J. Agric. Sci. Mansoura Univ., 32 (11): 9793 - 9799, 2007

ROLE OF WATERING STATUS ON CONTENTS OF COPPER, IRON AND MANGANESE IN RICE PLANTS GROWN IN THE NORTH MIDDLE NILE DELTA REGION

Kassab, M.M.; H.M.A.M. El-Sanafawy and E.A. Moursi
Soil, Water and Environment Res. Inst.; Agric. Res. Center.

ABSTRACT

Two field experiments were carried out at Sakha Agricultural Research Station to study the effect of soil wetness status on contents of the three heavy metals i.e. Copper (CU), Iron (Fe) and Manganese (Mn), in some rice cultivars. Main treatments were A. low wetness status 2.5 cm of irrigation water above soil surface (one third of traditional practice), B. medium wetness status roughly 5.0 cm of irrigation water above soil surface (two third of traditional) and C. high wetness status give or take 7.5 cm (traditional rice watering in the studied area by the local farmers). Subtreatments were assigned for rice cultivars which were Giza 171 (as along duration variety), Sakha 101 (as a medium duration variety) and Giza 177 (as a short duration one). In the first growing season the two rice cultivars Giza 171 and Giza 177 were under study), while in the second one, Sakha 101 was added to the abovementioned cultivars.

The main results in this present study can be summarized as follows:

- With all the studied rice cultivars and different soil wetness status, the contents of the studied elements (Cu, Fe and Mn) were higher in shoots in comparison with grains. The highest mean values were recorded in shoots of Sakha 101 rice cultivar and the values for Cu, Fe and Mn were 1329.9, 2150.5 and 1068.6 ppm, respectively. On the contrary, the lowest mean values were recorded in grains of Giza 171 rice cultivar for Cu, but the other two elements were in Giza 177 and the values were 800.0, 1451.4 and 628.0 ppm, respectively.
- Content of (Fe) was higher in both grains and shoots than the other two studied elements Cu and Mn.
- Under traditional irrigation, local farmers practice i.e. the high wetness status led to decreasing the contents of the three studied heavy metals in both grains and shoots for all studied rice cultivars.

INTRODUCTION

In Egypt, rice (*Oryza sativa* L.) is considered as the second export crop after cotton. Moreover, it is one of the most important cereal crops following to wheat. The present national cultivated area of rice is about 1, 400.000 feddan (588, 235 ha.) which equaled about one third from summer cropped area in the Nile Delta. Comparing with other regions all over Egypt, because of adaptation of both climatic and soil conditions for rice cultivation. In addition, rice grains consider a main nutritional food for the Egyptian people, also shoots are considered a main animal feeder particularly in winter season.

In Egypt, water resources have become limited in relation to irrigation and possible land reclamation purposes so, great efforts should be implemented to overcome the problem of water shortage which faces Egypt, presently. Excessive of irrigation water always leads to increasing leaching of soil nutrients such as heavy metals of Fe, Cu and Mn which find their way to pollute groundwater, drainage water and decreasing uptake rate by plants as well. Under conditions of water shortage, we will have to use ground and drainage water in the near future which have a high content in heavy metals, which move easily direct to human or to animals and indirectly way to human by eating meat and drinking milk of these animals. Higher amounts of heavy metals involved may have significant effect on either soil fertility or animal and human health (Oliver 1997 and El-Sanafawy, 2002).

MATERIALS AND METHODS

Two field trials were conduced at Sakha Agricultural Research Station, Kafr El-Sheikh Governorate in the North Middle Nile Delta region during the two successive growing seasons 2006 and 2007 to study the impact of soil wetness status on the contents of Cu, Fe and Mn in some rice cultivars. The soil texture of the experimental site is heavy clayey which is the most suitable soil for rice cultivation by having a high water holding capacity in comparison with the other types of soils. Some soil physical and chemicals properties for the experimental site were assigned in Tables (1 and 2).

Table (1): Mean values of some physical characteristics for the soil before cultivation in the two growing seasons.

Soil depth, cm.	Particle size distribution			Texture class	Bulk density, kg/m^3	Field capacity, %, wt
	Sand, %	Silt, %	Clay, %			
0-15	12.30	33.3	54.40	Clay	1.26	47.50
15-30	20.20	34.2	45.60	Clay	1.31	39.87
30-45	20.40	41.40	38.20	Clay loam	1.29	38.40
45-60	21.10	41.50	37.40	Clay loam	1.38	36.39

Table (2): Mean values of some soil chemical characteristics before cultivation in the two growing seasons.

