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EFFECT OF TWO APPLICATIONS OF SUBSTRATE ON NITRIFICATION AND pH OF SOILS

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Abstract: A laboratory incubation experiment at 15 ºC was carried out with two applications of substrate as ammonium sulfate on the measurement of ammonium disappearance, nitrate formation rates and measurement of pH of different soils at Glasgow University, Glasgow, United Kingdom during 1995. The ammonium disappearance and nitrate formation rates were not significantly different between the first and second application in neutral soils, however, a significant inhibitory effect was observed in ammonium disappearance and nitrate formation rates of second application of ammonium sulfate in an acidic soil. The application of ammonium sulfate decreased pH of soils. The ammonium disappearance and nitrate formation rates were low in the soils samples having low pH.

Keywords: Ammonium disappearance rate, nitrate formation rate, nitrification rates, substrate, pH.

INTRODUCTION

Fertilizers are applied to increase yield of the crops. The economical and efficient use of fertilizer depends upon the quantity of fertilizer applied at proper time. The economical dose of fertilizers is determined with knowledge of soil properties and the weather conditions that are likely to be encountered in the area. This is particularly true with nitrogen since its behavior in the environment, which is greatly influenced by various population of micro organism, soil organic matter, soil pH, textural classes of soil, soil condition in relation to human practices, the climate of the soil and climate of the area. Like the rain fall add up nitrogen compounds in the soil. The soil microorganisms convert atmospheric nitrogen into soil, which depends upon presence of the population of microorganisms.

The rate of microbial activity in soil depends on soil moisture content, temperature, availability of oxygen, pH and substrate availability in form of fertilizer. All other factors being equal, the production of inorganic nitrogen is greater in neutral than acid environments [Ishaque and Cornfield 1972]. In acid conditions nitrification proceeds slowly, even in the presence of an adequate supply of ammonium, and the responsible species are rare or totally absent at low pH. Although an exact limiting pH cannot be ascertained, The nitrification rate falls off markedly below pH 6 and become negligible below 5.0 [Dancer *et al.* 1973]. It has been reported that addition of nitrogen fertilizer sometimes enhances the mineralisation rate of native organic nitrogen in soils [Wickramasinghe *et al.* 1985]. On the other hand such amendments appear to have no influence or an adverse effect on the mineralisation process in other soils. For example, Williams [1975] found that addition of nitrogen (50 mg N per kg soil) as

ammonium sulfate decreased the quantity of mineralisation nitrogen in incubated coal mine soils. He suggested that this may be due to the increase in acidity that results from the addition of ammonium sulfate. Under ordinary conditions the rate of nitrogen mineralisation is closely correlated with the total nitrogen content, and therefore soils rich in nitrogen liberate more inorganic nitrogen than those deficient in total nitrogen in a given time interval. Amin [1995] concluded that the nitrification rates were higher in fresh soil sub samples while mineralisation rates were higher in air dried sub samples of the soil with application of substrate.

The application of nitrogen fertilizer in humid climate cause nitrate pollution in soil and water, which give rise environmental and public health concerns in numerous areas of the world. Over the last few years the subject of nitrogen contamination in the form of nitrate in soil and water has become one of the most debating environmental issues in the United Kingdom. In Pakistan due to the dry and warm climate pollution by nitrate and nitrate leaching is not a problem. However, the soils of Pakistan are deficient in plant nutrients due to low organic matter content and fertilizers are major source plant nutrients for high yield. About 70% of the cultivated area is canal irrigated and 30% is rainfed. The research organizations and extension workers in irrigated areas recommend two applications of nitrogen fertilizer dose, one at the time of sowing and the second at first watering. The farmers are unsure of the amount of mineralized and nitrified nitrogen which will be produced in growing season or during the fallow period. If more were known about the mineralisation and nitrification more effective use could be made of fertilizers because the principles set forth with regard to the metabolism of nitrogen can frequently be extended to the transformation of several elements such as phosphorus and potassium.

Pollution by ammonium in agricultural land is rare due to nitrification activities and gases losses. The nitrogen in the form of ammonium is subject to more loss than nitrate form of nitrogen. The knowledge of suitable condition for nitrification activities in soil help in economical use of nitrogenous fertilizers. The ammonium loss can be controlled with the formation of nitrate in alkaline soil conditions of Pakistan at suitable condition for application of nitrogenous fertilizer.

Keeping in view the above facts it was planned to see the effect of two application of ammonium sulfate on fresh soils samples on different soils having known initial pH values on the ammonium disappearance, nitrate formation rates and pH values for accurate prediction of fertilizer dose in the different soils.

