

**CHARACTERIZATION OF THE SOILS IN HORTICULTURAL FARM OF
PANDIT JAWAHARLAL NEHRU COLLEGE OF AGRICULTURE AND
RESEARCH INSTITUTE, KARAİKAL**

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TAMIL NADU AGRICULTURAL UNIVERSITY**

2009

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Thesis submitted in part fulfillment of the requirements for the Degree of
Master of Science (Agriculture) in Soil Science and Agricultural Chemistry
to the Tamil Nadu Agricultural University, Coimbatore

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CERTIFICATE

This is to certify that the thesis entitled “**Characterization of the Soils in Horticultural Farm of Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal**” submitted in part fulfillment of the requirements for the award of the degree of **Master of Science** (Agriculture) in **Soil Science and Agricultural Chemistry** to the Tamil Nadu Agricultural University, Coimbatore is a record of *bonafide* research work carried out by **Mr.P.RAJAMANI** under my supervision and guidance and that no part of this thesis has been submitted for the award of any other degree, diploma, fellowship or other similar titles or prizes and that the work has not been published in part or full in any scientific or popular journal or magazine.

Place: Karaikal

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(Dr. K. PARAMASIVAM)

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“What shall I render to the lord for all his benefits towards me?

Oh, give thanks to the lord for

He is good! For his mercy endures forever”

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(P.RAJAMANI)

ABSTRACT

CHARACTERIZATION OF THE SOILS IN HORTICULTURAL FARM OF PANDIT JAWAHARLAL NEHRU COLLEGE OF AGRICULTURE AND RESEARCH INSTITUTE, KARAİKAL

By

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An investigation was carried out in the farm soils of Horticultural Department, Pandit Jawaharlal Nehru College of Agriculture and Research Institute, with the purpose of characterizing the soils in order to identify the constraints restricting the crop growth. For this purpose, eleven soil profiles were dug from each of the block of the horticultural farm, from which a total number of 62 soil samples were collected and the profiles were morphologically described *in situ*. Similarly, surface soil samples were also collected in duplicate from each of the fields, numbering 53 to delineate the soils based on their properties. The soil samples collected from the different horizons of profile and that of the surface soil samples were subjected to various physical, chemical and physico chemical properties by adopting standard procedures of determination. The results thus obtained were statistically scrutinized and subjected to simple correlation and multiple regression analysis to draw valid conclusions.

The results of the investigation had shown that the soils of the horticultural farm belonged to Kottucherry and Thirunallar soil series, taxonomically Ustic Quartzipsamment and Typic Chromustert respectively. The Thirunallar soil series comes under the soil order Vertisol and are found to be very deep, clayey, moderately well drained to imperfectly drained with moderately slow to slow permeability. The

occurrence of mottles just below the surface had shown that these soils are poorly drained during the monsoon periods and the irrigation spell from the river Cauvery. The impeded drainage is most related to the location of the soil in a flat plain resulting in poor disposal of the run off water. On the contrary, the Kottucherry soil series is mostly sandy, sandy loam or sandy clay loam, making it more drainable than the Thirunallar soil series. However, the occurrence of mottles in the Kottucherry soil series down in the profile had indicated that the poor drainage in these type of soils might be due to not only its occurrence in a flat plain but also the rising of water table near the surface during the rainy season and river water flow.

A close scrutiny of the soil physical properties like bulk density, particle density and total porosity had shown that there were no extreme values in any of the field samples so as to classify them as problematic one. The other soil physical properties like soil moisture content and loss on ignition had shown that these properties are dependent on organic matter and clay content as established by the simple correlation and multiple regression analysis. Furthermore, it was established that there is a significant and negative relation between bulk density and clay content which indicated that heavier the soil lower was the bulk density. Similar results were obtained in the case of total porosity, wherein a positive and significant contribution was established in the multiple linear analysis.

The soil textural analysis of the profile soil samples had shown that, the clay content ranged from 2.40 to 52.90 per cent, the silt content ranging from 1.25 to 29.35 per cent, the coarse sand content ranging from 5.24 to 71.80 per cent and the fine sand content from 2.84 to 81.75 per cent. The wide variations in the relative distribution of sand, silt and clay was attributed to the differential deposition of river alluvium over a period of time coupled with the pedoturbation which occurred during the layout of the horticultural farm.

The soil reaction and the salinity of the horticultural farm soils were found to be within the optimum levels. For instance, the profile soil samples recorded the pH value of 7.54 to 8.98 and that of the surface soil samples from, 5.21 to 8.75. The higher values of pH in a few samples was attributed to the irrigation with sodium rich ground water and the lower values was attributed to the precipitation of iron with

sulphur, forming pyrites, which upon oxidation reduce the soil pH. The salinity of the saturation paste extract, however, did not show values above 4 dS m⁻¹ and hence, classified as non-saline.

The results of organic carbon status had shown that it varied from 0.30 to 10.40 g kg⁻¹ in the profile soil samples and in the surface soil samples it ranged between 3.20 to 13.60 g kg⁻¹. Based on this results it was inferred that most of the soils contained medium to high status of organic carbon.

The CEC values of the profile soil samples ranged between 3.50 to 31.70 cmol (p⁺) kg⁻¹ and from 5.70 to 65.20 cmol (p⁺) kg⁻¹ in the surface soils. The correlation and regression analysis had clearly indicated that the source of negative charges for this cation exchange property is mainly contributed by clay and not the organic matter. Among the different cations, Ca²⁺ dominated in most of the soils on the exchange sites followed by Mg²⁺, Na⁺ and K⁺.

As regards the total nutrient status, the total N ranged from 0.019 to 0.53 per cent in the profile soil samples and from 0.06 to 0.80 per cent in the surface soil samples. The corresponding values for P, K, Ca, Mg and Na were 0.023 to 0.206 per cent and 0.025 to 0.220 per cent, 0.003 to 0.229 per cent and 0.024 to 0.264 per cent, 0.150 to 0.841 per cent and 0.205 to 1.080 per cent, nil to 0.348 per cent and nil to 0.522 per cent and 0.025 to 0.149 per cent and 0.044 to 0.124 per cent in profile and surface soils respectively. It was revealed that the total N and P contents were more related to organic matter, whereas the total K is influenced by the clay content.

The available nutrient status of the horticultural farm soils had shown that the KMnO₄-N ranged between 4.70 to 131.70 kg ha⁻¹ in the profile and from 56.45 to 189.73 kg ha⁻¹ in the surface soil samples. As per the classification, it was found that all the soils are low in available N status. With respect to available P, the profile soil samples contained 2.64 to 12.61 kg ha⁻¹ and in the surface soil samples it contained 12.84 to 77.91 kg ha⁻¹. It was inferred that 9.5 per cent of the soils were possessing medium status of available P and the remaining 90.5 per cent of the soil contained higher P status. The available K ranged between 10.68 to 276.46 kg ha⁻¹ in the profile soils and from 170.96 to 496.84 kg ha⁻¹ in surface soil samples. It was inferred that

67.92 per cent of the soils were rated as medium and 32.08 per cent samples were rated as high in their available K status. As for as the available S status was concerned, it ranged between 1.24 to 157.13 mg kg⁻¹ in the profile soil samples and from 6.33 to 29.10 mg kg⁻¹ in the surface soil samples. It was concluded that 17.00 per cent of the soil samples were rated as deficient with respect to available S status.

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Symbols / Notations and Abbreviations

mg	-	Milligram
g	-	Gram
kg	-	Kilogram
ppm	-	Parts per million
dS m ⁻¹	-	Deci Siemen per metre
Mg m ⁻³	-	Megagram per meter cube
cmol (p ⁺) kg ⁻¹	-	Centimole of positive charges per kilogram
cmol (p ⁻) kg ⁻¹	-	Centimole of negative charges per kilogram
t	-	Tonne
Mt	-	Million tonnes
M ha	-	Million hectares
ha	-	Hectare
cm	-	Centimetre
EC	-	Electrical conductivity
C	-	Carbon
N	-	Nitrogen
P	-	Phosphorus
K	-	Potassium
Ca	-	Calcium
Mg	-	Magnesium
S	-	Sulphur
Na	-	Sodium
Zn	-	Zinc
Fe	-	Iron
Cu	-	Copper
Mn	-	Manganese
B	-	Boron
Mo	-	Molybdenum
CO ₃ ²⁻	-	Carbonate ion

Cl ⁻	-	Chloride ion
SO ₄ ²⁻	-	Sulphate ion
DTPA	-	Diethylene Triamine Penta Acetic acid
CEC	-	Cation exchange capacity
c	-	Clay
scl	-	Sandy clay loam
sl	-	Sandy loam
ls	-	Loamy sand
BD	-	Bulk density
PD	-	Particle density
TP	-	Total porosity
LOI	-	Loss on ignition
OC	-	Organic carbon
R ₂ O ₃	-	Sesquioxide
%	-	Per cent
>	-	More than
<	-	Less than
r	-	Co-efficient of simple correlation
C.V	-	Co-efficient of variation
R ²	-	Regression co-efficient
HCO ₃ ⁻	-	Bicarbonate ion

CHAPTER 1

INTRODUCTION

India occupies a landmass of 329 million hectares (Mha), area-wise ranking seventh in the world. The population position is next to China with 1012 million people (GOI, 2000). Ominous signs are that by 2050 India will become the most populous nation of the world (UNDP, 1998). India also remains as one of the very densely populated (304 person km⁻²) regions of the world with 17 per cent of the world population (~6 billions) and only 2.5 per cent of the world area.

During the last 50 years, population of India has grown at a rate of 2.15 per cent per annum (~13 million persons per year in an average with a range of 8 to 18 million persons per year). It is predicted that when compared to 2001, in 2020, population of India will raise by about 300 million more people, a gain of 30 per cent (UNDP, 1998). This will necessitate raising the current food grain production of 202 Million tonnes (Mt) to about 260 Mt in 2020. The major constraint which prevent such a daunting task is the limited extent of land availability, which has shrunken from 0.34 ha per person during 1950 to 0.14 ha per person in 2000 and it is expected that this will go down to 0.10 ha per person in the year 2025 (Tiwari, 2002). Even though enough food grains may become available, the widespread poverty will constrain their accessibility to many. Presently, one-third of the inhabitants are poor and equal number is food insecure also (FAO, 1999). In fact, India tenants the largest number of poor and malnourished people in the world.

As per the 1991 census, for 59 per cent (35 per cent land holders and 24 per cent landless workers) of the India's work force, agriculture remains the prime source of employment. Over the years, proportion of agriculture dependent population has not changed to that extent (from 70 per cent in 1950 to 59 per cent in 1991), as has been the fall in contribution of agriculture to gross domestic product. Continuous dependence of large proportion of population puts severe strain on the health of natural resources.

India devoted 170 Mha cropped land area to agriculture in 1998 (cropped land, as per FAO classification, includes area under arable and permanent crops, temporary meadows, market and kitchen gardens and temporary fallows). It constituted 11.2 per cent of the world cropped area. Of the cropped land, 142 million hectare is net sown area, which has remained constant over the last 30 years (Katyal *et al.*, 1999). Compared to net sown area, the gross sown area has exhibited an increasing trend. Over the last 50 years, against 0.66 per cent rise in gross sown area, population has increased at a rate of 2.15 per cent.

However, mainly because of economic and environmental reasons, further increase of shifts in food grain area is less likely to occur. In contrast, flow of population (+16 to 17 m persons per year) will remain unrelenting. In order to meet the needs for more food (~3 mt additional food grains per annum) from a relatively fixed land area, intensive cultivation practices will become necessary.

Our Indian agriculture has made some spectacular development during the last four to five decades mainly from the introduction of green revolution. Increased food grain production could be attributed to the introduction of high yielding varieties or hybrids, improved fertilizer usage, adaptation of high level of technologies, introduction of irrigation to areas which were under dry land cultivation etc. It is also due to increase in cultivable area which were well supplied with water and nutrients (Singh *et al.*, 1990). Though such an upward trend has been noticed in the production of majority of crops, the trend on productivity has shown that the yield levels has almost reached a plateau and adaptation of any new technology did not result in the anticipated level of yield increase as it was achieved so far. The reason for the above is manifold. The first one is that the genetic improvement resulting in the yield improvement had reached the level of exploitation and the second and foremost reason is that the green revolution, which not only increased the yield levels to 3 to 4 fold in the initial periods but also resulted in deleterious effects on the soil and environment. Over exploitation in terms of cultivation as well as due to other non-agricultural uses has also resulted in serious decline in the soil health.

In any agricultural system, soil is the base material upon which the plants nourish. The condition of the soil with respect to its physical makeup, chemical composition and biological characteristics has got a greater and direct impact on the soil productivity. For instance, a plant needs optimum soil depth with all other physical and chemical characteristics within the permissible limits. Any deviation on either side of the optimum will result in the deterioration of productivity and without that property is made optimum, the technology transfer may not be fruitful. Hence, identification of that property or soil characteristic which could pose limitation to crop growth is the foremost concern which can be done by systematic study.

Such studies were conducted in the soils of Andhra Pradesh by Anitha *et al.* (2001), Misra and Saithantuaanga (2000) in Mizoram soil, and Jawahar *et al.* (1999) in Theri soils of Tamil Nadu. Similar studies were also conducted by Ramesh (2001) in the soils of Karaikal region, by Valliammal (2004) in PAJANCOA and RI Agricultural farm soils, and Karthik Kumar (2005) in the soils of Bahour commune of the union territory of Pondicherry. Such a study, not only used to identify the soil constraints in regional level or in district level but also used under micro level, *i.e.*, farm level and village level. Such in-depth study is not done so far in the Horticultural farm soils of PAJANCOA & RI, Karaikal. Hence, the present study is focused in Horticultural farm soils of PAJANCOA & RI with the following prime objectives.

1. To identify the soil constraints that limit the crop production in the soils of PAJANCOA and RI, Horticultural farm.
2. To investigate the physical, chemical and physico-chemical properties of the soils of PAJANCOA and RI, Horticultural farm.
3. To study the inter-relationship among the properties of soils of PAJANCOA and RI, Horticultural farm.
4. To categorize the soils of PAJANCOA and RI, Horticultural farm based on their nutrient status.

CHAPTER 2

REVIEW OF LITERATURE

Characterization of the soils of a region or a farm is a pre-requisite to identify the limitations, which affect the crop growth and productivity. This can be done by studying the soils in detail by knowing the morphological features, physical, chemical and physico-chemical properties of the soil. The results thus obtained can be suitably interpreted with local conditions and the type of crops grown in that area, so as to categorize the soils into low, medium or high productivity. Such a study should also aim to suggest measures or management technologies to improve and sustain the present level of productivity. This chapter discusses the above mentioned aspects with the available literature under the following headings:

2.1. Soil physical properties

- 2.1.1. Soil colour
- 2.1.2. Soil texture
- 2.1.3. Bulk density
- 2.1.4. Pore size distribution

2.2. Soil physico-chemical properties

- 2.2.1. Soil electrical conductivity
- 2.2.2. Soil reaction
- 2.2.3. Cation exchange capacity
- 2.2.4. Exchangeable cations
- 2.2.5. Water soluble anions and cations.

