1.1 INTRODUCTION

Nitrogen, the balance wheel of nature, may rightly be recognised as the master key to agriculture under Indian conditions. The supply of available nitrogen is indispensable for maintenance and improvement of soil fertility and also adequate growth of plants leading to increased yield of crops. Nitrogen is the most expensive fertilizer element and easily lost from soil. The most effective cultural practice that seems to offset nitrogen losses is the growing of crops that utilize the available free nitrogen, in the growth process, arrest and convert in to forms which when returned to the soil constitute potential and more stable source of nitrogen, less subject to leaching (Amar Singh, 1967).

Similar type of view was expressed by Jaiswal (1969).

Tropical soils contain low quantities of nitrogen as compared to the soils of temperate regions. This is primarily due to the poor organic matter and consequently low nitrogen contents of these soils. The nitrogen content of Indian soils, varies from 0.02% to 0.1%. The average, however, ranges from 0.05% to 0.07%. Therefore, much of our endeavour to stepup food production depends on
the use of nitrogenous manures and fertilizers. Our soils contain low to medium quantities of the available phosphorus and the need for phosphatic fertilizers has become as important as that for nitrogenous fertilizers, today. (Mandal and co-workers, 1967).

1.2: LOSS OF NITROGEN

Dhar and co-workers, (1961) and Volk, (1961) have observed considerable losses of nitrogen when nitrogenous substances were added to the soils. The results obtained in field experiments have revealed the following results:

<table>
<thead>
<tr>
<th>Nitrogen</th>
<th>Phosphorus</th>
<th>Potassium</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.8 - 46.1 %</td>
<td>10.1 - 75.6 %</td>
<td>22.4 - 95.1 %</td>
</tr>
</tbody>
</table>

Thus the loss of nitrogen poses a great threat to soil fertility.

Runoff losses of nitrogen and phosphorus due to precipitation were followed from 1st January to 31st March for three consecutive years. For inorganic nitrogen the average runoff was 16, 1 and 0.2 Kg/ha, for the years 1972, 1973, and 1974 respectively. Corresponding values for phosphorus were 3.5, 0.7, and 0.01 Kg/ha. The extreme losses in the 1st year were due to the soil being frozen for 32 days, as compared with 12 and 3 days in the 2 subsequent years (Klausner and co-workers, 1976).
Losses of gaseous nitrogen were 13-31% from sodium-nitrate and 8-21% from ammonium-sulphate. Most of the gaseous losses and transformations of fertilizer nitrogen in soil occurred within 20 days after applications of nitrogen, 32-36% of nitrogen of sodium-nitrate and 49-55% of ammonium sulphate being transformed, (Korevokov & Lavrona, 1973).

Smirnov (1974) reported that gaseous losses of nitrogen fertilizers were highest during the first 10-30 days after their applications. Nitrogen losses from calcium nitrate (Ca(NO₃)₂) were higher than those from ammonium sulphate, (NH₄)₂S0₄ and urea also higher in anaerobic than aerobic conditions.

The fertilizer nitrogen was lost mainly in the form of N₂O and N₂, in anaerobic conditions the first day nitrogen losses from Ca(NO₃)₂ were mainly (75-80%) in the form of N₂. In aerobic conditions most losses of nitrogen shortly after fertilizer applications, occurred in the form of N₂O. In anaerobic conditions more N₂ loss formed at soil pH 7 than at pH 4.1-4.4.
\( \text{N}_2\text{O} \) was mainly formed with NO and \( \text{NO}_2 \) being formed when calcium nitrate was applied. More nitrogen was lost from \( \text{Na}_2\text{NO}_3 \) than from \( \text{Ca} (\text{NO}_3)_2 \) at low pH. \( \text{N}_2\text{O} \) and NO evolved from nonsterile soil and NO from sterile soil respectively. Both biological and chemical denitrification of applied nitrogen fertilizers occurred in soil.

