.e., japonica/japonica (J/J), japonica/indica japonica (J/IJ) and indica japonica/indica japonica (IJ/IJ). The parentage and variety group of genotypes are given in Table 1. The experiment was laid out in a split plot design in four replications, where varieties were represented in the main plots, while nitrogen levels were distributed in sub plots. All collected data were subjected to statistical analysis following the procedure described by Gomez and Gomez (1984) using the computer software (IRRISTAT).

Ten rice traits were recorded viz. flag leaf area (cm^2) at heading, days to heading, total chlorophyll content in the flag leaf were recorded using chlorophyll meter (SPAD-502 Minolta Camera Co. ltd., Japan) at heading stage, 7, 14 and 21 days after flowering, no. of filled grains/panicle, panicle weight (g), no. of panicles/hill, 1000-grain weight (g), grain yield t/ha (grains adjusted to 14% moisture content), grain yield efficiency index (GYEI) and agronomic nitrogen use efficiency (ANUE, kg kg^{-1}). The cluster analysis was carried out according to Rohlf,(2000).

Grain yield efficiency index (GYEI) was computed according to Fageria et al. (1988) as follows:

$$\textbf{GYEI} = \frac{\textbf{(Yield at low nutrient level)/(Exp. mean at low nutrient level)}}{\textbf{(Yield at high nutrient level) (Exp. mean at high nutrient level)}}$$

Nitrogen use efficiency (ANUE) was computed according to Saleque *et. al.* (2004) as follows:

$$\text{NUE} = \frac{\text{(Grain yield in fertilized plot kg) - (Grain yield in unfertilized plot kg)}}{\text{(Quantity of nutrient applied) kg}}$$

Table1. Origin and parentage of tested genotypes selected from Fn generation.

Number	Parentage	Origin	Variety Group
1	**Giza176/Giza177**	Egypt	Japonica/Japonica(Japonica)
2	**Giza176/Sakha101**	Egypt	Japonica/Japonica(Japonica)
3	**Giza176/GZ6379**	Egypt	Japonica/Japonica(Japonica)
4	**Giza176/ GZ6944**	Egypt	Japonica/Japonica(Japonica)
5	**Giza177/Sakha101**	Egypt	Japonica/Japonica(Japonica)
6	**Giza177/Sakha102**	Egypt	Japonica/Japonica(Japonica)
7	**Sakha101/Sakha103**	Egypt	Japonica/Japonica(Japonica)
8	**Sakha101/Sakha104**	Egypt	Japonica/Japonica(Japonica)
9	**Sakha101/GZ6906**	Egypt	Japonica/Japonica(Japonica)
10	**Sakha102/GZ6379**	Egypt	Japonica/Japonica(Japonica)
11	**Giza176/Giza178**	Egypt	Japonica/Indic Japonica(I/J)
12	**Giza178/ Sakha102**	Egypt	Japonica/Indic Japonica(I/J)
13	**Sakha101/GZ6296-1**	Egypt	Japonica/Indic Japonica(I/J)
14	**Sakha101/GZ6296-2**	Egypt	Japonica/Indic Japonica(I/J)
15	**Sakha101/GZ6296-3**	Egypt	Japonica/Indic Japonica(I/J)
16	**Sakha101/GZ6296-4**	Egypt	Japonica/Indic Japonica(I/J)
17	**Giza178/GZ6296-1**	Egypt	Indica Japonica/Indic Japonica(I/J)
18	**Giza178/GZ6296-2**	Egypt	Indica Japonica/Indic Japonica(I/J)
19	**Giza178/GZ6296-3**	Egypt	Indica Japonica/Indic Japonica(I/J)
20	**Giza178/GZ6296-4**	Egypt	Indica Japonica/Indic Japonica(I/J)
21	**Giza178/GZ6296-5**	Egypt	Indica Japonica/Indic Japonica(I/J)

RESULTS AND DISCUSSION

Flag leaf area :(cm^2)

Data in Table (2) indicated that the mean values of flag leaf area (cm^2) were significantly increased with increasing nitrogen levels from 0 up to 150 kg ha^{-1}. This is mainly due to the fact that nitrogen is the major factor influencing leaf growth and it affected average leaf size. These findings are supported by the results of Mhaskar *et. al.* (2005).

Generally the increase in flag leaf area of japonica/indica japonica was higher than japonica/japonica, mainly due to hybrid vigor resulting from crosses between japonica and indica japonica (there are genetic diversity among them). However, no significant differences were found between japonica/ indica japonica and indica japonica/indica japonica. The promising lines 16 and 14 (J/IJ) recorded the highest flag leaf area in the two seasons, indicating that these lines responded more to applied -N.

The japonica/indica japonica (I/IJ) entries No. 11 and 14 recorded the highest values of flag leaf area followed by the japonica/indica japonica (J/IJ) promising line No. 16 and the indica japonica/indica japonica (IJ/IJ) entry No. 20 in the two seasons of study. The J/IJ genotypes gave values of flag leaf area higher than J/J and IJ/IJ genotypes.

Table 2. Flag leaf area (cm2) at heading for 21 rice genotypes selected from Fn generation as affected by nitrogen application in 2008 and 2009.

