Correlation Between Micronutrients and Macronutrients of The Soils of Ramanathapuram District - An Approach To Improve the Fertility Status of Soil

By

K. Lathalu

A DISSERTATION SUBMITTED TO THE AVINASHILINGAM INSTITUTE FOR HOME SCIENCE AND HIGHER EDUCATION FOR WOMEN - DEEMED UNIVERSITY, COIMBATORE - 641 043

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE IN APPLIED CHEMISTRY

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April 1998

Certified As Bonafide Research Work

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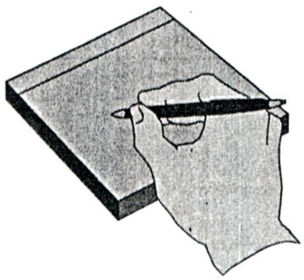

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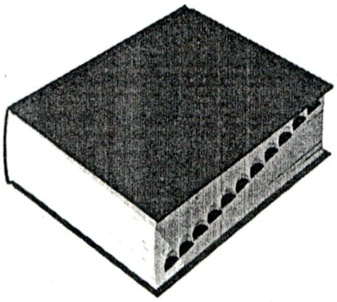

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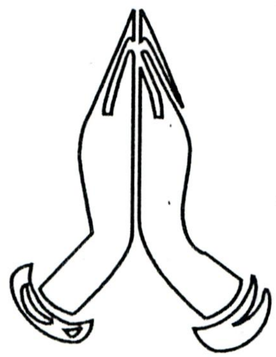


Introduction

INTRODUCTION

"Soil testing is a farmer's friend
If right fertility signals it can send
It is needed more than ever before
To estimate the soil fertility in store"

(Tandon, 1995)

Soil is a non-renewable resource and complex living natural body which forms the basic resource for agriculture production. A clear complete understanding of this resource is a prelude for practising scientific agriculture. Soil is an eternal store house of nutrients and knowing the intricate relationships of their existence is of a paramount importance.

The plant nutrient availability in soil is the measure of soil fertility. The availability depends on their soil resources and soil condition.

A large number of elements are required for the growth and completion of life cycle of a plant. They are termed as essential elements. They are of inorganic in nature. For an element to be considered as plant nutrient three criteria are to be met.

1. A deficiency of the element makes it impossible for the plant to complete its cycle.
2. The deficiency is specific for the element in question.
3. The element is directly involved in the plant either as a constituent of living molecules of the plant or required for the number of enzyme system.

Based on the above criteria, sixteen elements viz. C, H ,O, N, P, S, K, Ca, Mg, Fe, Mn, Cu, Zn, Mo, B, Cl are found to be essential.

Among the well recognised sixteen elements essential for growth and development of plants seven elements viz., B, Cl, Cu, Fe, Mo and Zn are grouped as micro nutrients in view of their relatively small requirements when compared to major nutrients (N,P and K) and secondary nutrients (Ca, Mg and S). From air and water plants utilise H, O and C.

Micro nutrients are present in the soil only in very small amounts. Lakshmi Narayanan (1992) reported that deficiencies of micro nutrients could be found in alkaline calcareous soils, where excess rainfall, extremes of temperatures; prolonged drought conditions prevailed.

An important component of soil health, whcih generally receives inadequate attention, is the micronutrient status of the soils (Swaminathan, 1995).

The various roles played by the important elements and deficiency symptoms are furnished in Table 1.

For maximising quality and productivity of crops, it is a must that all these nutrients are present or supplied in a balanced form. The concept of balanced fertilisation takes into account mainly (a) the soil factors, their influence/limit the dynamic availability of nutrients and b) the plant factors such as type, variety, requirement at critical growth phase etc., which demand on an uninterrupted supply of nutrients to attain the maximum (economic) yield potential. Though this concept is common to all the essential elements it is often ascribed to N,P, and K.

Looking back on the progress of major nutrients, it was a fact that we travelled a long way from usage of single major nutrient to multimajor nutrients (eg. NP, NK and NPK). Similarly after the discovery of field -scale Zn deficiency in rice at Pantnagar in mid 1960's and the subsequent intensive investigation carried out by Indian Council of Agricultural Research (ICAR), Agricultural Universities, Institutes, it has been established that micro nutrients should form a part in the balanced fertilisation of crops, especially that are high yielding, grown in deficient areas and cultivated intensively with high inputs.

The micronutrients deficiencies along with the deficiencies of major nutrients are responsible for the low yields of crops in India. It has become essential to demarcate areas where soils are deficient or likely to be deficient in micronutrients and suggest ways and means of avoiding / reducing such deficiencies.

Among the micronutrients, the nutrition and deficiencies of Cu, Zn, Mn and Fe have received considerable attention in recent years, because of their possible effects under intensively cultivated areas growing high yielding varieties.

Soil Survey information and soil testing data are highly useful in designing site-specific technology. Soil Survey is a primary and basic part of Agricultural Research and Advisory Programme. It provides a comprehensive information about soils and gives information needed for planning, land use and soil fertility management programmes.

Soil testing forms the corner-stone of soil fertility management system. It has been recognised as a tool to assess the available nutrient status of soils, which provides a basis for the identification of problems like acidity, alkalinity, salinity associated with the soils. It involves rapid chemical analysis for various elements, interpretations, evaluation and fertiliser recommendations.

The soil testing laboratories generally analyse soil samples for electrical conductivity, texture, pH and available nutrients like N, P, K. Facilities for micronutrient analysis for Zn, Fe, Mn, and Cu exist with the use of atomic absorption spectrophotometer.

Appavu (1976) has thrown a light on the association of micronutrients with various soil properties in the soils of Namakkal district.

Santhirani **et al** (1994) in their decade of reconnaissance soil survey of Ramanathapuram district, Tamilnadu covering an area of 4202.25 Sq.Kms studied the inventory of soil resources, classified them on the basis of characteristics, identified the problems associated with soils and suggested management practices based on the land capability and land irrigability classes for crops suitable for the soil.

Siddhamalai (1997) reported the correlation of micronutrients with physical and chemical properties of soils of Thanjavur district.

Considering the economically backward people and rainfed tract, an attempt was made to suggest location specific recommendation to the farmers of Ramanathapuram district by studying the correlation between micro and agronomically major nutrients N,P and K along with the soils properties EC, pH, and organic matter in the blocks Paramakudi and Devipattinam (Ramanathapuram taluk) with the following objectives:

1. To collect the representatives soil samples.
2. To estimate the chemical properties EC, pH and Organic matter.
3. To test the soil for the availability of agronomically classified major nutrients N, P, and K.
4. To analyse the soil for its micronutrients Zn, Fe, Mn and Cu.
5. To carry out the association of various elements by correlation studies.
6. To find out the influence of micronutrients on other nutrients N,P,K and properties like EC, pH and OM by multiple regression studies.
7. To suggest an approach to maintain soil fertility status of the area study area.

Table 1 Roles played and Deficiencies Symptoms of various Elements

	ELEMENT	ROLE	DEFICIENCY SYMPTOMS
1	Nitrogen	Main constituent of proteins, Enzymes, Chlorophyll and Nucleic acids Helps to harvest solar energy required for flowering and fruit setting	Leaves turn pale. Respiration rate lowered Flower Formation delayed or suppressed stunted growth Inhibits cell division - cell enlargement
2	Phosphorus	Main constituent of Nucleic acid (DNA and RNA) Essential for energy transfer Healthy root growth Promotes fruit ripening	Abnormally dark green leaves later turns brown to black Leaf fall Bronzing on back sides Dwarfing - retarded growth
3	Potassium	Helps in plant metabolism Essential in mitochondrial and cell membrane permeability (cell division) Controls respiration Activiates many plants enymes In fruits improves colour / flavour and size Increases plant resistance to moisture stress and heat	Stunded growth, loss of vigour Produces water imbalance in plants and leaves Chlorosis, small dead spots of specks at the tips and margins showing rusty appearance. Apical buds become inactive Lateral buds grow actively showing bushy appearance.

Table 1 (contd)

	ELEMENT	ROLE	DEFICIENCY SYMPTOMS
1	Zinc	- Chlorophyll formation - Leaf development - Activator of enymes in respiration - Role in protein synthesis - Essential for formation of auxins	- Dead spots in all over leaves - Chlorosis between veins - Bronzing and mottling of leaves leading to rosette formation - Flowers and fruits affected - Poor tillering
2	Iron	- Constituent of cytochrome for respiration - Brings about chlorophyll formation and electron transport	- Due to the reduction of photo synthesis, chlorosis seen in young leaves - Poor tender roots
3	Manganese	- Activator of oxidising enzymes in photosynthesis - Essential for formation of chlorophyll, predominant metal ion of krebs cycle of respiration. - Helps in reduction of Ferric to Ferrous iron - Affects the absorption of K, Ca ions - Helps in metabolism of Carbohydrates	- Intervenal chlorosis in young leaves, rosette appearance - Severely affected leaves turn brown and wither.
4	Copper	- Component of plastocyanin which plays a role in protein and carbohydrate synthesis - Helps in the process of respiration	- Die-back disease, death of young growing tips - Intervenal chlorosis and rosette apperance - Wilting of buds and young leaves

(Published by Institute For Micronutrient Technology, Pune, 1995).

OPERATIONALISATION OF BASIC CONCEPTS

Soil Sample: A small amount of soil carefully collected from a defined (Field) (representing the entire area) to study the various characteristics. Used in soil classification, Fertility evaluation and advisory work. Should be taken so as to be truely representative of the field.

Soil Analysis: Physical, chemical or biological assay of soil sample, usually in the laboratory providing information on fertiliser requirement and other properties when repeated over a period of years, provides information on soil fertility. It is a meaning guide and also a scientific tool that can be used with reasonable precision.

Available Soil Nutrient level : Defined as those forms present in the soil, the variations in the amounts of which are mainly responsible for variations in yield and response to added fertilisers.

Fertility Status: It indicates the ability to supply nutrients to the plants in adequate amounts and in suitable propositions.

Fertiliser: Fertiliser means any substance intended to be used as a source of one or more essential plant nutrient.

Saline Soil: Saline soils contain high content of soluble salts found in scanty rainfall, areas with a low crop productivity; pH < 8.5, ESP < 15, EC < 4.
High content of Na, Ca, K Carobonates insoluble in water.

Alkali Soil: Soils have an ESP > 15, pH > 8.5, EC < 4,. high content of Na, Ca, K carbonates insoluble in water.

Alley Cropping: Planting trees in strips or lines with wider spacing to accommodate 50% of the area under cereals, pulses in soils of low fertility.

Fym (Farm Yard Manure) : Organic manure consisting mans , animal dung, urine, and flour litter. Typical composition is 0.5-100 % N, 0.15-0.20 % P_2O_5, 0.5-0.6 % K_2O. Also contain appreciable amounts of micro nutrients.

Compost: Organic manure prepared by partial aerobic fermentation of diverse organic materials such as cattle dung, crop residues, rural / urban wastes. Usual composition of rural compost is 0.5-1.0% N, 0.2%, P_2O_5, 0.5%, K_2O and that of urban compost is 1.5-2.0 % N, 1.0 % P_2O_5, 1.5% K_2O.

Vermi Compost: A compost produced from the digestion and discharge of refuse and other organic wastes by earthworm. (2.14%N, 3.44%, P_2O_5 & 1.01% K_2O).

Ameliorant: Substances added to a soil for the improvement of its physical and chemical properties and to help in increasing crop yields. E.g.. Lime in acid soil, gypsum in alkali soils.

Amendment: A material added to normal soils to bring their pH, salt status or adverse features towards normally for production. E.g.. Lime, gypsum, pyrites.

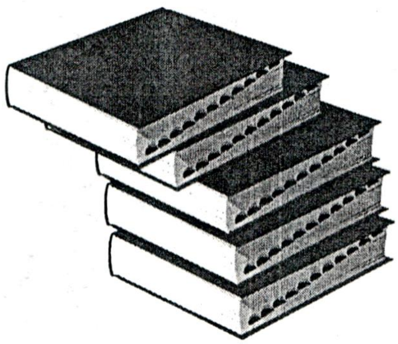
Bio-Fertilisers: Microbiological agents which fix the atmospheric nitrogen or help to solubilise/mobilise soil nutrients,. Rhizobium cultures fixes atmospheric N in legumes whereas Azospirillium in non-legumes. Phosphatic cultures solubilises the phosphates in the soil.

Soil Conditioner: Material added to soil mainly to improve physical and as a consequence its chemical and biological properties.

Abbreviations used

C - Carbon	Ca- Calcium	S-Sulphur
H - Hydrogen	Fe - Iron	Mo - Molybdenum
O - Oxygen	Mg - Magnesium	B - Boron
P - Phosphorus	Mn - Manganese	Cl - Chlorine
K - Potassium	Cu - Copper	OM - Organic matter
N - Nitrogen	Zn - Zinc	ESP - Exchangeable Sodium percentage

CHAPTER 2



Review of Literature

REVIEW OF LITERATURE

An acquaintance with related literature of past studies is a must for any research for formulating sound methodology. The literatures pertaining to the present investigation are reviewed in this chapter under the following headings:

1. Electrical Conductivity
2. Soil reaction - pH.
3. Organic matter
4. Macronutrients - Nitrogen, Phosphorus, and Potassium
5. Micronutrients - Zinc, Iron, Manganese and Copper
6. Research Findings on crop productivity.

2.1 Electrical Conductivity

EC us a measure of total amount of soluble salts present in the soil and expressed as mmhos/cm. (Normal 0-1, Injurious 1-3, Critical >3).

2.1.1 Status of Electrical Conductivity

Diwakar and Singh (1994) recorded very low values of EC (0.11 dsm^{-1}) for vertisols of Bihar.

Murthy **et al** (1994) reported that the EC of vertisols was less than 4 dsm^{-1}.

Santhirani **et al** (1994) noticed low EC values from 0.1 to 0.56 dsm^{-1} in the Entisols of Punjab.

According to Siddhamalai (1997), the EC of Thanjavur soils ranged from 0.10 to 1.83 dsm^{-1}.

Siddhu **et al** (1994) accounted for low EC values from 0.1 to 0.56 dSm^{-1} in the Entisols of Punjab.

2.1.2. Correlation studies

Dhane and Shukla (1995) depicted that in the vertisols of Maharastra, an increase in E.C. decreased the cation exchange capacity and organic carbon and increased the calcium carbonate content.

2.2 Soil Reaction - pH

pH is the negative logarithm of hydrogen ion activity expressed in numbers. This describes the degree of acidity or basicity of a solution. It decides the availability of plant nutrients in soil and affects the decomposition of organic matter, microbial activity in soil and physical properties of soil, thus determining the suitability of soil. Various soil categories are given in Table 2.

Table 2 : pH based soil categories.

pH value	Soil category
4.0 - 5.5	Strong acid
5.5 - 6.0	Medium acidic
6.0 - 6.5	Slighlty acidic
6.5-7.0	Very slighlty acidic
7.0	Neutral
7.0 -7.5	Very slighlty alkaline
7.5 - 8.0	Slighlty alkaline
8.0 - 8.5	Medium alkaline
8.5 - 10.0	Strong alkaline

2.2.1 Status of pH

Moosa Sheriff and Dharmaraj (1993) stated that an increase in pH induces Zn deficiency in pulses.

Diwakar and Singh (1994) found that the soils of old alluvial region of Bihar were neutral to slightly alkaline, the pH value ranged from 6.8 to 7.7.

