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Effect of Nitrogen Fertilization on the Avilabillty of Cadmium in Wheat Plant (*Triticum aestivum* L.)

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ABSTRACT

A pot experiment was carried out at the greenhouse of Agricultural Research Station., Sakha, Kafr El Sheikh Governorate ,during the winter season of 2015/2016 to investigate tolerance of wheat (*Triticum aestivum L.*) crop to cadmium element and study the effect of N-fertilization (ammonium sulfate, calcium nitrate and urea) on availability of cadmium (0, 40, 80 and 120 ppm) under both clay and sandy soils. The results showed that clay soil was higher than sandy soil in the studied soil and plant traits. The negative effect of the interaction between cadmium and urea more than between cadmium and calcium nitrate followed cadmium and ammonium sulfate. Availability of cadmium led to reduce fresh, dry weight and N % in the straw and grain of wheat plant while increased Cd (mg kg^{-1}) in the straw and grain. The highest values of NH_4 and Cd (mg kg^{-1}) in soil were found due to interaction between clay soil, ammonium sulfate and 120 ppm Cd. On the other hand, the highest values of NO^{-}_3 (mg kg^{-1}) in soil were found due to interaction clay soil, Urea and120 ppm Cd.

Keywords: Nitrogen fertilization, Cadmium, Wheat, clay, sandy soils.

INTRODUCTION

Wheat is a major diet component in Egypt and worldwide because of its high adaptability for various environmental conditions, ease of grain storage and grains conversion into flour for several food industries in the newly reclaimed areas (Awika J. M. 2011). There is an urgent need to use low-water quality for wheat cultivation in marginal soils to compensate the Nile water shortage. As a result of the use of wastewater for irrigation, trace metals have accumulated in agricultural soils (e.g. Cadmium). It is important, therefore, to understand the tolerance of wheat crop to potential toxic elements and the effect of soil management practices on cadmium availability in the rhizosphere El Sharkawi and Metwally (2017). Cadmium is potential toxic element and reduces plant growth, when Cd accumulated above the threshold level induces various toxic responses in plants, maximum decrease in percent germination (68%), shoot length (81.2%), root length (70.4%) and germination index (76.8%) at 80 mg L^{-1} Cd compared to control. Cadmium is to be as one of the 7th most hazardous materials that can cause potential threat to human health due to its known and suspected toxicity by CERCLA (Comprehensive Environmental Response, Compensation, and Liability Act) of year 2011. ATSDR, (2011), Cd contamination in soil is an increasingly serious problem (Fan *et al.* 2017), Cd is a highly toxic heavy metal for both plants and animals (Sarwar *et al*., 2010). For Heavy metals negative effect on growth of wheat, increasing level of cadmium led to reduce both grain yield and its quality indices Fathi *et al.,* (2011) and Ahmad *et al*., (2012). Riaz *et al*., (2014) and Rizwan *et al*., (2016e) investigated that cadmium cause a reduction on root and shoot dry and fresh weights of wheat plant. Toxicity of Cd reduced wheat yield and the growth due to the adverse effect on both biochemical and physiological plant attributes Rady and Hemida, (2015). Cadmium concentration in plants and soil varies by soil type; Soil type has a significant effect on the availability of potential toxic elements (e.g. Cd) in the rhizosphere. Uptake of cadmium by Plant affected by many factors including: type and regime of fertilization, soil factors which responsible for solubilization / fixation of Cd in soil (such as Cd available and total, agricultural practices, pH, CEC phosphate, organic matter, clay minerals, CaCO3 and Biological processes) (Kirkham, 2006), (Grant, and Sheppard, 2008). The type of nitrogen fertilizers applied determined whether there would be an increase or a decrease in Cd uptake with its application (Sarwar *et al*., 2010). Effect of nitrogen fertilizer on cadmium in the soil solution, and to determine cadmium uptake as a function of rates of nitrogen fertilizer application as urea for wheat, which grown in a fine sandy loam soil, they found that cadmium concentration increased significantly with increasing nitrogen rate (Mitchell *et al*., 2000). Uptake for NH_4^+ excess for cation over anion with net proton extrusion, acidification for rhizosphere potentially increase availability for heavy metal as well cadmium Wu *et al*., (1989). Cadmium concentration was highest with NO^{-}_3-N and lowest with NH^{+}_4-N in plant tissues. Nitrogen accumulation in plant tissues was significantly higher in Urea-N and NH^{+}_4-N than other two N forms applied. Plant response to N supply under Cd stress also varies with genotypes Qin *et al*. 2009 and Rizwan *et al*., (2016e). The objective of this work is to investigate tolerance of wheat *(Triticum sp.var. Sakha)* crop to cadmium element and study the effect of N-fertilization (ammonium sulfate, calcium nitrate and urea) on availability of cadmium (0, 40, 80 and 120 ppm) under both clay and sandy soils.

