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PRIMARY STUDY ON NITRATE POLLUTION OF RICE GRAIN IN KAFR EL-SHEIKH GOVERNORATE

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ABSTRACT

Rice is one of the most important food and export crops of Egypt. Kafr El-Sheikh Governorate is an important site of the six Governorates producing the rice in Egypt. Nitrate pollution in food crops gets high attention and efforts from the researchers because it causes health and economic damage.

The objective of the present study is finding the answer of the following question:

Are there nitrate pollution in the rice grain produced in Kafr El-Sheikh Governorate?

Four randomly rice grain samples from different fields replicated with four common varieties from every district of the ten districts of Kafr El-Sheikh Governorate in the two successive summer seasons of 2001 and 2002 were collected. This is equal to 320 samples (4 replication x 4 varieties x 10 districts x 2 seasons).

The samples were air dried, grinded and nitrate was extracted by acetic acid 2%. Nitrate was measured by colorimetric method.

Data show that the nitrate content of the rice grain of the studied varieties (Sakha 101, Sakha 102, Giza 177 and Giza 178) was less than the destructive level.

No clear correlation between the varities and the nitrate content.

Kafr El-Sheikh district had the highest average of rice nitrate content (10.1) $\mu g\ g^{-1}$, while Qualeen had the lowest average of nitrate content (3.5) $\mu g\ g^{-1}$.

INTRODUCTION

Agriculture is an industry which exists to provide food to feed people. Rice is one of the most important food and export crops of Egypt. The production of rice has increased from 2.4 million tons per year in 1984-86 to 5.9 million tons in 2000, an increase of 45%, Egypt has not only maintained its self sufficiency with the increasing population, it has also increased its export from 25000 tons in early 1980,s to 35000 tons in

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2001 (RRTC-2001). Whenever, the process of protein synthesis in plants is interrupted or slowed down, nitrate may accumulate in plant tissues. Different plant species vary in their tendency to accumulate nitrates. Environmental factors favoring the accumulation of nitrate in plants include high level of nitrate in the soil, cloudy periods, shading, drought, excessive temperatures, damage to plants from insects or weed control chemicals and nutrients imbalance in the soil (Olson *et al.*, 1971). Methemoglobinemia was first recognized by Comley (1945) who related infant illnesses to nitrate contaminated private wells in Iowa. Nitrate can be reduced to nitrite in the digestive tract and nitrite interferes with oxygen transport in the blood.

The US standard (maximum contaminant level), MCL of 10 mg/L of nitrate was established by the United States Environmental Protection Agency (USEPA) in 1977 as a safeguard against infantile methemoglobinemia (Kross *et al.*, 1992). Also, the potential for gastric cancer from ingested nitrate and nitrite, and its subsequent conversion to nitrosamines (NRC, 1978, 1981 and CAST, 1992).

The highest permissible limit for human total consumption is 3.65 mg NO_3-N and 0.133 mg NO_2-N for every one kg weight daily this equal 280 mg NO_3-N and 10 mg NO_2-N for adult one (Arnaoot, 2001).

The present study aim to have primary knowledge on nitrate pollution of rice grain produced in one of the most important rice productive governorates in Egypt of Kafr El-Sheikh.

MATERIALS & METHDOS

To achieve the mentioned objective, rice grain samples were randomly collected from the rice fields at maturity stage. 320 samples were collected 160 in the first season of 2001 and the other 160 samples in the second season of 2002 from the ten districts of Kafr El-Sheikh Governorate, where the samples include four varieties and replicated four times from different fields for every variety. The samples approximately cover the districts area. The samples were air dried, crushed and stored in stoppered bottles for nitrate determination. 5 g of the sample was extracted by 50 ml 2% acetic acid and nitrate was determined colormetrically in the extract using naphthyethelene diamine dihydrochloride powder mixture indicator according to Singh (1988).

