GRAIN QUALITY CHARACTERISTICS OF RICE AS AFFECTED BY DIFFERENT IRRIGATION WATER SOURCES AND NITROGEN LEVEL.

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Abstract

This investigation was carried out during 2001 and 2002 rice growing seasons at the Experimental Farm of the Faculty of Agriculture (Saba Basha), Alexandria Univ. to determine the effect of two irrigation water sources (normal and recycled irrigation water) and four nitrogen levels (zero, 40, 80, and 120 kg N/fed) on some grain quality characteristics of the Egyptian rice variety Giza 178.

Irrigation water sources affected significantly grain shape (L/W ratio) in 2002 season. While it affected translucent grain percent significantly in both season of study. Meanwhile the effect of nitrogen levels on all grain appearance characters was significant in both seasons.

The interaction between the two investigated factors affected significantly the mean values of all grain appearance characters except grain length which was not affected by this type of interaction.

The recycled irrigation water affected significantly hulling % and milling % in 2001 season and head rice (%) in the two seasons of study. Highly significant increase in the mean values of milling characters were found when nitrogen level was increased from zero kg N/fed. with no significant differences between 80 kg, and 120 kg N/fed. The interaction between the two studied factors was significant for hulling % and head rice % in 2002 season only.

Kernel elongation, amylose content and protein content were affected by irrigation water forms, and nitrogen levels. These effects differed from character to another, in case of irrigation water source. While nitrogen levels showed significant or highly significant effects on the three characters. Significant interaction effects between the two factors were found in 2002 for kernel elongation % and in both seasons for protein %.

INTRODUCTION

Rice (*Oryza sativa* L) is one of the most important cereal crops in the world. At present, it is the staple food of over half of the global population. In Egypt, rice is considered one of the major field crops for both local consumption and exportation.

Rice productivity in 2004 was 9.89 ton/ha (4.155 ton/fed) and the total rice production was about 6.38 million ton which was sufficient for local consumption and export (Anonymous, 2005). A total of about 840 thousand tons of milled rice was exported through 2004-2005 season due to the increase demand of the international markets according to the excellent grain quality of the Egyptian rice varieties.

In Egypt, the challenge that faces rice scientists is how to produce more yield with less water consumption. An adequate water supply is one of the most important factors in rice production. It affects the all characteristics including grain quality. Because of the limitation of irrigation water, the utilization of the before used water, such as drainage water, need to be studied as recycled irrigation water. The effect of the use of drainage water on grain quality of rice requires more studies.

Cirelli and Indelicato (2001) reported that planned exploitation of municipal waste water could help meeting the irrigation land, where farmers have been practicing uncontrolled waste water reuse for long time in many places. Where available water resources generally do not meet water needs for different purposes. Waste water reuse could play an important role to compensate the water shortage. The effect of the use of drainage water on grain quality of rice requires more studies. One the other hand, increasing cropping intensity demands more nutrients to sustain this high productivity. Moreover, there is a general tendency to increase nitrogen level in rice cultivation to enhance grain yield. Moorthy *et al.* (1998) studied the optimum nitrogen requirement for quality traits in long slender, none scented rice cultivars. They found that N levels did not have any adverse influence on the various quality traits. Sorour *et al.* (1998) found that splitting nitrogen doses into two or three splits gave a significant effect on hulling, milling head rice percent and protein content of milled rice. El-Kady and Abd-El Wahab (1999) reported that grain physical characters such as length, width and grain shape were not influenced, while hulling and milling percentages were significantly increased by the application of 50kg N/ha. They found that head rice and amylose content were markedly decreased as N levels increased up to 150 kg N/ha.

Thus, studying the effects of the use of nitrogen fertilizers on rice grain quality need to be investigated continuously. Accordingly, the present study aims to investigate the effect of two irrigation water qualities and four nitrogen levels on rice grain quality characteristics. Beside, the interaction between these two factors was also determined.

MATERIALS AND METHODS

Two irrigation water qualities and four nitrogen levels were used in an experiment conducted at the farm of the Faculty of Agriculture (Saba – Pacha), Alex. Univ. during 2001 and 2002 seasons to determine their effects on grain quality characteristics of the Egyptian rice variety Giza 178.

