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N- Mineralization of Organic Residues in Flooded and Aerated Saline Soils under Different Temperature

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Abstract: Serious of incubation studies were conducted at Department of soil Science and Water Resources, College of Agriculture, university of Basrah to study the effect of temperature incubation and soil salinity levels (3, 6, 12 and 24) $dS.m^{-1}$ on N mineralization of cow manure and alfalfa residue under aerobic and flooded conditions. Fifteen gram of air dry soil with salinity levels of 3, 6, 12 and 24 $dS.m^{-1}$ treated with 5% of cow manure or alfalfa residue were incubated at 10, 20 or 30 ˚C for 28 days. Moisture level of incubated soil was kept at either field capacity or flooded condition. NH_4^+ -N and NO_3^--N concentration of incubated samples were determined at the end of incubation period. Results showed that organic residues added to soils of all salinity levels increased NH_4^+ -N and NO_3^- - N. Concentrations of both ions were higher in alfalfa residue treatment than those of cow manure at all treatments. Highest concentrations of NH_3^+ -N and NO_3^-- N ions in all treatments obtained at samples incubated at 30 ˚C and E.C. of 3 $dS.m^{-1}$. Organic N mineralization under F.C. was higher than under logged water for all treatments.

Key words: NH_4^+, NO_3^-, Flooded , Field Capacity, Salinity, Temperature.

Introduction

Nitrogen is one of most important nutrient for plant growth. It involves in chlorophyll, proteins, enzymes, plant growth requires, among other (Leip *et al*., 2008). Plant absorbs N as NH_4^+ and NO_3^- which usually supplied to plant by mineral and organic fertilizers. Organic fertilizers usually used by farmer as a supplementary for mineral N fertilizers (Ryals & Silver, 2013). Organic nitrogen fertilizers are represented by manures, plant residues and urea. The N component of manure and plant residues is mostly in protein form. The nitrogen as compounds in pretentious material undergo the following microbial decomposition:

$$\text{Soil – organic – N} \rightarrow R - NH_2 + CO_2 + \text{other products} + \text{energy} \;\ldots\ldots..(1)$$

$$R - NH_2 + H_2O \rightarrow H_2O \downarrow NH_4OH + ROH + \text{energy} \;\ldots\ldots..(2)$$

Microbial decomposition of organic N in soil affected by properties of organic residues such as C/N ratio, easily or non-easily decomposable organic molecules such as lignin and other compounds_among other properties. In addition soil properties such as pH, CEC and E.C. (Sahrawat, 2010), temperature (Wetterstedt, 2010) and soil moisture show significant effect on organic N mineralization in soil. In addition Abbasi *et al*. (2015) pointed that C/N of organic residue is a major factor affected the N mineralization process in soil. Soil moisture and salinity levels of irrigation water averages throughout the growing season, which in turn effect soil microorganism activity and biological process in soils. Hence, this study was carried to study the mineralization of cow manure and alfalfa residue under different moisture levels(F.C and logged water condition) and soil temperatures (10, 20 and 30 °C) with different salinity levels (3, 6, 12 and 24 $dS.m^{-1}$).

Materials & Methods

Surface soil sample was collected from depth of 0-30 cm from a field located at Basrah province, southern part of Iraq. Some physical and chemical properties of the soil were determined following procedures described by Page *et al*. (1982) and presented in table (1). Initial electrical conductivity (E.C) of collected soil was raised to 3, 6, 12 and 24 $dS.m^{-1}$ through leaching with mixture of NaCl, $CaSO_4$ and $CaCl_2$ or decreased to 3 $dS.m^{-1}$ through leaching with distilled water, then soil samples were air-dried. Some chemical properties of soil after adjusting of E.C were determined according to Page *et al*. (1982) and presented in table (1).

Table (1): Some chemical and physical and biological properties to soil.

Property	Initial	EC ($dS.m^{-1}$)				Measure unit
E.C.	7.06	3	6	12	24	$dS.m^{-1}$
pH	7.94	7.97	7.95	7.92	7.89	-
CEC	20.43	20.40	20.42	19.90	17.50	$Cmol^{(+)} kg^{-1}$
Organic matter	13.00	-	-	-	-	$gm. kg^{-1}$
Organic carbon	7.55	-	-	-	-	
Total nitrogen	1.50	-	-	-	-	
C:N	5.03	-	-	-	-	-
NH_4-N	19.50	3.40	3.80	3.0	2.6	$mg. kg^{-1}$
NO_2-N	0.00	0.00	0.00	0.00	0.00	
NO_3-N	2.90	0.17	0.15	0.14	0.10	
$CaCO_3$	293.00	359.00	362.00	368.00	371.00	$gm. kg^{-1}$
Ca^{+2}	16.00	8.00	14.00	24.00	45.00	$mmol. L^{-1}$
Mg^{+2}	9.00	4.00	10.00	18.00	41.00	
Na^{+}	17.00	5.00	10.00	22.00	43.00	
K^{+}	3.00	1.50	3.00	9.00	18.00	
$CO_3^{=}$	0.00	0.00	0.00	0.00	0.00	
HCO_3^{-}	7.00	4.00	7.00	15.00	30.00	
Cl^{-}	16.00	5.00	12.00	28.00	56.00	
$SO_4^{=}$	22.00	10.00	20.00	36.00	72.00	
Soil texture			clay			$gm. kg^{-1}$ soil