Santhirani **et al** (1994) opined that the pH range of Ramanathapuram soils ranged from 6.5 to 8.4.

According to Panchrane **et al** (1996), Ferruginous soils were medium to neutral in contrast to vertisols that were moderately to strongly alkaline.

Dhanapalan Mosi and Jayadeesan (1993) stressed that pH is one of the factor that affects the availability and uptake of potassium.

Siddhamalai (1997) pointed out that the Alfisols of Thanjavur district was slightly acidic.

2.3 Organic matter

Organic Matter is an important component in the living system of soil and it gives structures to the soil. Organic matter forms the basic constituent in the availability of micronutrients. A gram of fertile soil would have atleast 4 to 40 billion microorganisms which causes organic matter to decay.

2.3.1 Status of organic matter

Kaistha **et al** (1990) and Sharma **et al** (1994) found that the alluvial soils contained low to high organic carbon content (0.8 to 1.4 per cent).

Santhirani **et al** (1994) stated that in general the soils of Ramanathapuram district have low organic carbon content.

Siddhamalai (1997) reported that organic matter content ranged from 0.05 to 1.87 per cent in Thanjavur soils.

2.3.2 Correlation studies

Ragupathy and Vasuki (1993) pointed out that the organic carbon content was positively correlated with copper.

Trace metal studies of Nigerian coastal plain sands (1994) indicates a positive correlation between organic matter and copper, zinc (Anon.1994).

Sidhu **et al** (1994) indicated that in some of the flood plain entisols an irregular distribution or organic carbon content with depth was observed indicating their stratified nature.

Diwakar and Singh (1994 b) stressed that organic carbon was positively correlated with total zinc, total iron and available iron.

Sambamurthi (1995) pointed out that atleast there should be 2% organic matter in the soil to sustain the minimum microbial load of about 15 million microbes per gram of soil. The dryland soils have only about 0.5% organic matter, with this level soils can bear only 1% of the potential microbial load thus reducing the conversion of food for plants.

2.4 Nitrogen

Among the major nutrients, nitrogen is the foremost nutrient which plays an important role in the crop growth.

2.4.1 Fertility status of nitrogen

Kothandaraman and Krishnamoorthy (1977) claimed that the total nitrogen content in Tamilnadu soils ranged 0.015 to 0.045 percent.

Thiyagarajan (1978) accounted that the total nitrogen content of Tamilnadu soils ranged from 0.015 to 0.045 percent.

Srivasthava and Srivasthava (1993) observed that the soils of Varanasi District, Uttar Pradesh ranged from 0.022 to 0.068 percent.

According to Anbazhagan (1994), the available nitrogen of Thanjavur soils ranged from 115 Kg to 224 Kg na^{-1}.

Ramesh **et al** (1994) reported that the available Nitrogen content of Andhra Pradesh soils ranged from 85 to 282 Kg ha^{-1}.

Siddhamalai (1997) encountered the available nitrogen to vary from 16 Kg ha^{-1} to 255 kg ha^{-1} in Thanjavur soils.

2.4.2 Correlation studies

Singh **et al** (1992) informed that the organic carbon and mineral nitrogen content are the prime factors affecting the available nitrogen of Haryana soils.

Goyal and Mahendra Singh (1986) established a linear relationship between organic carbon and available Nitrogen content in South Haryana alluvial soils.

According to Agarwal (1995), the availability of N, P and K significantly affected the availability of other nutrients.

2.5 Phosphorus

Phosphorus plays an important role in plant metabolisms and energy transformation, growth and yield are affected by the availability of soil phosphorus.

2.5.1 Fertility status of phosphorus:

Mayalagu and Paramasivam (1994a) accounted that the available phosphorus content ranged from 6.24 to 7.84 Kg ha^{-1} in Tamilnadu soils.

Ramesh **et al** (1994) reported that the available phosphorus content ranged from 5 to 38 Kg ha^{-1} in the soils of Andhra pradesh.

Siddhamalai (1997) recorded the available phosphorus content from 1.30 Kg ha^{-1} to 44.30 kg ha^{-1} in Thanjavur soils.

2.5.2 Correlation studies

Mayalagu and Paramasivam (1994a) observed a negative correlation of available phosphorous with available manganese but positive correlation with available zinc and available copper.

Agarwal (1995) opined a positive correlation between sodium, calcium, phosphorous, copper and nitrogen content in the alkali soils. Application of phosphorus depressed the availability of Mn and Mo.

2.6 Potassium

Potassium regulates the nutrient and water movement in the plant system and determines the quality of crop produce.

2.6.1 Fertility status of potassium

Anbazhagan (1994) observed that the range of total potassium content varied from 0.038 to 0.722 Kg ha^{-1} in Thanjavur soils.

Bellaki and Badanur (1994) reported that the available potassium content varied from 483 to 631.6 kg ha^{-1} in Bijapur (Karnataka) state.

Ramesh **et al** (1994) observed that in Andhra Pradesh soils, the available potassium content ranged from 49 to 336 Kg ha^{-1} with means value of 114 Kg ha^{-1}

Siddhamalai (1997) encountered the total potassium range as 0.005 to 0.4 percent the available potassium content ranged from 22 kg ha^{-1} to 1182 Kg ha^{-1} in soils of Thanjavur.

2.6.2 Correlation Studies

Jeevan Rao and Dakhore (1993) stated that the potassium application decreased the available Zinc content of the soil.

Ramesh **et al** (1994) and Siddhamalai (1997) informed a decrease of available potassium with the depth of the profile.

Agarwal (1995) opined that the application of potassium depressed the availability of sodium. He also found that the availability of potassium was increased by nitrogen fertilisation.

MICRO NUTRIENTS

Continuous use of high analysis nitrogen and phosphorous fertilisers in the intensive cropping system with diminishing use of organic manure results in quick depletion of micronutrients from all soils thus warrants the study of micro nutrients.

Natesan (1995) in his compendium pointed out that almost all the crops responded positively in one way or other to the combined application of two or more micronutrient. Any imbalance / inadequacy miconutrient supply at any stage of crop growth would not only affect the growth and development of plants, but also severely hinder the use of other nutrients like N, P, K, Ca,Mg and / or S.

2.7.1 Fertility Status Of Available Zinc

Appavu and Sri Ramulu (1981) reported that the available zinc content varied from 0.16 to 5.14 ppm in the major soil series of Namakkal taluk in Tamilnadu.

Mayalagu and Peer Mohammed (1992) observed that the available zinc content ranged from 0.70 to 1.00 ppm in the Andhra Pradesh horizons of Subramaniapuram soil series of Ramanathapuram taluk.

Paramasivam and Gopalasamy (1994 b) pointed that the available zinc content varied from 0.20 to 0.72 ppm in Lower Bhavani Project Command area of Tamilnadu.

According to Siddhamalai (1997), the available zinc content varied from 0.51 to 8.4 ppm in Thanjavur soils.

2.7.2 Correlation Studies

Malayagu and Peer Mohammad (1992), Paramasivan and Gopalasamy (1994 b), Kannan and Mathan (1994) and Siddhamalai (1997) revealed that the available Zn decreases with depth.

Paramasivam and Gopalsamy (1994 b) and Kannan and Mathan (1994) stated that the available Zn was positively correlated with organic carbon.

Saha **et al** (1996) reported a significant positive correlation with available phosphorous content.

Siddhamalai (1997) informed that the available zinc was in good association with organic matter and EC.

2.8 Available Iron

2.8.1 Fertility Status Of Available Iron

Appavu and Sree Ramulu (1991 b) explained that the available iron content varied from 2.01 to 12.66 ppm in Namakkal taluk.

Ramanthapuram taluk showed a variation from 1.60 to 1.90 ppm according to Mayalagu and Peer Mohammed (1992).

Paramasivam and Gopalsamy (1994 b) reported that the available iron content ranged from 2.6 to 10.3 ppm in Lower Bhavani Project command area.

Moosa and Sheriff (1993) noticed the Fe deficiency in pulses in high temperature, less irrigation and increase in total soluble salts prevailed areas.

According to Siddhamalai (1997) the available iron ranged from 0.62 ppm to 33.24 ppm in Thanjavur soils.

Appavu and Sree Ramulu (1991 b) and Siddhamalai (1997) observed that the available iron content decreased with depth whereas the content increased with depth was noticed by Paramasivam and Gopalasamy (1994 b), Kannan and Mathan (1994) in Lower Bhavani project Command area and hilly soils respectively.

2.8.2 Correlation Studies

Available iron content was positively correlated with organic matter according to Appavu and Sree Ramulu (1991 b) and with pH as reported by Velayutham (1974), Mayalagu and peer Mohammed (1992) and Saha **et al** (1996).

Kannan and Mathan (1994) informed a significant correlation between total iron and available iron in Tamilnadu soils.

Siddhamalai (1997) depicted that the available iron was negatively associated with pH and positively correlated with organic matter and fine sand.

2.9 Available Manganese

2.9.1 Fertility status of available Manganese

In the major soil series of Namakkal Taluk, the available Mn content varied from 0.63 to 26.64 ppm with a mean value of 3.93 ppm (Appavu and Sree Ramulu, 1990).

Mayalagu and Peer Mohammed (1992) pointed out that the available Mn content ranged from 0.60 to 0.95 ppm in Ramanathapuram taluk and from 6.0 to 18.6 ppm in the Lower Bhavani Project Command area.

According to Siddhamalai (1997), the available Mn content ranged from 1.41 ppm to 43.20 ppm in Thanjavur soils.

Mayalagu and Peer Mohammed (1992) observed that the available Mn content increased with depth while Paramasivam and Gopalasamy (1994 b) and Siddhamalai (1997) recorded a decrease in the content with depth.

2.9.2 Correlation Studies

Available Mn was negatively correlated with pH and positively correlated with clay and organic matter according to Mayalagu and Peer Mohammed (1992), Paramasivam and Gopalasamy (1994 b) and Saha **et al** (1996).

Siddhamalai (1997) reported a negative association with pH , calcium carbonate positive correlation with organic matter.

2.10 Available Copper

2.10.1 Fertility status of Available copper

The available copper content varied from 0.2 to 1.13 ppm in major soil series of Namakkal taluk (Appavu and Sree Ramulu, (1991 a).

Mayalagu and Peer Mohammed (1992) stressed that the available copper content ranged from 0.7 to 1.0 ppm in Ramanathapuram taluk. Paramasivam and Gopalasamy (1994 b) reported that the available copper content ranged from 2.26 to 6.43 ppm in Lower Bhavani Project Command area.

According to Siddhamalai (1997) the available copper ranged from 0.28 ppm to 8.48 ppm in Thanjavur soils.

Kannan and Mathan (1994), Paramasivam and Gopalasamy (1994) and Siddhamalai (1997) have encountered that the available copper content decreased with depth.

2.10.2 Correlation Studies

Available copper content was negatively correlated with pH and positively correlated with organic carbon as reported by Mayalagu and Peer Mohammed (1992), Paramasivam and Gopalasamy (1994 b).

Siddhamalai (1997) depicted that the available copper was positively associated with organic matter and silt content in all soils and with EC in surface samples only.

2.11 Research Findings And Crop Productivity

Jeevan Rao and Dakhore (1993) stated that the application of farm yard manure increased the available zinc content of the soils.

Aruna (1994) illustrated that the organic matter increased the availability of phosphorous; Mineralisation of organic forms increased the availability of potassium. Green manuring and green leaf manuring as a renewable source of input, increased the organic carbon content, available NPK status, secondary and micro nutrients.

Balasubramanian (1994) revealed that continuous application of mineral fertilisers resulted in lower yields besides decline in soil health (as they do not supply humus), while continuous application of farm yard manure alone had significantly enhanced yield under rainfed conditions.

Kempuchettty (1977) reported that application of vermi compost 2.5 t / ha increased the growth and yield of paddy besides increasing the availability levels of N,P,K and micronutrients in soil; an increase of 24% in the production of sugarcane is acidified soils.

Application of enriched coir pith at 12.5 t / ha or FYM at 12.5 t / ha was found to register higher yield of groundnut pods and sorghum .

Jayakaran (1994) had suggested a decentralised preparation of compost, growing N fixing legumes, both animals and trees mulching of soil with organic materials, use of biofertilisers, green manure , vermi culture adding silt brought from irrigation lands as a soil management policy.

The soil analysis data on available micronutrient status (Fe,Zn, Mn, Cu) in the soil showed compost applied plots registered higher sugarcane value than inorganic fertilisers above treated plots with an increase ranging from 13.7 to 30.7% among different micro nutrients.

Press mud is a waste product from sugar mills. According to Palaniappan and Siddheswaran (1994), application of 20 t / ha along with 75% NPK through fertiliser resulted in 26.3% and 35% higher yield in sorghum and wheat respectively.

Press mud application at the rate of 25 t / ha with NPK (280 g,.65 kg, 115 kg) recorded a higher sugarcane yield 107 t / ha, than inorganic fertiliser alone 96 t / ha (Anon, 1997).

Savithri (1978) pointed out that the addition of Cu increased the P, Fe content and decreased the N, K, and Zn content in sorghum and maize crop.

Tamilnadu Agricultural department has recommended the application of multi- micronutrients cropwise in various doses based on research data.

Groundnut, millets, cotton, coconut - 5 kgs.

Sugarcane, Bananas	- 10 kg,
Pulses	- 2 Kg.

In acid soils of high rainfall zone of Tamil Nadu liming increased the grain yield by 31% (64.79% q / ha) over control while foliar spray of micronutrients recorded 10.8% increase (59.3 q / ha).

Palaniswamy (1994) suggested the practice of seedling treatment with biofertilisers for the crops for which nurseries are raised and transplanted. These biofertilisers by way of fixing atmospheric N bring lot of benefits to the farming community in the economic use of fertilisers and improving the soil fertility status.

Ramachandran (1994) stated that groundnut crop registered 16% higher yield with the application of biofertilisers over untreated. Rhizobium treated groundnut registered 10% increased pod yields.

Combined application of Azospyrillum and phosphobacteria with 25 kg P/ha recorded higher Phosphorus solubilisation as well as yield of rice.

Sambandamurthy (1995) suggested to bring the dry land soils deep enough (atleast 1.75 metres) to sustain tree growth under perennials, recommended planting fruits trees as pure crop in soils of good fertility and in Alleys.

Sandy soil	- Cashew, Mango, Tamarind, Palmyrah.
Alkaline soils	- Tamarind, Kodukapuli, Palmyrah.
Red soil	- Cashew, Anona, Tamarind
Black clayey soil	- Tamarind, Ber, Amla, Anona.

CHAPTER 3

Materials and Methods

MATERIALS AND METHODS

In this chapter the details of the study area, soil sample collection and methods of analysis followed are presented.

3.1 Study area

3.2 Reasons for choosing the study area

3.3 Selection of the blocks

3.4 Field sampling

3.5 Processing of soil samples

3.6 Estimations of soil samples

3.7 Statistical tools.

3.1 Study Area

Ramanathapuram, a coastal district lies in south east part of Tamil Nadu and geographically situated between 9°5' and 9°57' north latitude and 78°10' and 79°27' east longitude. Its total geographical area is 4217.79 Sq.kms (421779 ha). The district is bounded on the west by Virudunagar District, North by Sivagangai District, East and South by Bay of Bengal. (Fig.1).

The irrigation potentialities are very limited. Hence the villagers normally depend upon the traditional water sources like ooranies, ring wells, tanks etc.