MATERIALS AND METHODS

Experimental site

A pot experiment was carried out at the greenhouse of Agricultural Research Station., Sakha, Kafr El Sheikh Governorate, during the winter season of 2015/2016 to investigate tolerance of wheat (*Triticum aestivum L.*) crop to cadmium element and study the effect of N-fertilization on availability of cadmium with using two studied soils (clay and sandy soils). The obtained soil samples were air dried, crushed and passed through a 2-mm sieve. The two soils were analyzed for some physico-chemical properties as shown in Table 1.

Experimental design and Cultivation.

The combined effects of cadmium and N- fertilizers on growth and yield of wheat plant were investigated by combining four cadmium rates and three different sources of N-fertilizers under a split- plot design with three replicates for each treatment. Cadmium levels: C0-Without Cd application, C_1-40 ppm, C_2-80 ppm and C_3-

120 ppm, added as cadmium chloride ($CdCl_2$). As well as three different sources of N-fertilizers: (N_1) ammonium sulfate, (N_2) calcium nitrate and (N_3) urea as recommended dose.

To carry out the experiment, plastic pots (25 cm diameter and 30 cm depth) were filled by 6.0 kg air dried soil of the two studied soils (clay and sandy soils). All agricultural operations were performed according to the traditional local agriculture management practices. Planting date for wheat was the 23th of November, 2015. Wheat grain were sown in each pot and were thinned to 10 plants per pot after 20 days from planting.

Table 1. Some physical and chemical characteristics of the studied soils .

Characteristics of studied soils		Clay Soil	Sandy Soil
Particle size distribution (%)	Sand (%)	23.95	91.00
	Silt (%)	26.55	2.50
	Clay (%)	49.50	6.50
Soil texture		Clay	Sandy
F. C (%)		36.00	13.00
Saturation (%)		72.00	26.00
Calcium carbonate (%)		4.05	1.86
OM (%)		1.45	0.20
pH*		7.80	7.91
EC** (dSm^{-1})		1.06	0.90
soluble ions** $meqL^{-1}$	Ca^{++}	2.20	2.12
	Mg^{++}	2.00	2.61
	Na^{+}	3.20	3.16
	K^{+}	3.21	1.20
	Co_3^{--}	N.D***	N.D***
	HCO_3^{-}	0.41	1.33
	Cl^{-}	5.100	4.43
	SO_4^{--}	5.10	3.33
Available ($mg.kg^{-1}$)	N	45.40	10.50
	P	11.00	3.25
	K	290.30	95.00
	Cd	0.33	0.10

***Soil pH was determined in soil paste. **Soil Electrical Conductivity (EC) and soluble ions were determined in soil paste extract.**
*****N.D means not detected**

Fertilization and Irrigation.

Super phosphate (15.5 % P_2O_5) was added before planting, it was applied at a rate of 100 kg P $fed^{-1}$for wheat and all the agricultural operations were performed according to the usual local agriculture management. Nitrogen fertilization was applied in three equal doses after sowing using: (N_1) ammonium sulfate (20 %N), (N_2) calcium nitrate (15.5%N) or (N_3) urea fertilizer (46%N) at the rate of 100 and 130 kg N $Fed^{-1}$for wheat planted in the clay and sandy soils, respectively. Potassium sulfate (48 % K_2O_5) was applied at a rate of 50 kg $fed^{-1}$for wheat at 60 days after sowing in both soils. Irrigation was applied to reach the field capacity and the assumed field capacity was readjusted every week.

Harvesting.

Wheat plants were harvested at 135 days after sowing. After harvesting, plants were divided into shoots and roots , and the fresh weight was measured as (g pot^{-1}). Thereafter, sample were oven-dried at 70^{o}c until weight constant, ground manually and preserved for chemical analysis.