RESULTS

Data presented in Table 1 show that nitrate content of rice samples which were collected from Kafr El-Sheikh district was between 7.2 to 10.4 $\mu g\ g^{-1}$ in Sakha 101 variety. The mean value of both seasons (8 samples)

for Sakha 101 variety was 8.8 μg g^{-1}. While in Sakha 102 variety the values of nitrate content was between 7.2 to 12.2 μg g^{-1}. The mean value of the both seasons was 10.2 μg g^{-1}. The values of nitrate content were between 8.0 to 10.4 μg g^{-1} in Giza 177 variety. The mean value of both seasons for Giza 177 was 9.3 μg g^{-1}. The fourth variety Giza 178 had values of nitrate content between 8 to 16 μg g^{-1}. The mean value of the both seasons was 11.9 μg g^{-1}. The sequence of the varieties from the highest nitrate content to the lowest were Giza 178 > Sakha 102 > Giza 177 > Sakha 101. The average of the total samples collected from Kafr El-Sheikh district (32 samples) was 10.1 μg g^{-1}.

Table (1): Nitrate content (μg g^{-1}) of the rice grain samples collected from Kafr El-Sheikh District.

Samples	Varieties							
	Sakha 101		Sakha 102		Giza 177		Giza 178	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd
1	7.2	8.8	11.2	9.2	10.4	9.2	13.2	10.6
2	10.4	7.6	7.2	11.6	8.0	9.8	16.0	12.6
3	8.0	8.4	12.0	9.6	9.2	9.2	11.6	14.6
4	9.6	10.4	8.0	12.2	8.0	10.0	8.0	8.2
Mean	8.8	8.8	9.6	10.7	8.9	9.6	12.2	11.5
Mean	8.8		10.2		9.3		11.9	

Results tabulated in Table 2 show that nitrate content of rice samples which were collected from Desuq district were low compared to Kafr El-Sheikh district. The values were between 5.2 and 9.6 μg g^{-1} of Sakha 101 variety. The mean value of Sakha 101 variety for both seasons was 7.5 μg g^{-1}. The values varied between 6.4 to 11.6 μg g^{-1} and the mean value for both seasons was 8.4 μg g^{-1} for Sakha 102 variety. Giza 177 variety had values between 6.4 to 9.6 and mean value of nitrate content for all samples (8 sample) was 7.8 μg g^{-1}. Giza 178 had the lowest nitrate content values (average the both seasons) of 6.8 μg g^{-1}. The sequence of the variety according to nitrate content were Sakha 102 > Giza 177 > Sakha 101 > Giza 178. The average of nitrate content for the all collected samples of Desuq district (32 samples) was 7.6 μg g^{-1}.

Data of Table 3 show that Sakha 101 contain nitrate values between zero to 9.6 μg g^{-1}. The average value of the both seasons was 6.1 μg g^{-1}. Also, the nitrate content varied between zero to 8.4 μg g^{-1} of Sakha 102 variety. The average of all collected samples (8 sample) was 6.5 μg g^{-1}. Giza 177 had the same trend in Sakha 101 and Sakha 102. While the

average of Giza 177 samples was 5.0 $\mu g\ g^{-1}$. Giza 178 had the highest average of the both seasons of 7.4 $\mu g\ g^{-1}$ compared to the other varieties. The nitrate content in Giza 178 were between 5.2 to 9.6 $\mu g\ g^{-1}$.

Table (2): Nitrate content ($\mu g\ g^{-1}$) of the rice grain samples collected from Desuq district.

Samples	Varieties							
	Sakha 101		Sakha 102		Giza 177		Giza 178	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd
1	9.6	7.6	11.6	9.0	9.6	8.4	5.6	5.0
2	5.6	9.0	6.4	9.4	7.2	8.4	4.4	8.6
3	8.4	7.4	7.2	9.4	7.2	8.0	11.6	5.4
4	5.2	7.0	7.2	6.8	6.4	7.2	5.2	8.4
Mean	7.2	7.8	8.1	8.7	7.6	8.0	6.7	6.9
Mean	7.5		8.4		7.8		6.8	

The sequence of the variety in its nitrate content were Giza 178 > Sakha 102 > Sakha 101 > Giza 177. The average of nitrate content for the all samples collected from Fowa district was 6.2 $\mu g\ g^{-1}$.