2.3. Soil chemical properties

- 2.3.1. Organic carbon
- 2.3.2. Macro nutrients
- 2.3.3. Secondary nutrients

2.1. Soil physical properties

The physical properties of soil decide not only the nutrient supplying ability but also the supply of air and water to plants (Harikrishnan Nair and Koshy, 1982). Soil productivity, though directly related to the chemical properties of the soil, like the content and the form of essential nutrients, the phenomena and the processes which regulate the nutrients to be made available to the crop growth are controlled by soil physical conditions, thereby directly influencing the crop growth. The anchorage of the plant, root penetration, aeration, drainage, moisture retention and also the biological behaviour of the soil are also determined by the physical properties.

2.1.1. Soil colour

Pendleton and Nickelson (1951) stated that the use of Munsell colour chart permitted reliable measurement of soil colour and the colour should be assessed under standard light conditions. The colour of the soil types depend on the degree of hydration, the red colour being associated with low hydration and yellow and orange colour with high hydration; all tropical soils have a hydrated ferric oxide and also red colour of the soil is due to presence of free iron oxides (Menon and Mariakulandai 1957; Patil and Dasog, 1999). The black colour of the soil may be due to the formation of organo clay complexes (Dudas and Pawluk, 1969) or due to the iron and titanium compounds and organic matter (Buol *et al.*, 1980) and dark brown colour of the soils is due to occurrence of iron oxides at various hydrated forms (Walia and Rao, 1996). Savithri and Rangasamy (1967) reported that hue was significantly correlated with moisture holding capacity, clay content and real specific gravity. Topography and drainage were responsible for colour difference (Yadav *et al.*, 1977). Altmuller and Poetsch (1986) were of the opinion that the red colour of the soils was due to oxidative weathering of limonite. The content of total ferric oxide in Alfisols increased with depth, which implied the enrichment of iron due to intense weathering and subsequent loss of bases due to their position of higher topography (Seshagiri Rao *et al.*, 1992)

Shyampura *et al.* (1994) attributed the non-hydrated state of iron oxide under high organic matter and excessive drainage to the dark reddish brown colour of the soils of

southern Rajasthan. In soils over a basaltic terrain in Rajasthan soils associated with elevated topography were redder (7.5 YR) which gradually became greyish (10 YR) down the slope. The reddish brown colour at higher topographic positions could be due to ferri-oxyhydrates formed due to excessive drainage (Sharma *et al.*, 1996). The subsurface horizons showed either constant or increased of chroma as compared to surfaces; free CaCO₃ had partly influenced the colour of the matrix (Singh and Mishra 1996). Walia and Rao (1996) after studying the Bundelkhand region of Uttar Pradesh reported that the soils were reddish brown to red in colour (2.5 YR to 5 YR) except Gonda soils which were strong brown to reddish brown in colour indicating the release of iron oxides and their occurrence in various hydrated forms due to difference in the drainage of soils.

Singh *et al.* (1998) reported that the soils at relatively higher topographic position, were redder than the other soils. Similarly, the colour was closely associated with texture and salinity as attributed by AI-Azidi (1985). Nanda and Pradhan (1985) reported that coastal salt affected soils developed over river alluvium had olive yellow mottles. Singh *et al.* (1983) observed that variations in soil colour had been attributed to differential characters of parent material and poorly drained soils had a hue of 2.5 with chroma around 2. Low chroma and high hue of the soil suggest the reduced conditions of soil, which remains saturated for a considerable period of time during the rice cultivation (Das *et al.*, 1997).

Khan *et al.* (1998) indicated that the soils of Gangetic alluvium exhibited uniform grey matrix colour with value of 4 to 5 and chroma 1 possibly due to prolonged submergence and reducing condition, low topographic position and nature of parent material of soils. Colours of higher chroma indicates better drainage conditions. Similar observations of soil colour relating to drainage conditions were also reported by Gerrad (1981) and Sharma *et al.* (1999). Sharma *et al.* (2001) reported that the colour of Entisols, Inceptisols and Vertisols of Kathiawar region in Gujarat varied from red to grey with hues of 5 YR, 7.5 YR, 10 YR, values of 3 to 4 and chromas of 2 to 4. Significant variations in soil colour indicated the release of iron oxides and their occurrence in various hydrated forms due to variation in internal drainage of soil as influenced by toposequence. Similar findings were observed by Sarkar *et al.* (2001). The colour can also be related to nutrient availability that the redder hue in the soil

profile could be linked to the P fixation and Zn deficiency problem due to high Fe status (Prasad, 2000).

Singh *et al.*(2000) stated that various shades of grey colour in profile layers related with reduction, oxidation and hydration of iron and manganese oxides.

Verma *et al.* (2001) reported about the four physiographic units in Bharthana and Chakarnagar blocks of Etawah district of U.P and he stated that the active flood plain soils are deep, well drained, pale brown to light yellowish brown (10 YR 6/3 to 6/4M) in colour. In recent alluvial plain, the soils are mostly deep well drained, dark yellowish brown (10 YR 4/4 M) in colour and the old alluvial plain soils are very deep, moderately well drained to well drained yellowish brown to dark yellowish brown (10 YR 4/3 to 5/4 M) in colour. Few yellowish red (5YR 5/8 M) distinct mottles were observed along 63-150 cm depth in soil profile which may be due to drainage problems in those areas and the ravinous plain soils are deep well drained to excessively drained, brown to dark yellowish brown (10 YR 5/3 to 4/4 M) in colour.

Marathe *et al.* (2003) stated that the soils are dark grayish brown (10 YR 4/2) in colour with sub-angular blocky structure. The soils were yellowish brown in colour (10 YR 5/6) and very deep (>180cm) and represented by a group of soils near the river banks or canals.

Thangasamy *et al.* (2005) reported that the soils on gently sloping topography have yellowish brown (10 YR 5/6) to dark red (25YR 3/6) colour and becomes light yellowish brown (10Y/R 6/4) to very dark grayish brown (10 YR 3/2) in nearly level lands. The soil colour appears to be the function of chemical and mineralogical composition as well as textural make up of soils and conditioned by topographic position and moisture regime (Walia and Rao, 1997).

Vara Prasad Rao *et al.* (2008) stated that the soil colour varied from very dark grayish brown (10 YR 3/2) to brown (7.5 YR 4/4) in plains, brown (10YR 4/3) to dark red (2.5 YR 3/6) in upland and very dark grayish brown (10 YR 3/2) to dark red (2.5 YR 3/6) on hill slope. In plains, the colour did not differ much between horizons in different pedons. Further variation of colour from dark grayish brown to brown in

plains was due to admixture of organic matter and iron oxides. Variation of colour in uplands and also on hill slope from dark grayish brown or brown to red or dark red was due to prevalence of well drained condition and occurrence of iron in oxidized ferric form. The colour appears to be a function of chemical and mineralogical composition of the soil (Swarnam *et al.*, 2004).

2.1.2. Soil texture

Soil texture is the average size distribution of the soil particles which depends on the relative proportions of sand, silt and clay particles. It is an important physical property as it is related to soil-water-fertility relationships. Though, all the primary particles in the soil have their own role to perform during the crop growth, the presence of clay in a soil at an optimum level enhances the soil to supply water and nutrient to the growing plants. However, in practice all the soils need not necessarily possess such an optimum range of sand, silt and clay. In situations, where the proportion of one group of soil separates exceeds beyond critical level poses serious problems not only for the soil physical condition but also affect the chemical processes.

Most of the properties of the soils are decided by their texture (Wamberke, 1959). The red soils of Coimbatore district were observed to be 'Surki' (gravelly) by Krishnamoorthy *et al.* (1965). Many of the physical constants and clay content were found to be interrelated as per the report of Parvathappa and Durairaj (1969). Digar and Barde (1982) found that the clay content increased with depth in deep to very deep red soils. Similar pattern of clay increase even in shallow red soils (Irugur series) of Coimbatore district was noticed by Mayalagu (1986). While describing the texture, the sand:silt ratio has been widely used as an index of parent material homogeneity (Ibrahimi *et al.*, 1986). Similar results were also reported by Das and Sarma (1997) and Bhaskar and Nagaraju (1998). The substantial increase in clay content in B_t horizon in some soils of Uttar Pradesh was due to illuviation of clay (Walia and Rao, 1996). Similar pattern of clay increase in subsurface horizons was noticed by Anandakrishnan (1998), Kadambavanasundaram (2000) and Rajavel *et al.* (2002).

Durairaj (1961) established close correlation among mechanical components of South Indian soils. Ibrahim *et al.* (1986) reported that soils developed on terraces are comparatively finer in texture than the soils developed on sand dunes and flood plains. In Tamil Nadu, alluvial soils of Ramanathapuram district were fine textured as pointed out by Balasubramanian *et al.* (1986).

The relative proportion of soil separates was also influenced by the quality of water flowing over the land as reported by Maji *et al.* (1998) who observed light textured soil under fresh water flow and heavy textured soil with brackish water. In case of transported soil, the textural distribution depends upon the distance of river flow or that of the carrying capacity of water. Coarser particles are deposited at short distances, whereas finer particles are deposited far away from its origin. Hence, the transported soils, whether it is alluvial, colluvial or aeolian, there cannot be a definite trend of particle size distribution in the profile (Khangarot and Mehra, 1977).

Tiwari *et al.* (1983), Das *et al.* (1997), Khan *et al.* (1998a), Patil and Dasog (1999) and Misra and Saithantuaanga (2000) reported that the clay content increased with depth in alluvial soils. But in certain situations, uniform distribution of clay can also be seen throughout the solum with limited water availability restricting the clay movement. In other soils the clay increased progressively upto a certain depth and decreased there after (Landey *et al.*, 1982; Venkateshwaralu, 1983; Biswas 1985; Subbaiah and Manickam, 1986), possibly due to limited water supply, leaching of the clay up to certain depth and there after deposited. Sidhu *et al.* (2000) reported that the wider sand-silt ratio indicated the deposition through different cycles and low pedogenic weathering in the alluvial soils of Haryana state.

Singh *et al.* (2000) reported that the physical properties like volume of expansion, pore spaces and water holding capacity seem to be related with the nature and amount of clay of these soils and texture seems to be influenced by deposition of clay by back- waters of the rivers.

Gupta *et al.* (2001) reported that the mechanical composition of soils under different land use pattern revealed that forest lands were finer in texture followed by cultivated

well managed cultivated unmanaged and barren lands. He also reported that a great variation in texture in surface and subsurface soils, the higher content of clay and silt in lower depths can be taken as illuviation rather than stratification of parent materials, higher sand content in barren group followed by cultivated unmanaged, cultivated well managed and forest land. It might be due to richness of parent material particularly of quartz type under barren land.

Sharma *et al.* (2001) reported that the free lime content increase the fineness of the soil particles. Sankar *et al.* (2002) reported that high clay content in low horizons has due to vertical migration or translocation of clay. The variations, in texture of the soils were mainly due to the differences in composition of parent material as reported by Nayak *et al.* (2002)

Marathe *et al.* (2003) reported high clay content due to smectite as the dominant mineral of the soil.

Sharma *et al.* (2004) reported that the variation in the depth and texture of soil profiles may be attributable to the differential degree of weathering as well as deposition of alluvium at various stages of erosion-deposition cycle. Similar observation for the salt affected soils of Rajasthan have also been made by Mehta *et al.* (1969) and Singh *et al.* (1994).

Bhaskar *et al.* (2005) reported that the high content of fine fractions (Fine sand + very fine sand + silt) indicated that they are deposited by over bank flooding. Sawhney *et al.* (2005) reported that the textural variations of the soils due to the heterogeneous nature of the parent material and topographical differences.

Jagmohan Singh *et al.* (2006) and Sidhu and Gilkes (1977) reported that the primary clay minerals are perhaps precipitated under alkaline pH condition under arid climate as these are not reported in the parent materials at the source.

Rudramurthy *et al.* (2007) reported that irrespective of land use systems, soil texture was finer in the subsurface horizons than in the surface horizons and this might be due to the pedogenic process viz., clay illuviation.

Shamsudheen *et al.* (2008) reported that high content of coarse fragment at higher topographic elements is due to removal of the soil material by erosion. Taha and Nanda (2003) and Vara Prasad rao *et al.* (2008), reported that the high clay contents in soils of plain as compared to uplands and hill slope was due to deposition of finer fractions in the plains from uplands and hill slopes.

2.1.3. Bulk density

Bulk density is the mass per unit volume of soil including pore space, expressed as Mg m^{-3} . The bulk density of the soil is not only related to the proportion of pore space but also depends on texture, humus content, soil depth etc.. Hence, it gives an indication, how compact or porous the soil is under field condition. It is the most important property among all other soil physical properties, since it controls the root development and mobility of soil and fertilizer nutrients as well as soil fluids.

Normally, the bulk density of the surface soils ranges from 1.20 to 1.50 Mg m^{-3} and 1.20 to 1.60 Mg m^{-3} in the lower layers. However, under extreme conditions, this can go as high as 2.0 Mg m^{-3} (Das and Sarma, 1997) and as low as 0.9 Mg m^{-3} (Varadan and Mammen, 1999). The value of bulk density increased from 1.49 to 1.56 Mg m^{-3} by the continuous application of nitrogenous fertilizers alone or in combination with phosphatic fertilizer, whereas the application of farm yard manure helped in lowering the bulk density to 1.41 Mg m^{-3} . While characterizing the soils of Dharmapuri and Trichi districts of Tamil Nadu state, Mathan *et al.* (1991a and b) had reported that the bulk density values ranged from 1.18 to 1.60 Mg m^{-3} in the surface and from 1.18 to 1.83 Mg m^{-3} in the subsurface soils of Dharmapuri district and in Trichy district the bulk density values of the surface soil were ranging from 1.16 to 1.63 Mg m^{-3} and from 1.35 to 1.63 Mg m^{-3} in the subsurface soil. Increase in bulk density with increasing depth is mostly related to leaching of the clay, organic matter and cations from the surface and their accumulation in the lower layers. Lower bulk density values in the surface can be due to tillage operation during cultivation. The increase in bulk density with depth was well documented by Wessling (1972), Kumaresan and Ramanathan (1981), Mathan *et al.* (1991a), Mayalagu *et al.* (1992), Elahi *et al.* (1996), Walia and Rao (1996), Varadan and Mammen (1999) and Ram Prakash and Seshagiri Rao (2002).

