ESTIMATION OF LOSS OF NITROGEN FROM DIFFERENT NITROGENOUS FERTILIZERS WHEN APPLIED TO DIFFERENT SOILS UNDER WATER-LOGGED CONDITION

By

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THESIS

SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN AGRICULTURE (AGRICULTURAL CHEMISTRY) OF THE UNIVERSITY OF KERALA

DIVISION OF AGRICULTURAL CHEMISTRY
AGRICULTURAL COLLEGE AND RESEARCH INSTITUTE
VELLAYANI, TRIVANDRUM

1968

CERTIFICATE

This is to certify that the thesis herewith submitted contains the results of bonafide research work carried out by Smt. M. Krishna kumari under my supervision. No part of the work embodied in this thesis has been submitted earlier for the award of any degree.

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ACKNOWLEDGEMENTS

The author wishes to acknowledge and express her deep sense of gratitude and indebtedness to:

Dr. N. Subramoney, Professor of Agricultural Chemistry for suggesting the problem and for his inspiring guidance and helpful criticisms;

Prof. P. Kumara Pillai, Vice-Principal-in-charge, for providing necessary facilities for this study and for many other courtesies extended;

Dr. M.M. Koshy, Additional Professor of Chemistry and Agricultural Chemist to his kind encouragement and interest in this investigation;

Prof. A.P.A. Brito Muthunayagom and Prof. E.J. Verghese, University Grants Commission Scheme, Division of Agricultural Chemistry to the keen interest evinced by them in this work;

Sri. Chitharanjan Nair, Research Officer for his sincere help and constructive criticisms at every stage of this investigation and in the preparation of the thesis.

Sri. E.J. Thomas, Junior Professor of Agricultural Statistics, Agricultural College and Research Institute, Vellayani for his valuable advice in the statistical treatment of the data;

Dr. R. Subramonia Aiyar, Sri. P. R. Ramasubramonian, Smt. T. Pankajakshi Amma, Junior Professors of Agricultural Chemistry for useful instructions.

Sri. K.P. Rajaram, Lecturer in Agricultural Chemistry for his generous help in this investigation and in the preparation of the thesis; and to

All of her colleagues and friends for the valuable help rendered by them which enabled the author to complete the present endeavour successfully.

M. KRISHNA KUMARI.

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INTRODUCTION

INTRODUCTION

The popularisation of newly introduced high yielding varieties of rice such as I.R.8, has brought in its wake a number of problems regarding fertilizer application. Apart from the high fertilizer requirements of such varieties, the technology of fertilizer application has come to merit serious consideration.

In the preparation of a manuring schedule for the rice crop, prime importance is given to nitrogenous fertilizers, because of its proved capacities in improving the vegetative phase of the crop and of its significant role in the biosynthetic and productive stages. However, the technology of nitrogen application is beset with greater problems than that of the other two major nutrients, phosphorus and potassium.

Rice, being a semi-aquatic plant, prefers a constant sheet of water in the soil. This habit of the crop projects a number of problems regarding application of fertilizer nitrogen. The chances for the loss of soluble nitrogen are many when we take into account the soil and climatic conditions of this state. The light texture of the soil favours easy percolation, accelerating leaching losses, while the heavy rainfall received in a short time during the growth period of the crop, results in losses due to over flow and surface run off.

The importance of minimising losses of nitrogen in flooded rice field by making use of fertilizers containing slightly soluble, slowly available form of nitrogen can therefore be never underestimated. In the case of phosphatic fertilizers, it has been made possible to get phosphorus in the non-watersoluble form, without seriously affecting its availability. But as far as nitrogenous fertilizers are concerned, attempts in this direction have not met with notable success. All the nitrogenous fertilizers now commonly used are highly water soluble ones. The need for formulating a suitable nitrogenous fertilizer in which at least a part of the nitrogen is water insoluble, is therefore keenly felt and therefore the present study has been undertaken.

In the present study, ammophos (Factamphos) was mixed with magnesium carbonate to render part of the nitrogen of ammophos water insoluble and using this material studies were conducted. The main objectives of the study are:-

1. to compare the extent of loss of nitrogen by leaching from this fertilizer, with that from the commonly used nitrogenous fertilizers, and

2. to find out whether the conversion of water soluble form of nitrogen to non-watersoluble form affects its efficacy as regards the growth and yield of rice variety I.R.8.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

1. Transformation of various nitrogenous fertilizers in the soil under different conditions

Nitrogenous fertilizers applied to a soil undergo several types of loss from the soil, nature of which depending on the type of fertilizer and soil.

According to Buckman and Brady (1960) the ammoniacal fertilizer applied to soil, undergo nitrification, 6 to 22 lb of nitrogen per two million pounds of soil being converted to nitrates daily, by the addition of hundred pounds of ammoniacal nitrogen. Sreenivasan and Subramonyan (1935) found that upto 40 per cent of nitrogen added in the form of urea or dried blood to waterlogged soils was lost through volatilization as ammonia in 78 days. According to Subramonium et al (1937) volatilization of ammonia will occur when ammoniated fertilizers were added, the loss increasing with rise in temperature, additional dressings of CaO and varies with the different ammonia salts used. Appreciable amounts of volatilization of nitrogen as ammonia from flooded soils was also demonstrated in laboratory experiments by Willis and Sturgis (1944).

Studies by Jackson and Chang (1947) on anhydrous ammonia retention by soils as influenced by depth of application, soil texture, moisture content, pH and tilth showed that placement of anhydrous ammonia at a 2" or 4" depth greatly reduced or eliminated volatilization losses. Steenbjerg (1947) reported that ammonia losses from soils fertilized with ammonium sulphate ranged from approximately 5 per cent at pH 6 to 60 per cent at pH 8, in 4 weeks and that the pH and calcium carbonate content of the soil were found to be important factors in determining the extent of loss. Dhar (1947) found when 100 lb per acre of nitrogen was added as ammonium sulphate, about 65 lb were lost without benefit to the soil or crop.

Oweno, Rogers and Winsor (1950) found that ammonium sulphate and guano were nitrified most rapidly and completely and horn meal most slowly and incompletely. Harding <u>et al</u> (1951) and Martin and Chapman (1951) have shown that loss of ammonia by high volatilization occurs from surface fertilized and nontilled soils of temperate regions.

Laboratory tests conducted by Dhar and Ghosh (1955) under aerobic conditions at light and in darkness, showed that over 50 per cent of the nitrogen given to the soil as ammonium sulphate or urea were lost in 15 to 60 days due to the formation of ammonium nitrate and its easy decomposition. The nitrogen losses were progressively decreased with increasing rates of potassium chloride leading to the formation of more stable potassium nitrate. Henderson, Bianchi and Doneen (1955) reported that loss of ammonia can be reduced to a minimum if the pH of the fertilizer solution be kept near neutral.

Volk and Sweat (1956) conducted studies on the mobility of urea nitrogen applied to Florida soils. The lysimeter tests showed the removal of 33 per cent of the applied nitrate nitrogen, 15 per cent of the urea nitrogen, but no measurable ammonium nitrogen, after 24 hours. The conversion rate of urea into ammonia was slower in virgin soils, sub soils and in presence of appreciable amounts of ~~cropes~~ residues. Van (1956) working with calcareous soils of North Eastern polder found that more nitrogen is volatilized from ammonium sulphate than from ammonium nitrate or from nitrochalk.

Broadbent, Tyler and Hill (1957) by their studies on nitrification of ammoniacal fertilizers in some California soils concluded that this depended on the mode of application of fertilizer and on the nature of the soil colloids. Broadbent, Hill and Tyler (1958) reported that hydrolysis of urea nitrogen depended on soil texture, buffering capacity of the soil and pH.

Kresge and Satchell (1960) were of the view that no volatilization of ammonia will occur from ammonium nitrate or ammonium sulphate as long as soil pH did not rise above 7. Schwartzbeck, Macgregor and Schmidt (1961) reported that substantial losses from fertilizers occur in water saturated condition, small losses occurring at field capacity.

Finfrock and Donahue (1965) showed that the reactions of nitrate and ammonium compounds in the soil were different. The nitrate radical was not absorbed on the soil colloids, as it had the same negative electronic charge as that of clay, further, in paddy soils, the nitrate radical was readily reduced (denitrified) to nitrogen gas and lost to the atmosphere. By contrast, ammonium radical has a positive electronic charge, opposite to that of clay and so the clay absorbed the ammonium resulting in no loss by leaching. Mustafa and Sornavelu (1965) showed greater loss due to volatilization from ammonium sulphate.

2. Availability and fixation of nitrogen from different nitrogenous fertilizers

It has been observed that different nitrogenous fertilizers react in soil in different ways, depending on the composition of the fertilizer, leading to difference in their availability to plants.

Andrews (1948) reported anhydrous ammonia to be the cheapest form of nitrogen available and that it is converted to nitrate within 4 to 6 weeks in fertile, well-aerated soils and more slowly in poor, heavy soils and during cold weather. Clark, Yee and Love (1948) prepared a new synthetic nitrogen fertilizer which contains 36 per cent or more of nitrogen and have varying rates of availability. Dijk (1948) applied ammonia through irrigation water to rice and observed that it was uneconomic owing to high losses by evaporation and due to adsorption by the water of earthen conduits.

Tovborg Jensen, Kjaer (1950) concluded by their studies on the nitrogen loss by volatilization from ammonium sulphate added as fertilizer. They found that ammonia losses were promoted by high calcium carbonate content and were increased as soil moisture decreased. Agriculturally significant volatilization occurred only on soils with pH > 7 and that nitrogen losses may be nearly arrested if the ammonium sulphate is well worked in. Nakagawa and Kitamoto (1950) found ammonium sulphate when mixed with fused magnesium sulphate, can be stored without nitrogen loss; and that if the mixture is applied within a few days after mixing, even if there is some moisture present in ammonium sulphate there will be very little nitrogen loss.

Chang *et al* (1953) while studying the relative availability of ammonium sulphate, ammonium chloride, ammonium nitrate and urea to rice, found that ammonium sulphate and ammonium chloride were more effective than urea.

From an experiment conducted on the effect of continuous application of ammonium sulphate to paddy soil in West Bengal, for a period of 6 years, Digar and Mandal (1955) found that the yield was increased and the soil organic matter was not appreciably decreased. Trickey and Smith (1955) measured the effect of temperature, soil moisture and methods of application on the loss of ammonia from solutions of ammonium nitrate and ammonia in water when applied to wheat. They found that loss of ammonia was increased with decrease in soil moisture and increase in temperature. Losses were less when application was made to soil than to crop residues. Yield increases from these solutions applied below the soil surface were similar to those from solid form of nitrogen. In a comparative study made by Boratynski et al (1954) from their experiments on the fertilising value of ammonia and urea, observed that aqueous ammonia was as effective as ammonium nitrate for mustard in soil cultures and for Oats in sand cultures. Aqueous ammonia and urea were better assimilated but this became reserved with mature plants.

Annsiu (1956) studied the effects of difficultly soluble nitrogenous fertilizers on yield of oats by pot culture experiments. He found that urea form fertilizers when applied in high doses were more efficient than application of equivalent amount of ammonium nitrate, and that the residual effect of urea form fertilizers were generally slight and lasted longer when the less soluble form was applied.

Izawa and Natake (1957) while working on the comparative effects of forms of nitrogenous fertilizers on the absorption of various ions by rice plants, observed that an increase of phosphorus caused a slight increase in nitrogen absorption from ammonium sulphate, but not from the nitrate form. Lee et al (1957) reported from laboratory tests that urea did not decompose for 3 to 5 days after application to the soil, thus suggesting that irrigation should be withheld during this period.

Winsor and Long (1958) reported that urea formaldehyde compounds were specialised nitrogenous fertilizers which release nitrogen slowly over long periods, have no residual salt effects and do not scorch foliage. Wagner (1958) applied different nitrogenous fertilizers such as urea, aquammonia ammonium sulphate, ammonium nitrate and sodium nitrate to different soils and found that nitrogen losses from urea ranged from 0.5 to 84 per cent. If temperature of the soil, moisture and pH are satisfactory the nitrate will be produced from an added ammonium fertilizer in sufficient quantity for growing plants in most soils. Rai (1959) observed that nitrogen loss from ammonium sulphate increased with higher doses of application. The loss was decreased when cowdung was added with the fertilizer. By a study of the effect of different factors on volatilization of ammonia formed from urea in the soil, Ernst and Massey (1960) concluded that under laboratory condition in silt loam soil loss increased with increasing temperature and/or pH.

Meyer, Olson and Rhoades (1961) found that nitrogen losses were high from urea and urea containing fertilizers than from nitrate and ammonium fertilizers. Larson and Gunerg (1962) found that the loss of ammonia from soil treated with calcium, barium or magnesium carbonate was much greater from ammonium sulphate than from diammonium phosphate or ammonium nitrate. Chin and Kroontji (1963) pointed out biochemical hydrolysis of urea to be rapid and nitrogen loss through ammonia volatilization to follow urea hydrolysis. Fuller (1963) found that loss of ammonia applied on the surface increases as the pH increases. Finfrock and Donahue (1965) found that only the ammonia form of nitrogen or urea are better for rice and that ammonium nitrate and calcium ammonium nitrate are not efficient when applied in wet land paddy as basal dressing.