Cow manure or alfalfa residue were mixed with soils at rate of 5% (organic source soil). Some chemical properties of organic source were determined according to Page *et al.* (1982) and presented in table (2). Fifteen grams (on dry soil bases) of the soils of different salinity levels treated with organic sources were placed in containers and incubated at three temperatures (10, 20 and 30 ˚C) for 28 days. The soil moisture of incubated samples was kept at either field capacity or logged water condition throughout incubation period. Desired moisture levels of incubated samples were maintained by periodic weighing of the containers.

Table (2): Some chemical properties to organic source.

Property (Unite)	Alfalfa residue	Cow manure
pH (5:1)	5.90	6.80
E.C (5:1) ($dS.m^{-1}$)	6.89	7.10
Organic matter ($gm. kg^{-1}$)	655.66	635.02
Organic carbon ($gm. kg^{-1}$)	381.20	369.20
Total nitrogen $gm. kg^{-1}$	46.50	29.20
Total phosphor ($gm. kg^{-1}$)	1.30	1.90
C:N Ratio	8.20	12.64

At the end of incubation period, samples were air-dried and mineralized N (NH_4^+-N and NO_3^- + NO_2^-) were determined by steam distillation following procedure of Bremner & Edwards (1965). The study was carried as factorial experiment with three replicates in complete randomized design. Data were analyzed using GenStat program.

Results & Discussion

NH_4^+ - N released

Results of tables (3 and 4) showed that increasing incubation temperature from 10 to 30˚C at all treatments resulted in significant increase in NH_4^+ -N released from both source of organic residue as well as from control treatmet at both moisture levels (F.C and logged water) and all salinity levels. Average of NH_4^+ - N increased from 159.0 to 318.1 mg kg^{-1} soil in samples incubated under F.C (table 3) and from 227.0 to 451.56 mg kg^{-1} soil in samples incubated under logged water condition (table 4). Amount of NH_4^+ - N produced in soil samples incubated under different soil moisture were significantly differ being higher for soils incubated under logged water then F.C (t value = 4.527).

Similar results were reported by Pérez-Batallón *et al.* (2001) and Cenkseven *et al.* (2017), who showed that increase soil temperature resulted in higher soil microorganisims activity, which in turn increase organic residue decomposition in soils. Data of tables (3 and 4) also revealed that NH_4^+ -N concentration in soil treated with organic residues were higher than of control treatment at both moisture levels.

NH_4^+ -N values were higher in soils amended with alfalfa residue (average 254.0 mg.kg^{-1}) than their counterparts of soil treated with cow residue (average 250.4 mg.kg^{-1}). However, lowest value was recorded at control treatment (196.9 mg.kg^{-1}) in soil under F.C (table 3).

However, different trend for NH_4^+ - N concentration was recorded at soils incubated under logged water condition. Values of NH_4^+ -N concentration were 464.44 mg.kg^{-1} as

Table (3): Effect of salinity levels and temperature on NH_4^+ - N mineralization in soil treated with cow manure or alfalfa residue incubated under F.C.

Source	Salinity levels (dS.m^{-1})	Temperature °C 10	20	30	Salinity level × source
Control	3	168.0	205.3	308.0	227.1
	6	158.7	177.3	289.3	208.4
	12	149.3	168.0	226.0	181.1
	24	121.3	140.0	251.3	170.9
Cow manure	3	205.3	345.3	392.0	314.2
	6	196.0	280.0	308.0	261.3
	12	168.0	224.0	280.0	224.0
	24	158.7	196.0	252.0	202.2
Alfalfa	3	185.7	391.3	656.0	411.0
	6	152.3	278.0	477.3	302.6
	12	132.3	172.3	198.7	167.8
	24	112.3	112.3	179.0	134.6
RLSD 0.05			55.71		233.7
Average effect temp.		159.0	224.2	318.1	Average type source
RLSD 0.05			16.08		
Type source × temp.	control	149.3	172.7	268.7	196.9
	Cow manure	182.0	261.3	308.0	250.4
	alfalfa	145.7	238.5	377.8	254.0
RLSD 0.05			27.85		233.7
					Average of effect salinity
Salinity × temp.	3	186.3	314.0	452.0	317.4
	6	169.0	245.1	358.2	257.4
	12	149.9	188.1	234.9	191.0
	24	130.8	149.4	227.4	169.2
RLSD 0.05			32.16		233.7

average in soil amended with cow manure and 304.39 mg.kg^{-1} as average in soil amended with alfalfa residue.

