CHARACTERISATION OF SOIL ORGANIC MATTER IN DIFFERENT SOIL TYPES OF KERALA

BY

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THESIS

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DECLARATION

I hereby declare that this thesis entitled "Characterisation of soil organic matter in different soil types of Kerala" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

Vellanikkara,

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CERTIFICATE

Certified that this thesis entitled "Characterisation of soil organic matter in different soil types of Kerala" is a record of research work done by Kumari P.B. Usha, under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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INTRODUCTION

INTRODUCTION

Organic matter influences physical and chemical properties of soil far out of proportion to the small quantity present. It commonly accounts for atleast half the cation exchange capacity of soil and is responsible perhaps more than any other single factor for the stability of soil aggregates.

In the production of a fertile and productive soil, organic substances play a direct role, they are the sources of plant nutrients which are liberated in available form during mineralisation. Besides being a source of nutrients for the plant, and the most important factor in structure formation, organic matter has also a fundamental role on the physical properties of the soil and determines to a large degree such physico-chemical properties like exchange capacity and buffering properties. These properties are of great importance not only in controlling the uptake of nutrients by the plant and their retention in soil but also in suppressing the deleterious effects of soil acidity. Furthermore, it supplies energy and body building constituents for the micro-organisms, chelates nutrients, interacts with clays, conserves moisture, increases water use efficiency and reacts with salts, fertilisers and organic chemicals such as pesticides and herbicides.

Soil organic matter differs widely in quality and quantity in different soils of the state. Though quantity estimates are often arrived at by simple chemical analysis, qualitative studies are not usually undertaken. Proportion of different elements in soil organic matter may differ with respect to the degree of decomposition, stabilisation with other soil components, the quality make up of the organic residues and soil conditions under which the soil organic matter is synthesised into a comparatively stable form. The relationship between organic carbon and total or available nitrogen content of the soil is often made use of in predicting the nitrogen content of soil. This relationship is invariably employed as a standard value in soil testing procedures for advisory works, without referring to the composition and quality make up of the soil organic matter in the soils concerned. It is highly essential that precise relationship between organic carbon and total or available nitrogen should be worked out for different types of soils which differ in the quantity and quality of organic matter contained in them before such values are made use of for advisory purposes.

Though methods for the estimation of empirical fractions of organic matter have been developed, detailed studies on fractionation of organic matter in soils of the state have not so far been undertaken. Similarly, information on the elemental components of soil organic matter in the soils of the state are scanty. This study was therefore oriented with the following objectives in view.

1. To study the relationship between soil organic matter and soil nitrogen in large number of soils so as to establish more precise factors for calculating the total and available nitrogen in soil based on organic matter or organic carbon content.

2. To study the pattern of distribution of empirical fractions and elemental constituents of soil organic matter in a few selected soils of the state.

The results of the investigation are presented in following pages.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Soil organic matter, the key component of soil, includes plant and animal residues at various stages of decomposition, cells and tissues of microbes and substances synthesised by soil population. The rate at which the organic matter is accumulated or depleted is strictly controlled by the overall influence of climate and plant communities, human interference and length of time (Jenny, 1941; Jones, 1973).

Gob et al. (1977) found that there was variation in the distribution and enrichment of the organic matter fractions both within the soil type and between soil types. Differences appeared to be primarily a function of the stage of decomposition and translocation of the fractions through the soil rather than due to differences in vegetation. Palaniappan (1975) found that the carbon content did not differ in any significant measure between cultivated soils of hills and virgin soils. Schmidt and Schmidt (1963) and Harvey (1964) also observed that the organic matter content did not register marked variation in virgin and cultivated soils.

Hamblin et al. (1977) found that the textural group with more organic matter had better physical properties relating to both plant growth and soil management. Increased organic matter gave higher water holding capacity and porosity and decreased compaction, breaking strength and bulk density.

1. Organic matter and plant nutrients

Zunino and Martin (1977) observed that naturally occurring soil organic matter bound the metal ions constituting an intermediate stage by which substantial percolation losses of free cations and metallic aquocomplexes or simple organic metal complexes were avoided. Soil organic matter highly saturated with metal ions might constitute the most important pool of micronutrients available to biological systems.

The relationships between the organic matter content of soils and the total and available plant nutrients have been worked out by a number of investigators all over the world. A brief review of the work done on this regard is given under.

1.1. Organic carbon and soil nitrogen

Palaniappan (1975) in a study on the influence of environmental factors on organic carbon, total nitrogen and available nitrogen found that there was a predictable combination of environmental factors operated at any single site. All forms of nitrogen were significantly correlated with organic carbon and variations in these constituents in relation to environmental factors followed a similar trend. Despite noticeable difference in carbon and nitrogen content of soil, the C:N ratios remained practically unaffected signifying both carbon and nitrogen were simultaneously and similarly affected. Norman (1968) stated that even after tremendous build up or breakdown of organic matter, the C:N ratio of the soil was remarkably stable. Harade and Inoko (1980) noted a highly significant negative correlation between the cation exchange capacity and C:N ratio of the city refuse composts.

A high degree of correlation between nitrogen and organic carbon was reported by a number of workers for various soil groups (Atkinson and Sowden, 1970; Craswell and Waring, 1972).

1.2. Total nitrogen

The organic nitrogen compounds account for well over 90 per cent of the total nitrogen in most soils and are mainly the products of microbial decomposition of plant and animal remains. Davidson et al. (1951), Stevenson et al. (1952) and Dadd et al. (1953) confirmed the presence of soil nitrogen mainly in organic forms. Observations of Black (1968) indicated that the inorganic form of soil nitrogen constituted only less than 2 per cent of the total nitrogen and the rest was in organic form and that nitrogen accounted about 5 to 6 per cent of soil organic matter by weight.

Purushothaman (1964) and Bopiah (1970) obtained a positive correlation between organic matter and total nitrogen. Kyuma et al. (1969) found that the nitrogen increase in forest soils was primarily due to the higher level of organic matter and also due to the humin content. Tokudome and Kanno (1968) and Mikhaylova (1970) revealed that the descisive factor in nitrogen variations was evidently governed by the organic matter status.

1.3. Available nitrogen

Guruswamy (1963) recorded a close correlation between total nitrogen and available nitrogen in the paddy soils of Tamil Nadu. Ramadass (1970) obtained a high correlation between available nitrogen and organic matter in the soils of South Arcot, Tamil Nadu.

Harigitai (1966) established relationship between available nitrogen and pH and Godlin and Sonko (1970) related available nitrogen to soil texture. Fine fractions possibly retained more of exchangeable ammonium and even nitrate nitrogen thus causing a perceptible increase in available nitrogen status with increasing altitude and rainfall and decreasing pH. Harigitai (1966) found that apart from the absolute amount of organic matter, which was considered to have a favourable influence on available nitrogen status, the quality of substances had also got a direct bearing on the availability. The higher the humic substances, greater was the available nitrogen content.

Bhat et al. (1971) reported a positive correlation between organic carbon content and available nitrogen, when the organic carbon content was greater than 0.7 per cent. Thakur et al. (1976) found that the percentage of organic carbon content can be used as an index of available nitrogen in soil for making fertilizer recommendations.

1.4. Organic phosphorus

Organic matter in soils contains a small but fairly uniform proportion of phosphates. In most mineral soils one half to two thirds of the total phosphorus is organic, but proportions varying from 4 per cent for a podzol to 90 per cent for an alpine humus have been reported by Williams and Steinbergs (1958). Pearson and Simonson (1939) studied the amount and distribution of organic phosphorus in soils. They reported that the amounts of organic phosphorus ranged from 205 ppm to 393 ppm in the surface layers and was as low as 8 ppm in the C horizon of some soils. The proportion of total phosphorus present in organic form ranged from 35.4 per cent in the plough layer to 72.6 per cent in the A_1 horizon. Ghani and Aleem (1943) found that organic phosphorus in soils ranged from 3 to 75 per cent and inorganic phosphorus from 25 to 75 per cent.

Kibe (1945) reported that the content of organic phosphorus in soils increased with the content of nitrogen. Jackman (1955) showed that both the quantity of organic phosphorus and the rate of mineralisation were correlated positively with amounts of organic carbon and nitrogen in soils. Kosaka and Abe (1958) observed an increase in the proportion of organic phosphorus to the total phosphorus with increasing humification. According to Kaila (1963) the proportion of organic phosphorus depended mainly on the carbon content of the soil. Significant correlation between organic carbon and total phosphorus was obtained by Purushothaman (1964). Talati and Mathur (1975) in a study on various forms of phosphorus in north west Rajasthan soils found that organic phosphorus was highest in surface layers and ratios of organic carbon and total nitrogen to organic phosphorus were narrow indicating high phosphorus mineralisation.

Bowman and Cole (1978) in a study on fractionation of organic phosphorus from grassland soils reported a high percentage of organic phosphorus and they were resistant to mineralisation. Somani et al. (1979) found that the organic phosphorus content of the soil and the various humus fractions decreased with depth. Of the total phosphorus, 35.2 to 74.8 per cent occurred in the humus. Organic phosphorus was highly correlated with organic matter, total phosphorus and total nitrogen in soils of forested and cultivated mollisols. Prolonged application of farmyard manure or fertiliser phosphorus increased the content of organic phosphorus and its proportion to total phosphorus (Gosh et al., 1981).

1.5. Organic potassium

Waksman and Iyer (1932) reported that calcium, magnesium and potassium were bound to the humus complex chemically. Nishita et al. (1956) observed that uptake of sodium and potassium was found to increase both in pot culture and neubauer experiment as the concentration of organic matter was increased. Vijayachandran (1963) reported that Kerala laterite soils contained only meagre quantities of potassium. Purushothaman (1964) indicated that the potash content was low in soils containing high amount of organic matter.

1.6. Organic sulphur

Sulphur is present in soils both in organic and inorganic forms. In well leached surface soils, much of the sulphur exist in organic forms. Organic sulphur of soil differentiated three broad fractions namely, HI- reducible sulphur, carbon bounded sulphur and residual or inert sulphur. The HI-reducible sulphur fraction contain sulphur compounds that were not directly bonded to carbon and it consist primarily of sulphate esters and others in the form of phenolic sulphates, sulphated polysaccharides, cholin sulphate and sulphated lipids, (Tabatabai and Bremner, 1972). This fraction was thought to be largely associated with active side chain components of fulvic and humic materials and accounted to about 33 to 78 per cent of total soil organic sulphur. In mineral soils carbon-bonded sulphur accounted for between 5 and 35 per cent of total organic sulphur. Carbon-bonded sulphur was relatively stable and primarily associated with strongly aromatic core of humic acids (Bettany et al., 1973).

Evans and Rost (1945) found that organic matter acted as a reservoir for sulphur. They obtained direct correlations for the humus sulphur and total organic sulphur with the amounts of nitrogen and carbon. Williams (1962) recorded a close relationship between total sulphur and total carbon and between total sulphur and nitrogen. Nelson (1964) reported a high correlation between organic sulphur and organic carbon. Leela (1967) indicated that organic sulphur constituted the major portion of the total sulphur in Kerala soils.

The reports of Freney et al. (1969) and Virmani and Kanwar (1971) also indicated a strong correlation between organic matter and total and organic sulphur. Krupskii (1971) reported that 91 per cent of the total sulphur was in organic form. The content of organic sulphur in the humus was 0.77 to 1.01 per cent. Ploughing and cropping produced parallel decreases in the humus content and content of total and organic sulphur. Somani and Saxena (1976) reported regular decrease in the total, inorganic and organic sulphur content in soils and sulphur present in various humus fractions with depth. Among the fractions humic acid contained highest amount of organic sulphur followed by fulvic acid, humin, beta humus and hymatomelanic acid for soils of Rajasthan.

Rahal and Paliwal (1978) reported on an average the total sulphur and organic sulphur were 1577.9 and 37.8 ppm for soils of Rajasthan. A positive significant correlation between organic sulphur and available sulphur and cold water extractable sulphur for Rajasthan soils was reported by Rahal and Paliwal (1980).

1.7. Ratios between carbon, nitrogen, phosphorus and sulphur

According to estimates of Swaby (1968) 98 per cent of nitrogen, 80 per cent of sulphur and 60 per cent of phosphorus were associated with the organic compounds in soil.

Pearson and Simonson (1939) observed that the ratios of organic phosphorus to organic carbon and nitrogen varied considerably within individual profiles as well as from one soil to another. Nye (1951) reported that soils having high ratios of carbon to nitrogen (13 to 17) gave greatest response to nitrogen fertilisation. Black (1968) showed that soil nitrogen was immobilised if the carbon to nitrogen ratio of the added organic material was in excess of about 33 to 1.

Walker and Adams (1958) recognised that the average C:N:S:Org.P ratio of twenty soils of New Zealand was 120:10:1.3:2.7 and a similar average ratio 140:10:1.4:2.4 was obtained from the analysis of fifty Scottish soils. C:P ratio had been taken to serve as an index of available phosphorus by a number of workers (Somani and Saxena, 1970; Sacheti and Saxena, 1974).

Virmani and Kanwar (1971) reported a C:S ratio of 66:1 for some north east Indian soils and Kanwar and Takkar (1964) reported a C:S ratio of 100:1 for some Assam soils. Somani and Saxena (1976) found that materials of narrow C:N, C:P and C:S ratios caused considerable mineralisation of nitrogen, phosphorus and sulphur while wide ratio materials caused considerable immobilisation. Kothandaraman and Krishnamoorthy (1978) found that the range of org.C:org.P ratio was from 5.05 to 123.4. Organic phosphorus significantly correlated with total phosphorus, organic carbon, total nitrogen and C:N ratio. Ratio of carbon to organic phosphorus significantly correlated with C:N ratio. Nagi (1978) found that organic carbon was significantly correlated with available nitrogen, phosphorus and potassium. Limits of organic carbon for categorising soil fertility into different classes had been fixed with respect to available nitrogen, phospherus and potassium.

Mukhopadhyay and Asit (1979) observed C:N:S ratios of soils of different agroclimatic zones and suggested the presence of variable proportion of different components of soil organic matter in different regions. The variation in soil organic matter had been influenced by the chemical composition of natural vegetation, climate, soil properties of the area as well as agricultural and other management practices. Singh et al. (1980) in a study on the influence of grazing and burning of grassland on rate of accumulation of carbon, nitrogen and sulphur found that organic carbon could be used as an index of nitrogen and available nitrogen in soils.

2. Soil texture in relation to organic matter

Trofimenko and Kisyakov (1967) reported humus enrichment on account of the association between humus and finer fractions and this situation was also favourable for acquired resistance of soil organic matter to decomposition process. Kyuma et al. (1969) and Lebedeva (1971) reported the complexing of soil organic matter with inorganic portions of soil so as to form stable compounds. Turchenek and Oades (1979) found that the organic carbon and nitrogen contents were highest in the finest separates. Organic matter was concentrated in low density fractions and C:N ratio was lowest in the finer separate. C:N ratio decreased with decrease in particle size and with increase in density. Hinds and Lowe (1980) found that contents of carbon, nitrogen, sulphur and organic phosphorus increased with decreasing particle size, average values for carbon increasing from 3.7 per cent in silt to 10.1 per cent in fine clay fractions. The corresponding increases for nitrogen, sulphur and organic phosphorus were 0.26-1.17, 0.037-0.178 and 0.043-0.172 per cent respectively. C:N and C:S ratio decreased with decreasing particle size indicating a relative enrichment of nitrogen and sulphur in finer particle size fractions. N:S ratio showed little variation with particle size while C:P ratio were erratic. The clay fraction accounted for an average of 52-59 per cent of soil nitrogen, sulphur and phosphorus. Broersma and Lavkulich (1980) found that the weight of organic matter per unit of surface area increased with increasing size of soil separates.

3. Soil reaction (pH) in relation to organic matter

Acharya (1935) found that the organic matter added to soil during decomposition under anaerobic conditions produced numerous organic acids, carbondioxide, ammonia and nitrate which affected the pH of the soil. Russell (1963) observed that soil reaction was important in determining the accumulation of organic matter in the surface soils or its mingling with other layers. Reinfenberg and Moshicky (1941) indicated that soil reaction affected the rate of decomposition of organic matter through its influence on microbial population and activity. Acquaye (1963) obtained a correlation between soil organic phosphorus and pH. Soundararajan (1965) obtained a close correlation between the organic carbon and pH. Bopiah(1970) observed a positive relationship between pH and total nitrogen, available potassium and total calcium. Ghosh and Schnitzer (1980) found that between pH 5.0 and 6.5 a range into which many agricultural soils belonged, humic materials appeared to be chemically least reactive which might explain atleast in part of their stability in soils. Kalisz and Stone (1980) found that organic matter was the chief source of exchange capacity at all localities. They also found that cation exchange capacity was linearly correlated with pH. Cation exchange capacity increased about 30 meq/100 g organic matter per pH unit. Primavesi (1968) and Palaniappan (1975) reported an increase of soil organic matter with decrease in pH.

4. Empirical fractions of organic matter

The important groups that make up humic substances are humic acid, fulvic acid and humin.

4.1. Humic acid

Humic acid is composed of two components (i) hymatomelanic acid which is alcohol soluble and (ii) insoluble fraction.

Dobereiner (1822) used the term humic acid for the first time. Oden (1919) described humic acid as being dark brown, almost black substance insoluble in alcohol but soluble in alkali and precipitated by acids. Springer (1931) obtained 4 per cent nitrogen and a C:N ratio of 14.2:1 from a humic acid of a neutral peat. Forsyth (1947) indicated the presence of carboxylic, phenolic, methoxyl, acetyl, quinone and probably carbonyl groups in humic acids.

Larsen et al. (1959) demonstrated the effect of humic acid on the apparent negative adsorption of phosphorus. Further, humic acid prevented adsorption of phosphorus in the presence of limited quantities of iron and aluminium. Burges (1968) suggested the synthesis of humic acid during decomposition of organic matter. Flaig (1968) noted that most of the humic acid compounds were degraded in about 18 days time. The higher humic acid content could be resulted from higher organic matter status and such a direct relationship between humus and humic acid was also stressed by Kononova (1967).

Nguyenkha et al. (1969) reported that formation of humic acid was maximum in winter and minimum in summer. A study of humification process showed the formation of two humic fractions, a stable non-extractable fraction reflected by a regular increase in cation exchange capacity of the litter and a soluble labile fraction which was fixed by clay and was decomposed in summer. Humic acid fractions were in dynamic equilibrium undergoing biodegradation as soon as they were formed.

Turski *et al*. (1970) found that the humic acids from near the surface were found to be low in carbon due to high microbial activity but from deeper layers were found to be slightly humified, still polymerised with lignin remnants in the nuclei. Turski (1971) found that erosion resulted in decreased humus contents, decreased humic acid:fulvic acid ratios and lower degrees of condensation and polymerisation of the humic acid fractions.

Swift *et al*. (1972) studied the nitrogen, phosphorus and sulphur contents of humic acids fractioned with respect to molecular weight and found that nitrogen and phosphorus contents were greatest in the high molecular weight fractions, but sulphur content was constant throughout the molecular weight range. The change in nitrogen content was mainly accounted for by the loss of amino acid nitrogen.

Anderson *et al*. (1974) stated some of the allophane minerals were known to react with and retain the humic acid part in considerably larger proportion and this mechanism was also evidently operating from the type of clay present. Workers like Hurst and Burges (1969) held the view that lignin was the chief contributor towards higher humic acid. Rusinelli *et al*. (1975) conducted a study on the composition and physico-chemical characteristics of the humus of some soils and found that the physico-chemical properties of the humus of four soils were very similar. The humic acid to fulvic acid ratio was always 1.0.

Ohta and Kumada (1976) investigated humus forms of forest soils and found that nitrogen in humic, fulvic and humin fractions increased with the progress of decomposition and the largest relative increase was found in fulvic acid nitrogen.

Zhigunov _et al_. (1977) found that as plant residue decomposed the features that determined the most important characteristics of humic acids changed suggesting the maturing of these acids.

Makarevich (1977) found that differences in the content and distribution of humic acids and fulvic acids in soils, when sufficiently pronounced, gave a good indication of the nature of the geochemical processes involved in soil formation. Banerjee and Chakraborthy (1977) found that there was a regular variation in the nature, distribution and composition of humus in surface soils from different climatic regions. A moderate moisture regime and slightly acidic to neutral reaction were the main factors leading to the formation of humic acids, while excess moisture and acidic condition favoured the formation of fulvic acid.

Arshad (1977), from the infra red spectra of humic and fulvic acid fractions extracted from solonetz soil suggested that their structures were similar but the humic acid might be more aromatic and more highly polymerised. Shozokuwatsuka et al. (1978) found that the elementary composition of various types of humic acids was significantly distinct. Carbon and oxygen content of humic acids might be apt to reflect the different conditions of soils. The deeper the visible light absorption of humic acids and so the higher the degrees of humification, the lower the hydrogen contents of humic acids were. Though nitrogen content showed a trend similar to the trend of hydrogen, the nitrogen content of less humified humic acids varied from very low to very high values, suggesting the enrichment of nitrogen into humic acid molecules in the early stage of humification. Tan (1978) reported a negative correlation between total soil nitrogen and ratio of fulvic acid to humic acid confirming that nitrogen was more closely associated with humic acid than fulvic acid. Differences in humic acid spectra between soil groups were attributed to inherent differences in soil conditions.

Budihal and Seshagiri Rao (1978) reported a humic acid content of 12.4 per cent of organic matter for Karnataka soils. They also observed that neutral reaction and relatively higher base saturation favoured predominance of humic acids.

The least degree of aromatisation of humic acid of the lateritic soil appeared to be due to acidic reaction, high base saturation and low exchange capacity.

Joshi (1981) found that alfisols and mollisols were characterised by the preponderance of humic acid whereas in entisols and vertisols less of humic and significantly higher amounts of nonhumic and fulvic acid fractions were observed. Studies revealed that though there were differences in the composition of humus in different soils, the nature of humic and fulvic acids in these soils were not very much different. Humic acid was the first transformation products of soil organic matter whereas fulvic acid was formed by further transformation and destructive synthesis (Ram and Raman, 1981).

4.1(a). Hymatomelanic acid

Oden (1919) observed hymatomelanic acid to be light chocolate brown in colour and contained 62.2 per cent carbon and 5.28 per cent hydrogen with an equivalent weight of 250. He also indicated the formation of hymatomelanic acid from humic acid during alkaline hydrolysis. Kukharenko (1948) based on chemical investigations concluded that hymatomelanic acids were apparently simpler forms of humic acid. Tan (1974) concluded that hymatomelanic acid was not an artifact but a naturally esterified or methylated fraction of the humic molecule liberated by ethanol extraction. But C^{14} labelled ethanol extraction of humic acid yielding hymatomelanic acid supported the assumption for the natural occurrence of hymatomelanic acid.

4.2. Fulvic acid

Oden (1919) described the fulvic acids as being soluble in alkalies and in acids with light yellow to golden yellow in colour. Aleksandrova and Nad (1958) suggested that fulvic acids and some forms of humic acids resembling them formed complex and intra complex compounds with iron, aluminium, manganese, copper, zinc and certain other elements. Stevenson (1960) showed that about one half of the nitrogen occurred in the fulvic acid fraction of the soil organic matter.

Kononova (1961) recorded a general inverse relationship between fulvic acid and humic acid content. The ratio of humic acid to fulvic acid was found to vary between 0.3 and 2.5.

Schnitzer (1970) reported 31 to 56 per cent fulvic acid in organic matter of podzol soils. Schnitzer and Khan (1972) explained the highly mobile nature of fulvic acid which resulted in the washing away of this constituent and comparatively lower amounts of this in the surface soils. Grati et al. (1965) adduced the higher fulvic acid content due to finer fractions. Krupskii *et al*. (1971) reported that humic + fulvic acids contained about 50 per cent of the sulphur in the organic matter of the soil. Felbeck (1971) observed that humic acid degraded to fulvic acid and Schnitzer and Khan (1972) stated that fulvic acid was the resultant product from humic acid.

Singh and Singhal (1976) found that in the outer Himalayan soils fulvic acid fraction predominated over humic acid component and the content of fulvic acids and ethanol benzene extractable fractions tended to increase with depth of profile, whereas the content of humic acids and calcium bound humus fractions decreased. The gel chromatography of the humic acids and humins showed that the different types of humus had the same basic chemical composition but differed in the nature and degree of the arrangement of the chemical constituents among themselves and with mineral colloids (Agbodjan-Prince *et al*., 1977).

Budihal and Seshagiri (1978) reported that the humus of the lateritic soil was fulvate type and humin was the dominant fraction for soils of Karnataka. They also observed for humic acid fulvic acid ratio increased with soil pH and base saturation. The acidic reaction and poor base status of soil appeared to be conducive to the formation of fulvic acids. For northern Karnataka soils they got a fulvic acid content of 22.3 in percentage of organic matter. Ram and Raman (1981) in a study on the characterisation of humic and fulvic acids extracted from different Indian soils observed high oxygen/hydrogen ratios for fulvic acid as compared to humic acid and also fulvic acid was more acidic. Fulvic acid (low molecular weight) were adsorbed more by the clay minerals than the high molecular weight ones. It was found that sesquioxides made bridges between functional groups and interacted strongly with clay minerals during the formation of clay-humus complex.

4.3. Humin

Orlov (1971) found that humin was the major contributor towards total nitrogen. Higher level of organic matter and building up of humin constituent could cause increase in nitrogen under high altitude and rainfall.

Ricardo (1968) found that in the top soil humic acid predominated accounting for more than 50 per cent of the humus. The humins represented 20-35 per cent of the humus. Fulvic acid content increased with depth and humic acid content decreased.

MATERIALS AND METHODS

MATERIALS AND METHODS

In order to establish the relationship between soil organic matter and soil nitrogen precisely, 490 surface soil samples (0-15 cm depth) representing the upland areas of different districts of the state were selected for the study by screening a large number of soil samples collected, assuring variations in the content of organic carbon, total and available nitrogen and texture of the soil. The following analyses were undertaken using these selected soils.

1. Organic carbon
2. Total nitrogen
3. Available nitrogen
4. pH
5. Electrical conductivity
6. Mechanical analysis

For the purpose of arriving at the relationship between these soil properties, the soils were also grouped into different classes based on the content of organic carbon and the soil texture. Based on the level of organic carbon present in the soil, soils were grouped into following categories.

1. Low organic carbon group with organic carbon less than 1.0 per cent. There were 210 soils under this group.

2. Medium organic carbon group with organic carbon 1.0 to 2.0 per cent. There were 220 soils under this group.

3. High organic carbon group with organic carbon more than 2.0 per cent. There were 60 soils under this category.

Based on texture, the soils were grouped into

1. Sand

2. Loam/clay

There were 141 soils in the sand group and 349 soils in the loam/clay group.

Fractionation of organic matter and determination of cation exchange capacity were carried out using twelve soils selected from the 490 soils already studied for their relationship between organic carbon and nitrogen. In addition to the fractionation, the chemical composition of the soil organic matter separated from these twelve soils was also examined. The constituents of organic matter thus examined were organic phosphorus, organic potassium and organic sulphur.

1. Organic carbon

Organic carbon was determined by the method of Walkley and Black (1934) in which soil was digested with standard potassium dichromate and sulphuric acid and the excess chromic acid was back titrated against standard ferrous sulphate in the presence of orthophosphoric acid using diphenyl amine indicator.

2. Total nitrogen

Total nitrogen was determined by Microkjeldahl method (Jackson, 1958). In this method, all forms of nitrogen was converted into sulphate of ammonia by digestion with sulphuric acid and salicylic acid in the presence of sodium sulphate as an electrolyte and selenium as a catalyst. A water extract of the sulphate of ammonia was distilled with excess of alkali and distillate was collected in a 4 per cent solution of boric acid. The amount of ammonia evolved was determined by titration with standard acid.

C:N ratio was worked out from the carbon and nitrogen contents estimated by the above procedures.

3. Available nitrogen

Available nitrogen was determined by alkaline permanganate method suggested by Subbiah and Asija, 1956. Here the amount of soil nitrogen released by alkaline permanganate solution (100 ml of 0.32 per cent potassium permanganate and 100 ml of 2.5 per cent sodium hydroxide) from 20 g of soil was estimated by distillation procedure. Care was taken to see that a fixed volume of distillate (30 ml) was collected in standard acid each time. The excess acid was then back titrated against standard alkali, using methyl red indicator.

4. pH in water

Soil pH was determined in a pH meter using a soil: water ratio of 1:2.5.