Plant analysis

To determine concentrations of nutrients in plant tissues, subsamples (0.2 g) was digested using 5 cm^3 from the mixture of sulfuric (H_2SO_4) and perchloric ($HClO_4$) acids (1:1) as described by Peterburgski (1968). Total N was determined using Micro kjeldahl apparatus as described by Jackson (1967). Total phosphorus was determined spectrophotomitrically by Milten Roy spectronic 120 at wavelength 725 nm as described by Peters *et al.,* (2003). Total potassium was determined by Jenway Flame photometer, Model corning 400 according to the modified method of Peters *et al.,* (2003). For Cd determination, 0.1 g from each sample was digested using microwave digestion apparatus (SensAA DUAL - GBC Scientific Equipment) using 5 ml HNO_3 (ultrapure), 2 ml H_2O_2 30 % and 0.5 ml HF. The mixture was put in microwave apparatus at 37 wt/12 min, and the digested sample was diluted into 50 ml vessels using redistilled water. The concentration of cadmium was analyzed by electrothermal atomic absorption spectrometery, Perkin elmer Model 5100.

Soil analysis

- Soil samples were air-dried, crushed, sieved to pass through a 2-mm sieve. To Judge perfectly on the soil physical and chemical properties, these methods were used according to the global standard methods. Particle size distribution (%) was carried out using the pipette method as described by Dewis and Freitas (1970). Saturation percentage (SP) of the soil was determined using the method described by Richards (1954). Soil organic matter content was determined by Walkley and Black method as described by Hesse (1971). Total carbonate was estimated geometrically using Collins calcimeter and calculated as calcium carbonate according to Dewis and Freitas (1970). Soil reaction (pH) was measured in soil paste using combined electrode pH meter as mentioned by Richards (1954). Electrical conductivity (EC) of soils was measured in the soil paste as explained by Jackson (1967). The amounts of water soluble cations (Ca^{2+}, Mg^{2+}, Na^+ and K^+) & anions (CO_3^{2-}, HCO_3^{-}, Cl^{-} and SO_4^{2-}) were determined in the extract of saturated soil paste by certified methods described by Hesse (1971). Sulfate was determined by calculating the difference between sum of cations (Ca^{2+}, Mg^{2+}, Na^+ and K^+) and anions (CO_3^{2-}, HCO_3^{-} and Cl^{-}). Available nitrogen in soil was extracted using 2.0 M KCl and determined by using macro-Kjelahl according to Hesse (1971). Available phosphorus in soil was extracted with $NaHCO_3$ (0.5 M) at pH 8.5 and determined calorimetrically by spectrophotometer (PG instrument-Model T80) after treating with ammonium molybedate and stannous chloride at a wavelength 725 nm, according to Jackson (1967). Available K was determined by extracting with ammonium acetate at pH 7 and measured using a flame photometer according to Hesse (1971). Available cadmium was extracted with diethylene-triamine-penta acitic acid (DTPA). The solution is made up of a mixture of 0.005 M DTPA, 0.1 M tri ethanol amin (TEA) and 0.01 M $CaCl_2$, adjusted to pH 7.3. The concentrations in extracts were analysed using an atomic absorption spectrophotometer; model of VARIAN specter AA. 20. Nitrate content in soil was extracted by 2% acetic acid using of N-1 naphthyle ethylene diamine dihydrochlorid as an indicator. A pinkish colour intensity of the filtrate was measured by a spectrophotometer at wave length 540 nm according to the method described by Singh, (1988). NH^+_4 concentration (mg Kg^{-1}) was calculated as follows : NH^+_4 (mg Kg^{-1}) = total nitrogen (mg Kg^{-1}) - NO^-_3 content (mg Kg^{-1}).

Statistical analysis.

All data were statistically analyzed according to the technique of analysis of variance (ANOVA), and the least significant difference (L.S.D) method was used to compare the deference between the means of treatment values according to Gomez and Gomez (1984). All statistical analysis was performed using CoStat software (Version 6.303, CoHort, USA, 1998–2004).

RESULTS AND DISCUSSION

1- Fresh and dry weights of wheat plant straw and grain at harvest:

Data in Table 2 show that effect of soil type was highly significant on fresh and dry weight yield of both straw and grain with a high superiority to clay soil (about three folds in most cases) given the abundance of available plant nutrients. Ammonium Sulfate showed superiority toward maximizing both fresh and dry weight yield of straw and grain this could be attributed to that $NH4^+$-containing fertilizers (Ammonium Sulfate) could result in enhanced Cd uptake due to a decrease in soil pH, also effect of calcium in $Ca(NO3)_2$ against Cd uptake (Sarwar *et al*., 2010). In addition, fresh and dry weight of wheat straw and grain yield significantly decreased with the increase of cadmium levels in irrigation water with all different sources of N-fertilizers. This trend was found under both soils types.