NH_4^+ -N in control treatment recorded value of 192.11 mg.kg^{-1} soil (table 4). Result of Abbasi *et al*. (2015) showed that organic residue added to soil increased NH_4^+ -N concentration.

Results of table (3) showed significant effect of organic sources on NH_4^+ - N concentration in soil being higher for logged water level than under F.C level (t value = 4.527). Increasing salinity levels from 3 to 24 dS.m^{-1} decreased NH_4^+ -N concentration from 317.4 to 169.2 mg.kg^{-1} in soils of field capacity treatment (table 3) and from 401.78 to 264.56 mg.kg^{-1} in soil incubation under logged water condition (table 4). These results are in accord with that of Inamura *et al*. (2009) and Walpola & Arunakumara (2010), who showed that increasing

Table (4): Effect of salinity levels and temperature on NH_4^+ - N mineralization in soil treated with cow manure or alfalfa residue incubated under logged water.

source	Salinity levels (dS.m^{-1})	Temperature °C			Salinity level × source
		10	20	30	
control	3	175.0	182.0	420.0	259.0
	6	147.0	161.0	294.0	200.67
	12	126.0	147.0	208.67	160.56
	24	105.0	140.0	199.67	148.22
Cow manure	3	312.67	336.0	582.0	410.22
	6	179.0	246.0	552.67	325.89
	12	157.0	202.0	403.0	254.0
	24	152.33	149.0	336.0	227.44
alfalfa	3	459.0	515.0	634.33	536.11
	6	332.33	440.67	616.0	463.00
	12	298.67	418.33	605.0	440.67
	24	280.0	406.67	567.33	418.0
RLSD 0.05			16.826		320.31
Average effect temp.		227.0	282.39	451.56	type Average source
RLSD 0.05			4.857		
Type source × temp.	Control	138.25	157.5	280.58	192.11
	Cow manure	200.25	244.50	468.42	304.39
	Alfalfa	342.5	445.17	605.67	464.44
RLSD 0.05			4.857		320.31
					Average of effect salinity
Salinity × temp.	3	315.56	344.33	545.44	401.78
	6	219.44	282.56	487.56	329.85
	12	193.89	255.78	405.56	285.07
	24	179.11	246.89	367.67	264.56
RLSD 0.05			5.609		320.31

salinity level decreased microbial activity in soil. Therefore, organic residue decomposing in soil is decreased.

On other hand, Khalil *et al*. (2005) indicated that increasing soil salinity level to about 6.0 dS.m^{-1} showed no significant effect on NH_4^+ -N concentration in soil. Al-Jaberi (2010) indicated that effect of salinity on soil microbial activity and depends on the initial soil salinity level. Data of tables (3 and 4) showed that highest value of NH_4^+ -N produced in soil was obtained at soil amended with alfalfa residue incubated at 30 C$^{\circ}$ and salinity level of 3 dS.m^{-1} and recorded values 656.0 mg.kg^{-1} and 634.33 mg.kg^{-1} for F.C and logged water conditions, respectively. Significant effect for the interaction between salinity level and source of organic residues, organic residue and temperature of incubation, temperature and salinity were recorded (tables 3 & 4). Results of tables (5 and 6) showed that increasing incubation temperature from 10 to 30 $^{\circ}$C at all treatment increased NO_3^- -N concentration in soil.

Table (5): Effect of salinity levels and temperature on NO_3^- - N mineralization in soil treated with cow manure or alfalfa residue incubated under F.C.

source	Salinity levels (dS.m^{-1})	Temperature $^{\circ}$C			Salinity level × source
		10	20	30	
control	3	196.0	252.0	616.0	354.7
	6	196.0	233.3	373.3	267.6
	12	177.3	186.7	364.0	242.7
	24	149.3	158.7	326.7	211.6
Cow manure	3	205.3	382.7	644.0	410.7
	6	196.0	308.0	625.3	376.4
	12	185.3	233.3	448.0	288.9
	24	168.0	177.3	420.0	255.1
alfalfa	3	666.3	697.7	876.0	746.7
	6	564.7	634.7	787.3	662.2
	12	425.3	609.0	704.3	579.6
	24	280.0	469.7	666.0	471.9
RLSD 0.05		130.14			405.7
Average effect temp.		284.1	361.9	570.9	Average type source
RLSD 0.05		37.57			
Type source × temp.	Control	179.7	207.7	420	269.1
	Cow manure	188.7	275.3	534.3	332.8
	Alfalfa	484.1	602.8	758.4	615.1
RLSD 0.05		37.57			405.7
					Average of effect salinity
Salinity × temp.	3	355.9	444.1	712.0	504.0
	6	318.9	392.0	595.3	435.4
	12	262.7	343.0	505.4	370.4
	24	199.1	268.6	470.9	312.9
RLSD 0.05		43.38			405.7