3. <u>The effect of soil characteristics on the nitrogen loss from different nitrogenous fertilizers</u>

It has also been noted that the nitrogen losses from the applied nitrogenous fertilizers are determined to a large extent by the nature of soil as well.

Jewett (1942) working on calcareous soils with pH 8 to 10 found that substantial loss of nitrogen occurred when ammonium sulphate was applied. But the loss was eliminated when evaporation was stopped. Van (1950) found by applying nitrogenous fertilizers to calcareous soils of the Zinderzea polders, that appreciable amount of ammonia may be lost to the air, the rate of loss being greater, the drier the soil. Harding <u>et al</u> (1951) and Martin and Chapman (1951) have also reported on the loss of ammonia by volatilization from surface fertilized and nontilled soils of temperate regions. Schreuen, Van (1955, 1956) applying ammonium containing fertilizers to calcareous soils of zuiderzee polders found that on most soils nitrate containing fertilizers were superior to ammonium containing ones, and that volatilization occur on polder and other soils with pH 7. Balasundaram, Sreenivasan and Giri (1955) observed on alkaline cotton soils, the nitrogen loss from farm yard manure was 2 to 5 per cent, from groundnut cake 6 to 18 per cent and from ammonium sulphate 20 to 70 per cent. The carbohydrate materials like straw, cotton stubbles etc. reduced the loss by 40 to 80 per cent and increased yield of cotton by 30 to 50 per cent. Volk (1959) found that the rate of conversion of urea into ammonium nitrogen was lowest in citrus soil containing much residual copper.

In some West Pakistan soils, Wahhab and Alam (1957) observed that when soils were treated with ammonium sulphate in aqueous solution, nitrification took place more rapidly in sandy loam soils of normal texture and salt content than from soils of high clay content or those with pH above 8.6. Wahhab, Randhawa and Alam (1957) working on West Pakistan soils which are alkaline and with a low nitrogen content found that twice as much ammonia volatilized from the sandy as from a sandy loam soil. Loss of ammonia increased with increase in ammonia nitrogen concentration, but it decreased with depth of fertilizer placement and fall in soil pH upto pH 5.4. Lowenstien et al (1957) found that when ammonium sulphate was applied to calcareous soil, nitrogen was lost as ammonia gas.

McDowell and Smith (1958) pointed out that the ammonium fixation increased with increasing clay content of the soil. The sandy loam soil 18.1 per cent and in calcareous clay 0.31 per cent ammonia were lost by volatilization from 3" depth 36 hours after application of anhydrous ammonia. Baldwin and Ketcheson (1958) studied the effect of texture of different soils and found when 80 lb of nitrogen was applied per acre only 50 to 100 per cent of the added nitrogen was recovered. Volk (1959) working on bare soil, found marked variations in the percentage of nitrogen lost as ammonia between pelleted and crystalline forms of urea. Vanstallen (1960) found that in alkaline soils ammonia volatilization occurred only when the ammonia concentration was high.

Low and Piper (1961) observed that when ammonium fertilizer were applied superficially to calcareous soils nitrogen will be lost as ammonia gas. Justice and Smith (1962) have concluded that in tropical countries very high losses of ammonia could be anticipated on application of ammoniacal fertilizers if they are not worked in to the soil. Harding et al (1963) have reported that substantial volatilization losses of ammonia would occur with urea on calcareous as well as acid soils. Lehr and Wesemael (1962) also found high volatilization of ammonia from calcareous soil when ammonium fertilizers were applied superficially.

4. Effect of different nitrogenous fertilizers on the yield and chemical composition of paddy

Different nitrogenous fertilizers exert varying influence on the growth and yield of paddy. Badische Anilinundsoda Fabric (1947) studied the effect of different levels of nitrogen 20 to 60 kg/ha applied to barley and found that 50 kg/ha was economic for summer barley and 60 kg/ha for winter barley. Halliday (1948) gave higher levels of ammonium sulphate (1 to 12 cwt per acre) and studied the yield response. The higher the nitrogen level, lower the yield value when the dose of nitrogen exceeded the optimum level. Petrosini and

Leone (1948) in their studies on fertilizing of different wheat varieties and on their nutritive value, reported that the fertilizer level did not affect the nitrogen content, but high yield was linked with reduced mineral content, especially in the case of phosphorus. Viets and Domingo (1949) showed significant yield differences between levels of nitrogen when applied to corn hybrids. Huppert and Buchner (1951) reported that low and moderate applications of nitrogen reduced the nitrogen content of grains and straw, but higher application had the opposite effect. Increased yield also reduced the nitrogen content in cereals. Fujiwara, Ohira and Narita (1951) found that top dressing with nitrogen causes a temporary rise of protein nitrogen in rice, but total nitrogen content subsequently falls as a result of increase of dry matter.

Lorenz and Johnson (1951) found that ammonium fertilizers provided greatly increased yields over nitrate fertilizers and that ammonium sulphate released native soil phosphate, whereas nitrogen from calcium nitrate and sodium nitrate did not. Sturgis, Miears and Walker (1952) pointed out that fertilizers increased yield, but gave no significant increase in protein nitrogen. Gardner (1953) showed that nitrogen fertilizers increased protein content of grain and straw of winter wheat, winter oats and spring oats. Singh and Anant Rao (1954) studied the manuring of wheat and the effect of excessive nitrogenous manuring on this crop. Considerable decrease in wheat yields at levels of 75 lb of nitrogen per acre and above, were principally associated with severe lodging. Test weight of the grains decreased with applications exceeding 60 lb of nitrogen. Chandnani (1954) from his studies on the relative value of ammonium sulphate, ammonium nitrate, chilean nitrate and urea as nitrogenous fertilizers, found that ammonium sulphate was most effective and urea least effective.

Misra and Samantarai (1955) reported that increasing application of nitrogen from 0.037 g/pot to 3 g/pot as nutrient solutions had no effect on time of earhead emergence, but increase the number of tillers and leaves and increased stem length, particularly at 1 and 3 g/pot. Results of trials conducted in Bombay, Madras, Bengal and Madhya Pradesh (1956) proved that application of nitrogen at 25 lb/acre over the yields by 3 md/acre over the yield generally obtained by cultivators practices.

Lin and Wang (1956) showed that with applications of 40, 80 and 120 kg/ha nitrogen first crop yield increased as the rate increased, in the second crop there was little difference between rates of 80 and 120 kg/ha. There was no significant difference between ammonium sulphate and ammonium chloride, but both were better than urea. Calcium ammonium nitrate was the least effective. Atanasiu (1957) in the field experiments with oats on a sandy soil, urea form fertilizers applied at 60 to 240 kg per hectare nitrogen showed only slight residual effects in the second year, the product of lower solubility showing greater efficiency. Ponnamperuma (1959) stated that on moderately well drained acid laterite soils, the response of rice to nitrogen was linear in the range 0 to 60 lb nitrogen per acre, and averaged 9 lb grain per pound of nitrogen applied. Digar (1960) obtained an increase in straw:grain ratio by an increased dose of ammonium sulphate and found that a combination of 30 lb of nitrogen and 60 lb of phosphorus appeared to be the best for higher production. Relwani (1960) emphazised that ammonium sulphate produced significant increase in wheat and nature of the response curve was quadratic. Jayasekera and Ariyanayagam (1962) while comparing relative efficiency of ammonium sulphate and urea found that for sandy soils urea was a more effective source of nitrogen. From the experiments conducted at Central Rice Research Institute, Cuttack (1963) it was noted that of the nitrogenous fertilizers, ammonium sulphate nitrate, ammonium chloride, ammonium sulphate, urea formaldehyde and ammonium phosphate, the yield response was maximum with ammonium sulphate nitrate. Mahapatra and Sahu (1963) obtained significantly higher yields over control with all the five nitrogenous fertilizers, viz., ammonium sulphate, ammonium sulphate nitrate, ammonium chloride, calcium ammonium nitrate and urea, while the maximum economic return was with the application of 60 lb nitrogen per acre of ammonium nitrate followed by ammonium sulphate nitrate and ammonium sulphate at 40 lb/acre. Bhattacharya _et al_ (1965) from their extensive field trials with different forms of nitrogen, phosphorus and complex fertilizers on paddy in Bihar, noted that the different forms of nitrogenous fertilizers were equally effective in increasing the yield of paddy in the state. Vachhani and Rao (1965) stated that from the point of view of mean yields and responses for rice ammonium sulphate was much superior to ammonium phosphate and ammonium chloride. According to these authors sodium nitrate and calcium cyanamide were not suitable nitrogenous fertilizers for the rice crop. Kochappan Nair and Koshy (1966) while evaluating the influence of different forms of nitrogen at the rate of 40 kg nitrogen per hectare on the growth and yield characters of some Kerala rice varieties reported that ammonium sulphate produced the largest number of grains per earhead and ammonium nitrate the lowest and that the maximum grain yield was for ammonium sulphate.

MATERIALS AND METHODS

MATERIALS AND METHODS

This investigation was carried out through the following experiments.

A. Laboratory studies

B. Pot culture experiment with paddy

A. Laboratory studies

It was intended primarily to assess the loss of nitrogen by leaching from different nitrogenous fertilizers, when applied to different types of soil.

Three types of soils were selected, namely sandy soil soil collected from a paddy field at Onattukara, red loam soil collected from the dry lands of Vellayani and clayey soil collected from Vellayani lake. The data regarding the mechanical and chemical analysis of these soils are given in the following table.

Mechanical composition and pH of the soils used in the pot culture experiment

Soil	Coarse sand %	Fine sand %	Silt %	Clay %	pH
Red loam	13.1	33.1	28.0	24.2	4.5
Clayey	12.3	26.0	11.0	47.8	4.6
Sandy	35.1	28.2	21.3	14.5	5.0

Chemical composition of the soils used in pot culture experiment (expressed in percentage)

Soil	N	P	K	Ca	Mg
Red loam	0.126	0.045	0.16	0.177	0.037
Clayey	0.423	0.043	0.18	0.215	0.035
Sandy	0.092	0.031	0.02	0.072	0.005

Preparation of pots

Eighteen glazed porcelain pots of height 8.5" and diameter 5" were filled with the three different types of soil to a definite depth, six pots being allotted for each type of soil. Each of the pots having sandy soil contained 2 kilograms of sand to a depth of 5.5". In the pots containing red loam soils, 2 kilograms of soils were taken in each pot to a depth of 6.5", while in the pots containing clay, 1 kilogram of soil was put in each pot to a depth of 7".

Application of fertilizers

The fertilizers used were urea, ammonium sulphate, and a mixture of ammophos and magnesium carbonate. This mixture was obtained by intimately mixing ammophos and magnesium carbonate in the ratio 23:17 by weight.

The three fertilizers were applied to soil in each pot at two levels of nitrogen, 120 kg N/ha and 240 kg N/ha. Each fertilizer at the required level was applied to the soil in each pot superficially and the soil at 2 cm depth from the surface was well mixed with the fertilizer.

Distilled water was added to each pot, sufficient enough to completely soak the soil and to have a water level of 3 cm above the soil surface.

Collection of leachate

100 cc of leachate was collected from each pot through a side tube at the bottom of the pot, at intervals of 12, 24, 48 and 72 hours after application of fertilizer. After the removal of leachate, fresh distilled water was added to each pot to maintain the level of water above the surface of soil always at 3 cm. The leachate was analysed for total and ammoniacal nitrogen.

B. Pot culture experiment

The same three types of soil used in the laboratory studies were used in this experiment. Glazed earthen pots of height 13" and diameter 9" were filled with the soil to a depth of 10".

1. Layout and treatments

The layout adopted was factorial experiment in randomised block design with 18 treatments and three replications.

2. Application of fertilizers

The three types of nitrogenous fertilizers used were urea (46% N), ammonium sulphate (20% N) and a mixture of ammophos and magnesium carbonate in the ratio 23:17 by weight. The levels of nitrogen applied were 80 kg N/ha and 120 kg N/ha.

In all the treatments K_2O was applied basally at the time of transplantation. P_2O_5 was given to the treatments with urea and ammonium sulphate as super phosphate (18% P_2O_5) so as to supply the same level of P_2O_5 as in the different levels of ammophos magnesium carbonate mixture. For all pots K_2O at 80 kg/ha was applied as muriate of potash (50% K_2O). In the pots treated with urea and ammonium sulphate, magnesium carbonate was also applied, in amounts equivalent to that in the ammophos magnesium carbonate mixture. Nitrogen was applied in split doses, 75% being applied at the time of transplantation and the remaining 25% after 21 days of transplantation.

3. Seedlings

Sprouted seeds of rice variety I.R.8 were sown in the nursery, receiving no fertilizers.

4. Transplanting

The seedlings were transplanted on the 31st day, in the pots. Six seedlings were planted in each pot, two seedlings each in three points, equidistant from one another.

5. Irrigation

The seedlings were irrigated periodically so as to maintain a constant level of 3 cm of water above the surface of the soil.

Plant protection measures were taken by spraying the plants with Bordeaux mixture and folidol.

6. Harvesting

The plants grown on red loam and sandy soils were harvested on 125th day after sowing and those grown on clayey soils were harvested on the 133rd day.

7. Observations

The following observations were made.

(a) Tiller counts. The tiller counts were taken on the 60th day after transplantation, which was the stage of maximum tillering. Symptoms of yellowing in plants grown on red loam and clayey soils were noted.