Table (3): Nitrate content ($\mu g\ g^{-1}$) of the rice grain samples collected from Fowa district.

Samples	Varieties							
	Sakha 101		Sakha 102		Giza 177		Giza 178	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd
1	9.6	8.4	7.2	8.4	5.6	0.0	7.2	6.2
2	7.2	7.6	9.6	7.2	7.2	4.6	5.2	8.4
3	5.6	0.0	7.2	6.	0.0	7.6	9.6	7.2
4	3.6	6.6	5.6	0.0	9.6	5.4	7.2	7.4
Mean	6.5	5.6	7.4	5.4	5.6	4.4	7.3	7.3
Mean	6.1		6.4		5.0		7.3	

Results tabulated in Table 4 show that Sakha 101 variety had nitrate content values varied between 5.2 to 8 $\mu g\ g^{-1}$. The mean value of both seasons was 7.1 $\mu g\ g^{-1}$. Results of nitrate content of samples collected from Motobas district for Sakha 102, Giza 177 and Giza 178 had values varied between 2.4 to 8.4 and 3.6 to 5.2 and 3.6 to 8.0 $\mu g\ g^{-1}$. respectively. The average of the varieties in the two seasons were 5.0, 4.7

and 6.2 μg g^{-1} with Sakha 102, Giza 177 and Giza 178, respectively. The average of all collected samples from Motobas district was 5.8 μg g^{-1}.

Data of nitrate content of the samples collected from Sidi Salem district (Table 5) show that the nitrate content varied between 3.6, 2.4, 5.2 and 5.2 to 6.4, 7.2, 7.2 and 7.2 μg g^{-1} with Sakha 101, Sakha 102, Giza 177 and Giza 178, respectively.

The mean values of the two seasons were 4.3, 4.6, 6.2 and 6.0 μg g^{-1} with Sakha 101, Sakha 102, Giza 177 and Giza 178, respectively. The average of all collected samples of Sidi Salem district (32 samples) was 5.3 μg g^{-1}.

Table (4): Nitrate content (μg g^{-1}) of the rice grain samples collected from Motobas district.

Samples	Varieties							
	Sakha 101		Sakha 102		Giza 177		Giza 178	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd
1	7.2	7.6	2.4	4.7	5.2	4.4	3.6	5.8
2	8.0	7.4	3.6	3.0	3.6	5.4	8.0	5.8
3	7.6	6.2	7.2	5.4	5.2	4.9	8.0	4.6
4	5.2	7.2	8.4	5.4	4.6	3.6	5.6	8.0
Mean	7.0	7.1	5.4	4.6	4.7	4.6	6.3	6.1
Mean	7.1		5.0		4.7		6.2	

Table (5): Nitrate content (μg g^{-1}) of the rice grain samples collected from Sidi Salem district.

Samples	Varieties							
	Sakha 101		Sakha 102		Giza 177		Giza 178	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd
1	3.6	3.6	2.4	4.8	6.4	6.8	5.2	6.2
2	3.6	5.0	7.2	3.4	7.2	5.8	7.2	5.4
3	6.4	3.6	4.4	3.6	5.2	5.9	5.6	5.8
4	3.6	5.0	4.8	5.8	5.4	6.2	6.4	6.4
Mean	4.3	4.3	4.7	4.4	6.1	6.2	6.1	5.9
Mean	4.3		4.6		6.2		6.0	

Data of nitrate content of the samples collected from Qualeen district (Table 6) show that the nitrate content varied between 2.4 to 5.2, 2.4 to 4.4, 1.6 to 2.4 and 1.2 to 5.2 μg g^{-1} with Sakha 101, Sakha 102,

Giza 177 and Giza 178, respectively. The mean values of the both seasons were 3.6, 3.7, 2.3 and 3.2 μg g^{-1} with Sakha 101, Sakha 102, Giza 177 and Giza 178, respectively. The average of the collected samples from Qualeen district (32 sample) was 3.2 μg g^{-1}. This was the lowest value in Kafr El-Sheikh Governorate.