MATERIALS AND METHODS

The study was done in the laboratory at Glasgow University, Glasgow, United Kingdom during 1995 on four soil samples, two (Midelney and

Freckenham) from England and two (Darvel and Darlieth) from Scotland. The effect of two application of ammonium sulfate on nitrification and pH was carried on two samples of Darvel series soils (one at pH 5.8 and the other at pH 7.5) a sample of Midelney of pH 7.4, a sample of Freckenham of pH 6.9 and two sample of Darlieth of (one of pH 7.3 and the other of pH 5.9 however this sample was not applied second application of ammonium sulfate). The samples were tested for moisture content, -0.5 Bar moisture content (It is moisture content under pressure of –0.5 bar), which is determined by placing the soil samples on the plate and flooded with water for 24 hours. The excess water was then removed from the plate which was then placed in the pressure plate apparatus and pressure adjusted to –0.5 bar using nitrogen gas from the cylinder. Samples were then allowed to equilibrate for the three days, by which time water loss had ceased.

Table 1: Physical properties of soils are tabulated as under.

Properties	Name of Soil			
	Darvel	Midelney	Frechenham	Darleith
LOI (%)	9.1	16.2	4.0	23.3
pH	7.4/5.8	7.5	6.9	7.3/5.9
Sand (%)	33.5	17.8	84.8	39.3
Silt (%)	24.1	40.2	8.8	19.2
Clay (%)	42.4	42.0	6.4	41.5
Texture Class	clay	clay	Sand/loam	Slit/clay

The incubation experiment at 15 ºC was carried out for nitrification and mineralisation in fresh soil with sample of 50 g of soil in a 500 ml glass bottle. The each sample was treated with 100 mg N per gram by adding 1 ml of ammonium sulfate solution containing 5000 mg Ammonium nitrogen per litre. Each soil sample was mixed thoroughly using a spatula and the moisture content was adjusted to the –0.5 Bar moisture potential by addition of an appropriate weight of deionized water with Pasteur pipette. The glass bottle containing the sample was allowed to stand in the cold room at 2 ºC for 3 hours. After taking a sub sample for measuring extractable N at day Zero (First day extract of incubation), each bottle was then placed in the incubation in a plastic tub lined with damp filter paper and containing water in base to ensure humid atmosphere in order to keep the samples at correct moisture content at fixed temperature. The change in ammonium, nitrate and nitrite were measured at intervals by extraction from sub samples. The soil samples were incubated until complete conversion of ammonium into nitrate. A second application of 100 mg ammonium per gram of soil was applied and incubation continued until conversion of the entire second dose of applied ammonium to nitrate. The sub samples were taken for extraction and determination of ammonium, nitrate, nitrite and pH with intervals. The extraction and determination was carried out by routine methods of measurements of inorganic nitrogen [Amin 1995].

In order to determine rates of nitrification and mineralisation in samples soil measured values of ammonium disappearance, nitrate formation, and total of ammonium and nitrate were regressed on time on computer Minitab Package (Version 7.2). A t-test was used to test the difference between two applications on the rates of ammonium disappearance and nitrate formation.

RESULTS AND DISCUSSION

Results presented in Table 2 show the effect of two applications of substrate on pH, ammonium disappearance, nitrate formation rates and mineralisation rates of different soils and effect of initial pH on the ammonium disappearance, nitrate formation and mineralisation rates in different soil samples.

Table 2: Fall in pH and nitrification rates on application of ammonium sulfate.

	First Application	Second Application
	(mg N per kg of soil per day)	
Darvel Soil (pH 5.8)		
pH fall	5.2	4.8
Ammonium disappearance rates	10.6 b	8.8 a
Nitrate formation rates	12.50 b	10.3 a
Mineralisation rates	1.9	1.5
Darvel soil (pH 7.5)		
pH fall	6.8	6.2
Ammonium disappearance rates	16.3 a	14.9 a
Nitrate formation rates	17.6	-
Mineralisation rates	1.3	-
Midelney Soil (pH 7.4)		
pH fall	6.7	6.3
Ammonium disappearance rates	27.2 a	28.5 a
Nitrate formation rates	27.1 a	30.5 a
Mineralisation rates	I.M.	2.0
Freckenham Soil (pH 6.9)		
pH fall	6.6	6.2
Ammonium disappearance rates	5.2 a	5.9 a
Nitrate formation rates	5.6	-
Mineralisation rates	0.4	-
Darlieth Soil (pH 7.3)		
pH fall	6.5	6.2
Ammonium disappearance rates	20.3 a	17.9 a
Nitrate formation rates	23.6	-
Mineralisation rates	3.3	-
Darlieth Soil (pH 5.9)		
Ammonium disappearance rates	12.2	-
Nitrate formation rates	13.0	-
Mineralisation rates	1.1	-

Data in a row with same subscript letter are not significantly different at 5% level (pooled t-test).