Low bulk density value of surface horizon is associated with high organic matter content but its progressive increase with depth are probably related to increase in coarse fraction and or coarse fragments of soils or filling of pores by eluvial materials leading to compaction (Walia and Rao, 1996). The sudden increase in the bulk density value in lower layer of some soils may be due to the development of hard pans like fragipan (Das and Sarma, 1997) and also due to the dispersion and migration of clays and clogging of pores (Khan *et al.*, 1998b). Presence of calcium carbonate nodules at the lower layer, can also result in sudden change in the bulk density. In soils, where the organic matter is leached down below the surface, the subsoil may have lower bulk density as compared to the surface (Sahu *et al.*, 2001). In general, lower value of bulk density is ascribed to higher clay content, particularly of montmorillonitic type (Bharambe *et al.*, 1999) and higher bulk density related to higher sand fraction (Agarwal *et al.*, 1974; Mathan *et al.*, 1991a).

Gupta *et al.* (2001) reported that bulk density showed negative and significant correlation with organic carbon and clay content and significant positive relationship with sand and also reported that bulk density and particle density increased with depth in all the locations, which may be due to the greater compaction in subsurface soils. Marathe *et al.* (2003) reported that bulk density varied from 1.46 to 1.74 Mg m⁻³ being low at surface horizon and increasing with depth.

Thangasamy *et al.* (2005) reported that bulk density varied from 1.32 to 1.90 mg m⁻³ and increased with depth which might be due to more compaction of finer particles in deeper layers caused by over head weight of the surface soils (Jewitt *et al.*, 1979).

Vara Prasad Rao *et al.* (2008) reported that the bulk density varied from 1.45 to 1.66 mg m⁻³ in soils of different physiographic units. The bulk density in soils irrespective of land forms increased with depth, which might be due to more compaction of finer particles in deeper layers caused by over head weight of the surface soils (Jewitt *et al.*, 1979).

2.1.4. Pore size distribution

Porosity is that fraction of soil volume not occupied by solid particles. When soil

particles are arranged in a random manner due to their irregular shape, they leave spaces / voids between themselves. Particles, which are bound together in the form of aggregate or peds are also possessing pores of various sizes within themselves and between them. The pores within the aggregate are considered to be relatively smaller in diameter and thereby holding the soil moisture than the voids between the peds.

Total porosity of the soil determines the volume of fluids (air and water) that a soil can hold under normal condition. The total porosity of the soils of Dharmapuri district ranged from 35.4 to 61.5 per cent (Mathan *et al.*, 1991a), while that of the Madurai district of Tamil Nadu ranged from 27.9 to 49.5 per cent (Mathan and Mahendran, 1994). Such a difference among the soils in total porosity can be related to texture, bulk density, soil structure, nature of clay, exchangeable cations, organic matter content etc. Among these factors, bulk density is negatively related to total porosity (Mathan and Mahendran, 1994; Singh *et al.*, 1999a; Ramesh, 2001 and Karthik Kumar, 2005).

In general, the soil pore is related to the clay type. The non-expansive soils had stable pores while the swell-shrink soils do not have stable pores as reported by Satyavathi (1996). Normally, the bulk density of soil increases with depth due to the granular structure in the surface. However, under certain conditions, the subsoil having clay and organic matter accumulation may possess higher pore space than the surface soil. Under such a situation, the relative proportion of different sized pores may vary with depth. Manorama Thampatti and Jose (2000) reported that the porespace did not follow a uniform pattern, which increased with depth evidently due to the increase in clay and organic carbon content.

2.2. Soil physico-chemical properties

2.2.1. Soil reaction

Soil reaction is one of the most important physico-chemical characteristics of the soil solution. Soil reaction is measured by the pH of a suspension of soil in water. The pH of the soil solution will depend upon the relative amount of adsorbed hydrogen and aluminium ions.

Ghabru and Ghosh (1980) reported that the profile soils have relatively higher soil pH values ranging from 5.6 to 6.4 and it increases from surface towards the lower layers. The red soils of Uttar Pradesh showed increase of pH with depth due to leaching and accumulation of bases. In some soils, the pH was higher in surface than in lower horizons suggesting accumulation of bases in surface due to vegetation (Walia and Rao, 1996). Anandakrishnan (1998) reported similar pattern of pH with depth in pedons and established a negative correlation with Fe and Mn contents.

In the coastal alluvial soils of Gujarat state, the pH values were alkaline ranging from 7.5 to 8.9 (Pathak and Patel, 1980). Black soils are generally calcareous and neutral to slightly alkaline in reaction, with pH values ranging from 7.2 to 8.5 as reported by Landey *et al.* (1982) and Deshmukh and Bapat (1993). Sahu and Antaryami Mishra (1994) observed that in Saplachara series, a red soil recorded acidic to neutral pH. Ferruginous soils are medium acidic to neutral (Pachrane *et al.*, 1996).

Pathak and Patel (1980) observed that the coastal alluvial soils of Gujarat were alkaline with pH values ranging from 7.5 to 8.9 and showing an irregular trend with depth. But, the pH increased with depth in Punjab alluvium derived sodic soils as concluded by Vinayak *et al.* (1981). Bhargava and Sharma (1982) recorded the pH values exceeding 9.0 in saline soils of Indo-Gangetic alluvial plain. Chellamuthu (1987) observed that the coastal alluvial soils of Ramanathapuram Taluk, Tamil Nadu were alkaline in whole pedon. Sharma *et al.* (1994) reported that in the Soan river Valley soils in Mid Shiwalik of Himachal Pradesh, the pH value ranged from neutral to alkaline (6.2 to 8.3). Sharma *et al.* (2001) observed that the pH values in Entisols of Kathiawar region in Gujarat ranged from neutral to mildly alkaline in reaction.

The soil pH is mostly related to the nature of parent material, climate and topography of the soil (Landey *et al.*, 1982; Deshmukh and Bapat, 1993). The soils of Sikkim are acidic, being influenced by leaching and very high organic matter content as reported by Lahiri and Chakravarthi (1989). The increase in pH towards the lower horizon might have been due to the proximity of the ground water table (Das and Sarma, 1997), the presence of CaCO₃ in the soil as well as higher base saturation (Das *et al.*, 1997), presence of greater amount of exchangeable and soluble Na (Tiwari *et al.*, 1983; Singh *et al.*, 1999b). In contrast, the pH was found to be low in

the surface horizons which may be due to more organic matter content, more biochemical weathering, upland physiography (Singh *et al.*, 2000) and leaching of exchangeable bases down the profile under high rainfall conditions (Sujata *et al.*, 1999).

Challa *et al.* (2000) observed that in soils of Maharashtra, the pH of soils varied from 8.1 to 8.9. The pH greater than 8.5 in horizons of soils indicated the progressive development of alkalinity.

Singh *et al.* (2000) reported that the wide variation in pH from 6.4 to 10.2 indicated that the soils of Dulhingaon and Agriaon series in Bihar are slightly acidic to neutral in reaction. This may be due to loss of bases under well drained conditions and upland physiography. The higher pH of 7.9 to 10.2 of the low land soils may be attributed to the accumulation of soluble salts and for sodium in saucer-shaped physiography under the influence of compact and hard layers formed due to concretions and high clay content.

Gupta *et al.* (2001) and Subbiah and Manickam (1992) observed low pH values in forest land followed by cultivated unmanaged and barren land. This may be attributed to higher organic matter. Verma *et al.* (2001) and Gawande and Tanhane (1971) reported that the higher pH values due to calcareousness and presence of lime rich parent material.

Marathe *et al.* (2003) observed that the soils of Nagpur recorded high pH value of 7.7 to 8.43. Sharma *et al.* (2004) and Abrol *et al.* (1988) reported that the range of 7.66 to 8.96 shows, an increase with an increase in the salinity except in strongly saline soils which is attributed to the dominance of neutral soluble salts.

Maji *et al.* (2005) reported that the soils developed on summitcrest, escarpment and isolated mounds are slightly acidic having pH values of 6.0 to 6.5, the soils developed on denuded plateau, foot slopes, upper and lower piedmonts and narrow valley floor and slightly alkaline with pH values 7.7 to 8.3. It may be concluded that the pH of the soils decreases with increasing altitude (Minhas and Bora, 1982).

Sanjay *et al.* (2005) observed high pH value 5.94 to 10.12 and 6.54 to 9.44 in Leh and Kargil district of Ladakh region. Das *et al.* (2006), Nodvin *et al.* (1986) and Huang *et al.* (1998) reported that soil pH has negative effect on SO_4^{2-} absorption.

Pal and Shurpali (2006) reported that the soil organic C content decreasing with increasing soil pH. Meena (2006) reported that the relative high pH of the soils might be due to the presence of high degree of base saturation.

Patton *et al.* (2007) observed in Dimapur district of Nagaland, the pH ranged from 4.4 to 6.2. It seems that higher pH in soils may be due to slash burning in fields, which is alkaline in nature. Such finding has been also recorded by Misra and Saithantuaanga (2000).

Vara Prasad Rao *et al.* (2008) conducted one experiment in major landforms of Ramachandrapuram mandal in Chittoor district of Andhra Pradesh. They observed that the pH of the soils varied from 6.9 to 8.3 (uplands) and 7.2 to 7.6 (Hill slopes). The higher pH in soils of plains may be due to more accumulation of base removed from uplands and hill slopes.

2.2.2 Electrical conductivity

Electrical conductivity of the soil is the total soluble salt concentration of the soil. The electrical conductivity of the soil water suspension is considered to be an index of the soluble salt concentration of the soil. When a soil has excess soluble salts, it is said to be saline. Saline soil is one in which the salt content is sufficiently high to interfere with plant growth, but this depends upon other soil conditions and the nature of the plant. In certain situations, where drainage is improper, shallow ground water or even capillary rise of soluble salts, can also increase the salinity of the root zone (Sahu *et al.*, 1986). The source of the salts in the soil is mainly from the weathering of rocks releasing electrolytes into the soil solution as well as by the addition of salts through irrigation water (Sidhu *et al.*, 2000).

Sharma *et al.* (1968) reported that the EC value of sandy loam soils of Rajasthan was 1.84 dS m^{-1} and it ranged from 0.10 to 0.56 dS m^{-1} in the Entisols of Punjab (Sidhu *et*

al., 1994). Sekar (1994) observed that the black soils of Kovilpatti and Aruppukottai of Tamil Nadu registered the EC value of 0.1 to 0.5 dS m⁻¹. Rajkumar *et al.* (1990) reported that the EC value ranged from 0.18 to 0.60 dS m⁻¹ in sodic alluvial soils of Sutlej-Yamuna Divide. However, presence of high salts in the deeper layers may also prove harmful and the salts can raise up to the surface by capillary during summer (Sahu *et al.*, 1986).

According to Balasubramanian (1987), the red soils of the Horticultural Research Station, Periyakulam, Tamil Nadu registered low EC values of around 0.59 dS m⁻¹ without any change with depth. Anandakrishnan (1998) reported that the EC values ranged from 0.1 to 0.4 dS m⁻¹ and it increased with depth in the red soils of Tamil Nadu Agricultural University Farm, Vaigai Dam in Theni district of Tamil Nadu. Similar observation was reported by Kadambavanasundaram (2000), Sharma *et al.* (2001) and Rajavel *et al.* (2002). In contrast to this, Balasubramanian (1987) observed the EC value of 0.2 dS m⁻¹, which was having a decreasing trend with the depth in alluvial soils and ascribed to higher evaporation than precipitation causing capillary rise of salt to the surface. Similar observations were made by Poonkodi (1991) and Chirsty Nirmala Mary (1992).

Chella *et al.* (2000) conducted experiment in Maharashtra, and observed the low to high EC values, that vary from 0.4 dS m⁻¹ to 7.8 dS m⁻¹. The low EC as observed in Khadambhe and Valpi soils also indicated high degree of sodicity due to accumulation of soluble salts from washings and due to more compact layer.

Gupta *et al.* (2001) reported that among the various land use patterns, the soils of barren lands were lowest in exchangeable cations followed by those of cultivated, unmanaged cultivated, well managed and forest lands.

Bhargava (2001) conducted an experiment in Naybans village of Haryana state. He observed that the electrical conductance varied between 9.7 to 97.0 dS m⁻¹ exhibiting highly saline nature. Marathe *et al.* (2003) reported EC values ranging from 0.03 to 0.79 dS m⁻¹ in Nagpur district of Maharashtra.

Sharma *et al.* (2004) observed in their experiment from Rajasthan, the EC of the soils under study, ranged from 1.84 to 33.20 dS m⁻¹ indicating a wide variation. A relatively higher EC values in surface layer as compared to sub-soils were observed except in moderately saline soils, which may be ascribed to the lateral movement of water from the construction of earthen-bund on ground (Mehta *et al.*, 1969, Sumner 1995).

Maji *et al.* (2005) conducted an experiment in Nagpur district of Maharashtra and reported that the electrical conductivity (EC) showed that the soils were very low in soluble salt concentration with EC values ranging from 0.07 to 0.2 dS m⁻¹ and have no salinity hazards. The soils on escarpment shows low EC value 0.07 dS m⁻¹ and soils developed on lower piedmonts have high EC value. The soils which are free from salts are responsive to fertilizer and management practices (Richards, 1954).

Meena *et al.* (2006) observed low EC values in their experiment which ranged from 0.10 to 1.5 dS m⁻¹ in Tonk district of Rajasthan. Sing *et al.* (2007) also observed low EC value (0.22 to 1.05 dS m⁻¹) in their experiment in Rampur district of Uttar Pradesh. Vara Prasad Rao *et al.* (2008) also got low EC values (0.01 to 1.05 dS m⁻¹) in their experiment in Chittor district of Andhra Pradesh.

2.2.3 Cation exchange Capacity

The cation exchange capacity (CEC) is the sum total of the exchangeable cations that a soil can adsorb on its surface. It is the most important physico-chemical property. The exchange capacity signifies, that the soil clay particles retain the fertilizer nutrients on its surface and release whenever the plant requires, by its exchange phenomenon. The exchangeable cations generally are available for both higher plants and micro organism.

Kaolinitic clay with the admixture of halloysite and illite minerals was responsible for the low CEC values of the soils studied by Hameed Khan and Hanuman Ram (1977). The study of Govindarajan and Gopal Rao (1978) showed that the Base Exchange Capacity varied from 5 to 25 cmol (p⁺) kg⁻¹ of soil depending upon the amount of clay

and organic matter. Rao and Sharma (1986) inferred that slightly high CEC was due to mixed clay mineralogy and high clay content.