Genotype	2008				2009			
	Nitrogen levels kg ha^{-1}			G Mean	Nitrogen levels kg ha^{-1}			G Mean
	0	75	150		0	75	150	
J/J								
1	24.53	26.80	31.23	27.52	24.36	26.40	32.36	27.71
2	25.06	35.46	41.43	33.89	24.00	36.63	41.73	33.78
3	27.30	32.20	38.36	32.62	27.03	31.33	37.23	31.86
4	27.63	32.03	35.53	31.73	26.76	31.30	36.06	31.37
5	24.46	27.86	33.23	28.52	24.43	27.53	32.43	28.13
6	22.56	25.66	28.23	25.49	22.26	25.36	28.33	25.32
7	19.06	24.26	33.46	25.60	19.26	24.33	32.16	25.25
8	21.30	23.73	27.80	24.27	20.83	22.36	27.03	23.41
9	25.73	31.70	36.23	31.22	25.30	32.20	34.96	30.82
10	23.50	28.53	35.50	29.17	23.50	28.40	34.66	28.85
J/IJ								
11	23.66	30.90	47.36	33.97	24.26	30.46	45.23	33.32
12	21.00	28.86	32.10	27.32	22.50	25.06	32.66	26.74
13	32.40	36.83	40.53	36.58	33.00	36.40	40.03	36.47
14	32.26	36.93	45.40	38.20	32.46	35.60	45.50	37.85
15	30.23	35.20	38.33	34.58	26.33	34.76	38.30	33.13
16	34.20	39.06	43.36	38.87	33.30	37.36	43.30	37.98
IJ/IJ								
17	30.80	36.30	40.50	35.86	29.43	34.43	40.26	34.71
18	27.10	33.23	36.26	32.20	25.83	31.30	35.50	30.87
19	30.83	33.60	40.90	35.11	31.13	32.53	41.36	35.01
20	26.36	40.96	43.60	36.97	25.83	41.00	42.90	36.57
21	30.20	32.73	38.30	33.74	29.33	33.10	37.30	33.24
N- Mean	26.67	32.02	37.51		26.24	31.28	37.11	

L.S.D at 0.05	2008	2009
Nitrogen (N)	0.78	0.49
Genotypes (G)	1.15	0.93
N X G Interaction	2.03	1.62

Days to heading:

In the two seasons of study, nitrogen doses had a significant effect on days to heading (Table 3). Maximum days to heading was observed in the plots fertilized with 150 kg N ha^{-1} followed by75 kg N ha^{-1}, while minimum days was observed in unfertilized plots. Since application of nitrogen increases vegetative growth and make the plant luxuriant, this in turn gets more days to heading. Days to heading differed significantly among genotypes and varied from 94.67 and 94.78 days in genotype No. 10 (J/J) in 2008 and 2009, respectively, to 105.33 and 104.67 days in genotype No. 13 (J/IJ) in 2008 and 2009, respectively.

Table 3. Days to heading for 21 rice genotypes selected from Fn generation as affected by nitrogen levels in 2008 and 2009.

Genotype	2008				2009			
	Nitrogen levels kg ha^{-1}			G Mean	Nitrogen levels kg ha^{-1}			G Mean
	0	75	150		0	75	150	
J/J								
1	95.0	97.0	99.0	97.0	96.0	96.6	99.6	97.4
2	102.0	104.0	106.0	104.0	101.3	103.0	106.0	103.4
3	93.0	95.0	97.0	95.0	93.3	94.6	97.6	95.2
4	92.3	96.0	100.0	96.1	91.6	95.3	99.0	95.3
5	96.0	96.3	98.0	96.7	96.6	96.6	99.0	97.4
6	98.0	100.0	101.0	99.6	97.0	101.0	101.7	99.8
7	94.0	97.3	99.0	96.7	93.0	97.0	99.3	96.4
8	91.0	96.0	98.0	95.0	92.3	94.0	98.0	94.7
9	94.0	100.0	102.0	95.6	93.3	99.0	102.7	98.3
10	92.0	95.0	97.0	94.6	91.3	95.0	98.0	94.7
J/IJ								
11	93.0	95.3	97.0	95.1	92.6	95.0	97.3	95.0
12	94.0	95.0	96.0	95.0	93.6	96.0	97.0	95.5
13	102.0	106.0	108.0	105.3	101.3	105.0	107.7	104.7
14	101.0	104.3	106.0	103.8	100.3	103.3	105.3	103.0
15	98.0	101.0	103.0	100.7	97.3	100.0	102.0	99.7
16	99.0	104.2	107.0	103.3	98.6	104.0	107.3	103.3
IJ/IJ								
17	100.0	102.0	105.0	102.3	100.3	101.3	105.0	102.2
18	101.0	103.0	106.0	103.3	100.3	103.0	105.0	102.8
19	100.6	102.0	105.3	102.7	100.0	102.3	104.0	102.1
20	99.6	102.0	104.0	101.9	99.0	101.0	103.3	101.1
21	99.0	100.0	102.0	100.3	96.0	100.0	101.0	99.0
N- Mean	96.8	99.5	101.7		96.4	99.2	101.7	

L.S.D at 0.05	2008	2009
Nitrogen (N)	0.52	0.63
Genotypes (G)	0.99	1.34
N X G Interaction	1.72	2.31

Chlorophyll content by SPAD at heading 7, 14 and 21 days after heading:

Results in (Tables 4, 5, 6 and 7) showed that nitrogen fertilizer rates and genotypes had significant effects on chlorophyll content. The highest value of leaf chlorophyll content was obtained from 150 kg N ha^{-1} urea fertilizer. Among genotypes, the J/J crosses had the highest chlorophyll content compared with the other groups where IJ/IJ crosses recorded the lowest value of SPAD reading in leaves at the four stages. From the day 0 to the day 21 after heading, leaf chlorophyll content decreased gradually at each leaf of nitrogen levels in all genotypes. These results indicated that the degradation for chlorophyll content was associated with leaf senescence. This is a normal process in the growth cycle of rice. The degradation for chlorophyll content was faster in IJ/IJ than the J/J.

Number of filled grains per panicle

Number of filled grains per panicle (Table 8) was significantly affected by both nitrogen fertilizer application and genotypes. Plants fertilized with 150 kg N ha^{-1} produced the highest number of filled grain per panicle, followed by plants which received 75 kg N ha^{-1}. However, plants that didn't receive nitrogen gave the lowest values of number of filled grains per panicle.

It could be concluded that nitrogen fertilization (as a very important plant nutrient) resulted in an increase in the amount of metabolites synthesized by rice plant and this, in turn, might account much for the superiority of number of filled grains per panicle. These results were true in both seasons and are in good agreement with those obtained by Khanda and Dixit (1995).