(b) Grain yield

(c) Length of earhead

(d) Number of grains per earhead

(e) Grain:chaff ratio

(f) Straw yield

8. Collection of soil sample after harvest

Soil samples from each pot were collected after harvest and analysed for total nitrogen, phosphoric acid, potash, calcium and magnesium, and the results are given in appendix.

Method of analysis

1. Analysis of leachate

Total nitrogen and ammoniacal nitrogen in the leachate were estimated colorimetrically by the method recommended by Sankaram. A Klett Summerson test tube model colorimeter was used.

2. Analysis of plant parts

Nitrogen and phosphorus in grain and straw were estimated in samples of about 0.1 g of the dry powdered materials. The two nutrients were determined by standard colorimetric methods after digestion of the material by a micro Kjeldhal Gunning method as adopted by Poidevin and Robinson (1964).

Potassium was estimated in 2 g of the sample using triple acid, by following the procedure given by Jackson (1958). Estimation was done by the turbidimetric method detailed by Lindner (1944).

3. Analysis of soil

(a) Total nitrogen, phosphoric acid, potash, estimated by methods recommended by Piper (1942).

(b) Calcium and magnesium estimated as their oxides by Versenate method outlined by Jackson (1958).

(c) Mechanical analysis of soil by International Pipette method.

RESULTS

R E S U L T S

The investigation envisaged the study of the loss of nitrogen due to leaching from different nitrogenous fertilizers applied to different types of soil and their comparative effect on the performance of rice variety I.R.8. The results obtained from the study are presented in Tables I to XI.

Laboratory studies

The mixture of ammonium phosphate and magnesium carbonate used as one of the nitrogenous fertilizers in this study, was prepared by mixing ammophos and magnesium carbonate in the ratio 23:17 and grinding the mixture to homogenity in a mortar. This mixture was allowed to remain in airtight polythene bags for three days before application to the soil. The mixture was analysed for nitrogen and phosphoric acid content and the results are given in Table I.

From Table I, it will be seen that more than 50 per cent of the total nitrogen in the ammophos of the mixture has been rendered water insoluble. Similarly as regards the P_2O_5 content, only 30 per cent of the total P_2O_5 was water soluble.

TABLE I

Analysis of Ammophos-Magnesium carbonate mixture

Total Nitrogen	9.8%
Water soluble	4.06%
Water insoluble N	5.74%
Total P_2O_5	11.50%
Citrate soluble P_2O_5	7.0%

Ammoniacal and total nitrogen present in the soil leachate from different soils treated with the three different nitrogenous fertilizers are given in Tables II (a), (b) and (c). In the red loam soil the ammoniacal nitrogen in the leachate from urea application at 120 kg N/ha abruptly fell from 65 ppm. after 12 hours to trace amounts in 24 hours and thereafter also there was only trace amounts of ammoniacal nitrogen in the leachate. With urea application at the higher level, namely 240 kg N/ha the content of ammoniacal nitrogen in the leachate from red loam soil decreased steadily, but much less slowly than at the lower level. In the leachate from clayey soil, the ammoniacal nitrogen from urea application was generally higher than that from the red loam soil at both levels of nitrogen application. In the sandy soil

TABLE II (a)

Ammoniacal and total nitrogen (in ppm) in soil leachate from different nitrogenous fertilizers applied at different levels in different soils

Red loam

Fertilizer	Urea				Ammonium sulphate				AM mixture			
Level	120 kg/ha		240 kg/ha		120 kg/ha		240 kg/ha		120 kg/ha		240 kg/ha	
Form of Nitrogen	Amm. N	Total N	Amm. N	Total N	Amm. N	Total N	Amm. N	Total N	Amm. N	Total N	Amm. N	Total N
Time of leachate collection												
12 Hrs.	65	70	55	73	65	66	79	87	11	20	15	25
24 Hrs.	Trace	87	88	265	35	93	52	103	62	89	75	152
48 Hrs.	Trace	106	110	252	15	100	28	115	37	106	43	134
72 Hrs.	Trace	43	35	60	Trace	37	12	58	16	52	20	63

AM mixture = Ammophos-Magnesium carbonate mixture

Amm. N = Ammoniacal Nitrogen

TABLE II (b)

Ammoniacal and total nitrogen (in ppm) in soil leachate from different nitrogenous fertilizers applied at different levels in different soils

Clayey soil

Fertilizer	Urea				Ammonium sulphate				AM mixture			
Level	120 kg/ha		240 kg/ha		120 kg/ha		240 kg/ha		120 kg/ha		240 kg/ha	
Form of Nitrogen	Amm. N	Total N	Amm. N	Total N	Amm. N	Total N	Amm. N	Total N	Amm. N	Total N	Amm. N	Total N
Time of leachate collection												
12 Hrs.	67	76	98	112	60	65	75	85	17	40	24	53
24 Hrs.	21	92	58	130	73	102	98	128	65	120	95	165
48 Hrs.	10	75	30	85	25	77	32	86	52	93	76	126
72 Hrs.	Trace	33	9	42	14	23	10	51	16	36	20	42

AM mixture = Ammophos-Magnesium carbonate mixture

Amm. N = Ammoniacal Nitrogen

TABLE II (c)

Ammoniacal and total nitrogen (in ppm) in soil leachate from different nitrogenous fertilizers applied at different levels in different soils

Sandy soil

Fertilizer	Urea				Ammonium sulphate				AM mixture			
Level	120 kg/ha		240 kg/ha		120 kg/ha		240 kg/ha		120 kg/ha		240 kg/ha	
Form of Nitrogen	Amm. N	Total N	Amm. N	Total N	Amm. N	Total N	Amm. N	Total N	Amm. N	Total N	Amm. N	Total N
Time of leachate collection												
12 Hrs.	Trace	45	Trace	66	150	159	170	173	135	235	220	386
24 Hrs.	40	210	60	333	105	214	240	287	150	260	250	460
48 Hrs.	60	206	100	165	37	290	318	366	120	327	106	344
72 Hrs.	12	106	36	113	27	197	210	247	35	240	63	280

AM mixture = Ammophos-Magnesium carbonate mixture

Amm. N = Ammoniacal Nitrogen

receiving urea at 120 kg N/ha the leachate collected after 12 hours did not contain any measurable amount of ammoniacal nitrogen. But the leachate collected at subsequent intervals contained higher amounts of ammoniacal nitrogen than that from the red loam or clayey soils. The same trend is noticed, more or less, at the higher level of nitrogen application.

Reference to Tables II (a), (b) and (c) shows that in the soils treated with ammonium sulphate, the content of ammoniacal nitrogen was generally much, higher in the leachate from sandy soil than that from red loam or clayey soils. At nitrogen application at 120 kg/ha the ammoniacal nitrogen in the leachate decreased from 65 ppm to trace amounts in red loam soil, from 60 ppm to 14 ppm in clayey soils and from 150 ppm to 27 ppm in sandy soils, during 72 hours. The application of ammonium sulphate at 240 kg N/ha did not appreciably increase the content of ammoniacal nitrogen in red loam soil, while it increased in clayey soil after 24 and 48 hours. In the sandy soil, the application of ammonium sulphate at 240 kg N/ha increased the content of ammoniacal nitrogen from 150 ppm after 12 hours to 318 ppm after 48 hours thereafter decreasing to 210 ppm after 72 hours. Moreover in the sandy soil, the total nitrogen in the leachate from nitrogen application at 240 kg/ha was very much higher than that found in the other two types of soil. While the total nitrogen content ranged from a minimum of 173 ppm to a maximum of 366 ppm in sandy soil leachate, the variation was only from 67 to 96 ppm in red loam soil and from 85 to 106 ppm in clayey soil during the same interval, namely 12 to 48 hours.

As regards the mixture of ammophos and magnesium carbonate, results in Tables II (a), (b) and (c) shows that in the leachate from all the three soils, the ammoniacal nitrogen was very much lower than the total nitrogen for both the levels of nitrogen application. In the leachate from sandy soil, both the total and ammoniacal nitrogen were very much higher than that in the leachate from the other two types of soils. In the red loam and clayey soils, the total nitrogen in the leachate generally increased to a maximum in 24 hours, thereafter tending to decrease steadily. In the sandy soil, the total nitrogen in the leachate increased rather at a much slower rate than that noticed in the red loam and clayey soils. At 240 kg N/ha the total nitrogen in the leachate obtained by application of ammophos-magnesium carbonate mixture to sandy soil rose from 386 ppm after 12 hours to 460 ppm after 24 hours and then fell to 280 ppm after 72 hours.

The amount of total nitrogen removed by leaching at successive intervals of time are depicted graphically in figures 1 to 6. It will be seen from the graphs that the rate of loss of nitrogen is most rapid from urea and least from ammophos-magnesium carbonate mixture. From the nature of the graph it may be seen that the loss of nitrogen by leaching after 48 hours is very slow.

Pot culture experiment

Results obtained from pot culture experiment using different nitrogenous fertilizers on the rice variety I.R.8 are given in Tables III to XI.

In Table III is given the tiller counts taken on the 60th day after transplantation. It will be seen from the table that the mean tiller counts are lowest in red loam soil and highest in clayey soil for the treatment with urea. Further, there is no appreciable increase in tiller number for the different levels of nitrogen applied as urea on clayey soil, whereas the most marked difference in this respect was noted in sandy soil. In the ammonium sulphate treated soils, the tiller number was lowest in clayey soil and highest in sandy soil, with the difference in effect for the different levels of nitrogen, being significant for all the three soil types. For the treatment with ammophos-magnesium carbonate mixture also, the tiller number was maximum in sandy soil and minimum in clayey soil, the values being 14.1 and 10.4 respectively. The effect of different levels of nitrogen applied as ammophos-magnesium carbonate mixture was also significant in the case of red loam and sandy soils.

Data regarding the length of earhead are recorded in Table IV, from which it may be noted that the length of earhead was maximum for the three soils treated with ammophos-magnesium carbonate mixture at 120 kg N/ha, the values being 19.0, 19.6 and 18.2 for red loam, clay and sandy soil respectively. However, there was not much significant difference between the different fertilizers or the different levels of nitrogen as regards length of earhead.

From Table V it may be noted that the number of grains per panicle was generally significantly increased with higher levels of fertilizers and different soils. The maximum number of grains per panicle was obtained for clayey soils receiving nitrogen at 120 kg/ha in the form of ammonium sulphate or ammophos-magnesium carbonate mixture. As regards the relative effects of the different fertilizers with respect to soil type, it will be seen that the effect of all the fertilizers was maximum in red loam and clayey soils.

The grain yields are recorded in Table VI. The different levels of nitrogen applied in the form of urea, ammonium sulphate and mixture of ammophos and magnesium carbonate have significantly enhanced yields, eventhough the effect of these fertilizers as regards soil type was not significant. The nitrogen applied at 120 kg/ha gave the maximum yield of grains with all the three fertilizers and the three soils. The mean grain yield at 80 kg N/ha was 39.9 g/pot while that at 120 kg N/ha was 45.4 g/pot.

In Table VII, data regarding grain:chaff ratio are given. It is evident that nitrogen applied at 120 kg/ha had not significantly altered the grain:chaff ratio over that at the lower level, namely 80 kg N/ha. There is significant interaction between fertilizer and soil at 1 per cent level. Thus, the effect of the fertilizers in influencing the grain:chaff ratio, depends also on the type of soil.

The yield of straw from the pot culture experiment are given in Table VIII. Results presented in this table showed that yield was significantly increased by different levels of nitrogen, different fertilizers and different types of soil. The mean straw yield in red loam, clay and sandy soils were 40.6, 33.8 and 35.5 g/pot respectively, the maximum value obtained thus being red loam soil. The mean yield for nitrogen at 80 kg/ha was 34.1 g/pot while that at 120 kg/ha was 38.9 g/pot, thus significant difference in yield for higher levels of nitrogen applied. Of the three fertilizers, the maximum straw yield was for the mixture of ammophos and magnesium carbonate.

In Tables IX and X are given the nutrient content of grain and straw. Reference to table IX shows that as regards nitrogen content of the grain, there was no significant difference between the two levels of nitrogen. But the form of nitrogen applied markedly influenced the nitrogen content of the grain. The nitrogen content of the grain was maximum for the treatment with mixture of ammophos and magnesium carbonate at 120 kg N/ha the value being 1.1 per cent.

There was significant increase in the phosphorus content of the grain when the level of nitrogen was increased from 80 kg/ha to 120 kg/ha. The phosphorus content of the grain was generally higher for the plants receiving nitrogen as mixture of ammophos and magnesium carbonate. As regards the potash content of the grain, it is seen that the content of this nutrient was depressed by higher levels of nitrogen. The different forms of nitrogen applied did not markedly affect the potash content of the grain. The calcium content of the grain was generally lowered by higher levels of application of nitrogen. Among the fertilizers used, the calcium content of the grain was greater for the treatment with ammonium sulphate and mixture of ammophos and magnesium carbonate. Among the different soils, the calcium content of the grain was less in the plants grown in sandy soil than that in clayey or red loam soils. In general it may be seen that magnesium content of the grain is enhanced by higher level of nitrogen regardless of the form in which nitrogen is applied (Table IX).