The CEC of Irugur series, a red soil was found to be in the range of 12.0 to 12.5 cmol (p⁺) kg⁻¹ soil correlating with clay distribution pattern (Mayalagu, 1986). Sampath (1987) found that the CEC was positively and highly correlated with clay content and exchangeable Ca²⁺ and negatively with sand in each series of the red soils he studied. The findings of Balasubramanian (1987), Sankayya (1988), Poonkodi (1991), Satyavathi *et al.* (1994), Alagu Nagendiren (1997), Anandakrishnan (1998) and Rajavel *et al.* (2002) were also similar.

The saline soils of North Bihar showed low CEC values and the cationic distribution was in the order of Mg²⁺ > Ca²⁺ > Na⁺ > K⁺ (Bhargava and Sharma, 1982), whereas in salt affected coastal soils of Orissa, the trend was Na⁺ > Mg²⁺ > Ca²⁺ > K⁺, the first two in the sequence being by far the most predominant ones (Nanda and Pradhan, 1985). In the alluvial soils in flood plains of Arunachal Pradesh, the exchangeable cations were in the order of Ca²⁺ > Mg²⁺ > Na⁺ > K⁺ (Walia and Chamuah, 1990). Sharma *et al.* (2001) reported that the soil in Kathiawar region of Gujarat has high cation exchange capacity and base saturation percentage. The exchangeable cations were in the order of Ca²⁺ > Mg²⁺ > Na⁺ > K⁺.

Chakraborty and Sinha (1983) reported that the CEC decreased as the depth increased. Similar results were also reported by More *et al.* (1988) and Sujata *et al.* (1999). They have attributed the decrease due to the organic matter content with the increase in depth, as the drop in CEC being not compensated by the increased clay content, whereas Ram Prakash and Seshagiri Rao (2002) stated that the soils of Andhra Pradesh showed variation in the value of CEC in the surface, but the profile layers exhibited increasing trend with depth increases. This variation was attributed to the type and content of the clay. There was no change or slight change in the value of CEC with depth (Walia and Chamuah, 1992; Sahu and Antaryami Mishra, 1994; Maji *et al.*, 1998; Singh *et al.*, 2000).

The CEC values ranged from 2.0 to 8.5 cmol (p⁺) kg⁻¹ in the flood plains of Himachal Pradesh (Sharma *et al.*, 1994), 14.0 to 29.9 cmol (p⁺) kg⁻¹ the soils of central

Brahmaputra valley (Das *et al.*, 1997), 15.32 to 36.18 cmol (p⁺) kg⁻¹ in the soils of Gangetic alluvium (Khan *et al.*, 1998a), and 5.8 to 9.3 cmol (p⁺) kg⁻¹ in Entisols of Mizoram (Misra and Saithantuaanga, 2000). Ramesh (2001) reported that the CEC of Karaikal soils ranged from 1.30 to 47.10 cmol (p⁺) kg⁻¹ in the profile soil samples and from 15.40 to 36.70 cmol (p⁺) kg⁻¹ in the surface soil samples.

Singh *et al.* (2000) reported that cation exchange capacity (CEC) is due to nature and amount of clay minerals. The higher values observed in the profiles (22.2 to 64.3 cmol (p⁺) kg⁻¹) with depth are again indicative of the process of haploidization as observed by Raychaudhuri *et al.* (1993) and Diwakar and Singh (1992,1994) for fine textural soils.

Datta *et al.* (2000) and Keng and Uehara (1973) reported that soils with variable CEC generally have high proportion of colloids with constant surface potential.

Gupta *et al.* (2001) reported that the soil of barren land showed the minimum CEC values followed in the order by cultivated well managed and forest lands. The variation in CEC among the soils of various land use patterns may be attributed to the differences in clay and organic matter content of these soils (Kaistha and Gupta, 1993). The CEC of surface soils was higher than the subsurface. It might be due to more organic carbon and clay content in surface soils.

Sharma *et al.* (2004) reported that the CEC observed in the soils is essentially contributed by their clay content, since the soils of the region are low in organic carbon content contributing least towards this parameter.

Maji *et al.* (2005) conducted an experiment in Ringnabodi watershed of Nagpur district. They observed that cation exchange capacity (CEC) of soils varied from 26.6 to 57.1 cmol (p⁺) kg⁻¹ and the CEC is related to clay and organic matter content. These high values of CEC are attributed to the smectite type of clay minerals and high amount of clays.

Patton *et al.* (2007) conducted an experiment under different land use pattern in Nagaland state and he observed that the CEC of some fields was higher (10.5 cmol

(p^+) kg^{-1}) than other fields (5.4 $cmol (p^+) kg^{-1}$) which may be due to losses of basic cations from the latter fields.

Vara Prasad Rao *et al.* (2008) observed CEC values in the soils ranging from 6.7 to 27.6 $cmol (p^+) kg^{-1}$ which corresponds to clay content in the horizons.

2.2.4. Exchangeable cations

The term exchangeable bases or exchangeable cations denote the sum of the bases in exchangeable sites, expressed as centimoles positive charges per kilogram of soil. Pathak and Patel (1980) reported that the general order of the exchangeable cations was $Ca^{2+} > Mg^{2+} > Na^+ > K^+$ in the soils of Thasra area, while in the soils of Mathar area and coastal area in Kaira District of Gujarat, the order was $Na^+ > Ca^{2+} > Mg^{2+} > K^+$, indicating that considerable amounts of sodium has gained entry in to the soil exchange complexes of these areas. Similar results are given by Tiwari *et al.* (1983) in the soils of central alluvial region of Uttar Pradesh that Na^+ was the dominant cation in the surface soils which lead to potential danger for the development of alkali condition. The amount of exchangeable Mg is generally higher than exchangeable Ca^{2+} , which was followed by K^+ and Na^+ (Chakravarthy and Barua, 1983). The exchangeable Ca^{2+} was the dominant cation which forms about 70 to 80 per cent of cation exchange capacity and the remaining was mostly Mg^{2+} (Bhoumik and Totey, 1990).

Patiram *et al.* (2000) reported that the value of exchangeable Ca^{2+} ranged from 1.05 to 3.80 $cmol (p^+) kg^{-1}$ and Mg from 0.4 to 1.4 $cmol (p^+) kg^{-1}$ in the acid soils of Mizoram. Similar results are given by Misra and Saithantuaanga (2000) in the acid soils of Mizoram. Nayak *et al.* (2002) reported that the Ca^{2+} is the dominant cation followed by Mg^{2+} , Na^+ , and K^+ in the acid soils of Arunachal Pradesh.

Challa *et al.* (2000) observed in their experiment that calcium is the dominant cation (11.6 to 36.4 $cmol (p^+) kg^{-1}$) in exchange complex, next to calcium is exchangeable sodium which shows increasing trend with depth and having a range of 2.8 to 27.6 $cmol (p^+) kg^{-1}$. The exchangeable magnesium shows irregular trends in distribution with depth and varies from 2.8 to 27.6 $cmol (p^+) kg^{-1}$.

Gupta *et al.* (2001) and Subbiah and Manickam (1992) observed the content of Ca^{2+} was highest followed in order by Mg^{2+} , K^+ and Na^+ . Exchangeable Ca^{++} , K^+ and Na^+ decreased with depth whereas Mg^{2+} showed opposite trend. Predominance of exchangeable Mg in the subsurface soils suggest leaching of this cation.

Sharma *et al.* (2004) studied salt affected soils of Rajasthan and observed that among the exchangeable cations, Ca^{++} dominated the exchangeable complex, followed by Mg^{++} which dominated over Na^+ . It was also observed that as the finer fraction increased there was a corresponding increase in content of exchangeable bases. It can be inferred that increase in clay content provided more exchange sites to get the cations observed on it (Gawande *et al.*, 1967 and Datta *et al.*, 1990).

Maji *et al.* (2005) reported in their experiment that calcium is the dominant cation followed by magnesium, potassium and sodium. The dominance of Ca^{2+} may be due to basalt, which is the source of high calcium. Magnesium varies from 3.6 to 14.3 $\text{cmol (p}^+) \text{ kg}^{-1}$. Higher amount of exchangeable calcium followed by magnesium contribute towards high base saturation condition. Thangasamy *et al.* (2005) reported exchangeable bases in their experiment in the order of $\text{Ca}^{2+} > \text{Mg}^{2+} > \text{Na}^+ > \text{K}^+$.

Patton *et al.* (2007) reported that exchangeable Ca^{2+} ranged from 2.1 to 6.0 $\text{cmol (p}^+) \text{ kg}^{-1}$ and exchangeable Mg from 0.3 to 1.5 $\text{cmol (p}^+) \text{ kg}^{-1}$ in fields of Nagaland.

Vara Prasad Rao *et al.* (2008) reported that the exchangeable base in all the pedons irrespective of land forms were in the order $\text{Ca}^{2+} > \text{Mg}^{2+} > \text{Na}^+ > \text{K}^+$.

2.3. Soil chemical properties

2.3.1. Organic carbon

The carbon content of the soil is an indirect index of the organic matter content, since majority of the carbon in the soil is in the form of organic matter. The influence of organic matter on soil physical, chemical and biological properties and its role on crop growth need no emphasis, since it is well established that presence of organic matter facilitates the soil physical processes like movement of water, heat and nutrients. It is the direct source of plant nutrient elements, the release of which depends upon

microbial activity and by affecting the cation exchange capacity, organic matter is directly involved in the availability of nutrient elements. Further more, organic matter supplies energy and body building constituents for most of the micro organisms.

Tiwari *et al.* (1983) reported that pasture lands contain higher organic carbon than the soils cultivated with annual crops, where the frequent opening up of the soil favours oxidation of organic materials. Nair and Chamuah (1988) reported that due to accumulation of organic matter at surface the organic carbon content was fairly high in the soils of pine forest and then decreases with depth. Das *et al.* (1997) reported that higher organic matter content of some soils of Brahmaputra valley were due to slower decomposition and more submergence of soil. The higher organic carbon content of North Eastern Himalayas were attributed the cooler climate and deciduous vegetation in the higher altitude (Singh *et al.*, 1986). Khan *et al.* (1998a) reported that the lower value of organic carbon in some of Brahmaputra and Tista alluvium was due to the higher rate of decomposition of plant residue under hypothermic temperature regime, whereas high organic matter in the soils of Gangetic alluvium was due to the accumulation of fresh organic residues.

The soils of Pudukottai district had the organic carbon content ranging from 0.1 to 1.4 per cent (Rajamannar *et al.*, 1979), from 0.06 to 0.88 per cent in the soils of Coimbatore district (Mayalagu, 1986), from 0.3 to 0.4 per cent in the soils of Punjab (Ibrahimi *et al.*, 1986), from 0.20 to 0.72 per cent in the soils of Maharashtra (More *et al.*, 1988), from 0.2 to 0.8 per cent in the soils of Andhra Pradesh (Bhaskar and Nagaraju, 1998), from 0.23 to 0.81 per cent in the soils of Majalgaon command area (Bharambe *et al.*, 1999), from 0.04 to 0.69 per cent in the soils of Haryana (Sidhu *et al.*, 2000) and from 0.02 to 0.67 per cent in the soils of Western Rajasthan (Moharana and Nepal Singh, 2001).

Khargarot and Mehra (1977) reported that organic carbon content decreases with depth. Srivastava and Srivastava (1993), Das and Sarma (1997), Sidhu *et al.* (2000), Moharana and Nepal Singh (2001) and Sharma *et al.* (2004) also reported similar findings. In contrast to the above, Das *et al.* (1997) reported an increase in organic carbon content in the subsurface and ascribed to slower decomposition of residues under submerged conditions. The major reason for organic matter depletion are the

continuous monoculture of high yielding rice varieties without proper replenishment of organic matter and the prevention of tidal deposition and in rice based wetland ecosystem soils having high organic carbon was found to accumulate in lower layers due to differential accumulation of organic matter and sedimentary nature of the parent material in the heterogeneity of organic carbon distribution (Manorama Thampatti and Jose, 2000). Singh *et al.* (2000) observed low organic carbon (0.5 to 4.3 g kg⁻¹) which was attributed to the oxidation loss of organic matter due to tropical climate condition.

Gupta *et al.* (2001) reported that the higher organic carbon content in forest lands may be due to better growth of vegetation and leaf fall. Tamgadge *et al.* (2003) reported in Chandrapur the organic carbon in those profiles varies from 0.4 to 15.0 g kg⁻¹ and Marathe *et al.* (2003) also reported low organic carbon content in Nagpur, ranging from 1.5 to 11.5 g kg⁻¹ which decreased with depth.

Sharma *et al.* (2004), and Miller and Donache (1982) reported that the organic carbon content decrease gradually with an increase in the depth of pedons. Maji *et al.* (2005) reported the organic carbon content the soils, ranging from 2.1 to 8.5 g kg⁻¹ and Gangopadhyay *et al.* (2005) reported higher organic carbon content from 3.6 to 12.2 g kg⁻¹ in Ranch district of Jharkhand.

Pal and Shurpali (2006) reported that the soil organic carbon content generally increases with increasing amount of rainfall. The rate of accumulation of organic carbon in a given soil depends not only upon rainfall but also on temperature and other factors (Brady and Weil, 2000).

Singh and Room Singh (2007) reported that organic carbon ranged from 0.4 to 7.6 g kg⁻¹ in Alfisols, 0.6 to 8.6 g kg⁻¹ in Inceptisols and 0.3 to 2.3 g kg⁻¹ in Entisol from mid-werstern Uttar Pradesh. Vara Prasad Rao *et al.* (2008) reported in the Chittor district in Anhra Pradesh, that organic carbon content in soils varied from 1.2 to 5.6 g kg⁻¹ (Plains), 1.5 to 7.1 g kg⁻¹ (Uplands) and 2.3 to 7.7 g kg⁻¹ (Hill slope). Irrespective of land forms, the organic carbon content decreased with depth in all the pedons.

2.3.2. Macronutrients

A mineral element is considered essential to plant growth and development, if the element is involved in plant metabolic functions and the plant cannot complete its life cycle without the element (Tisdale *et al.*, 1995). There are sixteen elements which are considered to be essential elements, out of which C, H, O, N, P, K, Ca, Mg and S are termed as macronutrients and Zn, Cu, Fe, Mn, B, Mo and Cl are termed as micronutrients or trace elements.

2.3.2.1. Nitrogen

Nitrogen is the most important and frequently deficient nutrient in crop production. Soils of India are found to be low in nitrogen status. Due to the importance to the crop growth and its relatively low levels in soil, it is considered to be the most limiting plant nutrient to crop production.

2.3.2.1.1. Total nitrogen

Total nitrogen is the total quantity of N present in the soil in organic or inorganic forms irrespective of its availability to crop growth. Majority of nitrogen present in the soil is in organic form, most of which need to be mineralized before it is being made available to crop growth.

Lahiri and Chakarvarthi (1989) reported that organic matter content is mostly related to the total N content of the soil. Anbazhagan (1994) and Bharambe *et al.* (1999) reported that total N content of the soil varied with the organic carbon status of soil and decreased with depth as that of organic carbon content.