The tested genotypes of rice showed significant differences in number of filled grains per panicle at the same treatment. Under the nitrogen control plots, number of filled grains per panicle ranged from 71.03 to 122.67 and from 61.00 to 118.67 in 2008 and 2009 respectively. The promising line No. 17 (IJ/IJ) gave the highest number of filled grains per panicle under nitrogen control treatments in the two seasons of study, thus we can utilize this genotype in breeding program for low input. However, under fertilized plots, the promising lines No. 19 and 21 (IJ/IJ) were superior in 2008 and 2009 respectively. In general, IJ/IJ genotypes are the most promising for low N input breeding program.

Panicle weight (g):

Panicle weight increased significantly by N application up to 150 kg followed by plants fertilized with 75 kg N ha^{-1} as in (Table 9).The lightest panicles were obtained when no nitrogen was applied. The significant increase in panicle weight by increasing nitrogen level up to 150 kg N ha^{-1} is attributed to the increase in number of filled grains per panicle. These findings agreed with Raghuwanshi *et. al.* (2003).

Panicle weight was significantly varied among genotypes and varied from 2.74 and 2.67 g produced by genotype, No. 14 (I/IJ) in the two seasons of study respectively to 3.87 and 3.69 g in 2008 and 2009 produced by promising lines No. 2 (J/J) and promising lines No. 11 (J/IJ), respectively.

Table 4. Leaf chlorophyll content SPAD at heading for 21 rice genotypes selected from generation as affected by nitrogen levels in 2008 and 2009.

Genotype	2008				2009			
	Nitrogen levels kg ha^{-1}			G Mean	Nitrogen levels kg ha^{-1}			G Mean
	0	75	150		0	75	150	
J/J								
1	41.00	44.00	47.33	44.11	40.67	44.33	45.67	43.56
2	43.00	45.00	48.00	45.33	41.00	45.33	46.33	44.22
3	42.00	46.00	48.67	45.56	41.67	44.33	48.00	44.67
4	41.67	45.00	47.00	44.56	41.00	45.33	46.00	44.11
5	41.00	46.00	48.00	45.00	40.33	45.00	46.00	43.78
6	40.00	44.00	47.00	43.67	41.00	45.00	46.00	44.00
7	42.00	45.00	48.00	45.00	43.33	43.33	47.67	44.78
8	43.00	45.00	49.00	45.67	42.33	44.67	48.00	45.00
9	42.00	44.00	46.67	44.22	41.67	44.33	48.00	44.67
10	44.00	45.00	48.00	45.67	42.67	44.67	46.33	44.56
J/IJ								
11	41.00	43.00	43.33	42.44	41.33	43.67	43.33	42.78
12	41.00	45.00	46.67	44.22	41.67	43.67	47.00	44.11
13	41.00	43.00	46.00	43.33	41.33	42.33	45.00	42.89
14	40.00	44.00	46.33	43.44	40.33	42.67	45.33	42.78
15	41.00	44.00	46.00	43.67	39.33	42.33	45.33	42.33
16	40.67	44.00	45.00	43.22	42.00	43.67	46.00	43.89
IJ/IJ								
17	36.00	39.00	43.00	39.33	33.00	38.00	43.33	38.11
18	39.00	41.00	44.00	41.33	38.00	42.00	43.00	41.00
19	38.00	41.00	42.33	40.44	35.00	40.33	41.67	39.00
20	37.00	40.00	43.00	40.00	35.00	39.00	41.33	38.44
21	35.00	36.67	41.00	37.56	34.33	37.33	40.00	37.22
N- Mean	40.44	43.32	45.92		39.86	42.92	45.21	

L.S.D at 0.05	2008	2009
Nitrogen (N)	0.78	0.53
Genotypes (G)	0.99	1.44
N X G Interaction	1.76	2.45

Table 5. Leaf chlorophyll content SPAD at 7 days after heading for 21 rice genotypes selected from Fn generation as affected by nitrogen levels in 2008 and 2009.

Genotype	2008				2009			
	Nitrogen levels kg ha^{-1}			G Mean	Nitrogen levels kg ha^{-1}			G Mean
	0	75	150		0	75	150	
J/J								
1	34.00	38.33	43.00	38.44	32.33	36.67	43.33	37.44
2	36.00	41.00	44.00	40.33	34.00	41.00	41.67	38.89
3	34.00	42.00	45.00	40.33	31.00	41.33	44.67	39.00
4	37.33	41.67	44.67	41.22	35.33	41.00	44.00	40.11
5	37.00	43.00	45.00	41.67	33.33	42.33	44.33	40.00
6	37.00	40.00	44.00	41.22	35.33	41.00	43.00	39.78
7	37.67	41.00	45.00	40.33	35.33	40.00	45.00	40.11
8	37.67	42.00	46.00	41.89	36.67	41.33	44.67	40.89
9	39.00	41.67	44.67	41.78	37.00	41.67	43.67	40.78
10	41.00	41.33	44.00	42.11	40.00	41.67	42.00	41.22
J/IJ								
11	35.00	38.00	41.00	38.00	34.33	39.00	40.00	37.78
12	36.00	41.00	45.00	40.67	37.33	40.00	44.67	40.67
13	37.00	41.00	42.00	40.00	35.00	39.00	41.00	38.33
14	32.33	39.00	43.00	38.11	29.33	38.00	41.00	36.11
15	35.33	39.00	43.00	39.11	34.33	40.00	41.00	38.44
16	38.00	41.00	41.00	40.00	36.33	40.67	42.00	39.67
IJ/IJ								
17	27.67	34.00	40.00	33.89	26.00	34.33	39.00	33.11
18	33.00	37.33	41.00	37.11	33.33	35.67	41.33	36.78
19	31.33	33.33	38.00	34.22	32.33	34.00	36.00	34.11
20	30.00	35.00	38.00	34.33	27.00	34.33	35.00	32.11
21	28.67	31.00	38.00	32.56	26.33	33.33	34.67	31.44
N- Mean	35.00	39.13	42.64		33.43	38.87	41.52	

L.S.D at 0.05	2008	2009
Nitrogen (N)	0.34	0.34
Genotypes (G)	1.06	1.35
N X G Interaction	1.81	2.29

Table 6. Leaf chlorophyll content SPAD at 14 days after heading for 21 rice genotypes selected from Fn generation as affected by nitrogen levels in 2008 and 2009.

