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Factors influencing nitrification in soils*

by

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Synopsis: The results of investigations carried out on the effect of phosphorus and different forms of nitrogen applied to soil on nitrogen mineralisation and yield of *ragi* are reported in this paper.

Introduction: The present study was undertaken to investigate the effect of phosphorus and different forms of nitrogen applied to soil on nitrogen mineralisation and yield of *ragi* under pot culture conditions. Mineralisation of organic nitrogen in soil has been fully reviewed by Harmsen and Van Schreven in 1955. Subsequently, many workers have described the effect of moisture content, temperature, pH and aeration during incubation on mineralisable nitrogen. But few attempts have been made to correlate the values obtained with responses of crops to nitrogen fertiliser application or forms of fertiliser applied and the influence of phosphorus and potash on nitrogen availability.

Review of Literature: Soils may gain combined nitrogen by four generally recognised processes. These are by (1) non-symbiotic fixation (2) symbiotic fixation (3) addition in rainfall and (4) fertilisation. Of these, we are concerned in this study only with the last process, as it is the only way in which the soil can be enriched quickly and adequately and which can be varied according to the needs of the soil and the crop.

Elemental nitrogen is present in gaseous form in the soil atmosphere and dissolved in the soil water. In dry soils it is present adsorbed on the soil particles. Nitrogen also occurs in the inorganic form in soils as nitrous or nitric oxide or as ammonium salts or as nitrites or nitrates. The first two of these forms are gases and are present only in traces. The last three are ionic forms and can be absorbed and used by plants. The inorganic forms constitute less than two per cent of the total nitrogen. The organic nitrogen added to the soils in the form of plant and animal residues is largely proteinaceous in nature. The microbes attack this form and replace this with microbial protein, releasing the inorganic form of nitrogen in this process. De and Mukerjee (1951) studied the nature of organic nitrogen

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compounds of a rice soil and fractionated it into humic and non-humic fractions. In the non-humic fractions, ammonium, amino compounds, amide, protein derivatives and non-amino compounds occurred. Much of the amide is non-protein in origin and basic in nature, while much of the nitrogen in the humic fraction is protein in nature.

Plants utilise nitrogen in its mineral forms. The organic forms change through decomposition into the mineral forms through ammonium and nitrite form to finally the nitrate form. Consequently nitrate is usually the most abundant form of mineral nitrogen in soil and it is also the principal form of mineral nitrogen utilised by plants.

Warington (1878) found also that nitrate formation in soil was a biological process and that ammonia was the starting point for nitrification. He also found that 94 per cent of the ammonia supplied to mixed cultures of bacteria was converted into nitrate.

The substrate has influence on the rate of nitrogen mineralisation. Black in 1957 has explained this phenomena. In fallow soils that remained warm and moist without inorganic material being added or mineral nitrogen lost by leaching, the content of mineral nitrogen increases because the net quantity of nitrogen tied up in the microbial tissue remains nearly the same while the organic compounds of the soil organic matter are undergoing gradual decomposition. If proteinaceous material is added, the microbial population increases rapidly and the content of mineral nitrogen continues to increase beyond the time when protein is exhausted, because of liberation of mineral nitrogen from the soil and the shrinking microbial population. The addition of carbonaceous material however provides a nitrogen deficient substrate. The microbial population increases but at the expense of mineral nitrogen present in the soil together with mineral nitrogen subsequently produced and this state of affairs continues until the carbonaceous material is exhausted and only then it might exceed initial amount present.

This has been described as due to carbon nitrogen ratio of the substrate. Jensen in 1929 examined the mineralisation of nitrogen in soils treated with organic materials having carbon-nitrogen ratio ranging from 85:1 to 10:1. No increase in organic nitrogen resulted within six months with materials having C,N ratio greater than 13:1 to 18:1 in an acid soil and above 26:1 in an alkali soil. Salter (1931) found that materials having C/N ratio greater than 10:1 reduce the nitrate level of soil. The work of Peevy

Supply of other minerals like Phosphorus and potash were also known to influence nitrification. Collins (1954) reported that addition of calcium carbonate alone or in conjunction with phosphorus or trace elements increased nitrification rate. Fitts (1953) found that nitrification was less in soils of low phosphorus and potassium levels.

Effect of Crops on Nitrification: More than all the other intrinsic factors that have been reported on nitrification, the kind of crop and nature of rotation followed in the soil determine the course of nitrification. Jones (1956) presented evidence to show that the nitrate nitrogen and organic carbon content are influenced by the nature of crop rotation. Helias (1953) found the amounts of mineral nitrogen liberated during incubation to be higher in samples of uncultivated acid forest soils than in productive cultivated soil. In the experiment of Goring and Clark (1949) the results showed that more nitrogen was mineralised in the fallow soils than in productive cultivated soil. Thus as already stated at the outset, there are numerous factors which affect nitrification. Of these the added fertilisers and the kind of crop grown have the maximum influence. Walker, Adams and Orchiston (1956) using N^{15} labelled fertilisers found that regardless of the plant grown approximately 30 per cent of the nitrogen was lost presumably due to denitrification. The present study was undertaken to investigate the effect of different forms of nitrogen applied to soil on nitrogen mineralisation and the yield of *ragi* and the influence of phosphorus on nitrogen mineralisation.