Zade and Kamat (1975), have observed in his pot experiments the losses of nitrogen by volatilization in deep black soil using urea and ammonium sulphate as nitrogen carriers. In bare soil, highest losses were observed during the first 30 days after which there was a gradual decline. Significant higher losses were observed (14.87, 17.88, 19.56 \% from added nitrogen after 30, 75, and 110 days respectively) more than from ammonium sulphate (11.50, 15.40, and 16.10 \% of added nitrogen after corresponding period).

Basdeo (1976) found his studies that volatilization of ammonia varied under varying conditions of soil, methods of application, temperature and the nature of nitrogen carriers. The losses were found to increase with increasing level of fertilizer application, temperature and soil pH but decreased with the depth of placement. The losses were higher under water-logged
conditions and on light textured soils. Among the nitrogen carriers the loss was maximum with urea followed by ammonium nitrate and ammonium sulphate.

In pot experiment with a Chernozem-like soil, the highest gaseous losses of applied nitrogen (23.4 and 25.1 %) were observed when the nitrogenous fertilizer was applied, and at early decreased the nitrogen gaseous losses ( to 13.8 %) and increased the percentage of utilized fertilizer nitrogen from 44.7 to 53.2 . Gaseous nitrogen losses were highest when applied to a bare soil ( 70-85.1% ). They increased with increasing degree of soil erosion and decreased when manure was applied (Zardalishvili and co-workers 1976 ).

Appreciable amounts of ammonia is volatilized when ammonical fertilizers are applied to calcareous soils. Ammonia is volatilized due to the dissociation of \( \text{NH}_4^+ \) ions to \( \text{NH}_3 \) and \( H^+ \)

\[
\text{NH}_4^+ \rightleftharpoons \text{NH}_3 + H^+
\]

It has been shown by many investigators that ammonia volatilizations is an important process mainly in basic soils, (Yorom Avnemeloch and co-workers, 1977; Mikkelsen and co-workers, 1978; Hargrove and Kessel 1979 ).
Gaseous losses of nitrogen at the end of 12 months varied from 73 to 94% of inorganic nitrogen added alone, with greatest loss occurring from KNO₃. Gaseous losses to 30-86% of total nitrogen applied and the smallest loss occurred with (NH₄)₂SO₄ most of the gaseous losses occurred within first three months, (Westerman and Tucker, 1979).

Mehta and co-workers, (1978), have observed that loss of ammonium was maximum from urea followed by ammonium sulphate, ammonium chloride, di-calcium ammonium phosphate and ammonium nitrate. The loss of ammonia from different soils were found to differ though they were kept in identical condition.

Mochosa and Reese, (1981) reported that after application of calcium nitrate, nitrogen losses in the infiltration water were high and the amounts retained in the soil were small occurring in organic form gaseous nitrogen losses were up to 10.5 to 37% in the soils. Losses of NO₃-N in infiltrations water amounted to only 6-3% in forest soil and 51-68% in arable soil. Gaseous nitrogen losses were 30% higher in forest soil amounting to 24.4-71% as compared to 15-20.3% in arable soil.
Hansen and co-workers, (1975) found that during the year 1971-74 systematic investigations of the quantity and quality of drain water were carried out on 15 different loamy soils in Denmark. The areas were drained with the tubes in 100 - 120 Cms depth. The areas were 3.22 ha, cultivated with the agricultural crops, which are characteristic of Danish agriculture and fertilized with nitrogen, phosphorus and potassium as is the usual practice. On an average of three years, the runoff was 177 MM/year over a period of 196 days in autumn and winter. Leaching per year was 40 gms phosphate/ha, 10 kg potassium/ha and 21.1 kg nitrogen as nitrate/ha.