Genotype	2008				2009			
	Nitrogen levels kg ha^{-1}			G Mean	Nitrogen levels kg ha^{-1}			G Mean
	0	75	150		0	75	150	
J/J								
1	29.00	33.00	37.00	33.00	28.00	33.00	38.00	33.00
2	28.00	38.00	41.00	35.67	28.00	38.33	41.33	35.89
3	27.00	31.00	39.00	32.33	26.67	31.33	38.33	32.11
4	31.00	36.00	42.00	36.33	30.00	35.67	41.00	35.56
5	25.00	36.00	40.67	33.89	26.00	35.00	40.00	33.67
6	31.33	35.33	38.00	34.89	29.00	33.33	37.00	33.11
7	29.00	37.00	41.00	35.67	28.33	34.00	42.00	34.78
8	31.00	37.33	41.00	36.44	30.00	35.67	41.33	35.67
9	34.67	38.00	42.00	38.22	33.67	35.00	41.00	36.56
10	36.67	37.67	41.00	38.44	33.33	34.67	41.33	36.44
J/IJ								
11	30.67	33.00	35.33	33.00	31.33	34.00	33.67	33.00
12	31.33	38.00	42.00	37.11	31.33	35.00	41.00	35.78
13	32.67	36.00	35.00	34.56	31.00	35.00	35.00	33.67
14	29.00	33.33	38.00	33.44	27.00	31.67	37.00	31.89
15	32.00	33.67	37.67	34.44	31.67	33.67	35.00	33.44
16	33.00	36.00	38.00	36.67	32.00	34.00	36.33	34.11
IJ/IJ								
17	23.33	28.33	34.67	28.78	21.67	26.67	32.33	26.89
18	24.67	29.00	36.67	30.11	23.00	27.00	36.33	28.78
19	24.67	27.00	31.00	27.56	22.00	25.67	32.67	26.78
20	24.00	29.00	31.00	28.00	22.33	26.00	30.67	26.33
21	22.00	26.67	30.00	26.22	23.67	23.00	30.00	25.56
N- Mean	29.04	33.78	37.71		28.10	32.27	37.21	

L.S.D at 0.05	2008	2009
Nitrogen (N)	0.69	0.71
Genotypes (G)	1.04	1.39
N X G Interaction	1.083	2.40

Table 7. Leaf chlorophyll content SPAD at 21 days after heading for 21 rice genotypes selected from Fn generation as affected by nitrogen levels in 2008 and 2009.

Genotype	2008				2009			
	Nitrogen levels kg ha^{-1}			G Mean	Nitrogen levels kg ha^{-1}			G Mean
	0	75	150		0	75	150	
J/J								
1	18.33	25.00	27.67	23.67	19.33	24.67	29.00	24.33
2	21.00	29.00	31.67	27.22	22.67	28.00	30.00	26.89
3	19.33	26.00	32.67	26.00	20.33	25.67	32.00	26.00
4	20.00	29.00	34.67	27.89	21.00	28.00	31.67	26.89
5	16.67	25.00	37.33	26.33	16.33	24.67	36.67	25.89
6	23.67	26.67	30.33	26.89	20.33	25.67	29.67	25.22
7	24.00	29.00	39.00	30.67	24.33	27.00	36.00	29.11
8	28.00	30.33	38.00	32.11	25.00	29.00	35.00	29.67
9	29.00	31.00	39.00	33.00	26.00	32.33	36.00	31.44
10	28.00	31.00	38.00	32.33	25.00	31.33	35.00	30.44
J/IJ								
11	17.33	23.33	25.00	21.89	19.33	21.00	26.67	22.33
12	23.00	27.00	39.00	29.67	23.67	25.00	36.00	28.22
13	20.00	27.67	31.33	26.33	21.00	25.67	32.67	26.44
14	20.00	24.00	32.33	25.44	19.67	26.00	33.00	26.22
15	17.33	27.00	33.00	25.78	19.00	26.67	32.33	26.00
16	22.67	28.33	33.00	28.00	23.67	26.00	31.33	27.00
IJ/IJ								
17	18.00	22.33	26.00	22.11	14.00	22.00	24.00	20.00
18	16.33	21.67	29.00	22.33	13.67	20.67	26.00	20.11
19	18.00	20.00	25.00	21.00	14.67	16.67	23.00	18.11
20	14.33	17.00	25.00	18.78	16.67	18.33	22.00	19.00
21	14.00	19.00	25.00	19.33	15.00	16.00	22.00	17.67
N- Mean	20.43	25.68	32.00		20.03	24.78	30.48	

L.S.D at 0.05	2008	2009
Nitrogen (N)	0.21	1.19
Genotypes (G)	1.39	1.33
N X G Interaction	2.35	2.40

Table 8. Number of filled grains per panicle for 21 rice genotypes selected from Fn generation as affected by nitrogen levels in 2008 and 2009.