Materials and Methods: The soil sample for the experiment was collected from the fields of Model Agronomic Research Station, Aduthurai, Thanjavur district. It had the following percentage of mechanical composition: coarse sand 20, fine sand 23.2, silt 12.8, clay 41.6 and acid solubles 2.4. Thus the clay content is fairly high and the soil could be classified as clay loam type. On analysis it gave 0.1 per cent total nitrogen and the available nitrogen was 182 lb. per acre. The soil had neutral reaction.

The crop grown for pot culture was Co. 7 *ragi*.

Methods: The total nitrogen was estimated by Kjeldahl's methods AOAC 1955. Organic carbon by Walkley and Black (Piper 1950) pH was estimated in 1:5 soil suspension with Beckman pH meter. Nitrifi-

Experimental details: The experiment was done on a pot culture scale with Co-7 *ragi* from 25th September to 27th December 1959. Earthen pots of size 16"/12" were used in the experiment. The pots were thoroughly washed with water, a layer of washed quartz was placed at the bottom of each pot along with washed river sand to facilitate aeration and drainage. Seedlings raised in nurseries separately in the same soil as used in the experiment were transplanted when one month old and 15 seedlings were planted in each pot. Watering was done uniformly in all the pots throughout the experiment.

TREATMENT: The following were the 13 treatments:

Treatment 1: 30 pounds P_2O_5 as super phosphate and 40 pounds nitrogen per acre as ammonium sulphate.

Treatment 2: 30 pounds P_2O_5 as super phosphate and 40 pounds nitrogen as sodium nitrate.

Treatment 3: 30 pounds P_2O_5 as super phosphate and 40 pounds nitrogen as groundnut cake.

Treatment 4: 30 pounds P_2O_5 as super phosphate and 20 pounds nitrogen as ammonium sulphate and 20 pounds nitrogen as sodium nitrate.

Treatment 5: 30 pounds P_2O_5 as super phosphate and 20 pounds nitrogen as groundnut cake and 20 pounds nitrogen as sodium nitrate.

Treatment 6: 30 pounds P_2O_5 as super phosphate and 20 pounds nitrogen as groundnut cake and 20 pounds nitrogen as ammonium snlphate.

Treatment 7: 40 pounds nitrogen as ammonium sulphate.

Treatment 8: 40 pounds nitrogen as sodium nitrate.

Treatment 9: 40 pounds nitrogen as groundnut cake.

Treatment 10: 20 pounds nitrogen as ammonium sulphate and 20 pounds as sodium nitrate.

Treatment 11: 20 pounds nitrogen as groundnut cake and 20 pounds nitrogen as sodium nitrate.

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INCUBATION PROCEDURE: Soil samples were taken on 10th November and 26th December, 1959 taking care to collect representative portions from different places in the pot. The samples were air-dried powdered and passed through a 2 mm. sieve.

Plastic vials with small holes at the bottom to permit leaching were used. Filter paper Whatman No. 1 was cut into small circles to fit in lightly at the bottom of the vials.

Ten gram of soil mixed with equal volume of vermiculite was added to the vial. Leaching was done with three successive 20 cc. portions of distilled water to make it free of any nitrate nitrogen initially present, Suction was applied to remove excess water. The vials were then placed in an incubator maintained at 35° C for 14 days. Moisture loss during incubation was minimized by maintaining high level of humidity inside the incubator.

At the end of 14 days the samples were leached free of nitrate with three successive 20 cc. portions of distilled water, collecting the leachate in small clean bottles.

The nitrate nitrogen in the leachate was estimated by developing yellow colour with phenoldisulfonic acid and reading the intensity of the colour in the Klett Summerson colorimeter. A standard curve for nitrate using 0, 1, 5, 10, 20, 40, 60, 100, 200, and 300 parts per million of nitrate nitrogen was prepared with Analar grade potassium nitrate. The Keltt readings were converted into parts per million of nitrate nitrogen with the help of this curve.

Results: *Yield data:* The yield of air-dry grain and straw were recorded on harvest.

TABLE 1

Yield in grams. Yield of 15 plants (Average of 3 replications)

Treatments	Grain	straw	Total dry weight
1.	1·19	2·91	4·10
2.	2·33	5·33	7·66
3.	1·28	2·55	3·83
4.	1·92	3·44	5·36
5.	2·91	4·29	7·20
6.	1·14	2·16	3·30
7.	1·47	2·13	3·60
8.	1·36	2·34	3·70

Grain: Super phosphate, oilcake and sodium nitrate (Tr. 5) gave highest grain yield. Super phosphate, and sodium nitrate (Tr. 2) was the next best.

Super phosphate, ammonium sulphate and sodium nitrate (Tr. 4) oilcake alone (Tr. 9), oilcake and ammonium sulphate (Tr. 12) and ammonium sulphate and sodium nitrate (Tr. 10) gave fair yields of grain.