The total N content in the soils of Tamil Nadu ranged from 0.015 to 0.045 per cent (Thiagarajan, 1978), from 0.022 to 0.068 per cent in the soils of Uttar Pradesh (Srivastava and Srivastava, 1993) and from 0.048 to 0.063 per cent in the surface layer and decreased with depth according to Bharambe *et al.* (1999) in the soils of Majalgaon command area. The total N content in the soils of Western Rajasthan ranged from 0.11 to 1.50 g kg⁻¹ (Sharma and Singh, 2001).

Das *et al.* (1997) reported that the soils of central Brahmaputra valley having wider C: N ratio due to slower decomposition rate of organic matter under submerged

condition of the soil. Bharambe *et al.* (1999) stated that the N status of medium deep Vertisols was medium in range, while that of Entisols was in the low range with comparatively low C: N ratio due to the rapid mineralization of litter.

Gupta *et al.* (2001) reported in Kandi belt soils of Jammu region, the total N content was higher in the surface soils in comparison to subsurface soils. It might be due to addition of more organic material through residual roots and leaf fall in the surface soils and its rapid mineralization.

Sharma and Nepal Singh (2001) reported the higher total N content in oron lands (0.11-1.50 g kg⁻¹) may be due to greater return of N through better vegetation cover and litter fall. Ramesh (2001) reported that the total N ranging from 0.001 to 0.145 per cent in Karikal soils. Valliammal (2004) reported that the total N ranging from 0.10 to 0.166 per cent in PAJANCOA & RI Agricultural farm soils. Karthik Kumar (2005) reported that the total N ranging from 0.01 to 0.076 g kg⁻¹ in Bahour commune of Pondicherry state.

Singh and Room Singh (2007) reported from Mid-western Uttar Pradesh, that in all the profiles, the total N content showed a distinct declining trend with depth.

2.3.2.1.2. Available nitrogen

Available nitrogen is that portion of soil N that is made available to plants during the crop growing period. Hence, the term available has got the real meaning when it is used with the specific time period before which the said quantity is made available to plants.

The available nitrogen was highly correlated with total nitrogen, organic carbon and cation exchange capacity. The available N content as determined by the alkaline permanganate method is highly varying depending upon the organic carbon status of the soil.

The profile distribution of various forms of nitrogen and organic carbon varied significantly due to influence of land forms (Goyal and Singh, 1987), altitude and

physiography (Agarwal and Prakash, 1984 and Verma *et al.*, 1990), pedogenic development (Beke *et al.*, 1995) and mineralogy (Walia *et al.*, 1998). Goyal and Singh (1986) and Singh *et al.* (1992) established a higher relationship between the organic carbon and available N content in the alluvial soils of Haryana. Kuldeep Singh and Ahuja (1990) studied the distribution of primary nutrients in relation to soil characteristics in the Ghaggar river basin and found that the surface horizons of all the profiles had higher content of available N which, in most cases decreased with the depth. Mandal *et al.* (1990) also found a similar trend in the Eastern Himalayan forest soil having highest amount in the surface and then gradually decreased down the profile.

The low available N content in Kerala red soils might be due to low organic matter and total N contents (Harikrishnan Nair and Koshy, 1982 and Subramanian, 1988). In red soils, Mayalagu (1986) observed low N and organic carbon contents. Bharambe *et al.* (1999) reported that the N status of Entisols was in the low range with comparatively low C: N ratio due to the rapid mineralization of litter. Misra and Saithantuaanga (2000) found that the soils of Mizoram were high in available N content based on the organic carbon of soil. Rama Lakshmi and Seshagiri Rao (2000) observed the available N content in the Inceptisol and Vertisol which ranged from low to medium level of available N while Entisols were low in available nitrogen. The available N content varied from low to medium, with maximum of 392 kg ha⁻¹ and a minimum of 38.2 kg ha⁻¹ in the soils of Andhra Pradesh as reported by Anitha *et al.* (2001). Ramesh (2001) reported that available N content of the soils of Karaikal was found to be varied from 89.50 kg ha⁻¹ to 134.97 kg ha⁻¹

Gupta *et al.* (2001) reported that the available N varied from 317.4 kg ha⁻¹ in forest lands, 113.0 kg ha⁻¹ in barren land (low content) and 25.0 kg ha⁻¹ in cultivated lands of Kandi belt soils of Jammu region.

The possible reason for low content of this nutrients under barren land might be low organic matter and fine fraction in the soils. These results corroborate the findings of Choudhary and Das (1990) who had also reported that soils having low content of fine fraction often exhibited low fertility.

Thangasamy *et al.*, (2005) reported in Chittor district in Anthra Pradesh, that the available nitrogen content of the soils varied from 58 to 502 kg ha⁻¹ throughout the depth. However, available nitrogen content was found to be maximum in surface horizon and decreased regularly with soil depth which might be due to decreasing trend of organic carbon with depth.

Sanjay *et al.* (2005) reported in cold arid region of Ladakh, the available N may be in low category in soils of the region because of the fact that the mineralization of the organic matter is very slow in cold arid region because of low temperature (Sharma and Tripathi, 2002) and losses of nitrogen through leaching under light textured soils (Foth and Turk, 1973).

Meena *et al.* (2006) reported in Tonk District of Rajasthan that the available N content varied from 125 to 555 kg ha⁻¹. Laxminarayana (2007) observed that the available N ranging from 220 to 345 kg ha⁻¹ in the soils of Mid-western Uttar Pradesh.

Vara Prasad Rao *et al.* (2008) reported that in Ramachandrapuram of Chittor district in Andhra Pradesh, the available nitrogen content of surface soil samples varied from 54 to 102 kg ha⁻¹. Low nitrogen status in the surface soils could be attributed to low amount of organic carbon in these soils (Prasuna Rani *et al.*, 1992).

2.3.2.2. Phosphorus

Phosphorus is found both in organic and inorganic forms and does not occur abundantly in the soil as N and K. It greatly influences the root growth, development of reproductive parts and seed formation.

2.3.2.2.1. Total phosphorus

On an average, about 50 per cent of the total P in the soils is contributed by organic P and it can vary from 15 to 80 per cent in most soils (Tisdale *et al.*, 1995). The quantity of organic P in soils generally increases with increasing organic carbon and nitrogen. The P content of the soil organic matter ranges from about 1 to 3 per cent.

Though, the total content of nutrients always possess a direct relationship with its available status, the quantity of total P in soil has little or no relationship to the availability of P to the plants. Rama Lakshmi and Seshagiri Rao (2000) reported that the high organic matter content in the surface and addition of phosphatic fertilizers were the causes for higher P content in surface soils.

Sood and Kanwar (1986) found more amounts of organic P in surface soil layers than in subsurface layers and the total P content of the soil decreased with increase with depth, while Mayalagu and Paramasivam (1994) reported a higher total P in subsoil than the surface soil. Anbazhagan (1994) observed a marginal decrease in total P content with depth.

The total P content was negatively correlated with the clay plus silt content and positively correlated with organic carbon as reported by Balasubramanian (1987) and Poonkodi (1991). Ramesh *et al.* (1994) reported that in Andhra Pradesh soils the total P varied from 0.01 to 0.32 per cent and from 436 to 462 mg kg⁻¹ in the soils of Thanjavur (Anbazhagan, 1994). The total P content in the soils of Karaikal region the U.T. of Pondicherry ranged from 0.010 to 0.200 per cent (Ramesh, 2001), from 0.029 to 0.127 per cent in Karaikal region (Vembu, 2003), from 0.012 to 0.210 per cent in PAJANCOA and RI Agricultural farm soils (Valliammal, 2004). Karthik Kumar (2005) reported that the total P content in the soils of Bahour commune of Pondicherry state was ranging from 0.02 to 0.15 per cent.

2.3.2.2.2. Available phosphorus

The available P content denotes the quantity of orthophosphate ions (H_2PO_4^- and HPO_4^{2-}) present in the soil solution as well as, the quantity of these ions that can be mineralized from the organic pool and that can be solubilised from the mineral 'P' fractions. Methods employed to determine the available P content mainly aim at extracting the orthophosphate ions that are present in soil solution and to complex the corresponding cations of the phosphate ion so as to create anion flux resulting in the dissolution of mineral P.

The available P showed positive correlation with pH, CEC and total P but it showed negative correlation with clay and organic carbon content (Mandal *et al.*, 1990; Mathan, 1998). The available P decreased with the increase in clay content which was confirmed by the negative correlation of available P with clay (Mayalagu and Paramasivam, 1994). In contrast to this Pandey *et al.* (2000) reported that availability of phosphorus was significantly and positively correlated with organic matter and finer soil particles.

Kuldeep Singh and Ahuja (1990) reported that phosphorus content decreased with depth in pedon and was found to be higher in surface horizons. Sharma and Singh (2001) observed that the available P content in the cultivated soils ranged from 7 to 55 kg ha⁻¹, the lower availability of phosphorus was due to fixation by clay minerals and precipitation by the oxides of iron and aluminum as iron phosphate and aluminum phosphate. Misra *et al.* (2000) reported acid soils of Mizoram, contained low available P ranged from 2.2 to 8.6 kg ha⁻¹.

Ramesh (2001) reported that the available P content in Karaikal region ranged from 3.54 to 63.56 kg ha⁻¹. Gupta *et al.* (2001) reported the available P content 24.6 kg ha⁻¹ in surface soils of forest land Kandi belt soils of Jammu region and Sharma *et al.* (2001) also reported available P in oran lands ranging from 7 to 55 kg ha⁻¹.

Thangasamy *et al.* (2005) reported in Chittor District of Andhra Pradesh, that available phosphorus content in the horizons of the pedons varied from 4.5 to 29.3 kg ha⁻¹. However the highest available phosphorus was observed in surface horizons. The available P decreased regularly with depth.

Sanjay *et al.* (2005) reported available P content in different places, ranging from 2.35 to 25.66 kg ha⁻¹ in Leh and 2.5 to 137.4 kg ha⁻¹ in Kargil. Meena *et al.* (2006) reported that the available phosphorus content varied from 9.2 to 65.2 kg ha⁻¹ in Tonk District of Rajasthan. Laxminarayana (2007) reported the available P content ranging from 6.56 to 10.93 in the mid-western Uttar Pradesh.

Vara Prasad Rao *et al.* (2008) reported from Chittoor District of Andhrapradesh, that available phosphorus content of surface soil samples varied between 9.29 and 23.96 kg ha⁻¹ in different places.

2.3.2.3. Potassium

Potassium is absorbed by plants in larger amounts than any other nutrient except nitrogen. It is present relatively in larger quantities in most soils, averaging about 1.9 per cent and K forms in soils are dynamic in nature. Depletion of solution K, results in the shift in the equilibrium thereby the other forms of K were released into the solution. Similarly, additions of K either through fertilizer or manure results in the fixation of this nutrient either on planar sites, which are non-specific to K or in the inter lattice position on the clay mineral which are highly specific to potassium. Hence, the availability of K to plants is mainly governed by the equilibrium of K fractions in the soil system.

2.3.2.3.1. Total potassium

In tropical soils, the total K content may be quite low because of the origin of the soils, high rainfall and continued high temperature resulting in the faster rate of weathering combined with the subsequent removal of the released K by the rain water. Although the total K content of soils is usually many times greater than the amount taken up by the crop during a growing season, in most cases, only a small fraction of it is available to the plants (Tisdale *et al.*, 1985)

Masilamani (1987) observed that K content of the red soils ranged from 231 to 1575 mg kg⁻¹, the mean total K content of these soils was low and there was a correlation between pH and total K content. Renganathan and Satyanarayana (1990) inferred that the variation in distribution of K depended upon the minerals present, particle size and degree of weathering of minerals in soils. Rama Lakshmi and Seshagiri Rao (2000) reported that the total K content ranged from 1000 to 2700 mg kg⁻¹ in the Entisols of Andhra Pradesh.

The total K content decreased with depth in the alluvial soils of Assam (Basumatary and Bordoloi, 1992) possibly due to the decrease in the clay content, whereas the total K content increased with depth and is possibly due to increase in clay content with depth (Mayalagu, 1982).

The total K content of black soils of Andhra Pradesh ranged from 1 to 2 per cent (Subbaiah and Manickam, 1989), from 1.3 to 2.8 per cent in the soils of Haryana (Sidhu *et al.*, 2000), from 0.10 to 0.27 per cent in the Entisols of Andhra Pradesh (Rama Lakshmi and Seshagiri Rao, 2000) and from 0.18 to 2.39 per cent in the soils of Karaikal region (Ramesh, 2001).

Total K varied from 0.008 to 2.036 per cent in Karaikal region (Vembu, 2003), and from 0.117 to 0.535 per cent in PAJANCOA and RI Agricultural farm soils (Valliammal, 2004). Karthik Kumar (2005) reported that the total K content in the soils of Bahour commune of Pondicherry state ranging from 0.36 to 2.47 per cent.

Gangopadhyay *et al.*, (2005) reported total K content of the Ranchi district of Jharkhand, the total K content of the soils varied from 0.20 to 2.11 per cent with a mean value of 0.8 per cent. The high total K content of these soils may be attributed to the presence of substantial quantities of K bearing minerals in the soils.

2.3.2.3.2. Available potassium

Available potassium is the potassium ions present in the soil solution and that are held on the exchange sites which are readily available to the crop growth. Harikrishnan Nair and Koshy (1982) registered satisfactory levels of total K and low levels of available K in Kerala red soils. The low availability of K might be because of low exchange capacity.

Yadav and Swami (1987) found that clay content had significant correlation with water soluble, exchangeable, nitric acid soluble and reserve K contents in soils. Different forms of potassium and K fixation capacity showed a positive relationship with clay, silt, organic carbon, CEC and base saturation. This was noticed by Basumatary and Bordoloi (1992) and Bourah and Nath (1992). Pal and Durge (1993)

observed that the rate of K release from soil clay micas was governed by the nature rather than the amount of micas.

Mayalagu (1986) noticed that surface layers of red soils had more available K than the subsurface layer. Similar observations were also made by the Ramesh *et al.* (1994), whereas Yadav *et al.* (1999) observed different pattern of distribution of available K in different soils and irregular distribution of total K with depth.

The clayey and loamy alluvial soils release more available K in subsurface than surface (Sailaksmiswari *et al.*, 1985). Balasubramanian (1987) reported that total K was positively correlated with available K and both showed an increasing trend with depth in Padugai series, a Typic Ustifluent. Kuldeep Singh and Ahuja (1990) reported that K content in the soils of Ghaggar river basin ranged from 25 to 1052 kg ha⁻¹. The large variation in potassium content might be because of the occurrence of the illitic and micaceous minerals in varying proportion in different areas through which water of the river passes.