There is a major river Vaigai running across the district feeding 1811 number of tanks. A vast stretch of black soil plains could be found in all taluks which are rained by Vaigai river.

The monthwise rainfall and temperature details are furnished in the Table 3.

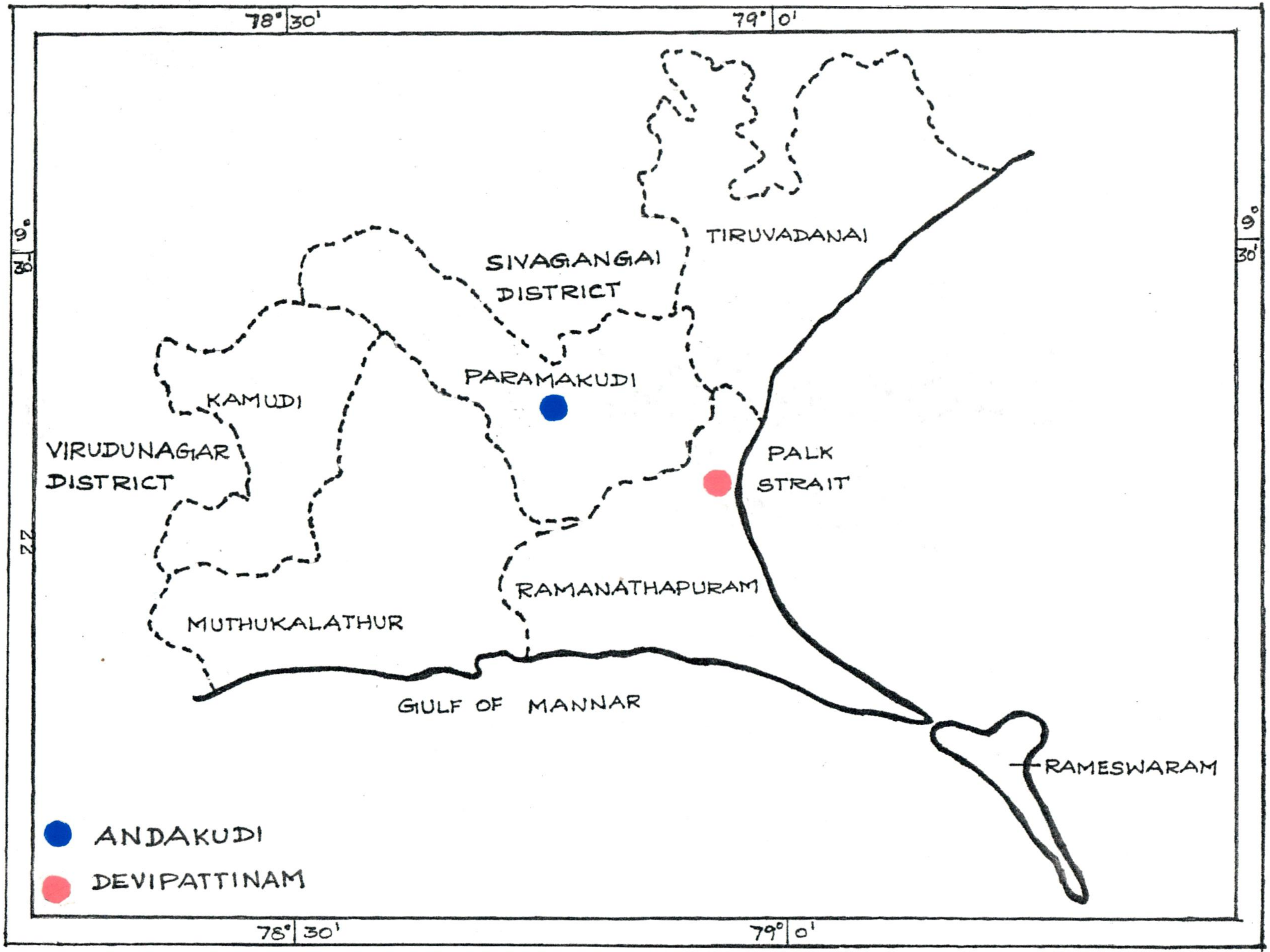


Fig.1 Location of the study (Ramanathapuram District).

Table 3 Monthwise Rainfall and Temperature

Month	Rainfall (in mm) Andakudid	Rainfall(in mm) Devipattinam	Average Temperatures		
			Max	Min	Mean
January	18.0	8.4900	8.49	18.0	24.0
February	7.0	19.77	19.77	21.0	57.7
March	14.0	31.8	31.8	23.0	28.5
April	42.0	61.62	61.62	25.0	31.0
May	44.0	28.73	28.73	25.0	31.0
June	12.0	8.01	8.01	26.5	31.5
July	29.0	27.15	27.15	26.5	30.5
August	57.0	31.22	33.5	25.0	30.0
September	68.0	40.14	33.5	24.5	29.0
October	168.0	205.62	33.5	24.5	28.7
November	110.0	205.56	33.5	22.5	28.0
December	88.00	194.27	30.5	20.0	25.2
Total/mean	657	668.11	34.0	23.4	28.7

Different Crops Grown in this district are illustrated in Table 4

Table 4 Area under different crops in Ramanathapuram District

Paddy	149245 ha	Cotton	3811 ha
Millets	6811 ha	Chillies	10000 ha
Pulses	4402 ha	Sugarcane	75 ha
Oilseeds	10715 ha		

Ramanathapuram is a dry and ecnomically back ward district prone to frequent drought. The farmers are very poor, mostly marginal and small

3.2 Reasons For Choosing The Study

Though there are more than 1800 tanks due to droughts normal yields are obtained once in every three or four years. Famous Ramnad "Mundu" variety of Chillies are grown in about 10,000 hectares.

In Ramanathapuram district, paddy is grown in about 5 to 7 percent of total Tamil Nadu area. Besides paddy, few thousands of acres of millets, pulses and oil seeds are grown. Cotton is also grown in this district.

On the whole, rainfed agriculture is predominant. The fertiliser off take is also less than the recommended doses, because of drought and economically backward farmers. Similarly the use of micronutrients was also sparce. Not much of research work has been done on use of micronutrients in the district.

Adequate infrastructural facilities like soil testing, fertiliser testing laboratories, biofertiliser production units are functioning in the district with full fledged analytical staff. Correlation study on the use of micro and macronutrients was felt useful to the farming communities as well as for the research workers. Hence Ramanathapuram district was selected .

3.3 Selection of the block

Two villages namely Andakudi and Devipattinam in the blocks of Paramakudi and Ramanathapuram respectively were selected. The former village represents the inland area and the later adjoining the east coast. These places differ in the receipt of quantum of rainfall. Twenty five representative samples from each village were taken for the study.

3.4 Field Sampling

For surface sample collection a "V" shaped cut was made. 1.5 cm thick slice of scrap soil from both the sides of cut for which soil is tested. Samples were taken from a `V' shaped cut at a depth of 9" or 23 cms. Each of the sample represented approximately 5 hectares. The samples were taken at this depth because the annual crops have the root system upto this depth. At random (zig zag) 10 to 15 places were selected for every sample. The soil was pooled in a clean basket. For micronutrient analysis wooden material was used as a sampling tool. After quartering the pooled samples (1kg) they were packed in a clean polythene bags which is again inserted in a cloth bag.

Staff of Agricultural Department helped in the collection of soil samples from the two villages of the study area. The following details were also recorded.

- Name and address of the farmers
- Survey number
- Previous crop.
- Fertiliser applied to the previous crop.
- Proposed crop along with the irrigation potentialities.

The samples were taken to the laboratory.

3.5 Processing of Soil Samples

The samples were shade -dried, powdered with a wooden mallet and sieved through a 2 mm sieve. Sieved fine soils is preserved in the container with label and used for laboratory analysis.

3.6The methodology followed for the various estimations are presented in Table 5

Table 5 Methodology followed - parameter wise

Parameters	Methodology Followed	Authors	Appendix No.
Electrical conductivity	Condcuctivity meter solubridge (Soil:Water) ratio (1:2)	Jackson (1973)	
pH	pH meter using glass electrode (Soil:Water) ratio (1:2)	Jackson (1973)	
Organic matter	Chromic acid wet digestion	Walkey and Black (1934)	I
Nitrogen	Alkaline permanganate method	Subbiah and Asija (1956)	II
Phosphorous	Colorimetry	Olsen **et al** (1954)	III
Potassium	Flame photometer	Standford and English (1949)	IV
Available Zn, Fe, Mn and Cu	Atomic Absorption spectro-photometer	Lindsay and Norvell (1978)	V

3.7 Statistical Tools

Correlation : Simple and multiple correlation's were worked out as per the method given by Fischer (1936)

Mean: The means of all the variables were worked out.

Multiple Regression Analysis: The analysis was carried out to find out the relationship between dependent and independent variable, when measured simultaneously. Regression Equations were formulated using the formula

$$Y = a + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4$$

$Y = Y_1$ to Y_6, Dependent variables EC, pH, OM, N, P and K respectively.

a = constant

b1 = Co-efficient of Zn, b2 = Co-efficient of Fe

b3 = Co-efficient of Mn, b4 = Co-efficient of Cu

$$b = \frac{\sum xy - \bar{x} \sum y}{\sum x^2 - \bar{x} \sum x}$$

Significance : Significance at 0.01 and 0.05 level of probabilities were arrived at 't' values from the `t' values given in the table.

CHAPTER 4

Results and Discussion

RESULTS AND DISCUSSION

The results of this study **'Correlation between micronutrients and macronutrients of the soils of Ramanathapuram District - An approach to improve the fertility status of soils"** are presented and discussed in the light of objectives set forth.

Twenty five representative samples each collected from the villages Andakudi (Paramakudi taluk) and Devipattinam (Ramanathapuram Taluk) were analysed for chemical properties EC, pH, and OM and macronutrients (N,P and K). The availability of micronutrients such as Zn, Fe, Mn and Cu were estimated with the help of atomic absorption spectrophotometer estimated.

The sample wise analytical data are represented in Tables 6 and 7 for Andakudi (Paramakudi) and Devipattinam (Ramanthapuram) Taluks respectively.

The fertility status - availability of nutrients are furnished in Table 8 with maximum, minimum and mean values in a systematic manner.

4.1 Electrical Conductivity

The electrical conductivity ranged from 0.1 to 0.5 mmhos/cm and 0.09 to 1.14 mmhos/cm with a mean of 0.284 mmhos/cm and 0.505 mmhos/cm in the soils of Andakudi and Devipattinam villages respectively.

The pooled data informed a range 0.09 to 1.14 mmhos/cm with a mean of 0.394 mmhos/cm.

The result highlighted the fact that the coastal area records more electrical conductivity. This may be due to the deposits of salts and sediments.

Table - 6 Sample wise Analytical data (Andakudi, Paramakudi Taluk)

S.No	EC(Y_1)	pH (Y_2)	OM (Y_3)	N (Y_4)	P (Y_5)	K (Y_6)	Zn (X_1)	Fe(X_2)	Mn((X_3)	Cu(X_4)
1	0.3	7.1	1.6759	200.0	60.56	686.38	1.23	6.89	6.89	1.23
2	0.1	9.3	0.3249	70.56	17.28	360.75	0.6	2.6	0.35	0.44
3	0.3	8.9	0.3987	88.88	12.56	335.21	0.63	3.54	1.5	0.48
4	0.4	8.7	0.5034	110.63	9.38	400.56	0.73	4.89	1.5	0.64
5	0.3	8.3	0.6199	134.56	10.36	543.18	0.84	6.66	3.09	0.78
6	0.1	9.2	0.3756	71.43	15.73	335.21	0.63	2.98	0.48	0.4
7	0.4	8.5	0.5889	118.51	10.36	459.35	0.78	5.39	1.64	0.68
8	0.3	7.2	1.3382	182.71	37.03	686.38	1.13	8.45	5.82	1.09
9	0.1	8.2	0.6248	143.22	15.51	543.18	0.82	6.54	3.62	0.78
10	0.5	8.6	0.4767	108.63	9.87	387.43	0.7	4.04	1.48	0.52
11	0.2	7.4	1.1576	175.3	29.09	655.75	1.13	7.59	5.49	1.1
12	0.5	8.3	0.6119	129.53	10.86	520.95	0.78	5.38	2.98	0.72
13	0.2	8.1	0.6748	148.14	15.51	602.43	0.96	6.97	4.38	0.84
14	0.4	7.6	0.9559	160.48	23.75	675.59	1.08	7.03	4.97	0.9
15	0.3	8.8	0.4488	98.76	10.86	360.75	0.68	3.79	1.75	0.64
16	0.5	8.5	0.6003	123.75	10.36	493.8	0.76	5.57	2.35	0.78
17	0.3	7	1.5613	129.59	54.78	686.38	1.24	10.08	5.82	1.24
18	0.5	7.2	1.3064	180.23	32.09	675.59	1.12	7.59	5.84	0.94
19	0.4	7.1	1.4019	187.64	44.44	686.38	1.14	9.48	6.14	1.1
20	0.1	7.6	0.7647	153.07	23.04	659.22	0.9	6.97	4.56	0.9
21	0.2	7.4	1.1471	172.83	25.93	675.59	1	7.34	4.81	0.88
22	0.1	8.2	0.6389	145.67	10.86	575.27	0.88	6.87	4.1	0.88
23	0.1	7.9	0.7163	150.61	19.75	632.06	0.92	6.84	3.98	0.78
24	0.3	8.6	0.5034	116.04	10.86	435.5	0.74	4.53	1.75	0.62
25	0.2	8.9	0.3987	88.88	12.56	335.21	0.63	3.54	1.50	0.48

Dependent Variables X_1-Zn, X_2-Fe, X_3-Mn,X_4-Cu,
Independent Variables Y_1-EC, Y_2-pH, Y_3-OM, Y_4-N, Y_5-P, Y_6-K.

Table - 7 Sample wise Analytica data (Devipattinam, Ramanthapuram Taluk)

S.No	EC(Y_1)	pH (Y_2)	OM (Y_3)	N (Y_4)	P (Y_5)	K (Y_6)	Zn (X_1)	Fe(X_2)	Mn((X_3)	Cu(X_4)
1	0.2	6.6	2.2959	234.55	39.5	481.45	1.14	10.00	6.14	1.02
2	0.6	7.4	1.4019	187.64	20.87	450.56	0.92	6.66	4.56	0.88
3	0.4	7.2	1.6759	200.00	25.75	467.71	1.08	6.91	4.97	0.9
4	0.2	6.7	1.8957	216.59	32.09	471.54	1.13	7.34	5.84	0.94
5	0.6	7.5	0.6372	140.49	17.07	442.78	0.90	6.54	4.38	0.86
6	0.3	6.5	2.1034	225.46	37.53	481.45	1.13	8.45	5.82	1
7	0.3	7.1	1.7843	207.39	32.09	471.54	1.00	7.03	5.44	0.92
8	0.8	7.8	1.1471	172.83	14.37	427.88	0.86	5.98	3.98	0.78
9	0.3	7.5	0.9559	160.48	12.57	408.14	0.86	5.38	2.95	0.7
10	0.09	7.7	0.6389	145.67	9.87	387.43	0.82	5.39	2.35	0.68
11	0.6	7.8	0.6372	140.49	10.97	351.43	0.82	4.53	1.63	0.64
12	0.4	8.4	0.6138	127.53	10.97	320.14	0.78	3.79	1.48	0.62
13	0.7	7.7	1.3064	180.23	16.49	738.43	0.88	6.32	4.1	0.84
14	0.2	6.8	1.7843	221.89	34.56	481.45	1.12	7.59	5.66	0.94
15	1.14	8.9	0.3987	88.88	10.74	220.00	0.63	2.6	0.35	0.4
16	1	8.7	0.4834	108.34	10.97	223.94	0.70	2.58	0.48	0.44
17	0.3	7.5	1.0188	167.75	13.09	413.59	0.88	5.57	3.62	0.72
18	0.9	8.9	0.4223	97.03	9.87	220.56	0.65	2.64	0.38	0.42
19	0.5	8.2	0.6215	131.64	8.88	333.00	0.68	4.04	1.5	0.62
20	0.5	7.4	1.5973	197.52	23.69	450.56	0.96	6.84	4.81	0.9
21	0.4	8.5	0.5989	118.51	7.41	285.63	0.73	3.32	0.94	0.48
22	0.2	7.7	0.7647	153.07	9.38	399.82	0.84	4.89	2.62	0.66
23	0.8	8.4	0.6003	123.67	10.74	301.55	0.76	3.54	1.14	0.52
24	0.4	7.8	0.6389	145.67	10.07	371.88	0.80	4.89	1.75	0.64
25	0.8	8.4	0.6003	123.67	10.74	301.55	0.74	2.98	0.78	0.46

X-Independent variable, X_1-Zn, X_2-Fe, X_3-Mn, X_4-Cu,
Y - Independent Variables Y_1-EC, Y_2-pH, Y_3-OM, Y_4-N, Y_5-P, Y_6-K.