5. Electrical conductivity

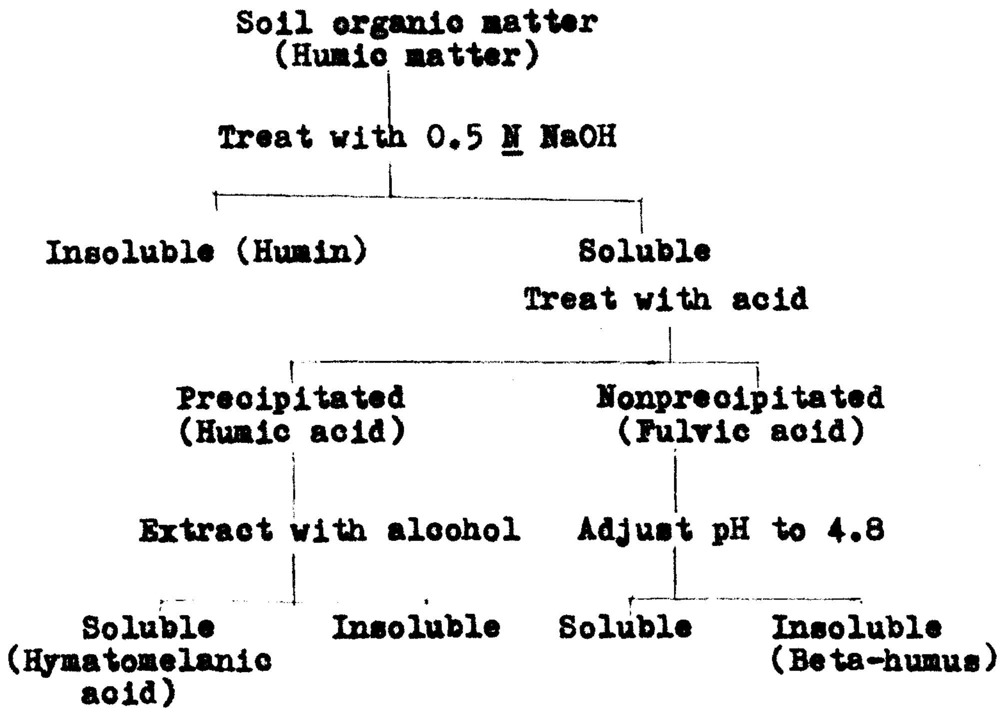
Electrical conductivity of soil solution (1:2.5 soil water ratio) was determined using a digital conductivity bridge.

6. Mechanical analysis

Particle size distribution was determined by hydrometer method as described by Piper (1942). Here the density of a suspension at a given depth as a function of time was calculated. Fifty gram of air dried soil was thoroughly dispersed in 100 ml of 1.5 per cent sodium hexametaphosphate solution by stirring. The dispersion mixture was transferred to a 1000 ml stoppered cylinder and hydrometer readings were taken after 4 minutes and 2 hours. The first reading accounted for silt and clay and second reading for clay alone.

7. Fractionation of soil organic matter

Fractionation of soil organic matter was carried out adopting the procedure suggested by Stevenson, 1965 as indicated in the flow chart given below.



a. Humic acid

The soil was washed with 0.1 N HCl and 40 g of the washed soil was taken in a polythene centrifuge bottle. To this 200 ml of 0.5 N sodium hydroxide solution was added. The mixture was shaken for 12 hours on a mechanical shaker, the sides of the bottle were washed with distilled water and the mixture was centrifuged. Dark coloured supernatant liquid was filtered and the pH of the solution was adjusted to 1.0 with conc. HCl. Additional 200 ml of 0.5 N sodium hydroxide was added to soil, the content was shaken, centrifuged and filtered. The residue was dispersed in 200 ml distilled water, centrifuged and the supernatant liquid was added to the previous extracts. The residue was discarded.

The pH of the extract was adjusted to 1.0 with conc. HCl and the humic acid was allowed to settle. The supernatant liquid in the acidified extract represented the fulvic acid. This was siphoned off. The humic acid suspension was transferred to a polythene bottle and the humic acid was separated by centrifuging. Humic acid was redissolved in 0.5 N sodium hydroxide and reprecipitated with conc. HCl. Humic acid was again separated by centrifuging. This purification procedure was repeated. The supernatant liquid in each case was transferred to the original acid filtrate. Humic acid was washed with distilled water until free of chloride. Now humic acid was dried and ground to a fine powder. This was weighed and reported as percentage of humic acid on moisture free basis and also as percentage of organic matter.

b. Fulvic acid

The acid extract collected in the humic acid preparation was fulvic acid. A known aliquot was taken, evaporated and dried. The residue was weighed and reported as percentage of fulvic acid on moisture free basis and also as percentage of organic matter.

c. Humin

Humin fraction was determined by deducting the weight of humic acid and fulvic acid from total soil organic matter.

d. Hymatomelanic acid

A known amount of humic acid was taken in a soxhlet apparatus and extracted with ethyl alcohol for 24 to 30 hours. The extract was made free of alcohol by evaporation in a vacuum oven and then dried. The residues was weighed and reported on moisture free basis as hymatomelanic acid.

e. Insoluble fraction

The weight of insoluble fraction was determined by deducting the weight of hymatomelanic acid from humic acid.

f. Beta-humus

To separate beta-humus, the pH of the fulvic acid fraction was adjusted to 4.8. For this purpose 5 N NaOH solution was added to the extract until practically all the acid was neutralised and then the neutralisation was completed by cautious addition of 0.1 N NaOH solution. After the precipitate had settled the supernatant liquid was siphoned off as much as possible and the remainder of the suspension was transferred to a polyethylene bottle and beta humus was centrifuged out. The beta-humus was then washed with distilled water and dried in an oven at 50°C.

8. Cation exchange capacity

In a weighed sample of soil cations were displaced by ammonium by leaching the soil with neutral ammonium acetate solution. The excess of ammonium acetate was removed by washing with alcohol. The soil was then distilled with magnesium oxide, the ammonia liberated being absorbed in a known excess of standard acid. The excess acid was then titrated with standard alkali and the cation exchange capacity was calculated.

9. Organic phosphorus

Organic phosphorus was estimated by difference in values of phosphorus content between ignited soil and nonignited soil. One gram of air dried soil (of less than 0.5 mm size) was taken in a silica crucible and heated at 240°C for one hour in an electric muffle furnace. After cooling the ignited soil was transferred to a centrifuge tube. This was mixed with 10 ml of hydrochloric acid and the tube was heated on a steam bath for 10 minutes and then a further addition of 10 ml acid was made. This was allowed to stand at room temperature for one hour and 50 ml of water was added to it and centrifuged. The solution was decanted into a 250 ml volumetric flask and volume made up. Likewise another one gram of nonignited soil was similarly treated in the centrifuge tube. The phospherus in these extracts of ignited and nonignited samples was estimated by the addition of chlorostannous acid in hydrochloric acid system and the blue colour developed was measured colorimetrically using a spectrophotometer. The difference between the two gave a measure of total organic phospherus.

10. Organic potassium

Potassium was determined flame photometrically in the acid extract of ignited and nonignited soil, prepared for the estimation of organic phosphorus. The difference between the two values represented the organic potassium.

11. Organic sulphur

The method of Evans and Rost (1945) was adopted for the determination of organic sulphur. Ten gram of finely powdered soil was leached first with distilled water and then with 1 per cent HCl and finally with water to make it free of chloride. The soil was then transferred to a beaker and organic matter was oxidised with hydrogenperoxide. Then sulphur in the soil was estimated as sulphate sulphur by the procedure described by Chesnin and Yien (1951). The difference in the sulphur content before and after the oxidation of organic matter was taken as organic sulphur.

12. Statistical analysis

The data were examined statistically making use of the principles of correlation and regression as described by Panse and Sukhatme (1967).

RESULTS AND DISCUSSION

RESULTS AND DISCUSSION

The present study was undertaken to establish precise relationship between soil organic matter and soil nitrogen in the acid laterite upland soils of Kerala. Attempts were also made to examine the empirical fractions and elemental constituents of organic matter in the soil. Since the carbon nitrogen ratio and the products of decomposition differ with the total content of organic matter and the texture of the soil, soil samples were selected assuring maximum variation in the total organic matter content and texture of the soil. The soils were grouped into different categories based on the content of organic matter as well as mechanical composition in order to derive separate precise relationships between soil nitrogen and soil organic matter in different categories of soil.

1. General characteristics of soil

The general characteristics of soil including the place of collection are presented in Table 1 and the mean values and ranges are given in Table 3. The 490 samples selected for the study were from 11 districts of the state namely Cannanore, Trichur, Palghat, Calicut, Ernakulam, Alleppey, Malappuram, Kottayam, Trivandrum, Idukki and Quilon.

In general the soils were acidic and pH ranged from 4.2 - 7.6, the average being 5.94. This is because, only

Table 1(a) General characteristics of soil

Sl. No.	Sample No.	Place of collection	District	pH	E.C. m mhos/cm	Mechanical analysis Sand %	Silt %	Clay %	Textural class
1	2	3	4	5	6	7	8	9	10
1	1	Pattambi	Palghat	6.15	0.24	68.0	16.0	24.0	Sandy clay loam
2	2	Pattambi	Palghat	5.00	0.45	35.5	28.3	36.3	Clay loam
3	4	Pattambi	Palghat	5.40	0.20	63.2	9.6	27.2	Sandy clay loam
4	5	Pattambi	Palghat	5.80	0.14	71.2	1.6	27.2	Sandy clay loam
5	6	Pattambi	Palghat	5.85	0.11	69.6	16.0	14.4	Sandy loam
6	7	Thaliparamba	Cannanore	6.00	0.21	56.2	13.4	28.8	Sandy clay loam
7	8	Irinjalakkuda	Trichur	6.20	0.20	47.2	11.2	41.6	Sandy clay
8	9	Ramapuram	Kottayam	6.25	0.26	66.4	19.4	11.2	Sandy loam
9	10	Elamkunnapuzha	Ernakulam	6.20	0.39	82.4	16.0	1.6	Loamy sand
10	11	Kunnamkulam	Trichur	6.65	0.26	72.8	16.0	11.2	Sandy loam
11	12	Eyyad	Trichur	5.25	0.13	85.6	6.4	8.0	Loamy sand
12	13	Edavanakad	Ernakulam	5.30	0.19	95.2	3.2	1.6	Sand
13	14	Elamkunnapuzha	Ernakulam	7.20	0.14	91.9	4.8	3.2	Sand
14	15	Chalakkudy	Trichur	5.50	0.23	72.8	12.8	14.4	Sandy loam
15	16	Eyyad	Trichur	5.85	0.16	65.8	22.5	11.7	Sandy loam
16	17	Pazhayannoor	Trichur	6.10	0.21	69.6	16.0	14.4	Sandy loam
17	18	Vaikom	Kottayam	6.80	0.21	95.2	0.0	4.8	Sand
18	19	Chalakkudy	Trichur	5.80	0.55	72.8	14.4	12.8	Sandy loam
19	20	Kunnamkulam	Trichur	6.55	0.43	79.2	9.6	11.2	Loamy sand

(contd.)

Table 1(a) continued

1	2	3	4	5	6	7	8	9	10
20	21	Ramapuram	Kottayam	5.65	0.37	72.8	12.8	14.4	Sandy loam
21	22	Thiruvalla	Alleppey	6.25	0.02	72.8	12.8	14.4	Sandy loam
22	23	Mukundapuram	Trichur	7.40	0.02	68.5	17.6	13.9	Sandy loam
23	24	Cherthalai	Alleppey	6.60	0.09	79.2	0.0	4.8	Loamy sand
24	25	Kunnamkulam	Trichur	6.75	0.18	72.8	9.6	17.6	Sandy loam
25	26	Kunnamkulam	Trichur	7.60	0.33	80.8	11.2	8.0	Loamy sand
26	27	Kizhuparamba	Malappuram	5.50	0.13	68.0	17.6	14.4	Sandy loam
27	28	Kizhuparamba	Malappuram	5.55	0.03	76.0	3.2	20.8	Sandy clay loam
28	29	Mukundapuram	Trichur	7.05	0.02	88.8	3.2	8.0	Sand
29	30	Attupuram	Ernakulam	5.50	0.15	72.8	16.0	11.2	Sandy loam
30	31	Patteripuram	Ernakulam	6.45	0.56	72.8	9.6	17.6	Sandy loam
31	32	Neyyattinkara	Trivandrum	6.10	0.51	80.8	8.0	11.2	Sandy loam
32	33	Neyyattinkara	Trivandrum	6.40	0.16	85.6	6.0	8.0	Loamy sand
33	35	Pashamthottam	Ernakulam	6.55	0.07	79.2	16.0	8.0	Sandy loam
34	36	Neyyattinkara	Trivandrum	6.55	0.13	85.6	8.0	6.4	Loamy sand
35	37	Thodupuzha	Idukki	5.95	0.23	85.6	6.4	8.0	Loamy sand
36	38	Mukkola	Trivandrum	5.45	0.13	88.8	6.4	4.8	Sand
37	39	Neyyattinkara	Trivandrum	6.00	0.17	85.6	6.4	8.0	Loamy sand
38	40	Kanjangadu	Cannanore	5.40	0.17	84.0	8.0	8.0	Loamy sand
39	41	Kanjangadu	Cannanore	5.15	0.16	84.0	8.0	8.0	Loamy sand
40	42	Aloor	Trichur	5.70	0.21	79.2	6.4	14.4	Sandy loam
41	43	Muvattupuzha	Ernakulam	5.60	0.28	72.8	11.2	16.0	Sandy loam

(contd.)

Table 1(a) contd.

1	2	3	4	5	6	7	8	9	10
42	44	Illickal	Kottayam	5.80	0.04	82.4	9.6	8.0	Loamy sand
43	45	Vellanikkara	Trichur	5.80	0.2	77.6	11.2	11.2	Sandy loam
44	46	Vellanikkara	Trichur	5.40	0.54	79.2	6.4	14.4	Sandy loam
45	47	Vellanikkara	Trichur	5.60	0.19	77.6	11.2	11.2	Sandy loam
46	48	Koratti	Ernakulam	5.80	0.28	45.7	32.4	22.0	Loam
47	49	Nileswar	Cannanore	6.30	0.11	72.8	11.2	16.0	Sandy loam
48	50	Koratti	Ernakulam	4.85	0.09	65.3	14.7	21.2	Sandy clay loam
49	53	Arecode	Malappuram	6.20	0.13	69.6	16.0	14.4	Sandy loam
50	54	Puthalam	Malappuram	5.15	0.10	66.4	14.4	19.2	Sandy loam
51	55	Kondotti	Malappuram	5.30	0.18	73.5	6.4	20.1	Sandy loam
52	56	Eravimangalam	Trichur	5.40	0.17	71.2	14.4	14.4	Sandy loam
53	57	Kuniyil	Malappuram	6.05	0.25	76.0	9.6	14.4	Sandy loam
54	58	Panniyoor	Cannanore	6.10	0.14	62.3	15.2	22.5	Sandy clay loam
55	60	Panniyoor	Cannanore	4.60	0.23	85.6	6.4	8.0	Loamy sand
56	61	Thaliparamba	Cannanore	4.60	0.23	80.8	11.2	9.6	Loamy sand
57	62	Panniyoor	Cannanore	4.70	0.16	76.0	14.4	11.2	Sandy loam
58	63	Nileswar	Cannanore	5.65	0.13	92.0	1.6	6.4	Sand
59	64	Padanacaud	Cannanore	6.25	0.10	92.0	1.6	6.4	Sand
60	65	Thaliparamba	Cannanore	5.00	0.13	71.2	27.2	1.6	Loamy sand
61	67	Thaliparamba	Cannanore	5.75	0.24	55.0	15.0	30.0	Sandy clay loam
62	68	Nileswar	Cannanore	5.85	0.11	92.0	0.0	8.0	Loamy sand
63	69	Thaliparamba	Cannanore	5.50	0.16	69.6	12.8	17.6	Sandy loam

(contd.)

Table 1(a) continued

1	2	3	4	5	6	7	8	9	10
64	70	Panniyoor	Cannanore	4.90	0.08	79.2	12.8	8.0	Loamy sand
65	71	Panniyoor	Cannanore	6.00	0.06	69.6	19.2	11.2	Sandy loam
66	72	Kodungalloor	Trichur	6.10	0.14	92.0	3.2	4.8	Sand
67	73	Pottore	Trichur	6.20	0.12	76.0	12.8	11.2	Sandy loam
68	74	Puthoore	Trichur	6.20	0.15	60.0	16.0	24.0	Sandy clay loam
69	75	Panniyoor	Cannanore	5.90	0.12	79.2	9.6	11.2	Loamy sand
70	76	Thaliparamba	Cannanore	5.80	0.13	74.6	11.0	14.4	Sandy loam
71	77	Panniyoor	Cannanore	5.20	0.08	41.4	20.2	38.5	Clay loam
72	78	Nileswar	Cannanore	6.40	0.01	88.8	4.8	6.4	Loamy sand
73	79	Panniyoor	Cannanore	5.25	0.13	68.0	16.0	16.0	Sandy loam
74	80	Padanacaud	Cannanore	6.00	0.08	92.0	0.0	8.0	Loamy sand
75	81	Peringavu	Trichur	6.10	0.17	66.4	14.4	19.2	Sandy loam
76	82	Ollukkara	Trichur	6.55	0.18	69.4	12.8	17.6	Sandy loam
77	83	Odakkali	Ernakulam	4.90	0.70	68.4	11.9	19.8	Sandy loam
78	85	Mannuthy	Trichur	6.90	0.12	72.8	12.8	14.4	Sandy loam
79	86	Pattikkadu	Trichur	6.05	0.04	77.6	11.2	11.2	Sandy loam
80	87	Mazhoor	Cannanore	5.60	0.09	76.5	5.7	17.9	Sandy loam
81	89	Puthupally	Kottayam	5.30	0.15	69.6	12.8	17.6	Sandy loam
82	90	Mala	Trichur	5.40	0.11	76.3	10.5	14.3	Sandy loam
83	92	Thalavadi	Alleppey	5.25	0.13	69.9	9.3	20.8	Sandy clay loam
84	93	Chenganoor	Alleppey	5.00	0.08	63.2	12.8	24.0	Sandy clay loam
85	94	Kallunkal	Alleppey	5.20	0.08	63.2	22.4	14.4	Sandy loam
86	95	Thiruvanvandoor	Alleppey	6.25	0.02	50.4	22.4	27.2	Sandy clay loam
87	96	Kizhakkummuri	Alleppey	4.80	0.15	60.0	22.4	17.6	Sandy loam

(contd.)

Table 1(a) continued

1	2	3	4	5	6	7	8	9	10
88	97	Thiruvalla	Alleppey	4.85	0.13	56.8	19.2	24.0	Sandy clay loam
89	98	Eramallikkara	Alleppey	4.70	0.13	63.2	19.2	17.6	Sandy loam
90	99	Venpala	Alleppey	5.55	0.06	40.5	22.8	36.8	Clay loam
91	100	Manipuzha	Alleppey	4.85	0.09	63.2	44.8	30.4	Clay loam
92	101	Madvana	Trichur	6.20	0.09	91.3	6.5	2.3	Sand
93	102	Cheruthuruthy	Trichur	5.95	0.22	45.6	31.6	22.9	Loam
94	103	Pazhayannoor	Trichur	6.25	0.32	79.2	8.5	12.4	Sandy loam
95	104	Parappokkara	Trichur	5.90	0.16	85.1	8.6	6.3	Loamy sand
96	105	Erunilamkode	Trichur	5.80	0.10	69.4	12.8	17.6	Sandy loam
97	106	Parappoor	Trichur	4.90	1.21	84.1	7.4	8.5	Loamy sand
98	107	Cheruthuruthy	Trichur	6.65	0.17	91.1	4.3	5.6	Loamy sand
99	108	Nedumpara	Trichur	5.30	0.13	70.5	19.6	9.9	Sandy loam
100	109	Kathiyalam	Trichur	6.30	0.06	98.4	0.0	1.6	Sand
101	110	Vallathole Nagar	Trichur	5.80	0.06	40.8	28.8	30.4	Clay loam
102	111	Ayyanthole	Trichur	6.25	0.09	58.5	19.2	22.3	Sandy clay loam
103	112	Nedumpara	Trichur	5.35	0.01	85.6	3.2	11.2	Loamy sand
104	113	Edavilanga	Trichur	6.55	0.01	95.2	0.0	4.8	Sand
105	114	Podiyan Bazar	Trichur	6.60	0.07	88.8	3.2	8.0	Sand
106	115	Pallam	Trichur	6.15	0.01	64.5	13.0	22.5	Sandy clay loam
107	116	Madavana	Trichur	6.65	0.08	92.0	4.8	3.2	Sand
108	117	Vallathole Nagar	Trichur	5.65	0.01	80.8	3.2	16.0	Sandy loam
109	118	Cheruthuruthy	Trichur	6.65	0.07	53.6	33.6	12.8	Sandy loam
110	119	Vettikkattini	Trichur	6.25	0.54	47.1	22.6	30.2	Clay loam

(contd.)

Table 1(a) continued

1	2	3	4	5	6	7	8	9	10
111	120	Kara	Trichur	6.75	0.01	98.4	1.6	3.2	Sand
112	121	Peruvalloor	Trichur	5.90	0.42	56.1	19.4	24.6	Sandy clay loam
113	122	Aala	Trichur	6.20	0.68	66.4	9.6	24.0	Sandy clay loam
114	123	Puthusseri	Trichur	6.70	0.22	65.0	10.0	25.0	Sandy loam
115	124	Elavalli	Trichur	5.65	0.14	66.4	9.6	24.0	Sandy clay loam
116	125	Nellayi	Trichur	6.15	0.14	85.6	6.0	8.0	Loamy sand
117	126	Tholoor	Trichur	5.55	0.07	56.2	13.4	28.8	Sandy clay loam
118	127	Azhikkodu	Trichur	6.60	0.08	95.2	3.2	1.6	Sand
119	128	Kolazhi	Trichur	6.35	0.13	74.4	11.2	14.4	Sandy loam
120	129	Kathiyalam	Trichur	6.40	0.05	96.8	1.6	1.6	Sand
121	130	Puthusseri	Trichur	6.30	0.60	48.1	27.8	24.1	Loam
122	131	Parappoor	Trichur	5.90	0.07	68.5	13.7	17.8	Sandy loam
123	132	Pattore	Trichur	6.25	0.06	93.6	0.0	6.4	Loamy sand
124	133	Mullesseri	Trichur	6.10	0.12	78.0	9.2	12.8	Sandy loam
125	134	Santhipuram	Trichur	6.35	0.06	95.2	0.0	4.8	Sand
126	135	Kara	Trichur	6.20	0.05	95.2	0.0	4.8	Sand
127	136	Veluthoor	Trichur	6.10	0.13	76.0	3.2	20.8	Sandy clay loam
128	137	Parappoor	Trichur	5.70	0.15	72.8	16.0	11.2	Sandy loam
129	138	Pallickal	Trichur	5.50	0.08	76.0	6.4	17.6	Sandy loam
130	139	Elavathooru	Trichur	5.60	0.11	68.0	17.6	14.4	Sandy loam
131	140	Puthoorkkara	Trichur	6.60	0.13	72.8	14.4	12.8	Sandy loam

(contd.)

Table 1(a) continued

1	2	3	4	5	6	7	8	9	10
132	141	Thottippal	Trichur	5.95	0.09	56.2	13.4	28.8	Sandy clay loam
133	142	Nellayi	Trichur	5.80	0.08	72.8	7.8	19.2	Sandy loam
134	143	Pullarkkara	Trichur	6.60	0.01	75.0	15.4	9.6	Sandy loam
135	144	Peruvalloor	Trichur	6.25	0.16	72.8	12.8	14.4	Sandy loam
136	145	Cheruthuruthy	Trichur	6.30	0.08	56.2	13.4	28.8	Sandy clay loam
137	146	Kara	Trichur	6.20	0.06	92.0	1.6	6.4	Sand
138	147	Puthusseri	Trichur	6.00	0.15	60.0	8.6	31.4	Sandy clay loam
139	148	Nedumpara	Trichur	6.75	0.29	84.0	10.0	6.0	Loamy sand
140	149	Azhikkodu	Trichur	5.70	0.09	93.6	0.0	6.4	Loamy sand
141	150	Pallickal	Trichur	6.15	0.15	76.0	8.0	16.0	Sandy loam
142	151	Nedumpara	Trichur	5.45	0.08	87.0	9.4	3.6	Loamy sand
143	152	Vettikkattiri	Trichur	5.95	0.18	52.8	16.8	30.5	Sandy clay loam
144	153	Elavally	Trichur	5.80	0.07	85.6	3.2	11.2	Loamy sand
145	154	Nellayi	Trichur	5.70	0.06	80.8	4.8	14.4	Sandy loam
146	155	Pulloor	Trichur	5.90	0.13	83.8	10.6	5.6	Loamy sand
147	156	Kanjirathinkal	Trichur	5.40	0.16	93.6	1.6	4.8	Sand
148	157	Muriyad	Trichur	6.40	0.13	90.4	1.6	8.0	Sand
149	158	Karumathil	Trichur	6.25	0.20	56.8	16.0	27.2	Sandy clay loam
150	159	Cheruthuruthy	Trichur	6.10	0.16	92.0	0.0	8.0	Loamy sand
151	160	Kodungalloor	Trichur	6.05	0.07	87.3	6.9	5.9	Loamy sand
152	161	Madavana	Trichur	5.50	0.01	78.0	6.0	16.0	Sandy loam

(contd.)

Table 1(a) continued

1	2	3	4	5	6	7	8	9	10
153	162	Vettikkattiri	Trichur	5.70	0.07	76.0	9.6	14.4	Sandy loam
154	163	Thottippal	Trichur	5.80	0.17	95.2	0.0	4.8	Sand
155	164	Palliekal	Trichur	6.30	0.16	83.6	8.3	6.4	Loamy sand
156	165	Mullesseri	Trichur	6.30	0.01	88.0	6.5	5.5	Sand
157	166	Pazhayanoor	Trichur	6.65	0.56	91.7	4.1	4.2	Sand
158	167	Mulloorkara	Trichur	6.45	0.18	70.7	10.5	18.7	Sandy loam
159	168	Ayyanthole	Trichur	5.10	0.01	86.1	8.7	5.3	Loamy sand
160	169	Peruvalloor	Trichur	6.15	0.36	65.0	10.0	25.0	Sandy clay loam
161	170	Elavally	Trichur	5.50	0.01	73.5	15.9	10.6	Sandy loam
162	171	Puthukkode	Palghat	5.40	0.24	67.0	9.6	23.4	Sandy clay loam
163	172	Manappadam	Palghat	5.55	0.01	62.7	15.6	21.7	Sandy clay loam
164	173	Ethannore	Palghat	6.75	0.15	75.9	13.5	10.6	Sandy loam
165	174	Tarur	Palghat	6.40	0.12	39.8	35.6	24.6	Loam
166	175	Thodusseri	Palghat	5.85	0.01	52.8	16.4	30.8	Sandy clay loam
167	176	Mannoore	Trichur	5.20	0.54	62.0	18.0	20.0	Sandy clay loam
168	177	Elavathooru	Trichur	5.40	0.12	67.5	10.0	22.5	Sandy clay loam
169	178	Peruvalloor	Trichur	5.55	0.08	68.0	7.0	25.0	Sandy clay loam
170	179	Viyyoor	Trichur	5.75	0.25	96.0	6.4	17.6	Sandy loam
171	180	Pazhayanoor	Trichur	6.70	0.26	18.0	47.1	34.9	Silty clay loam
172	181	Pudukkadu	Trichur	6.50	0.20	65.1	5.9	29.1	Sandy clay loam
173	182	Nellayi	Trichur	6.35	0.12	59.7	16.9	23.4	Sandy clay loam

(contd.)

Table 1(a) continued

1	2	3	4	5	6	7	8	9	10
174	183	Pullarkara	Trichur	6.60	0.44	41.4	22.9	35.7	Clay loam
175	184	Kodungalloor	Trichur	5.60	0.11	84.6	3.8	11.6	Loamy sand
176	185	Thottippal	Trichur	5.85	0.01	17.2	52.4	30.4	Silty clay loam
177	186	Vallathole Nagar	Trichur	6.30	0.91	43.5	29.8	26.8	Loam
178	187	Muriyadu	Trichur	5.90	0.82	71.2	11.2	17.6	Sandy loam
179	188	Pallom	Trichur	5.70	0.61	69.6	9.6	20.8	Sandy clay loam
180	189	Pallom	Trichur	6.00	0.17	49.8	29.3	20.8	Loam
181	190	Pazhayannoor	Trichur	6.20	0.25	86.0	0.0	14.0	Sandy loam
182	191	Mangalam dam	Palghat	6.10	0.16	58.9	16.1	24.9	Sandy clay loam
183	192	Parappokkara	Trichur	6.40	0.13	70.9	9.3	19.5	Sandy loam
184	193	Pullarkkara	Trichur	6.60	0.32	73.8	12.9	13.3	Sandy loam
185	194	Vettikkattiri	Trichur	6.85	0.11	74.6	10.9	14.5	Sandy loam
186	195	Ayyanthole	Trichur	5.70	0.07	61.3	15.8	22.9	Sandy clay loam
187	196	Mullesseri	Trichur	5.80	0.05	40.0	29.8	30.1	Clay loam
188	197	Parappokkara	Trichur	6.20	0.07	65.4	9.9	24.6	Sandy clay loam
189	198	Puthoorkara	Trichur	6.10	0.06	74.5	15.3	10.2	Sandy loam
190	199	Edavilangu	Trichur	6.00	0.13	68.1	14.6	17.2	Sandy loam
191	200	Killannore	Trichur	6.00	0.91	74.6	10.3	15.1	Sandy loam
192	201	Peruvalloor	Trichur	5.80	0.08	92.0	1.6	6.4	Sand
193	202	Pullarkkara	Trichur	5.90	0.17	86.0	0.0	14.0	Sandy loam
194	203	Mullesseri	Trichur	6.50	0.28	92.0	4.2	3.8	Sand

(contd.)

