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FACTORS AFFECTING THE CHEMICAL BEHAVIOUR OF SOME AMMONIACAL NITROGEN FERTILIZERS IN TWO DIFFERENT SOILS

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ABSTRACT: Chemical behaviour of certain ammoniacal nitrogen fertilizers in a clay soil and a sand soil was studied. In a laboratory study, water soluble ammonium values in the sandy soil was greater than those in the clay one. Exchangeable ammonium values in the clay soil were more than those in the sandy soil. The greatest percent of nitrified nitrogen was found in the clay and sandy soils treated with NH_4 NO_3, whereas the clay and sandy soils showed the lowest one when NH_4 OH was used. The loss volatilization of nitrogen as NH_3 or the leaching loss from soil columns was greater from the sandy soil than from the clay soil. The NH_3 volatilization was greater from NH_4 OH compared with $(NH_4)_2SO_4$, NH_4NO_3 and NH_4Cl. Loss through leaching was greater from NH_4NO_3 compared with $(NH_4)_2SO_4$, NH_4 OH and NH_4Cl.

Key words: Ammoniacal nitrogen fertilizers, clay and sandy soils, N-leaching and ammonia volatilization.

INTRODUCTION

Under Egyptian soil conditions, there are some factors affecting the behviour of N-fertilizers such as pH value, calcium carbonate-clay and organic matter contents. These factors affect transformation of ammoniacal fertilizers. Studying the behaviour of ammoniacal nitrogen fertilizers under Egyptian soil conditions certainly will help effecient utilization of such fertilizers.

To accomplish this work, some factors such as soil texture, $CaCO_3$ content and loss of nitrogen by volatilization and leaching, which may affect available nitrogen in soil are studied using laboratory experiments.

MATERIALS AND METHODS

Materials

Soil sample

Two different soil samples were collected from the surface 0-30cm for this study. The soils were as follows:

1- A clay soil from an arable field in Abu-Hammad District, Sharkia Governorate, Egypt.

2- A Sandy soil from the Farm of the Faculty of Agriculture, at El-Khattara, Zagazig Univ., Sharkia Governorate, Egypt.

Soil samples were air dried, crushed, sieved through 2mm plastic screen, throughly mixed and stored in plastic bags for analysis and experimental work. Table 1 shows some physical and chemical characteristics of the studied soils.

Soil analyses were done according to methods described by Black *et al.* (1965).

Mineral fertilizers

Nitrogenous fertilizers used as nitrogen sources are ammonium sulphate (AS), ammonium nitrate (AN), ammonium hydroxid (AH), and ammonium chloride (AC).

Experimental methods

A laboratory study was carried out to assess the behaviour of some ammoniacal nitrogen fertilizers added to the clay and sandy soils.

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Water soluble and exchangeable ammonium-N in the soils

For determination of water soluble and exchangeable NH^{+}_{4} -N were extracted (Balba *et al.,* 1969) and determined according to the method described by Hesse (1971).

Nitrification of ammonium

Portions of 100 g of air dried soil in plastic pots (8cm diameter and 6cm high) were used. Nitrogen was added as $(NH_4)_2$ SO_4, NH_4 NO_3, NH_4 OH and NH_4Cl at the rate of 56 mg N/100g soil, (≡4 cmolc kg^{-1} soil).

The pots were placed at room temperature (about 25ºC) for one month. Soil moisture was maintained at the field capacity by adding the required amount of water every two days. Nitrate nitrogen in the soil was determined at the end of the incubation period using the methods described by Hesse (1971).

Ammonia loss by volatilization from different nitrogen fertilizers added to the investigated soils

Ammonia loss by volatilization was determined using modified micro-diffusion unit according to method described by Hesse (1971). Portions of 100g air dried soil were placed in the outer plastic container and 4% boric acid with bromo creasol green-methyl red indecator was placed in the inner container. The vessel was covered with a plastic lid sealed with vaseline. Nitrogen was added as $(NH_4)_2$ SO_4, NH_4 NO_3, NH_4OH and NH_4 Cl at the rate of 1g Nkg^{-1} soil. Soil moisture was maintained at field capacity through the experimental period. Treatments were replicated two times. The plastic vessels were covered and incubated at room temperature (about 25ºC) for one month. Evolved ammonia was trapped in boric acid and titrated with 0.01 M hydrochloric acid.

Nitrogen loss by leaching from different nitrogen fertilizers added to soils under study

Portions of 400g soil were packed in columns using plastic cylenders. The columns were 30cm long and 4.5 cm in diameter. The bottoms of cylenders were perforated to facilitate drainage. Nitrogen fertilizers such as $(NH_4)_2$ SO_4, NH_4NO_3, NH_4 OH and NH_4Cl were mixed through within the upper 5cm of the soil columns at the rate of 200 mg N per column (0.5 g/kg soil). The soil moisture was kept at field capacity. Soluble nitrogen forms of ammonium and nitrate were determined in leachates.