Reference to Table X shows that the nitrogen content of the straw was not markedly affected by the different levels of nitrogen. With respect to the soil also, there was not much difference in the nitrogen content of the straw. As regards phosphorus content, it is seen that the phosphorus content was slightly increased by increasing levels of nitrogen. The phosphorus content was generally higher for the plants receiving ammonium sulphate or mixture of ammophos and magnesium carbonate. Increased levels of application of nitrogen had resulted in a decrease in the potash content of the straw, while the calcium content was not much affected. However the magnesium content of the straw was slightly increased by higher level of nitrogen application, particularly when nitrogen was applied as mixture of ammophos and magnesium carbonate.

The total quantity of each nutrient absorbed by the plants per pot is given in Table XI. The results show that the effect of ammophos-magnesium carbonate mixture was significant in causing a greater absorption of all the nutrients. The maximum quantity of each nutrient absorbed varied with the type of soil also.

TABLE III

Effect of different nitrogenous fertilizers on the number of tillers of paddy variety I.R.8, when applied at different levels in different soils

Soil		Red loam	Clay	Sandy	
Fertilizer	Level				Mean
Urea	80	8.9	11.2	9.5	9.9
	120	9.8	11.2	12.2	11.1
Mean		9.4	11.2	10.9	10.5
Ammonium sulphate	80	9.8	8.1	12.2	10.0
	120	11.3	10.9	14.0	12.1
Mean		10.6	9.5	13.1	11.0
AM mixture	80	9.9	10.6	12.7	11.1
	120	13.0	10.2	15.5	12.9
Mean		11.5	10.4	14.1	12.0
		10.5	10.4	12.7	

AM mixture = Ammophos-Magnesium carbonate mixture

TABLE IV

Effect of different nitrogenous fertilizers on length of earhead (cm) of paddy variety I.R.8, when applied at different levels in different soils

Soil		Red loam	Clay	Sandy	
Fertilizer	Level				Mean
Urea	80	17.7	17.8	17.2	17.6
	120	18.0	18.1	18.3	18.1
Mean		17.9	18.0	17.8	17.9
Ammonium sulphate	80	17.8	17.9	17.6	17.8
	120	18.7	18.6	17.9	18.7
Mean		18.3	18.3	17.8	18.3
AM mixture	80	18.2	17.7	17.4	17.8
	120	19.0	19.6	18.2	18.9
Mean		18.6	18.7	17.8	18.4
		18.3	18.3	17.8	

AM mixture = Ammophos-Magnesium carbonate mixture

TABLE V

Effect of different nitrogenous fertilizers on the number of grains per panicle of paddy variety I.R.8, when applied at different levels in different soils

Soil		Red loam	Clay	Sandy	
Fertilizer	Level				Mean
Urea	80	60	59	56	57
	120	61	62	60	61
Mean		61	61	58	59
Ammonium sulphate	80	58	60	53	57
	120	63	67	58	63
Mean		61	64	56	60
AM mixture	80	62	60	51	58
	120	60	67	61	63
Mean		61	64	56	61
		61	63	57	

AM mixture = Ammophos-Magnesium carbonate mixture

TABLE VI

Effect of different nitrogenous fertilizers on the yield of grain of paddy variety I.R.8, when applied at different levels in different soils (in g/pot)

Soil		Red loam	Clay	Sandy	
Fertilizer	Level				Mean
Urea	80	42.1	41.9	38.0	40.7
	120	47.1	47.1	44.5	46.7
Mean		44.6	44.5	41.3	43.7
Ammonium sulphate	80	37.9	40.5	37.0	38.5
	120	47.6	49.0	42.0	46.2
Mean		42.8	44.8	39.5	42.4
AM mixture	80	36.4	43.0	39.8	39.7
	120	44.2	44.8	40.8	43.3
Mean		40.3	43.9	40.3	41.5
		42.8	42.4	41.5	

AM mixture = Ammophos-Magnesium carbonate mixture

TABLE VII

Effect of different nitrogenous fertilizers on Grain:chaff ratio of paddy variety I.R.8, when applied at different levels in different soils

Soil		Red loam	Clay	Sandy	
Fertilizer	Level				Mean
Urea	80	7.9	7.3	7.3	7.5
	120	7.9	6.6	6.8	7.1
Mean		7.9	7.0	7.0	7.3
Ammonium sulphate	80	8.2	5.2	10.1	7.8
	120	8.9	5.5	7.9	7.4
Mean		8.6	5.4	9.0	7.6
AM mixture	80	5.8	7.1	7.0	6.8
	120	6.6	7.7	7.4	7.2
Mean		6.2	7.4	7.2	7.0
		7.3	7.6	6.9	

AM mixture = Ammophos-Magnesium carbonate mixture

TABLE VIII

Effect of different nitrogenous fertilizers on the yield of straw of paddy variety I.R.8, when applied at different levels in different soils (in g/pot)

Soil		Red loam	Clay	Sandy	
Fertilizer	Level				Mean
Urea	80	34.9	34.3	37.0	35.4
	120	41.2	33.1	37.3	37.2
Mean		38.0	33.7	37.1	36.3
Ammonium sulphate	80	34.5	28.5	35.2	32.7
	120	43.1	36.3	36.0	38.5
Mean		38.8	32.4	35.6	35.6
AM mixture	80	37.2	34.8	33.5	35.2
	120	53.1	36.2	34.0	41.1
Mean		45.1	35.5	33.7	38.2
		40.6	33.8	35.5	

AM mixture = Ammophos-Magnesium carbonate mixture

TABLE IX

Effect of different nitrogenous fertilizers on the composition of grain of paddy variety I.R.8, when applied at different levels in different soils (%)

Soil	Fertilizer	Level	N	P_2O_5	K_2O	CaO	MgO
Red loam	Urea	80	0.77	0.42	0.77	0.10	0.052
		120	0.77	0.63	0.56	0.08	0.073
	Ammonium sulphate	80	0.83	0.65	0.83	0.11	0.062
		120	0.88	0.57	0.80	0.07	0.093
	AM mixture	80	0.99	0.62	0.82	0.12	0.084
		120	1.10	0.74	0.75	0.11	0.080
Clay	Urea	80	1.05	0.58	0.69	0.11	0.073
		120	1.00	0.61	0.62	0.08	0.091
	Ammonium sulphate	80	0.88	0.64	0.97	0.13	0.092
		120	0.97	0.61	0.82	0.09	0.087
	AM mixture	80	0.99	0.58	0.83	0.11	0.069
		120	1.03	0.63	0.94	0.13	0.092
Sandy	Urea	80	0.99	0.68	0.97	0.11	0.080
		120	0.94	0.64	0.67	0.08	0.076
	Ammonium sulphate	80	0.99	0.58	0.83	0.10	0.082
		120	0.99	0.63	0.79	0.07	0.090
	AM mixture	80	1.05	0.62	0.89	0.06	0.086
		120	1.10	0.69	0.93	0.10	0.092

AM mixture = Ammophos-Magnesium carbonate mixture

TABLE X

Effect of different nitrogenous fertilizers on the composition of straw of paddy Variety I.R.8, when applied at different levels in different soils (%)

Soil	Fertilizer	Level	N	P_2O_5	K_2O	CaO	MgO
Red loam	Urea	80	0.814	0.046	0.888	0.960	0.143
		120	1.012	0.064	1.443	1.120	0.153
	Ammonium sulphate	80	0.781	0.094	1.203	0.890	0.133
		120	0.726	0.066	1.499	0.880	0.180
	AM mixture	80	0.902	0.110	0.740	1.050	0.190
		120	0.814	0.132	1.166	0.952	0.220
Clay	Urea	80	0.946	0.062	1.203	0.990	0.120
		120	0.880	0.020	1.055	0.992	0.192
	Ammonium sulphate	80	0.704	0.040	0.722	0.841	0.097
		120	0.770	0.046	1.443	0.736	0.122
	AM mixture	80	0.847	0.020	1.503	0.827	0.203
		120	0.902	0.040	1.320	0.881	0.182
Sandy	Urea	80	0.781	0.072	0.722	0.792	0.112
		120	0.979	0.118	1.443	0.892	0.099
	Ammonium sulphate	80	0.902	0.044	1.554	0.936	0.162
		120	0.869	0.106	1.110	0.872	0.156
	AM mixture	80	0.792	0.114	1.665	0.763	0.190
		120	0.781	0.260	1.110	0.884	0.212

AM mixture = Ammophos-Magnesium carbonate mixture

TABLE XI

Effect of different nitrogenous fertilizers in total uptake of nutrients by the paddy variety I.R.8, when applied at different levels in different soils (g/pot)

Soil	Fertilizer	Level	N	P_2O_5	K_2O	CaO	MgO
Red loam	Urea	80	0.608	0.133	0.633	0.377	0.071
		120	0.779	0.323	0.858	0.499	0.097
	Ammonium sulphate	80	0.583	0.278	0.729	0.349	0.068
		120	0.732	0.299	1.027	0.412	0.121
	AM mixture	80	0.692	0.266	0.573	0.434	0.101
		120	0.918	0.397	0.951	0.553	0.151
Clay	Urea	80	0.764	0.280	0.701	0.358	0.072
		120	0.762	0.294	0.641	0.366	0.106
	Ammonium sulphate	80	0.557	0.270	0.597	0.292	0.064
		120	0.755	0.316	0.625	0.311	0.086
	AM mixture	80	0.721	0.256	0.880	0.334	0.100
		120	0.788	0.296	0.898	0.376	0.106
Sandy	Urea	80	0.665	0.285	0.636	0.335	0.071
		120	0.783	0.329	0.836	0.368	0.070
	Ammonium sulphate	80	0.684	0.230	0.854	0.366	0.087
		120	0.729	0.303	0.731	0.607	0.094
	AM mixture	80	0.683	0.285	0.911	0.493	0.097
		120	0.714	0.370	0.756	0.708	0.110

AM mixture = Ammophos-Magnesium carbonate mixture

DISCUSSION

DISCUSSION

The study was aimed at assessing the loss of nitrogen due to leaching from different nitrogenous fertilizers applied to different types of soils and also to assess the comparative efficacy of these different nitrogenous fertilizers on the general growth characteristics of and the uptake of the different nutrients by the rice variety I.R.8. It was felt desirable to include a nitrogenous fertilizer containing some water insoluble nitrogen, as part of the study on the leaching loss of nitrogen. It was with this end in view that the mixture of ammophos and magnesium carbonate was selected. The results presented in Table I regarding the composition of this mixture shows that a total nitrogen present in the ammophos is rendered insoluble in water to the extent of 50%. So also with regard to the P_2O_5 content, a considerable portion seems to have been rendered water insoluble. Under the conditions at which this mixture was prepared and stored, some reactions between the two components might have taken place leading to the formation of a complex containing nitrogen which is water insoluble. A chemical reaction between ammophos and magnesium carbonate according to the equation,

$$NH_4H_2PO_4 + MgCO_3 \;\text{-----}\; MgNH_4PO_4 + H_2O + CO_2$$

need not be ruled out as entirely improbable. In this connection it is pertinent to note that according to Pierre and Norman magnesium ammonium phosphate has its occurrence in the mixtures of Dolomite and Ammonium phosphate. Whatever may be the probability of such a reaction it appears, in the light of the composition of this mixture, not incorrect to reckon this as a nitrogenous fertilizer containing some water insoluble nitrogen. The exact mechanism by which part of the nitrogen of ammonium phosphate has been rendered water insoluble is of course a matter deserving further investigation and is beyond the scope of the present study.

In the leachate obtained from urea treated soil (Tables II (a), (b) and (c)) there is only a very low amount of ammoniacal nitrogen showing that during the initial stages of application of this fertilizer, there is very little of ammonification taking place. In the leachate collected from ammonium sulphate treated soil it is observed that the amount of ammoniacal and total nitrogen are generally the same, especially so during the first twelve hours. This goes to show that when ammonium sulphate is applied to the soil most of the nitrogen is in the ammoniacal form during the initial stages. But with the passage of time, there is a rapid decrease in the content of ammoniacal nitrogen in the leachate from red loam and sandy soils.) In the case of clayey soil the content of ammoniacal nitrogen decreases with time, but the decrease is at a much slower rate than that observed in the case of the other two types of soil. As regards the mixture of ammophos and magnesium carbonate, the content of ammoniacal nitrogen in the leachate from red loam soil is much lower than that found in the case of ammonium sulphate. However, after 12 hours the ammoniacal nitrogen in the leachate from ammophos-magnesium carbonate mixture treated soil slightly increases and thereafter it decreases. As regards the content of total nitrogen there is an increase in its concentration in the leachate upto about 24 hours and thereafter there is a gradual decrease. It would thus appear that the loss of nitrogen by leaching is greatest from urea treated soil between ammonium sulphate and mixture of ammophos and magnesium carbonate. The nature of loss of nitrogen by leaching appears to be slightly different. In the case of ammonium sulphate the loss in the form of ammoniacal nitrogen is greatest in the initial stages, whereas in the case of ammophos magnesium carbonate mixture the loss as ammoniacal nitrogen as well as total nitrogen was much less. The results thus appear to show that in the case of ammophos magnesium carbonate mixture greatest loss may occur between 24 and 48 hours, whereas in the case of ammonium sulphate this may be between 12 and 24 hours. Thus applying nitrogen in water-insoluble form though does not altogether prevent leaching loss, makes loss by leaching a slower process.

The quantity of nitrogen present in the leachate varies with the texture of the soil. It is found that comparatively larger amounts of nitrogen are present in the leachate collected from sandy soil. This thus accounts for the open texture of this type of soil. Further this type of soil has a lesser capacity to bind ammonium ions. This finding is in general agreement with that of Van (1955) who reported that the capacity of the soil to bind ammonium ions increases with the high content of clay.