The highest values of the average for fresh (27.77, 23.27 and 23.66 (g pot^{-1}) and dry weight (4.51, 4.0 and 4.72) (g pot^{-1}) of wheat straw were obtained at clay soil, Ammonium Sulfate and control cadmium, respectively. The lowest averages for fresh and dry weight of wheat straw were obtained at sandy soil, Urea and 120 ppm of cadmium levels.

Cadmium showed an inhibitory effect to grain and straw yield. This was in according with those obtained by Riaz *et al*., (2014) and Rizwan *et al*., (2016e) investigated that cadmium causes a reduction on root and shoot dry and fresh weights on wheat plant.

The highest values of the average for fresh (55.24, 46.64 and 49.89 (g pot^{-1})) and dry weight (32.38, 29.73 and 29.55 (g pot^{-1})) of wheat grain were found at clay soil, Ammonium Sulfate and control cadmium, respectively. While, the lowest average for fresh and dry weight of wheat grain were obtained at sandy soil, Urea and 120ppm of cadmium levels.

Rizwan *et al*., (2016) showed that cadmium reduced wheat growth, biomass, germination, mineral nutrition, photosynthesis, and direct gas exchange of wheat plant due to the toxic effect of cadmium and the indirect Cd-induced oxidative stress.

Fig1. Show that the highest values of mean of fresh and dry weight (g pot^{-1}) of wheat straw were found due to clay soil + ammonium sulfate + control ppm of cadmium level which gave 33.14 and 8.01, and the lowest average of fresh and dry weight (g pot^{-1}) of wheat straw were found to be with sandy soil + Urea + 120 ppm of cadmium levels at harvest which produced ND (not detected- Plant death), but the highest values of average fresh weight grains and dry weight grains in wheat plant grains was found due to values of was clay soil * Ammonium Sulfate * control cadmium level 70.83 and 45.53 .While the interaction between sandy soil * Urea * 120 ppm cadmium level gave the lowest values ND (not detected- Plant death) .This result agreed with the finding of Mitchell *et al*., (2000).

Table 2. Means of fresh and dry weights (g pot^{-1}) of wheat plant straw and grain at harvest as affected by interaction between soil type, sources of N-fertilizers and different levels of cadmium.

Characters Treatments	Fresh weight of Straw (g pot^{-1})	Dry weight of Straw (g pot^{-1})	Fresh weight of grain (g pot^{-1})	Dry weight of grain (g pot^{-1})
	(A) Soil Type			
Clay Soil	27.77	4.51	55.24	32.38
Sandy Soil	9.87	1.69	20.90	12.12
F. test	**	**	**	**
	(B) N-fertilizers			
Ammonium Sulfate	23.27	4.00	46.64	29.73
Calcium Nitrate	20.28	3.19	39.67	23.19
Urea	12.91	2.11	27.92	13.83
F.test	**	**	**	**
LSD 0.05	0.31	0.048	0.83	0.57
	(C) Cd Level			
Control	23.66	4.72	49.89	29.55
40 ppm	19.50	3.44	37.82	22.82
80 ppm	17.52	2.49	33.95	20.17
120 ppm	14.60	1.76	30.64	16.46
F. test	**	**	**	**
LSD 0.05	0.376	0.106	1.44	0.43
	(D) Interaction			
A*B	**	**	**	**
A*C	**	**	**	**
B*C	**	**	**	**
A*B*C	**	**	**	**

2- Total nitrogen (%) and cadmium concentration in straw and grain at harvest:

Data in Table 3 show that the highest values of average total nitrogen (%) and cadmium (ppm) in wheat plant straw were obtained by the clay soil, ammonium sulphate and control cadmium ,which produced average total nitrogen, the values of 0.143, 0.132 and 0.136 % , respectively, but the best values of cadmium 1.907, 0.533 and 0 mg kg^{-1}, respectively.

The lowest values of average total nitrogen and cadmium in wheat plant straw were obtained by the sandy soil, Urea as source of N-fertilizer and 120 cadmium level ,which produced average total nitrogen the values of 0.073, 0.075 and 0.091 % respectively, but the values of cadmium 0.41, 2.573 and 2.85 mg kg^{-1}, respectively.

