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EFFECT OF NITROGEN FORMS AND RATES ON SOME HEAVY METALS AVAILABILITY AND RICE PRODUCTIVITY UNDER WASTEWATER IRRIGATION

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ABSTRACT

Water shortage in rice cultivation area in Egypt pushed rice farmer to use poor quality water in rice irrigation. Using the correct nitrogen form with the proper rate might be coping with the condition and possible heavy metals in such water. Two field experiments were conducted in 2010 and 2011 seasons at The Farm of Sakha Agriculture Research Station, Kafr-El Sheikh Governorate, Egypt. The soil texture was clayey. EC was 1.5dSm^{-1}. The study aimed to find out the effect of various nitrogen forms; Urea, ammonium nitrate and ammonium sulfate with varying nitrogen levels of 0, 109, 146 and 219 kg N ha^{-1} on Nickel (Ni), Cadmium (Cd) and Lead (Pb) concentrations in soil, rice straw and rice grain as well as yield and yield components of Giza 178 rice variety under poor quality water .The chemical analysis of irrigation water was as following, Ni 0.28, 0.27, Cd 0.15, 0.17 Pb 0.34, 0.36 mg kg^{-1}, ECw 2.66, 2.71 and pH 8.15 , 8.2 in the first and second seasons, receptively. Results indicated that the tested nitrogen forms and rate significantly affected the concentration of above-mentioned heavy metals, yield and yield components in both seasons. Ammonium sulfate was more efficient than other two nitrogen forms in minimizing heavy metals concentration in soil or rice plants and in enhancing yield and yield components under such poor quality water. The worst nitrogen form was ammonium nitrate regarding heavy metals concentration in plant or soil as well as yield and yield components of rice. Increasing nitrogen rate negatively affected the availability of heavy metals in soil, and their concentration in straw and grain of rice in both seasons. Furthermore, the increase nitrogen level (up to 146 kg ha^{-1}) significantly improved yield and yield components of rice in both seasons.

INTRODUCTION

Heavy metals are found ubiquitously in both polluted and unpolluted waters. Heavy metals are toxic to higher plants by causing oxidative stress, displacing other essential metals in plant pigments or enzymes, which cause disturbance in the function and of many metabolic processes, and finally reduce the growth and yield (Wang et al., 2003). Moreover, toxic heavy metals enter the food chain due to uptake and accumulation by crops which are posing a potential threat to human health.

Nitrogen (N is an important component of many structural, genetic and metabolic compounds in plants and of the total nutrients absorbed by plant roots (80% is contributed by nitrogen). It is taken up by plants through the two forms of ammonium (NH_4^+) and nitrate (NO_3^-), and some times NO_3^- is also reduced in plants to NH_4^+ for assimilation into amino acid, proteins and then nucleic acid. For better crop growth, a combination of ammonium (NH_4^+) and nitrate (NO_3^-) forms is preferred (Frechilla et al., 1999**).** One of the possible mechanisms to minimize heavy metals content in cereals and legumes is improving N nutrition. Rhizosphere chemistry, especially pH, is very important in determining the availability and absorption of nutrients and metals including Cd from soil (Oborn *et al.* 1995 Jansson and Oborn 2000). Roots have a profound influence on soil pH. Rhizosphere acidification occurs as a result of NH_4^+ nutrition due to the release of protons (H^+) by root cells or nitrification of NH_4^+, and this induced acidification can promote mobilization of a localized metals like Cd (Zaccheo *et al*. 2006**,** Loosemore *et al*., 2004). The type of N fertilizers applied will determine whether decrease or increase in heavy metal uptake with its application. Compared to NH_4^+ fertilizers, containing fertilizers NO_3^- could enhance Cd uptake due to a decrease in soil pH. However, the effect of counter ions in fertilizers like Ca in Ca $(NO_3)_2$ cannot be over looked. If applied at high rates, Ca in fertilizers could replace Cd present on soil particles, resulting in higher Cd concentration in the soil solution. However, this additive effect of counter ions like Ca on increased solubility and uptake of Cd is only possible at higher pH. At lower pH, the major effect on increased Cd uptake from soil would be of NH_4^+ leading to a decrease in soil pH **(**Nadeem *et al*., 2010**)**. In contrast to many researchers, Muhammad *et al*. (2005) stated that the treated rice plant with $(NH_4)_2SO_4$ growing under contaminated soil with heavy metals performed better regarding photosynthesis, growth and yield and yield components as well as less content of heavy metals particularly Cd rather than those treated by NH_4NO_3 or $Ca(NO_3)_2$. In addition Xie *et al*.(2009) recently investigated the effect of N form (NH_4NO_3) on growth and uptake of Cd and Zn by *Thlaspi caerulesscens* in hydroponics and rhizobox experiments and found that plants fed NO_3^- accumulated much more Cd than plants supplied with NH_4^+, even though the rhizosphere pH was lower in plants treated with NH_4^+. This NO_3^--induced heavy metal accumulation was speculated with the increase in organic acid exudation due to the accumulation of NO_3^- at the root surface. These contrasting results could also be related to the plant species used in the various experiments. Heavy metal concentration in wheat grain would decrease due to the dilution effect by binding to some protein molecules as more biomass production sequesters more heavy metal in vegetative parts and very little moves into the grain (Landberg and Greger, 2003). But Wangstrand *et al*. (2007) claimed that with application of a higher rate of N not to enhance biomass production but increase protein content of bread wheat grain, more heavy metal might be accumulated in plants. The time of N application is also important, because an extra dose of N applied at the vegetative stage enhance biomass production; however, during the grain filling stage, the application of an extra dose of N increase grain heavy metal concentration similar as NH_4^+ fertilization increases the availability of metals ions due to soil acidification (Zaccheo *et al*. 2006). So, heavy metal - contaminated soils, more N application should be done at the vegetative stage to increase biomass production, while high N doses during the grain filling stage to increase protein content should be avoided. This strategy can reduce the heavy metal accumulation in grain.