Leaching losses of nitrogen and phosphorus from medium black calcareous soil were determined. Losses of nitrogen under compound fertilizer containing nitrogen in ammonical form were less than that of a mixture of the same composition, while in case of compound fertilizer containing both the forms of nitrogen (NH₄ - N, and NO₃ - N), the losses were more than the compound fertilizer or mixture containing nitrogen in ammonical form losses of phosphoric acid (P₂O₅) from either compound fertilizer or form mixture were found to be negligible during leaching (Shinde and Shastie, 1978).
Dowdell (1975), reported that Ca(NO$_3$)$_2$ fertilizer was applied in a six equal doses at six week intervals for a total of 418 kg N/ha/year. 15N labeled fertilizer was added used in applications. The ryegrass gave >3 fold response to the nitrogen fertilizer with the leachate (as a present rainfall) dropping from 41 to 19%. The increase in nitrogen content of the herbage caused by fertilizer was equal to 57% of the added nitrogen, leaching accounted for 17% and > 40% of applied nitrogen was unaccounted.

Nitrogen losses due to leaching were large and were greater from Ca(NO$_3$)$_2$ and KNO$_3$ than from NH$_4$NO$_3$, (NH$_4$)$_2$SO$_4$ and urea, (Pratosav and Korosteleva, 1972).

Rae and Prasad (1980), reported that leaching losses of nitrogen were generally less than 20% of applied nitrogen.

Arora and Jue (1982) believed that rapid losses of native and applied nitrogen through leaching to be the major cause.

Forester and Lippsld (1976), found in his model experiments nitrite decomposition increased with decreasing pH or increasing hydrolytic acidity, the main decomposition product being gaseous NO$_2$. In the absence of O$_2$, part of NO$_2$ was transformed into NO, While N$_2$ and N$_2$O appeared as secondary product, soil nitrogen participated in N$_2$ formations. A high rate of nitrogen of nitrate decomposition
was observed even at low nitrate concentrations chemical denitrifications seems to be an important factor of gaseous nitrogen losses from the soil.

Dhar and co-workers (1966), have given an important photo-oxidation theory of decomposition of nitrogenous fertilizers in the soil. According to this theory, the nitrification takes place in the absence or without the agency of bacteria. Such process takes place under the surface of various soil catalyst and other substances. The following changes are supposed to take place:

(i) Protein or organic matter = Amino acids
(ii) Amino acids + O₂ = NH₃
(iii) NH₃ + O₂ = Nitrite
(iv) Nitrite + O₂ = Nitrate

Loss of nitrogen is supposed to be due to the formation of unstable compound ammonium nitrite as an intermediate product, (Dhar 1963).

\[ \text{NH}_4 \text{NO}_2 \rightarrow \text{N}_2 + 2\text{H}_2\text{O} + 718 \text{ K}\text{.Cal}. \]

1.3: Gain of Nitrogen.

Agarwal (1965), reported that all natural additions of nitrogen in the soil is brought about through the atmosphere which is the primary source of
this element. It is estimated that over every acre of land surface there are about 1,40,000 to 1,50,000 tones of free nitrogen two of the most important ways in which nitrogen additions in nature are made, from the atmosphere to the soil, are through rain water and biological nitrogen fixing agencies.

Some nitrogen is brought down through rain water (Acharya and Mishra, 1976) have observed that in average of 13.38 kg. of nitrate-nitrogen /ha was fixed through rains.

Biological nitrogen fixation is one of the most important factor contributing towards natural nitrogen gains in the soil. This is brought about three agencies of bacteria living in the root nodules, non-symbiotic or free living nitrogen fixing bacteria and through blue green algae.

The effect of nitrogen fixation by azotobacter when grown in association with other soil micro-organism has been studied by Lal and Achari (1953). Dhar (1955; 1956) found that the number of azotobacter and total bacteria are always greater in dark than in light. The amount of nitrogen fixed is always greater in light than in dark.

Field studies were conducted to evaluate the N₂ fixation in paddy soils alongwith laboratory studies
aimed at checking \( N_2 \) fixation and studying the effects of some environmental factors on \( N_2 \) fixation. In the field studies, \( N_2 \) fixation rate was 32 kg. \( N_2 /100 \) days/ha. The rate of paddy soil was considered to be the highest for nonsymbiotic \( N_2 \) - fixing system, comparable to the magnitude for peanut soil. \( N_2 \) fixation was affected by the environmental factors of illumination, air humidity, soil type and \( \text{NH}_4^+ \) content, a decrease in air humidity from 92.5% to 43.7% induced a decrease in \( N_2 \) fixation rate of from 1920 to 540 moles \( \text{C}_2\text{H}_4/\text{hr/g dry root} \).