The sequence of the varieties nitrate content were Sakha 102 > Sakha 101 > Giza 178 > Giza 177.

Nitrate content results of samples collected from El-Riad district (Table 7) show that nitrate content varied between 3.2 to 6.4, 2.4 to 5.2, 2.4 to 7.2 and 2.4 to 7.2 μg g^{-1} with Sakha 101, Sakha 102, Giza 177 and Giza 178, respectively. The mean values of the two seasons for the varieties were 4.9, 3.8, 5.1 and 4.2 μg g^{-1} with Sakha 101, Sakha 102, Giza 177 and Giza 178, respectively. The average of all collected samples (32 sample) for El-Riad district was 4.5 μg g^{-1}. The sequence of the varieties according to its nitrate content were Giza 177 > Sakha 101 > Giza 178 > Sakha 102.

Table (6): Nitrate content (μg g^{-1}) of the rice grain samples collected from Qualeen district.

Samples	Varieties							
	Sakha 101		Sakha 102		Giza 177		Giza 178	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd
1	2.4	3.2	3.2	3.8	2.4	2.2	1.2	1.8
2	3.6	3.8	4.4	3.8	1.6	2.4	2.4	2.8
3	5.2	3.2	4.4	2.8	2.4	2.4	4.4	4.4
4	3.7	5.2	2.4	4.4	2.4	2.2	3.2	5.2
Mean	3.7	3.4	3.6	3.7	2.2	2.3	2.8	3.6
Mean	3.6		3.7		2.3		3.2	

Results of the nitrate content of the samples collected from El-Hamool district (Table 8) show that nitrate content varied between zero to 4.4, 1.2 to 4.4, 5.2 to 13.2 and 8.4 to 15.2 μg g^{-1} with Sakha 101, Sakha 102, Giza 177 and Giza 178, respectively. The mean values of the two seasons for the varieties were 2.3, 3.2, 9.4 and 11.3 μg g^{-1} with Sakha 101, Sakha 102, Giza 177 and Giza 178, respectively. The sequence of the studied varieties in nitrate content were Giza 178 > Giza 177 > Sakha 102 > Sakha 101, respectively. The average of all collected samples from El-Hamool district was 6.6 μg g^{-1}.

Table (7): Nitrate content ($\mu g\ g^{-1}$) of the rice grain samples collected from El-Riad district.

Samples	Varieties							
	Sakha 101		Sakha 102		Giza 177		Giza 178	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd
1	5.2	5.8	2.4	2.8	5.6	4.0	2.4	7.2
2	6.4	4.4	3.2	5.2	2.4	7.2	3.2	2.8
3	3.6	4.2	5.2	3.8	7.2	6.4	7.2	4.8
4	3.2	6.4	3.8	3.2	3.2	4.4	3.2	2.8
Mean	4.6	5.2	3.7	3.8	4.6	5.5	4.0	4.4
Mean	4.9		3.8		5.1		4.2	

Data presented in Table 9 show that nitrate content of rice samples which were collected from Beyala district were between 3.6 to 7.2, 3.6 to 8.4. 5.2 to 13.2 and 3.6 to 8.4 with Sakha 101, Sakha 102, Giza 177 and Giza 178, respectively. The mean values of the two seasons were 5.4, 5.7, 8.3 and 7.3 $\mu g\ g^{-1}$ nitrate with Sakha 101, Sakha 102, Giza 177 and Giza 178, respectively.