Pankovic *et al*. (2000) performed an experiment to analyze the effect of N nutrition on photosynthesis in Cd-treated sunflower plants with three low levels of Cd (0.5, 2 and 5 mmol m^{-3}) in combination with three N treatments (2, 7.5 and 10 mmol N m^{-3}). He also, concluded that N supply could be manipulated as a means of decreasing heavy metal toxicity to plants but optimum N to Cd ratios must be determined for specific plant species and growth conditions in which the optimum nitrogen rate was 7.5 mol m^{-3}. Ammonium ions cause cell membrane potential depolarization, which results in the influx of NH_4^+ into the cytoplasm of the root cells (Zaccheo et al., 2006). The increase of dramatically increase NH_4 uptake and reduces the Cd uptake by cells. But the mentioned mechanism increased the translocation of Cd from root to shoot in sunflower plants possibly due to lack of a detoxification mechanism (Zaccheo *et al*., 2006). However, activities of superoxide dismutase (SOD) and peroxidase (POD) increased in the case of NH_4 nutrition, which is considered a protective mechanism against stress. Peroxidase is also involved in lipids biosynthesis which acts as a physical barrier against heavy metals (Jalloh *et al*., 2009). On the other hand, in plants fed with NO^-_3 most of the Cd accumulated in roots due to the detoxification mechanism (Zaccheo et al., 2006). Furthermore, Jalloh *et al*. (2009) in a pot experiment found that NH_4SO_4 gave the highest value of rice growth, yield components and grain yield as compared with other forms. As well as a higher heavy metal concentration and less N accumulation in plants treated with NO^-_3-N, and the opposite results in the case of NH_4^+ treatment. Observation of plants indicated antagonistic interactions between NH_4^+ and Cd, and synergetic interactions between NO_3^- and Cd. An increase in SOD and POD activities was also more significant in plants treated with NH_4^+, which is considered a protective mechanism against Cd stress. The authors argued that Cd stress could be alleviated by choosing a specific form of N fertilizer.

Milton *et al.* (2009) stated that Ni content in both root and shoots was greater in ammonium nitrate–grown rice plants rather than ammonium sulfate or urea. Also, they indicated that the omission of either Mo or Ni led to a decrease in urease activity, independent of N source. Nitrate reductase activity increased in nutrient solutions without Ni, although NO_3^- increased. Furthermore, Makino (2007 and Orathai *et al*.(2010) reported that under rice submergence condition the heavy metals concentrations were reduced by washing, leaching and by sulfur sedimentation resulted in decrease heavy metals content in rice grains. Still, further research is needed to fully understand how N nutrition plays an important role to minimize heavy metals accumulation in plants, under different N levels.

MATERIALS AND METHODS

Site and Experimental design

Two field experiments were conducted during summer seasons of 2010 and 2011 at farm of Sakha Agricultural Research Station, Kafr el sheikh city (31^o N, 31.1^o E) at the tail of the Nile River. Three forms of nitrogen were applied in the form of Ammonium sulfate $(NH_4)_2 SO_4$, Ammonium nitrate ($NH_4 NO_3$) and Urea. Each nitrogen source was applied in three levels (109, 164 and 219 kg N ha^{-1}). There were a total of 12 treatments [i.e. (three forms of nitrogen X three levels of nitrogen and zero application]. Forty eight plots (counting 12 treatments replicated 4 times) were arranged into a split-plot design. The rice (Giza 178) seeds were sown in the last week of April in both seasons for nursery culture. Each plot area was 12 m^2. A basal dose of phosphorus was applied during land preparation at the rate of 36 kg P_2O_5 ha^{-1} as Ca $(H_2PO_4)_2$ (15.5%) and zinc was added at the rate of 24 kg Zn SO_4 ha^{-1} as $ZnSO_4$ in dry soil. Nitrogen was split-applied; 2/3 was incorporated before the first irrigation and 1/3 was applied at panicle initiation stage. After 25 days of the nursery, 3-5 seedlings were transplanted per hill at a spacing of 20x20cm. Results of soil testing are presented in Table 1. Water samples were taken during the growth period and the chemical characteristics of irrigation water were determined according to the procedures of Klute, 1986 (Table 1).

Soil analyses

Prior to the experiment, the soil was sampled from the plowed layer (20 cm depth), air –dried and passed through a 2-mm sieve. Soil texture was determined by the pipette method. Soil texture was determined by the modified Walkley and Black method as described by Allison, 1965. Total N was measured using kjeldehl method (Bremner and Mulvaney, 1982) water soluble phosphorus was determined colorimetrically by a spectrophotometer and the content of water soluble K were determined using an atomic absorption spectrophotometer (AAS). The pH was measured using a pH glass electrode in H_2O at a water:solid ratio of 1: 2.5, and the electrical conductivity of the solution (1:5) was measured using an electrical conductivity meter (Richards, 1954) the concentration of heavy metals were determined in a diethlenetriaminepentaacetic acid (DTPA) extract using an AAS. A hundred mL of 0.05 M DTPA per 10g of soil was shaken for 2 hours at room temperature, and then the solution was filtered (Lindsay and Norvell, 1978). The selected properties are given in Table 1.

Sampling and chemical analysis

Crop was harvested in the 1^{st} week of October from each treatment within the central area of $5m^2$ (2.5x2 m) to determine the grain yield (ton ha^{-1}). Also, yield contributing parameters such as number of panicle $hill^{-1}$, panicle length, panicle weight, number of filled grains $panicle^{-1}$ and number of unfilled grains were measured. Three hills of mature rice plants from each plot were also sampled for plant chemical analyses. Samples of shoot and grain of rice plant were selected to determine heavy metals concentration. The sampled plants were washed in tap water and deionized water in the order, then separated into straw and grains, over-dried in an oven at 80 ^oC to constant weight was done, then the grains were milled into powder for measurement of heavy metals content. At harvest time, soil samples were taken from paddy soil (0-30 cm) for determining available Nickel (Ni), Cadmium (Cd) and Lead (Pb). The sampled soils were dried in an air-circulating room, and then were treated to remove stones and plant residues, ground with wood grinder and passed through a 2mm nylon sieve. The sieved samples were collected and stored in plastic bags for measurement of pH and extractable heavy metals content.