NO_3^- N Concentration

Average values of NO_3^- -N increased from 284.1 to 570.9 mg.kg^{-1} in soil incubated under F.C moisture level and from 104.97 to 184.19 mg.kg^{-1} for soil incubated under logged water level. Similar effect of temperature on NO_3^--N concentration in soil was reported by Yeasmin *et al*. (2012) and Cenkseven *et al*. (2017). Data of treated tables (5 & 6) clearly indicated that NO_3^- -N concentration in soil treatment with organic residues were higher than of control treatment at both moisture levels and all temperatures of incubation. Average values of NO_3^- -N increased from 269.1 at control treatment to 332.8 mg.kg^{-1} in soil amended with cow manure and 615.1. mg.kg^{-1} in soil treated with alfalfa residue in soil incubated under F.C condition. However, values of NO_3^- -N in soil incubated under logged water condition were 109.5 mg.kg^{-1} , 186.25 mg.kg^{-1}, 118.92 mg.kg^{-1} for control, cow manure and alfalfa residue, respectively.

Table (6): Effect of salinity levels and temperature on NO_3^- -N mineralization in soil treated with cow manure or alfalfa residue incubated under logged water.

source	Salinity levels (dS.m^{-1})	Temperature °C			Salinity level × source
		10	20	30	
control	3	99.0	111.0	209.33	139.78
	6	85.0	104.67	154.0	114.56
	12	74.0	92.0	129.0	98.33
	24	59.0	80.33	116.67	85.33
Cow manure	3	168.0	188.0	336.0	230.67
	6	140.0	168.0	242.67	183.56
	12	130.0	185.67	224.0	170.89
	24	115.67	149.33	214.67	159.89
alfalfa	3	116.0	131.0	176.0	141.0
	6	106.0	116.0	146.0	122.67
	12	91.0	106.0	141.0	112.67
	24	76.0	101.0	121.0	99.33
RLSD 0.05			14.631		138.22
Average effect temp.		104.97	125.5	184.19	Average type source
RLSD 0.05			4.224		
Type source × temp.	control	79.25	97.0	152.25	109.50
	Cow manure	138.42	166.0	254.33	186.25
	alfalfa	97.25	113.5	146.0	118.92
RLSD 0.05			4.224		138.22
					Average of effect salinity
Salinity × temp.	3	127.67	143.33	240.44	170.48
	6	110.33	129.56	180.89	140.26
	12	98.33	118.89	164.67	127.30
	24	83.56	110.22	150.78	114.85
RLSD 0.05			4.877		138.22

These results are in agreement with that of Balkcom *et al*. (2009) and Anggria *et al*. (2012) and who showed that concentration of NO_3^--N in soil differs according to types and amount of organic residue added to soils. Results showed a significant differences in NO_3^--N produce from different organic source at all moisture treatments of incubated soils, being higher in soils incubated under F.C than logged water condition (t value = 12.073).

Increasing salinity level from 3 to 24 $Ds.m^{-1}$ decreased NO_3^- -N concentration from 504.0 to 312.9 $mg.kg^{-1}$ in soils incubated under F.C moisture level (table 5) and from 170.48 to 114.85 $mg.kg^{-1}$ in soil incubated under logged water condition. Sahrawat (2009) stated that rate of organic residue decomposing in soil decreased as soil salinity level increased. Highest values (876.0 $mg.kg^{-1}$) for NO_3^- -N in soil incubated under F.C was obtained in soil with E.C 3 $dS.m^{-1}$ treated with alfalfa residue and incubated at 30 °C , while lowest value 149.3 $mg.kg^{-1}$ was record in control soil with E.C 24 $dS.m^{-1}$ incubated at 10°C in soils incubated under F.C condition. However, in soil amended with cow residue highest values were record in soil with E.C 3$dS.m^{-1}$ and incubated at 30ºC, while lowest value was obtained in control soil with E.C 24 $dS.m^{-1}$ incubated at 10ºC, these values were 336.0 $mg.kg^{-1}$ and 59.0 $mg.kg^{-1}$, respectively. Significant interaction between soil salinity levels and organic residue source and soil salinity level and temperature of incubation and temperature and organic source were recorded (tables 5 and 6).

Conclusions

It could be concluded from the data presented that organic residue source and soil salinity level have significant effect on organic N mineralization in soils under both F.C and logged water condition. Effect of soil logged water on organic N mineralization differs according to type of organic residue source.

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