Table - 8 Maximum, Minimum, Mean Values Of Andakudi, Devipattinam And Combined Data

Parameters	Andakudi (I)			Devipattinam (II)			Combined (I+II)		
	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN
Electrical Conductivity	0.5	0.1	0.284	1.14	0.09	0.5052	1.14	0.09	0.3946
pH	9.3	7	8.104	8.9	6.5	7.724	9.3	6.5	7.9140
Organic matter	1.6759	0.3249	0.7926	2.2959	0.3987	1.0649	2.2959	0.3249	0.9228
Nitrogen	200.0	70.56	138.104	234.55	88.88	160.6796	234.55	70.56	149.3918
Phosphorus	60.56	9.38	21.3352	37.53	7.41	17.6512	60.56	7.41	19.4932
Potassium	686.38	335.21	534.324	481.45	220.0	382.3204	686.38	220	458.3222
Available Zinc	1.23	0.6	0.882	1.14	0.63	0.8724	1.23	0.60	0.8772
Available Iron	9.48	2.6	6.1656	10.0	2.6	5.432	10.0	2.60	5.7988
Available Manganese	6.89	0.35	3.4716	6.14	0.78	3.106 0	6.89	0.35	3.2888
Available Copper	1.2300	0.4000	0.7936	1.0200	0.4000	0.7192	1.2300	0.4000	0.7564

4.2. Soil Reaction pH

The soil reaction-pH had a variation from 7.0 to 9.3 and 6.5 to 8.9 with a mean of 8.104 and 7.724 in Andakudi and Devipattinam soils respectively.

The combined data reflected a range from 6.5 to 9.3 with a mean of 7.94; thus conclusion drawn from this comparison is that not much differences could be seen in the study areas.

4.3. Organic Matter

The organic matter content indicated a range of 0.324 to 1.659 and 0.398 to 2.295 with a mean of 0.792 to 1.064 in Andakudi and Devipattinam soils respectively.

The pooled data exhibited a variation of 0.324 to 2.205 with a mean of 0.922.

The findings highlighted the fact that Devipattinam area is very closely located to the sea. During the North East monsoon period there was a heavy down pour as indicated from the rainfall data in the Table-3. Such irregular distribution of organic matter was supported by Sidhu **et al** in 1994.

The increase in organic matter might be due to the addition of organic matter by the respective farmers through organic residues.

4.4 Fertility Status of macronutrients

Mohr **et al.**, (1965) categorised the fertility status as illustrated in Table -9.

Table - 9 Categories of Fertility status

Nutrients	Low	Medium	High
Nitrogen	< 280	280 - 450	> 450
Phosphorus	< 11	11-22	> 22
Potassium	< 118	118-280	> 280

The fertility status of macronutrients are illustrated in fig.2

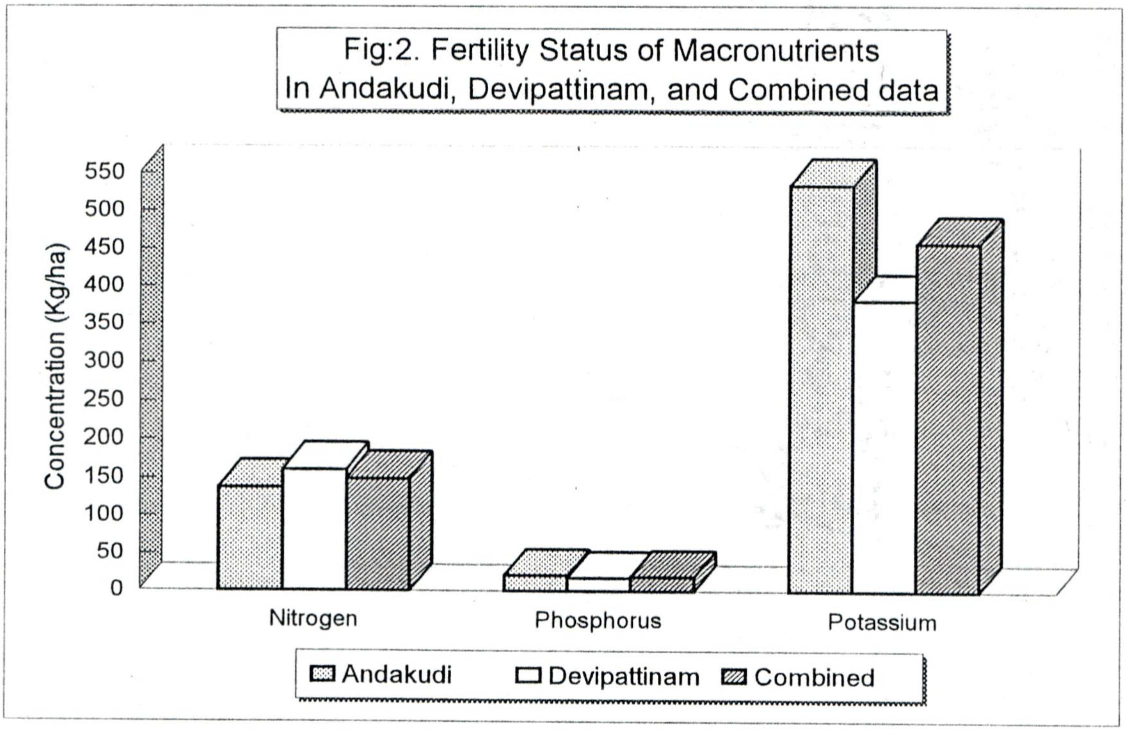


Fig:2. Fertility Status of Macronutrients
In Andakudi, Devipattinam, and Combined data
Concentration (Kg/ha)
550
500
450
400
350
300
250
200
150
100
50
0
Nitrogen
Phosphorus
Potassium
Andakudi
Devipattinam
Combined

4.4.1. Nitrogen

The data reported that the nitrogen content varied from 70.56 to 200 kg ha^{-1} and 88.88 to 234.53 kg ha^{-1} in Andakudi and Devipattinam with a mean of 138.104 and 160.679 kg ha^{-1} respectively.

The combined data showed that the nitrogen content ranged from 70.56 to 234.55 kg ha^{-1} with a mean of 149.39 kg ha^{-1}. This clearly shows the low fertility status of Nitrogen in the study areas.

4.4.2. Phosphorus

The phosphorus content varies from 9.38 to 60.56 kg ha^{-1} in Andakudi soils and 7.41 to 37.52 kg ha^{-1} in Devipattinam soils with a mean of 21.335 and 17.651 kg ha^{-1} respectively.

According to Mohr **et al** (1965) the phosphorus content of the soils were classified as low, medium, and high. In the present study 9,12 samples are low, 7,5 are medium, 9,8 samples are high in Andakudi and Devipattinam respectively.

The low availability of phosphorus might be due to the fixation of P by oxide minerals and clay content.

The higher availability could be due to the accumulation of organic matter in the surface soil as well as the close association between organic carbon and available nitrogen.

4.4.3. Potassium

The potassium content ranged from 335.21 to 686.38 kg ha^{-1} and from 220.00 kg ha^{-1} to 481.48 kg ha^{-1} with a mean of 534.324 kg ha^{-1} and 382.32 kg ha^{-1} in Andakudi and Devipattinam soils respectively.

The combined data showed a range from 220.00 to 686.38 with a mean of 458.322 kg ha^{-1}. Soils of Andakudi and Devipattinam recorded a high content of potassium except two samples in Devipattinam which had a medium content.

This high content depicted the fact that the applied fertilisers were restricted to the surface soil. This could be due to the higher amount of clay present in the surface layers.

4.5. Fertility Status of Micronutrients

Krishnaswamy **et al** (1994) found out various critical limits forr the available micronutrients. The limits are furnished in Table 10.

Table 10 Crictical Levels of Micronutrients

NUTRIENTS	CRITICAL LIMITS (ppm)
Available Zn	1.2
Available Fe	3.7
Available Mn	2.0
Available Cu	1.2

The fertility status of micronutrients are illustrated in fig.3.

4.5.1. Available Zinc

The available zinc content ranged from 0.60 ppm to 1.23 ppm and 0.63 to 1.14 ppm, with a mean of 0.8882 and 0.872 ppm in Andakudi and Devipattinam soils respectively.

The pooled data focused a range from 0.60 to 1.23 ppm with a mean of 0.877 ppm.

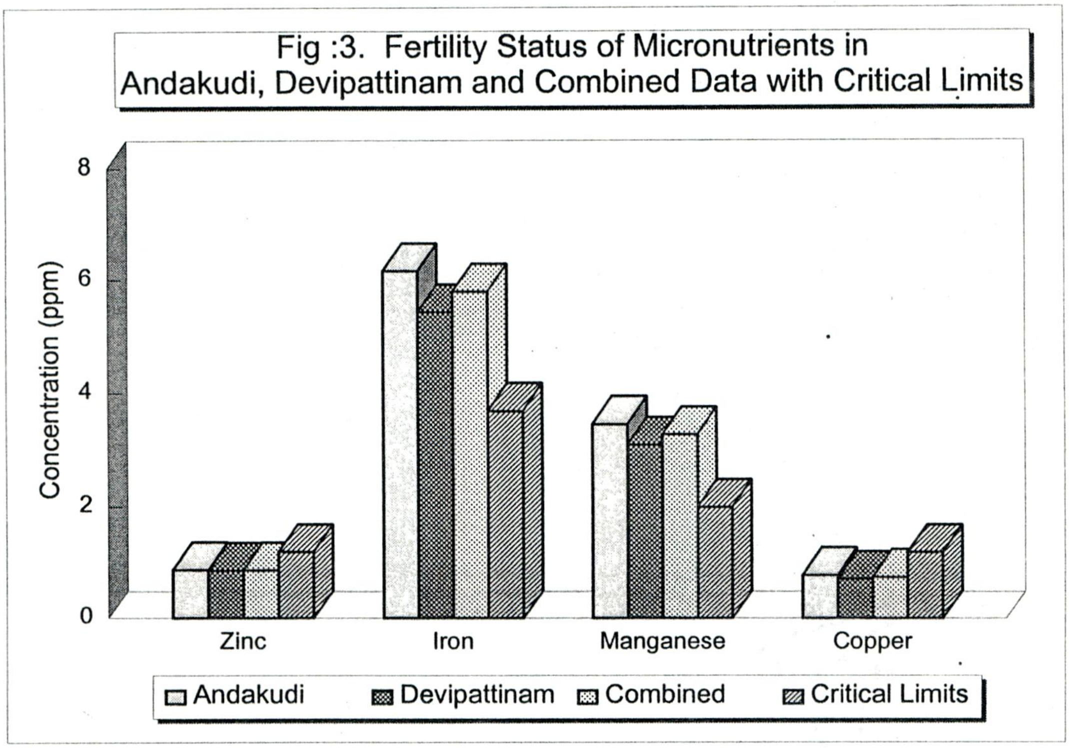


Fig :3. Fertility Status of Micronutrients in
Andakudi, Devipattinam and Combined Data with Critical Limits
Concentration (ppm)
8
6
4
2
0
Zinc
Iron
Manganese
Copper
Andakudi
Devipattinam
Combined
Critical Limits

The data depicted that the availability was below the critical level except two samples in the Andakudi area.

Lower values may be interpreted due to high pH, low organic matter and high calcium carbonate content.

4.5.2. Available Iron

Available iron content showed a variation from 2.6 to 9.48 ppm (Andakudi), 2.6 to 10 ppm (Devipattinam) with a mean of 6.165 and 5.432 ppm respectively.

The combined data revealed a range of 2.60 to 10 ppm with a mean of 5.798 ppm.

As per the limits reported by Krishnaswamy **et al** (1994) the ion content was low to high. 4 samples and 6 samples were below the critical limits in Andakudi and Devipattinam areas respectively.

Low pH and high organic matter content may account for higher iron content. The critical examination of the results showed lower iron content which could be due to a relatively low content of organic matter and clay content.

4.5.3. Manganese

The available manganese content ranged from 0.35 to 6.89 ppm and 0.78 to 6.14 ppm with a mean of 3.471 and 3.106 ppms in Andakudi and Devipattinam soils respectively.

The pooled data exhibited a range of 0.35 to 6.89 ppm with a mean of 3.288 ppm.

The data presented that 9 samples of Andakudi and 10 samples of Devipattinam were below the critical limits as reported by Krishnaswamy **et al** (1994).

Decrease in available content depicted a relatively lower content of organic matter and high pH. The increase in pH would will convert the manganese compounds into manganic oxides.

4.5.4. Available Copper

The available copper content ranged from 0.4 to 1.23 ppm and 0.40 to 1.02 ppm with a mean of 0.793 and 0.719 ppms respectively in the soils of Andakudi and Devipattinam.

The pooled data pictured a variation from 0.40 to 1.23 ppm with a mean of 0.756 ppm. It was in tune with the findings of Krishnaswamy **et al** [1994].

4.6 Correlation studies

By applying the principle of simple correlation and multiple regression analysis, the interrelation ships of the chemical properties of soils were carried out.

On the impact of micronutrients on EC, the correlation Table-11 enlisted that Zn showed more positive association. Regarding pH, the micronutrients, eerted a negative assocaition. The tabulation indicated the maximum positive association of Zinc with organic matter ($r=0.9591^{**}$) followed by other micro nutrients. Correlation coefficient values accounted higher association of Mn with N ($r=0.9794^{**}$). Similar maximum positive association were exhibited by Cu and Mn with P and K respectively ($r=0.8133^{**}$) and ($R-0.9514^{**}$) while others showed a mild positive associations whose ranks and strengths of associations are depicted in Table -12.