The irrigation water qualities were, normal irrigation water and fish culture drained water as recycled irrigation water. Moreover, the four nitrogen levels were zero, 40, 80 and 120 kg N/fed. added to the rice field in two splits, the first during land preparation in dry soil conditions while the second was added at the beginning of panicle initiation stage (25 days after transplanting)

The experimental design was split plot with four replications where the irrigation water qualities were allocated in the main plots, and the nitrogen levels were placed in the sub-plots. The size of each sub-plot was 3 x 3.5 m and 3 - 4 seedlings per hill were transplanted after 30 days from sowing at 20x20 cm spacing in the two seasons of study. All the other technical recommendations for rice cultivation were followed .

STUDIED CHARACTERISTICS:

Grain quality characteristics of rice grain were determined at the laboratories of the Rice Technology Training Center, Alexandria Egypt as follows:-

A- **Grain appearance characteristics**: Grain length and shape (L/W ratio) were measured as suggested by Khush *et al.* (1979). Translucent grain (%) was given a visual rating based on IRRI standard (1996).

B- **Milling recovery characteristics**: Hulling, milling and head rice percentages were estimated according to the methods reported by Khush *et al.* (1979).

C- **Cooking and eating quality characteristics**: Elongation ratio was calculated according to Azeez and Shafi (1966). Amylose content was determined according to Juliano (1971), and protein content percentage was analyzed according to the standard micro-kjeldahl method. Then, nitrogen was multiplied by the factor of 5.95 to estimate the crude protein content in rough rice grain.

Statistical analysis:

All data collected were subjected to statistical analysis as described by Gomez and Gomez (1984) The mean values were compared by Duncan's Multiple Range Test (Duncan 1955).

RESULTS AND DISCUSSION

The data obtained during the two seasons of study were analyzed and the results could be discussed as follows:

A- Grain appearance characteristics :

1- Grain length (mm.)

Data in Table (1) showed that no significant differences in grain length were detected as affected by the irrigation water sources in both seasons. Recycled irrigation water caused a slight increase in grain length, however, this increase was not significant. This could be attributed to the fact hat this character is less affected by the environmental factors. Similar results were reported by Nour *et al.* (1997).

Regarding the effect of nitrogen levels on the grain length character, data in Table (1) indicated that 120 kg N/fed. produced the longest grain, while the shortest one was found when plants were grown under zero nitrogen level in both seasons of study. These results revealed that increasing nitrogen level resulted in significant increase in grain length. These findings are in agreement with those reported by Yoshida (1981) and El-Wakeel (1991). While, El-Kady and Abd El-Wahab (1999) reported that grain physical characters such as length, width and grain shape were not significantly affected by increasing nitrogen fertilizer levels.

The interaction between irrigation water quality and nitrogen levels on grain length character was not significant in 2001 and 2002 growing seasons (Table 1).

2- Grain shape (Length/Breadth ratio)

With regard to irrigation water quality effect, grain shape was significantly affected in 2002 season and decreased significantly from 3.29 to 2.66 when the recycled irrigation water was used in this season (table 1). On the other hand, there was no significant effect on the same trait in 2001 season as affected by different irrigation forms.

Furthermore, data in Table (1) show that increasing nitrogen level from zero up to 120 kg N/fed. resulted in a significant decrease in grain shape. This could be attributed to the increase in grain width by increasing nitrogen levels that resulted earlier, while grain length was not affected. Similar findings were reported by Gorgy (1995). While Zhong *et al.* (1992) stated that application of nitrogen did not significantly affect grain length, width and grain shape.

In both seasons, the irrigation water qualities and nitrogen levels interaction was significant for grain shape. Table (2) shows that the highest value for grain shape was achieved at zero kg nitrogen / fed. in the first and second seasons when accompanied with recycled irrigation water.

3- Translucent grain percentage:

It is clear from Table (1) that translucent grain percentage was significantly affected by different irrigation water qualities. The highest percentages resulted when the normal irrigation water was used, meanwhile these percentages decreased significantly when the recycled water was utilized in the two seasons of study. Furthermore, increasing nitrogen levels caused a highly significant increase in translucent grain percentage in both seasons. This percentage was maximized at 120 kg N/fed. These results are in agreement with Silva and Brando (1987) and Champagen *et al.* (1996).

Table 1 . The effect of irrigation water quality and nitrogen levels on grain length, shape and translucent (%) in 2001 and 2002 seasons.