The available K status of soils ranged from 483 to 632 kg ha⁻¹ in the soils of Karnataka (Bellakki and Badanur, 1994), from 508 to 1321 kg ha⁻¹ in the Majalgaon Command area (Bharambe *et al.*, 1999), from 107.5 to 132.5 kg ha⁻¹ in Theri soils of Tamil Nadu (Jawahar *et al.*, 1999), from 53.27 to 1548 kg ha⁻¹ in the surface soils of Karaikal region (Ramesh, 2001) and from 90.8 to 672.2 kg ha⁻¹ in the soils of Andhra Pradesh (Anitha *et al.*, 2001).

Misra *et al.* (2000) reported in acid soils of Mizoram, the available potassium of the soil was either high (> 280 kg ha⁻¹) or medium (118 to 280 kg ha⁻¹). Gupta *et al.* (2001) also reported the available K content 164 kg ha⁻¹ in Jammu region.

Sharma *et al.* (2001) reported high content of available K in oran and cultivated fallow lands of Western Rajasthan, it varied from 90 to 520 and 80 to 408 kg ha⁻¹, respectively indicating there by relatively higher content in case of oran lands. This might be due to the action of plant roots of the existing vegetation in transporting potassium to the surface and also addition of plant residues.

Thangasamy *et al.* (2005) reported in Chittoor district of Andhra Pradesh the available K in all the pedons varied from 22 to 212 kg ha⁻¹. The highest available K content was noticed in the surface horizons and showed more or less decreasing trend with depth. This could be attributed to more intense weathering, release of labile K from organic residues, application of K and upward translocation of K from lower depths along with capillary rise of ground water. Similar results were reported by Hirekurabar *et al.* (2000).

Sanjay *et al.* (2005) reported available K content of 11 to 496 kg ha⁻¹ and 103 to 861 kg ha⁻¹ in soil samples of Leh and Kargil districts. Meena *et al.* (2006) reported in Tonk district of Rajasthan that the available potassium in the soils ranged from 105 to 1059 kg ha⁻¹.

Laxminarayana (2007) observed that the available K content of the soils of mid western Uttar Pradesh, ranging from 124 to 360 kg ha⁻¹. Vara Prasad Rao *et al.* (2008) reported from Chittoor district of Andhra Pradesh, that the available potassium content of the surface soil samples varied from 135 to 320 kg ha⁻¹.

2.3.3. Secondary nutrients

The secondary nutrients are calcium, magnesium and sulphur which are required in relatively large amounts for good crop growth. The Mg and S needed by plants is about the same quantities as P, whereas for many plant species, the Ca requirement is greater than that of P.

2.3.3.1. Calcium

Calcium is absorbed by plants as Ca²⁺ from the soil solution and is supplied to the root surface by mass flow and root interception. The calcium content is very low in the sandy soil of humid region and highly weathered soils of humid tropics, whereas it is generally high in arid region soils as a result of low rainfall and little leaching.

Tisdale *et al.* (1995) reported that in general the Ca content ranges from 0.7 to 1.5 per cent in the non calcareous soils of humid temperate region and

from 0.10 to 0.33 per cent in highly weathered soils of humid tropics. As a general rule, coarse textured humid region soils formed from rocks low in Ca minerals are low in Ca. Soils that are fine textured and formed from rocks high in Ca mineral are much higher in exchangeable and total Ca. In calcareous soils, the Ca content can vary as low as 1 per cent to more than 25 per cent. The red soils were generally deficient in Ca as concluded by Digar and Barde (1982).

Khengarot and Mehra (1977) reported that in the alluvial soils of Udaipur valley, the range of total calcium varied from 1.10 to 8.58 per cent; from 1.12 to 4.48 per cent in the coastal saline soils of Orrisa (Sahu *et al.*, 1986) and from 1.3 to 2.1 per cent in the soils of Haryana (Sidhu *et al.*, 2000), from 1 to 2 per cent in the black soils of Andhra Pradesh (Subbaiah and Manickam, 1989). Rose *et al.* (1985) reported that the acidification of soils adversely affect the calcium. Ramesh (2001) reported that total Ca content of the Karaikal varied from 0.42 per cent to 0.57 per cent.

Total Ca varied from 0.200 to 2.673 per cent in Karaikal region (Vembu, 2003), and from 0.50 to 5.11 per cent in PAJANCOA and RI farm soils (Valliammal, 2004). Karthik Kumar (2005) reported that the total Ca content in the soils of Bahour commune of Pondicherry state was ranging from 0.45 to 5.81 per cent.

2.3.3.2. Magnesium

The plants absorb magnesium as Mg^{2+} from the soil solution. The Mg content is highly variable ranging from 0.1 per cent in coarse sandy soils of humid region to 4 per cent in fine textured arid or semi-arid soils formed from high magnesium containing parent materials. The total Mg content in the alluvial soils of Udaipur valley ranged from 1.47 to 4.50 per cent (Khengarot and Mehra, 1977) and from 0.5 to 2.5 per cent in the soils of Haryana (Sidhu *et al.*, 2000). The total Mg content of Karaikal soils ranged from 0.13 to 0.312 per cent as reported by Ramesh (2001).

Total Mg varied from 0.06 to 0.776 per cent in Karaikal region (Vembu, 2003), and from 0.3 to 2.49 per cent in PAJANCOA and RI farm soils (Valliammal, 2004). Karthik Kumar (2005) reported that the total Mg content in the soils of Bahour commune of Pondicherry state was ranging from 0.14 to 2.57 per cent.

2.3.3.3. Sulphur

Sulphur has been recognized as an essential plant nutrient. It is known to be indispensable for many reactions in every living cell. Sulphur is present in the soil both in organic and inorganic forms. Although 90 per cent of the total S in most non-calcareous soil exist in organic form, the main S bearing minerals in rocks and soils are gypsum, epsomite, mirabilite, pyrite, sphalerite, chalcopyrite and cobaltite.

Manickam (1985) noticed inherent sulphur deficiencies in coarse textured Alfisols and Inceptisols and it decreased with depth (Mohinder Singh *et al.*, 1985) and followed a similar trend of decrease in total S with depth along with the decrease in organic matter content (Sunil Kumar and Vinay Singh, 1999). The distribution pattern of sulphur in Alfisols indicated that the total and organic sulphur of soils had significant correlations with clay and organic matter content of the soils (Misra *et al.*, 1990). Pandey *et al.* (2000) revealed that availability of S had positive and significant correlation with organic matter, CEC and finer soil particles.

The depth wise distribution of different forms of sulphur, *viz.*, water soluble sulphate, organic and total sulphur in Vertisols and Alfisols of North Karnataka showed wide variation; the extractable sulphur was only 2.5 per cent of the total sulphur (Balanagoudar and Satyanarayana, 1990). The available sulphur in the soils of Karaikal region ranged from 3.48 to 287.23 mg kg⁻¹ and total sulphur content in this region ranged from 0.196 to 2.227 per cent as reported by Ramesh (2001). Poongothai *et al.* (2003) reported that the soils of Coimbatore district was found to be well above the critical limit of 12 mg kg⁻¹ of mean sulphur content. Bhatnagar *et al.* (2003) reported that the organic sulphur content in the soils of Madhya Pradesh accounted for 59 and 62 per cent in the soils of Inceptisols and Vertisols respectively.

Suresh and Savithri (2001) reported that the available sulphur ranged from 13.5 to 21.1 kg ha⁻¹ in iron toxic soils of Kanyakumari district of Tamilnadu. Karthik Kumar (2005) reported the available S content in the soils of Bahour commune of Pondicherry state ranged from 10.89 to 159.51 mg kg⁻¹.

Thangasamy *et al.* (2005) reported from Chittor district of Andhra Pradesh that the available sulphur content varied from 12.5 to 35.2 mg kg⁻¹ of soil. Surface layers contained more available S content than in the deeper layers which could be due to higher amount of organic matter in surface layers than in deeper layers.

Nevneet Pareek (2007) reported that the available S of the soil of Pantnagar district of Uttarakhand, ranged from 6.25 to 36.25 mg kg⁻¹. Vara Prasad Rao *et al.* (2008) reported the available sulphur content which ranging from 3.42 to 9.82 mg kg⁻¹ in soils of Chittor district of Andhra Pradesh.

CHAPTER 3

MATERIALS AND METHODS

In this chapter, details about the study area, selection of profile site, method of profile and surface soil sample collection and the analytical procedures followed are presented.

3.1. Description of study area

The Pandit Jawaharlal Nehru college of Agriculture and Research Institute is about 9 km northwest to Karaikal which lies between 10°49' and 11°00' latitude and between 78°43' and 79°52' eastern longitude. It is bounded on the north by Serumavilangai, south by Sorakudy, east by Melakasakudi and by the development on the west. The study area is situated 4 m above mean sea level having the maximum and minimum of 31.95°C and 25.52°C temperatures with an annual intensity of 1506.87 mm rainfall. The whole area of Horticultural farm was divided into Eastern farm and Western farm. Western farms has the orchard and new botanical garden, the Eastern farm otherwise called as old botanical garden. Currently, the Eastern farm is not divided into blocks and the area of the Western farm (divided into ten blocks) with botanical garden occupying 30 acres and the Eastern farm occupies an area of 15 acres (Fig 1). Totally an area of 45 acre is now taken as the study area in the present investigation. The extent of area in each of the blocks are described in Table 1.

3.2. Profile study

Eleven profiles were excavated during summer season, out of which ten profiles were in Western farm and one was in Eastern farm. The profiles were selected based on their heterogenetic nature of the soil with respect to morphological feature, crop growth and yield variability. In the profiles, horizons were differentiated based on the variability with the colour, texture, structure, root density, effervescence, consistency etc, that differ from layer above or below. Soil samples were collected from individual horizon in polythene bags with proper labelling and brought into the laboratory. The samples were air dried in shade, gently malleted and sieved through 2 mm sieve and preserved for further analysis.

3.3 Collection of surface soil sample

To characterize the surface soil, the surface soil samples were collected from each and every field of the farm. The soil samples were collected during summer, when the fields were fallow. The details about the sampling are presented in Table 2. The samples were collected from top 30 cm depth in 5 to 10 places in each field by adopting the standard procedures of soil sample collection from which, a composite soil sample of about 1 kg was collected by quartering technique. The collected soil samples were air dried, gently malleted and sieved through 2 mm sieve and preserved in polythene bags with proper labeling for further analysis.

3.4. Soil analysis

The surface soil samples and horizon wise soil samples were analyzed for various soil properties by adopting standard procedures. The methods employed are given in Table 3.

3.5. Statistical analysis

The results of the analysis are expressed on oven dry basis and the data are subjected to statistical scrutiny. Simple correlation and multiple regression analyses was attempted to draw valid conclusion by adopting the procedures as described by Gomez and Gomez (1976).

Table 1. Area of distribution of eastern and western farm

Western farm			Eastern farm		
S.No	Name of the Blocks	Area (ha)	S.No	Name of the Block	Area (ha)
1	A ₁	0.4	1	No Blocks	6.0
2	A ₂	0.4			
3	A ₃ ,A ₄	0.6			
4	B,C ₁ ,C ₂ ,E ₂	1.3			
5	C ₁	0.2			
6	D	0.32			
7	J ₁ ,F ₁	0.90			
8	F ₂ ,F ₃ ,F ₄ ,G ₁ ,G ₂	2.0			
9	G ₄	0.2			
10	E ₁ ,G ₃ ,H ₁ ,H ₂ ,I ₁	2.0			
11	B	0.10			
12	I ₂ ,I ₁	0.8			
13	P ₁ ,P ₂ ,P ₃	1.2			
Total		10.42	Total		6.0

Table 2. Details of profile and surface soil samples collected

Eastern farm				Western farm			
Name of the block	No. of fields	No. of profiles	No. of surface sample	Name of the block	No. of fields	No. of profile	No. of surface sample
A	4	1	8	No Blocks	-	1	5
B	1	1	2				
C	2	1	4				
D	1	1	2				
E	2	1	4				
F	4	1	8				
G	4	1	8				
H	2	1	4				
I	2	1	4				
J	2	1	4				
Total		10	48	Total		1	5

Table 3. Details of analytical methods employed in soil analysis

Sl.No	Parameter	Methodology followed	Authors
A. Physical properties			
1.	Soil colour	Munsell colour chart	Pendleton and Nickelson (1951)
2.	Textural analysis	International pipette method	Piper (1966)
3.	Apparent specific gravity	Cylinder method	Dakshinamoorthy and Gupta (1968)
4.	Absolute specific gravity		
5.	Pore space		
B. Physico-chemical properties			
6.	Soil reaction (Saturation past extract)	Using glass electrode in the 'ELICO pH meter	Jackson (1973)
7.	Electrical conductivity (Saturation past extract)	Using 'ELICO' EC meter	
8.	Loss on ignition	Gravimetric method	Piper (1966)
9.	Moisture per cent	Oven drying	A.O.A.C (1962)
C. Chemical properties			
10.	Acid insoluble	The residue in HCl extraction was dried and weighed	Piper (1966)
11.	Sesqui oxides	Gravimetric method	Piper (1966)
12.	Organic carbon	Chromic acid wet digestion method	Walkley and Black (1934)
13.	Total N	Macro Kjeldahl method	Piper (1966)
14.	Total P	Vanadomolybdate phosphoric acid yellow colour method	Jackson (1973)
15.	Total K	Hydrochloric acid extract	Standford and English (1949)
16.	Total Na		
17.	Total Ca and Mg	Versenate titration	Jackson (1973)

Contd/-...

Table 4 Contd...

Sl.No	Parameter	Methodology followed	Authors
18.	Available N	Alkaline Permanganate method	Subbiah and Asija (1956)
19.	Available P	Colorimetric method using 0.5 M Na HCO ₃ of pH 8.5	Olsen <i>et al.</i> (1954)
20.	Available K	Flame photometer method using neutral normal ammonium acetate	Standford and English (1949)
21.	Available S	CaCl ₂ extraction method	Williams and Steinbergs (1959)
24.	Cation exchange capacity	Neutral normal NH ₄ OAc leaching and washing with C ₂ H ₅ OH	Schollenberger and Dreibelbis (1930)
25.	Exchangeable Ca and Mg	Versenate titration method	Jackson (1973)
26.	Exchangeable K and Na	Flame photometer	Standford and English (1949)

Chapter 4

EXPERIMENTAL RESULTS

A detailed investigation was undertaken to characterize the farm soils of the Horticultural department, PAJANCOA and RI, Karaikal with a view to delineate the soils possessing any constraints limiting crop production. For this purpose, eleven soil profiles were dug in each of the blocks of the horticultural farms and 53 surface soil samples were collected from each of the fields. The collected soil samples were subjected to various physical, physico-chemical and chemical analysis by adopting the standard procedure as described in chapter 3. The results thus obtained are presented in this chapter with the following sub sections.