Table -11 Inter Correlation Netween Variables - Andakudi

Variables	EC	pH	OM	N	P	K	Zn	Fe	Mn	Cu
EC	1.0000									
pH	-0.1291	1.0000								
OM	0.1725	-0.9457**	1.0000							
N	0.1242	-0.9853**	0.9284**	1.0000						
P	0.0251	-0.8097**	0.9309**	0.7741**	1.0000					
K	0.0077	-0.9444**	0.8351**	0.9540**	0.6684**	1.0000				
Zn	0.1109	-0.9715**	0.9591**	0.9708**	0.8466**	0.9224**	1.0000			
Fe	0.0794	-0.9562**	0.9144**	0.9773**	0.7928**	0.9243**	0.9575**	1.0000		
Mn	0.0467	-0.9750**	0.9222**	0.9794**	0.7971**	0.9514**	0.9682**	0.9559**	1.0000	
Cu	0.0935	-0.9471**	0.9277**	0.9658**	0.8133**	0.9013**	0.9618**	0.9726**	0.9534**	1.0000

* - Significance at 0.05 level of probability.

** - Significance at 0.01 level of probability.

Table 12 Strength and Rank of Association of Variables (Andakudi)

S.No	Parameters	Zn	Fe	Mn	Cu
1	EC	-	-	-	-
2	pH	-ve(2)	-ve(3)	-ve(1)	-ve(4)
3	Organic matter	+ve(1)	+ve(4)	+ve(3)	+ve(2)
4	Nitrogen	+ve(3)	+ve(2)	+ve(1)	+ve(4)
5	Phosphorus	+ve(1)	+ve(3)	+ve(2)	+ve(4)
6	Potassium	+ve(3)	+ve(2)	+ve(1)	+ve(4)

On the impact of micronutrients on EC and pH, the tabulation (Table - 13) accounted for a negative association with all the variables. A positive association association of Zn with OM was observed ($r=0.9401^{**}$). The coefficients furnished in Table-13 indicated a maximum association of Zn with N and P respectively ($r=0.9625^{**}$) and ($r=0.9166^{**}$). The coefficient value enlisted a maximum positive association of Cu with K ($r=0.9523^{**}$). The other dependant variables reflected a mild positive association whose ranks and strengths are furnished in Table -14.

Table - 13 Inter Correlation between variables - Devipattinam

Variables	EC	pH	OM	N	P	K	Zn	Fe	Mn	Cu
EC	1.0000									
pH	-0.7226**	1.0000								
OM	-0.5198**	-0.8944**	1.0000							
N	-0.6380**	-0.9580**	0.9684**	1.0000						
P	-0.4445**	-0.8510**	0.9513**	0.8940**	1.0000					
K	-0.6757**	-0.9256**	0.8097**	0.9136**	0.7131**	1.0000				
Zn	-0.6398**	-0.9610**	0.9401**	0.9625**	0.9166**	0.8809**	1.0000			
Fe	-0.6225**	-0.9583**	0.9134**	0.9537**	0.8730**	0.9210**	0.9404**	1.0000		
Mn	-0.5747**	-0.9466**	0.9299**	0.9614**	0.8843**	0.9386**	0.9518**	0.9677**	1.0000	
Cu	-0.6069**	-0.9505**	0.9029**	0.9538**	0.8510**	0.9523**	0.9361**	0.9758**	0.9837**	1.0000

* - Significance at 0.05 level of probability.
** - Significance at 0.01 level of probability.

Table 14 Strength and Rank of Association of Variables (Devipattinam)

S.No	Parameters	Zn	Fe	Mn	Cu
1	EC	-ve(1)	-ve(2)	-ve(4)	-ve(3)
2	pH	-ve(1)	-ve(2)	-ve(4)	-ve(3)
3	Organic matter	+ve(1)	+ve(3)	+ve(2)	+ve(4)
4	Nitrogen	+ve(1)	+ve(4)	+ve(2)	+ve(3)
5	Phosphorus	+ve(1)	+ve(3)	+ve(2)	+ve(4)
6	Potassium	+ve(1)	+ve(3)	+ve(2)	+ve(1)

On the impact of micronutrients on EC, Fe showed a maximum negative association. The tabulation Table - 15 encountered a significant negative association of pH will all the variables. A maximum positive association of Zn with OM was accounted which is indicated by the correlation coefficient values (r=0.8626**). The correlation coefficient values encountered for prominent association of Zn with N (r=0.9067**). Further results indicated a similar maximum positive association of Zn and Cu with P and K (r=0.8645**) and (r=0.8360**) respectively. The other dependent variables accounted for mild positive association whose ranks and strengths are indicated in the Table- 16.

Table -15 Inter correaltion matrix between variables (Combined data)

Variables	EC	pH	OM	N	P	K	Zn	Fe	Mn	Cu
EC	1.0000									
pH	0.2327**	1.0000								
OM	-0.1704	-0.9059**	1.0000							
N	0.2055	-0.9716**	0.9487**	1.0000						
P	-0.2614	0.7379**	0.8016**	0.7256**	1.0000					
K	-0.4954	0.5732**	0.4472**	0.5556**	0.6382**	1.0000				
Zn	-0.2877	0.9177**	0.8627**	0.9067**	0.8645**	0.7581**	1.0000			
Fe	-0.3948**	0.8588**	0.8010**	0.8595**	0.8210**	0.8356**	0.9342**	1.0000		
Mn	-0.3544	0.8968**	0.8503**	0.9013**	0.8216**	0.8079**	0.9500**	0.9580**	1.0000	
Cu	-0.3497	0.8512**	0.7872**	0.8513**	0.8293**	0.8360**	0.9418**	0.9721**	0.9589**	1.0000

* - Significance at 0.05 level of probability.

** - Significance at 0.01 level of probability.

Table - 16 Strength and rank of association of variables (Combined data)

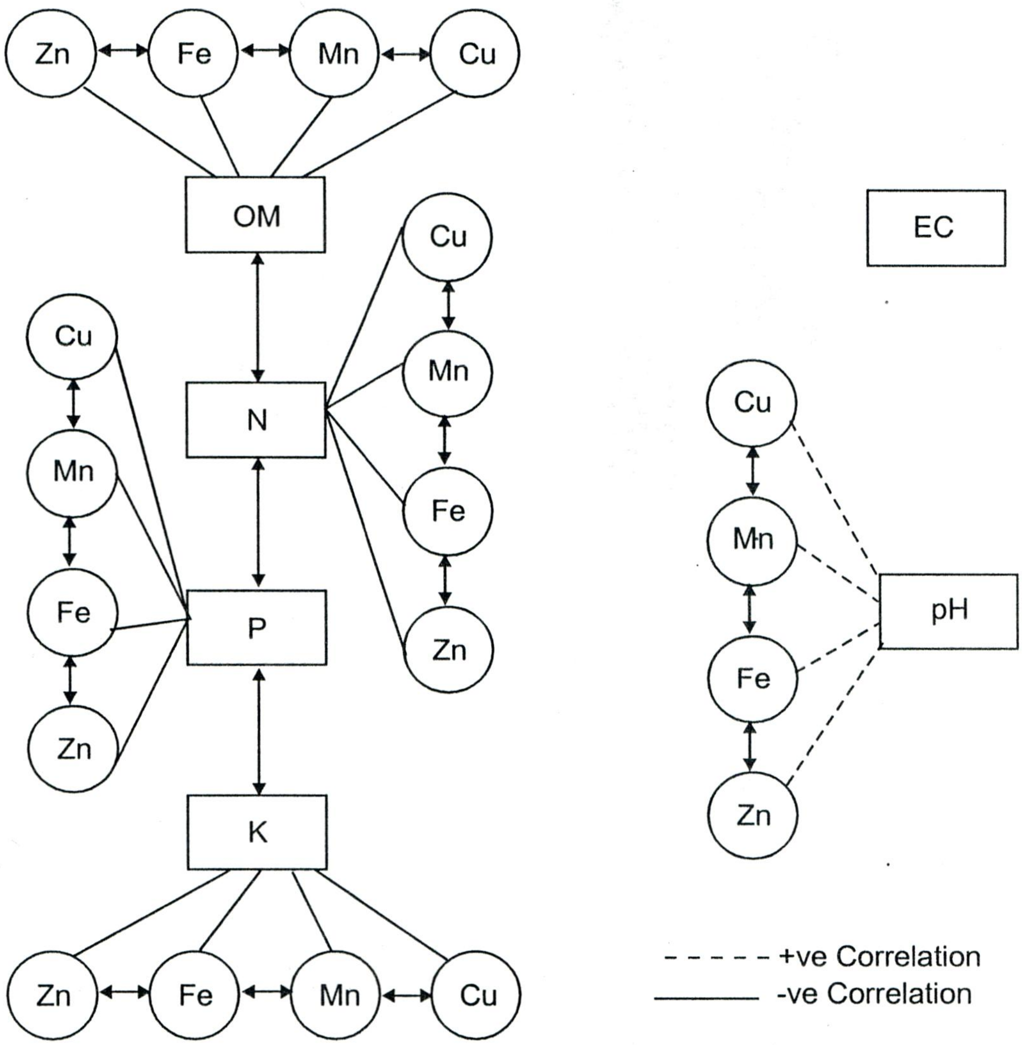
S.No	Parameters	Zn	Fe	Mn	Cu
1	EC	-ve(4	-ve(1)	-ve(2)	-ve(3)
2	pH	-ve(1)	-ve(3)	-ve(2)	-ve(4)
3	Organic matter	+ve(1)	+ve(3)	+ve(2)	+ve(4)
4	Nitrogen	+ve(1)	+ve(3)	+ve(2)	+ve(4)
5	Phosphorus	+ve(1)	+ve(4)	+ve(3)	+ve(2)
6	Potassium	+ve(4)	+ve(2)	+ve(3)	+ve(1)

A conceptual model showing the selected variables and the postulated relationships are depicted in fig. 4.

4.7. Regression Analysis

The correlation studies reveal only an association. It measures only the interdependence / intensity of relationship and does not give any idea (prediction) of how far one is directly dependent on the other variable. The regression analysis measures the rate of change of Y.

Fig. 4 Conceptual model showing the significant correlation between variables



The multiple regression analysis data with Beeta, Coefficient, Standard error, 't' value with 'R^2' and 'a' values for each dependent variable for Andakudi, Devipattinam and pooled data are given in Table-17 and 18.

4.7.1 Electrical Conductivity

Regression estimates are not significantly exhibited. Zn and Cu exerted a positive influence while Fe and Mn showed a negative influence on EC in the soils of Andakudi.

In Devipattinam soils, Mn depicted a positive influence while others revealed a negative influence.

A positive influence of Zn & Cu with EC and a negative influence of Fe and Mn with EC was claimed from the pooled data.

4.7.2 Soil Reaction -pH

All the four variables together significantly explained 96.5, 95.19 and 86.11 per cent variation among Andakudi, Devipattinam and pooled data respectively.

Among the four variables Cu alone revealed a non significant positive influence with pH in Andakudi and pooled data.

In respect of Devipattinam samples, Mn encountered a non significant positive influence.

In all the three categories, Zn showed a positive influence on pH; every unit increase in Zn would result in a decrease of pH to an extent of 1.4, 2.5 and 3.2 units in Andakudi, Devipattinam and Pooled data respectively.

The Andakudi and pooled data revealed a negative significant influence of Mn on pH; every unit increase of Mn would result in a decrease of 0.17 and 0.19 units of pH.

Such negative influence was emphatically stated by Mayalagu and Peer Mohammad (1992) and Saha **et al** (1996).

Table - 17 Multiple Regression Analysis With Selected Independent Variables (Micro Nutrients) ON EC, pH, and OM

	VARIABLES	Andakudi (I)				Devipattinam (II)				Combined (I+II)			
		BEETA	CO-EFFICIENT	S.E	t.VALUE	BEETA	CO-EFFICIENT	S.E	t.VALUE	BEETA	CO-EFFICIENT	S.E	t.VALUE
EC 1	Zinc	0.9866	0.6842	0.7018	0.9750	-0.9098	-1.6384	0.9898	-1.6550	0.6624	0.9120	0.6221	1.4660
2	Iron	-0.09140	-0.0062	0.0691	-0.0890	-0.3921	-0.0559	0.1121	-0.4980	-1.0969	-0.1325	0.0740	-1.7910
3	Manganese	-0.9922	-0.0714	0.0678	-1.0520	1.6589	0.2349	0.1455	1.6140	-0.2715	-0.0342	0.0711	-0.4810
4	Copper	-0.1793	0.1053	0.6138	0.1720	-1.0046	-1.4485	1.5393	-0.9410	-0.3530	0.3969	0.7152	0.5550
		R^2=0.0726		a=-0.1171		R^2=0.4825		a=2.5503		R^2=0.2152		a=0.1753	
pH 1	Zinc	-0.4069	-1.4231	0.6878	-2.0690*	-0.5632	-2.5175	0.7492	-3.360**	-0.8046	-3.2434	0.7661	-4.233**
2	Iron	-0.2217	-0.0755	0.0677	-1.1140	-0.3711	-0.1313	0.0849	-1.5470	-0.0539	-0.0191	0.0911	-0.2090
3	Manganese	-0.4930	-0.1789	0.0665	-2.6910**	0.2722	0.0957	0.1102	0.8680	-0.5152	-0.1901	0.0876	-2.169*
4	Copper	0.1299	0.3846	0.6015	0.6390	-0.3289	-1.1771	1.1652	-1.0100	0.4530	1.4914	0.8808	1.6930
		R^2=0.9650**		a=10.1403		R^2=0.9519**		a=11.1829		R^2=0.8611**		a=10.3667	
OM 1	Zinc	1.0043	1.9960	0.5832	3.422**	0.5058	1.9023	0.8762	2.171*	0.7639	2.2038	0.6846	3.219**
2	Iron	-0.1289	-0.0249	0.0574	-0.4340	0.3775	0.1124	0.0993	1.1320	0.0507	0.0128	0.0815	0.1580
3	Manganese	-0.1106	-0.0228	0.0564	-0.4050	0.7115	0.2104	0.1288	1.6340	0.7261	0.1917	0.0783	2.448*
4	Copper	0.1926	0.3242	0.5101	0.6360	-0.6387	-1.9235	1.3626	-1.4120	-0.6778	-1.5968	0.7871	-2.0290
		SR^2=0.9220**		a=-0.9923		R^2=0.9070**		a=-0.4753		R^2=0.7835**		a=-0.5014	

* Significant at 0.05 level of probability, **Significant at 0.01 level of probability

Table - 18 Multiple Regression Analysis With Selected Independent Variables (Micro Nutrients) On N,Pand K

	Variables	Paramakudi (I)				Devipattinam (Ii)				Combined (I+Ii)			
		Beeta	Co-Efficient	S.E	T.Value	Beeta	Co-Efficient	S.E	T.Value	Beeta	Co-Efficient	S.E	T.Value
N 1	Zinc	0.1406	26.4500	27.9848	0.9450	0.4666	126.3007	45.4691	2.778**	0.6444	149.0473	45.6234	3.267**
2	Iron	0.4166	7.6271	2.7560	2.767**	0.1815	3.8899	5.1515	0.7550	0.0506	1.0263	5.4280	0.1890
3	Manganese	0.4338	8.4682	2.7050	3.131**	0.2273	4.8408	6.6851	0.7240	0.6646	14.0656	5.2174	2.696**
4	Copper	0.0117	1.8698	24.4763	0.0760	0.1162	25.2039	70.7148	0.3560	-0.4421	-83.4980	52.4527	-1.5920
		R^2=0.9800**		a=36.8671		R^2=0.9517		a=-3.7971		R^2=0.8504		a=29.5931	
P 1	Zinc	1.1658	82.9765	38.9590	2.13*	0.7171	46.8447	18.7798	2.494*	0.7911	55.2280	17.7764	3.107**
2	Iron	-0.2670	-1.8494	3.8368	-0.4820	0.3757	1.9425	2.1277	0.9130	0.0728	0.4463	2.1149	0.2110
3	Manganese	-0.3332	-2.4606	3.7658	-0.6530	0.6809	3.4977	2.7611	1.2670	-0.1576	-1.0071	2.0329	-0.4950
4	Copper	0.2693	16.2277	34.0746	0.4760	-0.8567	-44.8097	29.2068	-1.5340	0.1646	9.3891	20.4373	0.4590
		R^2=0.7287**		a=-44.7839		R^2=0.8584**		a=-12.4044		R^2=0.7508**		a=-35.3307	
K 1	Zinc	0.0264	17.2757	202.3638	0.0850	-0.1004	-54.7315	125.2973	-0.4370	-0.4041	-303.3903	201.6282	-1.5050
2	Iron	0.4132	26.3167	19.9293	1.3210	-0.1476	-6.3692	14.1959	0.4490	0.4793	31.5769	23.9884	1.3160
3	Manganese	0.8672	58.8866	19.5606	3.01**	0.1906	8.1741	18.4218	0.4440	0.1592	10.9370	23.0580	0.4740
4	Copper	-0.3527	-195.4223	176.9931	-1.1040	1.0027	437.7462	194.8655	2.246*	0.5979	366.5831	231.8097	1.5810
		R^2=0.9134**		a=307.4853		R^2=0.9095**		a=124.4496		R^2=0.7227**		a=228.0948	

* Significant at 0.05 level of probability, **Significant at 0.01 level of probability

4.7.3 Organic Matter

Table -17 reflected that all the four variables together significantly inferred 92.2, 90.70 and 78.35 per cent in Andakudi, Devipattinam and Pooled datas respectively.