Table 1(a) continued

1	2	3	4	5	6	7	8	9	10
195	204	Vyloor	Trichur	6.40	0.01	73.2	10.6	16.1	Sandy loam
196	205	Ayyanthole	Trichur	6.20	0.13	94.0	2.2	3.8	Sand
197	206	Parappoorkkara	Trichur	5.60	0.37	84.0	10.1	5.9	Loamy sand
198	207	Cheruthuruthy	Trichur	5.80	0.22	85.2	8.4	6.4	Loamy sand
199	208	Mullesseri	Trichur	5.90	0.17	69.6	9.6	20.8	Sandy clay loam
200	209	Aara	Trichur	6.00	0.09	92.0	3.2	4.8	Sand
201	210	Penakam	Trichur	6.10	0.16	72.5	12.5	15.2	Sandy loam
202	211	Nellayi	Trichur	6.10	0.09	71.2	10.5	18.3	Sandy loam
203	212	Chembilode	Cannanore	4.75	0.01	82.9	11.4	5.7	Loamy sand
204	213	Peringemvayakkara	Cannanore	6.85	0.01	85.2	7.6	7.2	Loamy sand
205	214	Mamba	Cannanore	6.00	0.10	88.7	4.8	6.5	Loamy sand
206	215	Peringemvayakkara	Cannanore	6.25	0.06	92.0	0.0	8.0	Loamy sand
207	216	Ediveri	Cannanore	5.65	0.27	67.2	17.3	15.5	Sandy loam
208	217	Puthoor	Cannanore	6.30	0.08	83.9	8.5	7.5	Loamy sand
209	218	Kanithedu	Cannanore	6.10	0.13	40.5	26.3	33.2	Clay loam
210	219	Pappinisseri	Cannanore	5.50	0.79	51.6	9.3	39.1	Sandy clay
211	220	Mamba	Cannanore	5.60	0.78	62.5	12.9	24.5	Sandy clay loam
212	221	Pallinisseri	Cannanore	5.35	0.82	41.2	28.5	30.3	Clay loam
213	222	Mangattidom	Cannanore	5.60	0.13	50.0	22.0	38.0	Clay loam
214	223	Erivetti	Cannanore	6.30	0.13	61.6	15.5	22.8	Sandy clay loam
215	224	Viyyoor	Kozhikode	6.05	0.01	50.4	18.9	30.6	Sandy clay loam

(contd.)

Table 1(a) continued

1	2	3	4	5	6	7	8	9	10
216	225	Chudali	Cannanore	6.10	0.08	72.7	15.3	12.0	Sandy loam
217	226	Pallinisseri	Cannanore	5.25	0.13	64.8	10.4	24.8	Sandy clay loam
218	227	Srikandapuram	Cannanore	6.85	0.01	88.8	6.4	4.8	Sand
219	228	Peringemvayakkara	Cannanore	6.30	0.17	92.2	3.6	4.2	Sand
220	229	Muchukunnu	Kozhikode	5.70	0.23	77.6	6.4	16.0	Sandy loam
221	230	Srikandapuram	Cannanore	5.90	0.06	74.0	6.0	20.0	Sandy clay loam
222	231	Narikkuni	Kozhikode	5.55	0.06	60.0	13.0	27.2	Sandy clay loam
223	232	Edakulam	Kozhikode	5.60	0.12	78.0	6.0	16.0	Sandy loam
224	233	Kalyasseri	Cannanore	5.80	0.21	48.7	28.5	22.8	Loam
225	234	Narikkuni	Kozhikode	5.45	0.05	74.5	15.4	10.1	Sandy loam
226	235	Karanjithode	Cannanore	5.35	0.16	74.5	15.4	10.1	Sandy loam
227	236	Mamba	Cannanore	5.20	0.08	45.3	32.2	22.6	Loam
228	237	Chembilode	Cannanore	5.10	0.13	63.2	11.2	25.6	Sandy clay loam
229	238	Paleri	Cannanore	6.35	0.05	85.6	1.6	2.8	Loamy sand
230	239	Chembilode	Cannanore	7.00	0.22	87.2	1.6	11.2	Loamy sand
231	240	Mangattidam	Cannanore	6.00	0.74	50.0	12.9	37.2	Sandy clay
232	241	Dharmadam	Cannanore	5.60	0.21	63.9	12.3	23.9	Sandy clay
233	242	Peringemvayakkara	Cannanore	5.65	0.24	87.4	6.2	6.4	Loamy sand
234	243	Kunnothuparamba	Cannanore	5.60	0.14	69.0	12.9	18.1	Sandy loam
235	244	Peringemvayakkara	Cannanore	6.75	0.37	69.4	14.4	16.1	Sandy loam
236	245	Mangattidam	Cannanore	6.30	0.37	71.3	13.2	15.5	Sandy loam

(contd.)

Table 1(a) continued

1	2	3	4	5	6	7	8	9	10
237	246	Peranganam	Cannanore	6.40	0.21	83.0	10.6	6.4	Loamy sand
238	247	Chengayi	Cannanore	6.90	0.13	58.0	12.9	29.2	Sandy clay loam
239	248	Pallinisseri	Cannanore	5.10	0.74	52.7	10.8	36.4	Sandy clay
240	249	Cheruthuruthy	Trichur	6.60	0.09	61.6	13.5	24.9	Sandy clay loam
241	250	Vandazhi	Palghat	6.10	0.18	57.0	15.4	27.6	Sandy clay loam
242	251	Elavancheri	Palghat	6.50	0.10	55.5	22.3	23.1	Loam
243	252	Manappadam	Palghat	5.70	0.08	40.9	25.7	33.5	Clay loam
244	253	Kozhikkottiri	Palghat	5.60	0.11	62.1	14.3	23.6	Sandy clay loam
245	254	Kanjirampara	Palghat	5.20	0.16	91.3	3.6	5.1	Sand
246	255	Elavancheri	Palghat	5.10	0.10	64.8	14.4	20.8	Sandy clay loam
247	256	Perumudiyoor	Palghat	5.40	0.65	64.4	19.1	18.5	Sandy loam
248	257	Mulayankara	Palghat	5.70	0.71	59.4	16.1	24.5	Sandy clay loam
249	258	Paravasseri	Palghat	5.90	0.08	66.0	16.0	18.0	Sandy loam
250	259	Puthupparyaram	Palghat	6.00	0.05	63.8	14.6	21.6	Sandy clay loam
251	260	Kanyamangalam	Palghat	6.30	0.22	61.9	14.3	23.9	Sandy clay loam
252	261	Chelliparambu	Palghat	6.10	0.11	71.0	9.5	19.6	Sandy loam
253	262	Koduvayoor	Palghat	6.40	0.43	73.2	10.6	16.1	Sandy loam
254	263	Perumudiyoor	Palghat	5.80	0.16	69.6	14.4	16.0	Sandy loam
255	264	Puthukkodu	Palghat	6.70	0.04	48.1	27.8	24.1	Loam
256	265	Kannambra	Palghat	6.20	0.01	64.8	14.4	20.8	Sandy clay loam
257	266	Erimayoor	Palghat	6.10	0.08	73.5	15.9	10.6	Sandy loam

(contd.)

Table 1(a) continued

1	2	3	4	5	6	7	8	9	10
258	267	Alathoor	Palghat	5.90	0.18	76.0	9.6	14.4	Sandy loam
259	268	Alanalloor	Palghat	5.20	0.10	64.8	14.4	20.8	Sandy clay loam
260	269	Manappadam	Palghat	6.85	0.01	48.1	27.8	24.1	Loam
261	270	Kannambra	Palghat	6.90	0.18	85.6	6.0	8.0	Loamy sand
262	271	Keralasseri	Palghat	6.40	0.14	74.4	11.2	14.4	Sandy loam
263	272	Vadavannore	Palghat	6.50	0.16	76.0	3.2	20.8	Sandy clay loam
264	273	Muthalamade	Palghat	6.80	1.23	56.1	19.4	24.6	Sandy clay loam
265	274	Manappadam	Palghat	5.55	0.08	48.7	28.5	22.8	Loam
266	275	Hamzagiri	Cannanore	5.60	1.03	56.8	22.4	20.8	Sandy clay loam
267	276	Alanalloor	Palghat	6.55	0.11	74.4	14.4	11.2	Sandy loam
268	277	Elavancheri	Palghat	6.90	0.02	60.0	16.0	24.0	Sandy clay loam
269	278	Kallayi	Palghat	6.85	0.01	68.0	11.2	20.8	Sandy clay loam
270	279	Puthukkode	Palghat	5.10	0.01	76.0	11.2	12.8	Sandy loam
271	280	Kallanchira	Cannanore	5.30	0.01	74.5	15.3	10.1	Sandy loam
272	281	Pappinisseri	Cannanore	5.60	1.26	61.6	13.5	24.8	Sandy clay loam
273	282	Theovakkunnu	Cannanore	5.05	0.14	64.5	13.0	22.5	Sandy clay loam
274	283	Panthalayani	Kozhikode	5.50	0.13	72.8	16.0	11.2	Sandy loam
275	284	Panthalayani	Kozhikode	5.60	0.01	74.4	14.4	11.2	Sandy loam
276	285	Oduvallythattu	Cannanore	6.50	0.13	84.0	10.1	5.9	Loamy sand
277	286	Mazhoor	Cannanore	5.90	0.12	69.6	16.0	14.4	Sandy loam
278	287	Thrikaryoor	Ernakulam	5.70	0.13	96.4	2.4	3.2	Sand

(contd.)

Table 1(a) continued

1	2	3	4	5	6	7	8	9	10
279	288	Alakode	Cannanore	6.50	0.61	83.6	8.1	8.3	Loamy sand
280	289	Alakode	Cannanore	6.00	0.14	38.4	15.4	46.2	Clay
281	290	Chembukkavu	Trichur	6.40	0.15	85.6	9.6	4.8	Loamy sand
282	291	Mukundapuram	Trichur	6.65	0.03	88.8	0.0	11.2	Loamy sand
283	292	Aayakkadu	Trichur	5.50	0.10	63.2	22.4	14.4	Sandy loam
284	293	Puthoor	Trichur	5.40	0.03	72.8	12.8	14.4	Sandy loam
285	294	Nellikkunnu	Trichur	5.30	0.03	60.0	9.6	30.4	Sandy clay loam
286	295	Poovam	Cannanore	5.20	0.03	56.8	19.2	24.0	Sandy clay loam
287	296	Mullakkara	Trichur	5.30	0.04	76.0	12.8	11.2	Sandy loam
288	297	Kanjirangadu	Trichur	6.20	0.28	56.2	20.8	24.0	Sandy clay loam
289	298	Edanadu	Ernakulam	6.40	0.10	79.2	6.4	14.4	Sandy loam
290	299	Panniyur	Cannanore	4.90	0.05	80.8	8.0	11.2	Sandy loam
291	300	Mazhoor	Cannanore	5.00	0.03	66.4	19.2	14.4	Sandy loam
292	301	Pindimana	Ernakulam	5.25	0.05	56.8	22.4	20.8	Sandy clay loam
293	302	Mazhoor	Cannanore	5.65	0.19	79.2	6.4	14.4	Sandy loam
294	303	Mundakkapadi	Trichur	5.90	0.09	68.0	14.0	17.6	Sandy loam
295	304	Valappadu	Trichur	6.90	0.08	72.8	11.2	16.0	Sandy loam
296	305	Mukundapuram	Trichur	5.50	0.06	56.8	16.0	27.2	Sandy clay loam
297	307	Anthikkadu	Trichur	6.30	0.04	62.3	15.2	22.5	Sandy clay loam
298	308	Panancheri	Trichur	6.55	0.07	66.4	9.6	24.0	Sandy clay loam

(contd.)

1	2	3	4	5	6	7	8	9	10
299	309	Kothamangalam	Ernakulam	6.10	0.17	60.0	16.0	24.0	Sandy clay loam
300	310	Thankalam	Ernakulam	6.60	0.01	69.6	11.2	19.2	Sandy loam
301	311	Nellikkuzhi	Ernakulam	6.35	0.05	96.8	1.6	1.6	Sand
302	312	Ollukkara	Trichur	5.30	0.10	72.8	9.6	17.6	Sandy loam
303	313	Alakode	Cannanore	6.50	0.04	93.6	0.0	6.4	Loamy sand
304	314	Nadathara	Trichur	5.25	0.07	88.8	6.4	4.8	Sand
305	315	Chiraladu	Ernakulam	5.65	0.05	48.8	8.0	43.2	Sandy clay
306	316	Ollukkara	Trichur	5.85	0.06	63.2	9.6	27.2	Sandy clay loam
307	317	Panniyur	Cannanore	6.60	0.01	50.4	16.0	33.6	Sandy clay loam
308	318	Mala	Trichur	5.60	0.04	56.8	16.0	27.2	Sandy clay loam
309	319	Alakode	Cannanore	6.00	0.14	72.8	8.0	19.2	Sandy loam
310	320	Valakkavu	Trichur	5.50	0.05	72.8	12.8	14.4	Sandy loam
311	321	Pananchери	Trichur	6.20	0.01	76.0	9.6	14.4	Sandy loam
312	322	Chiraladu	Ernakulam	6.45	0.11	72.8	16.0	11.2	Sandy loam
313	323	Kanjirangadu	Cannanore	6.30	0.01	63.2	16.0	20.8	Sandy clay loam
314	324	Oduvallythattu	Cannanore	5.90	0.04	79.2	9.6	11.2	Sandy loam
315	326	Alakode	Cannanore	7.30	0.04	72.8	16.0	11.2	Sandy loam
316	327	Poovam	Cannanore	6.30	0.01	79.2	14.4	6.4	Loamy sand
317	328	Kanjirangadu	Cannanore	6.50	0.09	72.8	16.0	11.2	Sandy loam
318	329	Madakkathara	Trichur	6.45	0.05	72.8	22.4	4.8	Sandy loam
319	330	Anthikkadu	Trichur	6.85	0.03	72.8	16.0	11.2	Sandy loam

(contd.)

Table 1(a) continued

1	2	3	4	5	6	7	8	9	10
320	332	Chirakkakkode	Trichur	6.60	0.05	72.8	16.0	2.8	Sand
321	333	Mullakkara	Trichur	5.50	0.06	69.6	14.4	16.0	Sandy loam
322	334	Aalathoor	Palghat	5.55	0.04	68.0	11.2	20.8	Sandy clay loam
323	335	Puthukkodu	Palghat	5.20	0.07	76.0	16.0	8.0	Loamy sand
324	343	Nhangattiri	Palghat	5.30	0.05	60.0	12.4	27.6	Sandy clay loam
325	344	Kannambra	Palghat	6.50	0.37	62.9	13.6	24.4	Sandy clay loam
326	345	Cheruthuruthy	Trichur	6.75	0.01	62.8	14.3	22.8	Sandy clay loam
327	346	Cheruthuruthy	Trichur	5.10	0.01	60.3	11.3	28.4	Sandy clay loam
328	347	Cheruthuruthy	Trichur	5.75	0.06	58.1	12.7	29.2	Sandy clay loam
329	348	Shornur	Palghat	5.30	0.12	53.3	13.9	30.8	Sandy clay loam
330	349	Kallingalpadam	Palghat	5.10	0.33	53.1	28.5	18.4	Loam
331	367	Peringemvayakkara	Cannanore	5.20	0.27	41.0	26.8	32.2	Clay loam
332	374	Thoovakkunnu	Cannanore	5.40	0.13	43.1	26.8	30.1	Clay loam
333	375	Quilandy	Kozhikode	5.65	0.15	43.7	29.2	27.1	Loam
334	376	Edakulam	Kozhikode	6.55	0.10	93.6	2.6	3.8	Sand
335	377	Puthoor	Cannanore	6.60	0.15	92.3	3.6	4.1	Sand
336	378	Quilandy	Kozhikode	6.35	0.01	44.6	23.7	31.6	Clay loam
337	380	Chengali	Cannanore	6.20	0.01	74.5	15.3	10.2	Sandy loam
338	381	Peringemvayakkara	Cannanore	5.55	0.01	49.0	26.2	24.8	Loam
339	382	Narikkuni	Kozhikode	6.70	0.01	81.6	15.2	31.6	Loamy sand
340	383	Chembilode	Cannanore	5.00	0.12	49.0	26.2	24.8	Loam

(contd.)

Table 1(a) continued

1	2	3	4	5	6	7	8	9	10
341	384	Mangattidam	Cannanore	6.40	0.01	65.4	9.2	26.4	Sandy clay loam
342	385	Kunnothuparambu	Cannanore	6.40	0.01	85.0	9.0	6.0	Loamy sand
343	386	Bella	Cannanore	5.90	0.01	55.9	16.9	27.2	Sandy clay loam
344	387	Pallinisseri	Cannanore	5.35	0.01	67.0	10.2	22.8	Sandy clay loam
345	389	Peringemvayakkara	Cannanore	5.90	0.01	57.1	14.5	28.4	Sandy clay loam
346	390	Kallyasseri	Cannanore	5.80	0.05	85.0	4.8	11.2	Loamy sand
347	391	Pappinisseri	Cannanore	6.00	0.01	69.0	12.8	18.1	Sandy loam
348	392	Panthalayam	Kozhikode	6.30	0.01	66.2	18.1	15.7	Sandy loam
349	393	Kallanchira	Cannanore	6.90	0.01	96.2	2.7	3.1	Sand
350	394	Kalyasseri	Cannanore	6.35	0.09	59.2	24.8	16.0	Sandy loam
351	396	Edakulam	Kozhikode	5.35	0.06	43.7	36.1	20.2	Loam
352	397	Peravoor	Cannanore	6.50	0.01	83.5	8.4	8.1	Loamy sand
353	398	Madavoor	Kozhikode	5.75	0.01	92.1	4.1	3.8	Sand
354	399	Mangattidam	Cannanore	6.30	0.37	92.0	3.9	4.1	Sand
355	400	Mamba	Cannanore	6.95	0.01	92.3	3.9	3.8	Sand
356	401	Mamba	Cannanore	6.30	0.01	92.4	4.0	3.6	Sand
357	402	Meloor	Cannanore	6.35	0.26	66.6	16.4	27.0	Sandy clay loam
358	403	Mangattidam	Cannanore	6.10	0.16	50.1	16.8	33.1	Sandy clay loam
359	406	Viyoor	Kozhikode	6.20	0.01	93.5	3.6	2.9	Sand
360	416	Padanacaud	Cannanore	5.80	0.22	69.6	19.0	21.4	Sandy clay loam
361	417	Kallanchira	Cannanore	5.85	0.49	50.0	15.0	35.0	Clay loam

(contd.)

Table 1(a) continued

1	2	3	4	5	6	7	8	9	10
362	456	Chembilode	Cannanore	5.25	0.36	59.2	24.8	16.0	Sandy loam
363	457	Pappinisseri	Cannanore	5.40	1.18	72.8	12.8	14.4	Sandy loam
364	458	Mangattidam	Cannanore	6.50	0.62	69.6	11.2	19.2	Sandy loam
365	459	Narikkuni	Kozhikode	6.70	0.18	94.6	2.8	2.6	Sand
366	460	Edakulam	Kozhikode	5.30	1.57	96.8	1.6	1.6	Sand
367	461	Srikandapuram	Cannanore	5.80	0.18	70.0	9.0	21.0	Sandy clay loam
368	462	Peringemvayakkara	Cannanore	5.40	0.13	75.0	11.4	13.6	Sandy loam
369	463	Erivetti	Cannanore	6.20	0.14	93.5	3.6	2.9	Sand
370	464	Chembilode	Cannanore	6.40	0.20	96.2	2.6	3.1	Sand
371	465	Puthoor	Cannanore	6.20	0.21	65.5	10.0	24.5	Sandy clay loam
372	466	Payyavoor	Cannanore	6.90	0.21	96.4	2.4	3.2	Sand
373	467	Peringemvayakkara	Cannanore	5.10	0.11	39.1	22.3	37.6	Clay loam
374	468	Mamba	Cannanore	5.10	0.36	39.5	22.0	38.5	Clay loam
375	469	Meloor	Cannanore	5.00	0.23	88.0	6.5	6.5	Loamy sand
376	470	Mangattidam	Cannanore	5.65	0.40	69.6	11.2	19.2	Sandy loam
377	471	Chembilode	Cannanore	6.80	0.31	79.6	12.4	8.0	Sandy loam

(contd.)

Table 1(a) continued

Sl. No.	Sample No.	Place of collection	District	pH	E.C m.mhos/cm^3	Textural classes
1	2	3	4	5	6	7
378	331	Mazhoor	Cannanore	6.65	0.06	Sandy loam
379	336	Thiruvazhamkunnu	Palghat	5.45	0.06	Sandy clay loam
380	337	Thenkurussi	Palghat	6.10	0.06	Sandy loam
381	338	Aayakkadu	Palghat	5.50	0.09	Sandy clay loam
382	339	Kadampazhippuram	Palghat	6.40	0.26	Sandy loam
383	340	Koduvayoor	Palghat	6.50	0.28	Sandy loam
384	341	Valayar dam	Palghat	6.65	0.25	Sandy clay
385	342	Terumittacode	Palghat	6.25	0.13	Sand
386	350	Nagalassery	Palghat	5.20	0.07	Sandy clay loam
387	351	Perinthalmanna	Malappuram	6.40	0.01	Sandy clay loam
388	352	Aayakkadu	Palghat	6.60	0.38	Sandy clay loam
389	353	Shornur	Palghat	6.60	0.003	Sandy clay loam
390	354	Kizhakkancheri	Palghat	5.10	0.01	Sandy clay loam
391	355	Kannambra	Palghat	5.60	0.08	Sandy clay loam
392	356	Kerallasseri	Palghat	5.80	0.01	Clay loam
393	357	Kizhakkancheri	Palghat	6.60	0.01	Sand
394	358	Cheruthuruthy	Trichur	6.35	0.10	Sand
395	359	Chembilode	Cannanore	6.15	0.09	Sandy clay loam
396	360	Padanakkad	Cannanore	5.90	0.32	Sandy clay loam
397	361	Srikandapuram	Cannanore	6.25	0.01	Loamy sand
398	362	Chembilode	Cannanore	6.40	0.01	Sandy clay loam

(contd.)

Table 1(a) continued

1	2	3	4	5	6	7
399	363	Pappinisseri	Cannanore	6.10	0.01	Sandy clay loam
400	364	Kunnothuparambu	Cannanore	5.80	0.01	Sandy clay loam
401	365	Mamba	Cannanore	5.50	1.42	Loamy sand
402	366	West Eleri	Cannanore	6.10	0.01	Sand
403	368	Kunnothuparambu	Cannanore	5.50	0.15	Sandy loam
404	369	Thoovakkunnu	Cannanore	6.80	0.82	Loamy sand
405	370	Kalyasseri	Cannanore	5.50	0.06	Clay loam
406	371	Puthoor	Cannanore	5.85	0.01	Sandy clay loam
407	372	Peringemvayakkara	Cannanore	5.60	0.16	Clay loam
408	373	Pallinisseri	Cannanore	5.20	0.14	Sandy clay
409	379	Srikandapuram	Cannanore	5.65	0.01	Sandy clay loam
410	388	Srikandapuram	Cannanore	5.15	0.05	Sandy clay loam
411	395	Edakulam	Kozhikode	5.80	0.08	Sandy loam
412	405	Quilandy	Kozhikode	6.00	0.01	Loam
413	407	Kalyasseri	Cannanore	5.90	0.13	Sandy loam
414	408	Kallanchira	Cannanore	5.45	0.06	Loamy sand
415	409	Erimeri	Cannanore	6.65	0.06	Sand
416	410	Peringemvayakkara	Cannanore	6.20	0.38	Loamy sand
417	411	Mangattidam	Cannanore	6.20	0.31	Sand
418	412	Edakulam	Kozhikode	6.65	0.13	Loamy sand
419	413	Chembilode	Cannanore	5.60	0.08	Sandy clay loam

(contd.)

Table 1(a) continued

1	2	3	4	5	6	7
420	414	Pallinisseri	Cannanore	5.40	0.11	Sand
421	415	Thanikkadavu	Cannanore	6.60	0.06	Sand
422	418	Mamba	Cannanore	6.35	0.01	Sand
423	419	Eyyavoor	Cannanore	6.30	0.01	Sand
424	420	Kunnothuparambu	Cannanore	5.15	0.01	Sandy clay loam
425	421	Quilandy	Kozhikode	5.30	0.07	Sand
426	422	Mamba	Cannanore	6.65	0.06	Sand
427	423	Peringemvayakkara	Cannanore	6.40	0.26	Sand
428	424	Peringemvayakkara	Cannanore	5.80	0.10	Loamy sand
429	425	Puthoor	Cannanore	5.80	0.01	Sandy clay loam
430	426	Pallinisseri	Cannanore	6.25	0.06	Sandy clay loam
431	427	Puthoor	Cannanore	6.85	0.01	Sand
432	428	Mamba	Cannanore	6.00	0.17	Sandy clay loam
433	429	Peringemvayakkara	Cannanore	5.90	0.01	Clay loam
434	430	Vayanarikuniyil	Kozhikode	5.85	0.19	Sandy clay loam
435	431	Kalyasseri	Cannanore	5.80	0.01	Loam
436	432	Payyavoor	Cannanore	5.90	0.48	Sand
437	433	Chengayi	Cannanore	6.10	0.01	Sandy clay loam
438	434	Quilandy	Kozhikode	6.20	0.06	Sandy clay loam
439	435	Mangattidam	Cannanore	5.30	0.70	Loam
440	436	Dharmadam	Cannanore	6.40	0.59	Sand

(contd.)

Table 1(a) continued

1	2	3	4	5	6	7
441	437	Quilandy	Kozhikode	6.20	0.10	Sandy clay loam
442	438	Quilandy	Kozhikode	6.00	0.30	Sandy clay loam
443	439	Kalyasseri	Cannanore	5.90	0.01	Sandy clay loam
444	440	Pallinisseri	Cannanore	6.40	0.08	Loamy sand
445	441	Peringemvayakkara	Cannanore	6.35	0.23	Loamy sand
446	442	Padanakkad	Cannanore	6.80	0.05	Sand
447	443	Meloor	Cannanore	6.40	0.14	Loamy sand
448	444	Madavoor	Kozhikode	5.80	0.01	Loamy sand
449	445	Mangattidam	Cannanore	6.10	0.14	Loamy sand
450	446	Edakulam	Kozhikode	6.00	0.27	Sandy clay loam
451	447	Madavoor	Kozhikode	5.25	0.40	Clay loam
452	448	Peringemvayakkara	Cannanore	5.10	0.12	Loamy sand
453	449	Kasmikandy	Kozhikode	5.80	0.28	Loamy sand
454	450	Mamba	Cannanore	6.20	0.08	Sandy clay loam
455	451	Cherilodu	Cannanore	6.90	0.004	Loamy sand
456	452	Meloor	Cannanore	4.20	0.27	Sandy loam
457	453	Cheruthuruthy	Trichur	4.80	1.36	Loam
458	454	Pappinisseri	Cannanore	4.80	0.01	Loam
459	455	Chembilode	Cannanore	6.50	0.56	Sand
460	472	Puthoor	Cannanore	6.40	0.13	Clay loam
461	473	Mamba	Cannanore	6.00	0.01	Loam

(contd.)