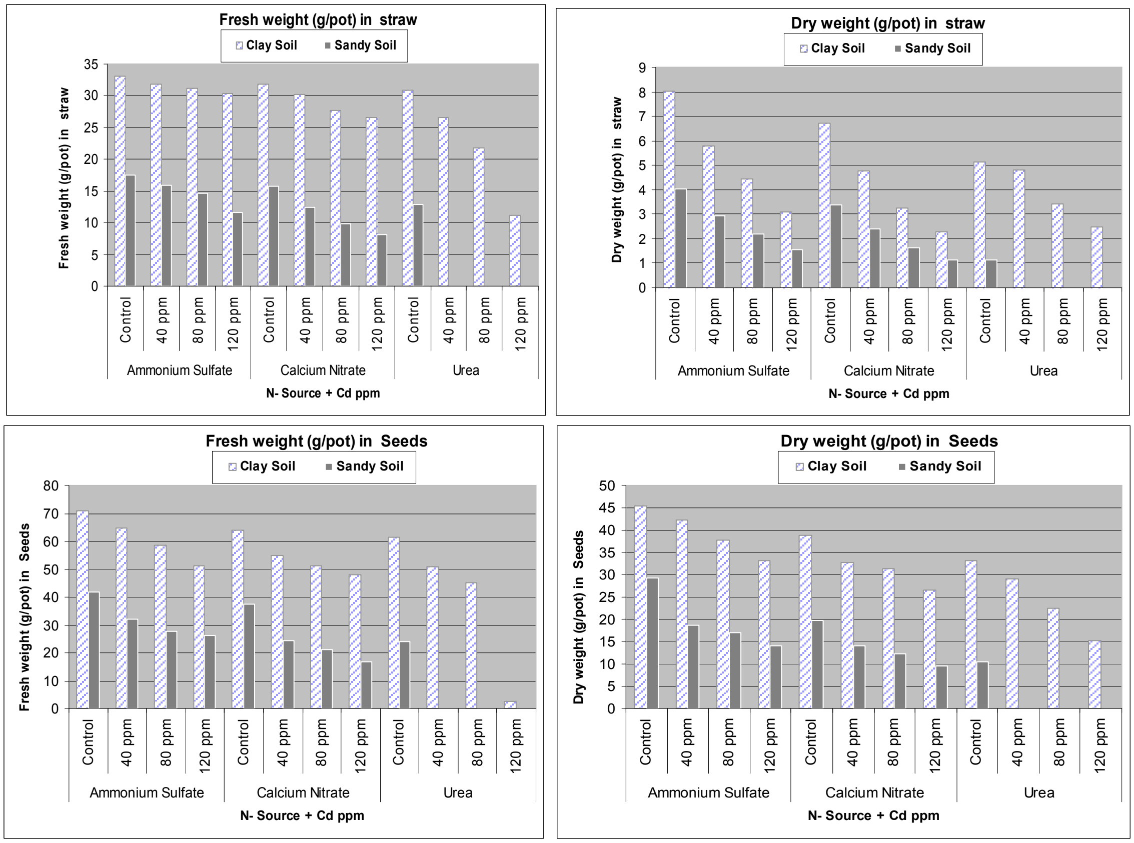

Fig. 1. Means of Fresh and dry weights (g pot^{-1}) of wheat plant straw and grains at harvest that is affected by the triple interaction among soil types, sources of nitrogen fertilization and cadmium level.

Table 3. Means of total nitrogen (%) and cadmium (mg kg^{-1}) in wheat plant straw and grain at harvest as affected by soils type, source of nitrogen fertilization and cadmium levels and their interactions .

Char. Treat .	N% in straw	Cd mg kg^{-1} in straw	N% in grains	Cd mg kg^{-1} in grains
A-Soil Type				
Clay Soil	0.143	1.907	0.319	1.092
Sandy Soil	0.073	0.410	0.163	0.163
F.test	**	**	**	**
B-F.type				
Ammonium Sulfate	0.132	0.533	0.315	0.088
Calcium Nitrate	0.117	1.181	0.263	0.571
Urea	0.075	2.573	0.146	1.860
F. test	**	**	**	**
LSD 0.05	9.23	0.071	0.0063	0.094
C-Cd Level				
Control	0.136	0	0.332	0
40 ppm	0.108	0.599	0.253	0.587
80 ppm	0.099	1.867	0.220	0.930
120 ppm	0.091	2.85	0.162	1.396
F.test	**	**	**	**
LSD 0.05	0.001	0.063	0.005	0.056
Interaction				
A*B	**	**	**	**
A*C	**	**	**	**
B*C	**	**	**	**
A*B*C	**	**	**	**

This demonstrated that cadmium concentration of wheat straw (mg kg^{-1}) at harvest stage significantly increased with increasing cadmium application levels and using urea fertilizer with irrigation water having 0, 40, 80 and 120 Cd ppm and induced a decrease in N % in wheat straw on both soils more than calcium nitrate and ammonium sulphate.