Main effect & interaction	Grain length (mm.)		Grain shape (L/W) ratio		Translucent grain %	
	2001	2002	2001	2002	2001	2002
Water forms (W)						
Normal water						
Recycling water	7.23	7.14	2.73	3.29	80.13	82.36
F- test	7.26	7.24	2.65	2.66	75..25	71.158
	n.s	n.s	n.s	*	**	**
Nitrogen levels(N)						
Zero	6.79	6.72	2.93	3,03	66.52	68.93
40	6.92	6.87	2.76	2.82	69.45	72.82
80	7.57	7.54	2.77	2.75	73.70	75.44
120	7.69	7.83	2.58	2.73	81.82	80.07
F- test	*	*	*	*	**	**
Interaction						
W x N	n.s	n.s	n.s	**	**	n.s

* , ** significant and highly significant at 0.05 and 0.01, respectively.

Highly significant interaction effects were estimated in the two seasons of study. The highest values of translucent grain percentage were obtained at 120 kg N/ fed. together with normal irrigation water. These results revealed that nitrogen application accompanied with the normal water enhanced the maturity of the grain and as a final product of chalky spots in the endosperm decreased, so the translucent grain percentage increased (Table 2).

Table 2 . The interaction between irrigation water quality and nitrogen levels on grain shape and grain translucent %

Year	N. level	Grain Shape		Translucent %	
		Normal Water	Recycled Water	Normal Water	Recycled Water
2001	Zero	2.92	2.86	73.11	70.66
	40	2.83	2.79	76.72	74.52
	80	2.75	2.70	79.83	77.95
	120	2.63	2.62	81.55	79.13
L.S.D. 0.05	W	0.015		1.23	
	N	0.019		3.06	
2002	Zero	2.98	3.01	72.89	68.55
	40	2.92	2.87	75.73	70.49
	80	2.68	2.70	79.84	75.93
	120	2.72	2.72	81.51	79.45
L.S.D. 0.05	W	0.013		2.38	
	N	0.023		3.65	

B- Milling recovery characteristics

Table (3) summarizes the effects of different irrigation water sources and nitrogen levels on the percentages of milling recovery characters i.e. hulling, milling and head rice percentages during 2001 and 2002 seasons.

1- Hulling percentage:

Recycled irrigation water gave the highest hulling percentage that differed significantly from that irrigated with normal irrigation water in 2002 growing season.

This result led to the conclusion that grain filling was optimum when rice plants were irrigated by the recycled water.

Highly significant differences in hulling percentage in both 2001 and 2002 seasons were estimated as affected by different nitrogen levels. Meanwhile, there was no significant difference in hulling percentage between 80 and 120 kg N/ fed. This in turn suggested that increasing nitrogen level up to 80 kg N/fed is quite sufficient for improving hulling percentage in 2002 season only.

Moreover, it is clear from Table (4) that hulling percentage character was significantly affected by the interaction between the two studied factors in 2002 season.

2 - Milling percentage:

Regarding the effect of irrigation water sources on milling % the results indicated that it had a significant effect in the second season only (Table 3). Using normal water irrigation resulted in a significant increase in milling % in this season.

Data in Table (3) show also that the nitrogen fertilizer had a highly significant effect on milling percentage of rice as a result of raising nitrogen level. Obviously, increasing nitrogen level up to 120 kg N/fed. increased milling (%) in both seasons. This finding is in agreement with those reported by El-Kady and Abd El-Wahab (1999) and Badawi (2002).

The differences in milling percentage as affected by the interaction between nitrogen level fertilizer levels and irrigation water sources was not significant in both seasons. These finding are in a close agreement with Gorgy (1995) and Sorour *et al.* (1998).

3- Head rice percentage:

Data given in Table (3) show the mean values of head rice percentage as affected by different irrigation water sources and nitrogen level in 2001 and 2002 rice growing seasons. Recycled irrigation water gave the highest head rice percentages comparing with the normal irrigation water. In addition, the increase in nitrogen level fertilization from 0 to 120 kg N/fed. increased the head rice percentage. The differences were significant in the two seasons. This result is in agreement with Gorgy (1995) and Sorour *et al.* (1998).

The interaction between nitrogen levels and water irrigation sources was not significant during 2001 season only. While, using recycled water accompanied with 120 kg N/fed. gave the highest head rice percentage in 2002 season of study (Table 4).