Genotype	2008				2009			
	Nitrogen levels kg ha^{-1}			G Mean	Nitrogen levels kg ha^{-1}			G Mean
	0	75	150		0	75	150	
J/J								
1	84.33	112.67	168.67	121.89	88.33	115.00	167.67	123.67
2	109.00	134.33	163.33	135.56	104.00	133.67	166.33	134.67
3	89.00	126.00	144.33	119.78	83.00	125.33	143.00	117.11
4	107.33	140.67	174.67	140.89	105.00	144.33	182.67	144.00
5	71.033	134.33	154.67	120.11	61.00	135.67	150.67	115.78
6	110.67	130.00	147.67	129.44	112.67	129.33	143.00	128.33
7	80.33	111.67	143.33	111.78	75.00	107.67	136.00	106.22
8	104.00	123.67	159.33	129.00	101.67	126.00	160.67	129.44
9	101.67	112.00	154.00	122.56	97.67	115.00	155.00	122.56
10	95.33	123.00	143.67	120.67	89.00	123.67	143.33	118.67
J/IJ								
11	93.33	160.00	172.00	141.78	89.33	161.00	171.67	140.67
12	109.67	130.67	157.00	132.44	113.00	130.67	156.67	133.44
13	102.33	136.33	139.67	126.11	103.00	133.00	138.67	124.89
14	82.00	125.00	155.00	120.67	88.00	124.33	153.33	121.89
15	96.00	135.00	163.00	131.33	92.67	139.33	164.67	132.22
16	81.67	112.67	160.00	118.11	80.00	116.00	165.33	120.44
IJ/IJ								
17	122.67	137.67	175.33	145.22	118.67	139.67	169.67	142.67
18	116.00	142.67	167.67	142.11	116.00	137.67	168.33	140.67
19	104.33	156.33	188.33	149.67	105.67	155.33	174.67	145.22
20	116.33	131.33	184.00	143.89	115.00	133.00	172.67	140.22
21	113.33	145.33	180.00	142.22	111.00	148.00	178.67	145.89
N- Mean	99.56	131.49	161.70		97.60	132.08	160.13	

L.S.D at 0.05	2008	2009
Nitrogen (N)	3.97	2.68
Genotypes (G)	6.03	4.63
N X G Interaction	10.58	8.05

Table 9. Panicle weight (g) for 21 rice genotypes selected from Fn generation as affected by nitrogen levels in 2008 and 2009.

Genotype	2008				2009			
	Nitrogen levels kg ha^{-1}			G Mean	Nitrogen levels kg ha^{-1}			G Mean
	0	75	150		0	75	150	
J/J								
1	2.80	3.50	3.93	3.41	2.23	3.37	3.73	3.11
2	3.00	3.67	4.93	3.87	2.73	3.60	4.70	3.68
3	2.03	2.90	4.83	3.26	1.93	3.33	4.27	3.18
4	1.90	3.20	3.70	2.93	1.80	3.23	3.60	2.88
5	1.80	3.00	3.77	2.86	1.67	2.83	4.00	2.83
6	2.50	3.23	3.83	3.19	2.13	3:20	3.77	3.03
7	2.00	3.30	4.00	3.10	2.17	3.23	4.07	3.16
8	2.80	3.63	4.80	3.74	2.53	3.63	4.50	3.56
9	2.30	3.13	3.77	3.07	2.17	3.20	3.87	3.08
10	2.20	3.10	4.10	3.13	2.03	3.10	3.97	3.03
J/IJ								
11	2.97	3.77	4.77	3.83	2.70	3.70	4.67	3.69
12	2.50	3.17	3.73	3.13	2.30	3.23	3.60	3.04
13	2.00	3.10	4.80	3.30	2.33	3.13	4.60	3.36
14	2.17	2.70	3.37	2.74	2.10	2.70	3.20	2.67
15	2.70	3.20	4.67	3.52	2.53	3.37	4.53	3.48
16	2.60	3.40	4.40	3.47	2.40	3.30	4.07	3.26
IJ/IJ								
17	2.70	3.63	4.77	3.70	2.50	3.70	4.73	3.64
18	2.33	3.70	4.80	3.61	2.13	3.27	4.80	3.40
19	2.90	3.87	4.50	3.76	2.53	3.60	4.67	3.60
20	2.97	3.40	5.00	3.79	3.03	3.43	4.97	3.81
21	2.70	3.63	5.00	3.78	2.50	3.70	4.97	3.72
N- Mean	2.47	3.34	4.36		2.31	3.33	4.25	

L.S.D at 0.05	2008	2009
Nitrogen (N)	0.10	0.14
Genotypes (G)	0.24	0.21
N X G Interaction	0.41	0.37

Number of panicles per hill

A significant positive effect on the number of panicles per hill of the rice entries was observed from the application of nitrogen fertilizer (Table 10). The application of nitrogen fertilizer at the rate of 75 or 150 kg N ha^{-1} increased number of panicles per hill over the control. The effect of nitrogen application on number of panicles per m^2 attributed mainly to the stimulation effect of nitrogen on effective tillers formation. These findings are consistent with those reported by Ebaid and Ghanem (2000), Chopra and Chopra (2004) and Singh *et. al.* (2004).

Genotypes differed significantly in the number of panicles per hill under all nitrogen levels in the two seasons of the study. The genotypes No. 17 (IJ/IJ), 19 (IJ/IJ), 21 (IJ/IJ), 7 (J/J) and 16 (J/IJ) produced the greatest number of panicles per hill in the first season while in the second season the greatest number was recorded by promising lines No. 21 (IJ/IJ), 17 (IJ/IJ), 18 (IJ/IJ), 6 (J/J), 7 (J/J) and 16 (J/IJ).

1000-grain weight (g):

Resulted in (Table 11) revealed that application of nitrogen significantly decreased the 1000-grain weight. Thus, the highest values of 1000-grain weight appear when nitrogen was not applied. This is mainly due to the higher number of spikelets per panicle in plants received nitrogen at any of the rates than those did not received any nitrogen. So the sink capacity is high and the source is limited, therefore, the filling of grains will be more consequently the weight of grains will be high. These findings are in agreement with those reported by Lai *et. al.* (1996), Xu and Zhou (1999) and Singh *et. al.* (2004).