Soil depth cm	SAR	ESP	ESR	E.C dS/m	Cations, meq/L				Anions, meq/L			
					Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3^{-}	HCO_3^{-}	Cl	SO_4^{--}
0-20	2.20	1.95	0.02	1.24	4.60	4.39	4.64	0.193	0.25	4.63	7.59	1.32
20-40	3.995	4.7	0.046	1.75	6.13	3.71	8.82	0.157	0.38	2.88	10.93	4.62
40-60	3.84	4.11	0.044	1.95	7.04	3.88	9.67	0.206	0.38	3.63	8.58	8.4

Treatments and experimental design:

The split plot experimental design with four replicates was used in this study where main plots were assigned by soil wetness status which were as follows:

A. Low wetness status roughly 2.5 cm of irrigation water depth above soil surface (A.S.S.) (one third of traditional water).
B. Medium wetness status roughly 5.0 cm of irrigation water depth above soil surface (A.S.S.) (two third of traditional water) and.
C. High wetness status roughly 7.5 cm of irrigation water depth above soil surface (A.S.S) (traditional watering by local farmers in the studied area).

Sub plots were assigned by rice cultivars as follows:

1. Giza 171 (as a long duration variety).
2. Giza 177 (as a short duration one). These two varieties were cultivated in the first growing seasons. In the second growing season, in addition to the above mentioned two cultivars Sakha 101 (as a medium duration variety was added).

Experimental layout:

All of common agricultural practices for rice production were carried out as recommended from preparation of nursery bed till harvesting, otherwise, the studied parameters in this work. The submain experimental plot area was 52.5 m^2 (i.e. 1/80 feddan), where each plot was isolated to prevent any horizontal water movement from one plot to another. Soil samples were taken before cultivation for analysis were done and required according to (**Jackson, 1967**).

Data collection:

Plant samples (straw and grains) were collected from each plot at the end of the two growing seasons. Each plant sample was thoroughly washed with distilled water and dried in an oven at 65°C for 24 hours. One gram of each sample was wet digested in H_2SO_4. H_2O_2 mixture to determine the concentration of the three heavy metals Cu, Fe and Mn by using atomic absorption 3300.

RESULTS AND DISCUSSION

Effect of watering status on contents of Cu, Fe and Mn in rice grains and shoots:

Presented data in Tables (3, 4 and 5) clearly showed that under all irrigation treatments and studied rice cultivars, the contents of the three heavy metals under study were increased in shoots in comparison with grains. The mean values for Cu in grains were 800.0, 1047.2 ppm and in shoots were 978.3 and 1225.3 ppm for Giza 171 rice cultivar in 1st and 2nd seasons, respectively. The same trend was obtained for Fe element but the mean values were higher than that obtained for Cu, Fe which reached 1592.7, 1596.7 ppm and in shoots were 1608.6 and 1796.7 ppm in 1st and 2nd seasons, respectively. For Mn content the same trend was recorded but the mean values were lower in comparison with the other two elements, and comprised in grains 839.8, 716.1 and in shoots were 853.8 and 1004.5 ppm 1st and 2nd seasons, respectively. The same was found for the other two rice cultivars Giza 177 and Sakha 101. The mean value of the three studied cultivars can be, generally, arranged for the three rice cultivars as follows Sakha 101 > Giza 177 > Giza 171. Increasing the contents of these shoots elements in comparison with grains, may be due to the low mobility resulting in through plant so, these elements were more accumulated in shoots in comparison with grains (Zein *et al.*, 1998). The obtained values for the three studied elements are high and exceeded the safe limits for these elements and this is great dangerous for both human being and animal health but these values are not reached the toxicity limit, where toxicity limit for Mn for example in rice leaves ranges from 4000 to 8000 ppm (Adriano, 1986).

Moreover, the sufficiency ranges fc˙ Fe 90-190 ppm, Mn 40-740 ppm and Cu 6-25 ppm.

Table (3): Effect of water status on content of Cu, Fe and Mn in grains and shoots of Giza 171 rice cultivar grown in the North of Middle Nile Delta.

Irrigation depth (cm)	First season (2006)		Second season (2007)	
	Copper (Cu) (ppm)			
	Grains	**Shoots**	**Grains**	**Shoots**
2.5	871.3	989.4	1067.5	1097.5
5.0	745.1	1000.0	950.8	1226.0
7.5	783.8	945.6	1123.3	1352.5
Mean	800.0	978.3	1047.2	1225.3
	Iron (Fe)			
2.5	1638.8	1601.3	1612.5	2032.5
5.0	1546.9	1681.3	1830.8	2004.2
7.5	1592.5	1543.3	1346.7	1353.4
Mean	1592.7	1608.6	1596.7	1796.7
	Manganese (Mn)			
2.5	753.8	833.1	690.8	926.9
5.0	960.0	919.4	726.7	1001.7
7.5	805.6	808.8	730.8	1085.0
Mean	839.8	853.8	716.1	1004.5

Table (4): Effect of water status on content of Cu, Fe and Mn in grains and shoots of Giza 177 rice cultivar grown in the North of Middle Nile Delta.