RESULTS AND DISCUSSION

Water Soluble and Exchangable of Ammonium Added to Soils under Study

Results in Table 2 show values of soluble and exchangeable ammonium ions. In studied soils, $(NH_4)_2$ SO_4, NH_4 NO_3 and NH_4 Cl, showed higher soluble and exchangeable ammonium ions as compared with the NH_4 OH fertilizer. The obtained results might be explained on the basis of acidity of those salts compared with the alkalinity of NH_4 OH, (Osman 1975) and Mohamed *et al.,* (1986).

Comparing the different soils, values of water soluble NH_4^+ in the sandy soil was greater than those in a clay soil. Values of exchangeable ammonium were higher in the clay soil than those in the sandy one reflecting the higher cation exchange capacity (CEC) of the clay soil.

Nitrification of Ammoniacal Nitrogen in Soil

The values representing the content of soluble NO^-- N as well as percents of nitrified nitrogen are shown in Table 3. Results, generally, showed that the absolute amounts of soluble NO^-_3 and percents of nitrified nitrogen in all treatments receiving fertilizers in the two studied soils increased as compared with those of the control. This caused the enhanced of microbial activity brought about by applied ammonium salts through the incubation period, (Ardakani *et al*., 1974; Osman, 1975; Mohamed *et al.,* 1986; Dahdouh *et al*., 2004 ; Merwad, 2009).

The values of NO^-_3 -N and percents N nitrified in the two different soils treated with NH_4 NO_3 were relatively higher than those of the other three fertilizers. NH_4NO_3 in these soils was more favourable for the maximum rate of nitrification (Tisdale and Nelson, 1970; Osman, 1975; Mohamed *et al.,* 1986).

The NO^-_3 - N given by NH_4OH was lower value than given by the other three fertilizers due to biological and chemical transformation of ammonia.

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

Soil property	Soil location		Soil property	Soil location	
Soil particles size distribution	Abu-Hammad	El-Khattara	Soluble cations and anions, $cmolcl^{-1}$	Abu Hammad	El-Khattara
Sand (%)	30.63	91.20	Ca^{++}	7.9	5.36
Silt (%)	20.30	2.59	Mg^{++}	6.1	4.00
Clay (%)	49.07	6.21	Na^{+}	6.85	3.72
Textural class	Clay	Sand	K^{+}	0.25	0.11
Field capacity (%)	30	12	$CO_3^{=}$	-	-
$CaCO_3$, (gkg^{-1})	10	28.5	HCO^{-}_3	3.8	2.8
Organic matter (gkg^{-1})	16.2	5	Cl^{-}	10.9	4.39
CEC cmolc kg^{-1} soil	42.0	9.0	$SO_4^{=}$	6.4	6.00
pH^{*}	8.2	8.0			
EC (dSm^{-1})**	2.1	1.26			

* Soil-water suspention 1:2.5 ** Soil paste extract

Table 2. Water soluble and exchangeable ammonium (cmolc kg^{-1} soil) as influenced by different N sources added to the two tested soils.

Treatment	Solube NH^{+}_4	Exch. NH^{+}_4
	Clay soil	
Untreated	0.06	1.09
$(NH_4)_2$ SO_4	1.00	3.7
NH_4NO_3	0.97	3.60
NH_4 OH	0.89	3.10
NH_4 Cl	1.30	3.50
	Sandy soil	
Untreated	0.02	0.36
$(NH_4)_2$ SO_4	2.52	1.65
NH_4NO_3	2.86	1.36
NH_4OH	2.40	1.40
NH_4Cl	2.60	1.70

Table 3. Nitrification of added nitrogen fertilizers after one month in two different soils

Treatment	NO^-_3 formed cmolc N/kg soil	Percent N nitrified
	Clay soil	
Untreated	0.90	-
$(NH_4)_2$ SO_4	3.10	55.0
NH_4NO_3	3.75	71.3
NH_4 OH	2.50	40.0
NH_4 Cl	3.08	54.5
	Sandy soil	
Untreated	0.30	-
$(NH_4)_2$ SO_4	1.80	37.5
NH_4NO_3	2.10	45.0
NH_4OH	1.30	25.0
NH_4Cl	1.70	35.0

The lowest NO^-_3 -N values and nitrified N percents were found in the sandy soil treated with NH_4OH, possibly due to its low cation exchang capacity and presence of $CaCO_3$. These results are in agreement with those obtained by Swart *et al.* (1971), Fenn and Kissel (1974), Mohamed *et al.* (1986) and Dahdouh *et al.* (2004).