Grain yield (t/ha):

Grain yield was significantly varied among nitrogen levels and genotypes. The application of nitrogen fertilizer up to 150 kg N ha^{-1} increased rice grain yield in all genotypes in the two seasons of study (Table 12). Grain yield, in fact, is the out-product of its main components. Any increase in one or more of the components without decrease in the others will lead to an increase in grain yield. Therefore, the increase in grain yield due to applying nitrogen was the logical result due to achieving increase in yield components, i.e., number of panicles per hill and number of filled grains per panicle. Similar trend was found by Ebaid and Ghanem (2000), Chopra and Chopra (2004), Singh et al (2004) and Mhaskar et al (2005). The promising line No. 19 (IJ/IJ) gave the highest grain yield in the two seasons of study. The yield of genotypes No. 17 (IJ/IJ) and No. 21 (IJ/IJ) were statistically similar to that of line No. 19 (IJ/IJ) in 2008 season only. Under the nitrogen control plots, the promising line No. 5 (J/J) gave the highest grain yield (9.04 and 8.93 t ha^{-1} in 2008 and 2009, respectively).On the other hand, this genotype yielded 10.97 and 10.79 with 75 kg N ha^{-1}, as well as, 12.25 and 11.78 with 150 kg N ha^{-1} in the two seasons of study.

Generally the IJ/IJ crosses gave the highest grain yield followed by J/J crosses, while, J/IJ crosses gave the lowest grain yield. This is mainly due to the genetic diversity among them.

Table 10. Number of panicles per hill for 21 rice genotypes selected from Fn generation as affected by nitrogen levels in 2008 and 2009.

Genotype	2008				2009			
	Nitrogen levels kg ha^{-1}			G Mean	Nitrogen levels kg ha^{-1}			G Mean
	0	75	150		0	75	150	
J/J								
1	15.67	20.00	22.00	19.22	15.00	19.00	21.33	18.44
2	16.00	18.33	21.67	18.67	15.00	17.67	20.33	17.67
3	16.33	19.00	20.33	18.56	17.00	18.00	21.00	18.67
4	16.67	20.00	23.00	19.89	16.67	19.67	22.67	19.67
5	17.67	20.67	23.33	20.56	18.33	20.00	23.00	20.44
6	16.67	20.00	21.00	19.22	16.00	19.00	22.00	19.00
7	18.33	21.00	24.00	21.11	17.00	20.67	23.00	20.22
8	18.00	19.00	22.00	19.67	18.33	20.00	21.33	19.89
9	15.00	19.00	21.00	18.33	17.00	18.67	20.00	18.56
10	16.33	19.00	21.00	18.78	15.67	18.33	21.67	18.56
J/IJ								
11	16.33	19.00	22.00	19.11	17.67	20.00	22.67	20.11
12	17.33	20.00	21.67	19.67	16.67	19.00	22.67	19.44
13	18.67	20.00	22.00	20.22	17.00	20.00	22.33	19.78
14	16.33	19.67	21.33	19.11	18.00	20.00	21.00	19.67
15	16.00	19.00	21.00	18.67	15.67	20.00	20.00	18.56
16	17.00	22.00	24.00	21.00	16.67	21.00	23.00	20.22
IJ/IJ								
17	17.67	22.00	25.00	21.56	18.33	21.00	23.00	20.78
18	17.33	21.00	23.00	20.44	16.67	20.33	23.00	20.00
19	17.00	20.33	24.00	20.44	17.67	19.67	22.67	20.00
20	16.67	19.67	22.00	19.44	16.00	19.00	21.00	18.67
21	17.67	21.00	24.00	20.89	19.00	20.00	24.00	21.00
N- Mean	16.89	19.98	22.35		16.92	19.57	21.98	

L.S.D at 0.05	2008	2009
Nitrogen (N)	0.23	0.60
Genotypes (G)	1.14	1.19
N X G Interaction	1.94	2.06

Table 11. 1000- grain weight for 21 rice genotypes selected from Fn generation as affected by nitrogen levels in 2008 and 2009.

Genotype	2008				2009			
	Nitrogen levels kg ha^{-1}			G Mean	Nitrogen levels kg ha^{-1}			G Mean
	0	75	150		0	75	150	
J/J								
1	26.33	25.00	21.00	24.11	25.70	24.33	21.00	23.68
2	28.67	26.67	24.00	26.44	28.00	26.00	24.67	26.22
3	29.67	27.00	24.00	26.89	29.00	26.00	23.33	26.11
4	26.67	25.00	21.33	24.33	26.00	24.67	21.00	23.89
5	28.67	26.00	24.00	26.22	28.00	25.67	23.33	25.67
6	29.67	28.67	25.00	27.78	29.00	27.00	25.00	27.00
7	28.33	26.00	24.00	26.11	28.00	25.00	23.67	25.56
8	31.00	28.033	25.00	28.11	29.67	27.00	24.67	27.11
9	27.67	25.00	22.00	24.89	28.00	24.67	20.33	24.33
10	25.00	24.33	19.00	22.78	25.00	23.00	18.33	22.11
J/IJ								
11	27.67	25.67	23.00	25.44	27.00	25.00	22.67	24.89
12	24.00	24.00	21.00	23.00	25.00	22.67	20.33	22.67
13	27.00	24.00	20.00	23.67	26.00	23.00	19.67	22.89
14	26.00	23.00	19.00	22.67	25.00	23.00	18.00	22.00
15	25.67	24.00	18.00	22.56	25.00	24.00	17.00	22.00
16	26.33	25.00	21.33	24.22	27.00	24.67	20.33	24.00
IJ/IJ								
17	25.67	24.00	23.00	24.22	26.00	24.33	22.00	24.11
18	25.67	24.33	22.33	24.11	25.00	23.00	22.00	23.33
19	28.00	24.67	22.67	25.11	26.00	24.67	22.67	24.44
20	25.33	23.00	20.33	22.89	24.00	23.67	20.67	22.78
21	28.33	25.00	22.33	25.22	27.00	25.33	21.33	24.56
N- Mean	27.21	25.18	22.02		26.64	24.60	21.52	

L.S.D at 0.05	2008	2009
Nitrogen (N)	0.49	0.46
Genotypes (G)	0.83	1.01
N X G Interaction	1.44	1.74

Table 12. Grain yield (t/ha) for 21 rice genotypes selected from Fn generation as affected by nitrogen levels in 2008 and 2009.