Table 1: Chemical analysis of the experimental field soil and the used irrigation water

Analysis	Unit	Amount	Irrigation water	
Sand	%	11.59	2010	2011
Silt	%	32.93	-	-
Clay	%	55.48	-	-
Texture class	-	clayey	-	-
EC	dSm^{-1}	1.5	2.66	2.71
pH	-	7.52	8.15	8.20
Total N	$mg\ kg^{-1}$	48.5	-	-
Soluble P (Olsen)*	$mg\ kg^{-1}$	18.6	-	-
Water-soluble K	$meq\ kg^{-1}$	1.19	-	-
heavy metals		**Available**	**Total**	**Total**
Nickel (Ni)	$mg\ kg^{-1}$	0.18	0.28	0.27
Cadmium (Cd)	$mg\ kg^{-1}$	0.02	0.15	0.17
Lead (Pb)	$mg\ kg^{-1}$	0.16	0.34	0.36

***Olsen *et al.,* 1954**

For analysis of available heavy metals in soil, air-dried soils were extracted by a mixture containing 0.05 mol L^{-1} ethylene-diamine-tetra-acetic acid disodium (EDTA-Na_2), 0.01 mol L^{-1} $CaCl_2$ and 0.1 mol L^{-1} Tri-ethanolamine (TEA) (soil mixture ratio 1:2 at pH ¼ 7.0). Briefly, 20 ml of the EDTA solution (the EDTA $CaCl_2$- TEA mixture) was added to 10 g of soil sample placed in polypropylene tubes. The tubes were shaken on a rotating shaker for 3 h and then centrifuged (Page *et al.,* 1982). Metals contents in the supernatant liquid were measured with a flame atomic absorption spectrometry (FAAS). The same procedure without samples (blank) was used as control. For analysis of heavy metals in rice straw and grains, 1 g of milled dry sample was extracted by digestion with nitric acid (HNO_3), 10 ml for 3 h and then filtered (45mm). Contents of heavy metals were determined by FAAS. The same procedure without samples was used as blank. Three replications were conducted for each sample.

Statistical analysis

Data were statistically analyzed according to ANOVA test and treatment means were compared using least significant difference (LSD) using a statistical analysis by IrriStat program and the nitrogen forms and their levels were compared for heavy metals concentration in straw, grain and soil using the least significant difference (LSD) test at 5% level of significance.

RESULTS AND DISCUSSION

Effect of N forms and their levels on Ni, Cd and Pb in soil

Data in Table 2 showed that the various tested nitrogen forms and levels significantly influenced the concentration of the three tested heavy metals in the soil in both seasons. The application of nitrogen in the form of ammonium nitrate NO_3 NH_4 gave the highest values of heavy metals in the soil in both seasons without any significant differences with those produced by urea nitrogen form. On the other hand nitrogen application in the form of ammonium sulfate in the terms of NH_4SO_3 significantly gave the lowest values of heavy metals in the soil in both seasons. Unfertilized treatment by N significantly reduced NI, Cd and Pb concentrations in soil in the both seasons. It is hold true with the three studied heavy metals.

The interaction (Figure 1) between nitrogen forms and nitrogen levels had significant effect on the kinetics of the studied heavy metals in the soil. It was observed that increasing nitrogen level up to 219 kg N ha^{-1} use ammonium sulfate as nitrogen source significantly reduced the concentrations of the three tested heavy metals. On the other hand, increasing nitrogen levels beyond the level of 109 kg N ha^{-1} significantly increased the heavy metals concentrations in the soil solution at the case of both ammonium nitrate and Urea at the level of 219 kg N ha^{-1}. Since, Egyptian soil tend to be alkaline soil, the application of $(NH_4)_2SO_4$ might improve the chemical and physical properties as well as their drainage (Zayed *et al.,* 2011). At the same time, ammonium sulfate increases the solubility of some heavy metals which will leach or move to drain well and quickly under rice submergence due to conversion of sulfate. One other possibility, increasing nitrogen rate at the case of ammonium sulfate will increase the sulfur concentration which will complex the heavy metals and deposited them and reduced their availability in the soil as a result of sedimentation. It is worthy to mention that the concentrations of the three heavy metals in the soil are less the permissible limits of WHO/FAO. The current findings are in a good accordance with those reported by Makino (2007) and Orathai *et al.* (2010).

Table 2: Concentration of Ni, Cd and Pb mg kg^{-1} dry soil as affected by N forms and levels.

N forms	Ni		Cd		Pb	
	mg kg^{-1}					
	2010	2011	2010	2011	2010	2011
Urea	3.12 a	3.15 ab	0.199a	0.210a	4.23 a	4.20 a
NH_4 No_3	3.17 a	3.23 a	0.202a	0.213a	4.21 a	4.13 a
$(NH_4)_2So_4$	2.85 b	3.09 b	0.185b	0.179b	4.09 b	3.96 b
F Test	**	*	*	*	*	*
LSD (0.05)	0.178	0.070	0.013	0.015	0.104	0.108
N levels kg ha^{-1}						
0	3.22 a	3.34 a	0.213a	0.208a	5.32 a	5.34 a
109	3.15 a	3.12 b	0.178b	0.190b	4.16 b	4.17 b
146	2.94 b	3.09 b	0.192b	0.198ab	4.00 c	3.75 c
219	2.89 b	3.07 b	0.187b	0.193ab	3.23 d	3.13 d
F Test	**	**	*	**	**	**
LSD (0.05)	0.109	0.087	0.015	0.016	0.089	0.192
Interaction	**	**	**	*	**	**

Effect of N forms and levels on Ni, Cd and Pb in straw and grain of rice

Data presented in Tables 3 and 4 revealed that the favorable effect of using different N forms in minimizing heavy metals in the soil significantly reflected on heavy metals concentration on rice grain and straw (Table 3). Interestingly, the tested nitrogen forms significantly affected the concentrations of heavy metals in rice straw in both seasons. Especially ammonium sulfate form which gave the lowest values in tested heavy metals in grain and straw of rice.