In the case of \( \text{NH}_4^+ \) content, no nitrogenase \text{(9013-04-1) synthesis} repression occurred with addition of \( \text{NH}_4^+ \), \( N < 40 \) PPM, but \( > 40 \) PPM \( N_2 \) fixation was severely reduced, \text{(Balandreau and co-workers, 1975). Various of the soils studied, 45% of them contained \( N_2 \) - fixing algae, with the maximum (93%) occurring for calcareous soils. Environmental conditions affecting \( N_2 \) - fixing blue green algae were soil moisture, soil \( \text{pH} \), light, and temperature. \( N_2 \) fixing by blue-green algae in swedish soil varied between 0.06 and 25.7 mg \( N_2 / \text{m}^2/ \text{hr} \) in the light and the main \( N_2 \) - fixing genera were Anabaena, Cylindrospermum, and Nostoc. Clay soils were the most suitable habitats with the environ-
mental conditions being nearly optimal, (Granhall, 1976).

Hanniksson et al. (1975), reported that nitrogen fixation in aerobic conditions in soils of Uppsala, Sweden, and near Bombay and New-Delhi, India. The Swedish soils generally has a much higher N₂-fixing capacity than the Indian soil with maximum rates occurring, at 20° for the Swedish and 25° for the Indian soils. The differences in N₂-fixing activities were explainable on the basis of nutrient content of the soils.

1.4: Role of organic matter in improving soil status:

The role of organic matter in improving the physicochemical and biological properties of the soil is well known. When the organic matter is allowed to decompose in the soil, it adds the major constituent elements, e.g. C, N, P, K, Ca and S and minor: - Cu, Zn, Mo, Mn, Fe, B, Cu, and Mo to the soil. Moreover, in the presence of organic matter, the native plants nutrients present in the soil are made available. The humus content of the soil is increased. Many organic compounds liberated in the soil as a result of the break down of organic matter have an ameliorating action on soil pH. These also bear growth promoting properties. Physical properties of the soil, like, water-stable-aggregates, water holding capacity
till, porosity and stickly point are improved. The microflora and the nitroslove of the soil grows rapidly. A number of reviews covering the many sided aspects of soil organic matter have been published in the last two decades (Dhar 1961; Kononova, 1961; Zenobius, 1962; Mortensen, 1963; Whitehead, 1963; Dubash & co-workers, 1964; Fuller, 1965; and Nagar and co-workers, 1967). In India, significant condition has been made in this field by Dhar and co-workers.

On account of these beneficial effects of organic matter, an observation made by the soil scientists and agronomists, all over the world, to direct all available and possible crop residues to the fields.

According to Dhar (1967), the most important function of the incorporation of organic matter in soils is the fixation of atmospheric nitrogen in the soil directly by the energy liberation in the slow oxidation of organic matter. Moreover the organic substances also nearly retard the loss of nitrogen from soil by acting as negative catalysts in the nitrification of nitrogenous substances present in the soil or added as fertilizers and manures.

According to Ray-Chaudhuri (1967) Indian soils are poor in organic matter. It has been proved beyond doubt
that the continued use of bulky organic manures, including green manures, helps to build up soil fertility. It has also been established that, by increasing the inherent soil fertility through the application of bulky organic manures, crop yields can go beyond the existing yardsticks of increased production to various other inputs in agriculture.

The loss of nitrogen was appreciably checked by the addition of organic matter and the retarding influence was much pronounced when phosphate was incorporated along with organic matter. There was an increase in the available nitrogen in the systems having organic matter and phosphate matter and phosphate is essential for maintaining the nitrogen and humus of soils, (Dhar and Rishi, 1968).