Genotype	2008				2009			
	Nitrogen levels kg ha^{-1}			G Mean	Nitrogen levels kg ha^{-1}			G Mean
	0	75	150		0	75	150	
J/J								
1	6.59	10.97	13.13	10.23	6.30	10.91	12.89	10.03
2	5.72	9.86	12.66	9.41	5.48	9.22	11.55	8.75
3	5.25	8.75	11.84	8.16	5.43	8.58	11.20	8.40
4	8.81	10.85	12.48	10.71	7.64	10.79	12.37	10.27
5	9.04	10.97	12.25	10.75	8.93	10.79	11.78	10.50
6	6.01	9.33	11.08	8.80	5.89	9.39	10.79	8.69
7	5.66	8.81	11.14	8.54	5.83	8.63	10.79	8.42
8	7.29	10.50	12.25	10.01	7.35	9.92	11.90	9.72
9	6.01	9.33	10.91	8.75	5.72	9.16	10.50	8.46
10	5.48	7.64	9.86	7.66	5.60	7.53	9.10	7.41
J/IJ								
11	5.08	8.81	10.50	8.13	4.73	8.40	10.15	7.76
12	4.96	7.64	10.03	7.54	4.38	7.23	9.63	7.08
13	5.76	7.58	9.10	7.49	5.60	7.18	9.04	7.27
14	5.08	6.77	8.81	6.88	4.90	6.71	8.81	6.81
15	5.48	7.47	10.15	7.70	5.60	7.12	9.22	7.31
16	6.07	8.05	10.97	8.36	5.89	7.58	10.38	7.95
IJ/IJ								
17	7.88	10.91	13.88	10.89	7.18	10.15	13.71	10.34
18	7.29	10.27	13.65	10.40	7.41	10.21	12.71	10.11
19	7.64	11.38	14.23	11.08	7.23	11.20	14.29	10.91
20	6.65	10.85	13.07	10.19	7.35	10.62	13.18	10.38
21	7.82	11.03	14.12	10.99	7.29	10.85	13.48	10.54
N- Mean	6.46	9.42	11.72		6.27	9.15	11.31	

L.S.D at 0.05	2008	2009
Nitrogen (N)	0.22	0.14
Genotypes (G)	0.29	0.30
N X G Interaction	0.51	0.51

Grain yield efficiency index (GYEI):

The Grain yield efficiency index helps to separate genotypes into high-yielding, stable, nutrient efficient genotypes and low-yielding, unstable, nutrient inefficient genotypes. Tolerant genotypes have a GYEI of 1 or higher response. The susceptible or nutrient inefficient genotypes have a GYIE in the range of 0 to 0.50 and the genotypes between these two limits are considered intermediate types (Fageria et al., 1988, Fageria, and Baligar, 2003). Data in (Table 13) indicated that the genotypes No. 1, 4, 5 and 8 (J/J) and genotypes derived from crossing between Giza178/GZ6296 gave more than unity of GYEI. This indicated that these genotypes should be classified as tolerant, high-yielding, stable and nutrient efficient genotypes. While the other genotypes gave intermediate values. There are wide variations in GYEI among genotypes under low and high nitrogen condition. The results provide under low soil fertility conditions or for sustainable agriculture using different fertilizers.

Nitrogen use efficiency (NUE):

The nitrogen use efficiency can be defined as the maximum economic yield produced per unit of nitrogen applied, absorbed or utilized by the plant to produce grain and straw. However, in the literature, nutrient use efficiency has been defined is several ways. Nitrogen use efficiency (ANUE) is one of the most important nitrogen use efficiencies. ANUE were from 21.07 to 61.47 kg kg^{-1}(Table 13). Generally NUE decreased with increasing N rate. Similar results are reported by Saleque et al (2004) and Xie et al (2007). The tested genotypes showed a wide variation in NUE. The highest NUE was obtained with promising line No. 1 (J/J) and the lowest with genotypes No. 13 (IJ/IJ) and No. 5 (J/J).

Clustering rice genotypes:

Cluster analysis was carried out using the mean values of all traits studied for the 21 genotypes. The genotypes were grouped into four main clusters (Fig 1.). Cluster I consisted of 8 indica/japonica type genotypes, (promising lines No. 18, 19, 21, 20 and 17) as sub clusters indicating high similarity among them, while the lines no. 11 (J/IJ), No.4 (J/J) and No.2 (J/J) cluster together in the first group. Cluster II consisted of six rice genotypes, 15, 16, 14, 13 (J/IJ) and the line No.10 (J/J) and No.5 (J/J) type. On the other hand the cluster IV consisted of six rice genotypes, included one rice variety (J/IJ) type No.12, the other 5 genotypes of (J/J) type. These classification by cluster analysis corresponded to genotypes characteristics The varieties in cluster I always had an increase grain yield with an increase in nitrogen application, also these genotypes had the highest values of grain yield efficiency index and nitrogen use efficiency (Table 13).

Table 13. Grain yield efficiency index GYEI and agronomic Nitrogen use efficiency ANUE (kg kg^{-1}) for 21 rice genotypes as affected by nitrogen levels in 2008 and 2009.