Regarding Ni concentration in rice straw urea application had significant ability to reduce Ni concentration in rice grain and straw whereas; it occupied the second rank after ammonium sulfate in this concern. The effect of urea nitrogen source in Ni concentration was not coincided with that happened in rice straw. This contradictory effect might be due to the role of Ni element in urea metabolism inside the plant tissue as co-activator urease enzyme (Milton *et al.,* 2009).

The favorable effect of NH_4^+ in reducing heavy metals in rice straw contributed to its effect on their concentrations in soil as abovementioned. Other possibilities are; the antagonistic effect between NH_4^+ and some heavy metals such as Cd which was reduced its uptake, dilution effect and ammonium ions cause cell membrane potential depolarization, which results in the influx of NH_4^+ into the cytoplasm of the root cells reducing Cd uptake (Zaccheo *et al.,* 2006). Ammonium nitrate gave the highest values of all studied heavy metals in both seasons. Both Urea and ammonium sulfate were at the same level of significance in both seasons regarding the concentration of Cd and Pb in rice straw and that was corresponding with their effect in soil. The obtained results are in a good harmony with those reported by Milton *et al.* (2009), Jalloh *et al*. (2009) and Xie *et al*. (2009). On the other hand, the abovementioned results were in a contrast with those reported by (Nadeem *et al.,* 2010).

Regarding the effect of nitrogen levels, data in table 3 revealed that significant effects was given by the nitrogen levels on the concentration of the three heavy metals in rice straw in both seasons. The nitrogen level up to the higher studied one i.e. 219 kg N ha^{-1} significantly reduced the concentration of Ni and Pb in e rice straw in both seasons which gave the lowest values. Regarding Cd, increasing level beyond 109 kg N ha^{-1} didn't exert significant reduction in Cd concentration in rice straw. Minimizing the heavy metals by increasing nitrogen level might be attributed to the dilution effect and increasing biomass production.

It was observed that the straw content of heavy metals were higher than those obtained in unpolished rice grain in both seasons under nitrogen forms and levelsand that was clearly with using ammonium sulfate. Haytham *et at.* (2004) and Hammad *et al*.(2011) found that heavy metals content in unpolished rice is less than those obtained by rice straw. It is mentioning here the concentration of the studied heavy metals in either straw or grain of rice is less the permissible limits according to WHO/FAO.

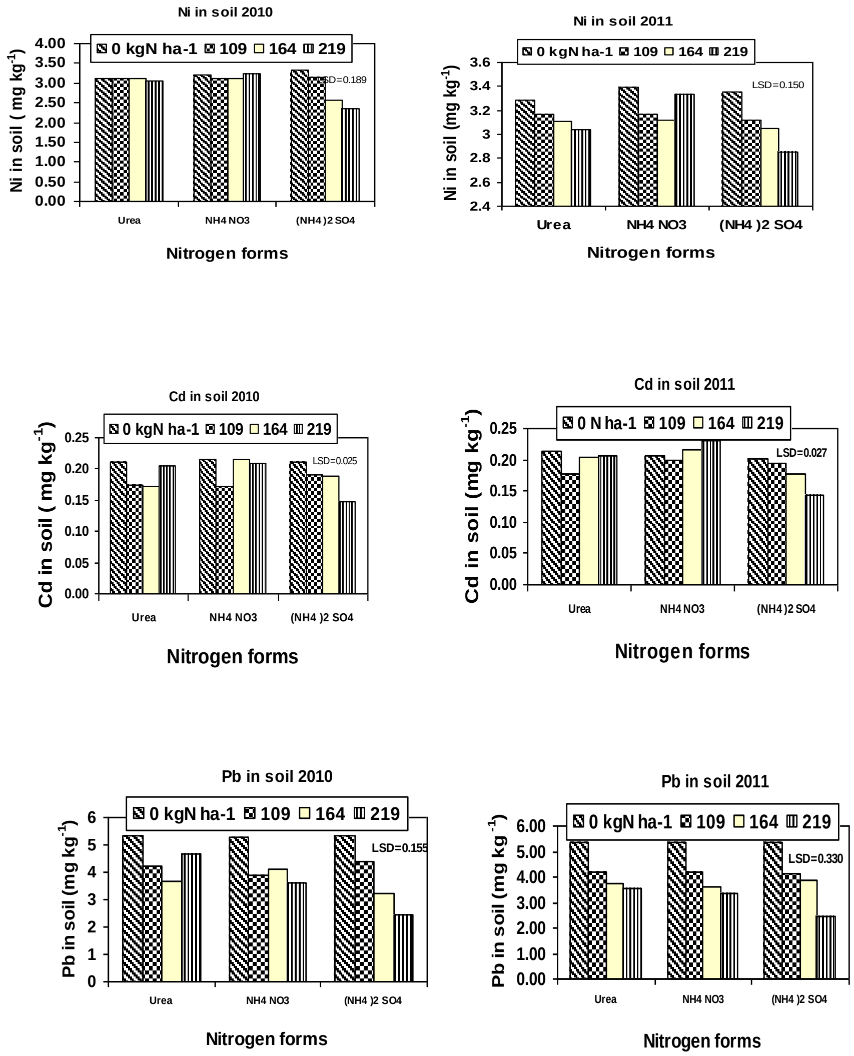

Figure (1): Availability of Ni, Cd and Pb mg kg^{-1} in soil as affected by the interaction between N forms and their levels during 2010 and 2011 seasons.