1.5: ROLE OF PHOSPHATES IN SOIL FERTILITY:

Nitrogen and phosphorus play a vital role in improving soil fertility. Phosphatic status of a soil mostly determines its nitrogen content. In this way it also indicates the productive potential of a particular soil. Dhar while stressing the importance of such a relationship has stated from a survey of soils of different countries it appears that nitrogen status of
a soil is intimately connected with the phosphorus status all over the world. When the $P_2O_5$ content is 1,000 lbs. per acre the nitrogen content cannot be greater than 0.1% when $P_2O_5$ content becomes 2,000 lbs. or more, the nitrogen content can go up to 0.2% or more. In other words as $P_2O_5$ contents of the soil increases there is marked increase in nitrogen contents. As a matter of fact the increase of nitrogen content appears to be more steep with increasing amount of $P_2O_5$ content in the soil; Sharma (1968); Dighe (1974); and others (1965 and 1966); have also observed that to a great extent the phosphate content in soil is responsible for its nitrogen content.

Dhar has emphasised that phosphate when incorporated with organic matter helps a great deal in nitrogen enrichment.

The loss of nitrogen was appreciably checked by the addition of organic matter and the retarding influence was much pronounced when phosphate was incorporated alongwith organic matter. There was an increase in available nitrogen in the system having organic matter and phosphate (Dhar and Rishi, 1968).

The total amount of nitrogen (plant and soil) fixed symbiotically in phosphate treated pots over
control was more than double in each case, (Khare and Rai, 1968).

Increase in the supply of phosphorus significantly increased nitrogen content of the crop, (Singh and Jain, 1968).

Ghosh (1982) reported that, next to nitrogen, phosphorus is one of the most essential nutrient required for proper plant growth. In all chemical and biochemical reactions taking place in soil, phosphates present or added play an important role in maintaining soil productivity. Phosphates have got real value in crop production when these are mixed with decomposing organic matter since their use stimulates the nitrogen fixing bacteria, both symbiotic and non-symbiotic to greater activity.

1.6: Role of Farmyard Manure and Wheat Straw in Soil Fertility:

Sigh and Verma (1968) have suggested that a mixture of organic substances like farmyard manure, straw, plant leaves, and grass etc. fortified by addition of calcium phosphate prove to be of immense value in building up soil fertility permanently by decreasing acidity, fixing atmospheric nitrogen and also supplying available phosphate, potash and trace elements.

Dayal et al. (1965) studied the application of farmyard manure over a period of five years, over a medium
black soil, it's a fact on soil properties and yield of Jowar crop. Continuous application of farmyard manure increased the nitrogen content and increased the yield of crops.

Havangi and Mann (1970) studied the long term effect of farmyard manure and fertilizer on chemical and physical properties of soil. Farmyard manure increased the organic carbon and phosphorus content in the soil.

Farmyard manure and green manuring with phosphate have resulted in the highest contents of organic matter and nitrogen in the soil (Maurya and co-workers, 1972).

Debnath and Hajra (1972) studied the suitability of different sources of organic matter like farmyard manure, straw, for building up the level of organic matter of soil. The rate of CO₂ evolution from all the treatments was found to be the highest but farmyard manure has been graded as the best among the two as the soil organic matter builder. As supplier of N, P, and K to the immediately following crop the efficiency of the farmyard manure as organic material have been graded 1st.

Application of narrow ratio materials like farmyard manure and poultry manure increased the availability of nitrogen, phosphorus, and potassium and consequently increased the crop yield. So with the higher levels used. Farmyard manure and poultry manure were found to be good sources for organic matter build up in the
soil. All these sources significantly increased humic acid content, (Somani and Saxena, 1975).

The effect of manure application was highest in 3rd year of its applications, the use of farmyard manure increased the yield capability of the soil by 18% (Herrmann, 1976).

Continuous use of farmyard manure helped in maintaining and improving physical properties and organic matter content of the soil. It is calculated that if nitrogen fertilizer is used in combination with phosphorus and potassium plus farmyard manure, higher yields can be obtained without causing any deterioration of soil physical properties, (Gattani and co-workers, 1976).