Genotype	GYEI				ANUE			
	2008		2009		2008		2009	
	Nitrogen levels kg ha^{-1}							
	75	150	75	150	75	150	75	150
J/J								
1	1.19	1.14	1.20	1.15	58.40	43.60	61.47	43.93
2	0.93	0.96	0.88	0.89	55.20	46.27	49.87	40.47
3	0.75	0.82	0.81	0.86	46.67	43.93	42.00	38.47
4	1.57	1.45	1.44	1.33	27.20	24.47	42.00	31.53
5	1.63	1.46	1.68	1.48	25.73	21.40	24.80	19.00
6	0.92	0.88	0.96	0.90	44.27	33.80	46.67	32.67
7	0.82	0.83	0.88	0.89	42.00	36.53	37.33	33.07
8	1.26	1.18	1.27	1.23	42.80	33.07	34.27	30.33
9	0.92	0.87	0.91	0.85	44.27	32.67	45.87	31.87
10	0.69	0.71	0.74	0.72	28.80	29.20	25.73	23.33
J/IJ								
11	0.74	0.70	0.69	0.68	49.73	36.13	48.93	36.13
12	0.62	0.66	0.55	0.59	35.73	33.80	38.00	35.00
13	0.72	0.69	0.70	0.71	24.27	22.27	21.07	22.93
14	0.57	0.59	0.57	0.61	22.53	24.87	24.13	26.07
15	0.67	0.73	0.69	0.73	26.53	31.13	20.27	24.13
16	0.80	0.88	0.78	0.86	26.40	32.67	22.53	29.93
IJ/IJ								
17	1.41	1.44	1.27	1.39	40.40	40.00	39.60	43.53
18	1.23	1.31	1.32	1.33	39.73	42.40	37.33	35.33
19	1.43	1.44	1.41	1.46	49.87	43.93	52.93	47.07
20	1.19	1.15	1.36	1.37	56.00	42.80	43.60	38.87
21	1.42	1.46	1.38	1.39	42.80	42.00	47.47	41.27

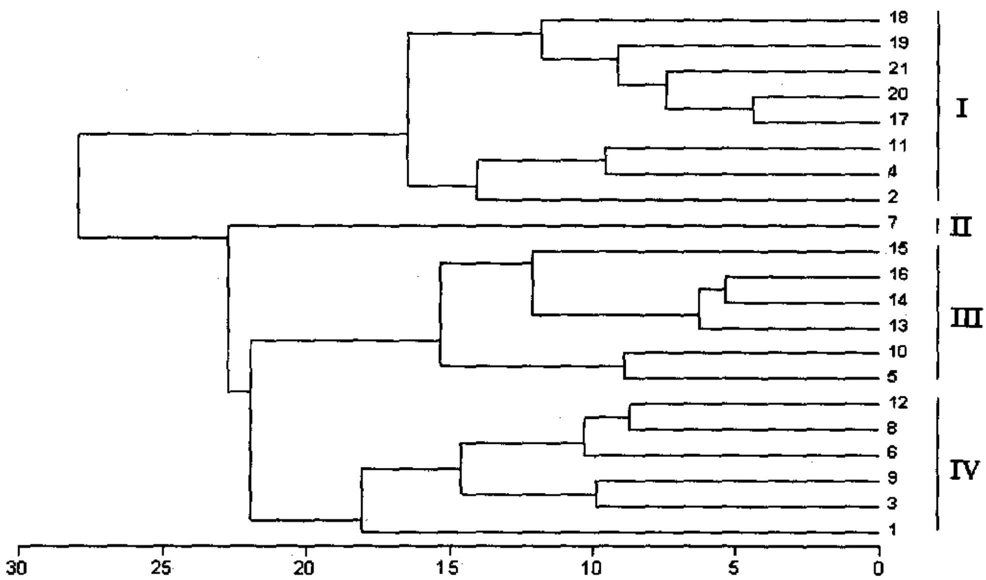

Fig. 1. Hierarchical cluster analysis based on all studied characters for the 21 rice genotypes select from Fn generation.

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الاختلافات الصنفية فى الكفاءة الفسيولوجية لاستخدام النيتروجين فى الارز

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مركز البحوث والتدريب في الارز– معهد بحوث المحاصيل الحقلية – مركز البحوث الزراعية - مصر

اجريت تجربتان حقليتان بمزرعة مركز البحوث والتدريب فى الارز– سخا– كفرالشيخ – مصر فى موسمى الزراعة ٢٠٠٨ و٢٠٠٩ لدراسة سلوك بعض اصناف الارز وصفاتها المورفو–فسيولوجية تحت الاضافة المنخفضة والمرتفعة من السماد النتروجينى . تم تقييم ٢١ تركيب وراثى من اصناف الارز اشتملت على ١٠ اصناف ناتجة من التهجين بين (يابانى xيابانى)، ٦ ناتجة من التهجين بين (يابانى x يابانى هندى) و ٥ ناتجة من التهجين بين (يابانى هندى x يابانى هندى) اختبرت تحت ثلاث مستويات من التسميد النتروجينى صفر ، ٧٥ و ١٥٠ كم نتروجين / هكتار. تم دراسة ١٠ صفات لهذة الاصناف وهى مساحة ورقة العلم، المحتوى الكلى للكلورفيل، عدد الايام للتزهير، وزن السنبلة، عدد الحبوب الممتلئة بالسنبلة، عدد السنابل بالجورة وزن الالف حبة، محصول الحبوب بالهكتار، دليل كفاءة المحصول، و الكفاءة لاستخدام النتروجين.

اظهرت النتائج مايلى:

أعطت التراكيب الوراثية رقم ١٧ و ١٩ (GZ6296 x Giza 178) أعلى قيم لعدد الحبوب الممتلئة بالسنبلة وعدد السنابل بالجورة تحت المستوى المنخفض من التسميد النتروجينى.بينما اعطت التراكيب الوراثية الناتجة من التهجين بين الاباء Giza177/Sakha101 وGiza176/GZ6944 (يابانى xيابانى) اعلى قيم لمحصول الحبوب تحت مستوى النتروجين المنخفض يلية التراكيب الوراثية الناتجة من التهجين بين Giza178/GZ6296.