This finding are in a good conformity with those reported by Pankovic *et al*.(2000) and Wangstrand *et al*.(2007) and in a contrasting with Hammad *et al*.(2011) which reported increasing heavy metals in all rice organs with increasing urea rate and farm yard manure rate. With respect to the interaction effect (figures 2&3), the interaction between nitrogen forms and level had significant effect on the concentrations of heavy metals in either grain and straw yield in both seasons. From data related to the interaction, it ca be concluded that the heavy metals continue to decrease as nitrogen level progressively increased up to 219 kg N ha^{-1} when ammonium sulfate was used as nitrogen forms. Increasing nitrogen level beyond 109 kg N ha^{-1} increased the heavy metals content in rice straw and grain respectively when ammonium nitrate was used as nitrogen source. Regarding the response of heavy metals to nitrogen level, it was found that the nitrogen at the rate of 109 kg N ha^{-1} using urea form succeeded to reduce the concentration of Ni and Cd in rice grain and straw in both seasons. In continuously, the increasing urea application up to 219 kg N ha^{-1} significantly diminished the concentration of Pb in rice straw and grain in both seasons.

Table 3: Concentration of Ni, Cd and Pb mg kg^{-1} in rice straw as affected by N forms and their levels during 2010 and 2011 seasons.

N forms	Ni		Cd		Pb	
	mg kg^{-1}					
	2010	2011	2010	2010	2011	2010
Urea	9.97b	10.31b	0.395 b	0.400b	10.31b	9.97 b
NH_4 No_3	10.88a	11.59a	0.437 a	0.440a	11.59a	10.88a
$(NH_4)_2So_4$	9.88b	10.21b	0.376 b	0.390b	10.21b	9.88 b
F Test	**	**	**	**	**	**
LSD (0.05)	0.500	0.610	0.006	0.500	0.006	0.500
N levels kg ha^{-1}						
0	10.7a	11.52a	0.440a	0.440a	11.52a	10.70a
109	10.6a	11.04b	0.410 b	0.410b	11.04b	10.60 a
146	10.11b	10.45c	0.401 b	0.400b	10.45c	10.11b b
219	9.46c	9.75d	0.400 b	0.390b	9.75d	9.46c b
F Test	**	**	**	**	**	**
LSD (0.05)	0.470	0.430	0.005	0.005	0.430	0.470
Interaction	**	**	**	**	**	**

Table 4: Concentration of Ni, Cd and Pb mg kg^{-1} in rice grain as affected by N forms and their levels during 2010 and 2011 seasons.

N forms	Ni		Cd		Pb	
	mg kg^{-1}					
	2010	2011	2010	2011	2010	2011
Urea	2.975 ab	2.974 a	0.234 a	0.250 a	2.682 a	2.726 a
NH_4 No_3	3.077 a	2.987 a	0.230 a	0.241 a	2.578 b	2.644 b
$(NH_4)_2So_4$	2.899 b	2.876 b	0.197 b	0.200 b	2.542 b	2.549 c
F Test	*	*	**	**	**	**
LSD (0.05)	0.121	0.090	0.007	0.006	0.037	0.054
N levels kg ha^{-1}						
0	3.226 a	3.238 a	0.248 a	0.270 a	2.852 a	2.843 a
109	2.991 b	2.697 c	0.230 ab	0.240 b	2.689 b	2.700 b
146	2.940 b	2.915 b	0.235 b	0.240 b	2.609 c	2.638 c
219	2.778 c	2.932 b	0.233 b	0.237 b	2.251d	2.378 d
F Test	**	**	*	**	**	**
LSD (0.05)	0.089	0.121	0.006	0.007	0.045	0.049
Interaction	**	**	**	**	**	**

Form going discussion, it could be concluded that the ammonium sulfate was more efficient than other two tested nitrogen forms in reducing the concentration of heavy metals either in soil or in rice grain even though with using higher nitrogen level of 219 kg N ha^{-1}. The form of ammonium sulfate gave the highest values of abovementioned traits, except number of unfilled grains without any significant differences with those produced by urea nitrogen form in one season of the two study seasons.

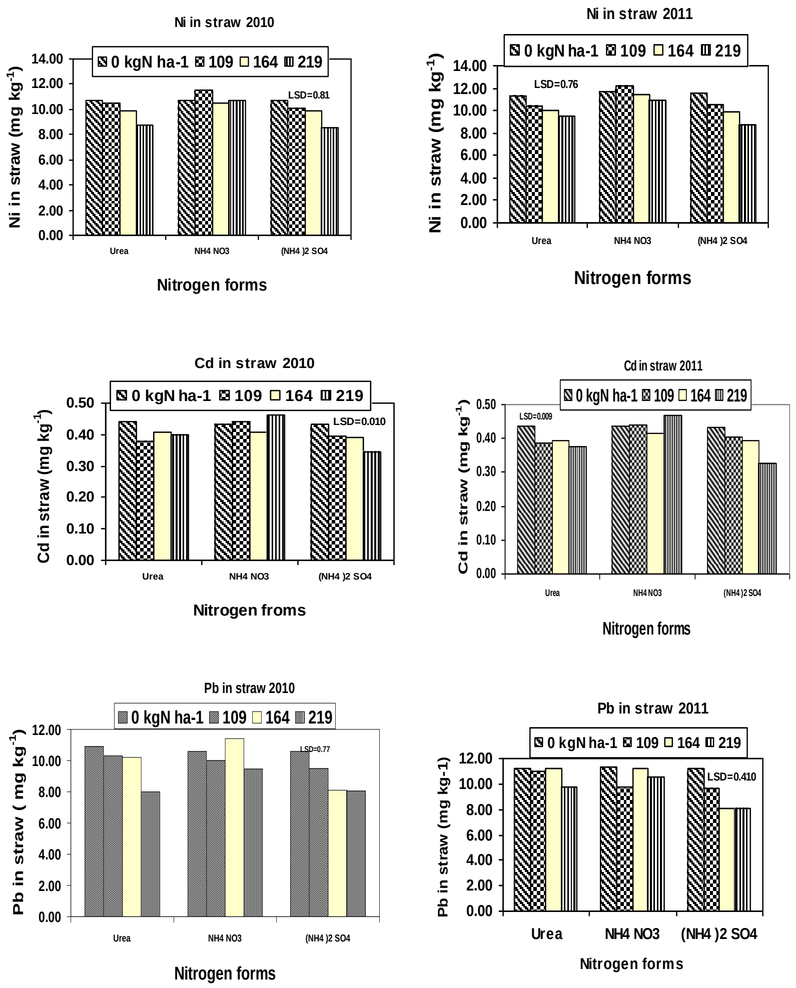

Figure 2: Concentrations of Ni, Cd and Pb mg kg^{-1} in straw as affected by the interaction between N forms and their levels during 2010 and 2011 seasons