A positive significant influence was focused by Zn in all the three data; for every unit increase of Zn, it would result in an increase of OM by 1.99, 1.90 and 2.20 units in Andakudi, Devipattinam and Pooled data.

It could also be inferred that one unit of increase of Mn would increase in 0.19 unitof OM which is significant at 0.05 level of probability.

4.7.4. Nitrogen

Table - 18 presented that all the four variables together implied 98, 57 and 85.07 per cent variations on the influence of Nitrogen in Andakudi, Devipattinam and Pooled datas respectively.

An impressive positive significant influence of Zn with N was understood. For every unit increase of Zn, nitrogen is expected to increase about 126.3 and 149.04 units in respect of Devipattinam and Pooled datas respectively.

These findings are in line with Paramasivam and Gopalasamy (1994 b) and Siddhamalai (1997).

Well pronounced possible significant influence of Fe with N at 0.01 level of probability (7.6 units are increased per unit increase in Fe) was noted from Andakudi data.

It was clear from Andakudi data a positive significant influence of Mn with N. For every unit increase of Mn, there was an expected increase of nitrogen to a tune of 8.46 and 14.06 units respectively.

4.7.5 Phosphorus

Table illustrated that all the four variables together significantly explained 72.87, 85.84 and 75.08 per cent variations on the influence of P in Andakudi, Devipattinam and pooled datas respectively.

Only Zn evidently exhibited a positive significant influence among the micronutrients. For every unit increase in Zn, Phosphorus is expected to increase to an extent of 82.97 and 46.84 unit in Andakudi and Devipattinam soils respectively at 0.05 level of probability. Such an increase would be about 55.22 units in the pooled data which is significant at 0.01 level of probability.

The above findings were in tune with Saha **et al** [1996].

4.7.6 Potassium

The Table -18 impressed that all the four variables together contributed to 91.34, 90.95 and 72.27 per cent variations on the influence of micronutrients on potassium in Andakudi, Devipattinam and Pooled data respectively. Considering the micronutrients, Mn alone exerted a significant positive influence (0.01 level of probability) with potassium. For every unit increase of Mn, Potassium, would be expected to increase by 58.88 units in Andakudi soils. Similar trend was noted in the case of Cu with K in Devipattinam soils.

The positive / negative influence of each of the micronutrients Zn, Fe, Mn, and Cu on dependent variables, viz., EC, pH, OM, N, P and K with their significance (Village wise and Pooled data) are presented in Table - 19.

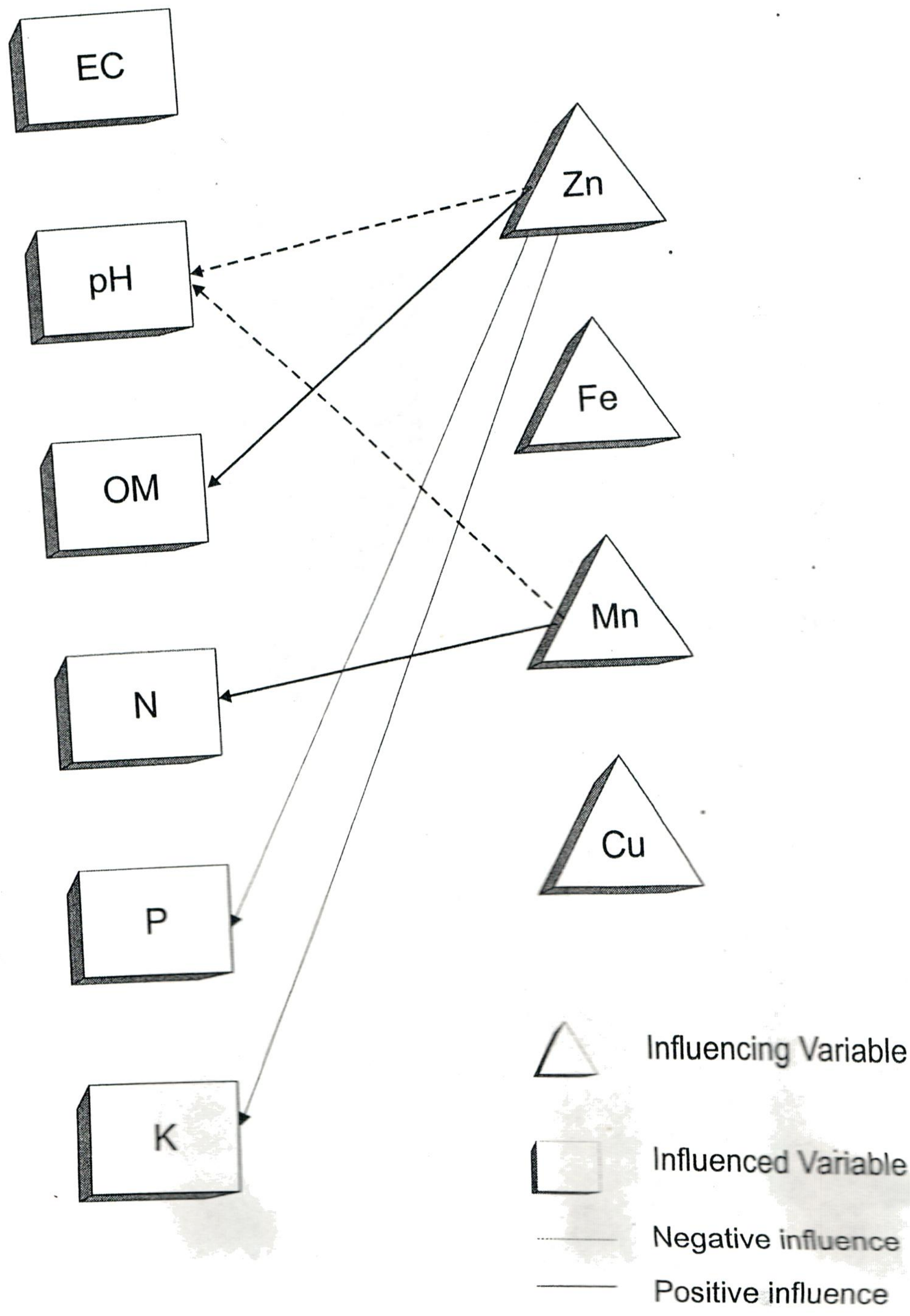
An Empirical Model showing the influence of micronutrients on EC, pH, OM, N, P and K are depicted in Fig.5.

Graphs showing the influence of Zinc with Organic matter, pH and Phosphorus are depicted in figures 6,7 and 8 respectively, while that showing the influence of Manganese with pH and Organic matter are depicted in Figures 9 and 10 respectively.

Table - 19 Influence Of Micro Nutrients On Dependent Variables

S.No		ANDAKUDI (I)				DEVIPATTINAM (II)				COMBINED (I+II)			
		Zn	Fe	Mn	Cu	Zn	Fe	Mn	Cu	Zn	Fe	Mn	Cu
1	Electrical Conductivity	+ve	-ve	-ve	+ve	-ve	-ve	+ve	-ve	+ve	-ve	-ve	+ve
2	pH	-ve (1.4)	-ve	-ve (0.17	+ve	-ve (2.5)	-ve	+ve	-ve	-ve (3.2)	-ve	-ve (0.19)	+ve
3	Organic matter	+ve (1.99)	-ve	-ve	+ve	+ve (1.90)	+ve	+ve (0.19)	-ve	+ve (2.2)	+ve	+ve	-ve
4	Nitrogen	+ve	+ve (7.6)	+ve (8.46)	+ve	+ve (45.46)	+ve	+ve	+ve	+ve	+ve	+ve (14.06)	-ve
5	Phosphorus	+ve	+ve (82.97)	-ve	+ve	+ve (46.84)	+ve	+ve	-ve	+ve (55.22)	+ve	-ve	+ve
6	Potassium	+ve (56.88)	+ve	+ve	-ve	-ve	-ve	+ve	+ve (437)	+ve	+ve	+ve	+ve

Fig. 5 Empirical model showing the influence of micronutrients on pH, OM, N, P and K (Pooled Data - Table - 19)



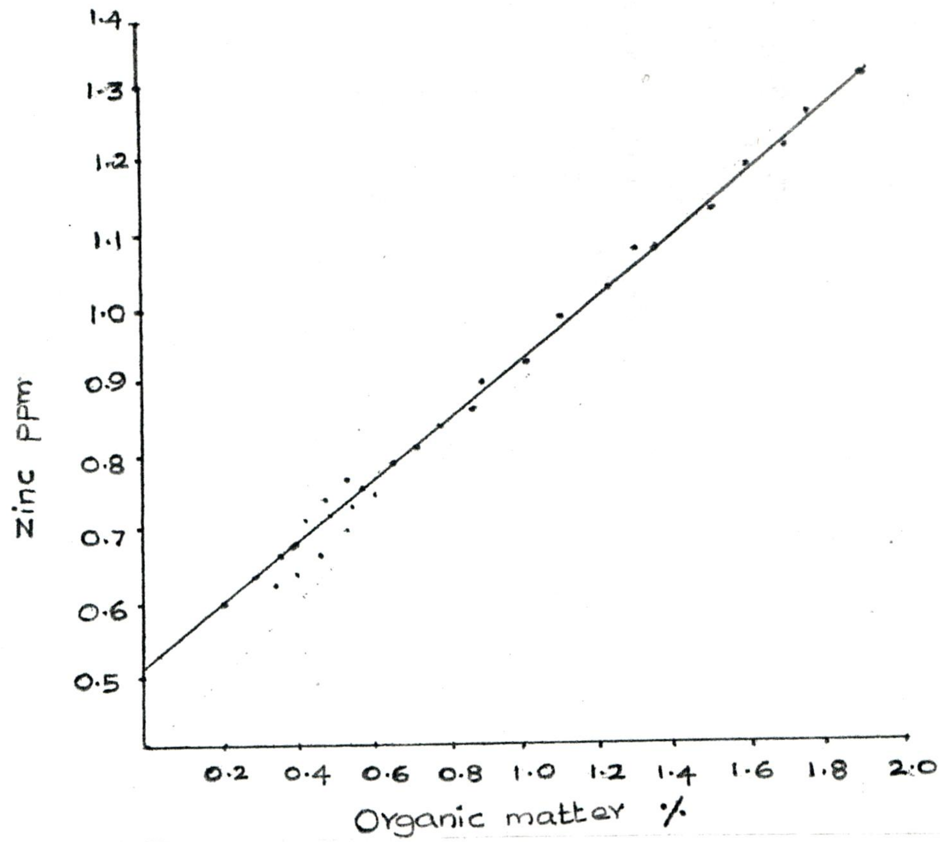


Fig. 6. Graph showing Influence of Zinc with Organic matter.

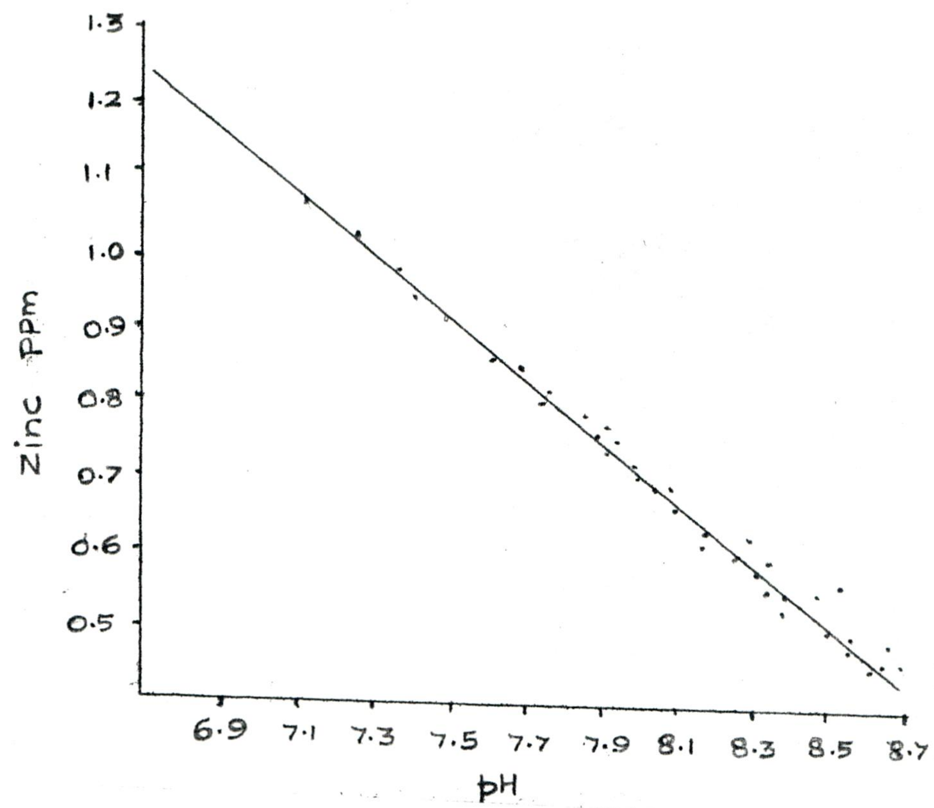


Fig.7. Graph showing Influence of Zinc with pH.