4.1. Profile samples

4.1.1. Soil moisture content (Table 4)

The results of the soil moisture content in the soil samples collected from different horizons of eleven soil profiles are presented in Table 4. It was seen that the moisture content of the air dried soils ranged from 0.26 to 7.03 per cent with a mean value of 2.57 per cent and a co-efficient of variation (CV) of 54.53 per cent. It was also seen that the lowest value of 0.26 per cent was recorded in the bottom most layer of profile D and the highest value was in the second layer of profile A.

A further scrutiny of the data had revealed that in profile A, the range of soil moisture content was from 1.53 to 7.03 with a mean value of 3.03 per cent. In profile B, it ranged from 0.90 to 2.82 (mean value 1.74 per cent), in profile C from 1.23 to 3.15 (mean value 2.09 per cent), in profile D it was ranging from 0.26 to 3.73 per cent (mean value 2.08 per cent), in profile E 1.23 to 4.33 (mean value 2.91 per cent), in profile F from 2.56 to 3.91 (mean value 3.36 per cent), in profile G from 1.62 to 3.79 (mean value 2.75 per cent), in profile H from 1.30 to 5.80 (mean value 3.37 per cent), in profile I from 0.90 to 3.38 (mean value 2.04 per cent), in profile J it was 1.40 and 5.14 (mean 3.56 per cent) and in the botanical gardens it ranged from 0.28 to 2.24 with a mean value of 1.44 per cent. Among the different blocks, the minimum

variation was observed in F block (16.09 per cent) and the maximum was in A block (74.98 per cent).

As regards the variation in the moisture content of the air dried soils with the change in depth, it was found that except in profile C, the moisture content decrease with depth, in all other profiles, these was no specific trend.

The simple correlation studies had revealed that the moisture content was positively related to the loss on ignition, clay content, cation exchange capacity and total calcium but negatively related to bulk density and per cent acid insoluble (Table 5).

The linear multiple regression analysis had revealed that the variations in the moisture content after air drying can be significantly explained to the tune of 19.4 per cent (Table 6), though no single soil separate viz., clay, silt, coarse sand and fine sand could contribute significantly. It was further concluded that among the two contributing factors viz., clay and organic matter to the moisture retained after air drying, the clay was significantly contributing along with organic matter (insignificant to the tune of 18.3 per cent) (Table 7).

4.1.2. Loss on Ignition (Table 4)

The results of the weight loss in the soil sample after ignition had revealed that, it ranged from 0.05 to 5.91 per cent with a mean value of 2.24 per cent and the CV of 64.54 per cent. The lowest value of 0.05 per cent was recorded in the fourth layer of the profile in the botanical garden whereas, the highest value of 5.91 was registered in the surface soil of profile in H block.

As regards the profile in the A block, the values ranged from 0.71 to 5.87 per cent with a mean value of 1.97 per cent. The corresponding values for the B block was 0.25, 3.09 and 1.76, for C block it was 0.86, 2.79 and 1.77, for D block 0.25, 3.32 and 2.06, for E block it was 0.25, 4.07 and 2.54, for F block it was 2.21, 3.48 and 2.93, for G block it was 2.06, 4.56 and 3.29, for H block it was 0.56, 5.91 and 3.33, for I block it was 1.17, 2.31 and 1.81, for J block it was 0.41, 3.96 and 2.36 and 1.81,

for the botanical garden it was 0.05, 0.77 and 0.51 per cent respectively. The CV ranged from 17.46 per cent in the F block to 111.38 per cent in A block.

Except in profile C and I, where the loss on ignition declined with depth of soil profiles, in all other profiles there is no specific trend with depth.

The loss on ignition was significantly and positively correlated to moisture content, clay content, CEC and total Ca, whereas it was negatively related to bulk density and coarse sand content (Table 5).

The linear multiple regression analysis had further revealed that none of the soil separate could contribute to the loss on ignition, whereas between clay and organic matter the content of clay was able to determine the significant variation in the loss of ignition as compared to organic matter (Table 7).

4.1.3. Bulk density (Table 4)

The range of values in the bulk density among the different soil samples collected from the profiles of the horticultural farm had shown that the minimum value of 1.176 Mg m^{-3} was recorded in surface soil of A block and that of the maximum value of 1.538 Mg m^{-3} was recorded in the fourth layer of H block. The overall mean value was 1.246 Mg m^{-3} and the CV was only 5.778 per cent.

The maximum and minimum values of bulk density in the different profiles are 1.176 and 1.250 in A and C block, 1.176 and 1.330 in B, D, E, F block and Botanical garden, 1.250 and 1.330 Mg m^{-3} in G block, 1.176 and 1.538 Mg m^{-3} in H block. The minimum variation in the bulk density value was observed in C block (2.425 per cent) and that of the maximum in H block (9.523 per cent).

The variation in bulk density was found to be increasing with depth in profiles B, I and botanical gardens, whereas in all other profiles there was a slight increase in the second / third layer and then a decrease was noticed.

The simple correlation studies had shown that, it was negatively and significantly correlated to the loss of ignition, moisture content, total porosity, clay content, organic carbon content and organic matter content. It was positively related to total Ca content (Table 5).

The multiple regression analysis had revealed that among the different soil particles clay alone could contribute to the variation in bulk density, though all the soil separates failed to determine the bulk density significantly (Table 6). It was further noticed that 19.3 per cent variation in the bulk density can be explained by the variations in clay and organic matter content, the significant contribution being made by the organic matter content.

4.1.4. Particle density (Table 4)

The particle density values of the profile sample ranged from 2.000 to 3.333 Mg m^{-3} with a mean value of 2.380 Mg m^{-3} with a CV of 8.00 per cent. The maximum and minimum value of the particle density was registered in the profile H viz., the last and second layers respectively.

The range of values of particle density was between 2.222 to 2.50 in the profiles A, C, D, E, F, I, J and botanical garden. In the profiles B and G, there was no variation, all the horizons recording 2.50 Mg m^{-3} . In the profile H alone the minimum value was 2.000 Mg m^{-3} in the second layer and 3.333 Mg m^{-3} in the bottom most layer. The mean values of particle density in the different blocks were 2.333, 2.500, 2.690, 2.278, 2.389, 2.361, 2.500, 2.463, 2.361, 2.315 and 2.389 respectively from A to J blocks and botanical garden .

The particle density however, did not show much variation or any trend with depth in majority of the profile.

The simple correlation studies had shown positive and significant relationship of this property with total porosity and the contents of fine sand and acid insoluble. It was also negatively related to moisture content. (Table 5)

The regression analysis did not show any significant result (Table 6 and 7).

4.1.5. Total porosity (Table 4)

The total porosity of the profile soil samples ranged from 37.50 per cent (second layer of profile H) to 60.00 per cent (bottom most layer of same profile) with an average value of 47.37 per cent. The CV was only 9.40 per cent.

The values of total porosity ranged from 47.06 to 56.94 per cent in profile A, from 46.67 to 52.94 per cent in profile B, from 43.75 to 52.94 per cent in profile C, from 40.00 to 50.00 in profile D, from 40.00 to 62.94 in profile E, F, I and Botanical garden from 46.67 to 50.00 in profile G, from 37.50 to 60.00 in profile H, and from 43.75 to 47.06 per cent in profile J. The CV was minimum (3.53 per cent) in profile J and maximum (19.08 per cent) in profile H.

As seen in the case of particle density, the total porosity did not follow any specific trend as depth increases.

The simple correlation studies had shown that the total porosity was positively related to loss on ignition and negatively to bulk density (Table 5).

The multiple regression analysis had revealed that the variations in the total porosity could be ascribed to different soil separates except silt content ($R^2 = 0.213^{**}$) (Table 6). It was further seen that neither the clay content nor the organic matter content either alone or in combination could determine the porosity (Table 7).

4.1.6. Textural analysis

4.1.6.1 Clay content (Table 8 ; Fig. 2-12)

The textural analysis of the profile soil samples is presented in Table 8. It was found that the clay content of the soil samples in the profile ranged between 2.40 per cent in III layer of profile in I block to 52.90 per cent in the surface layer of H block . The mean clay content was estimated to be 20.73 per cent with a CV of 53.38 per cent.

The clay content of profile dig in A block was ranging from 15.90 to 27.65 per cent and that of the B block from 13.15 to 28.65 per cent. The minimum and maximum values in the remaining profiles were 2.65 and 15.15 per cent, 2.90 and 30.15 per cent, 16.15 and 28.40 per cent, 22.15 and 51.15 per cent, 7.90 and 40.15 per cent, 4.65 and 52.90 per cent, 2.40 and 25.90 per cent, 8.15 and 30.40 per cent and 13.65 to 31.65 per cent in C, D, E, F, H, I, J and botanical gardens respectively. Among the different profiles the highest CV was recorded in H block (69.68 per cent) and the least was in A block (23.94 per cent).

As regards the variations in the clay content with the depth of soil profile, it was seen that there was no clear cut trend that could describe the pathway of pedogenesis.

The simple correlation studies had shown that the clay content was positively and significantly related to loss on ignition, moisture content, CEC, exchangeable Ca²⁺, Mg²⁺, total Na, total N, available N and K. It was negatively related to bulk density and coarse sand content (Table 9).

The multiple regression analysis had shown that the different compounds of soil texture viz., clay, silt, coarse sand and fine sand could significantly explains the variations in soil moisture content ($R^2 = 0.194^*$), total porosity ($R^2 = 0.213^{**}$), CEC ($R^2 = 0.248^{**}$) and available N ($R^2 = 0.260^{**}$) (Table 6). It was further observed that between the clay and organic matter, clay could significantly explain the variation in soil moisture content, loss on Ignition, CEC, exchangeable Ca and Mg, available N and P and total Na

4.1.6.2. Silt content (Table 8; Fig. 2-12)

The silt content of the soil samples ranged between 1.25 per cent of penultimate layer of botanical garden to 29.35 per cent of the same layer in I block, with a mean value of 6.44 per cent and the CV of 87.79 per cent.

The silt content of different profiles of each of block had shown that it ranged from 2.50 to 8.50 per cent in profile A, 1.25 to 19.25 pre cent in profile B, 2.25 to

12.50 per cent in profile C, 1.25 to 8.75 per cent in profile D, 2.75 to 19.25 per cent in profile E, 1.25 to 9.25 per cent in profile F, 5.25 to 24.75 per cent in profile G, 2.75 to 11.75 per cent in profile H, 2.75 to 29.35 per cent in profile I, 1.75 to 9.50 per cent in profile J and 1.25 to 5.75 per cent in botanical garden. The CV was found to be the least in J block (46.60 per cent) and higher in B block (117.44 per cent).

As seen in the case of the clay content, the content of silt did not show any variations with the depth of profile.

It was further noticed from the simple correlation analysis that the silt content of the soil samples did not show any significant correlation with any of the soil properties (Table 5 and 9).

From the multiple regression analysis it was already pointed out that the different soil separates could significantly explained the variability in soil moisture content ($R^2 = 0.194^*$), total porosity ($R^2 = 0.213^{**}$), CEC ($R^2 = 0.248^{**}$) and available N ($R^2 = 0.260^{**}$). However, in none of the above cases, the silt content could significantly contributes towards the variability.

4.1.6.3 Coarse sand (Table 8 ; Fig 2-12)

The content of coarse sand in the different horizons of profiles dug in the horticultural farms had revealed that it ranged from 5.24 in the surface horizon of G block to 71.80 in the fourth layer of J block, with a mean value of 34.29 per cent and the CV 73.83 per cent.

The range of values of the coarse sand content, the different profiles had shown that it ranged from 14.45 to 59.25 per cent in the profile A and 9.45 to 66.16 per cent in profile B. The corresponding values for the profiles C, D, E, F, G, H, I, J and botanical garden were 11.81 to 66.15 per cent, 10.91 to 59.74 per cent, 10.96 to 66.15 per cent, 7.83 to 30.13 per cent, 5.24 to 70.41 per cent, 6.04 to 70.32 per cent, 9.85 to 66.02 per cent, 8.87 to 71.80 per cent and 7.72 to 68.10 per cent respectively. Among the different profiles, the least variability in terms of CV was recorded in profile A (89.07 per cent) and the maximum was observed in profile G (149.74 per cent).

It was further noticed that the coarse sand content did not show any clear cut trend of increase or decrease or both with the depth of the profile.

The results of the simple correlation studies had shown that the coarse sand content was significantly and negatively related to the loss on ignition ($r = - 0.298^*$), fine sand ($r = - 0.886^{**}$) and CEC ($r = - 0.331^{**}$) (Table 9).

The multiple regression analysis had shown that the different soil separates could account for the variation in the soil moisture content, total porosity, CEC and available nitrogen. However in none of the above prediction, the coarse sand could contribute significantly (Table 6), except in total porosity.

4.1.6.4 Fine sand (Table 8; Fig . 2-12)

The content of fine sand ranged from 2.84 per cent in the second horizon of H block to 81.75 per cent in the third layer of D block, with a mean value of 34.37 per cent and a CV of 69.15 per cent.

Among the different profiles dug in the various blocks of horticultural farm, A block profile recorded the minimum fine sand content of 8.80 and a maximum of 58.20 per cent. The corresponding minimum and maximum values of the fine sand content in the different profiles of blocks were 7.74 and 54.80 per cent for profile B, 14.66 and 66.97 per cent for profile C, 7.66 and 81.75 for profile D, 7.06 and 47.10 per cent for profile E, 6.02 and 61.40 per cent for profile F, 7.88 and 55.86 per cent for profile G, 2.84 and 64.21 per cent for profile H, 11.53 and 66.11 per cent for profile I, 6.79 and 60.95 per cent for profile J and 10.91 to 58.70 per cent in the botanical gardens. The CV variation ranged from 40.52 per cent in the profile of the I block to 100.21 per cent in the profile of the D block.

Similar to other soil separates the fine sand also did not vary much between the different layers of the profile or followed any specific trend.

The simple correlation studies had revealed that this property could established a significant and negative relationship only with the coarse sand ($r = -0.886^{**}$) (Table 9).

The significant contribution of fine sand was observed only in the case of total porosity, though this property along with other soil separates could explain the variation in soil moisture content, total porosity, CEC and available nitrogen.

4.1.7 Acid Insoluble

The percentage acid insoluble fractions of the different soil samples drawn from the profiles are presented in Table 10. A simple statistical scrutiny of the results had shown that it ranged from 81.60 per cent to 97.10 per cent with a mean value of 89.00 per cent and the CV of 15.24 per cent. The highest and the lowest values were recorded in the profile dig in H block viz., the penultimate and the bottom most layer respectively.