That there is a greater loss of total nitrogen and only smaller quantities of ammoniacal nitrogen in ammonium sulphate treated soil after 24 hours of fertilizer application shows that nitrification is maximum during that period. Volk (1955) studying the conversion of urea in a sandy soil reported that 5 to 35 ppm of urea nitrogen was converted to ammoniacal nitrogen in the first hour of its application and 20 to 60 ppm in 22 hours.

After 72 hours there is a reduction in the total nitrogen irrespective of the form in which nitrogen is applied (Tables II (a), (b) and (c)). This goes to show that a condition of stabilization is reached in about 72 hours after the application of fertilizers. In other words the conditions are such as to prevent loss of nitrogen during the first 48 hours, then there will not be any further leaching loss even if the fields are subjected to heavy rains.

From the foregoing, it appears that the loss of nitrogen by leaching not been prevented altogether by application of soluble nitrogen fertilizer. Nevertheless the rate of loss by leaching may be reduced substantially by using such a fertilizer. The leaching loss also depends on the texture of the soil in addition to the nature of the fertilizer.

Pot culture experiment

Results obtained in the present study indicate that highly significant differences in the number of tillers in different soils. The interaction between soil and fertilizer and between levels were also significant. For the maximum level of nitrogen viz., 120 kg/ha maximum number of tillers were obtained in sandy soils. The results have therefore definitely shown that tillering is influenced markedly by level of nitrogen and also by the nature of the fertilizer. The results also reveal that the type of soil is also as important a factor as fertilizer in initiating tillers. It would seem appropriate to modify the conclusion of Misra and Samantarai (1955) that fertilizers increase the tillering capacity of the plants as tillering is the combined effect of soils and fertilizers. Since the sandy soils are open textured, the mechanical composition of the soil has evidently played an important part in the growth of paddy. Further it may be observed in this connection that the tiller counts from the sandy soil at the nitrogen level of 80 kg/ha was even higher than that at 120 kg N/ha in the clay and red loam soils. Of the three fertilizers used, ammophos magnesium carbonate mixture appears to be superior to the other two in the matter of initiating tillers.

It would appear that the length of earhead is not much influenced by the different fertilizers or the different levels of nitrogen or the type of soil. However the maximum length of earhead was noted when nitrogen was given at 120 kg/ha as ammophos magnesium carbonate mixture. It may therefore be concluded that the length of earhead is not generally much influenced by the type of soil nor the fertilizer.

There appear to be significantly difference between levels of fertilizers and between soils as regards number of grains per panicle. However, no difference in effect between fertilizers as such is noted. It thus appears that the length of the panicle remaining the same the change in yield has been brought about by the number of grains per panicle. The maximum number of grains per panicle is obtained in clayey soils while the least in sandy soils.

As regards the yield of grains difference between levels of nitrogen are significant at 1% level. But difference in effect is not significant between different fertilizers and between soils. Thus there is no interaction between soil and fertilizer, and also soil and level so far as grain yield is considered. It may be mentioned in this connection that in field trials conducted by various authors higher doses of nitrogen was not very responsive as regards yield and that on the other hand higher nitrogen levels depressed the yield. Badische Anilin-Lindsoda Fabrik (1947) demonstrated that the nitrogen efficiency rose slightly between 20 and 40 kg/ha levels and then fall sharply, the economic level being reached at 60 kg/ha. Halliday (1948) also reported the depressing effect of higher dose of nitrogen on yield when used at a rate exceeding 1-12 cwt of ammonium sulphate per acre for barley. Walker and Robinson (1952) also showed increased yield with 1 to 3 cwt per acre of ammonium sulphate, but proportionately less yield for higher dressings. However, in the present study the grain yields are maximum for the maximum levels of nitrogen, thus the results being at variance with those mentioned above. This may be attributed to the fact that the variety I.R.8 is a high fertilizer responsive one. The result thus brings out the importance of high nitrogen fertilization for obtaining maximum response in the case of this variety.

In the case of the grain: chaff ratio the interaction between fertilizer and soil is significant at 1% level. The higher level of nitrogen application however has not increased the grain:chaff ratio significantly. This finding is in agreement with the results obtained by Prema (1967) who found that the grain:chaff ratio was not affected by the level of nitrogen applied.

As far as the yield of straw is concerned there is significant difference between treatments, between soils and between levels of fertilizers. Also the interaction between soil and level is significant at 1% level. Straw yield is maximum in red loam soil, the value being 40.7 g/ pot (Table VI). Eventhough the straw yield for different fertilizers are not significantly different, the mixture of ammophos and magnesium carbonate appears slightly superior to ammonium sulphate and urea. It would therefore appear that the mixture of ammophos and magnesium carbonate is superior from the point of view of both grain and straw yield.

The results obtained in the present study indicate that there is no significant difference in the nitrogen content of the grain between the two levels of nitrogen viz., 80 kg/ha and 120 kg/ha. The results obtained by Sturgis, Miears and Walker (1952) also shows that though fertilizers increased yield in rice, there was no significant increase in protein nitrogen in the plant. This finding was again confirmed by Takahashi, Murayania, Oshima et al (1955) who showed that the nitrogen content never exceeded 4% in rice irrespective of the amount of nitrogen applied.

An entirely different picture emerges as regards the phosphorus content of the grain and straw. The results indicate that higher levels of nitrogen, regardless of the form in which nitrogen is applied, will enhance the phosphorus content of the grain and straw. This is in partial confirmity with the results of Tanaka et al (1958) who found that an increasing nitrogen supply of the medium will increase the P_2O_5 content of the plant although not to the extent as noted in the case of nitrogen content.

It is observed that in general, the percentage of potassium in grain has been increased by higher levels of nitrogen application when nitrogen is applied in the form of ammophos magnesium carbonate mixture. However when nitrogen is applied in the form of urea there is generally a decrease in the percentage of potassium in grains, but in the case of straw this peculiarity is not much in evidence. Moreover, of the three nitrogenous fertilizers ammonium sulphate and ammophos magnesium carbonate mixture is seen to influence the percentage of potassium in grain and straw more than that of urea.

It is generally seen that higher levels of nitrogen do not show much significant difference in calcium content of straw and grain. The same holding good with regard to the different soils. While in the case of magnesium, the trend is for an increase in magnesium content of both grain and straw. The difference between the three soils under comparison is not of any significant extent.

Removal of nutrients by rice.

The removal of nitrogen by rice is seen enhanced as the level of nitrogen is increased from 80 kg/ha to 120 kg/ha. That the absorption of nitrogen by rice plant increased with increased levels of nitrogen as obtained in the present study has also been reported by Ishizuka and Tanaka (1950, 1951 b).

The pattern of removal of phosphorus by rice plant is similar to that of nitrogen. Maximum P_2O_5 removal has been noted at the highest level of nitrogen supplied. These results are in accordance with Kanapathy (1957) who obtained increase in P_2O_5 uptake with increase in nitrogen levels and Grunes (1959) who recorded marked increase in the removal of phosphorus due to application of nitrogenous fertilizers because of the effect of nitrogen in effecting the phosphorus uptake through increased root growth and better nutrient absorbing capacity.

With increasing levels of nitrogen, removal of K_2O by the crop also tended to increase. That nitrogen to a certain extent controls the efficient utilization of potassium (Anonymous, 1967) is found to hold good in the present work also.

An enhancement of removal of CaO and MgO as in the case of nitrogen, P_2O_5 and K_2O, with increasing levels of nitrogen has been noted in the present study. From the results obtained, it can be seen that nitrogen at 120 kg/ha irrespective of the form of fertilizer and soil in which it is applied, has produced higher amounts of dry matter and evidently this has resulted in a greater removal of CaO and MgO as in the case with other nutrients also.

SUMMARY AND CONCLUSIONS

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The investigation envisaged the study of the loss of nitrogen due to leaching from different nitrogenous fertilizers applied to different types of soil and their comparative efficiency on the performance of rice variety I.R.8. The study has enabled the following conclusions to be drawn.

1. The loss of nitrogen by leaching is not reduced even when nitrogen is applied in the water-insoluble form.

2. That the loss of nitrogen through leaching even from the fertilizer containing insoluble form of nitrogen might be due to the reaction between fertilizer and soil solution.

3. The loss of nitrogen depends on the texture of soil receiving nitrogenous fertilizers, maximum loss occurring in sandy soil and minimum in clayey soil.

4. The maximum loss of nitrogen through leaching occurs between 12 and 24 hours after the application of fertilizers.

5. After 72 hours of application there will be very little loss of nitrogen by leaching.

6. In red loam and clayey soils the leaching loss is considerably reduced when treated with the mixture of ammophos and magnesium carbonate, where as in sandy soil the maximum leaching loss occurs for the treatment with the mixture of ammophos and magnesium carbonate.

7. The ammophos-magnesium carbonate mixture can be recommended for red loam and clayey soils, but not for sandy soil of Kerala.

8. The initiation of tillering is influenced by level of nitrogen, form of fertilizer and the type of soil. Number of tillers increases with the increased level of nitrogen. The ammophos-magnesium carbonate mixture is superior to urea and ammonium sulphate for tiller initiation.

9. Length of earhead is not influenced by the level of nitrogen, form of fertilizer or type of soil, while the number of grains is influenced by the level of nitrogen and type of soil. The number of grains per panicle is greatest in clayey soil, and also for the higher level of nitrogen.

10. The grain:chaff ratio is not considerably affected by the level of nitrogen.

11. The straw yield is maximum when treated with ammophos-magnesium carbonate mixture in red loam soil. It is increased by the higher level of nitrogen.

12. In grain and straw there is no increase in nitrogen content with increased level of nitrogen. The P_2O_5 content is higher for higher level of nitrogen. K_2O content of grain is slightly increased when ammophos-magnesium carbonate mixture is applied, but in all the other treatments the higher level of nitrogen shows a negative tendency both for grain and straw. The CaO content is not affected. The MgO content is slightly increased in grain and straw with higher levels of nitrogen.

13. The uptake of all the nutrients, viz., N, P_2O_5, K_2O, CaO and MgO increases with increased level of nitrogen irrespective of the form of fertilizer or type of soil.

REFERENCES

REFERENCES

Andrews, W.B. 1948 The use of anhydrous ammonia as a source of nitrogen. Amer. Fert. 107, No.12, 1947.

Atnasiu, N. 1957 Investigations on the effects of difficultly soluble nitrogenous fertilizers on yields. Landw. Forsch. Sondesh. 7: 108-113. Abstracted in Soils and Fertilizers Vol. XXI. No.1-6, 1958.

Anonymous 1967 Hand book of Agriculture. Third Edition. Published by I.C.A.R., New Delhi.

Badische Anilin-Und Soda-Fabric 1947 The effect of nitrogen in barley cultivation. Z. Pfl. Ernahr. Dung, 39, 1947 (227-245) (G). Abstracted in Soils and Fertilizers. Vol. XII, 1947.

Bhuiyan, S. 1949 Transformation of nitrogen in rice soil. Soil Sci. 67, 1949 (231-237).

Boratynski, K., Malysowa, E., Turyna, Z. 1954 The fertilizing value of ammonia and urea. Roczn. Naukrol. 69 A, 33-56. Abstracted in Soils and Fertilizers. Vol. XVIII, 1955.

Balasundaran, S., Sreenivasan, K.S., Giri, K.V. 1955 Stabilization of nitrogen, an aspect of manuring of alkaline cotton soils. Indian Cott. Gr. Rev. 9, 123-128.

Broadbent, F.E., Tyler, K.B., Hill, G.N. — 1957 — Nitrification of ammoniacal fertilizers in some California soils. Hilgardia. 27: 247-267.

Broadbent, F.E., Hill, G.N., Tyler, K.B. — 1958 — Transformation and movement of urea in soils. Soil Sci. Soc. Amer. Proc. 22, 303-307.

Baldwin, C.S., Ketcheson, J.W. — 1958 — Influence of soil texture, reaction and temperature on the uptake. Canad. J. Soil Sci. 38: 134-142.

Clark, K.G., Yee, J.Y., Love, K.S. — 1948 — New synthetic nitrogenous fertilizer preparation and properties of urea form. Indust. Engng. Chem. 40: 1948 (1178-1183).

Chang, S.C., Tseng, H.D., Huang, K.S. — 1953 — A study on the relative availability of ammonium sulphate, ammonium chloride, ammonium nitrate and urea to rice. Agric. Res. Taiwan 4, No. 2, 1-41.

Chandanani, J.J. — 1954 — Primary studies on the relative value of different forms of commercial nitrogenous fertilizers. Indian J. Agric. Sci. 24: 213-226.

Dhar, N.R. — 1947 — Fixation and loss of nitrogen and the source of soil nitrogen. Proc. Ind. Acad. Sci. India. 16 A, 1947 (6-13).