These results could be enhanced with those obtained by Marschner, (2011) and Rizwan *et al* ., (2016) . Also, the highest values of average total nitrogen (%) and cadmium (mg kg^{-1}) in wheat plant grains were obtained by the clay soil, ammonium sulphate and control cadmium ,which produced average total nitrogen the values of 0.319, 0.315 and 0.332 (%) respectively, but the values of cadmium 1.092, 0.088 and 0.00 (mg kg^{-1}), respectively.

On the other hand, The lowest values of average total nitrogen (%) and cadmium (ppm) in wheat plant grains were obtained by the sandy soil, Urea as source of N-fertilizer and 120 cadmium level, which produced average total nitrogen the values of 0.163, 0.146 and 0.162 (%) respectively, but the values of cadmium 0.163, 1.86 and 1.396 (mg kg^{-1}) , respectively .

This demonstrated that cadmium concentration of wheat grains at harvest stage significantly increased with increasing cadmium application levels and using urea fertilizer with irrigation water having 0, 40, 80 and 120 Cd ppm and induced a decrease in N % in wheat grains on both soils more than calcium nitrate and ammonium sulphate. These results could be enhanced with those obtained by Li *et al*., (2013); Ishikawa *et al*., (2015); Matraszek *et al*., (2016) and Rizwan *et al*., (2016).

Fig 2 illustrates, the highest values of average total nitrogen (%) in wheat plant straw and grains was clay soil * Ammonium Sulfate * control cadmium level. While lowest values ND (not detected) of average cadmium (ppm) in wheat plant straw and grains were obtained by the sandy soil, Urea as source of N-fertilizer and 120 cadmium level. This result agreed with the finding of Qin *et al*., (2009) who showed that cadmium concentration was highest with N-NO^-_3 and lowest with N-NH^+_4 in plant tissues.

3- NH^+_4, NO^-_3 and Cd (mg kg^{-1}) content in soil at harvest:

Data presented in Table 4 show that the highest values of average sum NH^+_4+ NO^-_3 (mg kg^{-1}) in soil at harvest were obtained by the clay soil, Urea and 120 ppm cadmium ,which produced average the value 56.11, 54.06 and 53.85 (mg kg^{-1}) , respectively. These results might be attributed to decrease Uptake of nitrogen by plant with the same of previous treatments. While the lowest values of average sum NH^+_4+ NO^-_3 (mg kg^{-1}) in soil at harvest were obtained by the sandy soil, ammonium sulfate as source of N-fertilizer and control Cd respectively. These results agree with Qin *et al*., (2009).

On the other hand, The highest values of average Cd (mg kg^{-1}) in soil at harvest were obtained by the clay soil, ammonium sulfate as source of N-fertilizer and 40 cadmium level ,which produced average the values 4.55, 5.23 and 5.21 (mg kg^{-1}), respectively. While, the lowest value were obtained by the sandy soil, urea and control Cd ppm 1.13, 1.14 and 0.00 (mg kg^{-1}), respectively. These results could be enhanced with those obtained by Mitchell *et al*., (2000) , Matraszek *et al*., (2016) and Rizwan *et al*., (2016) .

Table 4. Means of NH^+_4 , NO^-_3 and Cd (mg kg^{-1}) on soil at harvest as affected by soils type, type of nitrogen fertilization and cadmium levels and their interactions .

Char. Treat.	NH^+_4 (mg kg^{-1})	NO^-_3 (mg kg^{-1})	Cd (mg kg^{-1})
	A-Soil Type		
Clay Soil	22.40 Sum 56.11	33.71	4.577
Sandy Soil	14.55	12.33	1.13
F. test	**	**	**
LSD 0.05	0.21	0.67	0.13
	B- F. type		
Ammonium Sulfate	21.67	12.60	5.23
Calcium Nitrate	17.58	18.57	2.18
Urea	16.17 Sum 54.06	37.89	1.14
F.test	**	**	**
LSD 0.05	0.11	0.62	0.12
	C-Cd Level		
Control	14.33	16.63	0
40 ppm	16.41	19.96	5.21
80 ppm	19.47	25.33	4.06
120 ppm	23.69 Sum 53.85	30.16	2.15
F.test	**	**	**
LSD 0.05	0.11	0.62	0.07
	Interaction		
A*B	**	**	**
A*C	**	**	**
B*C	**	**	**
A*B*C	**	**	**