Irrigation depth (cm)	First season (2006)		Second season (2007)	
	Copper (Cu) (ppm)			
	Grains	Shoots	Grains	Shoots
2.5	918.1	997.5	1115.0	1314.8
5.0	873.8	106.9	1042.5	1337.5
7.5	786.3	1020.6	985.8	1245.8
Mean	859.4	1026.7	1047.8	1299.4
	Iron (Fe)			
2.5	1643.1	2328.8	1849.2	1845.0
5.0	1736.3	1537.5	1272.5	1767.5
7.5	1527.5	1480.0	1232.5	1745.8
Mean	1635.6	1782.1	1451.4	1786.1
	Manganese (Mn)			
2.5	1017.5	723.8	645.8	1140.8
5.0	910.6	871.3	668.3	992.5
7.5	721.9	796.9	570.0	979.2
Mean	883.3	797.3	628.0	1037.2

Table (5): Effect of water status on content of Cu, Fe and Mn in grains and shoots of Sakha 101 rice cultivar grown in the North of Middle Nile Delta.

Irrigation depth (cm)	Copper (Cu) (ppm)		Iron (Fe) (ppm)		Manganese (Mn) (ppm)	
	Grains	Shoots	Grains	Shoots	Grains	Shoots
2.5	1083.3	1340.8	1662.5	2288.3	1510.2	1000.0
5.0	945.0	1306.3	2138.3	2015.0	764.2	1047.5
7.5	1181.7	1342.5	1860.8	2148.3	779.2	1158.3
Mean	1070.0	1329.9	1887.2	2150.5	1017.9	1068.6

Data in the same Tables illustrated that the content of Fe in grains and shoots was higher in comparison with the other two elements Cu and Mn. This may be due to the highest availability of Fe element in the soil because of its lower catchments power so, it moves more freely in soils, consequently, the higher amount was absorbed by plants for this element, comparing with the other two elements. These results are in a great harmony with those obtained by Barsoum (1996) who declared that the absorption of iron was higher than manganese.

Increasing the contents of these elements in shoots is very dangerous due to easily moves to the animals and then accumulate in meat and milk and, consequently, transplant to the human being and causes a lot of problems. The most dangerous aspect for transportation such toxic elements by milk to the kids and cause a lot of dangerous diseases such as cancer. Finding these elements in grains is also dangerous because find direct way to move to human being.

Increasing these elements to such level may be attributed to decreasing the quality of drainage water used under shortage of fresh irrigation water, since the farmers always will have to mix fresh water with drainage water and in some cases use drainage water only which is rich in contents of these elements, that plays a drastic effect on increasing the level of these elements (Oliver, 1997).

Increasing these elements in Sakha 101 rice cultivar in comparison with the other two cultivars Giza 171 and Giza 177 is a great problem because this cultivar is a high yielding and it is widely grown by the local farmers in cultivation in this area as a main food (Zein *et al.*, 2002c).

In a general with increasing irrigation water depth up to 7.5 cm decreased the amounts of absorbed elements, where the highest mean values usually recorded under the lowest depth of irrigation water of 2.5 cm. Irrigation depths 5 and 7.5 cm. may led to losses of a large amount of these elements with drainage water so, the contents in soil are low, subsequently, low absorbed amount by plants in comparison with the lowest irrigation depth 2.5 cm. The movement of these elements to drainage water is low so, highly increasing absorbed amount by plants under these conditions. These findings are in a good agreement with those obtained by Abou-Seada *et al.* (1997). Who found that the highest Cu, Zn and Cd concentrations were recorded under the strongly oxidizing conditions.

The problem is how to reduce the plant contents of such heavy metals under low irrigation rate? so treating the drainage water before mixing and irrigation with higher Fe, may be the simplest solution in that aspect.

REFERENCES

Abou-Seada, A.; S. Slayman and A. Khatter (1997). Cu, Zn and Cd content in rice plants and their fractions in soil amended with sewage sludge controlled pH and redox. Potential Egyptian Journal of Soil Science Vol. 37: 61-79, 1997.

Adriano, D.C. (1986). Trace elements in the terrestrial environment. New York: Springer-Verlage.

Barsoum, W.W. (1996). Effect of nitrogen sources on some micronutrients uptake. Annals of Agricultural Science. SPC. Iss P. 279-286.