Table 3. The effect of irrigation water quality and nitrogen levels on milling % , hulling % ,head rice % and green grain %

Main effect & interaction	Hulling %		Milling %		Head rice %	
Water quality	2001	2002	2001	2002	2001	2002
Normal water	79.26	79.47	68.50	68.79	62.33	62.41
Recycling water	79.79	79.56	68.94	69.04	63.55	63.87
F. test	*	n.s	*	n.s	*	*
Nitrogen level(N)						
Zero	69.41	75.10	67.04	66.14	60.88	60.2
40	79.11	79.02	68.42	68.55	62.35	62.16
80	79.53	79.95	69.10	69.31	62.66	62.78
120	80.06	80.02	69.43	69.66	62.88	63.12
F.test	**	**	**	**	**	**
Interaction W x N	n.s.	*	n.s	*	n.s	*

- , ** signification and highly signification at 0.05 and 0.01 respectively.

Table 4. The interaction between irrigation water quality and nitrogen level on hulling (%) and head rice (%)

Year	Nitrogen level	Hulling %		Head rice %	
		Normal Water	Recycled Water	Normal Water.	Recycled Water.
2002	Zero	75.03	76.10	56.88	55.83
	40	77.98	78.06	59.26	59.65
	80	79.88	80.01	60.55	61.01
	120	79.98	80.06	64.95	63.28
L.S.D. 0.05	N	0.096		0.235	
	W	0.064		0.373	

C- Cooking and eating quality characteristics:

1- Kernel elongation (%)

It is evident from Table (5) that recycled water caused highly significant differences in kernel elongation % compared with that of the normal irrigation water in 2002 season only. This in-turn led to the conclusion that recycled irrigation water improved the kernel elongation % in the second season of study.

On the other hand, increasing nitrogen level from zero kg N/fed to 120 kg N/fed resulted a gradual and highly significant decrease in kernel elongation % in both seasons of study.

These findings could be explained on basis that at high rate of nitrogen fertilization, the moisture content of rice grain might increase and accordingly the kernel elongation (%) decreases upon cooking.

Data in Table (5) further clarify that the interaction between the two studied factors on kernel elongation (%) were significant in 2002 season. Recycled irrigation water together with zero kg N/fed produced the highest values of such character.

2- Amylose content (%)

Amylose content % was not affected by the quality of water irrigation in both seasons. This result indicates that the ratio between the two starch components of the rice grain (amylose and amylopectin) was not affected by different irrigation water sources (Table 5).

Table 5. The effect of irrigation water quality and nitrogen levels on some cooking and eating quality characters.

Main effect & interaction	Kernel elongation (%)		Amylose (%)		Protein %	
Water quality (W)	2001	2002	2001	2002	2001	2002
Normal	50.36	56.75	17.31	17.49	7.32	7.08
Recycling	52.17	67.83	17.55	17.82	8.63	8.88
F test	n.s	**	n.s	n.s	*	*
Nitrogen levels (N)						
Zero	56.82	60.54	15.39	14.81	6.51	6.82
40	50.63	53.15	17.19	16.92	7.15	7.29
80	50.14	52.78	17.25	17.07	7.81	7.87
120	45.66	41.92	17.61	17.82	8.12	8.19
F test	**	**	*	*	**	**
Interaction W x N	n.s.	*	n.s	n.s.	*	*

Evidently from Table (5), amylase content (%) increased significantly by increasing nitrogen levels from zero kg to 120 kg N/fed. It is worthy to note that the lowest amylose content (%) was obtained under no fertilization treatment, while no significant difference in the mean values of this character was found between the other three nitrogen levels in 2001 season and between 40 and 80 kg N/fed. in 2002 season. This could be attributed to the duration of grain filling under different nitrogen levels which was shortest under zero kg N/fed. This naturally affected the starch constitution of the rice grain. These results are in harmony with those reported by Khalid and Chaudhary (1999). From another point of view, the interaction between the two studied factors on amylase (%) was not significant in the two seasons of study.

3 - Protein content (%)

Recycling irrigation water caused highly significant increase in protein content (%) in 2001 and 2002 seasons (Table 5). The differences between the mean values of this character as affected by the two irrigation water forms indicated that recycled irrigation improved the nutritional value of the rice grain under this study.