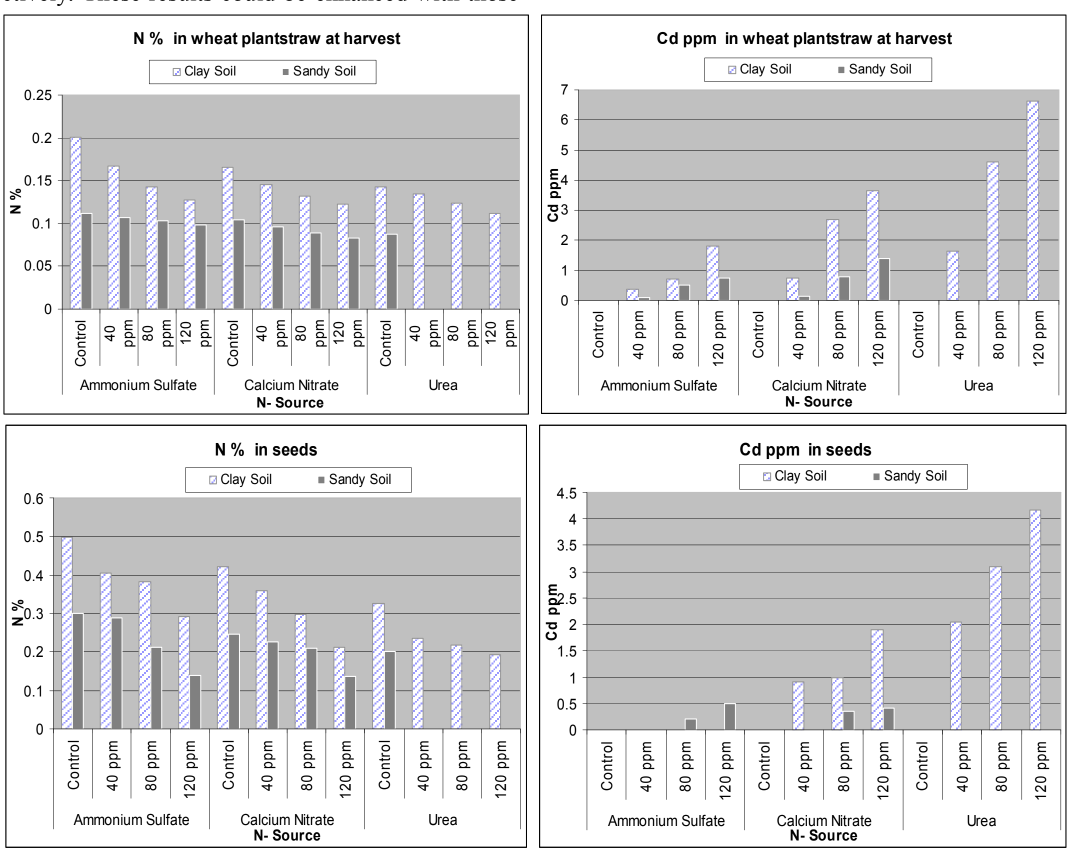

Fig. 2. Means of total N (%) and Cd (mg kg^{-1}) in wheat plant straw and grains at harvest as affected by the triple interaction among soils type, sources of nitrogen fertilization and cadmium level.

Fig(3) detected , the highest values of average NH^+_4 and Cd (mg kg^{-1}) in soil after harvest (mg kg^{-1}) was found due to clay soil* ammonium sulfate *120 ppm Cd, which recorded 31.66 and 14.56 (mg kg^{-1}), respectively. These results might be attributed to increase Cd total and acidification of soil due to sulfate anion and $NH4^+$-containing fertilizers could result in enhanced a decrease in soil pH, which increase availability of cadmium (Sarwar *et al*., 2010).. While the interaction between sandy soil* Urea * control ppm cadmium level gave the lowest values of NH^+_4 (8.26 mg kg^{-1}); these results might be attributed to decrease OM content and microbial activity which lead to decrease Mineralization operations in sandy soil. But, the lowest values of average Cd in soil after harvest was found by sandy soil * Calcium Nitrate * 40 ppm Cd - after control - which recorded (0.13 mg kg^{-1}).