On the other hand, the form of ammonium nitrate gave the highest values of number of unfilled grains in both study seasons followed by urea form. By the way, the lowest values of yield and yield components were produced by ammonium nitrate in both seasons.

Under poor quality water in the terms of contamination one by heavy metals, ammonium sulfate had higher efficiency for protect plants from the harmful effect of heavy metals by increasing protective antioxidant (Jalloh *et al*. 2009), increasing nitrogen uptake and photosynthesis rate during vegetative growth and during grain filling period leading to improve of yield components resulted in higher grain yield followed by urea.

Table 5: Number of panicle hill^{-1}, panicle length and panicle weight as affected by nitrogen forms and their levels during 2010 and 2011 seasons.

N forms	No of panicle hill^{-1}		Panicle length(cm)		Panicle weight(g)	
	2010	2011	2010	2011	2010	2011
Urea	16.89b	17.43a	19.06 b	19.05 a	2.73 a	2.78 b
NH_4 No_3	13.54c	14.24b	18.53 b	18.03 b	2.60 b	2.57 c
$(NH_4)_2So_4$	17.69a	17.80a	19.64 a	19.39 a	2.80 a	2.91 a
F Test	**	**	**	**	**	**
LSD0.05	0.51	1.13	0.556	0.375	0.088	0.107
N levels kg ha^{-1}						
0	15.07 d	15.13 c	17.85 d	17.58 c	2.55 d	2.32 c
109	15.86 c	15.74bc	18.82 c	18.83 b	2.60 c	2.64 b
146	16.51 b	17.22ab	19.48 b	19.30 a	2.89 b	2.98 a
219	17.25 a	17.87 a	20.15 a	19.58 a	3.10 a	3.06 a
F Test	**	**	**	**	**	**
LSD0.05	0.357	1.47	0.446	0.365	0.09	0.118
Interaction	ns	ns	**	**	*	**

Other possibilities that is the Egyptian soil tend to be alkaline as mentioned in table 1, the application of ammonium sulfate might be improved the physical and chemical soil properties resulted in improving rice growth and subsequently yield and yield components. On the other hand ammonium nitrate was less efficient that might be attributed to the higher nitrogen losses under submergence condition and its failure to reduce heavy metals uptake. Similar findings were reported by Zaccheo et al., 2006, Milton *et al*.(2009), Jalloh *et al*.(2009) and Xie *et al*.(2009). Regarding nitrogen levels impact, nitrogen fertilizer treatments had significant and positive impact on yield attributes in both seasons (Tables 5&6). Increasing nitrogen level up to 219 kg N ha^{-1} significantly increased panicle numbers hill^{-1}, panicle length and weight, number of filled grains panicle^{-1}and grainy yield t ha^{-1} in both seasons without significant differences with those produced by 146 kg N ha^{-1} regarding number of panicle hill^{-1}, panicle length and panicle weight in 2011, and filled grain per panicle and grain yield in both seasons. The tested higher nitrogen level of 219 kg N ha^{-1} gave the highest values of abovementioned traits in both study seasons. However, increasing nitrogen rates up to 219 kg N ha^{-1} pronounced reduced number of unfilled grains per panicle.

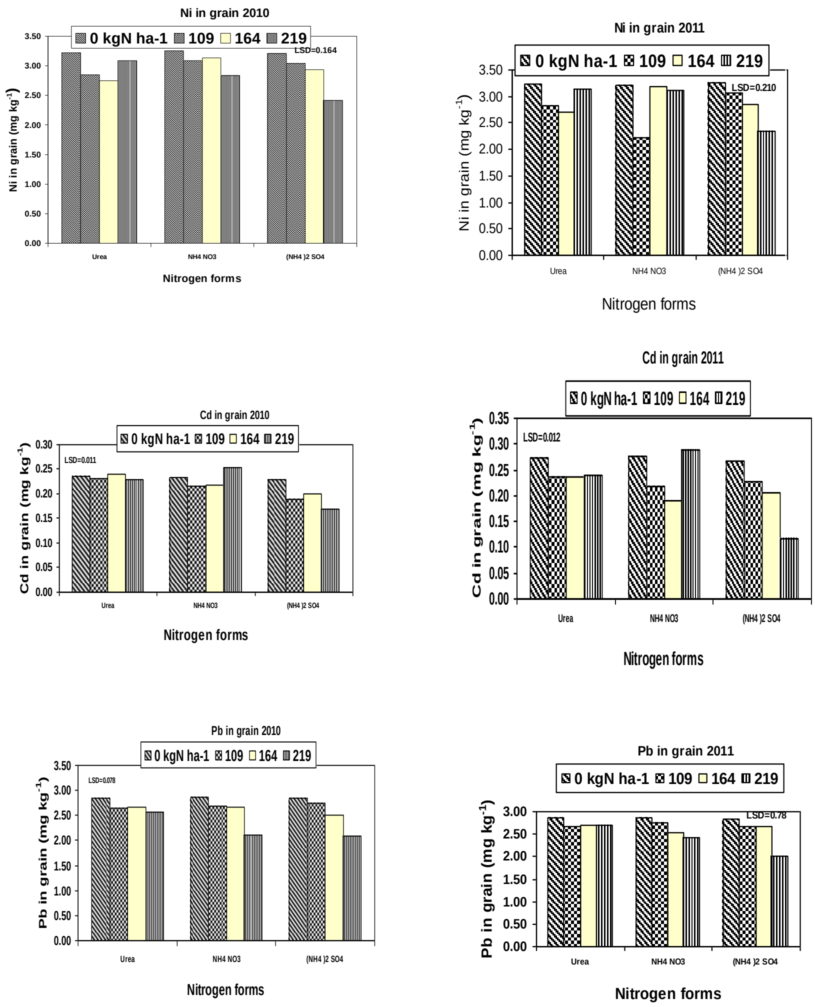

Figure 3. Concentrations of Ni, Cd and Pb mg kg^{-1} in grain as affected by the interaction between N forms and their levels during 2010 and 2011 seasons