Furthermore, protein (%) increased significantly by increasing nitrogen levels in both seasons. It can be said that increasing nitrogen fertilization affects directly the nitrogen metabolism in the rice plant resulting in an increase in protein content (%) in the grain,. This result is in agreement with that of Youssef *et al.* (1980), Parida *et al.* (1995) and Khalid and Chaudhary (1999).

The interaction between different irrigation water sources and nitrogen levels on protein content (%) was significant in the two seasons of study (Table 6). Protein content (%) was maximized when recycled irrigation water was used together with maximum nitrogen level (120 kg N/fed.)

Table 6. The interaction effects between irrigation water quality and nitrogen levels on cooking and eating quality characters.

Year	N. levels	Kernel elongation %		Protein %	
		Normal	Recycled	Normal	Recycled
2001	Zero	----	----	6.03 c	6.82c
	40	----	----	7.32b	7.32b
	80	----	----	7.78b	8.07a
	120	----	----	8.24a	8.29a
L.S.D 0.05 (W)				0.26	
L.S.D 0.05 (N)				0.34	
2002	Zero	54,83a	59.81a	6.48c	7.03c
	40	52.15b	55.36b	7.39b	7.48b
	80	52.03b	50.58c	7.66b	8.02a
	120	48.35c	47.15d	8.19a	8.32a
L.S.D. 0.05 (W)	1.23		0.29		
L.S.D. 0.05 (N)	1.63		0.40		

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دراسة تأثير بعض مصادر مياه الرى ومستويات التسميد النيتروجينى على صفات جودة الحبوب فى الأرز

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أجرى هذا البحث فى مزرعة كلية الزراعة (سابا باشا) جامعة الإسكندرية خلال موسمى ٢٠٠١ – ٢٠٠٢ لدراسة مدى تأثر صفات جودة الحبوب لصنف الأرز جيزة ١٧٨ بمصادر رى مختلفة (مياه رى عادية ومياه معاد تدويرها بعد صرفها من مزارع سمكية) وكذلك أربعة مستويات تسميد نيتروجينى (صفر، ٤٠ ، ٨٠ ، ١٢ وحدة نيتروجين / فدان).

أوضحت النتائج أن الصفات المظهرية للحبوب (طول الحبة – شكل الحبة – النسبة المئوية للحبوب الشفافة) اختلفت فى تأثرها باختلاف مصدر المياه ففى حين لم تتأثر صفة طول الحبة فقد تأثرت صفة شكل الحبة خلال موسم ٢٠٠٢ فقط وتأثرت النسبة المئوية للحبوب الشفافة فى كلا الموسمين وبصفة عامة أعطت المياه المعاد تدويرها نتائج أفضل من المياه العادية – من ناحية أخرى أثرت زيادة مستويات التسميد النيتروجينى تأثيرا معنويا على كل الصفات المظهرية للحبوب كما كان للتفاعل بين عاملى الدراسة تأثيرا معنويا على هذه الصفات فيما عدا صفة طول الحبوب فى كلا الموسمين.

من ناحية أخرى كان لاستخدام المياه المعاد تدويرها تأثير معنوى على صفتى تصافى التقشير وتصافى التبييض فى موسم ٢٠٠١ فقط وعلى صفة نسبة الحبوب الكاملة فى كلا موسمى الدراسة كما تأثرت نفس الصفات معنويا بزيادة مستوى التسميد النيتروجينى حتى ١٢٠ كجم نيتروجين / فدان – كما أظهرت النتائج أن التفاعل بين عاملى الدراسة كان معنويا فى موسم ٢٠٠٢ فقط فى حالة صفتى تصافي التقشير ونسبة الحبوب الكاملة.

أوضحت الدراسة أيضا أن صفة نسبة الأميلوز فى الحبوب لم تتأثر معنويا بإختلاف مصادر الرى بينما تأثرت صفة نسبة إستطالة الحبوب فى موسم ٢٠٠٢ فقط كما تأثرت صفة نسبة البروتين فى الحبوب فى كلا الموسمين فقد أدى استخدام المياه المعاد تدويرها إلى تسحن هذه الصفات فى كلا الموسمين – وكان تأثير التفاعل بين عاملى الدراسة معنويا فى موسم ٢٠٠٢ على صفة نسبة إستطالة الحبوب وفى كلا الموسمين على صفة نسبة البروتين فى الحبوب.