EFFECT OF SOIL ON NITRIFICATION AND MINERALISATION

The ammonium disappearance and nitrate formation rates showed same trend in a soil in same condition. But the ammonium disappearance, nitrate formation and mineralisation rates vary from soil to soil due to difference in soil properties and presence of variation in population of nitrifying bacteria. In the clay soil ammonium disappearance and nitrate

formation rates were higher compared with the sand soil. The positive relations were measured in mineralisation rates with organic mater content of soils. The study was conducted on the soils of United Kingdom. Similar types of studies are required for accurate prediction of fertilizer for Pakistani soils.

EFFECT OF pH ON NITRIFICATION RATES

The ammonium disappearance and nitrate formation rates were low in Darvel and Darlieth soil samples having pH below than 6 compared with pH over 7. Because responsible species for nitrification inhibit below pH 6. It was reported in previous studies that in acid environment, nitrification proceeds slowly even in the presence of adequate supply of the substrate, and the responsible species are rare or totally absent at great acidities.

EFFECT OF TWO APPLICATIONS OF SUBSTRATE ON NITRIFICATION

The t test on the rates of ammonium disappearance rates were non significant in neutral soils and nitrate formation rates were not calculated due to high measured values of nitrates which was thought may be analytical error for Darvel (pH 7.5) Freckenham and Darlieth soil.

In Midelney soils both ammonium disappearance and nitrate formation rates were non significant for both applications. While in other Darvel soil sample (pH 5.8) rates of second application were lower than first application of substrate. A significant inhibitory effect on second application was found on both ammonium disappearance and nitrate formation. The reason for inhibition of nitrification in the second application in the Darvel soil (pH 5.8) was due to fall in pH. In the Darvel soil (pH 5.8) the pH decreased from 5.8 to 5.2 in the first incubation. The second application was applied at 5.2 and pH fell further to pH 4.8. In acid environment, nitrification proceeds slowly even in the presence of adequate supply of the substrate, and the responsible species are rare or totally absent at great acidities. Flowers and O'Challaghan [1983] reported that nitrification rate constants relates to initial pH although, as there was no change in nitrification during incubation. The rates were not affected by the decrease in pH resulting from nitrification. They suggested that there was a small increase in the population of nitrifiers and that growth would be balanced by the effect of the fall in pH. The non significant effect of ammonium disappearance with repeated application of substrate has not increased nitrification in availability of sufficient amount of substrate. It is therefore suggested that different soils has different ammonium disappearance rates which do not increase availability of sufficient substrate.

EFFECT OF NITRIFICATION ON SOIL pH

In all soils pH of soil have fell with application of ammonium sulfate during incubation period of nitrification which has further fallen with second application of ammonium sulfate. The pH of soils decrease with disappearance of ammonium, remain constant in slack period which further decreased with second nitrification process. Soil biochemistry of nitrification confirm this results [Wood 1989]

EFFECT OF TWO APPLICATIONS OF SUBSTRATE ON MINERALIZATION

The mineralisation rates in Darvel soil with first application was less than second application and in the Midelney soil with first application ammonium sulfate showed immobilization of nitrogen while the second application showed mineralisation, which were 2 mg per Kg of soil per day.

Some what similarly has been reported that addition of nitrogen fertilizer sometimes enhances the mineralisation rate of native organic nitrogen in soils [Wickramasinghe *et al.* 1985]. On the other hand such amendments appear to have no influence or an adverse effect on the mineralisation process in other soils. For example, Williams [1975] found that addition of nitrogen (50 mg N per kg soil) as ammonium sulfate decreased the quantity of mineralisation nitrogen in incubated coal mine soils. He suggested that this may be due to the increase in acidity that results from the addition of ammonium sulfate. Under ordinary conditions the rate of nitrogen mineralisation is closely correlated with the total nitrogen content, and therefore soils rich in nitrogen liberate more inorganic nitrogen than those deficient in total nitrogen in a given time interval. In the present study addition of nitrogen was higher than previous studies i.e. (100 mg N per kg soil) in first application in which immobilization in Midelney soils and mineralisation rate were measure in second application and high level of nitrate formation. It prove that when soil is reach in nitrogen liberate more inorganic nitrogen.

The higher mineralisation rates in neutral soil sample of Darlieth confirm the finding of Ishaque and Cornfield [1972]. Who stated that all other factors being equal, the production of inorganic nitrogen is greater in neutral than acid environments. However low mineralisation rates in neutral soil sample of Darvel soil sample with acidic Darvel soil samples were measured which are contrary to the finding of Ishaque and Cornfield [1972]. The studies are required to find out facts.

CONCLUSIONS

Following conclusions were drawn from the present studies.

1. Comparatively low fertilizers should be applied in clay and organic soil because less nitrogen losses due to high nitrification rates and microbial activities.

2. Acidic pH of soil has inhibitory on nitrification rates.
3. Soil rich in nitrogen liberate more inorganic nitrogen.
4. The different soils have different ammonium disappearance rates which do not increase with availability of sufficient substrate in form of ammonium.
5. Similar types of studies are required for Pakistani soils for efficient and economical use of fertilizers.

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