Table 1(a) continued

1	2	3	4	5	6	7
462	474	Kalyasseri	Cannanore	5.50	0.01	Sandy loam
463	475	Edakulam	Trichur	5.00	0.07	Sandy loam
464	476	Chembilode	Cannanore	5.90	0.07	Sandy loam
465	477	Kalyasseri	Cannanore	5.80	0.01	Sandy loam
466	478	Peringemvayakkara	Cannanore	6.00	0.01	Loam
467	479	Kallanchira	Cannanore	5.26	0.17	Sandy loam
468	480	Alakode	Cannanore	6.00	0.08	Sandy clay loam
469	481	Puthukkodu	Palghat	6.45	0.01	Sandy loam
470	482	Mullakkara	Trichur	6.00	0.12	Loam
471	483	Mukundapuram	Trichur	5.50	0.01	Loamy sand
472	484	Kollam	Kozhikode	6.30	0.11	Sandy clay loam
473	485	Valayar dam	Palghat	5.50	0.25	Sandy loam
474	486	Viyoor	Kozhikode	5.40	0.01	Sandy loam
475	487	Puthoor	Cannanore	6.60	0.01	Sand
476	488	Panthalayam	Kozhikode	6.50	0.40	Sandy loam
477	489	Quilandy	Kozhikode	5.40	0.01	Loamy sand
478	490	Edakulam	Kozhikode	5.40	0.78	Sandy loam

Table 1(b) General characteristics of soil selected for fractionation of organic matter

Sl. No.	Sample No.	Place of collection	District	pH	E.C. m.mhos/ cm^3	Mechanical analysis			Textural class	C.E.C. me/100 g
						Sand %	Silt %	Clay %		
479	3	Pattambi	Palghat	6.95	1.37	61.6	12.8	25.6	Sandy clay loam	3.7
480	34	Kadakkavoor	Trivandrum	5.50	0.15	76.0	16.0	8.0	Sandy loam	4.6
481	51	Ranni	Quilon	5.35	0.10	72.8	12.8	14.4	Sandy loam	4.7
482	52	Kizhuparamba	Malappuram	5.90	0.20	64.8	14.4	20.8	Sandy clay loam	4.2
483	59	Panniyoor	Cannanore	5.00	0.20	50.5	6.4	38.4	Sandy clay	5.0
484	66	Nileswar	Cannanore	5.20	0.12	88.8	3.2	8.0	Sand	0.8
485	84	Odakkali	Ernakulam	5.00	0.07	69.4	12.8	14.4	Sandy loam	1.3
486	88	Marayoor	Idukki	6.65	0.15	56.5	23.0	20.5	Sandy clay loam	5.1
487	89	Puthupally	Kottayam	5.30	0.15	69.6	12.8	17.6	Sandy loam	3.8
488	91	Othara	Alleppey	4.95	0.13	41.4	20.2	38.5	Clay loam	7.9
489	306	Anthikkadu	Trichur	5.70	0.03	56.8	20.8	22.4	Sandy clay loam	1.3
490	325	Chavakkadu	Trichur	6.40	0.07	88.8	6.4	4.8	Sand	0.6

Table 3. General characteristics of soils (ranges and means)

Soil properties	All soils	Organic carbon group			Textural group	
		Low	Medium	High	Sand	Loam/clay
pH	4.20-7.60 (5.94)	4.75-7.60 (6.04)	4.20-7.20 (5.85)	4.60-7.30 (5.75)	4.60-7.60 (6.12)	4.20-7.40 (5.86)
E.C m.mhos/cm	0.003-1.570 (0.165)	0.005-1.260 (0.144)	0.005-1.570 (0.183)	0.003-0.820 (0.152)	0.005-1.570 (0.146)	0.003-1.370 (0.194)
O.C %	0.21-4.87 (1.25)	0.21-0.99 (0.71)	1.00-2.00 (1.34)	2.01-4.87 (2.82)	0.21-3.19 (1.03)	0.32-4.87 (1.31)
N %	0.026-0.534 (0.138)	0.026-0.165 (0.090)	0.053-0.319 (0.149)	0.099-0.534 (0.253)	0.026-0.417 (0.113)	0.032-0.534 (0.151)
aN %	0.004-0.038 (0.016)	0.004-0.027 (0.012)	0.004-0.037 (0.016)	0.004-0.038 (0.024)	0.004-0.028 (0.014)	0.004-0.038 (0.068)
Clay %	1.6-46.2 (16.49)	1.6-36.3 (15.12)	1.6-46.2 (16.65)	4.8-39.1 (19.38)	1.6-11.6 (8.86)	4.8-46.2 (20.98)
C/N	4.17-25.44 (9.23)	4.68-25.44 (8.19)	4.17-20.80 (9.68)	5.58-20.52 (11.26)	4.68-19.74 (9.11)	4.17-25.44 (9.25)
C/aN	18.62-436.22 (81.68)	18.62-165.31 (60.87)	31.67-282.76 (94.30)	34.12-436.22 (131.87)	18.62-436.22 (95.25)	27.57-317.98 (80.65)
N/aN	1.88-29.28 (9.24)	1.88-22.14 (7.74)	3.33-29.28 (11.17)	4.5-25.65 (12.52)	3.05-29.28 (10.78)	1.88-24.87 (9.13)

(The values in parenthesis are means)

the laterite and lateritic alluvium were included for the study and the neutral to alkaline soils of Chittoor Taluk were not represented. All the soils selected for the study were nonsaline, electrical conductivity ranging from 0.003 to 1.57 m.mhos/cm^3, since the saline as well as the problem soils were not included under the study. It was seen (Table 5) that in general the pH of the soil was significantly and negatively correlated with the total organic carbon (Fig.1), total nitrogen (Fig.2) and available nitrogen (Fig.3) of the soil. Increased accumulation of organic matter in soil tended to decrease the soil pH due to release of organic acids during the decomposition of organic matter (Russell, 1963). The relationship between pH and total or available nitrogen is only the consequence of the relationship between pH and organic matter explained above. Whenever a soil contains higher amounts of organic matter naturally it will contain higher amounts of total or available nitrogen since organic matter is the major source of nitrogen in soil. Therefore any parameter which is correlated with the organic matter of the soil will also be correlated with the total or available nitrogen of soil. The electrical conductivity of the soil was found to be significantly and negatively correlated with pH in the sand category of soils. In this type of soils probably due to extreme leaching and drainage the amount of exchangeable ions and soluble salts retained in soil is

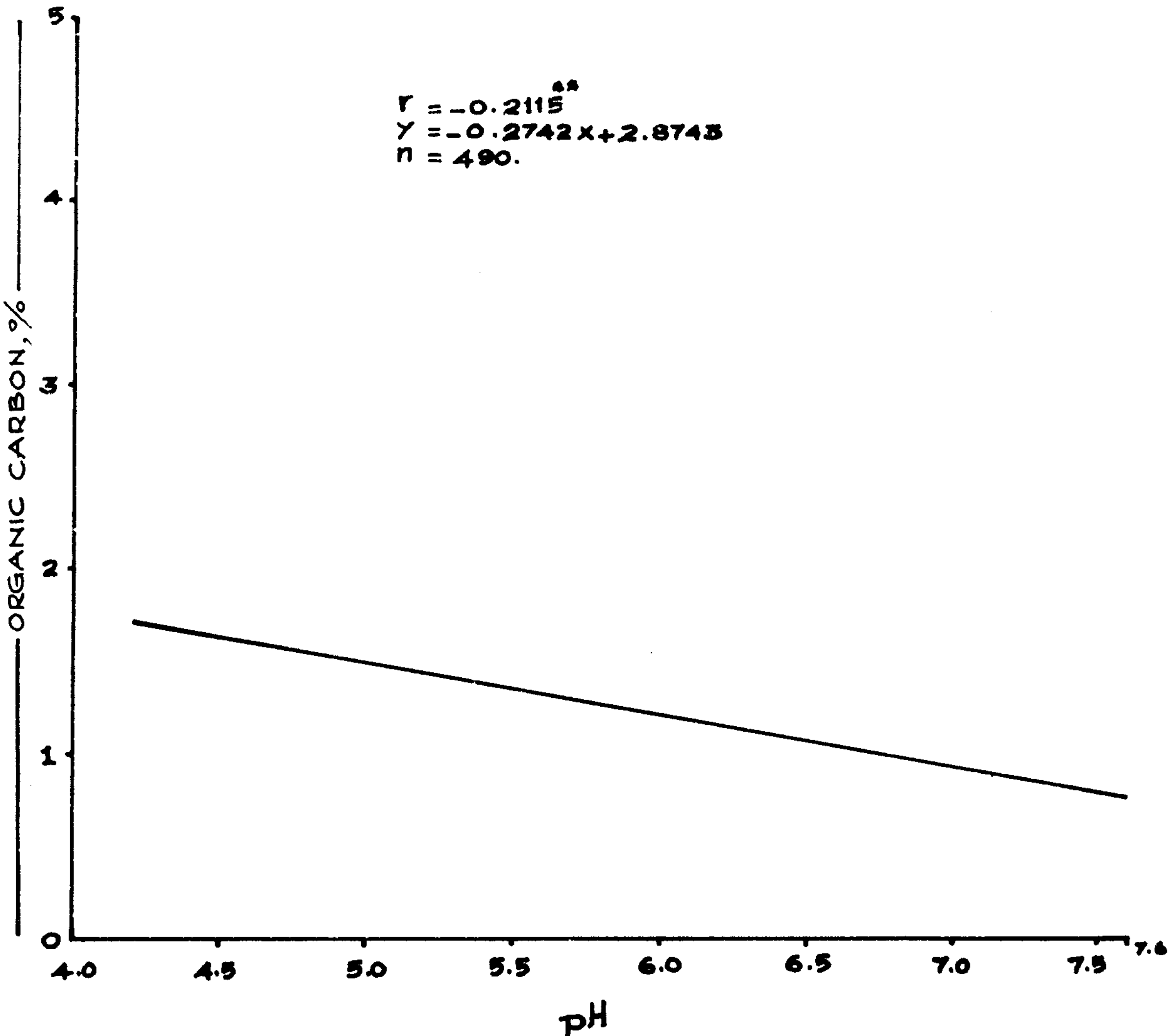


FIG. 1 - RELATIONSHIP BETWEEN pH AND ORGANIC CARBON IN SOIL.

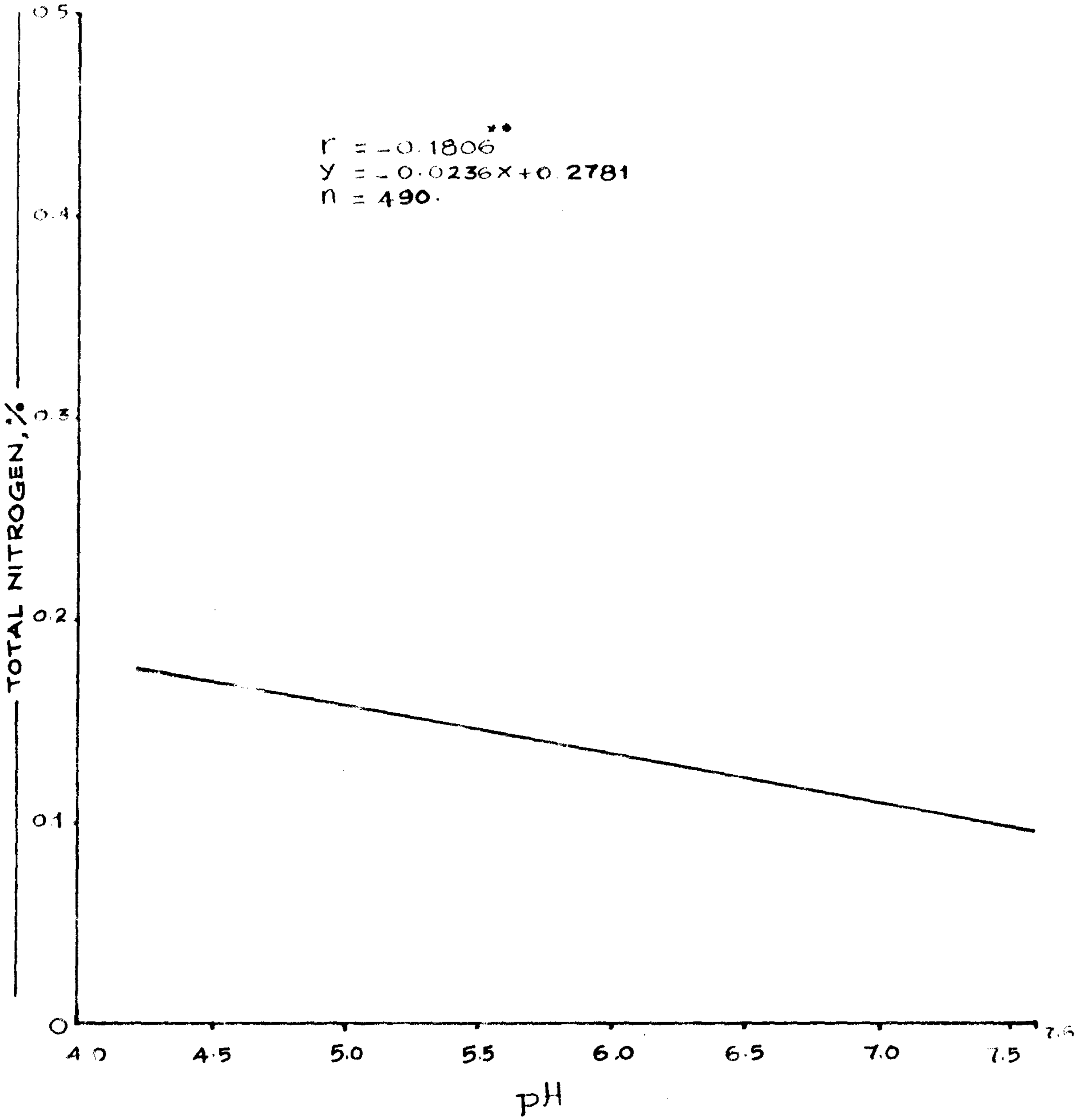


FIG. 2 - RELATIONSHIP BETWEEN pH AND TOTAL NITROGEN IN SOIL.

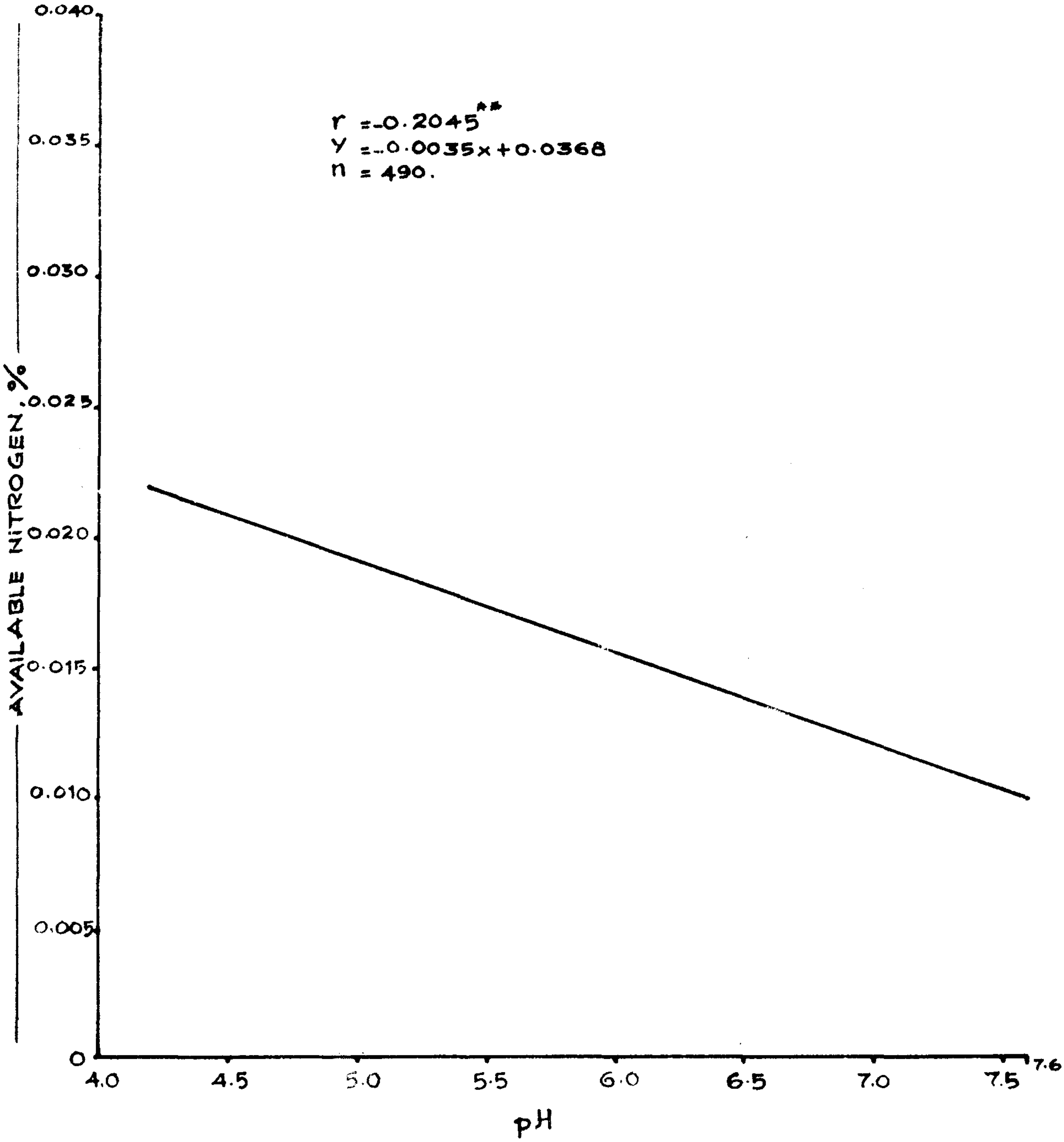


FIG. 3 - RELATIONSHIP BETWEEN pH AND AVAILABLE NITROGEN IN SOIL.

very negligible and as a result these soils register low values for electrical conductivity and relatively higher values for soil pH due to the decreased presence of hydrogen ions and hence the negative correlation between pH and E.C. in sand. The electrical conductivity of the sand category of soil is only 0.146 m.mhos/cm^3 and the corresponding value for clay/loam category was 0.194 m.mhos/cm^3. Similarly the mean pH value for the sand category of soil was 6.12 while the clay/loam category of soil the mean value was 5.86. These observations support the fact that sandy soils in general retained less exchangeable ions including hydrogen ions and water soluble salts among the soils selected for the study.

The mechanical analysis of soil presented in Table 1 revealed that out of the 490 samples selected for the study 141 were sand, 340 were loam and 9 were clay in texture. Most of the soils predominated in the sand fraction and as a result even the loams and clays were sandy in nature. The clay content of the soil ranged from 1.6 to 46.2 percentage with a mean value of 16.49. As already stated the soils were grouped in two categories namely, 1) sand and (2) loam/clay in order to examine the soil property studied in the textural groups separately. There were 141 soils under the sand category and 349 soils under loam/clay category. The loams and clays were put into a single category since there were only 9 soils in the textural class of clay and moreover ratings for organic carbon and available nitrogen followed by soil testing laboratories of the state is same for clays and loams. The clay content of the soil was found to be significantly and positively correlated with the organic carbon content of the soil (r=0.1282*) when all the soils were pooled. However, the coefficient of correlation between organic carbon and clay content was not significantly correlated in different groups of soil examined separately. It is quite natural that clay soils are always associated with higher amounts of organic matter. Conditions which normally help the accumulation of clay fraction also favour the accumulation of organic matter since both are mainly colloidal in nature. As per the fertility rating of the soil testing laboratories of the state clay soil is considered to be medium in organic matter when it contains 0.5 per cent organic carbon whereas a sandy soil is considered medium in organic matter even when it contains 0.3 per cent organic carbon.

2. Carbon-nitrogen relationship of soil

Data on the content of organic carbon, total nitrogen and available nitrogen content of soil and their ratios are presented in Table 2. Their mean values and ranges are given in Table 3.

Table 2. Carbon-nitrogen relationship of soil

Soil sample No.	Org.C%	Nitrogen %		Ratios		
		Total	Available	C/N	C/aN	N/aN*
1	2	3	4	5	6	7
1	1.54	0.118	0.012	13.09	123.60	9.44
2	0.84	0.078	0.019	10.80	43.56	4.00
3	1.19	0.161	0.015	7.37	81.44	11.10
4	0.98	0.165	0.012	5.94	82.08	13.81
5	1.26	0.196	0.012	6.40	103.05	16.09
6	1.07	0.143	0.013	8.20	90.72	11.13
7	1.95	0.263	0.020	7.44	97.56	13.11
8	0.67	0.112	0.008	6.01	80.91	13.49
9	1.56	0.147	0.012	10.60	125.12	11.85
10	1.59	0.112	0.012	14.19	136.50	9.62
11	0.72	0.077	0.010	9.35	71.29	7.56
12	1.38	0.092	0.016	14.98	85.87	5.73
13	0.80	0.054	0.011	14.78	73.96	5.00
14	1.47	0.082	0.018	17.86	84.00	4.70
15	1.22	0.098	0.008	12.47	149.27	11.97
16	0.94	0.144	0.014	6.53	66.94	10.22
17	0.83	0.119	0.012	7.00	68.35	9.77
18	0.46	0.059	0.007	7.80	63.97	8.20
19	1.09	0.133	0.010	8.21	104.50	12.73
20	1.53	0.123	0.010	12.50	150.51	12.03
21	1.38	0.170	0.018	8.12	78.37	9.65
22	0.97	0.161	0.018	6.02	55.09	9.15
23	0.88	0.116	0.012	7.64	72.46	9.48
24	0.32	0.032	0.009	10.21	34.77	3.40
25	0.75	0.103	0.012	7.29	65.53	8.98
26	0.75	0.102	0.010	7.42	75.97	10.25
27	0.70	0.140	0.019	4.97	35.95	7.23

(contd.)

Table 2 continued

1	2	3	4	5	6	7
28	0.77	0.112	0.012	6.86	65.92	9.61
29	0.51	0.072	0.006	7.09	80.38	11.40
30	1.18	0.071	0.010	16.41	115.64	7.05
31	1.38	0.116	0.012	11.96	114.66	9.58
32	0.42	0.149	0.009	9.51	150.55	15.83
33	0.63	0.066	0.008	9.47	84.37	8.87
34	0.42	0.046	0.007	9.28	57.16	6.16
35	1.28	0.074	0.015	17.40	87.80	5.07
36	1.32	0.147	0.009	8.96	149.69	16.61
37	1.78	0.124	0.013	14.32	140.15	9.79
38	0.92	0.106	0.010	8.66	95.19	10.98
39	0.80	0.170	0.010	7.47	90.79	12.16
40	1.93	0.252	0.018	7.64	107.55	14.08
41	1.37	0.186	0.021	7.41	65.75	8.85
42	0.94	0.037	0.015	25.44	60.78	2.39
43	0.97	0.126	0.017	7.71	58.62	7.64
44	1.07	0.170	0.013	6.33	80.35	12.70
45	1.28	0.184	0.016	6.96	77.86	11.20
46	0.84	0.138	0.017	6.07	48.34	7.97
47	0.99	0.151	0.018	6.56	56.39	8.60
48	0.72	0.095	0.011	7.64	68.26	8.93
49	0.50	0.058	0.009	8.61	56.24	6.53
50	1.37	0.180	0.015	7.62	90.09	11.83
51	1.53	0.220	0.021	7.04	72.93	10.35
52	1.23	0.168	0.019	7.33	65.86	8.93
53	0.76	0.112	0.012	6.77	61.66	7.10
54	0.80	0.112	0.015	7.14	54.79	7.67
55	1.26	0.168	0.016	7.50	80.24	10.70
56	1.06	0.158	0.018	6.74	58.34	8.65
57	0.72	0.091	0.017	7.94	43.51	5.48
58	4.81	0.445	0.025	10.83	189.81	17.55

(contd.)

Table 2 continued

1	2	3	4	5	6	7
59	4.09	0.362	0.024	11.29	170.40	14.29
60	3.07	0.417	0.024	7.36	129.10	17.54
61	3.15	0.295	0.026	10.68	120.27	11.27
62	2.21	0.232	0.025	9.56	89.15	9.33
63	1.41	0.093	0.008	15.12	169.04	11.18
64	0.35	0.046	0.008	7.77	44.85	5.76
65	1.49	0.156	0.018	9.55	85.33	8.93
66	0.28	0.060	0.007	4.77	43.02	9.03
67	1.50	0.157	0.015	9.59	99.36	10.36
68	0.84	0.085	0.008	9.89	105.76	10.70
69	1.78	0.155	0.014	11.54	132.10	11.44
70	2.36	0.201	0.020	11.71	116.65	9.96
71	3.09	0.234	0.019	13.21	162.82	12.32
72	0.37	0.063	0.011	5.66	34.97	5.89
73	0.69	0.087	0.017	7.86	39,80	5.06
74	0.84	0.126	0.027	6.70	35.45	5.31
75	3.56	0.382	0.038	9.34	95.00	10.17
76	2.37	0.189	0.020	12.57	120.98	9.64
77	12.72	0.427	0.025	11.05	91.20	17.36
78	1.16	0.090	0.009	12.85	128.60	10.11
79	4.87	0.459	0.019	10.63	157.11	24.18
80	0.31	0.067	0.008	12.68	36.85	7.87
81	0.80	0.095	0.014	8.47	56.98	6.73
82	0.66	0.086	0.012	7.68	56.40	7.35
83	1.38	0.100	0.015	13.78	31.67	6.65
84	1.16	0.121	0.017	9.63	70.19	7.32
85	0.39	0.064	0.012	6.02	32.41	5.39
86	0.61	0.089	0.011	6.88	54.60	7.94
87	0.94	0.138	0.014	6.82	64.71	9.85
88	0.67	0.091	0.015	7.38	46.08	6.25

(contd.)

Table 2 continued

1	2	3	4	5	6	7
89	0.71	0.105	0.016	6.80	45.29	6.69
90	2.14	0.206	0.026	10.40	84.03	8.08
91	1.94	0.240	0.022	8.10	88.75	10.95
92	1.74	0.210	0.024	8.10	72.98	8.82
93	1.87	0.097	0.019	19.39	98.70	5.09
94	1.93	0.126	0.021	15.31	90.29	5.90
95	1.86	0.242	0.034	7.69	54.30	7.06
96	1.86	0.196	0.021	9.48	86.78	9.16
97	2.00	0.189	0.024	10.58	81.77	7.73
98	2.20	0.208	0.021	10.56	100.50	9.52
99	1.69	0.207	0.021	8.16	78.81	9.65
100	1.12	0.112	0.022	10.03	51.07	5.24
101	0.47	0.056	0.008	8.35	57.72	6.91
102	0.73	0.098	0.017	7.41	41.80	5.64
103	1.01	0.147	0.015	6.90	63.81	9.97
104	1.04	0.133	0.011	7.85	98.20	12.50
105	1.07	0.161	0.008	6.66	139.32	20.90
106	0.86	0.119	0.012	7.25	73.79	10.18
107	0.93	0.109	0.010	8.55	88.46	10.34
108	0.95	0.140	0.009	6.78	105.52	15.55
109	0.37	0.039	0.006	9.61	59.31	6.20
110	0.66	0.130	0.013	5.06	49.78	9.84
111	0.94	0.130	0.016	7.23	57.10	7.90
112	0.67	0.088	0.011	7.65	61.48	8.03
113	0.96	0.091	0.014	10.53	66.77	6.34
114	1.12	0.123	0.009	9.17	121.72	13.27
115	0.66	0.077	0.014	8.51	47.96	5.64
116	1.09	0.091	0.006	11.96	170.80	14.29
117	0.58	0.126	0.013	4.61	44.56	9.68
118	0.94	0.102	0.007	9.29	128.22	13.81

(contd.)

Table 2 continued

1	2	3	4	5	6	7
119	0.87	0.116	0.012	7.55	72.02	9.56
120	0.31	0.028	0.009	11.03	33.68	3.05
121	1.12	0.135	0.010	8.29	106.47	12.85
122	0.97	0.105	0.008	9.26	118.18	12.76
123	0.64	0.103	0.009	6.23	69.13	11.10
124	1.01	0.119	0.018	8.47	57.61	6.80
125	1.31	0.165	0.012	7.99	113.71	14.23
126	0.98	0.123	0.008	8.00	121.04	15.12
127	0.38	0.054	0.008	6.98	50.53	7.24
128	1.05	0.123	0.009	8.61	113.41	13.17
129	0.41	0.046	0.005	9.09	86.75	9.54
130	1.21	0.158	0.015	7.69	80.60	10.49
131	1.07	0.126	0.015	8.53	73.58	8.57
132	1.23	0.131	0.011	9.39	113.21	12.06
133	1.16	0.130	0.017	8.98	66.86	7.44
134	1.08	0.137	0.008	7.89	135.29	17.15
135	0.68	0.082	0.006	8.30	112.03	13.49
136	0.99	0.123	0.016	8.06	63.73	7.90
137	0.92	0.126	0.008	7.31	113.70	15.55
138	1.03	0.082	0.009	12.50	115.17	9.21
139	0.69	0.098	0.010	7.05	72.26	10.25
140	1.31	0.154	0.010	5.49	131.23	15.46
141	0.91	0.103	0.011	8.78	86.30	9.83
142	1.23	0.140	0.012	8.81	99.43	11.29
143	1.64	0.158	0.017	10.42	98.28	9.43
144	0.83	0.081	0.012	10.33	69.56	6.73
145	1.03	0.175	0.012	5.90	85.32	14.46
146	1.69	0.186	0.009	9.09	189.42	20.84
147	0.68	0.090	0.011	7.55	64.38	8.52
148	0.65	0.098	0.010	6.67	67.39	10.10

(contd.)