Dijk, J.W. Van — 1948 — Experiments on the use of ammonia in irrigation water applied to rice. Meded. Alg. Proefsta. Land Bouw. 70: 1948, 18 (E)

Digar, S., Mandal, A.K.	1955	Effect of continuous application of ammonium sulphate on paddy soil in West Bengal. Proc. nat. Acad. Sci. India. 24 A, 405-410.
Dhar, N.R., Ghosh, S.K.	1955	Nitrogen loss in soils on the application of nitrogenous compounds and its retardation by the addition of KCl. Proc. nat. Acad. Sci. India. 24 A, 219-224.
Digar, S.	1960	Manurial requirements of paddy in a lateritic soil. J. Ind. Soc. Soil Sci. Vol. 8: No.1. March 1960.
Dwight, C. Finfrock and Roy. L. Donahue	1965	Efficiency of various nitrogenous fertilizers. Fertilizer News. July 1965.
Dutt, A.K.	1963	Farming is now in the fertilizer epoch. Indian Farming, August 1963.
Ernst, J.W., Massey, H.F.	1960	The effects of several factors on volatilization of ammonia formed from urea in the soil. Soil Sci. Soc. Amer. Proc. 24: 87-90.
Fujiwara, A., Ohira, K., Narita, S.	1951	Studies on the nitrogen nutrition of crops. II. Forms and amounts of assimilated nitrogen. J. Sci. Soil Man. Japan 22: 97-102 (Je).
Gardner, H.W.	1953	Nitrogenous dressings to increase protein in cereals. Agriculture (London) 60: 95-97.

Grunes, D.L. 1959 Effect of nitrogen on the availability of soil and fertilizer phosphorus to plants. Advances in Agronomy. 11: 369-393.

Halliday, D.J. 1948 Nitrogen for cereals. The response of cereals to increasing rates of nitrogen fertilization. Jealott's Hill Res. Sta. Bull. 6, 1948, 38.

Huppert, V., Buchner, A. 1951 Nitrogen fertilizing and protein content of cereals. Z. PflBau. Pflschutz. 115-122. Abstracted in Soils and fertilizers. Vol. XV. 1-6.

Henderson, D.W., Bianchi, W.C., Doneen, L.D. 1955 Ammonia loss from sprinkler jets. Agric. Engng. Mich. 36: 398-399.

Izawa, G., Natake, M. 1957 Comparative effects of forms of nitrogenous feeding on the adsorption of various ions by rice plants. J. Sci. Soil Tokyo 28: 31-34.

Ishizuka and Tanaka 1950 Studies on the nitrogen, phosphorus and potassium metabolism of rice plant. J. Sci. Soil Manure Japan. 21: 23-28.

Ishizuka and Tanaka 1951 b Studies on the nitrogen, phosphorus and potassium metabolism of rice plant. J. Sci. Soil Manure Japan. 22: 103-106.

Jewitt, T.N.	1942	Loss of ammonia from ammonium sulphate applied to alkaline soils. <u>Soil Sci.</u> <u>54</u>: 401-409.
Jackson, M.L., Chang, S.C.	1947	Anhydrous ammonia retention by soils as influenced by depth of application, soil texture, moisture content, pH value and tilth. <u>Jr. Amer. Soc. Agron.</u> <u>39</u>: 623-633.
Jayasekara, E.H.W., Ariyanayagam, E.P.	1962	Efficiency of urea and sulphate of ammonia as a source of nitrogen for rice in sandy soils of the Batticaloa Dist. <u>Trop. Agriculturist. Agrl. J.</u> C.F.C. XVIII (<u>3</u>): 100.
Kanapathy, K.	1957	Mineral nutrition of Padi. 1. N and P uptake of paddy grown on an extremely poor lateritic soil compared with that of dry land crops. <u>Malay. Agric. J.</u> 40, 110-121. Abstracted in Soils and Fertilizers. Vol. XXI, 1-6, 1958.
Kresge, C.B., Satchell, D.P.	1960	Gaseous loss of ammonia from nitrogenous fertilizers applied to soils. <u>Agron. J.</u> <u>52</u>: 104-107.
Kochappan Nair, K., Koshy, M.M.	1966	The influence of different forms of nitrogen on the growth and yield characters of some Kerala rice varieties. <u>Agric. Res. J. Kerala</u> <u>4</u>: (2).
Lorenz, O.A., Johnson, C.M.	1951	Nitrogen fertilization as related to the availability of P in certain Californian soils. <u>Soil Sci.</u> 75 (2): 119.

Lin, K.C., Wang, C.Y.	1956	The relative availability of ammonium sulphate, ammonium chloride, calcium ammonium nitrate and urea to rice. Agric. Res. Taiwan, 6: 23-39.
Lee, L.T., Hsu, S.M., Lin, C.T. et al	1957	An experiment on the method of application of urea on rice. Agric. Res. Taiwan, 6: 61-68.
Martin, J.P., Chapman, H.D.	1951	Volatilization of ammonia from surface fertilized soils. Soil Sci. 71: 25-34.
Misra, G., Samantarai, B.	1955	Effects of various levels of nitrogen on the vegetative growth and earhead emergence of rice plants. J. Indian bot. Soc. 34: 451-454. C.A. 50 (8955).
McDowell, L.L., Smith, G.E.	1958	The retention and reaction of anhydrous ammonia on different soil types. Soil Sci. Soc. Amer. Proc. 22: 38-42.
Meyer, R.D., Olson, R.A., Rhoades, H.F.	1961	Ammonia losses from fertilized Nebraska soils. Agron. J. 53: 24-244.
Mahapatra, I.C., Sahu, B.N.	1963	Efficiency of different nitrogenous fertilizers for rice. Rice News teller. II (2): 45.
Mustafa, S.P., Sornavelu, S.	1965	Volatilization of ammonia from black cotton soil of Madras state. Fertilizer News. Nov. 1965.

Nakagawa, M., Kitamoto, A.	1950	Studies on the miscibility of fused magnesium phosphate and ammonium sulphate 1. <u>Bull</u>. <u>Fert</u>. <u>Res</u>. <u>Inst</u>. 31. <u>Rec</u>. <u>Res</u>. <u>Univ</u>. <u>Tokyo</u>. 1950-1951. No. 1 (33). Abstracted in Soils and Fertilizers Vol. XVI. 1953.
Owen, O., Winsor, G.W.	1950	Part I. The nitrification of some nitrogenous fertilizers. J. Agric. Sci. 40; 185-190. Part II."The nitrogen status of soils". The effect of levels of application on the nitrification of some nitrogenous fertilizers. J. Agri. Sci. 40: 191-197.
Petrosini, G., Leone, G.	1948	Fertilizers of wheat variety and their nutritive value. Quanderni Nutriz. 10, 1948 (302-319) C.A. 43 (5524) (1) Abstracted in Soils and Fertilizers. Vol. XII. 1949.
Ponnamperuma	1959	Trials in cultivator's fields in Ceylon. <u>International Rice Committee</u>. <u>News Lett</u>. 1:1 - 80. Abstracted in Field crops abstracts 12 (<u>4</u>): 285.
Prema, M.K.	1967	Studies on the effect of nitrogen on the growth. Yield, and nutrient uptake of two newly introduced Rice varieties. Thesis submitted for the Degree of M.Sc.(Ag.), Univ. of Kerala. (unpublished)
Rai, M.M.	1957	The effect of increasing applications of ammonium sulphate and organic matter on nitrogen loss. <u>An</u>.<u>Edafol</u>. <u>Fisiol</u>. <u>Veg</u>. <u>18</u>: 693-699.

Relwani, L.L. 1960 The effect of ammonium and superphosphate in conjunction with farm yard manure on wheat yields. Indian J. Agron. V (1): 22.

Sreenivasan and Subramanyan, V. 1935 Biochemistry of water logged soils. J. Agr. Sci. 54: 401-409.

Steenbjerg, F. 1947 Ammonia loss from nitrogen containing commercial fertilizers when applied to top soil. Tidsskr. Planteavl. 48: 516.43. (1944). Chem. Zentbl. 11: 574. (1944)

Schreven, D.A. Van 1950 Loss of nitrogen from ammonia containing fertilizers applied to calcareous soils of the Zuiderzee polders. Trans. Fourth Internal. Cong. Soil Sci. 1: 259-261. Abstracted in Soils and Fertilizers. Vol. XIV. 1951.

Sturgis, F.E., Mierrs, R.J., Walker, R.K. 1952 Protein in rice influenced by variety and fertilizer levels. La. State Univ. Tech. Bull. 466, 28. Rice J. 56 (26). Abstracted in Soils and Fertilizers. Vol. XVI: 1953.

Singh, R., Anant Rao, N.K. 1954 Studies on the manuring of wheat. II. Effect of excessive nitrogenous manuring on wheat. Agra. Univ. J. Res. Sci. 3: 499-508.

Schreven, D.A. Van 1956 Effect of some ammonium containing fertilizers on the loss of nitrogen after application to a calcareous soil of the North eastern polder. VIe. Congr. Int. Sci. Sol Rapp. D. 67-73. Abstracted in Soils and Fertilizers Vol. XIX. 1956.

Schwartzbeck, R.A., Maggregor, J.M., Schmidt, E.L. 1961 Gaseous nitrogen losses from nitrogen fertilized soils measured with infra red and mass spectroscopy. Soil Soc. Amer. Proc. 25: 186-189.

Tovborg-Jensens, S., Kjaer, B. 1950 Nitrogen losses through ammonia volatilization after fertilizing with ammonium sulphate. Z. Pfl. Ernahr Dung. 50: 25-38 (G). Abstracted in Soils and Fertilizers. Vol. XIV. 1951.

Trickey, N.G., Smith, G.E. 1955 Losses of nitrogen from solution materials. Soil Sci. Soc. Amer. Proc. 19: 222-224.

Takahashi, J., Murayama, N., Oshima, M. 1955 The effect of the amount of nitrogenous fertilizer on the composition of paddy rice plants. Bull. Nat. Inst. Agric. Sci. Tokyo. B_4. Part 1, 85-101. Part 2, 102-118. Abstracted in Soils and Fertilizers. Vol. XIX, 1956.

Viets, F.G. Jr. Domingo, C.E. 1949 Yield and nitrogen content of corn hybrids as affected by nitrogen supply. Proc. Soil Sci. Soc. Amer. 1948, 13, 1949 (303-306). Abstracted in Soils and Fertilizers. Vol. XIII. 1950.

Volk, G.M. 1955 Urea nitrogen and sandy soils. Agric. Chemic. 10, No. 9, 41-42, 133, 135. Abstracted in Soils and Fertilizers Vol. XIX. 1956.

Volk, G.M. 1959 Volatile loss of ammonia following surface application of urea to turf or bare soils. Agron. J. 51: 746-749.
Abstracted in Soils and Fertilizers. Vol. XXIII. 1960.

Volk, G.M. 1961 Gaseous loss of ammonia from surface applied nitrogenous fertilizers. J. Agric. Food Chem. 9: 280-283.
Abstracted in Soils and Fertilizers. Vol. XXIV. 1961.

Volk, G.M., Sweat, A.W. 1956 Mobility of urea nitrogen applied to Florida Soils. Soil Sci. Soc. Flaproc. 1955, 15, 117-123.
Abstracted in Soils and Fertilizers. Vol. XX. 1957.

Vanstallen, R. 1960 Nitrogen loss through ammonia volatilization. Agricultura Louvain 8: 91-102.
Abstracted in Soils and Fertilizers Vol. XXIII. 1960.

Vachhani, M.V., and Rao, M.V. 1965 Relative efficiency of nitrogenous fertilizer for rice in Orissa. Rice News teller. 13: 71.

Willis, W.H., Sturgis, M.B. 1944 Loss of nitrogen from flooded soils as affected by changes in temperature and reaction. Soil Sci. Soc. Amer. Proc. (1944) 9: 106-113.

Wahhab, A., Alam, Q. 1957 Nitrification of ammonium sulphate in some West Pakistan soils. Pakistan J. Sci. Res. 9: 41-44. CA.51. (18423).
Abstracted in soils and Fertilizers Vol. XXI. 1958.

Wahhab, A., Alam, Q., Muhammad, D.	1957	Nitrification of ammonium sulphate in some West Pakistan soils. II. Effect of irrigated and rainfed soils. Pakistan J. Sci. Res. 9: 58-62. C.A. 52 (5712). Abstracted in Soils and Fertilisers Vol. XXI. 1958.
Wahhab, A., Randhawa, M.S., Alam, Q.	1957	Loss of ammonia from ammonium sulphate under different conditions when applied to soils. Soil Sci. 84: 249-255.
Wagner, G.H., Smith, G.E.	1958	Nitrogen losses from soils fertilized with different nitrogen carriers. Soil Sci. 85: 125-129.
Winsor, G.W., Long, M.I.E.	1958	Development of urea formaldehyde compounds as nitrogenous fertilizers. J. Sci. Food Agric. 9: 185-194. Abstracted in Soils and Fertilizers. Vol. XXI. 1958.