Regarding the nitrified N percent in soils, results indicated that, this percent ratio was dependent upon the nature of ammonium source, the cation exchang capacity, and the calcium carbonate content. The nitrified N percent was higher in the clay soil than the sandy soil, indicating a reaction of the added ammonium fertilizers with the $CaCO_3$ in the sandy soil causing formation of $(NH_4)_2CO_3$, which dissotiates forming NH_3, which is lost by volatilization and losses of ammonia (Larsen and Gunary, 1962).

Compartive Loss by Volatilization of Ammonia from Nitrogen Fertilizers Added to the Investigated Soils

The susceptibility of ammoniacal fertilizers added to the soil to loss through volatilization as NH_3 was examined, Table 4 shows that loss of nitrogen added as fertilizers by volatilization as NH_3 was greater from the sandy soil than from the clay one. This is most certainly due to presence of $CaCO_3$ and also to the low cation exchang capacity of the sandy soil. Loss of nitrogen through volatilization was greater from NH_4OH than that from the other ammoniacal nitrogen fertilizers since NH_4OH is easily dissociated evolving NH_3 gas.

Ammonia volatilization is depends upon the nature of ammonium source, the cation exchange capacity, the soil content of calcium carbonate, the pH of the soil, the temperature, the depth of the fertilizer placement and the soil moisture content (Fuller, 1963, Mohamed *et al.,* 1986 ; Dahdouh *et al.,* 2004).

Loss of Nitrogen by Leaching from Applied Ammoniacal Fertilizers

Table 5, shows the loss of nitrogen in the leachates. The quantity of leached nitrogen from the sandy soil was greater than that from clay one. This is a demonstration of the soil texture, cation exchange capacity and fixation of ammonium in soils as well as the difference in nitrification rate (Fuller, 1963) and (Mohamed 1976). This finding is in agreement with that

Table 4. Loss ammonia by volatilization form nitrogen fertilizers added to the soils

Treatment	Clay soil	Sandy soil
	Percent N lost of added	
Untreated	1.2	0.5
$(NH_4)_2SO_4$	15.5	24.5
NH_4NO_3	5.3	10.7
NH_4OH	20.9	41.8
NH_4Cl	12.5	19.9

Table 5. The leaching losses of available-N from soils treated with various nitrogen fertilizers

Treatment	Clay soil		Sandy soil	
	mg N/ soil column	Added N (%)	mg N/ soil column	Added N (%)
Non-fertilized	2.00	-	0.0	-
$(NH_4)_2SO_4$	39.50	18.8	60.5	30.3
NH_4NO_3	55.80	27.9	93.5	46.8
NH_4OH	23.60	10.8	40.8	20.4
NH_4Cl	30.80	15.4	57.8	28.8

obtained by Mohamed (1976), Mohamed *et al.* (1986) Dahdouh *et al.* (2004) and Merwad (2009).

Comparing the different forms of nitrogen applied, the amount of available-N lost by leaching was in the following descending order: NH_4NO_3 > $(Nh_4)SO_4$ > NH_4cl > NH_4OH. This reflects the different nature of nitrogen sources. These findings are in agreement with those obtained by Fuller (1963), Mohamed *et al.,* (1976), Dahadouh *et al.* (2004) and Merwad (2009).

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العوامل المؤثرة على السلوك الكيميائى لبعض الأسمدة النيتروجينية الأمونيوميه فى أرضين مختلفتين

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يهدف هذا البحث إلى دراسة بعض العوامل المؤثرة على السلوك الكيميائي لبعض الأسمدة النيتروجينية في الصورة الأمونيومية فقد استخدم لهذه الدراسة بعض التجارب المعملية التى أجريت على أرضين مختلفتين فى القوام وهى عينة أرض طينية وعينة أرض رملية ولقد أوضحت الدراسات المعملية أن قيم الأمونيوم الحرة كانت مرتفعة فى الأراضي الرملية عنها في الأراضي الطينية، بينما قيم الأمونيوم المتبادلة كانت متعاظمة فى الأراضى الطينية عنها فى الأراضي الرملية، تعاظم معدل التأزت للنيتروجين الأمونيومى في الأراضي الطينية والرملية المعاملة بسماد نترات الأمونيوم بينما سماد أيدروكسيد الأمونيوم أعطى أقل معدل تأزت له فى التربة الطينية والرملية تحت الدراسة، كما أوضحت النتائج أن فقد النيتروجين بالتطاير أو بالغسيل كان أعلى ما يمكن من التربة الرملية إذا ما قورنت بالتربة الطينية كما تبين أن أعلى فقد للنيتروجين بالتطاير كان عاليا من سماد ايدوركسيد الأمونيوم إذا ما قورن مع أسمدة كبريتات الأمونيوم ونترات الأمونيوم وكلوريد الأمونيوم بينما كان أعلى فقد للنيتروجين بالغسيل من سماد نترات الأمونيوم إذا ما قورن مع أسمدة كبرتيات الأمونيوم ايدروكسيد الأمونيوم وكلوريد الأمونيوم.

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