The treatment without nitrogen application gave the lowest values of yield attributes, except unfilled grains where it gave the maximum value of it. The obtained improvement in yield attributes to the increase in the accumulation of photosynthesis from source to sink especially during grain filling as well as delaying leaf senescence. That might be also due to stimulate the vigorous growth superficial roots, increased the synthesis of cytokinins (mainly Zeatian) in roots, and delayed the appearance of the absesic acid (ABA) peak in both leaves and filling grains .High ratio of Zeatian /ABA enhanced the synthesis of RNA ,which resulted in protein synthesis for carbon assimilation and transportation (Yang and Sun, 1992) .The present findings are in good accordance with the results of Meena *et al.* (2003) ,Shivay and Singh .(2003) ,Gautam .(2004) and Zayed *et al* .(2005) as well as Zayed *el al*.(2006). With respect to the interaction effect, the interaction (figures 4and 5) between nitrogen forms and nitrogen levels had significant effect on panicle length, panicle weight, number of filled grain, number of unfilled grains panicle^{-1} and rice grain yield in both seasons. The results of interaction came to confirm the superiority of ammonium sulfate to higher nitrogen level of 219 kg N ha^{-1}. The latter combination gave the maximum values of abovementioned traits in both seasons. Also the results confirmed the inferiority of ammonium nitrate. At the same time, the results of interaction showed that the rice plants significantly responded to nitrogen level up to only 146 kg N ha^{-1} with using Urea as nitrogen form.

Table 6: Number of filled grains panicle^{-1}, number of unfilled grains panicle^{-1} and grain yield t ha^{-1} as affected by nitrogen forms and their levels during 2010 and 2011 seasons.

N forms	No of filled grains panicle^{-1}		No of unfilled grains panicle^{-1}		Grain yield t ha^{-1}	
	2010	2011	2010	2011	2010	2011
Urea	123.9b	122.9a	13.66c	18.75a	7.95a	8.20b
NH_4 No_3	118.2c	117.9b	18.63a	19.75a	6.69b	7.20c
$(NH_4)_2So_4$	127.8a	125.9a	15.29b	15.56b	8.19a	8.60a
F Test	**	**	**	**	**	**
LSD (0.05)	2.25	3.08	1.36	1.01	0.76	0.325
N levels kg ha^{-1}						
0	109.8c	108.5c	25.00a	25.92a	5.57c	6.05c
109	121.2b	119.8b	16.93b	19.08b	7.58b	7.80b
146	131.0a	129.8a	11.58c	15.17c	8.80a	9.00a
219	131.3a	130.8a	9.92c	11.92d	8.50a	9.15a
F Test	**	**	**	**	**	**
LSD (0.05)	3.33	2.85	1.76	1.11	0.805	0.38
Interaction	**	**	*	**	**	**

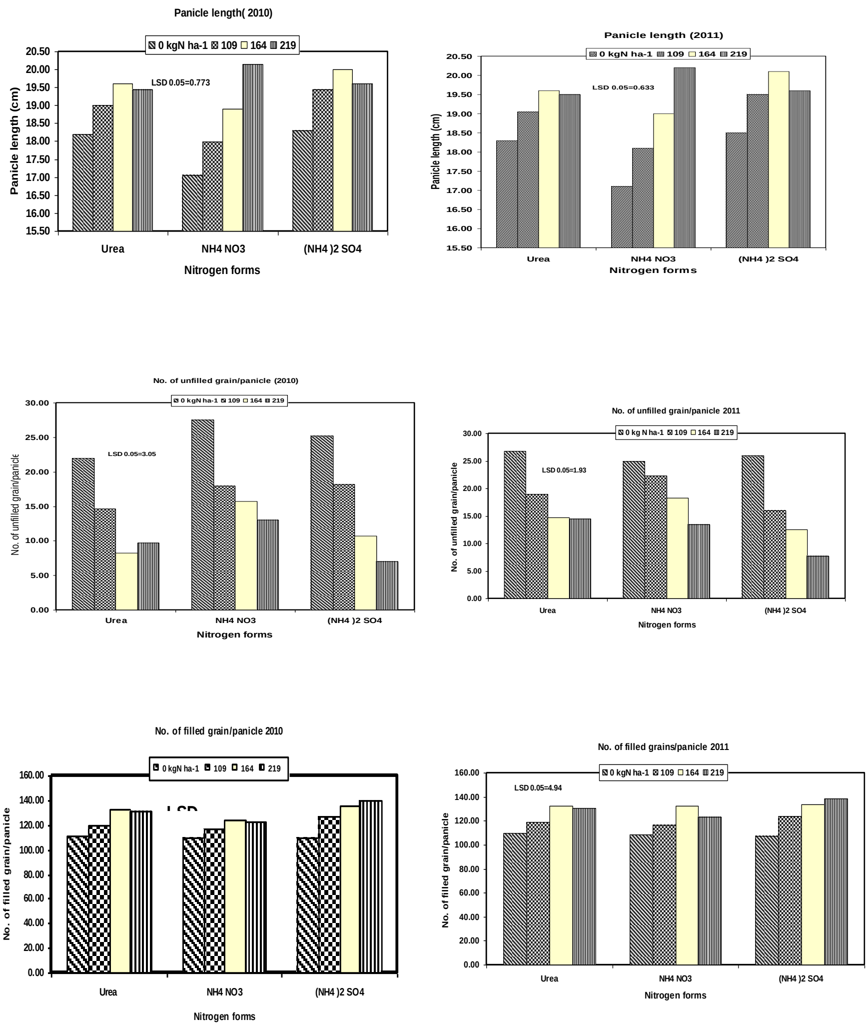

Figure 4: Panicle length, number of filled grains panicle^{-1}, and number of unfilled grains panicle^{-1} of rice as affected by the interaction between N forms and their levels.