Super phosphate and ammonium sulphate (Tr. 1), super phosphate, oilcake and ammonium sulphate (Tr. 6) and oilcake and sodium nitrate (Tr. 11) gave poor yields of grain and were almost like control.

The yield of straw and the total dry weight also follow similar trends and follow the same order of yield.

Nitrogen in plant material: Both grain and straw were separately analysed for their nitrogen content by the Kjeldahl's method.

TABLE II

Nitrogen in plant material (Percentage of dry matter)

	Treatment												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Grain	1·51	1·62	1·32	1·68	1·65	1·48	1·12	1·23	1·15	1·23	1·09	1·34	1·18
Straw	2·68	2·86	2·35	2·91	2·74	2·70	2·46	2·80	2·63	2·80	3·02	2·74	2·18

Grain: The nitrogen content is high for super phosphate, ammonium sulphate and sodium nitrate (Tr. 4), super phosphate, oilcake and sodium nitrate (Tr. 5) and super phosphate and sodium nitrate (Tr. 2) The nitrogen content for super phosphate and ammonium sulphate (Tr. 6) were medium. The other treatments analysed low nitrogen content. Super phosphate treated plants generally gave higher nitrogen percentage of the grain and straw than super phosphate-less plants.

Available nitrogen: Available nitrogen was measured by the nitrate nitrogen producing capacity of the soil on incubation.

The soil was incubated for two weeks to estimate the nitrate nitrogen produced in that period.

TABLE III

(Average of 3 replications) Original soil 84 ppm.

NOTE: The nitrate nitrogen in ppm given above was estimated in 2 cc. aliquots of 60 cc. of leachate obtained by leaching 10 gm. of soil.

10—11—1959. Generally the treatments in which super phosphate has been included recorded high nitrification rates. Combination of sodium nitrate with ammonium sulphate and oilcake and with super phosphate produced high nitrogen mineralization. Oilcake alone produced good nitrification. Sodium nitrate alone gave poor nitrification.

26—12—1959. Super phosphate and sodium nitrate gave high nitrogen mineralization. Again sodium nitrate with ammonium sulphate and super phosphate was good. Treatment ammonium sulphate with sodium nitrate was fair and same as control. The other treatments were lower than the control.

TABLE IV

Soil Reaction. C/N Ratio and Available N

Treatments	Carbon	Nitrogen	Available nitrogen in lb./acre		pH			
			10-11-'59	27-12-'59	25-9-'59	25-10-'59	25-11-'59	27-12-'59
1.	0·36	0·095	196	182	7·1	7·0	6·9	7·0
2.	0·33	0·97	182	168	7·0	6·9	6·9	6·9
3.	0·36	0·98	168	182	7·1	7·0	7·0	6·9
4.	0·30	0·099	196	168	6·9	6·9	6·8	6·8
5.	0·39	0·095	182	168	7·0	7·0	7·0	7·0
6.	0·36	0·095	182	154	7·1	7·0	6·9	6·9
7.	0·33	0·097	168	154	7·1	7·0	7·0	7·0
8.	0·39	0·97	168	168	7·0	6·9	6·9	6·9
9.	0·36	0·095	168	182	7·0	7·0	6·9	7·0
10.	0·036	0·098	168	140	7·0	7·0	6·8	6·9
11.	0·36	0·098	182	154	7·0	7·0	7·0	7·0
12.	0·33	0·097	168	182	7·0	7·1	7·0	6·9
13.	0·33	0·095	154	140	7·0	7·1	7·0	7·0

(b) The figures for available nitrogen by the alkaline permanganate method indicated a comparatively higher amount of available nitrogen in treatments in which sodium nitrate and ammonium sulphate have been included. The available nitrogen in all cases was superior to control.

(c) The carbon to nitrogen ratio was also not affected by the treatment.

Discussion: From the results, it is found that both sodium nitrate alone and ammonium sulphate alone produced poor nitrification at first which increased gradually. Both were equal in performance. But sodium nitrate with ammonium sulphate and oil cake with super phosphate produced high nitrification. This indicated that the fertilizers were best applied in combination than alone. The organic manure, oil cake produced high nitrification (Sinha 1957). So oil cake was found to be superior to inorganic nitrogen fertilizers applied alone but inferior to combination of ammonium sulphate with sodium nitrate and super phosphate. Presence of P_2O_5 also tended to increase the efficiency of nitrification (Sinha 1957) Collins (1954). The yield data show that the grain and straw yields have a direct relationship with nitrification, showing that crop productivity is directly related to nitrification capacity of the soil (Sinha 1957).

Summary and conclusions: A pot culture experiment with alluvial soil from Aduthurai and Co-7 *ragi* as the crop was started to study the effect of different forms of nitrogen on nitrification and also the effect of phosphorus on nitrification.

The following conclusions could be drawn. There was a fair degree of relationship between nitrifying power of soil, nitrogen uptake by plant and the crop response. Phosphorus improved nitrification of soil and increased the efficiency of nitrogen uptake by the plants. Combination of nitrate and ammoniacal forms, with phosphorus was superior than any one form alone. Sodium nitrate and ammonium sulphate in combination with oil cake and super phosphate was better than sodium nitrate or ammonium sulphate alone.

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