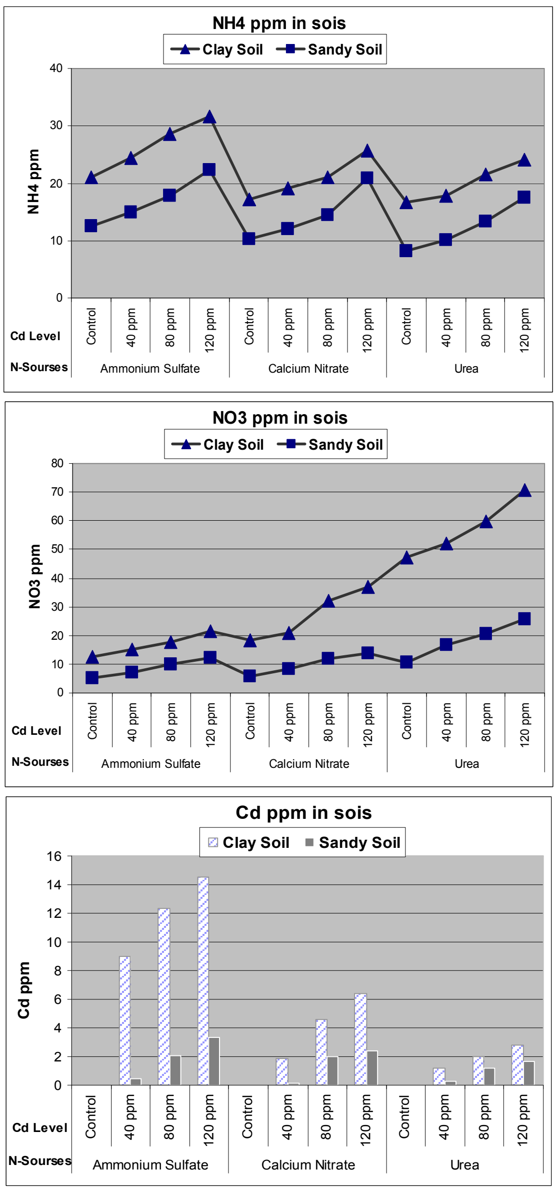

Fig. 3 . Means of NH^+_4, NO^-_3 and Cd (mg kg^{-1}) in soil after harvesting as affected by the triple interaction among soils type, sources of nitrogen fertilization and cadmium level.

On the other hand, the highest values of average NO^-_3 (mg kg^{-1}) in soil at harvest was found due to clay soil* Urea *120 ppm Cd, which recorded (70.76 mg kg^{-1}).While the interaction between sandy soil* ammonium sulfate * control ppm cadmium level gave the lowest values (5.10 mg kg^{-1}). These results might be attributed to increase OM content and microbial activity, which leads to increase Mineralization and Nitrification operations in clay soil, compared sandy soil.

CONCLUSION

Nitrogen fertilization led to increase uptake of cadmium by wheat plant. But, effect of Ammonium Sulfate on cadmium uptake was more than Calcium Nitrate and Urea, respectively. In addition, availability of cadmium due to nitrogen fertilization in clay soil was highest than in sandy soil.

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تأثير التسميد النيتروجينى على تيسر الكادميوم فى نبات القمح

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اجريت تجربة أصص فى الصوبة الزراعية بمحطة البحوث الزراعية فى سخا – محافظة كفر الشيخ خلال موسم ٢٠١٤ / ٢٠١٥ م لدراسة مدى مقاومة محصول القمح لعنصر الكادميوم ولدراسة تأثير الأسمدة النيتروجينية (كبريتات الأمونيوم , نترات الكالسيوم و اليوريا) على تيسر عنصر الكادميوم (صفر , ٤٠ , ٨٠ و ١٢٠ ملجم كجم$^{-١}$) باستخدام كلا من التربة الطينية والرملية . أظهرت النتائج أن التربة الطينية كانت أعلى من التربة الرملية في صفات المدروسة لكل من التربة والنبات، كما اوضحت النتائج ان التأثير السلبى بين تفاعل عنصر الكادميوم مع سماد اليوريا اعلى جدا من التأثير السلبى لتفاعل عنصر الكادميوم مع سماد نترت الكالسيوم ثم يليه تفاعل عنصر الكادميوم مع سماد كبريتات الامونيوم . تيسر عنصر الكادميوم ادى الى انخفاض الوزن الجاف و الوزن الرطب , النسبة الئوية للنيتروجين بالقش والحبوب مع زيادة عنصر الكادميوم ماجم كجم$^{-١}$ بالقش والحبوب . وجدت أعلى قيمة للأمونيوم مع الكادميوم ملجم كجم$^{-١}$ فى التربة الطينية باستخدام سماد نترات الكالسيوم عند مستوى ١٢٠ ماجم كجم$^{-١}$ كادميوم . بالجانب الاخر وجدت أعلى قيمة للنترات ملجم كجم$^{-١}$ بالتربة فى التربة الطينية باستخدام سماد اليوريا عند مستوى كادميوم ١٢٠ ملجم كجم$^{-١}$.