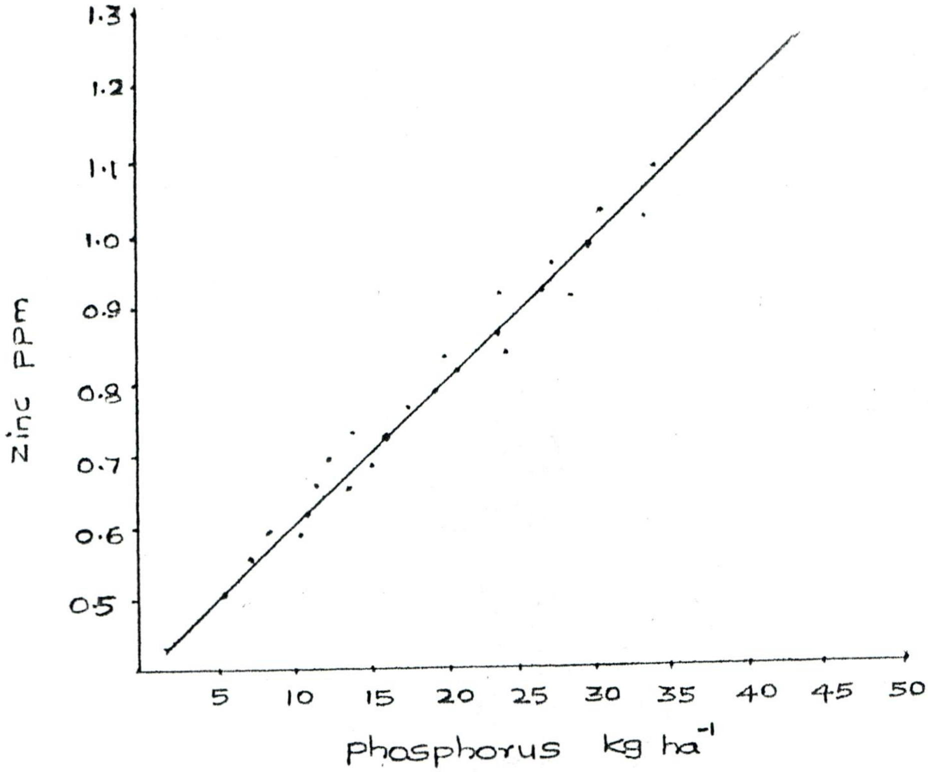


Fig.8. Graph showing Influence of Zinc with Phosphorus.

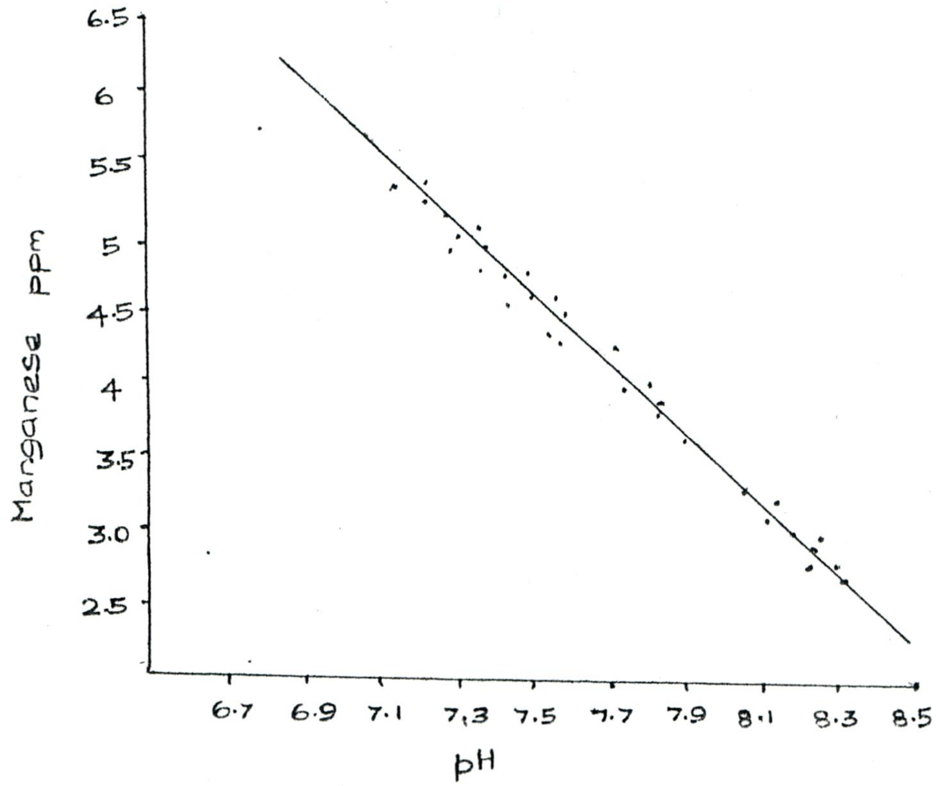


Fig.9. Graph showing Influence of Manganese with pH.

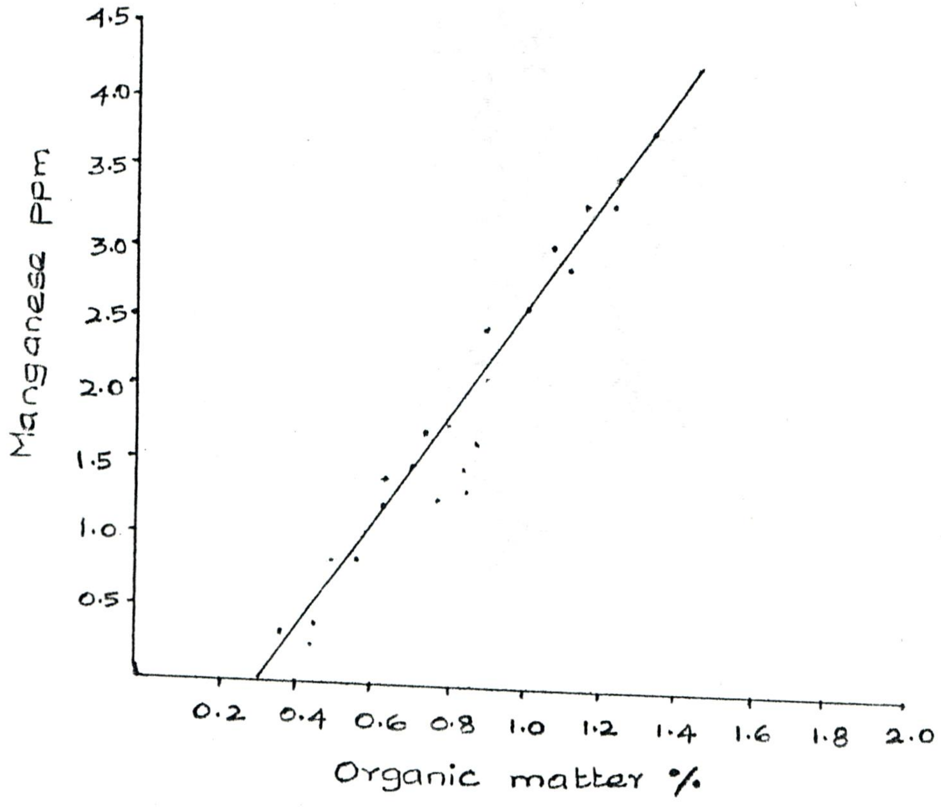


Fig.10. Graph showing Influence of Manganese with Organic matter.

The various critical limits for each of the parameters and specific recommendations arising out of the study that might be put forward are furnished in the Table -20.

Table - 20 Critical limits and Recommendations

S. No	Param-eters	Critical limits	No. of Samples below C.L	Recommendations	Mode of soil
1	E.C	3.0 mmhos/cm	-	Leaching of soluable salts with water	Soil
2	pH	> 7 <7	4.7 3	Addition of gypsum Liming of Soils	Soil
3	OM	-	-	Application of FYM, Compost, Green manure, Press mud, Bio fertilizer	Soil
4	N	Low Medium High	50	Application of straight nitrogeneous fertilizer like Urea, Ammonium sulphate, Ammonium sulphate nitrate, Calcium, Ammonium nitrate + Biofertilizers (Asospyrillum/Rhizobium) recommended doses of phosphate fertilizers	Soil
5	P	Low Medium High	21 12	Application of (super phosphate, Diammonium phosphate) with biofertilizer (Phospho bacteria)	Foliar, Soil
6	K	Low Medium High	2	Application of potassium chloride	Foliar, Soil
7	Zn	1.2	48	Application of Zinc Sulphate	Foliar, Soil
8	Fe	3.7	10	Application of Ferrous sulphate	Foliar, Soil
9	Mn	2.0	19	Application of Manganous sulphate	Foliar, Soil
10	Cu	1.2	48	Application of copper sulphate	Foliar, Soil

4.8. An Integrated Approach

The findings of the correlation and regression studies pertaining to micro and macro nutrients brought about the importance of the use of micronutrients in the balanced nutrition. There is an urgent need to improve the deteriorating soil fertility so as to enable the poor farmers to attain atleast a normal crop.

Though some recommendations are possible for the deficiency of the parameters EC, pH, OM, N,P,K, Zn, Fe, Mn and Cu in the field level such applications could not be practical and economically feasible. Hence an integrated approach would be sought for.

An integrated approach is suggested based on the available findings, past research reviews and crop production schemes, those are implemented in the districts by the Agricultural Department in the following systematic manner (Table - 21).

A) Input supply to the farmers through agricultural extension centres and co-operative institutions at subsidised rates.
B) Analytical system extending laboratory facilities for analysis- Free service approach.
C) Quality control system - sampling by fertilizer inspectors and following legal action
D) Training programmers to improve and mobilise Human Resource.
E) Mass media support to augment training programmes.

Table - 21 An Integrated Approach To Improve The Fertility Status Of Soils Of Ramanathapuram

A	B	C	D	E
Input supply system	Analytical	Quality control system	Training programmes	Mass media support
* Straight NPK, Complex and mixed fertilizers * Crop based multi micronutrients for full recommended doses. * Green manure seeds * Bio Fertilizers * Soil amendment (Gypsum) * Soil ameleorants (lime) * Soil conditioners to improve physical, biological properties (preparing enriched farm yard manure Coir pith compost ./ Vermi compost) * Tree seedings for Alley cropping	* Soil analysis * Water analysis * Micronutrient analysis * Fertilizer analysis	Sampling in sale points by fertilizer inspectors * Fertilisers * Micronutrients * Soil amendments * Licencing and renewal * Legal action	* Reseach workers * Analysts * Extension Functionaries * Farmers	* Television * All India Radio * Seminars * Campaigns * Print media * Demonstration * Model forms in reseach stations * Field days * Study hours

The Agricultural Research System along with Extension Functionaries should play a major role in making the farmers to have a clean, complete understanding on the use of multi micronutrients along with the major N,P,K fertilizers to reap a good crop. The field functionaries should be given proper training at all levels.

CHAPTER 5

Summary and Conclusion

SUMMARY AND CONCLUSION

With a view to correlate the micronutrients and macronutrients of the soils of Ramanathapuram district, twenty five samples each from Andakudi, and Devipattinam villages of Paramakudi and Ramanathapuram taluk were collected at a depth of 23 cms. Considering it as a dry and ecnomically backward area prone to frequent drought and also the cropping pattern with annual crops. The samples were analysed for EC, pH, organic matter, macro and micronutrients. The data were subjected to statistical tools like mean, correlations and multiple regressions. The findings are furnished below.

- EC was more in Devipattinam than Andakudi.
- pH of soil revealed a neutral to alkaline reaction except 4 samples which were found to be acidic.
- The organic matter content was found to be low in both areas.
- The nitrogen content was under the low fertility status.
- The phosphorus content fell under three groups. viż., low, medium, and high. Out of 50 samples 22 were low, 12 were medium and 16 were found to be high.
- The potassium content was high.
- The micronutrient content revealed that out of 50 samples, 48 samples of Zn and Cu, 10 samples Fe and 19 samples of Mn were below the critical limits.
- Correlation studies of EC revealed no significant association . pH showed a negative association with all macro and micronutrients. OM, N, P & K claimed a positive significant association with all other parameters.

- Regression estimates exhibited a non significant influence. A negative significant influence was exerted by pH with Zn and Mn. An impressive positive significant influence was encountered by OM with Zn and Mn. N influenced significantly with Zn, Fe and Mn while P and K reflected a positive significant influence with Zn and Mn respectively.

Though recommendations could be possible for the deficient nutrients , it is not economically feasible. An attempt has been made to integrate various aspects to improve the fertility status of soils of Paramakudi and Ramanathapuram taluk of Ramanthapuram district in the following manner.

1. Input supply system
2. Analytical system
3. Quality control system
4. Training programme
5. Mass media support.

BIBLIOGRAPHY

Agarwal, R.R., J.S.P.Yadav., R.N.Gupta (1995). **Saline and alkali soils of India .**

Anbazhagan, S., (1994). Studies on profile development in relation to toposequence in lateritic soils of Thanjavur district and strategies for resources management. **Unpub. M.Sc.,(Ag).Thesis**, TNAU, Coimbatore.

Anonymous., (1994). Status of Copper, Zinc, Lead , Iron and Manganese, Trace Metal Studies on soils of the Nigerian Coastal Plain Sands. **Jr. Soils and Crops.**

Anonymous., (1995). Pub.by Institute for Micronutrient Technology, Pune.

Anonmyous., (1997). Notes on Discussions. "**Scientific Workers Conference**" held in June 1997. TNAU, Coimbatore.

Appavu, K., and U.S. Sree Ramulu. (1981). Forms of Zinc and their distribution in some soil profiles of Tamil Nadu. **Madras Agricultural Jr**., **68:** 323-334.

Appavu, K., and U.S. Sree Ramulu.,(1990). Distribution of manganese in soils. **Madras Agric.Jr.,** 77:320-325.

Appavu, K., and U.S. Sree Ramulu.,(1991a). Distribution of copper in soils. **Madras Agric.Jr., 78:**182-185.

Appavu, K., and U.S. Sree Ramulu(1991b). Forms of iron and their distribution in some soil profiles of Tamil Nadu. **Madras Agric.Jr., 78:**186-187.

Aruna. L., (1994), Studies on decomposition and mineralisation of green manures under salt affected rice soils **Unpub. M.Sc. Thesis**, TNAU, Coimbatore.

Balasubramanian., (1994).**Paper presented during National Training on Organic Farming** held at TNAU, Coimbatore.

Bellakki, M.A., and V.P. Badanur(1994). Effect of Crop residue incorporati7on on physical and chemical properties of a Vertisol and yield of sorghum. **J. Indian Soc.Soil Sci., 42:**533-535.

Dhanabalan Mosi., and M.Jayadeesan, (1993). **Test your soil for getting higher yields**. Farm information unit, Directorate of Extension, Ministry of Agriculture New Delhi.

Dhane, S.S., and L.M. Shukla. (1995). Distribution of DTPA-Extractable Zn, Cu, Mn, and Fe, in some soil series of Maharastra and their relationship with some soil properties. **Jr. Indian Soc.Soil Sci., 43:**597-600.

Diwakar, D.P.S., and R.N.Singh. (1994a). Characterisation of soils of Diara land occuring in Gangetic Plains, Bihar. **Jr.Indian Soc.Soil Sci., 42:**420-425.

Diwakar, D.P.S., and R.N.Singh. (1994b). Characterisation, classification and productivity potential of Vertisols and associated soils of Bihar. **Agropedology, 4:**19-30.

Fisher, R.A., (1936). **Statistical Methods for Research Workers**. Oliver and Boyd, London.

Goyal, V.P., and Mahendra Singh (1986). Pedogenic characterisation of the soils of different land forms in a part of south Haryana. 51st Annual Convention. **Jr.Indian Soc.Soil.Sci., 207**.

Jackson, M.L., (1973). **Soil Chemical Analysis**. Oxford IBH Publishing Co., Bombay.