Table 2 continued

1	2	3	4	5	6	7
149	0.22	0.032	0.004	6.84	50.85	7.43
150	0.73	0.095	0.011	7.70	68.55	5.90
151	0.64	0.095	0.010	6.73	62.98	9.37
152	0.86	0.084	0.011	10.20	78.71	7.71
153	1.01	0.112	0.012	9.04	85.64	9.48
154	0.78	0.102	0.012	7.72	66.95	8.68
155	0.79	0.084	0.009	9.41	84.11	8.91
156	0.36	0.042	0.006	5.62	62.00	7.19
157	1.08	0.124	0.009	8.68	121.35	14.13
158	1.07	0.130	0.015	8.27	73.29	8.87
159	1.23	0.130	0.010	9.53	122.29	12.83
160	0.75	0.109	0.012	6.88	60.19	4.83
161	0.92	0.102	0.012	9.10	76.34	8.39
162	0.95	0.112	0.009	8.44	106.27	12.58
163	2.05	0.250	0.011	8.37	183.69	21.95
164	1.28	0.149	0.016	8.62	82.70	9.60
165	2.42	0.123	0.016	19.74	147.92	7.49
166	1.74	0.228	0.011	7.65	165.73	21.67
167	1.21	0.074	0.013	16.45	90.93	5.53
168	1.53	0.182	0.016	8.39	94.81	11.41
169	1.26	0.123	0.016	10.25	77.99	7.61
170	1.14	0.077	0.015	14.76	75.68	5.13
171	1.35	0.131	0.018	14.26	73.50	7.16
172	0.93	0.095	0.013	9.86	71.67	7.27
173	0.91	0.079	0.014	13.30	65.14	4.87
174	0.80	0.077	0.014	10.39	58.54	5.64
175	1.02	0.091	0.016	11.84	63.81	5.70
176	1.40	0.158	0.020	8.90	70.26	7.90
177	1.18	0.070	0.010	16.80	123.82	7.37
178	0.79	0.067	0.015	11.93	51.50	4.32

(contd.)

Table 2 continued

1	2	3	4	5	6	7
179	0.54	0.049	0.012	11.06	45.93	4.15
180	0.87	0.102	0.022	8.53	39.05	4.58
181	1.45	0.196	0.012	7.38	125.63	17.01
182	1.03	0.088	0.015	11.78	67.83	5.76
183	0.96	0.100	0.019	9.60	51.74	5.39
184	0.74	0.063	0.014	11.75	53.64	4.57
185	0.98	0.098	0.017	9.98	56.21	5.62
186	1.03	0.159	0.018	6.47	56.60	8.75
187	0.77	0.088	0.012	8.82	62.26	7.04
188	0.66	0.084	0.012	7.80	55.53	7.12
189	1.31	0.130	0.021	10.11	61.59	6.09
190	0.32	0.042	0.009	7.73	36.89	4.77
191	0.80	0.130	0.024	6.16	33.51	5.44
192	0.96	0.133	0.016	7.25	59.51	5.21
193	0.74	0.095	0.012	7.79	59.85	7.68
194	1.99	0.098	0.029	20.40	68.40	3.35
195	1.12	0.116	0.017	9.68	67.78	7.00
196	1.02	0.133	0.020	7.64	50.67	6.64
197	0.59	0.088	0.012	6.73	47.52	7.06
198	1.16	0.078	0.004	14.79	282.76	19.12
199	0.96	0.085	0.011	11.23	87.66	7.79
200	1.58	0.153	0.014	10.33	114.64	11.09
201	1.62	0.190	0.020	8.49	80.64	9.50
202	0.73	0.076	0.007	9.55	104.26	10.91
203	1.35	0.216	0.016	6.28	82.66	13.15
204	1.04	0.132	0.012	7.90	86.02	10.89
205	1.24	0.113	0.008	10.94	151.35	13.83
206	0.78	0.093	0.012	8.42	61.21	7.99
207	1.25	0.125	0.011	10.07	115.04	11.42
208	1.17	0.109	0.012	10.76	99.40	9.24

(contd.)

Table 2 continued

1	2	3	4	5	6	7
209	0.72	0.070	0.006	10.25	112.16	10.94
210	0.94	0.126	0.015	7.42	61.81	8.33
211	2.02	0.099	0.017	20.52	117.69	5.73
212	0.97	0.137	0.013	7.12	75.54	10.61
213	1.30	0.086	0.014	15.17	90.10	5.94
214	1.19	0.144	0.014	8.28	86.77	10.47
215	1.19	0.109	0.009	10.94	139.59	12.76
216	1.00	0.128	0.016	7.79	63.41	8.14
217	1.08	0.137	0.017	7.89	64.33	8.14
218	2.46	0.207	0.021	11.90	116.51	9.79
219	2.96	0.305	0.030	9.73	100.07	10.29
220	1.03	0.109	0.014	9.50	73.95	7.78
221	2.93	0.315	0.037	9.29	79.34	8.54
222	2.94	0.187	0.023	15.68	128.86	8.22
223	1.02	0.124	0.018	8.23	56.52	6.87
224	0.82	0.088	0.014	9.33	60.47	6.48
225	1.02	0.123	0.020	8.31	51.93	6.25
226	1.03	0.130	0.014	7.96	73.11	9.18
227	0.51	0.063	0.009	8.16	54.39	6.67
228	1.34	0.082	0.014	16.35	100.34	5.90
229	1.32	0.133	0.013	9.93	98.86	10.00
230	0.80	0.098	0.019	8.13	41.73	5.13
231	0.53	0.079	0.012	6.68	42.63	6.39
232	0.86	0.084	0.014	10.27	62.96	6.13
233	0.97	0.093	0.017	10.44	56.32	5.40
234	2.48	0.259	0.026	9.58	96.88	10.12
235	1.34	0.124	0.019	10.78	80.75	7.49
236	1.87	0.090	0.018	20.80	104.36	5.01
237	1.06	0.132	0.018	8.04	60.71	7.55
238	0.91	0.161	0.009	5.68	99.00	17.44

(contd.)

Table 2 continued

1	2	3	4	5	6	7
239	0.31	0.182	0.017	12.70	18.62	10.87
240	1.17	0.112	0.014	10.42	82.21	7.89
241	1.12	0.116	0.014	9.69	80.49	8.31
242	0.84	0.105	0.012	8.01	66.75	8.73
243	0.92	0.081	0.013	11.37	72.62	6.39
244	1.05	0.075	0.012	13.88	86.91	6.26
245	1.12	0.109	0.013	10.78	92.71	8.60
246	1.71	0.236	0.013	7.25	130.14	17.94
247	0.64	0.123	0.015	5.25	51.19	8.25
248	2.01	0.116	0.026	17.43	78.39	4.50
249	1.43	0.077	0.016	18.62	31.89	4.94
250	1.50	0.242	0.011	6.22	137.67	22.16
251	2.22	0.142	0.018	15.63	120.23	7.72
252	2.44	0.119	0.015	20.48	180.24	7.82
253	1.30	0.207	0.018	6.27	72.75	11.60
254	1.31	0.130	0.011	10.13	120.34	11.88
255	1.15	0.147	0.015	7.82	76.60	9.80
256	0.97	0.144	0.014	6.73	70.50	10.47
257	1.00	0.144	0.018	6.99	55.02	7.88
258	1.32	0.084	0.018	15.68	65.64	4.72
259	1.17	0.137	0.014	8.56	85.91	10.04
260	1.05	0.137	0.012	7.66	86.98	10.04
261	0.40	0.060	0.010	6.77	40.57	6.01
262	1.10	0.119	0.014	9.25	76.28	8.95
263	0.59	0.067	0.019	8.80	30.92	3.51
264	0.55	0.074	0.013	7.47	41.83	5.60
265	0.75	0.084	0.017	8.91	42.95	4.82
266	0.67	0.091	0.013	7.32	51.22	7.00
267	0.42	0.081	0.019	5.27	22.76	4.32
268	0.72	0.081	0.015	8.91	47.81	4.32

(contd.)

Table 2 continued

1	2	3	4	5	6	7
269	0.59	0.063	0.014	9.29	43.04	4.63
270	0.44	0.060	0.005	7.38	91.29	12.37
271	0.54	0.084	0.015	6.37	35.39	5.49
272	1.43	0.193	0.014	7.39	99.78	13.50
273	0.89	0.130	0.026	6.89	35.01	5.08
274	1.38	0.173	0.016	7.98	89.22	11.18
275	1.07	0.151	0.020	7.10	52.89	7.45
276	0.99	0.107	0.017	9.28	78.60	6.40
277	1.13	0.140	0.014	8.10	78.60	9.70
278	0.81	0.098	0.013	8.26	60.88	7.37
279	0.72	0.088	0.014	8.25	53.13	6.44
280	0.98	0.084	0.013	11.65	74.38	6.38
281	0.49	0.098	0.016	5.04	30.89	6.13
282	1.96	0.191	0.034	10.29	58.09	5.64
283	0.57	0.084	0.014	6.75	40.51	6.00
284	1.04	0.121	0.013	5.59	77.19	8.99
285	0.38	0.074	0.014	5.12	27.06	5.29
286	0.66	0.077	0.011	8.61	58.59	6.80
287	0.28	0.047	0.010	6.01	29.93	4.98
288	1.59	0.116	0.012	13.81	134.01	9.71
289	1.07	0.133	0.020	8.07	54.78	6.79
290	0.25	0.046	0.011	5.55	22.36	4.03
291	0.38	0.058	0.015	6.56	25.27	3.85
292	2.45	0.273	0.024	8.97	102.89	11.47
293	0.69	0.124	0.016	5.15	39.78	7.72
294	0.95	0.091	0.019	10.41	49.34	4.74
295	3.10	0.286	0.023	10.82	136.95	12.65
296	2.07	0.371	0.036	5.58	56.87	10.19
297	1.21	0.114	0.016	10.60	76.22	7.20
298	0.70	0.088	0.014	7.95	49.72	6.25

(contd.)

Table 2 continued

1	2	3	4	5	6	7
299	0.82	0.112	0.017	7.33	47.63	6.50
300	0.53	0.077	0.015	6.88	35.72	5.19
301	0.54	0.032	0.017	17.07	32.01	1.88
302	2.41	0.273	0.028	8.84	87.71	9.93
303	0.95	0.119	0.016	7.96	59.96	7.53
304	3.03	0.334	0.032	9.07	93.58	10.32
305	1.04	0.112	0.016	9.33	67.41	7.23
306	0.37	0.039	0.010	15.04	185.96	12.30
307	3.08	0.534	0.021	5.77	143.48	24.87
308	0.79	0.084	0.015	9.39	53.71	5.74
309	2.05	0.208	0.024	9.86	85.54	8.68
310	0.85	0.119	0.021	7.17	40.22	5.61
311	0.23	0.026	0.009	8.62	24.09	2.79
312	1.23	0.138	0.022	8.91	55.98	6.29
313	0.38	0.040	0.010	9.42	36.34	3.86
314	0.51	0.051	0.010	9.96	49.03	4.90
315	0.57	0.096	0.014	5.96	41.04	6.88
316	0.93	0.154	0.017	6.07	54.66	9.01
317	0.99	0.165	0.021	6.00	46.30	7.72
318	1.00	0.124	0.020	8.04	50,25	6.25
319	0.63	0.084	0.017	7.45	37.26	5.00
320	3.28	0.247	0.029	13.31	114.73	8.63
321	1.53	0.138	0.022	11.06	70.85	6.40
322	0.91	0.114	0.019	7.97	47.17	5.92
323	0.77	0.098	0.016	7.81	47.85	6.13
324	2.71	0.224	0.018	12.11	51.58	12.51
325	2.46	0.235	0.024	10.47	102.50	9.79
326	2.06	0.294	0.016	6.99	128.50	18.38
327	0.85	0.112	0.027	7.62	31.62	4.15
328	0.58	0.091	0.017	6.40	35.26	5.52

(contd.)

Table 2 continued

1	2	3	4	5	6	7
329	0.82	0.116	0.025	7.11	32.71	4.60
330	1.58	0.224	0.028	7.05	57.40	8.15
331	2.40	0.270	0.026	8.91	34.12	10.57
332	2.46	0.298	0.012	8.26	211.80	25.65
333	2.01	0.193	0.018	10.42	112.66	10.81
334	1.17	0.133	0.017	8.79	69.55	7.92
335	1.67	0.196	0.029	8.54	58.73	6.88
336	0.83	0.103	0.016	8.05	51.66	6.42
337	0.32	0.063	0.011	5.01	27.57	5.50
338	1.31	0.180	0.028	7.28	46.36	6.37
339	0.77	0.098	0.015	7.89	52.95	6.71
340	0.85	0.110	0.018	7.73	46.80	6.05
341	1.45	0.133	0.019	10.92	76.83	7.04
342	0.83	0.056	0.014	14.79	58.72	3.37
343	1.61	0.112	0.016	14.41	99.02	6.87
344	1.06	0.114	0.019	9.33	57.41	6.15
345	1.04	0.233	0.015	4.49	68.24	15.22
346	1.26	0.103	0.021	12.20	58.88	4.83
347	1.20	0.123	0.018	9.80	67.61	6.90
348	0.86	0.114	0.013	7.59	68.30	8.99
349	0.86	0.123	0.015	7.00	58.97	8.42
350	0.99	0.063	0.015	15.71	64.71	4.12
351	1.43	0.124	0.015	11.57	98.56	6.71
352	1.33	0.163	0.024	7.77	54.57	6.71
353	1.37	0.131	0.008	10.46	162.99	15.58
354	1.27	0.123	0.016	10.31	80.64	7.82
355	1.27	0.081	0.017	15.73	75.81	4.82
356	1.88	0.175	0.016	10.75	115.46	10.74
357	0.81	0.109	0.005	7.46	165.31	22.14
358	1.92	0.228	0.020	8.44	95.25	11.29

(contd.)

Table 2 continued

1	2	3	4	5	6	7
359	1.22	0.126	0.024	9.71	51.21	5.27
360	1.31	0.158	0.023	8.31	57.88	6.97
361	1.67	0.056	0.016	10.69	103.28	3.47
362	1.63	0.140	0.013	11.66	124.68	10.70
363	1.50	0.089	0.020	16.80	75.38	4.49
364	0.71	0.098	0.013	7.27	54.41	7.48
365	1.05	0.091	0.019	11.53	54.65	4.74
366	0.20	0.042	0.006	4.93	32.34	6.56
367	1.81	0.200	0.020	9.08	88.75	9.78
368	0.66	0.120	0.019	5.37	34.80	6.48
369	1.69	0.290	0.026	5.83	65.78	11.30
370	1.05	0.154	0.019	6.81	55.52	8.15
371	1.32	0.131	0.018	10.06	74.73	7.43
372	2.75	0.291	0.029	9.46	94.14	9.95
373	1.43	0.109	0.026	13.21	54.71	4.14
374	1.99	0.168	0.016	11.83	125.80	10.63
375	1.91	0.235	0.027	8.15	70.49	8.65
376	0.50	0.061	0.011	8.20	47.40	5.78
377	0.78	0.077	0.007	10.11	113.79	11.26
378	1.16	0.133	0.016	8.73	70.76	8.11
379	2.90	0.280	0.027	10.36	107.84	10.41
380	0.72	0.112	0.013	6.44	53.86	8.36
381	2.96	0.334	0.030	8.85	97.29	11.00
382	0.83	0.080	0.010	10.28	75.88	7.38
383	2.76	0.298	0.029	9.28	95.48	10.28
384	0.87	0.095	0.017	9.21	52.02	5.65
385	0.70	0.084	0.016	8.34	42.60	5.11
386	1.34	0.140	0.016	9.60	80.50	8.38
387	1.32	0.133	0.015	9.89	87.85	8.80
388	2.71	0.301	0.030	9.00	91.86	10.20

(contd.)

Table 2 continued

1	2	3	4	5	6	7
389	0.86	0.085	0.018	10.14	47.45	4.68
390	1.13	0.137	0.011	8.29	103.77	12.51
391	2.32	0.210	0.012	11.05	191.79	17.35
392	1.39	0.161	0.014	8.61	99.27	11.52
393	1.34	0.137	0.005	9.80	265.34	27.08
394	1.60	0.207	0.016	7.74	100.13	12.99
395	1.06	0.053	0.011	20.22	94.93	4.70
396	2.70	0.179	0.009	15.14	317.98	21.00
397	1.30	0.182	0.019	7.15	68.09	9.52
398	0.58	0.093	0.006	6.25	93.47	14.97
399	1.12	0.161	0.007	6.97	163.96	23.54
400	1.42	0.168	0.006	8.44	238.80	28.28
401	0.476	0.075	0.006	6.32	80.05	12.68
402	0.55	0.068	0.009	8.06	58.49	7.27
403	0.92	0.143	0.017	6.42	54.59	8.51
404	1.72	0.186	0.015	9.28	117.85	12.68
405	0.99	0.100	0.012	9.97	82.21	8.25
406	1.20	0.137	0.006	8.79	187.50	21.33
407	0.85	0.109	0.010	7.86	88.09	11.21
408	0.60	0.102	0.010	5.92	61.99	10.49
409	0.46	0.042	0.006	10.91	71.56	6.56
410	1.17	0.133	0.012	8.79	98.61	11.25
411	0.47	0.091	0.010	5.21	46.09	8.85
412	0.51	0.077	0.009	6.56	56.78	8.57
413	1.48	0.168	0.019	8.83	77.71	8.80
414	1.14	0.095	0.028	12.03	40.06	3.33
415	0.36	0.036	0.007	10.06	54.24	5.39
416	1.60	0.175	0.013	9.14	119.86	13.11
417	2.79	0.280	0.023	13.39	119.23	12.09
418	0.79	0.061	0.006	12.89	136.12	10.56

(contd.)

Table 2 continued

1	2	3	4	5	6	7
419	0.55	0.063	0.010	8.69	52.95	6.09
420	1.07	0.154	0.011	6.97	95.53	13.70
421	0.42	0.061	0.006	6.78	71.58	10.55
422	2.03	0.116	0.006	17.59	369.30	21.00
423	0.59	0.056	0.009	10.48	63.16	6.02
424	1.39	0.177	0.014	7.86	37.51	12.41
425	1.42	0.142	0.015	10.01	94.74	9.47
426	2.44	0.259	0.020	9.41	120.07	12.76
427	0.87	0.144	0.012	6.10	75.81	12.44
428	0.81	0.105	0.015	7.74	53.62	6.93
429	2.03	0.228	0.029	8.93	70.90	7.94
430	4.31	0.277	0.027	15.60	162.12	10.39
431	1.41	0.193	0.024	7.30	59.23	8.11
432	3.19	0.280	0.017	11.38	189.73	16.67
433	1.55	0.177	0.019	8.75	80.98	9.26
434	0.84	0.109	0.017	7.78	48.49	6.24
435	1.33	0.319	0.034	4.17	39.06	9.37
436	0.81	0.098	0.011	8.29	74.26	8.96
437	1.19	0.160	0.024	7.22	49.07	6.80
438	2.17	0.266	0.031	8.16	70.28	8.61
439	1.19	0.151	0.020	7.89	59.97	7.60
440	1.09	0.149	0.014	7.35	78.40	10.67
441	1.00	0.080	0.0118	12.42	84.45	6.80
442	0.22	0.042	0.005	5.21	44.45	8.54
443	0.62	0.098	0.013	6.38	48.82	7.66
444	0.51	0.063	0.005	8.13	105.22	12.94
445	1.74	0.142	0.012	12.25	147.24	12.07
446	3.85	0.237	0.023	16.29	164.70	10.11
447	1.45	0.277	0.029	5.25	49.42	9.40
448	0.53	0.095	0.013	5.62	42.16	7.50

(contd.)

Table 2 continued

1	2	3	4	5	6	7
449	0.87	0.114	0.016	7.69	54.01	7.02
450	1.03	0.140	0.011	7.37	94.78	12.87
451	2.28	0.187	0.039	12.18	58.19	4.78
452	1.09	0.124	0.021	8.82	53.26	6.04
453	1.41	0.179	0.020	7.88	70.42	8.94
454	2.31	0.256	0.024	9.05	95.95	10.60
455	0.59	0.056	0.005	10.56	114.39	10.83
456	1.16	0.128	0.017	9.02	69.73	7.73
457	1.09	0.161	0.013	6.79	82.54	12.15
458	1.53	0.126	0.011	12.15	143.10	11.78
459	0.84	0.081	0.008	10.38	106.71	10.28
460	1.13	0.156	0.017	7.23	66.84	9.24
461	1.49	0.172	0.012	8.70	123.18	14.50
462	1.53	0.161	0.009	8.86	162.03	18.23
463	1.16	0.165	0.014	7.04	83.35	11.83
464	2.67	0.252	0.006	10.61	436.22	41.10
465	1.17	0.126	0.009	9.25	129.84	14.03
466	1.67	0.196	0.013	8.53	132.61	15.56
467	1.41	0.166	0.014	8.49	99.37	11.71
468	3.02	0.283	0.024	10.65	126.42	11.87
469	0.65	0.070	0.008	9.38	82.96	8.85
470	1.71	0.205	0.011	8.34	159.64	19.14
471	2.39	0.238	0.015	10.05	164.68	16.41
472	2.53	0.238	0.024	10.64	104.64	9.83
473	0.79	0.105	0.011	7.57	70.90	9.37
474	0.85	0.103	0.010	8.19	82.61	10.09
475	1.16	0.161	0.014	7.19	81.49	11.34
476	1.56	0.196	0.010	7.94	109.65	19.12
477	1.57	0.203	0.016	7.74	96.64	12.48

(contd.)

Table 2 continued

1	2	3	4	5	6	7
478	1.17	0.158	0.014	7.44	81.57	10.96
479	1.33	0.245	0.011	5.42	125.81	23.20
480	2.09	0.212	0.022	9.85	93.36	9.48
481	1.80	0.224	0.019	8.04	94.24	11.79
482	2.03	0.238	0.025	8.52	80.18	9.41
483	1.04	0.149	0.009	7.01	112.13	16.00
484	1.86	0.263	0.024	7.07	79.03	11.17
485	1.43	0.179	0.016	8.00	90.35	11.29
486	1.29	0.175	0.020	10.94	65.43	8.91
487	1.09	0.158	0.005	6.85	200.68	29.28
488	1.38	0.193	0.012	7.20	111.76	15.52
489	1.60	0.200	0.021	8.02	76.92	9.59
490	1.39	0.207	0.011	6.71	128.31	19.12

* aN = available nitrogen

2.1. Organic carbon

In general the percentage of organic carbon in soil ranged from 0.21 to 4.87 with a mean value of 1.25. Based on the content of organic carbon the 490 soils studied in this investigation were grouped into three categories namely (1) low (2) medium and (3) high when the percentage of organic carbon was less than one, between one and two and greater than two so as to understand the carbon-nitrogen relationships in these categories of soil more precisely. There were 210 soils in the low organic carbon group, 220 in medium organic carbon group and 60 in high organic carbon group. As already pointed out the content of organic carbon and total nitrogen in soil were highly correlated ($r=0.7966^{**}$). The relationship between organic carbon and total nitrogen is presented in Table 5 and graphically represented in Fig.4 and 5. Organic carbon was also correlated with available nitrogen ($r=0.4008^{**}$) though not to the extent of that between total nitrogen and organic carbon (Fig.6). Interestingly organic carbon was significantly and negatively correlated with pH of soil. The probable reasons for this interrelationships between organic carbon, total nitrogen, available nitrogen and pH have already been furnished.

2.2. Total nitrogen

The total nitrogen of the soil ranged from 0.026 to 0.534 per cent with a mean value of 0.138 when all the soils

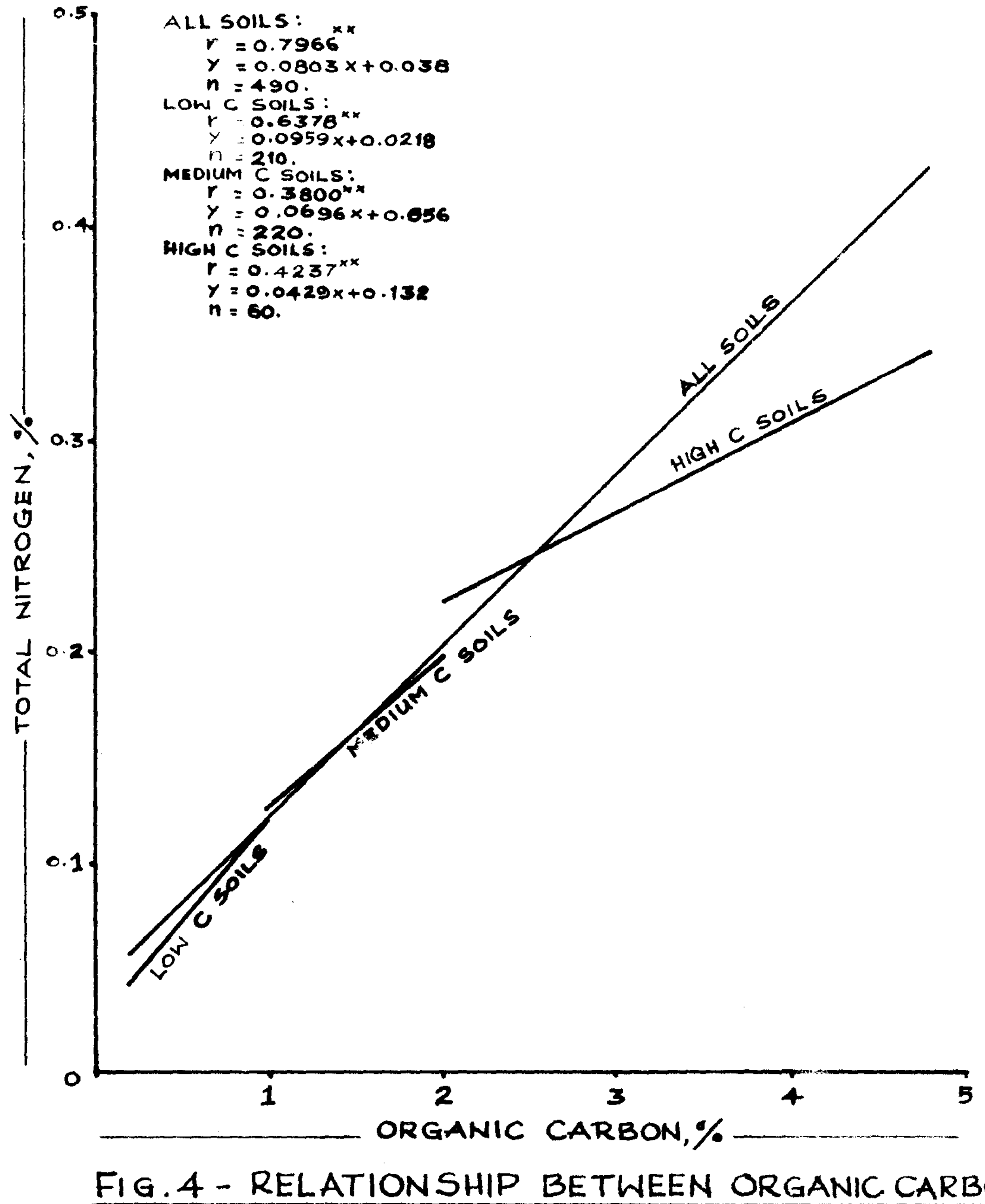


FIG. 4 - RELATIONSHIP BETWEEN ORGANIC CARBON AND TOTAL NITROGEN IN SOIL.

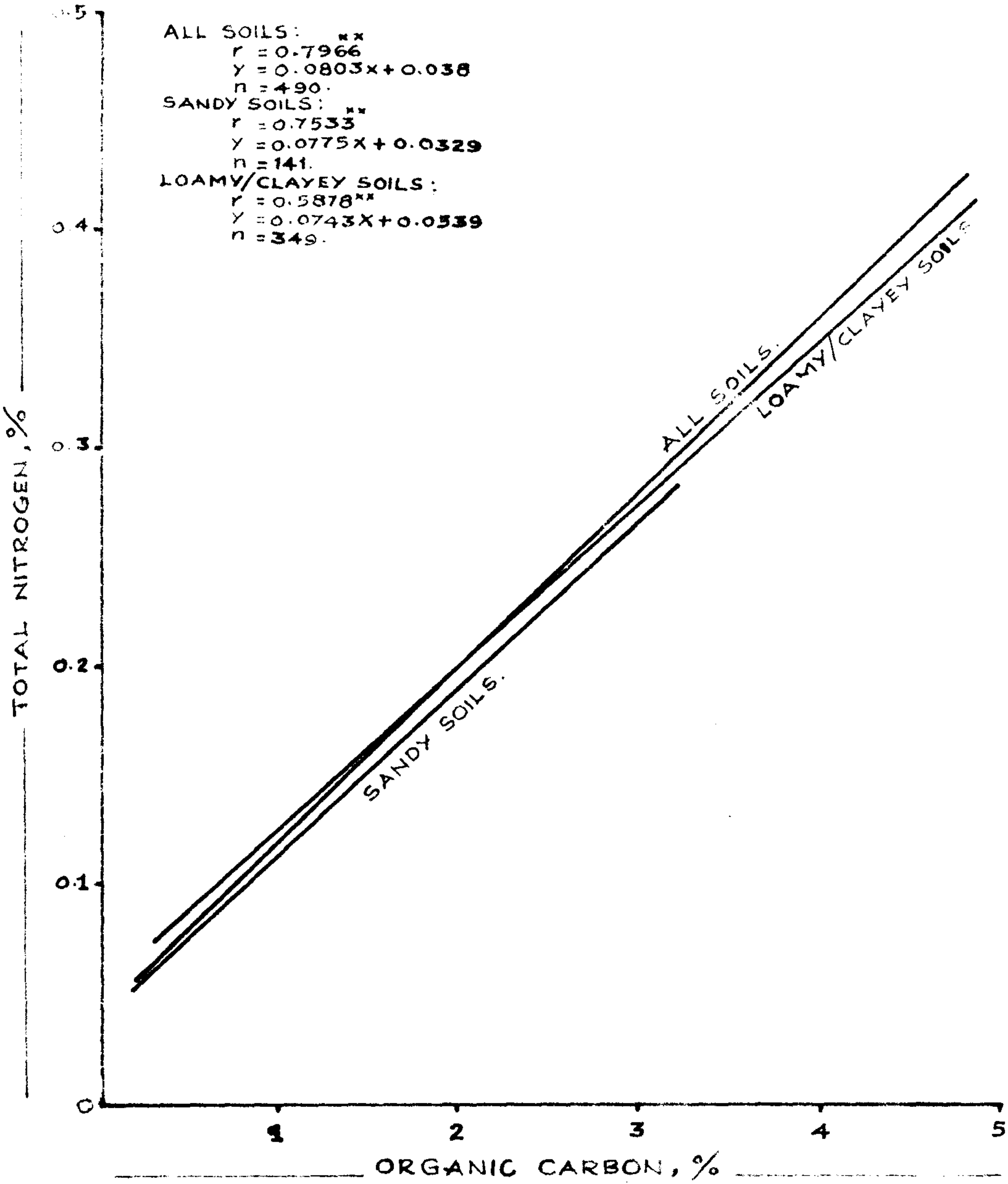


FIG. 5 - RELATIONSHIP BETWEEN ORGANIC CARBON AND TOTAL NITROGEN IN SOIL.