Singh and co-workers (1980) have been reported that continuous application of farmyard manure to a silty soil in the semi-arid region of Haryana resulted in the fall of pH and increase in organic content, cation exchange capacity and exchangeable cations.

Mixture of organic substances like wheat straw, plant residues and calcium phosphate when incorporated into soil, can build up the soil fertility permanently by fixing atmospheric nitrogen and making available nitrogen, phosphate, potash, trace elements and humus, and thus maintain soil fertility (Dhar, 1986).
An increase in total nitrogen values by addition of wheat straw may be due to suppression of denitrification and fixation of atmospheric nitrogen by biological and physico-chemical agencies, the oxidation of energy material providing energy for the endothermic process. Effect of organic matter in the form of wheat straw and phosphate as German basic slag on loss of soil and fertilizer nitrogen was studied. Wheat straw not only conserved soil and fertilizer nitrogen but also helped in nitrogen fixation (Dhar and co-workers, 1968).

Dhar and Bhat (1970) have observed that by applying different organic materials like wheat straw mixture of grasses and paddy straw to the field, higher yield both of wheat and paddy were obtained than in the 'Control' plots in which no organic materials have been added. It is further observed that mixtures of phosphates and organic matter is better to increase grain yields of wheat and paddy than organic matter alone. The efficiency of different treatments in increasing the yield of paddy and wheat crops was in the following order:
Phosphated Wheat Straw > Phosphated Grasses > Phosphated-paddy straw > Wheat straw > Grasses > Paddy Straw > G.B.S. > T.B.S. > Control.

A mixture of organic substances like farmyard manure, wheat straw, plant residues, etc. and phosphates,
when incorporated in soil, can build up the soil fertility permanently by fixing atmospheric nitrogen and supplying available nitrogen, phosphate, potash, trace elements and humus and thus maintain soil fertility. Results were obtained at Burdwan, Midnapore, and Birbhum (Bengal) in India by the incorporation of straw and phosphates together.

Energy materials, when added to soil are slowly oxidised and considerable increase in total nitrogen content of the system takes place. The efficiency of nitrogen fixation is always nearly double in light than in the dark, suggesting that light energy absorbed by the system is also utilized in accomplishing the endothermal reaction of ammonia formation. There is an appreciable increase in the availability of phosphate when energy materials are allowed to undergo slow oxidation on the soil surface. The increase in available phosphate is enhanced considerably when phosphates are added. It is found that the amount of carbon oxidised as well as in increase in nitrogen fixed with energy materials are in the following order:

Wheat Straw > Bans Leaves > Coal.

Material like wheat straw, Bans leaves, and Coal when added to the soil, are slowly oxidised in contact with air and there is an increase in the total nitrogen content of
the system. This is possible in the energy released during the process of carbon oxidation is actually utilized in fixing atmospheric nitrogen, (Dhar and Panwar, 1970).

Bhar and co-workers (1970) have found that the direct application of organic materials produces more yield of both grains and straw than the compost formed the same organic matter on equivalent nitrogen basis. Wheat straw as an organic matter is found to be more useful. It is found that direct ploughing of organic matter is certainly better than the addition of compost obtained from the same organic matter compost in pits. In view of the vital role of organic matter in maintaining soil fertility and its general deficiency in our soils, one of the major problem of Indian agriculture is to build up soil organic matter and to conserve it.

Scherbakov and co-workers (1973) have studied that the total bacterial population and the cellulose (9012-54-8) activity in soil increased with increasing fertilizer rates. Highly increased by fertilizer application was the Azotobacter population in spring and the Actinomyces population during the entire growth season. Straw addition to fertilizers increased the CO₂ (124-35-9) evolution, the bacterial population except for Azotobacter.
Novak (1974) has found that ground wheat straw was added to 500 gm. of chernosemic clay loam soil, to supply 0 - 3360 % carbon. Each day plus straw sample also received 0 - 188 mg. nitrogen as (NH₄)₂SO₄. The samples were incubated at 25°C for 60 days. CO₂ formed in proportion to the amount of straw added. The relative amount of straw covert to CO₂ decreased, however, as the amount of added increased. The additions of fixed nitrogen increased the conversion of C to CO₂ up to a C : N ratio of 20. Further additions of nitrogen (C : N < 20) did not affect the carbon mineralization rate for a given level of straw.