APPENDICES

APPENDIX I

Analysis of variance table for tiller counts

Source	S.S.	DF	Variance	F ratio
Total	262.74	53		
Block	7.32	2	3.66	1.56
Treatments	175.73	17	10.34	4.42**
Fertilizer	19.92	2	9.96	2.26
Soil	62.60	2	31.30	13.38**
Soil x fertilizer	34.56	4	8.64	3.70*
Level	38.84	1	38.84	16.60**
Soil x level	6.02	2	3.01	1.28
Error	79.69	34	2.34	

* Significant at 5 per cent level

** Significant at 1 per cent level

APPENDIX II

Analysis of variance table for grain yield

Source	S.S.	DF	Variance	F ratio
Total	2469.18	53		
Block	47.11	2	23.56	< 1.00
Treatments	807.57	17	47.50	1.00
Fertilizers	22.02	2	11.01	< 1.00
Soils	178.56	2	89.28	1.80
Fertilizer x soil	38.36	4	9.59	< 1.00
Levels	379.57	1	379.57	8.00**
Soil x level	97.32	2	48.66	1.03
Error	1614.50	34	47.48	

** Significant at 1 per cent level

APPENDIX III

Analysis of variance table for grain:chaff ratio

Source	S.S.	DF	Variance	F ratio
Total	167.82	53		
Block	6.15	2	3.08	1.172
Treatments	72.34	17	3.26	1.123
Fertilizer	4.48	2	2.24	0.853
Soil	14.46	2	7.23	2.75
Fertilizer x soil	41.46	4	20.73	7.889**
Level	0.06	1	0.061	0.0023
Soil x level	4.12	2	2.061	0.784
Error	89.32	34	2.63	

** Significant at 1 per cent level

APPENDIX IV

Analysis of variance table for straw yield

Source	S.S.	DF	Variance	F ratio
Total	2080.14	53		
Block	46.30	2	23.15	1.15
Treatments	1348.41	17	79.32	3.93**
Fertilizer	44.63	2	22.32	1.11
Soil	436.61	2	218.31	10.83**
Soil x fertilizer	210.16	4	52.54	2.61
Level	224.08	1	224.08	11.12**
Soil x level	282.33	2	141.17	7.00**
Error	685.43	34	20.16	

** Significant at 1 Per cent level

APPENDIX V

Chemical analysis of soil after treatment in pot culture experiment (%)

Soil	Fertilizers	Levels	N	P	K	Ca	Mg
Red loam	Urea	80	0.122	0.046	0.14	0.18	0.038
		120	0.133	0.042	0.13	0.20	0.029
	Ammonium sulphate	80	0.050	0.039	0.16	0.19	0.030
		120	0.068	0.036	0.17	0.19	0.032
	AM mixture	80	0.056	0.044	0.11	0.18	0.038
		120	0.077	0.040	0.13	0.17	0.039
Clay	Urea	80	0.442	0.041	0.19	0.19	0.032
		120	0.452	0.032	0.18	0.20	0.034
	Ammonium sulphate	80	0.412	0.040	0.20	0.21	0.033
		120	0.436	0.033	0.19	0.19	0.033
	AM mixture	80	0.445	0.042	0.18	0.18	0.034
		120	0.461	0.036	0.21	0.20	0.036
Sandy	Urea	80	0.032	0.036	0.01	0.08	0.004
		120	0.040	0.036	0.02	0.07	0.006
	Ammonium sulphate	80	0.110	0.034	0.009	0.06	0.003
		120	0.041	0.025	0.01	0.07	0.004
	AM mixture	80	0.035	0.024	0.02	0.08	0.006
		120	0.050	0.034	0.01	0.07	0.008

AM mixture = Ammophos-Magnesium carbonate mixture

VARIATION IN THE TOTAL NITROGEN CONTENT IN THE SOIL LEACHATE WHEN TREATED WITH FERTILIZER UREA 120 N Kg / Ha.

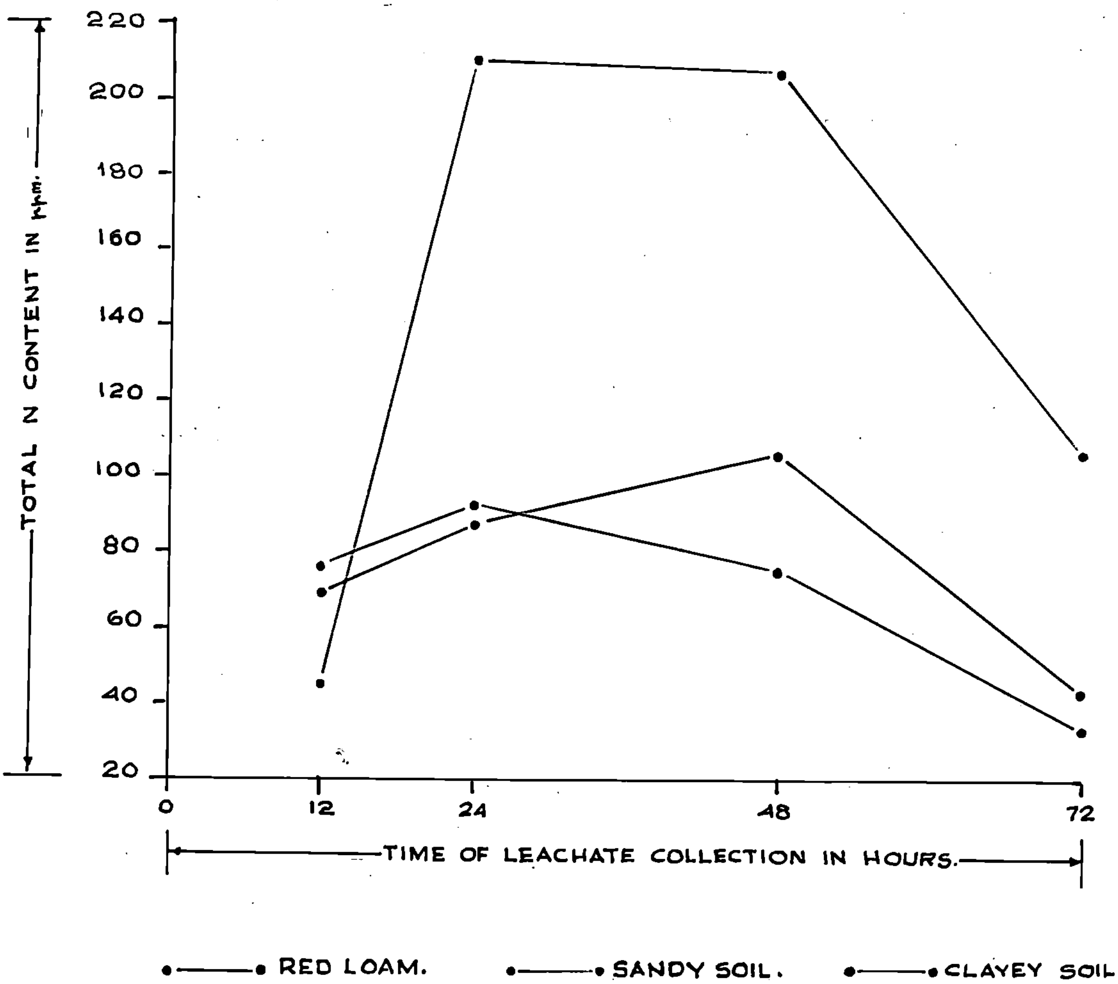

Fig: 1

VARIATION IN THE TOTAL NITROGEN CONTENT IN THE SOIL LEACHATE WHEN TREATED WITH FERTILIZER UREA 240 N Kg/Ha.

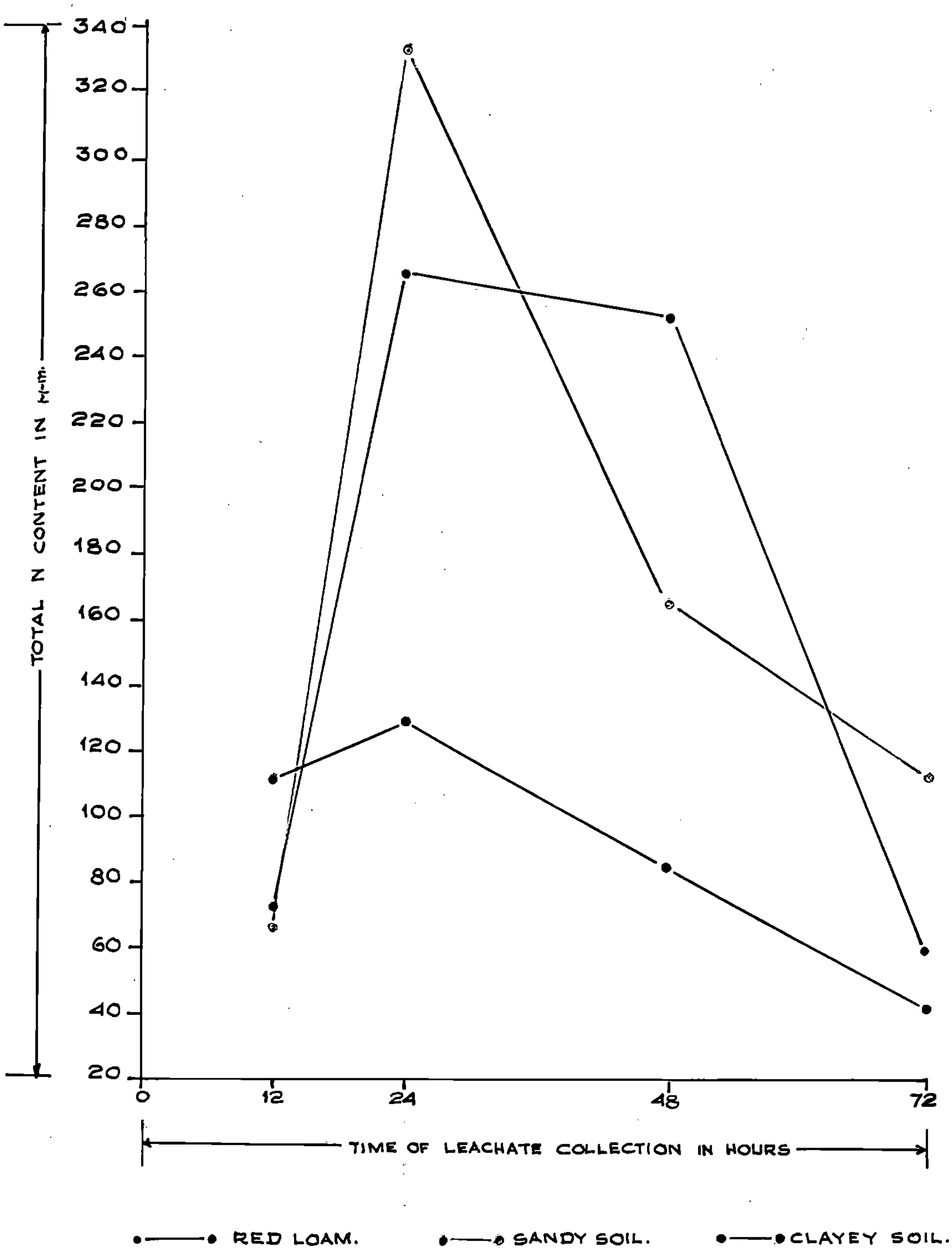

Fig. 2

VARIATION IN THE TOTAL NITROGEN CONTENT IN THE SOIL LEACHATE WHEN TREATED WITH FERTILIZER AMMONIUM SULPHATE 120 N Kg/Ha.