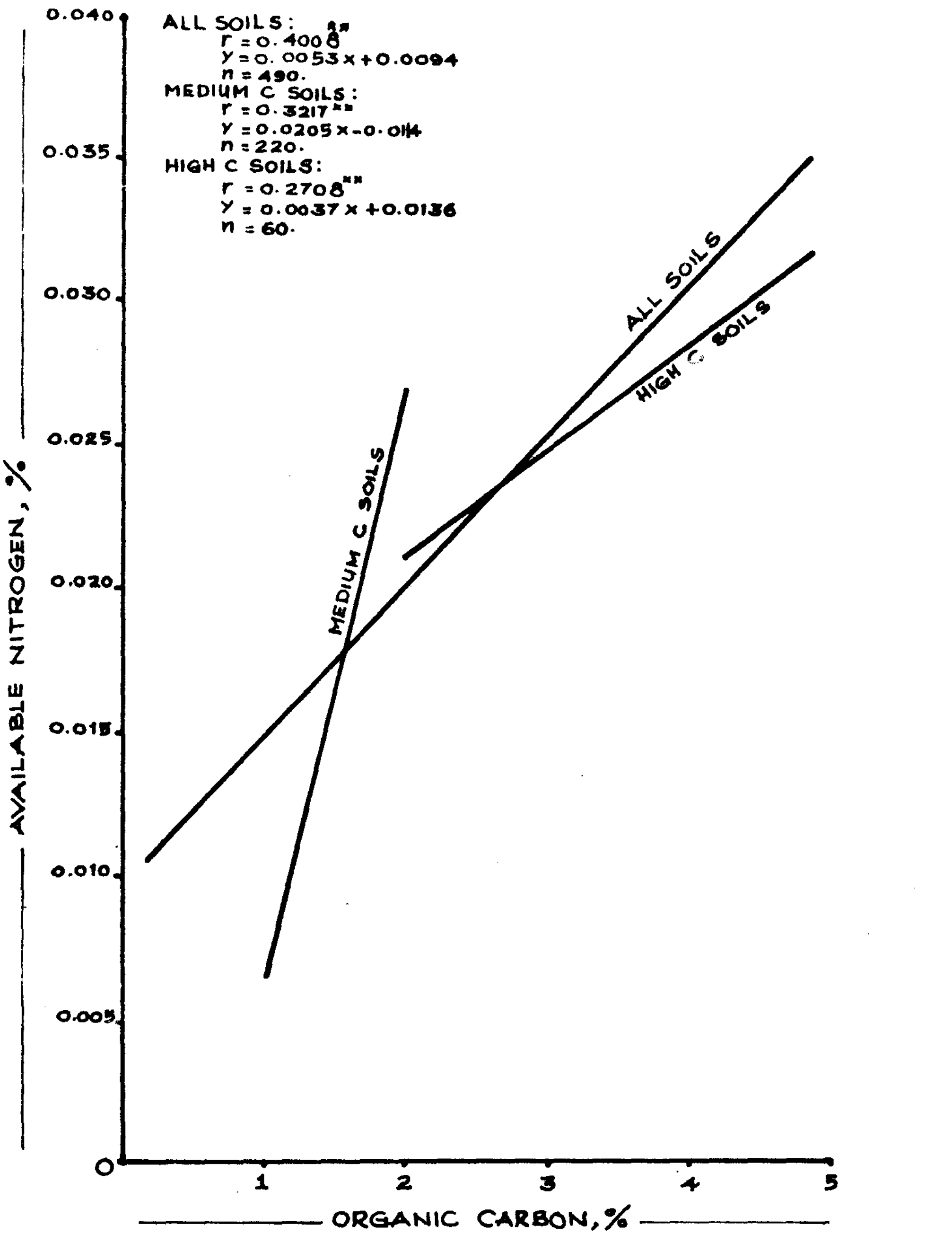


FIG. 6- RELATIONSHIP BETWEEN ORGANIC CARBON AND AVAILABLE NITROGEN IN SOIL.

were considered. As expected, total nitrogen content increased with increase in organic matter. Consequently, the mean values for total nitrogen in the low, medium and high organic carbon groups of soil were 0.090, 0.149 and 0.253 per cent respectively. Similarly, loam and clay soils retained large amount of total nitrogen than the sandy soils. Since the clay and loam soils contained larger quantities of organic matter it is natural that these soils retained higher amounts of total nitrogen since the organic matter and total nitrogen are interrelated.

2.3. Available nitrogen

The content of available nitrogen determined by alkaline permanganate method ranged from 0.004 to 0.038 per cent with a mean value of 0.016 when all the soils were pooled. As in the case of total nitrogen available nitrogen also increased with increase in organic carbon. Accordingly, the values for available nitrogen in the low, medium and high organic carbon groups of soil were 0.012, 0.016 and 0.024 per cent respectively. Also, clay and loam soils contained large amounts of available nitrogen as compared to sandy soils. When the sand group of soil registered a mean value of 0.014 per cent for available nitrogen the corresponding value for clay and loam group of soil was 0.068 per cent, the increase being 385.71 per cent. This showed that clay and loam group of soil were capable of retaining extremely larger quantities of available nitrogen as compared to sandy soil. It should be pointed out that such a conspicuous difference between sandy soils and loam/clay soils was not seen in the case of total nitrogen though loam and clay soil contain relatively higher content of nitrogen than sandy soils. When sand group of soil registered a mean value of 0.113 per cent for total nitrogen the corresponding value for clay and loam group was 0.151 per cent the increase being only 33.628 per cent. Available nitrogen content of the soil was correlated with total nitrogen ($r=0.4233^{**}$), organic carbon ($r=0.4008^{**}$) and pH of the soil. The relationship between total nitrogen and available nitrogen has been graphically represented in Fig.7. As already pointed out conditions which favour the accumulation of organic matter consequently result in higher amounts of total and available nitrogen since organic matter is the major source of nitrogen in soil. However, it should be pointed out that the relationship between organic carbon and available nitrogen is not as high as the relationship between organic carbon and total nitrogen. This is because major part of total nitrogen is represented by organic nitrogen which is a component of organic matter as in the case of organic carbon whereas transformations and retention of available nitrogen are not governed by any such direct linkage with organic carbon.

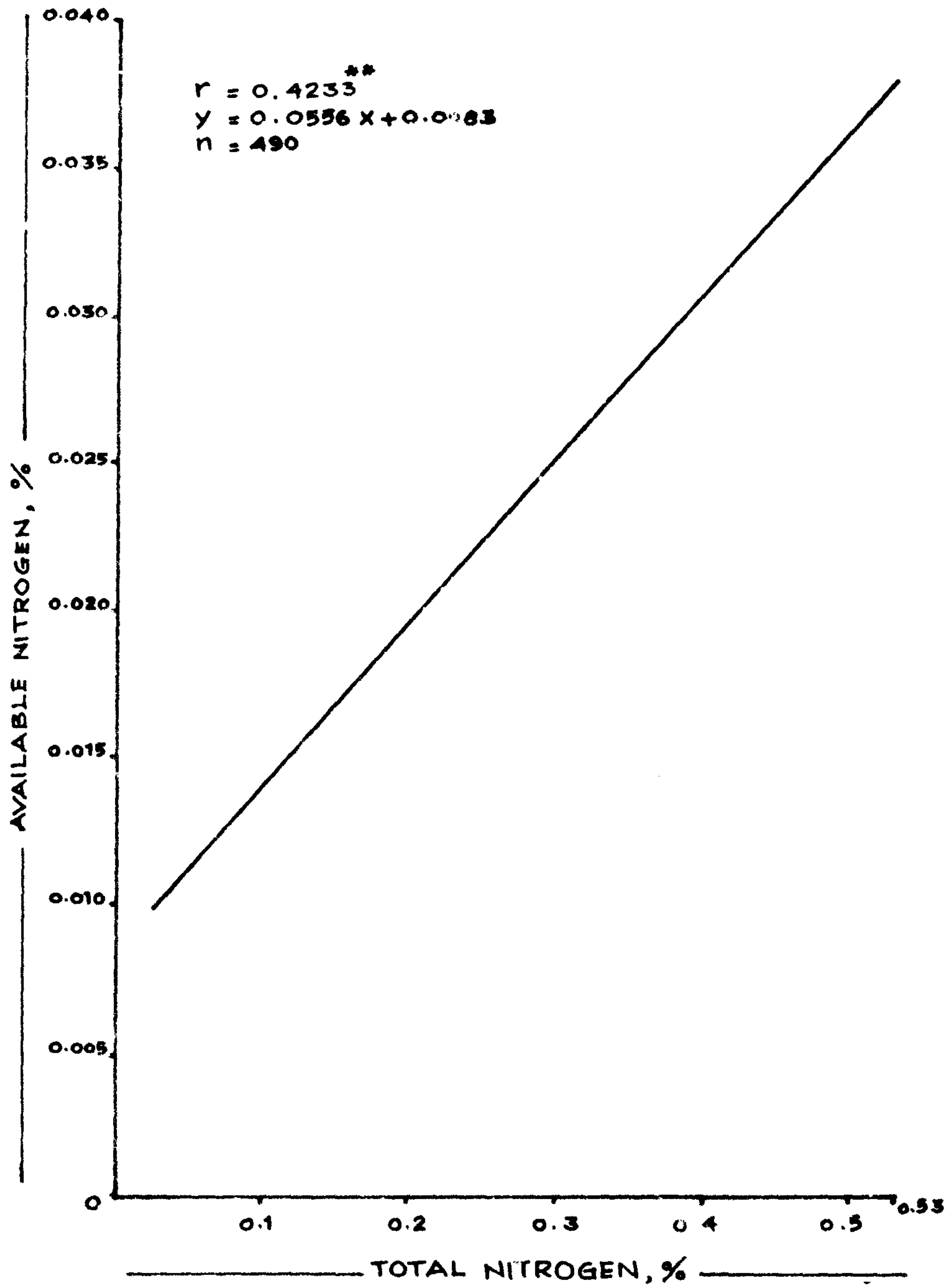


FIG. 7- RELATIONSHIP BETWEEN TOTAL NITROGEN AND AVAILABLE NITROGEN IN SOIL.

2.4. C:N ratio

In general the C:N ratio of the soils ranged from 4.17 to 25.44 with a mean value of 9.23. This showed that considerable variation existed in the C:N ratio of soil. The range and mean values of C:N ratio in different categories of soil are presented in Table 3. It is interesting to observe that the mean C:N ratio increased with the increasing content of organic carbon of the soil. Thus the mean C:N ratio for the low organic carbon, medium organic carbon and high organic carbon soils were 8.19, 9.68 and 11.26 respectively. This showed the need of establishing different C:N ratios in groups of soils varying in their content of organic matter. It is generally stated that the C:N ratio of soil will be usually within the range of 10 to 12 whereas the results of the present investigation gave a mean value of less than 10 except in soils containing organic carbon more than 2 per cent. The simple linear regression equation established considering all the soils taken for the study (Table 5) is N% = 0.0803 C% + 0.038. This would mean that even soil containing no organic matter will contain 0.038 per cent nitrogen and obviously soil containing very little of organic carbon will have a low C:N ratios. The increase in C:N ratio due to increase in the organic matter content of soil is explained as follows. In soils which retain only very low content of organic carbon the organic matter has undergone a greater degree of oxidation thereby decreasing the ratio between carbon and nitrogen whereas in soils which are rich in organic carbon, the organic matter includes fractions which have not undergone the process of decomposition fully, thereby exhibiting a higher C:N ratio. Considering the above regression model, a soil with 0.2, 1,2 and 3 per cent organic carbon will have a C:N ratio of 3.70, 8.47, 10.05 and 10.75 respectively. However, variation in the C:N ratio is getting narrowed down when the values for organic carbon is getting higher. However, since the average carbon content of the soil was only 1.25 per cent and the range of variation was from 0.21 to 4.87, it is highly essential that separate C:N ratios should be established and utilised for different categories of soil based on their organic carbon content for interpreting the nitrogen status of the soil since C:N ratio of a soil with 0.2 per cent organic carbon is as low as 3.70 whereas the C:N ratio of a soil with 3 per cent carbon is as high as 10.75. Table 4 presents the predicted values of total nitrogen and C:N ratio for different values of organic carbon making use of the regression model N% = 0.0803 C% + 0.038. In the present study, regression equations between carbon and nitrogen has been worked out for groups of soil categorised according to the percentage of organic carbon. The regression equations presented in Table 5 showed that for low, medium and high carbon groups of soil the coefficients of regression were 0.0959,

Table 4. C:N ratio of soil predicted using the regression model N% = 0.0803 C% + 0.038

Org. C%	Total N%	C:N ratio
0.2	0.054	3.70
0.3	0.062	4.84
0.4	0.070	5.71
0.5	0.078	6.41
0.6	0.086	6.98
0.7	0.094	7.45
0.8	0.102	7.84
0.9	0.110	8.18
1.0	0.118	8.47
1.1	0.126	8.73
1.2	0.134	8.96
1.3	0.142	9.15
1.4	0.150	9.33
1.5	0.158	9.49
1.6	0.166	9.64
1.7	0.175	9.71
1.8	0.183	9.84
1.9	0.191	9.95
2.0	0.199	10.05
2.1	0.207	10.14
2.2	0.215	10.23
2.3	0.223	10.31
2.4	0.231	10.39
2.5	0.239	10.46
2.6	0.247	10.53
2.7	0.255	10.59
2.8	0.263	10.65
2.9	0.271	10.70

(contd.)

Table 4 continued

Org. C%	Total N%	C:N ratio
3.0	0.279	10.75
3.1	0.287	10.80
3.2	0.295	10.85
3.3	0.303	10.89
3.4	0.311	10.93
3.5	0.319	10.97
3.6	0.327	11.01
3.7	0.335	11.04
3.8	0.343	11.08
3.9	0.351	11.11
4.0	0.359	11.14
4.1	0.367	11.17
4.2	0.375	11.20
4.3	0.383	11.23
4.4	0.391	11.25
4.5	0.399	11.28
4.6	0.407	11.30
4.7	0.415	11.33
4.8	0.423	11.35
4.9	0.431	11.37

Table 5. Relationship between different properties of soil

X	Y	r	Regression equations
All soils (n=490)			
Organic carbon	Total nitrogen	0.7966**	N% = 0.0803 C% + 0.0380
Organic carbon	Available nitrogen	0.4008**	aN% = 0.0053 C% + 0.0094
Organic carbon	Clay	0.1282*	Clay% = 1.661 C% + 14.4593
Total nitrogen	Available nitrogen	0.4233**	aN% = 0.0556 N% + 0.0083
pH	Organic carbon	-0.2115**	C% = -0.2742 pH + 2.8743
pH	Total nitrogen	-0.1806**	N% = -0.0236 pH + 0.2781
pH	Available nitrogen	-0.2045**	aN% = -0.0035 pH + 0.0368
Clay	Total nitrogen	0.1520**	N% = 0.0012 Clay% + 0.1172
Clay	Available nitrogen	0.1535**	aN% = 0.0002 Clay% + 0.0127
Low carbon soils (n=210			
Organic carbon	Total nitrogen	0.6376**	N% = 0.0959 C% + 0.0218
pH	Organic carbon	-0.1767*	C% = -0.0691 pH + 1.1286
Medium carbon soils (n=220)			
Organic carbon	Total nitrogen	0.3800**	N% = 0.0696 C% + 0.056
Organic carbon	Available nitrogen	0.3217**	aN% = 0.0205 C% - 0.0114
Total nitrogen	Available nitrogen	0.3340**	aN% = 0.1161 N% - 0.0013
pH	Available nitrogen	-0.1981**	aN% = -0.0046 pH + 0.0429

(contd.)

Table 5 continued

X	Y	r	Regression equations
High carbon soils (n=60)			
Organic carbon	Total nitrogen	0.4237**	N% = 0.0429 C% + 0.1320
Organic carbon	Available nitrogen	0.2708*	aN% = 0.0037 C% + 0.0136
Sandy soils (n=141)			
Organic carbon	Total nitrogen	0.7533**	N% = 0.0775 C% + 0.0329
pH	Organic carbon	-0.2223**	C% = -0.2346 pH + 2.4702
pH	Total nitrogen	-0.1887*	N% = -0.0205 pH + 0.2380
pH	E.C	-0.1680*	E.C = -0.0578 pH + 0.5000
Clay	Available nitrogen	0.2751**	aN% = 0.0016 Clay % + 0.0016
Loamy/clayey soils (n=349)			
Organic carbon	Total nitrogen	0.5878**	N% = 0.0743 C% + 0.0539

** Significant at 1% level

* Significant at 5% level

0.0696 and 0.0429 respectively which evidently showed that C:N ratio will be low for low organic carbon group of soil and high for high carbon group of soil. These regression equations also present that the nitrogen content which does not vary with the organic carbon content (the constant of the regression equation) is however high for soils containing large amounts of organic matter than soils of low organic matter content probably because of the interrelationship between the clay and organic matter content of the soil.

The relationships between soil properties and C:N ratio are presented in Table 6. The C/N ratio of the soil was found to be positively and significantly correlated with the organic carbon ($r=0.3468^{**}$) which indicated that increase in the content of organic carbon resulted in a corresponding increase in C/N ratio of soil. Normally, an increase in C/N ratio may result either due to an increase in the content of organic carbon or due to decrease in the content of total nitrogen. But in the present investigation it is seen that the negative correlation between total nitrogen and C/N ratio is not statistically significant indicating that variation in the nitrogen content of soil is not in tune with the variation in the organic carbon. As a result, the C/N ratio of the soil is mainly decided by the organic matter content of soil rather than the content of total nitrogen. The coefficients of correlation between available nitrogen and

Table 6. Relationship between soil properties and carbon-nitrogen ratios

X	Y	r	Regression equations
Organic carbon	C/N	0.3468**	C/N = 0.7072 C% + 8.3530
Organic carbon	C/aN	0.6128**	C/aN = 4.8368 C% + 78.6629
Organic carbon	N/aN	0.8736**	N/aN = 2.1742 C% + 6.8371
Total nitrogen	C/aN	0.3209**	C/aN = 7.6569 N% + 83.5913
Total nitrogen	N/aN	0.4587**	N/aN = 3.4514 N% + 9.0788
Available nitrogen	C/aN	-0.2317**	C/aN = -19.6427 aN% + 84.9596
Available nitrogen	N/aN	-0.2671**	N/aN = -7.1401 aN% + 9.6427
Clay	C/aN	-0.1617*	C/aN = -0.3510 Clay% + 89.7532
Clay	N/aN	-0.1705*	N/aN = -0.1172 Clay% +11.3778

** Significant at 1% level

* Significant at 5% level

C/N ratio as well as clay and C/N ratio were not statistically significant.

2.5. Ratio between organic carbon and available nitrogen (C:aN)

The ratio of organic carbon to available nitrogen varied from 18.62 to 436.22 with a mean value of 81.68. Thus the mean C/aN ratio is 8.849 times more than the mean C/N ratio of soil. When the C/aN ratio of different groups of soil was separately examined it is seen that the ratio overwhelmingly increased with the increasing content of organic matter. Thus when the ratio was 60.87 in low organic carbon group its values in medium organic carbon groups were 94.3 and 131.87 respectively. The excessively inflated C:aN ratio in soils of high organic matter content may probably be due to the fact that the soil could retain only a limited quantity of mineralised nitrogen and therefore loss of nitrogen due to leaching and denitrification became pronounced in soils where large amount of nitrogen was released by mineralisation. This phenomenon would have resulted in an increased C/aN ratio in soils containing large amount of organic carbon. This argument is further substantiated by the relatively high N/aN ratio of soil containing higher amounts of organic carbon as compared to other soils. Moreover, the negative and significant correlation between clay per cent and C/aN ratio (Table 6) is also indicative that the C/aN ratio is dependent on the retentive power of the soil. The mean C/aN ratios for the sand and clay/loam groups of soil were 95.25 and 80.65 respectively. The decreased C/aN ratio in clay/loam soils is obviously due to increased accumulation of available nitrogen in this group of soil. As already pointed out the mean organic carbon content of sand and clay/loam groups of soil were 1.03 and 1.31 per cent, the increase being 26.40 per cent whereas the mean values for available nitrogen in these two groups of soil were 0.014 and 0.068 per cent respectively, the increase being 385.71 per cent. These observations also substantiate the influence of the finer fractions of soil in decreasing the C/aN ratio of the soil. Data presented in Table 6 also showed that C/aN ratio is positively and significantly correlated with the organic carbon ($r=0.6128^{**}$) and with total nitrogen ($r=0.3209^{**}$) and negatively correlated with the available nitrogen ($r= -0.2317^{**}$). The positive correlation between organic carbon and C/aN ratio as well as the negative correlation between available nitrogen and C/aN ratio are quite understandable because of the mathematical relationship of the ratios with these parameters. Also, the positive correlation between C/aN ratio and total nitrogen is quite expected since total nitrogen and available nitrogen are significantly correlated.

2.6. Ratio between total nitrogen and available nitrogen

The ratio of total nitrogen to available nitrogen varied from 1.88 to 29.28 with a mean value of 9.24. Thus, on an average 10.82 per cent of the total nitrogen was retained in soil in available form. The mean values of N/aN ratio in low, medium and high organic carbon groups of soil were 7.74, 11.17 and 12.52 respectively. This revealed that the ratio increased with the increase in organic matter content of soil. This is because of the fact that though the content of available nitrogen increased with the increasing content of organic matter, the increase in available nitrogen was not in proportion with the increase in organic carbon. As already explained the increase in the content of available nitrogen consequent to mineralisation of organic nitrogen is restricted by the limited adsorptive power of the soil thereby resulting in a enlarged N/aN ratio in soils of high organic carbon content. As expected, the clay/loam group of soil registered relatively low value of N/aN ratio (9.13) as compared to sand group of soil (10.78).

3. Fractionation of soil organic matter

Out of the 490 soils studied, 12 soils were selected in order to examine the pattern of distribution of the different fractions of organic matter in them. Humic substances were grouped into different fractions based on the solubility in alkali, acid and alcohol. In the scheme of fractionation followed the humic substances were extracted with 0.5 N sodium hydroxide. The extracted soluble material was then treated with acid, the substance precipitated in acid medium was called as humic acid while the acid soluble fraction referred as fulvic acid. The humic acid fraction was extracted with alcohol and categorised into soluble and insoluble fractions. The acid soluble fulvic acid fraction was adjusted to pH 4.8 and that portion of fulvic acid which became insoluble at this pH was referred as beta humus. The fraction of organic matter which could not be extracted by 0.5 N sodium hydroxide was found out by the difference and termed as humin.

Humic substances arise from the chemical and biological degradation of plant and animal residues and from the synthetic activities of micro-organisms. The humic substances in soil influence the soil properties considerably since they possess ability to form water soluble and water insoluble complexes with metal ions and hydrous oxides and to interact with clay minerals and organic compounds such as alkanes, fatty acids, dialkyl phthalates, pesticides, etc. They are dark coloured, acidic, predominantly aromatic, hydrophilic, chemically complex, polyelectrolyte-like material, the molecular weight ranging from a few hundreds to several thousands. Structurally, the three humic substances namely humic acid, fulvic acid and humin are similar but they differ in molecular weight, ultimate analysis and functional groups.

Data on the distribution of different fractions of organic matter expressed as percentage to soil on moisture free basis are presented in Table 7. The distribution of soil organic fractions expressed as percentage to the total organic matter is given in Table 8.

3.1. Humic acid

The humic acid fraction of soil organic matter ranged from 0.172 to 2.706 per cent with a mean value of 0.629 per cent when the percentage contribution of this fraction to total organic matter was worked out, it was seen that it accounted for 8.30 to 47.55 per cent of the total organic matter with a mean value of 28.28 per cent. Palaniappan (1975) reported that on an average soil organic matter contained about 10 per cent humic acid fraction. But in the present investigation the mean content of this fraction of organic matter is quite high. This is because, the tropical humic conditions favour the accumulation of humic and fulvic acid as compared to that of humin. The reaction of the soil selected for the study is acidic which favours the relatively higher accumulation of humic acid in soil. Lignin being the chief constituent of humic acid remains resistant to degradation even under strongly leached acid conditions.

The coefficients of correlation between different fractions of organic matter and soil properties are presented

Table 7. Fractions of organic (humic) matter expressed as percentage to soil on moisture free basis

Sl. No.	Soil sample No.	Humic acid			Fulvic acid			Humin	Total humic substances
		Hymatomelanic acid	Insoluble	Total	Soluble	Beta-humus	Total		
1	3	0.127	0.294	0.421	0.453	0.057	0.510	1.086	2.017
2	34	0.100	0.072	0.172	0.038	0.141	0.179	0.367	0.718
3	51	0.131	0.349	0.480	0.126	0.329	0.455	1.664	2.599
4	52	0.136	0.241	0.377	0.060	0.670	0.730	0.987	2.094
5	59	0.252	2.454	2.706	2.537	0.348	2.885	1.362	6.953
6	66	0.113	0.116	0.229	0.152	0.072	0.224	0.029	0.482
7	84	0.125	0.219	0.344	0.517	0.050	0.567	1.066	1.977
8	88	0.122	0.394	0.516	0.470	0.071	0.542	0.081	1.139
9	89	0.114	0.132	0.246	0.230	0.264	0.494	0.474	1.214
10	91	0.136	1.341	1.477	1.426	0.112	1.538	0.288	3.303
11	306	0.097	0.132	0.229	0.134	0.170	0.304	0.097	0.630
12	325	0.099	0.248	0.347	1.444	0.084	1.528	2.302	4.177
Range		0.097-0.252	0.072-2.454	0.172-2.706	0.038-2.537	0.050-0.670	0.179-2.885	0.029-2.302	0.482-6.953
Mean		0.129	0.500	0.629	0.632	0.197	0.830	0.817	2.276

Table 8. Fractions of soil organic (humic) matter expressed as percentage to total organic matter on moisture free basis

Sl. No.	Soil sample No.	Humic acid			Fulvic acid			Humin	HA/FA ratio
		Hymatome-lanic acid	Insoluble	Total	Soluble	Beta-humus	Total		
1	3	6.28	14.57	20.85	22.39	2.82	25.30	53.85	0.82
2	34	13.87	10.06	23.93	5.34	19.64	24.98	51.09	0.96
3	51	13.43	5.05	18.48	4.84	12.66	17.50	64.02	1.06
4	52	6.48	11.50	17.98	2.86	32.00	34.86	47.16	0.52
5	59	3.62	35.30	38.92	36.49	5.00	41.49	19.59	0.94
6	66	23.43	24.12	47.55	31.57	14.89	46.46	5.99	1.02
7	84	6.31	11.08	17.40	26.16	1.26	28.69	53.91	0.61
8	88	10.70	34.49	45.19	41.20	6.24	47.44	7.37	0.95
9	89	9.44	10.84	20.28	18.94	21.72	40.66	39.05	0.50
10	91	4.13	40.60	44.73	43.19	3.37	46.56	8.71	0.96
11	306	15.14	20.60	35.74	20.99	26.61	47.60	16.66	0.75
12	325	2.38	5.92	8.30	34.57	2.01	36.58	55.12	0.23
Range		2.38-23.43	5.05-40.60	8.30-47.55	2.86-43.19	1.26-32.00	17.50-47.60	5.99-64.02	0.23-1.06
Mean		9.60	18.68	28.28	24.05	12.35	36.51	35.21	0.78

in Table 9. Humic acid is found to be significantly and positively correlated with total organic carbon (r=0.8520**), total nitrogen (r=0.7597**), fulvic acid (0.9082**) and clay (0.7799**). The relationship between humic acid with organic carbon, total nitrogen, and clay are graphically represented in Fig.8, 9 and 10 respectively. The correlation between humic acid and total organic matter is expected since humic acid is one of the constituents of total organic matter. Because of the same reason it is also correlated with the total nitrogen content of the soil. The relationship between humic acid and fulvic acid is indicative that these two fractions maintain a constant proportion between them irrespective of the variation in the content of total organic matter. The relationship between clay and humic acid may be due to high degree of correlation between clay and organic carbon (r=0.8244**) observed in the study.