In experiments using ¹⁵N - labeled liquid manure, (¹⁵NH₄)₂SO₄, and straw in various combinations, the highest total nitrogen uptake by silage corn and wheat was observed when liquid manure was added. Straw application decreased the uptake of nitrogen from liquid manure, where as the mineral nitrogen seemed to change little when organic nitrogen was added. At increased mineral nitrogen fertilization (250 kg. N/ha) the amounts of nitrogen observed by plants and lost from the soil increased. The mineralization of organic nitrogen exceeded the immobilization of mineral nitrogen when the latter was applied together with straw. The incorporation of nitrogen
of liquid manure specially of its solid plants into stable humic fractions was higher than mineral nitrogen plus straw (Rauhe, K. 1974).

1.7: OBJECT AND SCOPE OF STUDY OF THE PRESENT INVESTIGATION

Farmyard manure is a very valuable material for maintaining soil fertility in its widest sense. The upward trend in fertilizer prices has necessitated improvements in the storage and application of farmyard manure so as to make better use of its plant nutrient content. The common farmyard manure is produced from cattle dung, 27 kg. per adult animal per day, urine, 18 kg. per adult animal per day, and bedding straw estimated at 1.5 kg. per adult animal per day.

The overall mean value for the composition of farmyard manure in terms of organic matter and primary and secondary plant nutrients is given in Table A.

The pH of farmyard manure is usually high (8.0 or higher) due to the presence of ammonia, but when incorporated in the soil it does not greatly affect on the soil pH.

Table 'A': Composition of farmyard manure as percentage of fresh material

<table>
<thead>
<tr>
<th>Dry</th>
<th>Ash free</th>
<th>Total N</th>
<th>Total P₂O₅</th>
<th>Total K₂O</th>
<th>Total Mg₀</th>
<th>Total Ca₀</th>
</tr>
</thead>
<tbody>
<tr>
<td>23</td>
<td>17</td>
<td>0.6</td>
<td>0.3</td>
<td>0.7</td>
<td>0.04</td>
<td>0.20</td>
</tr>
</tbody>
</table>

Where earliness is important particularly in vegetable crops, application of heavy dressings of farmyard manure along with chemical fertilizers usually gives better results than by using chemical fertilizers alone.

Treatment with farmyard manure increases the biological activity of the soil as is evidenced from the increased rate of evolution of carbon dioxide; earthworm activity of soil is greatly increased, the nodulation of legumes is improved and the population of pathogens causing plant diseases is reduced.

Farmyard manure contains other nutrients including micromutrients, the average level of which is shown in Table 'B':

**Table 'B': Composition of Farmyard Manure Indicating Micro Nutrients (Fresh Material Basis)**

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Content (mg/kg.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium</td>
<td>1000</td>
</tr>
<tr>
<td>Chlorine</td>
<td>2000</td>
</tr>
<tr>
<td>Iron</td>
<td>180</td>
</tr>
<tr>
<td>Manganese</td>
<td>45</td>
</tr>
<tr>
<td>Zinc</td>
<td>20</td>
</tr>
<tr>
<td>Copper</td>
<td>4</td>
</tr>
<tr>
<td>Boron</td>
<td>4</td>
</tr>
<tr>
<td>Cobalt</td>
<td>0.3</td>
</tr>
<tr>
<td>Molybdenum</td>
<td>0.3</td>
</tr>
<tr>
<td>Iodine</td>
<td>0.05</td>
</tr>
</tbody>
</table>

Dean analysed the yield records of Pusa Permanent Manurial-cum-Rotation Experiments for selected treatments with farmyard manure, NPK and NP which are summarised in Table 'C':