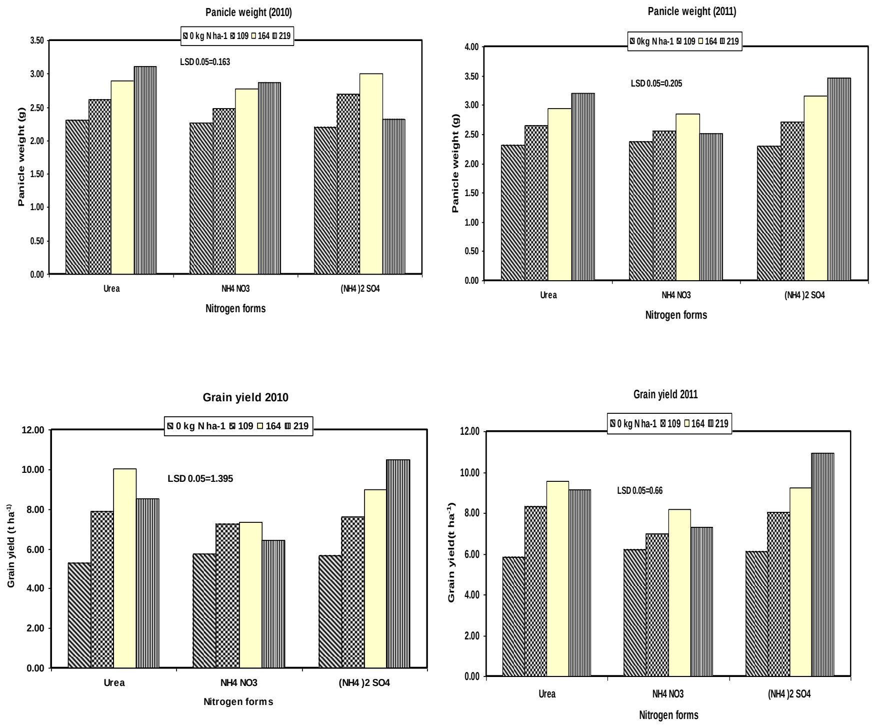

Figure 5: Panicle weight and grain yield of rice as affected by the interaction between N forms and their levels

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تأير صور و معدلات النيتروجين على التيسر لبعض العناصر الثقيلة وإنتاجية الأرز تحت ظروف استخدام مياه الصرف الزراعى

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يقوم بعض مزارعى الأرز بإستخدام مياه الصرف الزراعى فى كثير من مناطق زراعته نظرا لقلة مياه الرى وعليه فأستخدام المصدر النيروجينى الأفضل بالمعدل الأمثل وبما قد يساهم فى تقليل الأثر الضار الناتج عن وجود بعض العناصر الثقيلة بتلك المياه. أقيمت تجربتان حقليتان بموسم ٢٠١١,٢٠١٠ بمزرعة محطة بحوث سخا الزراعية بتربة طينية ذات درجة ملوحة ١.٥ ملليموز/سم. وهدفت الدراسة لإيجاد أثر مصادر النيتروجين المختلفة وهى اليوريا ونترات النشادر وسلفات الأمونيوم وكانت معدلات النيتروجين هى صفر ، ١٠٩ ، ١٤٦ ، ٢١٩ وحدة أزوت للهكتار وذلك على تركيز النيكل والكادميوم والرصاص فى التربة وقش الأرز وحبوب الأرز وكذلك على المحصول ومكونات الصنف جيزة ١٧٨ فى هذه الدراسة وكان تركيز العناصر الثقيلة فى المياه هو النيكل .٢٨ ، .٢٧ و الكادميوم ٠.١٥ ، ٠.١٦ والرصاص ٠. ٣٤ ، ٠.٣٦ ملجم/لتر فى السنتين على التوالى بدرجة توصيل كهربى ٢.٦٦ ، ٢.٧١ ملليموز/سم ، درجة حموضة ٨.١٥ ، ٨.٢ . وافادة النتائج أن مصادر النيتروجين أثرت على تركيز العناصر الثقيلة المدروسة فى كل من التربة والنبات (قش وحبوب) وكذلك أثرت على المحصول ومكوناته. وجد أن استخدام سلفات الأمونيوم كمصدر للتسميد النيتروجينى ذو كفاءة عالية فى تقليل تركيز العناصر الثقيلة أعلاه فى كل من التربة والنبات وكذلك أعطى أعلى محصول وتلاه اليوريا أما نترات النشادر فكانت الأسوء بخصوص ما ذكر. أثرت معدلات النيتروجين معنويا على العناصر الثقيلة والمحصول ومكوناته وأدت زيادة معدلات النيتروجين حتى ١٤٦ وحدة نيتروجين/هكتار فى زيادة المحصول ومكوناته وتقليل الناصر الثقيلة فى التربة والنبات سواءً عن طريق الغسيل أو التخفيف. وأوضحت نتائج التفاعلات أن أفضل مصدر سماد نيتروجينى هو سلفات الأمونيوم حتى معدل ٢١٩ وحدة نيتروجين/هكتار فى تقليل تركيز العناصر الثقيلة وزيادة المحصول ومكوناته ولذا يمكن التوصية به تحت مثل هذه الظروف.

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