Based on the solubility in alcohol the humic acid is fractioned into alcohol soluble hymatomelanic acid and an alcohol insoluble fraction. The percentage of hymatomelanic acid in the twelve soils studied ranged from 0.097 to 0.252 with a mean value of 0.129. When this fraction was expressed as percentage to total organic matter it ranged from 2.38 to 23.43 with a mean value of 9.60. In general the content of hymatomelanic acid increased with the increasing content of total organic matter. Hymatomelanic acid is a naturally

Table 9. Relationship between soil properties and empirical fractions of organic matter (12 soils)

X	Y	r	Regression equations
Organic carbon	Humic acid	0.8520**	HA% = 0.5794 C% - 0.1468
Organic carbon	Fulvic acid	0.9618**	FA% = 0.6954 C% - 0.1011
Organic carbon	Humin	0.6455**	Humin % = 0.4273 C%+0.2428
Organic carbon	Clay	0.8244**	Clay % = 8.1935 C%+9.3039
Total nitrogen	Humic acid	0.7397**	HA % = 5.3142 N% - 0.216
Total nitrogen	Fulvic acid	0.8913**	FA% = 6.8081 N% - 0.2525
Total nitrogen	Humin	0.7374**	Humin% =5.1568 N% + 0.0312
Total nitrogen	Clay	0.8448**	Clay% =88.7035 N% + 6.1711
Humic acid	Fulvic acid	0.9082**	FA% = 0.9656 HA% + 0.2226
Humic acid	Clay	0.7799**	Clay% = 11.3983 HA% + 13.1055
Fulvic acid	Clay	0.8552**	Clay% = 11.7557 FA% +10.5178

** Significant at 1% level

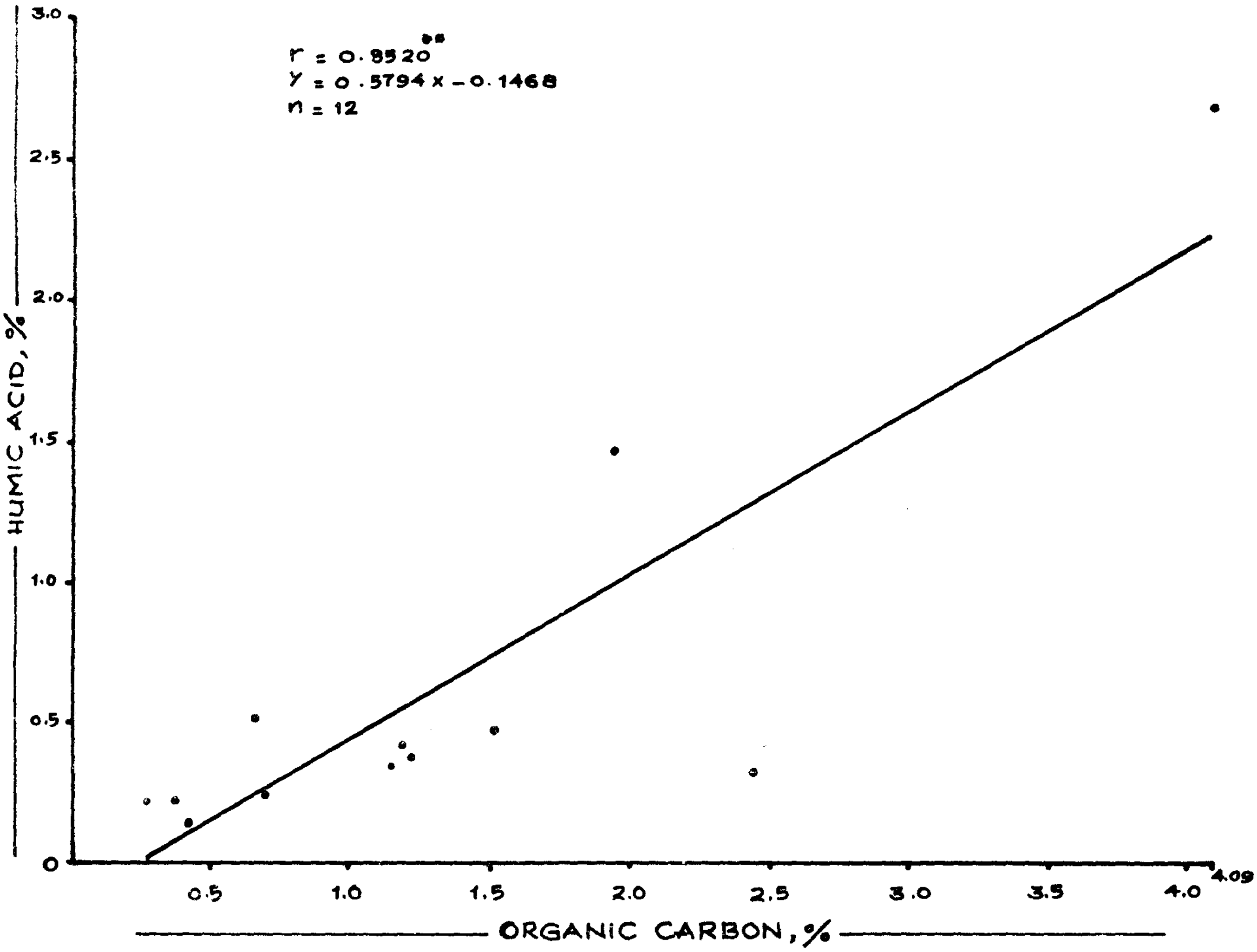


FIG. 8 - RELATIONSHIP BETWEEN ORGANIC CARBON AND HUMIC ACID IN SOIL.

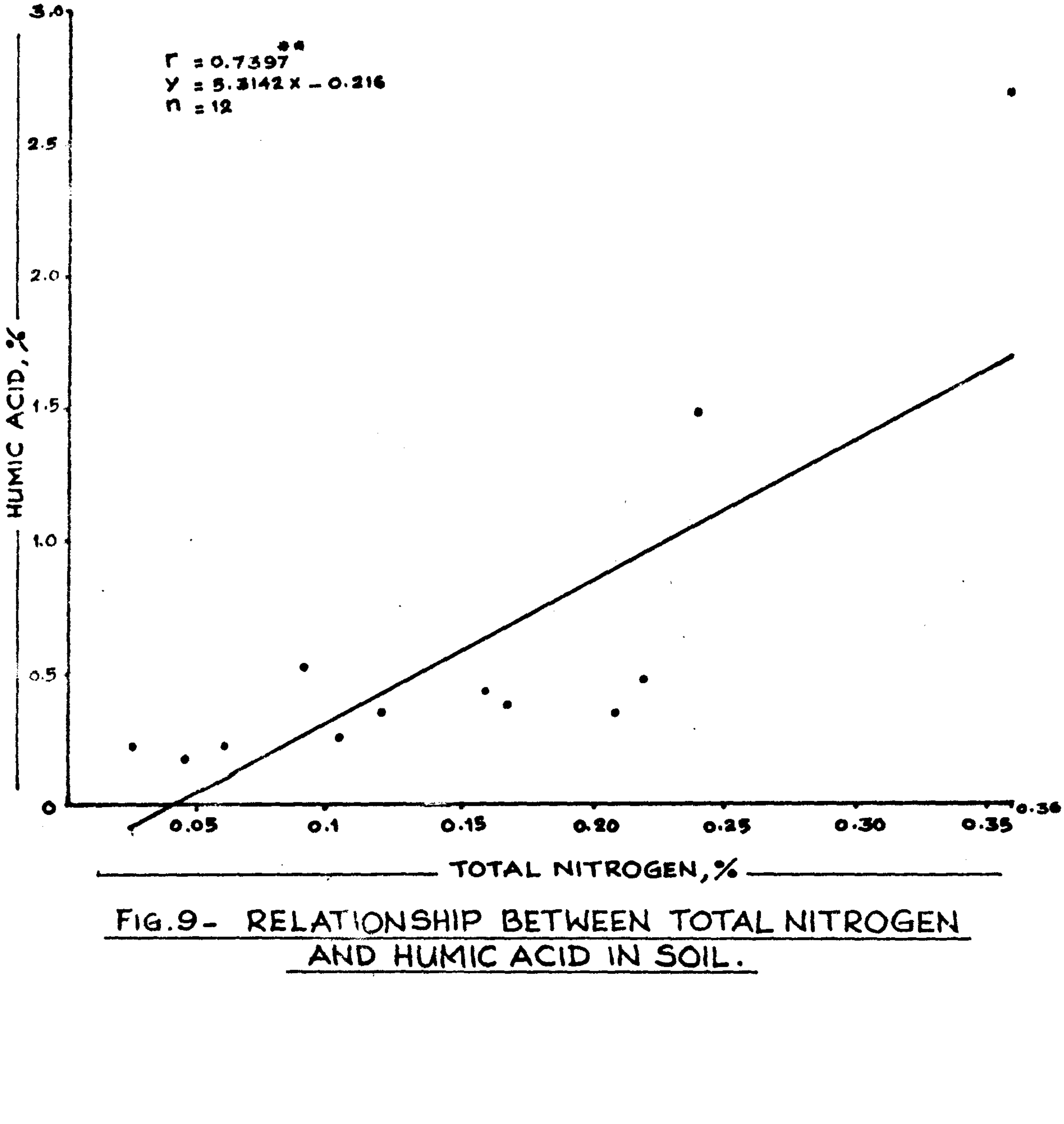


FIG. 9 - RELATIONSHIP BETWEEN TOTAL NITROGEN AND HUMIC ACID IN SOIL.

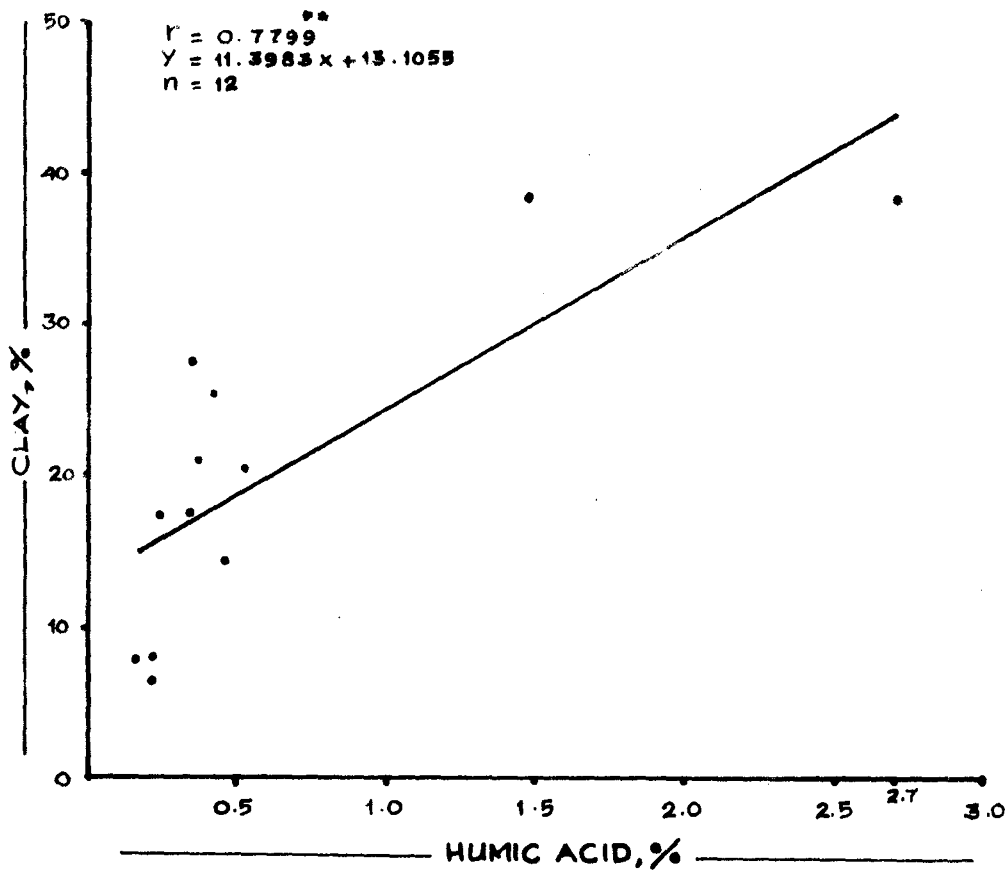


FIG. 10 - RELATIONSHIP BETWEEN HUMIC ACID AND CLAY IN SOIL.

esterified or methylated fraction of the humic acid which can be liberated by ethanol extraction and therefore its content will obviously depend upon the total content of organic matter.

The alcohol insoluble fraction of humic acid in soil ranged from 0.072 to 2.454 per cent and when expressed as per cent to total organic matter it ranged from 5.05 to 40.6 with a mean value 18.68. These observations revealed that the major part of humic acid was constituted by alcohol insoluble fractions and the alcohol soluble part was only about half of the alcohol insoluble fraction.

3.2. Fulvic acid

The fulvic acid fraction of humic substances in soil ranged from 0.179 to 2.885 per cent with a mean value of 0.83. This fraction, on an average accounted for 36.51 per cent of the total organic matter. The proportion of fulvic acid to total organic matter appeared to be relatively high when it was compared with the values reported by Palaniappan (1975) for high altitude soils of Tamil Nadu. He reported that on an average, fulvic acid fraction contributed only ten per cent of total organic matter. However, Schnitzer (1970) observed that the fulvic acid fraction in podzol soils ranged from 31 to 56 per cent of total organic matter. The relatively high content of fulvic acid observed in the present study can be attributed to the low pH, high content of the soil. The relationship between fulvic acid with organic carbon, total nitrogen, humic acid and clay are graphically represented in Fig. 11, 12, 13 and 14 respectively. As in the case of humic acid the relationship of fulvic acid with total organic matter was quite expected since it is one of the constituents of organic matter and hence an increase in the total content of humic substances will obviously reflect on the content of its fractions. The relationship between total nitrogen and fulvic acid appeared to be indirect since organic carbon and total nitrogen are highly correlated. It was highly interesting to observe that not only the total content of fulvic acid increased with the total content of humic acid which might be due to increase in the content of total organic matter but also the proportion of fulvic acid in total organic matter increased with the proportion of humic acid. In other words, any increase in the content of humic acid results in the content of fulvic acid even without a change in the content of total organic matter. This relationship was indicative of an intense association between these two fractions of organic matter during its formation and accumulation in soil. As already pointed out fulvic acid is the fraction of organic matter resulting from the degradation of humic acid and as a result an increase in the content of humic acid gives rise to an increase in the accumulation of its degradation product.

rainfall, high content of sesquioxides of the soil since these factors favour the accumulation of fulvic acid. High content of organic matter gives rise to a higher proportion of fulvic acid since the carbohydrate fraction of humic substance stabilises the fulvic acid fraction. Fulvic acid can be considered as the more oxidised and degraded products of humic acid with a higher proportion of oxygen containing functional groups like COOH, OH, C=O as compared to the other humic acid fractions of soil. As a result cultivated soils and high weathered soils of warm humid tropics tend to register high values for fulvic acid fraction. Low pH greatly favours accumulation of humic substances since the interlayer adsorption of humic substances is greatest at lower pH values. Stabilisation of fulvic acid results from the formation of aggregates due to hydrogen bonding, Van der Waal's interactions and electron systems of adjacent molecules. As pH increases these forces become weaker and because of increasing ionisation of COOH and phenolic OH groups, particles separate and begin to repel each other electrostatically so that molecular arrangements become smaller (Schnitzer and Kodama, 1975).

When the relationship between fulvic acid and other soil properties was examined it was seen that this fraction of soil organic matter was significantly and positively correlated with total organic carbon ($r=0.9618^{**}$), total nitrogen ($r=0.8913^{**}$), humic acid ($r=0.9082^{**}$) and clay ($r=0.8552^{**}$)

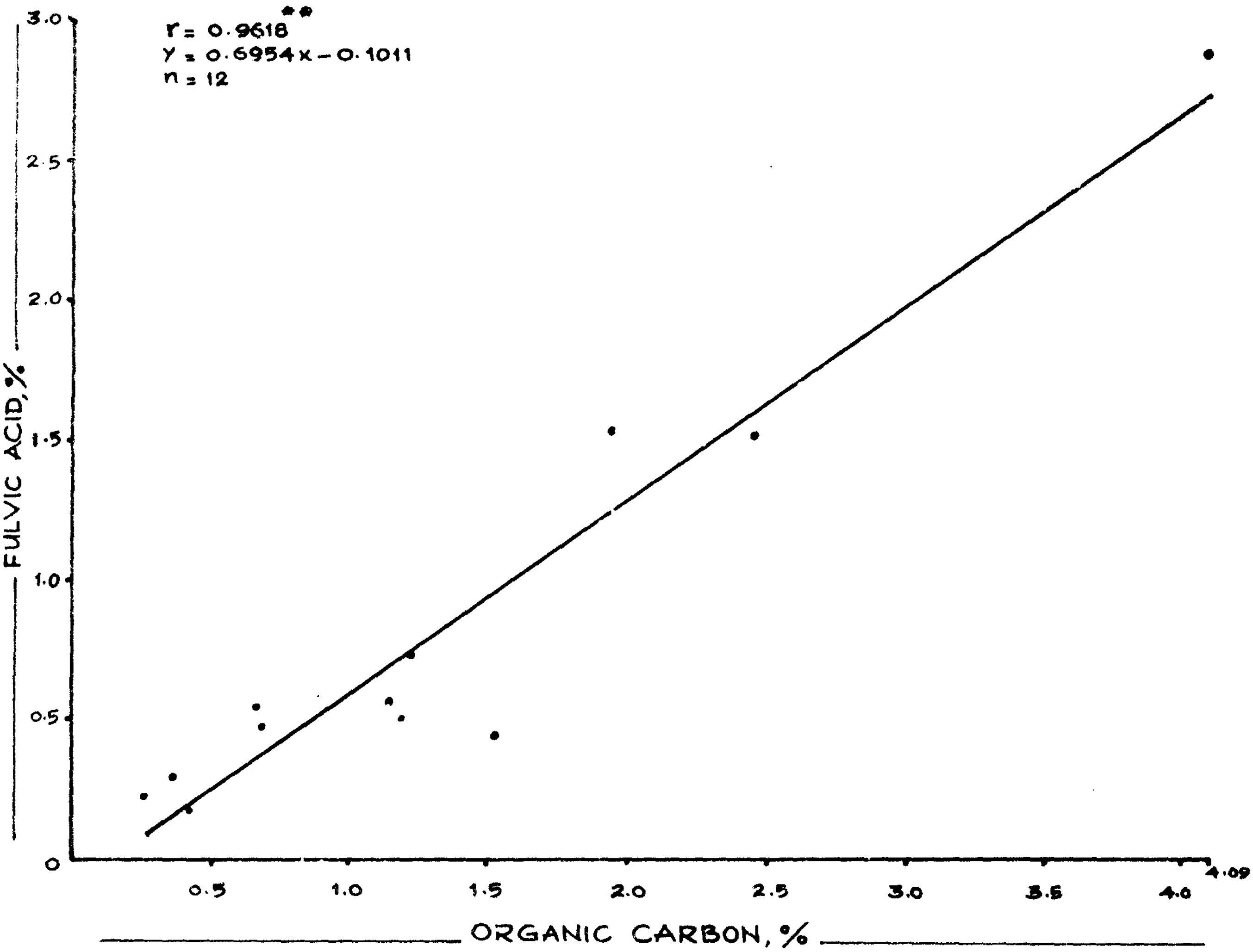


FIG. 11 - RELATIONSHIP BETWEEN ORGANIC CARBON AND FULVIC ACID IN SOIL.

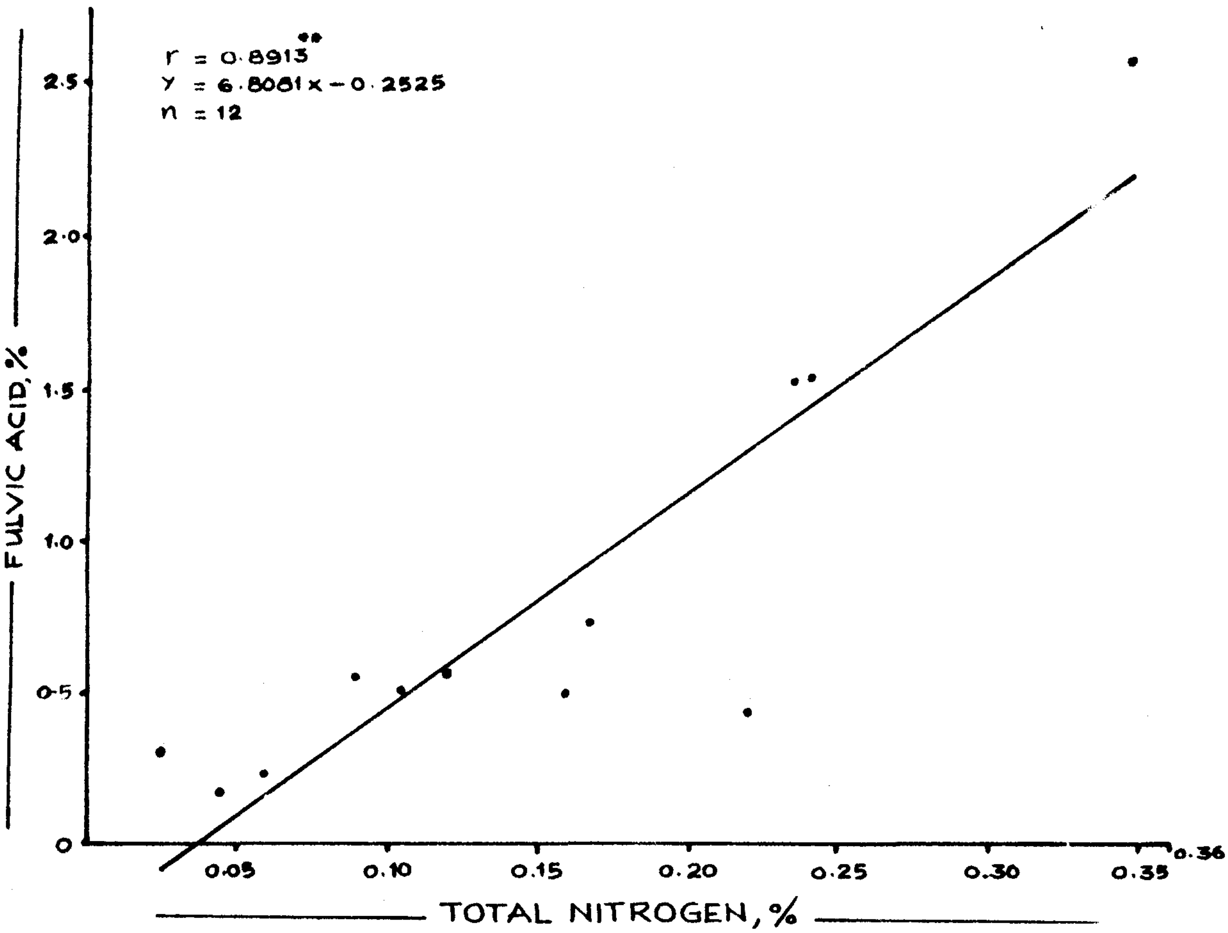


FIG. 12 - RELATIONSHIP BETWEEN TOTAL NITROGEN AND FULVIC ACID IN SOIL.

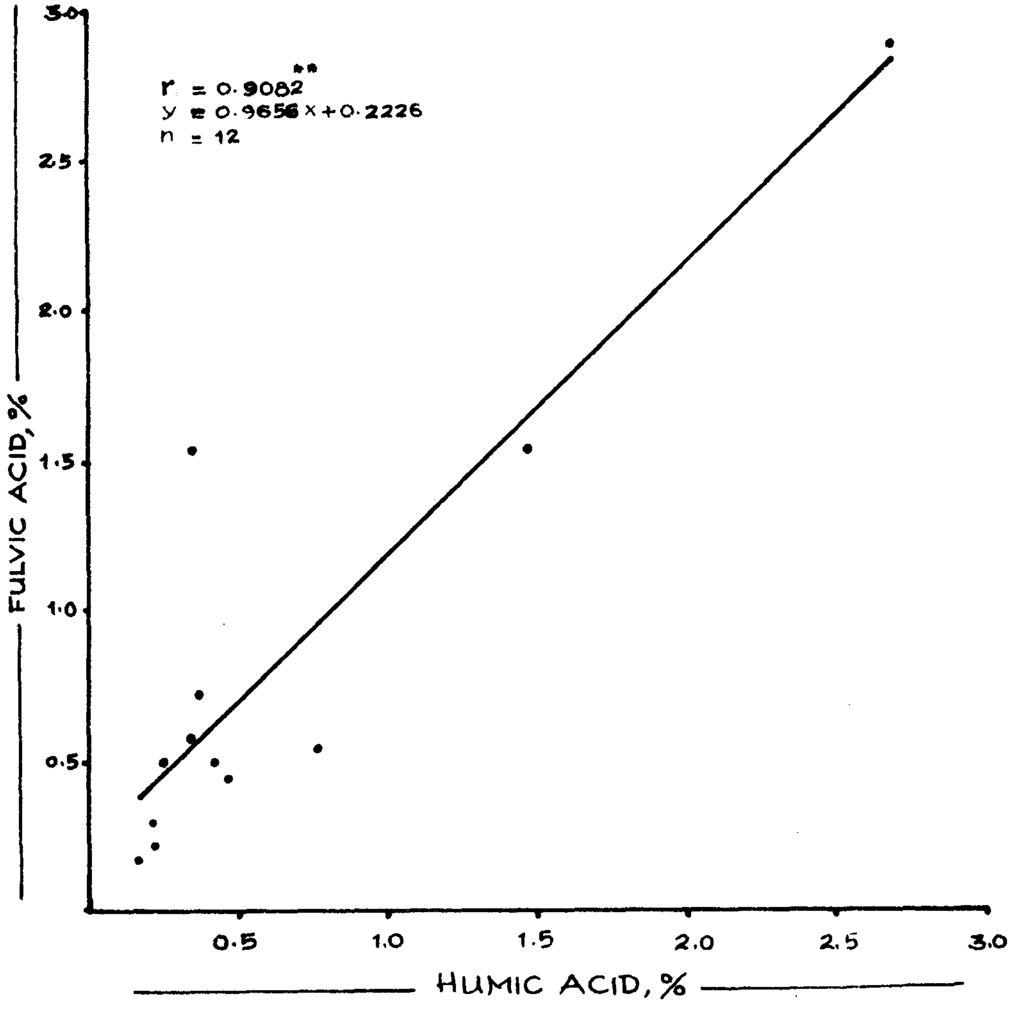


FIG. 13- RELATIONSHIP BETWEEN HUMIC ACID AND FULVIC ACID IN SOIL.

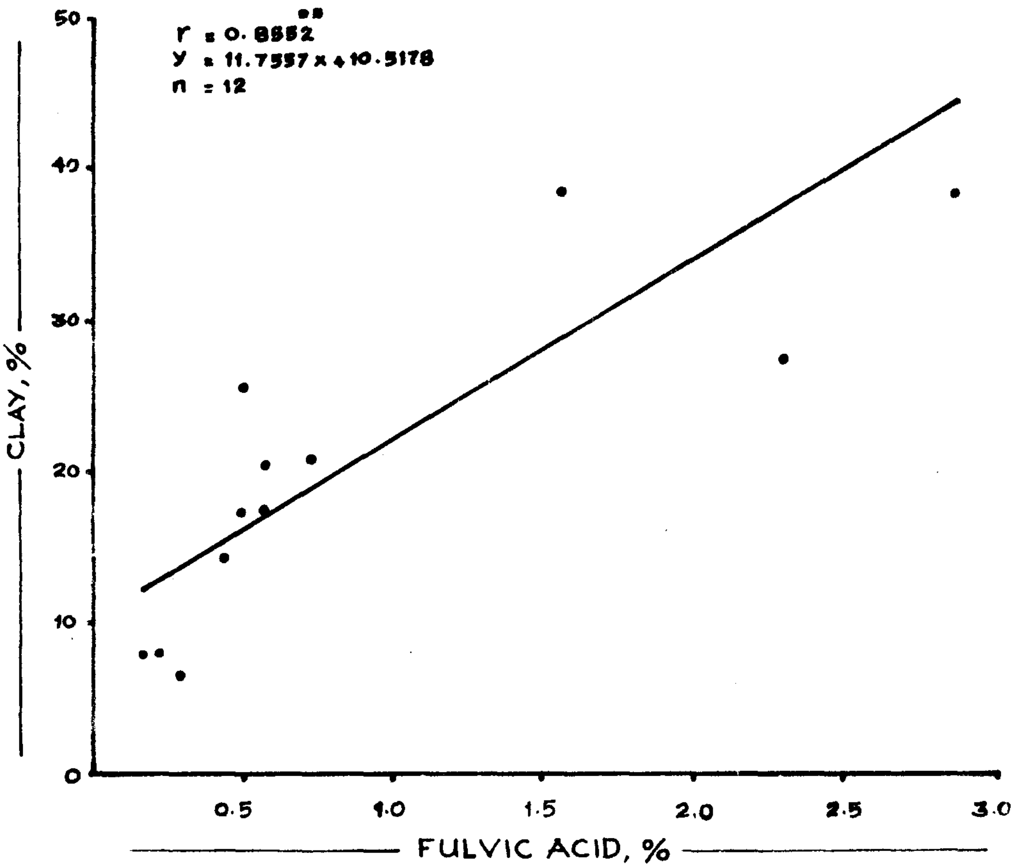


FIG. 14 - RELATIONSHIP BETWEEN FULVIC ACID AND CLAY IN SOIL.