The sequence of nitrate content of the varieties were Giza 177 > Giza 178 > Sakha 102 > Sakha 101, respectively. The average of the all collected samples from Beyala district was 6.7 $\mu g\ g^{-1}$.

Table (8): Nitrate content ($\mu g\ g^{-1}$) of the rice grain samples collected from El-Hamool district.

Samples	Varieties							
	Sakha 101		Sakha 102		Giza 177		Giza 178	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd
1	3.2	2.4	4.4	2.8	13.2	8.4	15.2	8.4
2	3.2	4.4	1.2	3.4	8.4	10.8	8.4	11.8
3	0.0	1.2	2.4	4.4	5.2	9.2	10.0	12.2
4	0.0	4.0	2.8	3.6	8.9	11.1	11.2	13.2
Mean	1.6	3.0	2.7	3.6	8.9	9.9	11.2	11.4
Mean	2.3		3.2		9.4		11.3	

Results presented in Table 10 show that nitrate contents of rice samples collected from El-Brolos district varied between 3.6 to 5.6, 3.6 to 8.4, 5.2 to 8.4 and 3.2 to 9.2 $\mu g\ g^{-1}$ with Sakha 101, Sakha 102, Giza 177 and Giza 178, respectively. The mean values of nitrate content in the two seasons were 4.7, 5.8, 6.8 and 6.1 $\mu g\ g^{-1}$ with Sakha 101, Sakha 102, Giza

177 and Giza 178 respectively. The sequence of nitrate of the variety content were Giza 177 > Giza 178 > Sakha 102 > Sakha 101, respectively. The average of the all collected samples from El-Brolos district was 5.9 μg g^{-1}.

Table (9): Nitrate content (μg g^{-1}) of the rice grain samples collected from Beyala district.

Samples	Varieties							
	Sakha 101		Sakha 102		Giza 177		Giza 178	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd
1	5.2	4.8	4.4	4.0	5.2	6.8	8.4	7.8
2	4.4	7.2	3.6	8.4	8.4	13.2	7.2	8.4
3	7.2	6.2	8.4	6.4	13.2	9.2	8.4	8.4
4	3.6	4.4	5.2	4.8	5.2	5.2	3.6	6.0
Mean	5.1	5.7	5.4	5.9	8.0	8.6	6.9	7.7
Mean	5.4		5.7		8.3		7.3	

Table (10): Nitrate content (μg g^{-1}) of the rice grain samples collected from El-Brolos district.

Samples	Varieties							
	Sakha 101		Sakha 102		Giza 177		Giza 178	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd
1	3.6	4.4	5.2	4.3	5.2	7.3	6.4	5.8
2	5.2	5.6	3.6	8.4	8.4	6.0	5.2	9.2
3	5.6	4.6	4.4	4.8	6.8	-	3.2	4.8
4	4.4	4.0	8.4	6.8	-	-	9.2	7.8
Mean	4.7	4.7	5.4	6.1	6.8	6.7	6.0	6.1
Mean	4.7		5.8		6.8		6.1	

DISCUSSION

The previous results show that the studied rice varieties had not stable sequence in its nitrate content of all Kafr El-Sheikh Governote districts.

This mean that no clear correlation between nitrate contents and the varieties. There were clear differences in the same variety in its nitrate content at the same district, this mean that nitrate content in rice grain depends on the field management and the agriculture practices i.e., fertilizers, density and planting date. These results agree with those stated

by **(Olson *et al.*, 1971)**, who stated that environmental factors favoring the accumulation of nitrate in plants include high level of nitrate in the soil, cloudy periods, damage of plants from insects or weed control chemicals, nutrients imbalance in the soil and shading.