**Table 'C': Average Yield (kg/acre) in Pusa Permanent Manurial-cum-Rotation Experiments, 1930-57.**

<table>
<thead>
<tr>
<th>Crop</th>
<th>Treatment</th>
<th>FYM</th>
<th>NPK</th>
<th>NP</th>
<th>No manure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Annual</td>
<td>1920</td>
<td>1462</td>
<td>1253</td>
<td>449</td>
<td></td>
</tr>
<tr>
<td>Maize</td>
<td>1020</td>
<td>656</td>
<td>419</td>
<td>213</td>
<td></td>
</tr>
<tr>
<td>Pigeon pea</td>
<td>1066</td>
<td>940</td>
<td>1076</td>
<td>386</td>
<td></td>
</tr>
<tr>
<td>Peas</td>
<td>584</td>
<td>463</td>
<td>477</td>
<td>146</td>
<td></td>
</tr>
<tr>
<td>Wheat</td>
<td>905</td>
<td>724</td>
<td>851</td>
<td>241</td>
<td></td>
</tr>
<tr>
<td>Barley</td>
<td>1061</td>
<td>1056</td>
<td>1090</td>
<td>343</td>
<td></td>
</tr>
</tbody>
</table>

* : FYM was applied to supply 44.8 kg. N/ha.

The yields of farmyard manure plot have been maintained at higher level of annual production than rest of the treatments. The yields of barley and pigeon pea have been materially influenced by applied to the soil, of peas and wheat to a slightly lesser extent. Potash appears to be limiting for the yield of maize, (Ray-Chaudhuri, S.P. 1982.)
Prinavesi and co-worker (1974) have observed in his experiment when wheat straw was applied to soil receiving various fertilizer treatments at a 10 tons/ha rate. The highest yield occurred with 500 kg/ha of Thomas slag together with wheat straw, surpassing the treatment receiving 9.5 metric tons nitrogen/ha. The former treatment also gave the lowest soil nitrogen value, but the highest index of NH$_4$-N in the plant. The increase in nitrogen without nitrogen fertilization indicates nitrogen fixation of at least 40 kg nitrogen/ha. The observed nitrogen increase occurred despite rapid vegetative growth.

F armyard manure and wheat straw are easily available in Sagar district and there is much high cultivation of wheat (In 1982-83, 2,60,640 ha land gave 2,46,319 metric tons wheat; Bhuvabhiksha Madhya Pradesh, Gwalior). Keeping in mind the value of farmyard manure and wheat straw were selected for the present studies.

The aim of the present investigation is to investigate the nitrogen fixation by using farmyard manure and wheat straw. Potassium chloride and disal- sium phosphate has also been used with the farmyard manure and wheat straw in order to study the possible
enhancement in the rate of nitrogen fixation.

Microbiological studies in the form of counting of Azotobacter colonies in soil at the stage of nitrogen fixation have also been undertaken.

The present work is thus an attempt to elucidate the effect of ammonium salts and farmyard manure, wheat straw on the nitrogen transformations and fixation and their effect on plant growth by field experiments. The thesis has been divided into six-chapter as given below:

CHAPTER I: Discuss the general introduction and the aim and the scope of the work.

CHAPTER II: Consist of details of analytical procedures used in the present studies.

CHAPTER III: Gives an idea of physical and chemical analysis of twelve soil samples and decomposition of ammonium salts and effect of farmyard manure and wheat straw on retarding nitrogen loss in Sugar soil.

CHAPTER IV: Deals with the effect of micro-elements (Polybdenium, iron, and vanadium) on nitrogen fixation.

CHAPTER V: Present the investigation of the effect of:
(i) Ammonium salts alone and in combination with farmyard manure and wheat straw on the yield and its components of Maundi. (HIBISCUS ESCULENTUS)

(ii) Combined effect of trace element with farmyard manure and wheat straw on yield and its components of Maundi. (HIBISCUS ESCULENTUS)

CHAPTER VI Presents the summary and conclusion.


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