This explanation is further supported by the fact that the soil properties which are closely associated or correlated with the content of fulvic acid are also correlated with the content of humic acid. The reasons attributed for the significant correlation between clay and humic acid is also applicable in explaining the significant correlation observed between clay and fulvic acid.

3.3. Ratio between humic acid and fulvic acid (HA/FA ratio)

The HA/FA ratio of soil are presented in Table 8. This ratio ranged from 0.23 to 1.06 with a mean value of 0.78. Except for two soils the ratio was lower than one thus indicating a higher preponderance of fulvic acid in soil as compared to humic acid. Palaniappan (1975) observed that the HA/FA ratio of the soils he studied was about unity. However, he observed that the ratio was lower in soils under tea and coffee plantations due to the presence of higher amounts of fulvic acid in these soils. Kononova (1968) reported that the ferralitic soils were associated with a lower HA/FA ratio. As already pointed out, in acid soils which are rich in humic substances fulvic acid fraction accumulates due to the increased rate of degradation of humic acid under conditions favourable for the formation of this fraction. Felbeck (1971) also held the view that the increasing content of fulvic acid is accompanied by a concomitant reduction in the humic acid fraction of soil.

3.4. Humin

Humin, the alkali insoluble part of organic matter represents the high molecular fractions of humic substances. This fraction accounted for 5.99 to 64.02 per cent of the total organic matter in soils studied with a mean value of 35.21 per cent. Ricarde (1968) also observed that the humin fraction of organic matter represented 20-38 per cent of the humus. Humin was found to be significantly correlated with total organic carbon ($r=0.6455^{**}$) and also with total nitrogen ($r=0.7374^{**}$). The relationship between humin with organic carbon and total nitrogen are graphically represented in Fig.15 and 16 respectively. The correlation between humin and total organic carbon is understandable since humin is one of the constituents of humic substances. The significant and positive coefficient of correlation between humin and total nitrogen may be due to indirect effect since total nitrogen and total organic matter are correlated significantly. Moreover, humin is that fraction of the humic substances which contributes maximum towards the total nitrogen of the soil.

4. Elemental constituents of organic matter

Data on the elemental constituents of soil organic matter are presented in Table 10. A limited number of soils (twelve soils) selected for fractionation of soil organic matter were analysed for the elemental constitution of organic

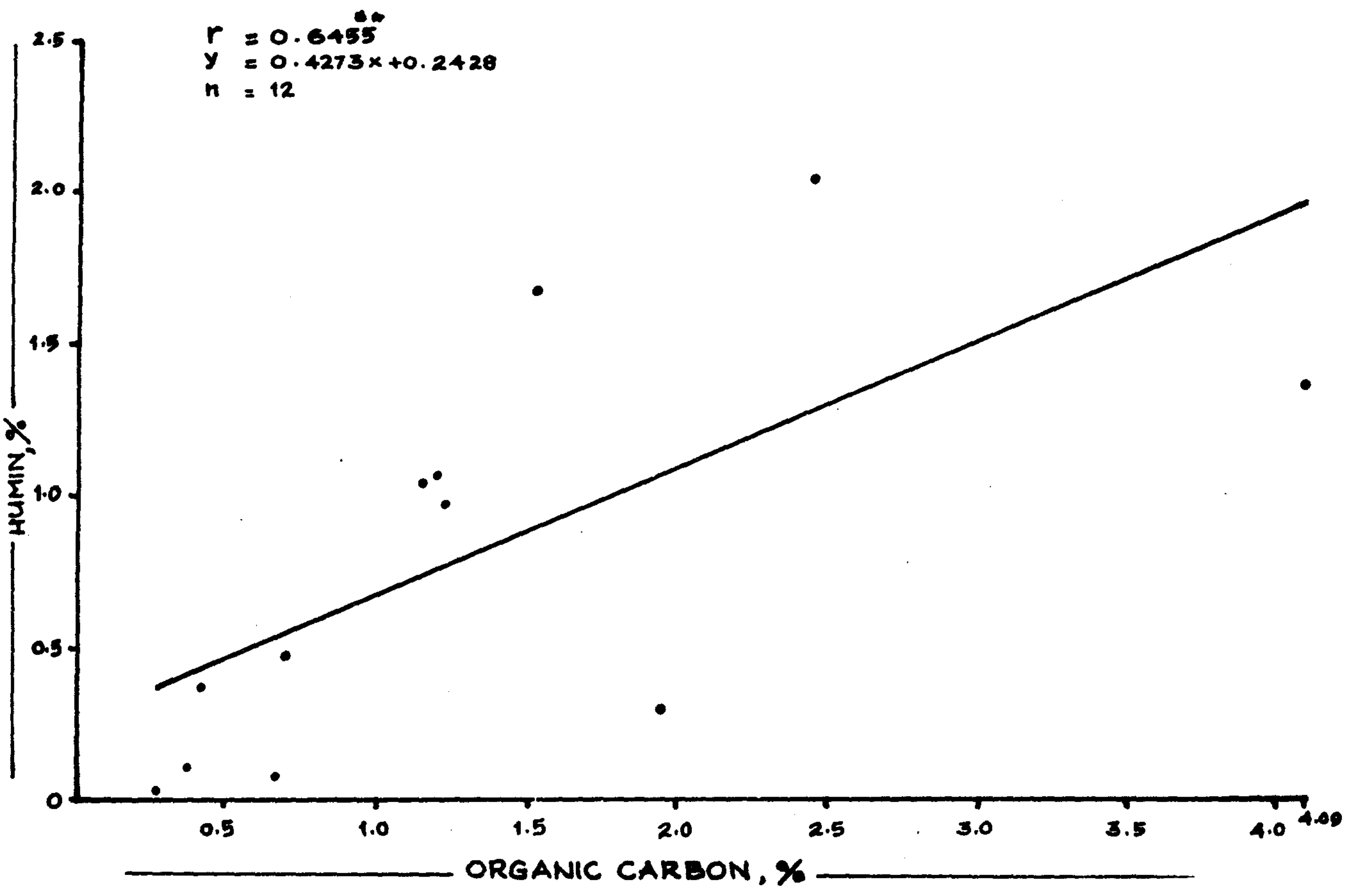


FIG. 15 - RELATIONSHIP BETWEEN ORGANIC CARBON AND HUMIN IN SOIL.

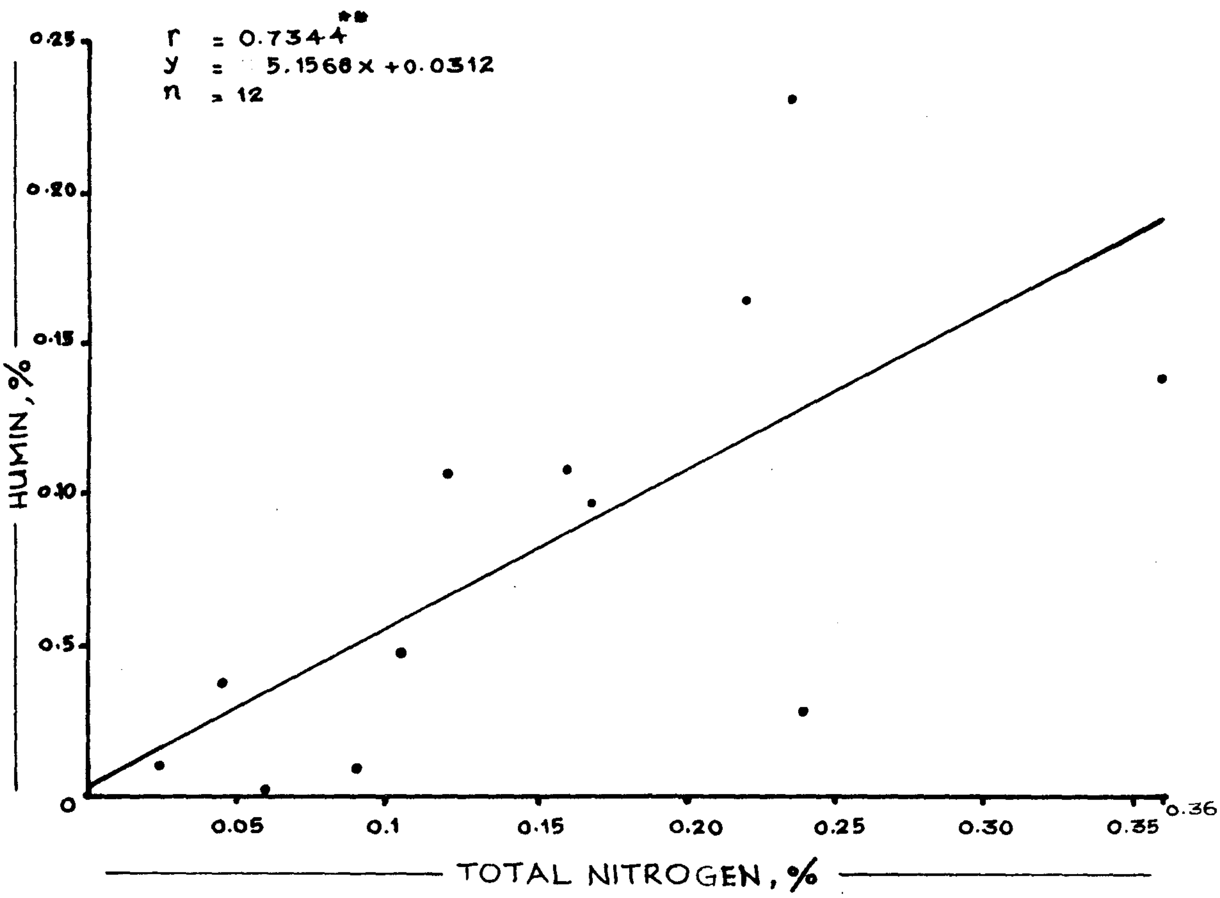


FIG. 16 - RELATIONSHIP BETWEEN TOTAL NITROGEN AND HUMIN IN SOIL

Table 10. Elemental constituents of soil organic matter on moisture free basis

Sl. No.	Soil sample No.	Percentage to soil					Percentage to total organic matter			
		C	N	P	K	S	N	P	K	S
1	3	1.19	0.161	0.0003	0.0100	0.060	7.98	0.015	0.496	2.97
2	34	0.42	0.046	0.0011	0.0025	0.065	6.41	0.153	0.348	9.05
3	51	1.53	0.220	0.0003	0.0000	0.101	8.47	0.012	0.000	3.89
4	52	1.23	0.168	0.0000	0.0000	0.101	8.02	0.000	0.000	4.82
5	59	4.09	0.362	0.0000	0.0000	0.096	5.21	0.000	0.000	1.38
6	66	0.28	0.060	0.0000	0.0000	0.099	12.45	0.000	0.000	20.54
7	84	1.16	0.121	0.0004	0.0250	0.090	6.12	9.020	1.265	4.55
8	88	0.67	0.091	0.0003	0.0075	0.024	7.98	0.026	0.657	2.10
9	89	0.71	0.105	0.0006	0.0000	0.016	8.65	0.049	0.000	1.32
10	91	1.94	0.240	0.0000	0.0000	0.095	7.27	0.000	0.000	2.88
11	306	0.37	0.025	0.0003	0.0063	0.171	3.91	0.047	0.985	27.62
12	325	2.46	0.235	0.0008	0.0038	0.1021	5.63	0.019	0.091	2.44
Ranges		0.28-4.09	0.025-0.362	0.000-0.0011	0.000-0.025	0.016-0.171	3.91-12.45	0.000-0.153	0.000-1.265	1.32-27.62
Mean		1.34	0.153	0.0003	0.0046	0.0855	7.34	0.051	0.320	6.96

matter. The content of carbon as determined by the Walkley and Black method and total nitrogen determined by the Kjeldahl digestion distillation method were already been presented in Table 2 since these estimations were carried out for all the 490 soils. Also the relationship between carbon and nitrogen in these soils have already been discussed. Elements other than carbon and nitrogen estimated in the twelve soils for describing the elemental constitution of soil organic matter were phosphorus, sulphur and potassium.

4.1. Organic phosphorus

The organic phosphorus content of the soils selected for the fractionation study ranged from 0 to 0.0011 per cent with a mean value of 0.0003 per cent. This constituent of organic matter accounted only for 0.051 per cent of the total weight of organic matter in soil. The proportion of phosphorus in organic matter appeared to be very low as compared to the findings of Ghosh _et al_. (1981). They observed that on an average, organic matter in cultivated and forest mollisols in India contained 1.204 per cent phosphorus. Bowman and Cole (1978) also reported that the organic phosphorus content of grassland soils studied accounted for 1.19 per cent of total organic matter. In general, the organic phosphorus per cent of soil organic matter is very low as compared to that of nitrogen and sulphur. The important phosphorus containing organic compounds in soil are inositol phosphates, nucleic acids, and phosphodipids. Under warm humid tropical conditions these compounds are easily subjected to mineralisation. Moreover, these compounds do not form the structural component of organic matter. As a result, phosphorus content of organic matter derived from plants grown in soils which are deficient in available phosphorus will naturally contain only negligible quantities of phosphorus. Kowalenko (1978) observed that the organic matter of soils derived from granite tended to have a low content of phosphorus as compared to the organic matter of soil derived from basalt or basic igneous materials. The relatively low content of phosphorus in soil organic matter observed in the present study could therefore be attributed to the low content of phosphorus in plants grown in these soils and also to the increased rate of phosphorus mineralisation possible under the warm humid tropical conditions.

4.2. Organic sulphur

On an average this component of organic matter accounted for 6.96 per cent of total organic matter the values ranging from 1.32 to 27.62. Singh et al. (1980) in soils of Uttar Pradesh, observed that the content of organic sulphur accounted only for 0.59 per cent of total organic matter. Similarly Rahal and Paliwal (1978) in a study on the distribution of sulphur in Rajasthan soils reported that, on an average, the organic matter of the soils contained 0.67 per cent sulphur. Considering the report of the above workers the sulphur

SUMMARY

content of organic matter of soils under the present investigation appeared to be relatively high. The soils of the states are, in general, very rich in sulphur. These soils are even referred as the acid sulphate soils when the acidity and the sulphate concentrations are very high as that occurs in certain tracts of the state. The increased dissolution of sulphates under acid conditions leads to increased availability of this nutrient to plants resulting in its accumulation in plant tissue. Obviously, organic matter derived from such plant materials will have a higher proportion of sulphur in it. Sulphur compounds form a strong linkage to carbon and therefore resist the chemical and physical forces of decomposition. Cellulose, protein and hemicelluloses can form stable complexes with sulphur. The acid conditions prevailing in these soils inhibit the activity of sulphur oxidising bacteria resulting in the accumulation of sulphur compounds at larger proportion in soil organic matter.

4.3. Organic potassium

Data presented in Table 10 showed that organic potassium content of soil varied from 0 to 0.025 per cent. The relative contribution of this element to the total weight of soil organic matter was rather negligible, since on an average this element accounted only for 0.32 per cent of total organic matter. This is due to the fact that potassium does

Table 11. Relationship between elemental constituents of soil organic matter

Sl. No.	Soil sample No.	Ratios									
		C/N	C/P	C/K	C/S	N/P	N/K	N/S	P/K	P/S	K/S
1	3	7.37	3966.6	119.0	19.8	536.7	16.1	2.68	0.03	0.005	0.17
2	34	9.28	381.8	168.0	6.5	41.8	18.4	0.71	0.44	0.017	0.04
3	51	7.04	5100.0	..	15.1	733.3	..	2.18	0.00	0.003	0.00
4	52	7.33	..	..	12.2	..	..	1.66	0.00	0.000	0.00
5	59	11.29	..	..	42.6	..	..	10.42	0.00	0.000	0.00
6	66	4.77	..	..	2.8	..	0.0	0.60	0.00	0.000	0.00
7	84	9.63	2900.0	46.4	12.9	302.5	4.84	1.34	0.02	0.004	0.28
8	88	7.38	2233.3	89.3	27.9	303.3	12.1	3.79	0.04	0.013	0.31
9	89	6.80	1183.3	..	44.4	175.0	..	6.56	0.00	0.038	0.00
10	91	8.10	..	..	20.4	..	..	2.52	0.00	0.000	0.00
11	306	15.04	1233.3	58.73	2.1	83.3	4.0	0.14	0.05	0.002	0.04
12	325	10.47	3075.0	647.4	24.1	293.8	61.8	2.30	0.21	0.008	0.04
Range		4.77-15.04	381.8-5100.0	46.4-647.4	2.1-44.4	41.8-733.3	4.0-61.8	0.14-10.42	0.00-0.44	0.00-0.038	0.00-0.31
Mean		8.71	1672.8	94.1	19.23	205.81	9.77	2.91	0.07	0.008	0.0073

not form the structural component of soil organic matter and as a result this element easily moves into its inorganic pool in soil during the process of decomposition of organic residues. The soil organic matter, which has undergone decomposition and has reached an equilibrium with the soil forming processes will not retain any appreciable quantities of potassium thereby registering very low values for the organic potassium in soil.

5. Ratios between elemental constituents of organic matter

The relationship between carbon and nitrogen in soil has already been discussed in preceding paragraphs since the content of these elements was examined in all the 490 soils taken for the study.

The ratios between elemental components of organic matter are presented in Table 11. The C/org.P ratio of the organic matter of the twelve soils studied ranged from 381.8 to 5100 with a mean value 1672.8. In north west Rajasthan soils, Talati and Mathur (1978) reported a C/org.P ratio of 23.33 to 35 with a mean value of 30.46. Rostogi and Mishra (1976) reported a C/org.P ratio of 89.5 to 341.4 for soils of Karnataka. Considering the reports of the above workers the C/org.P ratio of the soil under the present study appeared to be very high. This is because of the very low content of phosphorus in the organic matter of the soil.

Table 11. Relationship between elemental constituents of soil organic matter

Sl. No.	Soil sample No.	Ratios									
		C/N	C/P	C/K	C/S	N/P	N/K	N/S	P/K	P/S	K/S
1	3	7.37	3966.6	119.0	19.8	536.7	16.1	2.68	0.03	0.005	0.17
2	34	9.28	381.8	168.0	6.5	41.8	18.4	0.71	0.44	0.017	0.04
3	51	7.04	5100.0	..	15.1	733.3	..	2.18	0.00	0.003	0.00
4	52	7.33	..	..	12.2	..	..	1.66	0.00	0.000	0.00
5	59	11.29	..	..	42.6	..	..	10.42	0.00	0.000	0.00
6	66	4.77	..	..	2.8	..	0.0	0.60	0.00	0.000	0.00
7	84	9.63	2900.0	46.4	12.9	302.5	4.84	1.34	0.02	0.004	0.28
8	88	7.38	2233.3	89.3	27.9	303.3	12.1	3.79	0.04	0.013	0.31
9	89	6.80	1183.3	..	44.4	175.0	..	6.56	0.00	0.038	0.00
10	91	8.10	..	..	20.4	..	..	2.52	0.00	0.000	0.00
11	306	15.04	1233.3	58.73	2.1	83.3	4.0	0.14	0.05	0.002	0.04
12	325	10.47	3075.0	647.4	24.1	293.8	61.8	2.30	0.21	0.008	0.04
Range		4.77-15.04	381.8-5100.0	46.4-647.4	2.1-44.4	41.8-733.3	4.0-61.8	0.14-10.42	0.00-0.44	0.00-0.038	0.00-0.31
Mean		8.71	1672.8	94.1	19.23	205.81	9.77	2.91	0.07	0.008	0.0073

The probable reasons for the extremely low content of phosphorus in the organic matter of the soil have already been discussed.

N/org.P ratio ranged from 41.8 to 733.3 with a mean value of 205.81. As in the case of C/org.P ratio, N/org.P ratio of the soil under the study is very high. In north west Rajasthan soils, Talati and Mathur (1978) reported a N/org.P ratio of 4.4 to 4.6. Gosh and Omanwar (1981) reported a N/org.P ratio of 2.07 to 5.53 for cultivated and forested mollisols of India. The relatively high N/org.P ratio observed under the present study is again a function of the extremely low content of org.P in soil. As already pointed out under warm humid conditions the org.P compounds such as inositol phosphates, nucleic acids and phospholipids are easily subjected to mineralisation. The explanation for the low content of org. P in soil has already been discussed in detail in forgoing pages.

The observations presented in Table 11 showed the org.P/org.S value ranged from 0 to 0.038 with a mean value of 0.008. The ratio was found to be exceedingly small as compared to the report of Bhardwaj and Pathak (1969) who observed a org.P/org.S ratio of 1.0. The very low value of this ratio is obviously due to the large accumulation of organic sulphur and the negligible content of organic phosphorus in these soils. As a result, the org.P/org.S ratio of these soils ran out of proportion as compared to values for this ratio reported by other workers.

Org.C/org.S ratio of the soils studied ranged from 2.1 to 44.4 with a mean value of 19.23. For north east Indian soils Virmani and Kanwar (1971) reported a C/org.S ratio of 66:1. Also, Singh et al. (1980) reported a org.C/org.S ratio of 61.43 to 152.5 for Uttar Pradesh soils. Mukhopadhyay and Asit (1979) reported a C/org.S ratio of 59.4 to 164.0 for Indian soils. The relatively low C/org.S ratio observed in the present study is due to the accumulation of organic sulphur in soil. The probable explanations for the accumulation of this constituent of organic matter has already been discussed.

N/org.S ratio of the twelve soils studied ranged from 0.14 to 10.42 with a mean value of 2.91. Mukhopadhyay and Asit (1979) reported a N/org.S ratio of 5.6 to 17.9 for Indian soils. The relatively low C/org.S ratio obtained was due to high accumulation of sulphur in these soils. The reasons for accumulation of sulphur has already been given. Under conditions of low pH sulphur oxidation of microbial activity would have been suppressed resulting in a greater accumulation of sulphur, consequently lowering of N/org.S ratio.

The mean values for C/org.K and N/org.K were 94.1 and 9.77 respectively. These ratios appeared to be relatively high due to the fact that potassium content of soil organic matter was negligibly low. The soils registered very low org.P/org.K and org.K/org.S ratios because of low content of phosphorus, potassium and high content of sulphur in organic matter.

SUMMARY

SUMMARY

Surface soil samples from 490 sites representing upland areas of the different districts of Kerala were analysed in order to establish precise relationships between organic carbon and total as well as available nitrogen in these soils. These soils were categorised into different groups based on soil texture and content of organic matter so as to present the variation in the relationship between carbon and nitrogen in different categories of soil. Twelve soils were then selected and subjected to fractionation of organic matter. The distribution of elemental components of organic matter was also examined. The results of the study are summarised as follows.

1. The soils in general were acidic in reaction. As acidity increased the content of organic carbon, total nitrogen and available nitrogen in soils also increased.

2. All the soils were nonsaline. In sand category of soil electrical conductivity increased with decrease in pH. The loam/clay category of soil recorded higher electrical conductivity compared to sand group.

3. The content of organic carbon in soil was found to be significantly and positively correlated with the clay content ($r=0.1282^{*}$).

4. Organic carbon content had positive and significant correlation with total nitrogen ($r=0.7966^{**}$) and available nitrogen ($r=0.4008^{*}$) of soil. Loam/clay group of soil was capable of retaining larger quantities of available nitrogen compared to sand category of soils. Also, available nitrogen content of soil correlated positively with total nitrogen ($r=0.4233^{**}$).

5. In general the C/N ratio ranged from 4.17 to 25.44 with a mean value of 9.23. The mean C/N ratio for low, medium and high organic carbon soils were 8.19, 9.68 and 11.26 respectively. Simple linear equation for calculating total nitrogen based on organic carbon content of soil was worked out as N%=0.0803 C% + 0.038. A table of nitrogen values and C/N ratios was presented for different values of organic carbon in soil based on the above regression equation.

6. The mean C/aN ratio was 81.68 and this was 8.849 times more than the mean C/N ratio of soil. The C/aN ratio increased with increasing content of organic matter. The ratios for low, medium and high organic carbon soils were 60.87, 94.3 and 131.87 respectively. While the C/aN ratio had positive and significant correlation with organic carbon ($r=0.6128^{**}$) and total nitrogen ($r=0.3209^{**}$) the same negatively correlated with available nitrogen ($r=-0.2317^{**}$).

7. On an average 10.82 per cent of total nitrogen in soil was retained in available form. The mean N/aN ratios in low, medium and high organic carbon soils were 7.74, 11.17 and 12.52 respectively. The ratio increased with increase in organic matter content but, not in linear proportion with increase in organic carbon.

8. The humic acid accounted for 28.28 per cent of organic matter. Humic acid was found to be significantly and positively correlated with organic carbon ($r=0.8520^{**}$), total nitrogen ($r=0.7397^{**}$), clay content ($r=0.7799^{**}$) and fulvic acid ($r=0.9082^{**}$). Humic acid and fulvic acid maintained a constant proportion irrespective of the variation in content of organic matter.

Hymatomelanic acid, the alcohol soluble fraction of humic acid accounted for only 9.6 per cent of organic matter while the alcohol insoluble fraction was 18.68 per cent.

9. Fulvic acid registered a value of 36.51 per cent of total organic matter. Significant and positive correlation was observed between fulvic acid and organic carbon ($r=0.9618^{**}$) as well as with total nitrogen ($r=0.8913^{**}$), humic acid ($r=0.9082^{**}$) and clay content ($r=0.8552^{**}$).

10. The HA/FA ratio of soil organic matter ranged from 0.23 to 1.06 with a mean value of 0.78.

11. Humin fraction accounted for 35.21 per cent of soil organic matter. Humin content was found to be positively and significantly correlated with total nitrogen ($r=0.7374^{**}$) and organic carbon ($r=0.6455^{**}$).

12. The mean phosphorus, sulphur and potassium content of soil organic matter were 0.051, 6.96 and 0.32 per cent respectively. Compared to the findings of other workers the phosphorus and potassium contents of soil organic matter were very low while the value of organic sulphur was appreciably high.

Among the ratios between elemental constituents of organic matter ie., C/org.P, N/org.P and C/org.K ratios were found to be very high while org.P/org.S and N/org.S ratios were relatively low in comparison with reports by scientists in the past.

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CHARACTERISATION OF SOIL ORGANIC MATTER IN DIFFERENT SOIL TYPES OF KERALA

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ABSTRACT OF A THESIS

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ABSTRACT

Large number of surface soils representing the different districts of the state were analysed in order to work out precise relationships between organic carbon, total nitrogen and available nitrogen in these soils. The soils were categorised into different groups based on soil texture and content of organic matter. Relationships between different soil properties applicable to the different categories of soil were then examined. Fractionation of soil organic matter was carried out in a limited number of soils. Also the distribution of elemental components of soil organic matter was studied in soils selected for the fractionation of organic matter.

Observations on the general characteristics of soil revealed that the content of organic carbon, total nitrogen and available nitrogen showed an increasing trend with increase in acidity of soil. In general more organic carbon was seen in fine textured soils. The total and available nitrogen content of soil increased with increase in content of organic matter. The content of available nitrogen showed significant and positive correlation with total nitrogen. Since the C/N ratio increased with increase in content of organic carbon it was necessary to predict the total and available nitrogen content of soil based on precise regression

equations rather than depending on a conversion factor. On an average 10.82 per cent of the nitrogen in soil was extracted as available nitrogen. The C/aN ratio was positively and significantly correlated with organic carbon and total nitrogen while it was negatively correlated with available nitrogen.

On an average the percentage of humic acid, fulvic acid and humin in soil organic matter were 28.28, 36.51 and 35.21 respectively. Of the 28.28 per cent humic acid, 9.60 per cent (of organic matter) was represented by hymatomelanic acid and the remaining 18.68 per cent by the insoluble fraction of humic acid. Humic acid was found to be significantly and positively correlated with total organic carbon, total nitrogen, clay and fulvic acid. Of the total fulvic acid, 12.35 per cent (of organic matter) was represented by beta humus and the remaining by the soluble fraction of fulvic acid. Fulvic acid was positively and significantly correlated with organic carbon, total nitrogen, humic acid and clay. Humic acid and fulvic acid maintained a constant proportion irrespective of the variation in content of total organic matter. Humin was also positively and significantly correlated with organic carbon and total nitrogen.

The mean phospherus, sulphur and potassium content of organic matter were 0.051, 6.96 and 0.32 per cent respectively. The C/org.P, C/org.K, C/org.S, N/org.P, N/org.K, N/org.S, Org.P/org.K, Org.P/org.S and Org.K/org.S ratios were 1672.8, 94.1, 19.23, 205.81, 9.77, 2.91, 0.07, 0.008 and 0.0073 respectively.