CONCLUSION

From the results shown, it could be concluded that:

- The nitrate content of the rice grain in the studied variety in Kafr El-Sheikh Governorate districts less than the destructive effects because the amount of nitrate entering to the body from the rice is less than the amount from drinking water, but it become danger when there are additional sources to the body beside it, like drinking water, vegetables, ... etc.
- Kafr El-Sheikh district had the highest average of rice nitrate content.
- The sequence of the districts from highest nitrate content in the rice grain to lowest were Kafr El-Sheikh (10.1) > Desuq (7.6) > Beyala (6.7) > El-Hamool (6.6) > Fowa (6.3) > El-Brolos (5.9) > Motobas (5.8) > Sidi Salem (5.3) > El-Riad (4.5) > Qualeen (3.2) $\mu g\ g^{-1}$.
- No clear correlation between the varieties and nitrate content.
- The nitrate content in the rice grain depended on field management and agricultural practices, so we must study the relationship between planting date, plant density and fertilizers levels and balance to nitrate content in rice grain.

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دراسة أولية عن التلوث النتراتى فى حبوب الأرز بمحافظة كفرالشيخ

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الملخص العربى

يعتبر الأرز واحدا من أهم المحاصيل الغذائية والتصديرية فى مصـــر. وتشـــغل محافظـــة كفرالشيخ مكانة متميزة بين المحافظات الستة لإنتاج الأرز فى مصر. ويشغل التلوث النتراتى اهتمـــام وجهود كثير من الباحثين لما يسببه من أضرار صحية وخسائر اقتصادية. ويتلخص الهدف مـــن هـــذا البحث فى محاولة الإجابة عن السؤال الآتى:

هل يوجد تلوث نتراتى فى حبوب الأرز المنتج فى محافظة كفرالشيخ؟ وللاجابة عـــن هـــذا السؤال تم جمع أربع عينات عشوائية من حبوب الأرز من حقول مختلفة لكل صنف مـــن الاصنـــاف الأربعة الشائعة فى كل مركز من المراكز العشرة فى محافظة كفرالشيخ خلال موسمين متتالين ٢٠٠١ ، ٢٠٠٢ ليكون عدد العينات ٣٢٠ عينة (٤ مكررات × ٤ اصناف × ١٠ مراكز × ٢ موســـم) وتـــم تجفيف العينات هوائيا ثم طحنت وتم استخلاص النترات من العينات بحامض الخليك ٢% ثم تم قيـــاس النترات فى المستخلص بالطريقة اللونية وتشير النتائج إلى وجود اختلاف فى تركـــيز النـــترات بيـــن العينات.

حيث أوضحت النتائج:

١- أن كميه النترات التى تصل إلى الانسان من تناول الأرز تحت هذا المستوى أقل مما يصل اليه من ماء الشرب.

٢- لا توجد علاقة واضحه بين الأصناف الأربعة المدروسة (سخا ١٠١ و سخا ١٠٢ وجيزة ١٧٧ وجيزه ١٧٨) ومحتوى الحبوب من النترات.

٣- يتضح من الدراسة أن محتوى الحبوب من النترات يرجـــع الـــى الاداره الحقليـــة والعمليـــات الزراعية مثل مواعيد الزراعة وكثافة النباتات ومستويات وإتزان الأسمده ... الخ.

٤- وجود أعلى متوسط عام للنترات فى الاصناف بمركز كفرالشيخ (١٠,١ ميكروجرام/جم) بينمـــا كان اقل متوسط عام بمركز قلين (٣,٢ ميكروجرام/جم).

٥- وكان ترتيب المتوسطات العام للأصناف والمواقع فى المراكز كالتالى: كفرالشـــيخ (١٠,١) > دسوق (٧,٦) > بيلا (٦,٧) ا > الحامول (٦,٦) > فوه (٦,٣) البرلس (٥,٩) > مطوبـــس (٥,٨) > سيدى سالم (٥,٣) > الرياض (٤,٥) > قلين (٣,٥).

توصية:

نوصى باجراء دراسات عن العلاقة بين مواعيد الزراعة وكثافة النباتـــات وطـــرق الشـــتل وكميات الأسمدة ومصادرها وتوازنها على محتوى الحبوب من النترات لتقليـــل الأضـــرار الصحيـــة للإنسان.