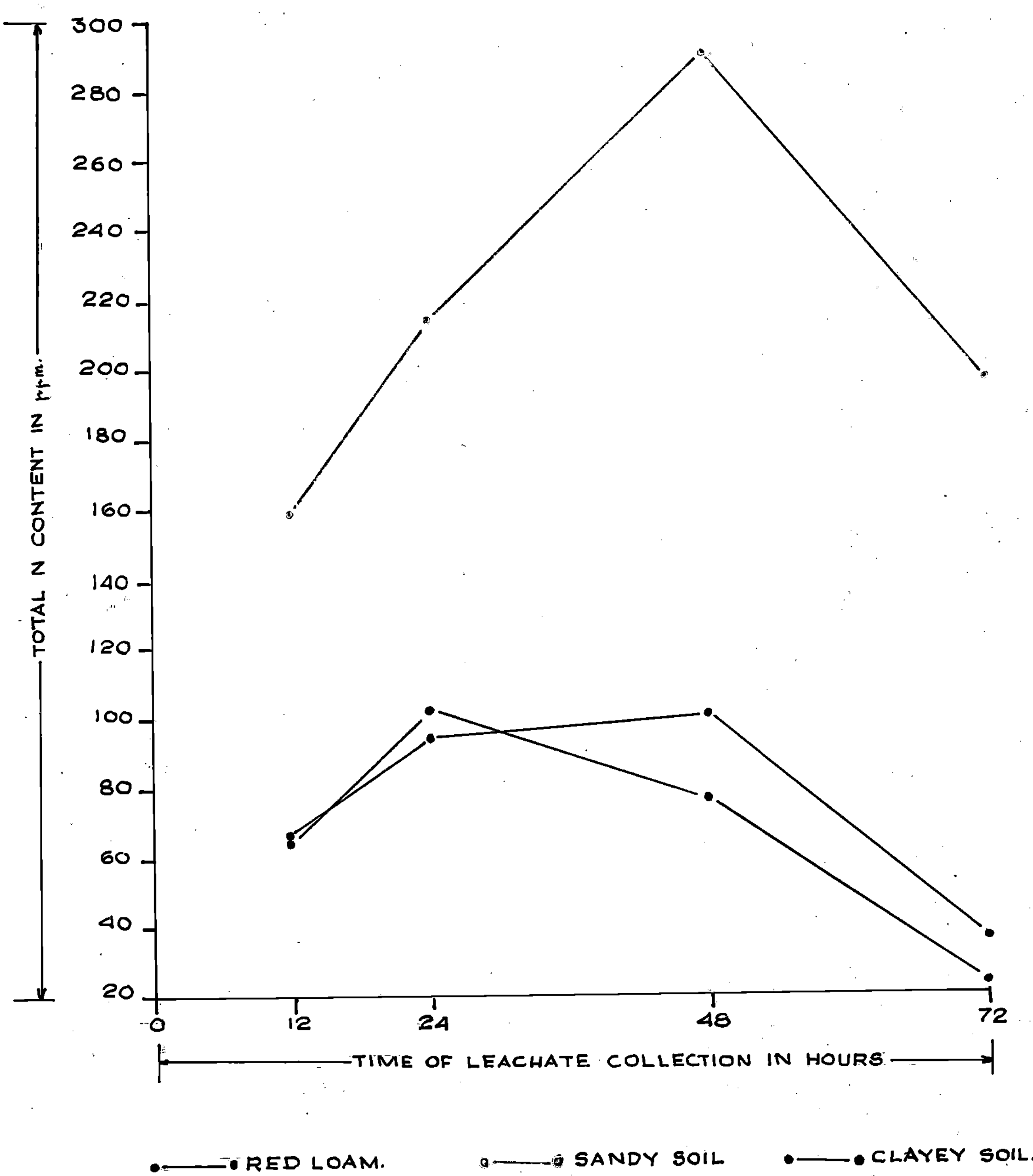

Fig. 3

VARIATION IN THE TOTAL NITROGEN CONTENT IN THE SOIL LEACHATE WHEN TREATED WITH FERTILIZER AMMONIUM SULPHATE 240 N Kg/Ha

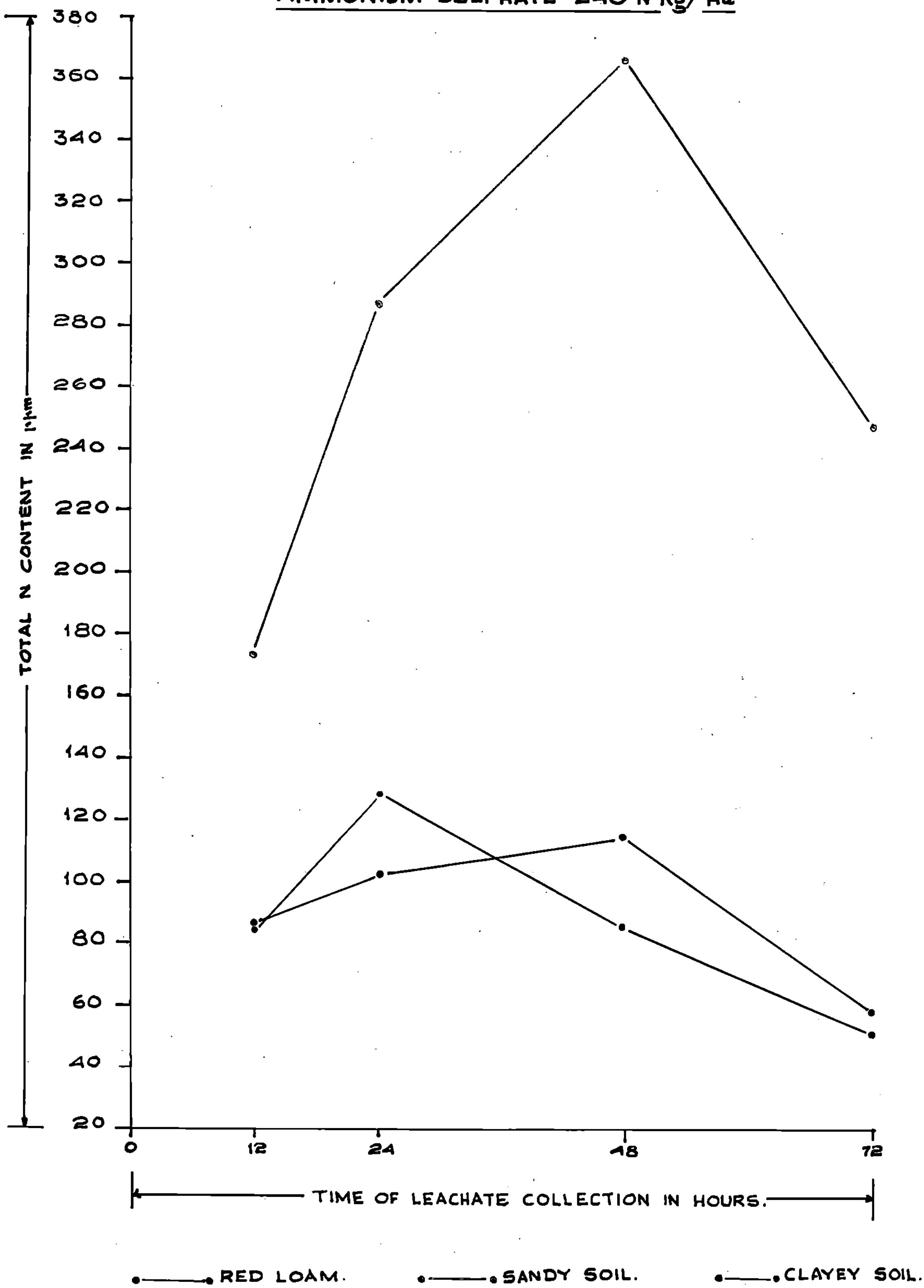

Fig: 4

VARIATION IN THE TOTAL NITROGEN CONTENT IN THE SOIL LEACHATE WHEN TREATED WITH FERTILIZER AMMONIUM PHOSPHATE – MAGNESIUM CARBONATE MIXTURE 120 N Kg/Ha.

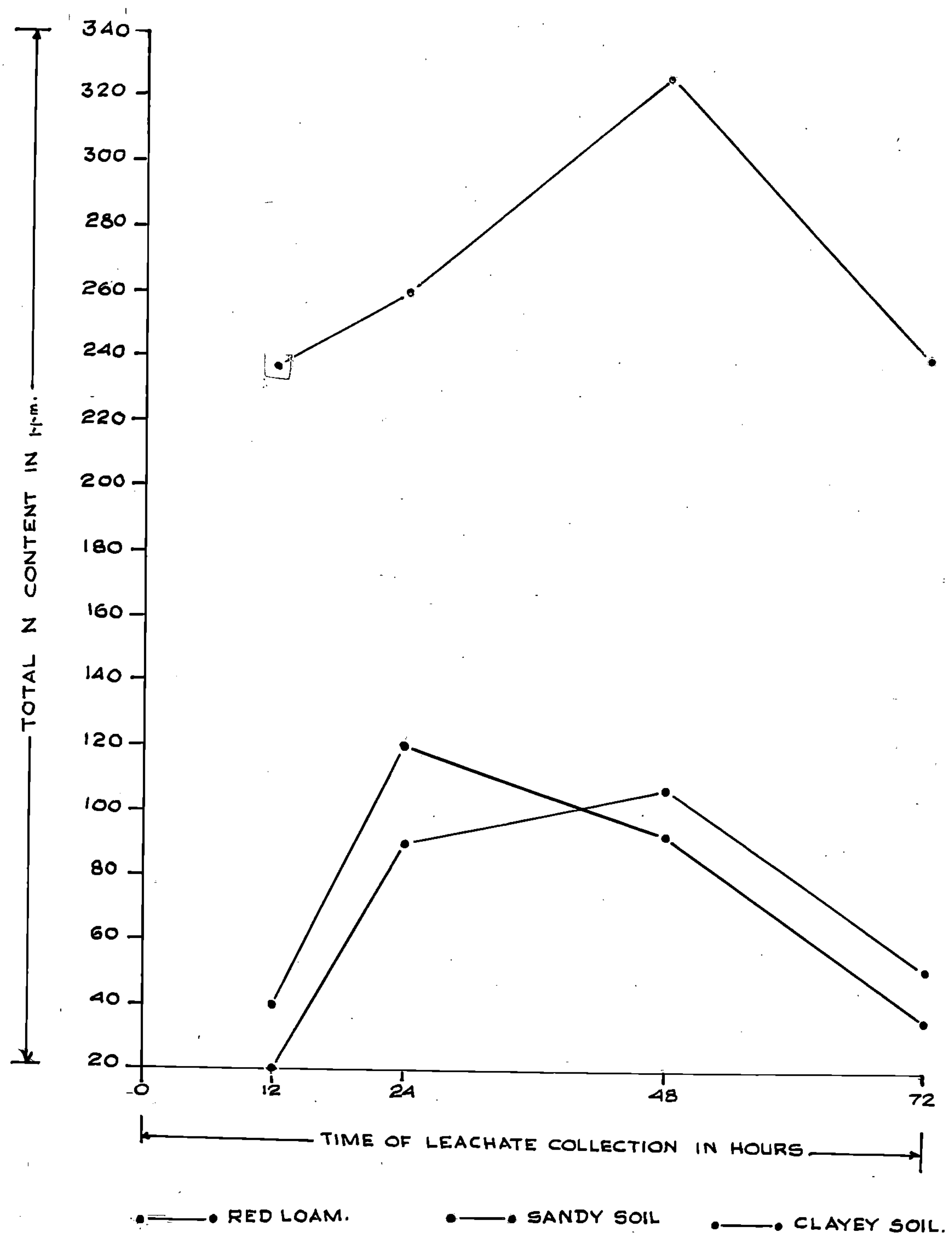

Fig. 5

VARIATION IN THE TOTAL NITROGEN CONTENT IN THE SOIL LEACHATE WHEN TREATED WITH FERTILIZER

AMMONIUM PHOSPHATE — MAGNESIUM CARBONATE MIXTURE 240 N Kg:/Ha

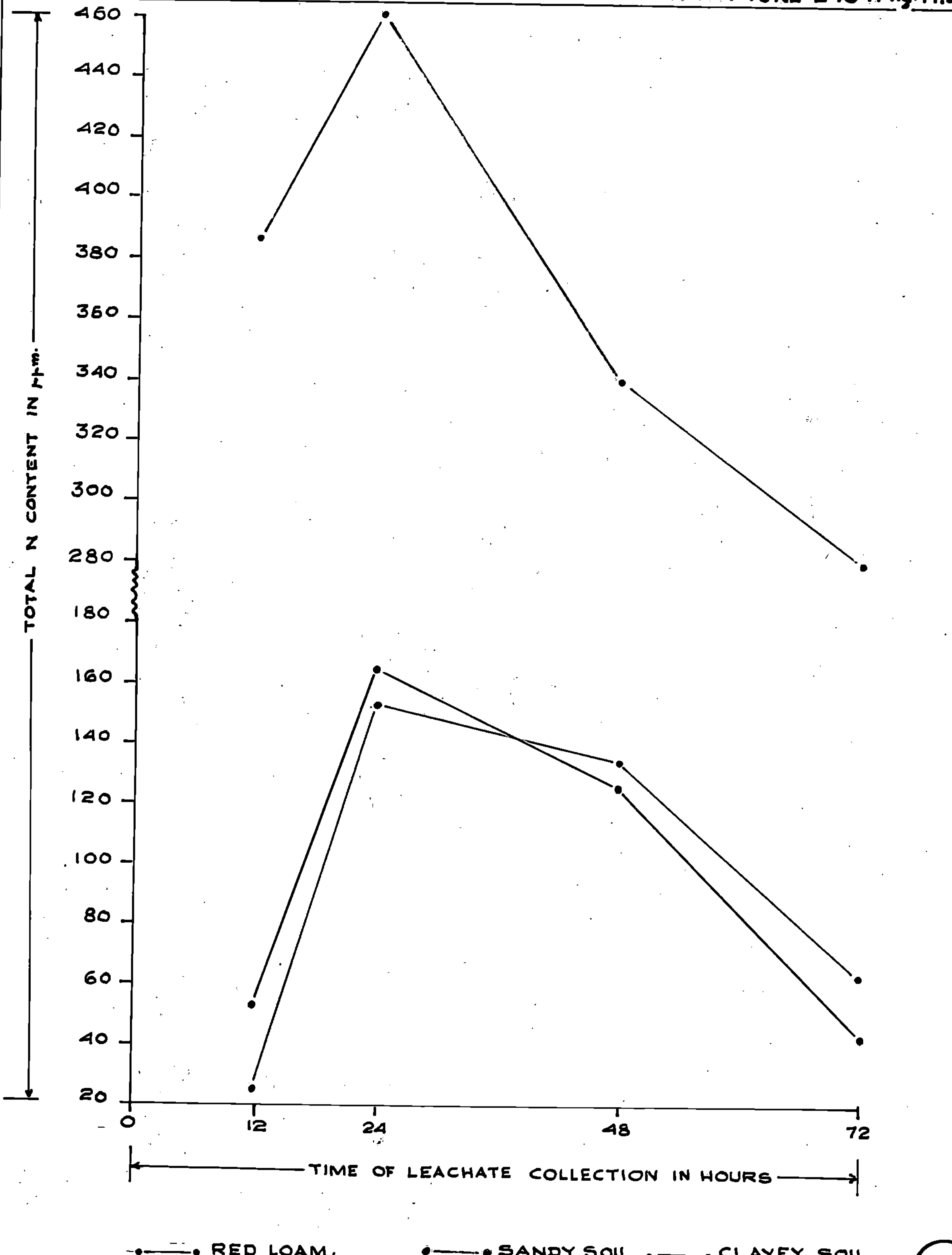

Fig: 6