Jayakaran, C.,(1994). **Paper presented during national training on organic farming** held at TNAU, Coimbatore.

Jeevan Rao, K., and R.C. Dakhore, (1993), Effect of long term application of Potassium, Phosphorous and Farmyard manure on micronutrient status of vertisols of Akola, **Jr.of Soils and Crops**.

Kaistha, B.P., R.P.Sood and B.S.Kanwar., (1990). Distribution of surface applied chloride in a montmorillonitic clay soils. **Jr.Indian Soc.Sci., 38:**15-20.

Kannan, N., and K.K. Mathan.,(1994). Iron, Manganese, Zinc and Copper contents of selected watersheds in hilly region of Tamilnadu. **Madras Agric.Jr. 8:**512-514.

Katyal, J.C., and B.J.Sharma. 1991. DTPA-extractable and total Zn, Cu, Mn and Fe in Indian soils and their association with some soils properties. **Geoderma, 49:** 165-179.

Kempu Chetty, N., (1997), **Organic farming, Reading material of Rabi Pre season Training Programme** held on Kudimiyanmalai in July 1997.

Kodhandaraman, G.V., and K.K.Krishnamoorthy,(1977). Disribution of inorganic P fractions in Tamilnadu soil. **Madras Agric.Jr., 64:**516-521.

Krishnasamy,R., M.Shanmugam, S. Poongothai, K. Valliappan, S. Mani, Mallika Vanangamudi, P. Savithiri and R. Devarajan. 1994. Twenty Five years of micronutrients research in soils and crops of Tamilnadu, 1967-92. **Report published by the Department of Soil Science and Agricultural Chemistry, TNAU,** Coimbatore.

Lakshmi Narayanan.S., (1992). **Paper Presented during state level Pre-Rabi season compaign** at STAMIN, Kudimiyanmalai.

Lindsey, W.L., and W.A.Norwell, (1978). Development of a DTPA soil test for Zinc, Iron, Manganese and Copper. **Jr. Soil Sci.Soc.Am.Proc., 42:**421-428.

Mayalagu, K., (1971). Investigation of morphological, physical, chemical and biological properties of nine major soil series of Coimbatore district, Tamilnadu **Unpub.M.Sc.,(Ag) Thesis**, TNAU, Coimbatore.

Mayalagu, K and P. Paramasivam., (1992). Soil survey and evaluation for land use interpretative grouping - Horticultural Reseach Station Farm, Periyakulam. **Unpub.Madras Agric.Jr.79:** 614-619.

Mayalagu, K and P.Paramasivam.,(1994a). Major nutrients status of Kothakottai series of Sivagangai, **Madras Agric.Jr.81(1):**39-40.

Mayalagu, K., and P.Paramasivam., (1994b). Sand grain mineralogy of Padalus series in Lateriticsoil tract of Sivagangai taluk, Tamilnadu,**Madras Agric. Jr. 8:** 347-348.

Mayalagu, K., and M.Peer Mohammed, (1992). Micronutrient status of Subramaniyapuram soil series, **Madras Agric.Jr.79:** 467-470.

Mohr, G.R., N.P.Datta, H.Sankarasubramoney, V.K. Leley and R.L. Donahus. (1995). **Soil testing in India**. 2nd Ed., U.S. Agency for International Development Mission to India, New Delhi.

Moosa Sherriff, M, and G. Dharmaraj.,(1993). **Training manual on Pulses Production Technology, TNAU**, Coimbatore.

Murthy, IYLN., T.S.Sastry, S.C. Datta, G.Narayanaswamy and P.K.Rattan, (1994). Characterisation and Classification of Vertisols derived from different parent materials. **Agropedology, 4:**100-105.

Natesan, S., (1995). **Compenduim on multimicronutrient fertiliser in India**, Pub by Indian micro fertilisers manufactures Association, Pune.

Olsen, S.R., C.V. Cole, F.S. Watanabe and L.A. Dean. (1954). Estimation of available phosphorus in soils by extraction with sodium bicarbonate. **Circ. U.S. Dept. Agric., 939**.

Pachrane, T.R., D.K. Pal and S.P. Deshpande., (1996). Genesis and transformation of clay minerals in the formation of ferruginous inceptisols and Vertisols in Saptadhara water shed of Nagpur District. **Jr. Indian Soc.Soil Sci. 44:** 300-309.

Paramasivam, P., and A.Gopalasamy. (1994a). Morphology genesis and classification of some red soils of Lower Bhavani Project of Tamilnadu. **Madras Agric.Jr.,81:** 483-486.

Paramasivam, P., and A. Gopalaswamy. (1994b). Distribution of micro nutrients in Lower Bhavani Project Command area soil profiles. **Madras Agric.Jr. 81:**545-547.

Palaniappan and Siddeshwaran., (1994). **Papers presented during Scientific Workers Conference** held in June 1997 at TNAU, Coimbatore.

Palniswamy, S., (1994). **Paper presented in the state level Khariff Pre Season Campaign** held at Kudumianmalai.

Raghupathy, H.B., and N. Vasuki (1993). Relationship of available copper with total copper in some vertisols. **Jr.Indian Soc.Soil Sci**. **41:** 569-571.

Ramachandran, T.K., (1994). **Paper presented in the State Level Khariff Preseason Campaign** held at Kudimiyanmalai in June 1994.

Ramesh, V., K.H. Rao, R.N. Pillai, T.R. Reddy and Appa Rao, (1994). Correlation between soil chemical properties and available nutrients in relation to soil fertility. **Jr. Indian Soc.Soil Sci., 42:** 322-323.

Saha, P.K., S. Adhikari and D.K. Chatterjee, (1996), Available Iron, Copper, Zinc and Manganese in some fresh water pond soils of Orissa in relation to soil characteristics. **Jr.Indian Soc.Soil Sci., 44:** 681-684.

Sambandamoorthy, S., (1995). Theme paper on 'Dryland and wasteland development for fruit production' presented in the **Scientific workers conferences** held on 22/5/96.

Santhirani, V., M.Duraipandian, K.Krishnamoorthy and S.S. Subramanian, (1994). **Soils of Ramanathapuram district, Soil survey and land use Organisation.** Palayamkottai.

Savithri, P.(1978)., Studies on the effect of micronutrient fertilisation on the availability of nutrients in soils and their uptake in a cropping system. **Unpub.Ph.D.Thesis**, TNAU, Coimbatore.

Swaminathan, M.S., (1995). Foreward note to the **Compendium on multimicro- nutrient fertilisers in India, Indian Microfertilisers Manufacturers Association**, Pune.

Sharma, S.P., P.D. Sharma, S.P. Singh and R.S. Minhas., (1994). Characterisation of soan river valley soils in lower shivaliks of Himachal Pradesh II. Piedmont and Flood Plain soils. **Jr.Indian Soc.Soil Sci., 42(1):**105-110.

Siddhamalai, A., (1997). Characterisation of major soil series of Thanjavur District for physical and chemical properties. **Unpub. M.Sc., (Ag) Thesis**, TNAU, Coimbatore.

Sidhu, P.S., Rajkumar and B.D. Sharma.(1994) Characteristics and Classification of Entisoles in different soil moisture regimes of Punjab. **Jr Indian Soc.Soil., 42:**633-640.

Singh, J.P., D.J. Dahiya, Vinod Kumar and Mahendra Singh (1992). Distribution and status of different forms of nitrogen in soils of Haryana. **Jr.Indian Soc.Soil Sci., 40:**698-704.

Srivastava, A.K., and O.P. Srivastava, (1993). Forms of nitrogen in relation to pH. **Jr.Indian Soc.Sci., 41:** 551-553.

Stanford, D., and English(1949). Use of flame photometer in rapid soil tests of K and Ca, **Agron, Jr., 4:**446-447.

Subbiah, B.V., and G.L. Asija. (1956). A rapid procedure for estimation of available nitrogen in soils.

Tandon, H.L.S., (1994) **Dictonary of soil fertility, fertilisers and intergrated nitogen management.**

Tandon, H.L.S., (1995). **Fertiliser development and consultation organisation**, Enclave New Delhi.

Thiagarajan, T.M., (1978), Physico - Chemical appraisal of selected soil profiles, **Unpub. M.Sc.,(Ag) Thesis,** TNAU, Coimbatore.

Velayutham, K.S., (1974). Studies on the nature and properties of salt affected soils and their improvement. **Unpub. M.Sc.,(Ag) Thesis,** TNAU, Coimbatore.

Walkey, A.J., and C.A. Black,(1934). An estimation of Degtrareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. **Soil Sci., 37:** 29-38.

APPENDIX - I

Estimation Of Organic Matter

Principle

The organic matter (humus) in the soil is oxidised by chromic acid (potassium dichromate and concentrated Sulphuric acid). utilising the heat of dilution of sulphuric acid. The unreacted dichromate is determined by back titration with standard ferrous ammonium sulphate.

Procedure

One gram of soil was ground and passed through 0.2 mm sieve, added with 20ml of Con. Sulphuric acid in a conical flask; allowed for 30 minutes. Added 200 ml distilled water and 10 ml of 85% phosphoric acid. Titrated with 0.5 N ferrous ammonium sulphate till the colour flashes from bluish violet to green, using Diphenyl amine indicator. Run a blank with out the soil sample.

Calculation

1cc N $K_2Cr_2O_7$ = 0.003 gm of C

$$\text{Organic carbon \%} = \frac{10(B-T)}{B} \times 0.003 \times \frac{100}{\text{Weight of soil}}$$

$$= \frac{B-T}{B} \times 3$$

B = Volume of ferrous ammonium sulphate required for blank titration

T = Volume of ferrous ammonium sulphate required for soil sample.

Weight of Soil = 1 gm.

APPENDIX II

Estimation Of Nitrogen

(Alkaline Permanganate Method)

Principle

The method involves distilling the soil with alkaline potassium permanganate solution and determining the NH_3 liberated which serves as an index of the Nitrogen status.

Procedure

30 gms of soil was taken in a dry kjeldahl flask; added 20 ml of distilled water followed by the addition of 100 ml of 0.32% potassium permanganate solution (16 mg/lit) and 100 ml of 2.5% Sodium hydroxide solution. Distilled the contents at a steady rate and collected the liberated ammonia in a conical flask containing 20ml of 2% boric acid. Collected 100 ml of the distillate in 30 minutes. Titrated with N/50 sulphuric acid (0.6 ml in 1 litre of water) with double indicator. (Methyl red and Bromo Cresol green dissolved in alcohol). A blank was run without the soil.

Calculation

$$\text{Nitrogen 1} = R \times 0.00028 \times \frac{1000}{20} \times \frac{1000000}{1000}$$

$$= R \times 14 \text{ Kg / ac.}$$

$$R = \text{Titre value}$$

APPENDIX - III

Estimation Of Phosphorus

Principle

Phosphorus is estimated colorimetrically by adding ammonium. molybdate and reducing the Molybdenum Phosphate complex in acidic medium. The intensity of blue colour on reduction provides a measure for the concentration of phosphorus in the best solution.

Preparation Of Solutions

12 gms of ammonium molybdate (AR) was dissolved in 250 ml of distilled water. 0.291 gm of antimony potassium tartrate (AR) was dissolved in 100 ml of distilled water. Both these solutions in 100 ml added to 1000 ml of 5N sulphuric acid and thoroughly mixed; made upto 2 litres with distilled water thus forming reagent A. Reagent B was prepared by dissolving 1.056 gm of ascorbic acid (AR) in 200 ml of reagent A.

Procedure

To 5 gm of soil, 50 ml of reagent B was added, followed by the addition of activated carbon. The contents were shaken for 30 minutes and filtered through Whatman No.1 filter paper. The filterate was collected discarding the turbid solution.

Colour Development

5 ml of the filtrate was acidified with 5N sulphuric acid, diluted upto 20 ml in a 25 ml; volumetric flask; 4 ml of reagent B was added and made upto the mark. After 10 minutes measured the intensity of the blue colour in a photoelectric colorimeter using 730-840 nm filter (red filter).

Standard Curve For Phosphorus

4.393 gms of AR potassium dihydrogen ortho phosphate was dissolved in 1 litre distilled water which gives 1000 ppm phosphorus solution. From that prepared solutions for 0.05, 0.1, 0.15,0.2 upto 0.5 ppm dilution. Added 5 ml Olsen extractant, developed colour and read the colour in the colorimeter. Plotted the curve taking the colorimetric reading on the vertical axis and amount of phosphorous in the horizontal area.

Calculation

$$\text{Phosphorus} = R \times \frac{50}{5} \times \frac{25}{5} \times \frac{10^6}{10^6}$$

$$= R \times 50 \text{ Kg/ac.}$$

APPENDIX IV

Estimation Of Potassium

Principle

When soil is treated with neutral ammonium acetate, the ammonium ion replaces potassium ion of the soil and bring into the solution. The estimation of potassium is carried out with the help of flame photometer.

Preparation Of Solutions

Ammonium acetate - 77 gms was dissolved in 900 ml of distilled water and adjusted the pH to 7 with ammonia or acetic acid and made upto 1 litre with distilled water.

Procedure

To 5 gm of soil added 25 ml of extractant shaken for 5 minutes and filtered through Whatman No.1 filter paper. Measured the amount of potassium in the filtrate in the Flame photometer.

Standard Curve For Potassium

1.9074 gm of potassium chloride (AR) was dissolved in 1 litre which gave 1000 ppm potassium stock solution. Dilutions were done to get 10,20,30... 100 ppms. The reading was taken in the flame photometer. Plotted the curve taking the flame photometer readings in the vertical axis and the amount of potassium in the horizontal axis.

Calculation

$$\text{Potassium} = \frac{\text{Rx Vol.of the extractant} \times 10^6 \text{ Kg/ac}}{\text{Wt of soil taken} \times 10^6}$$

R = ppm of potassium in the extractant

APPENDIX - V

Estimation of DTPA Extractable Soil Available Micronutrients

Principle

DTPA soil is the best chelating agent offered great promise for assessing readily available micronutrient cations in soils.

Preparation of DTPA extract solution

Dissolved 149.2 gm of AR {$(OHCH_2CH_2CH_2)_3N$ (TEA)}, 19.67 gm of diethylene triamine penta acetic acid (DTPA) and 14.7 gm $CaCl_2$ $2H_2O$ in 200 ml distilled water. Diluted. pH was adjusted to 7.3(+/-) 0.05 with 4:1 Hydrochloric acid while stirring and made upto 10 litres.

Preparation of Standard Solution.

Zn (100 ppm)	- 0.4398 gm of $ZnSo_4$. $7H_2O$ + 1 ml 10% sulphuric acid in 1 litre.
Fe(1000 ppm)	- 0.702 gm of ferrous ammonium sulphate + 5 ml sulphuric acid (10%) in 1 litre.
Mn(1000 ppm)	- 3.0673 gm of $MnSo_4$ in 1 litre.
Cu(100 ppm)	- 0.3929 gm of $CuSo_4.5H_2O$ + 1 ml of 10% sulphuric acid in 1 litre.

Procedure

10 gm of soil was taken in 200 ml polythene shaking bottle, 20 ml of DTPA extract was added (1:2 ratio) and shaken for 2 hours; filtered through Whatman No.-1 filter paper. The extract was collected in vials and fed to the atomic absorption spectro photometer for the determination of concentration of Zinc, Iron, Manganese and Copper in the soil solution. For each element a series of dilutions were prepared and fed to the atomic absorption spectrophotometer and readings noted.