El-Sanafawy, H.M.A.M. (2002). Geochemical investigation of soil and water on polluted areas in Mid. Nile Delta for Environmental assessment. Ph.D. Thesis, Fac. of Science, Geology Department, Mansoura University.

Jackson, M.L. (1967). Soil Chemical Analysis Prentice-Hall of India, New Delhi.

Mahrous, F.N.; S.A. Abd El-Hafez; A.Y. Badawi; M.A. Metwally and H.W. Tawadros (1984). Water management and irrigation schedule for rice production in North Delta Agric. Res. Rev., Egypt. 62(4A).

Oliver, M.A. (1997). Oil and human health: a review. European Journal of Soil Science, 48, 573-592.

Zein, F.I.; E.H. Omar; M.A.A. Abd Allah and M.S. El-Yamani (2002c). Influence of irrigation water quality on some crops, soils and water table and their content of heavy metals, at the Northern Nile Delta. Egypt. Egypt. J. Soil Sci., Vol. 42 (In Press).

Zein, F.I.; O.A. Hegab and M. El-Sanafawy, Hamida (1998). Geochemical studies on some polluted soils in Kafr El-Sheikh Governorate, Egypt. J. Agric. Sci. Mansoura Univ., Vol. 23(6): 2887-2918.

J. Agric. Sci. Mansoura Univ., 32 (11), November, 2007

دور محتوى التربة المائى على محتويات بعض نباتات الأرز من النحاس ، الحديد والمنجنيز بمنطقة شمال وسط الدلتا

ماهر محمد كساب ــ حميدة محمد انور الصنفاوى ــ السيد ابو الفتوح مرسى
معهد بحوث الاراضى والمياة والبيئة ــ مركز البحوث الزراعية

أجريت تجربتان حقليتان تم تنفيذهما بمحطة البحوث الزراعية بسخا لدراسة تأثير محتوى التربة المائى على محتويات بعض العناصر الثقيلة مثل النحاس ، الحديد والمنجنيز فى بعض أصناف الأرز. حيث كانت المعاملات الرئيسية هى حالة التربة المائية وهى:

١- محتوى رطوبى منخفض (٢,٥ سم = ٣/١ الطريقة التقليدية فى رى الأرز بالمنطقة).
٢- محتوى رطوبى متوسط (٥ سم = ٣/٢ الطريقة التقليدية فى رى الأرز بالمنطقة).
٣- محتوى رطوبى عالى (٧,٥ سم وهى الطريقة التقليدية بالمنطقة = ٧,٥سم).

كانت المعاملات تحت الرئيسية كانت عبارة عن أصناف الأرز والتى كانت فى الموسم الأول جيزه ١٧١ ، جيزه ١٧٧ كصنف طويل وقصير فى فترة نموه على الترتيب. ولكن فى الموسم الثانى تم إضافة صنف سخا ١٠١ كصنف متوسط النمو بالإضافة إلى جيزه ١٧١ ، جيزه ١٧٧.

أهم النتائج التى تم التوصل إليها فى تلك الدراسة:

تحت كل أصناف الأرز وحالات الرطوبة المختلفة محتويات العناصر موضع الدراسة كانت عالية فى القش عن الحبوب. وكانت أعلى القيم للعناصر المدروسة (نحاس ــ حديد ــ منجنيز) قد سجلت فى قش الصنف سخا ١٠١ والقيم هى: ١٣٢٩,٩ ، ٢١٥٠,٥ ، ١٠٦٨,٦ جزء فى المليون على الترتيب وعلى العكس من ذلك أقل القيم قد سجلت فى حبوب الصنف جيزه ١٧١ لعنصر النحاس ، ولكن بالنسبه للحديد والمنجنيز كانت فى الصنف جيزه ١٧٧ والقيم هى: ١٤٥١,٤ ، ٦٢٨,٠ جزء فى المليون على الترتيب.

النتائج أوضحت كذلك أن محتوى الحديد كان عاليا فى الحبوب والقش عن عنصرى النحاس والمنجنيز والقيم يمكن ترتيبها تنازليا هكذا حديد > نحاس > منجنيز.

وبصفة عامة ، زيادة محتوى التربة الرطوبى (تحت نظام الرى التقليدى) أدى إلى تناقص محتويات العناصر موضع الدراسة فى الحبوب والقش لأصناف الأرز المدروسة.

ولكن هذا يخالف الاتجاه المطلوب فى ترشيد استهلاك مياه الرى ولكن من الممكن معالجة مياة المصارف قبل خلطها مع مياه الرى ذو الجودة العالية والرى بالمعدل الاعلى (٧,٥ سم) والذى يؤدى الى تقليل امتصاص هذه العناصر فى حبوب وقش الارز.