The variation in the acid insoluble fractions among the different profiles was also found to be marked. It was seen that the highest and lowest values of acid insoluble fraction in profile A was 92.03 per cent and 87.93 per cent respectively. The corresponding values in the rest of the profiles were 95.42 and 87.54 per cent in profile B, 94.51 and 86.79 per cent in profile C, 90.81 and 81.70 per cent in profile D, 94.72 and 84.22 per cent in profile E, 88.89 and 81.71 per cent in profile F, 94.48 and 82.40 per cent in profile G, 97.10 and 81.89 per cent I, 92.54 and 83.31 per cent in profile J, and 93.15 and 89.97 per cent in the botanical garden. The CV was found to be the minimum in the botanical garden 1.57 per cent and maximum in the H block (6.37 per cent).

In general the acid insoluble fraction tended to increase with the depth of soil profiles.

4.1.8. Sesquioxide (Table 10)

The sesquioxide content of the soil samples ranged from 2.05 per cent in the third layer of botanical garden and 19.86 per cent in the fourth layer of profile F. The mean sesquioxide content in the horticultural farm soil was estimated to be 11.09 per cent with a CV of 40.78 per cent.

Between the soil profiles and within the soil profiles there were wide variations in the sesquioxide content. It ranged from 7.13 to 18.28 per cent in profile A, 11.23 to 16.69 per cent in profile B, 7.12 to 12.85 per cent in profile C, 7.02 to 18.82 per cent in profile D, 7.59 to 17.18 per cent in E, 2.57 to 19.86 per cent in profile F, 2.57 to 12.99 per cent in profile G, 2.61 to 18.05 per cent in profile H, 8.69 to 15.53 per cent in profile I, 6.31 to 17.39 per cent in profile G and 2.05 to 18.28 per cent in the botanical gardens. Among the different profiles, the highest variation was observed in profile H (77.20 per cent) and the least was observed in profile B (14.84 per cent) as determined by the coefficient of variation.

As regards the variations among the different horizons of the profile, there is no trend, as evidenced by a random distribution of this fraction within the profile.

The simple correlation and the multiple regression analysis had shown that this property neither related to other soil properties nor contributed significantly forwards the variations.

4.1.9. Organic carbon (Table 10)

The organic carbon content of the soil samples drawn from the different horizons of the profiles dug in the horticultural farm is presented in Table 10. The descriptive statistics of the above data had shown that the organic carbon content was as low as 0.3 g kg⁻¹ in the penultimate layer of the H block to 10.4 g kg⁻¹ in the surface layer of the B block with a mean value of 3.3 g kg⁻¹ and CV of 65.04 per cent.

A close scrutiny of the data obtained from the individual profiles had further revealed that the organic carbon content was ranging from 2.90 to 5.80 g kg⁻¹ in the profile A and from 0.60 to 10.40 g kg⁻¹ in profile B. In the case of profile C, it ranged from 1.70 to 6.10 g kg⁻¹ and in the case of D, it was 2.20 to 8.90 g kg⁻¹. In the rest of

the profile viz., E, F, G, H, I, J and botanical gardens the corresponding values were 1.40 and 8.40, 0.90 and 7.50, 2.00, and 7.80, 0.30 and 4.60, 1.70 and 5.20, 0.60 and 2.90 and 2.90 to 4.90 g kg⁻¹ respectively. Among the different profiles, the minimum CV was recorded in botanical garden (20.16 per cent) and the maximum was registered in E block (97.49 per cent).

In general there was a decrease in the organic carbon content of the soil as the depth increases, except in the profiles A, B, C, F, G and I where, there is no clear cut trend was noticed.

The simple correlation studies had clearly indicated that the organic carbon content was positively and significantly related to total N ($r = 0.585^{**}$), total P ($r = 0.591^{**}$), available N ($r = 0.679^{**}$), available P ($r = 0.339^{*}$) and available K ($r = 0.463^{**}$). It was also negatively related to exchangeable Na (Table 11).

4.1.10. Organic matter

The organic matter status of the soil samples drawn from the different horizons of the profile are presented in Table 10, which had indicated that it ranged from 0.072 per cent in the penultimate layer of profile in H block to 1.790 per cent in the surface layer of B block. The overall mean of the organic matter status in the horticultural farm soil was 0.731 per cent and the CV was 53.43 per cent.

It was further noticed that there was wide variations between the profiles dug in the different blocks of horticultural farm as indicated by the range of values within the horizons. For instance it ranged from 0.721 to 1.442 per cent in A block, 0.144 to 1.790 per cent in the B block, 0.298 to 1.514 per cent C block, 0.505 to 1.542 per cent in D block, 0.361 to 1.442 in E block, 0.216 to 1.293 per cent in the F block, 0.505 to 1.343 per cent in the G block, 0.072 to 1.082 per cent in H block, 0.433 to 0.895 per cent in I block, 0.144 to 0.721 per cent in the J block and between 0.721 to 1.082 per cent in the botanical gardens. The CV within the horizons of the different profile was found to be the minimum in the botanical garden and maximum in the H block, viz., 14.87 and 76.01 per cent respectively.

As for as the variation between the layers in the organic matter content, it declined with depth only in the profile G and in all other profiles there was no clear cut trend.

The simple correlation studies had shown the positive and significant relationship of the organic matter towards the total N, P and available N, P, K (Table 11).

The linear multiple regression had shown the significant contribution of organic matter towards the variation in bulk density, electrical conductivity, exchangeable Na. Total N & Mg and available N, P, K (Table 7).

4.1.11. Soil reaction in saturation paste extract (Table 12)

The pH of the soil samples registered in the soil samples drawn from the various horizons of the profiles of horticultural farm is given in Table 12. Where in it was found to vary between 7.54 to 8.98 with a CV of 4.23 per cent.

It was also observed that the pH of the soil samples varied not only within the horizons of different profiles but also among the profiles. For instance, the minimum pH value recorded in profile A was 8.02 in the surface layer and 8.85 in the penultimate layer. In profile B, the lowest pH values (7.84) was in the surface layer and the highest (8.98) was in the penultimate layer. In profile C the lowest values was in the second horizon (8.11) and the highest was in the bottom most layer (8.62). In profile D the lowest was in the penultimate layer (8.11) and the highest was in the second layer (8.74). In profile E the surface layer registered the lower pH of 7.83 and the penultimate layer, the highest (8.91). Similarly in profiles F,G, H, I and botanical gardens the lowest pH values was in the surface layer and the highest was in the bottom most layers. In profile J the minimum of 7.54 was recorded in the surface soil and the maximum was in the third layer (8.47). Among the different profiles, the lowest CV among the depths of the profiles was registered in C block and the highest was in the G block.

In general the pH values tended to increase with the depth of profiles in most of the block.

The simple correlation studies had shown the positive relationship of pH with bulk density and negative relationship with CEC, loss of ignition, soil moisture content, total N, P, K, Na, available N, P, K, S and exchangeable Ca and Mg (Table 13).

The simple linear multiple regressions had shown that this property was contributed by none of the soil separate (Table 6). Similarly the pH remains unchanged due to the variations in clay and organic matter content of soil samples (Table 7).

4.1.12 Electrical conductivity of the saturation extract (Table 12)

The electrical conductivity of the saturation paste extract (ECe) ranged between 0.15 dS m⁻¹ to 2.04 dS m⁻¹ with a mean value of 0.77 dS m⁻¹ and CV of 57.66 per cent.

The electrical conductivity of the saturation paste extract ranged from 0.64 to 1.12 dS m⁻¹ in profile A, 0.28 to 2.04 dS m⁻¹ in profile B, 0.47 to 1.08 dS m⁻¹ in profile C, 0.82 to 1.73 dS m⁻¹ in profile D, 0.68 to 1.85 dS m⁻¹ in profile E, 0.82 to 1.55 dS m⁻¹ in profile F, 0.15 to 1.77 dS m⁻¹ in profile G, 0.15 to 0.24 in profile H, 0.43 to 0.58 dS m⁻¹ in profile I, 0.32 to 0.46 dS m⁻¹ in profile J and 0.47 to 0.68 dS m⁻¹ in the botanical garden. The CV was found to range from 10.58 per cent in profile I to 66.49 per cent in profile G.

As regards the changes in the ECe with depth, there were no marked variations (or) clear cut trend observed.

The simple correlation studies had shown that, the EC was positively related to total N, total Na, available P and K and exchangeable Na and K. It was negatively related to bulk density (Table 13 and 14).

The linear multiple regressions did not show any variation in the electrical conductivity due to variation in the different soil separates (Table 6).

4.1.13. Cation exchange capacity (Table 12)

The cation exchange of the soil ranged from 2.20 to 31.70 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ with a mean value of 11.76 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ and CV of 57.57 per cent. The minimum was recorded in the penultimate layer of profile E and the maximum was registered in the second layer of G block profile.

As regards the variations in the profiles of different blocks, the minimum CEC of 4.30 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ was in the bottom most layer, and the maximum was 20.00 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ in the second layer of profile A. In profile B the minimum and maximum value of CEC was in the fourth layer and surface layer respectively. The corresponding values of minimum and maximum was 3.00 and 10.70 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ in profile C, 6.70 and 11.10 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ in profile D, 2.20 and 12.20 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ in profile E, 6.20 and 25.70 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ in profile F, 11.10 to 31.70 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ in profile G, 9.80 to 22.00 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ in profile H, 9.50 to 18.90 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ in profile I, 12.80 to 17.00 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ in profile J and 4.10 to 7.70 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ in botanical garden. Within the different profiles the least variation was observed in J block (12.08 per cent) and the maximum variation was found to be in the profile dug in A block.

As has been observed in the case of clay content, the CEC also did not follow any specific trend.

The simple correlation studies had indicated that the cation exchange capacity was positively and significantly related to the loss on ignition ($r = 0.585^{**}$), moisture content ($r = 0.620^{**}$), (Table 5) clay content ($r = 0.429^{**}$) (Table 9), total K ($r = 0.376^{**}$) and available nitrogen ($r = 0.281^*$) and K ($r = 0.468^{**}$)(Table 11). It was also found to be negatively related to coarse sand ($r = -0.331^{**}$), pH ($r = -0.264^*$) and exchangeable Na ($r = -0.476^{**}$) (Table 14).

The simple linear multiple regressions had shown that the variation in CEC can be attributed to the different soil separates to the tune of 24.8 per cent (Table 6). By regression the clay and organic matter with CEC, the positive and significant role of clay was clearly established ($R^2 = 0.189$).

4.1.14 Exchangeable cations

4.1.14.1. Exchangeable calcium

The exchangeable calcium content ranged from 2.20 to 23.50 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ in the profiles of horticultural farm soils with a mean value of 7.06 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ and the CV of 48.86 per cent. The least value was observed in the bottom most layers of H block and the highest value was in the second layer of the profile A.

The variations in the exchangeable calcium content within the profiles and between the profiles are depicted in Table 12, which indicated that the minimum and maximum values of exchangeable Calcium in profile A was 5.00 and 23.50 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$. The corresponding values of minimum and maximum of the profiles B, C, D, E, F, G, H, I, J and botanical garden were 4.00 and 9.50, 3.50 and 10.00, 3.50 and 7.00, 3.00 and 10.00, 6.00 and 9.00, 5.00 and 8.50, 2.00 and 15.00, 3.50 and 8.50, 3.50 and 12.50 and 3.50 and 6.50 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ respectively. The CV was found to be the minimum in F block (16.35 per cent).

In general the exchangeable calcium content tended to increase up to a certain depth and thereafter decrease in majority of the profiles.

The simple correlation studies had indicated the positive and significant relationship of exchangeable Calcium with clay content (Table 9) exchangeable Mg and K (Table 14), Total N, K, Ca, Mg and available N & K (Table 15).

The simple multiple regression analysis had revealed that, the exchangeable Ca content is not dependent on different soil separates (Table 6). However, the significant contribution of clay was exhibited towards this property when clay and organic matter content were regressed with exchangeable Ca content (Table 7).

4.1.14.2. Exchangeable Magnesium. (Table12)

The exchangeable magnesium content was found to be to the level of non detectable range in the penultimate layer of botanical gardens to that of 16.50 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ in the bottom most layer of the D block. The mean exchangeable Mg content was found to be 4.15 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ and the CV was 78.49 per cent.

Between the profiles and within the profiles, there were wide differences which was exhibited by the range of values and the CV. For instance, in profile A the minimum value was 1.00 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ and the maximum was 14.00 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$. In other profiles it ranged from 1.00 to 4.50 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ in profile B, 1.00 to 5.50 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ in profile C, 3.00 to 16.50 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ in profile D, nil to 6.00 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ in profile E, 3.50 to 8.00 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ in profile F, nil to 8.50 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ in profile G, 1.00 to 10.00 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ in profile H, nil to 8.00 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ in profile I, 1.50 to 8.50 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ in profile J and nil to 4.50 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ in botanical garden. The range of CV values was found to be 36.02 per cent in the F block to 110.88 in the A block.

When the exchangeable magnesium was related to depth of soil profile, there is no specific trend observed.

The exchangeable magnesium was found to be positively related to clay content (Table 9), exchangeable calcium (Table 13), total N, P, K, Calcium and magnesium, available N and K (Table 11 and 15). It was negatively related to acid insoluble and pH (Table 13).

As seen in the case of exchangeable Ca, the different soil separates failed to explain the variation in the exchangeable magnesium content of soil samples (Table 6). However, along with organic matter content it was significantly influenced by clay content (Table 7).

4.1.14.3. Exchangeable sodium (Table 12)

The exchangeable sodium content was found to be as low as 0.08 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ in the bottom most layer of G block to 3.11 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ in the fourth layer of F

block, the mean value being $0.43 \text{ cmol(p}^+\text{)kg}^{-1}$ and a high co-efficient variation of 117.70 per cent.

In profile A, the surface soil registered the least $10.69 \text{ cmol(p}^+\text{)kg}^{-1}$ exchangeable Na content and the maximum $10.81 \text{ cmol(p}^+\text{)kg}^{-1}$ was observed in third layer. In profile B the minimum and maximum values were 0.76 and $1.12 \text{ cmol(p}^+\text{)kg}^{-1}$ in the penultimate and second layer of the profile. Similarly in profile C, the least was in the fifth layer ($0.60 \text{ cmol(p}^+\text{)kg}^{-1}$) and the maximum was in the fourth layer ($1.12 \text{ cmol(p}^+\text{)kg}^{-1}$). In profile D it was in the surface ($0.09 \text{ cmol(p}^+\text{)kg}^{-1}$) and fourth layer ($1.19 \text{ cmol(p}^+\text{)kg}^{-1}$) respectively. In profile E the least was in the fourth layer and the highest was in the surface layer. In profile F the least was observed in the penultimate layer and the maximum was observed in the layer above this. In the profile G, least value of $0.08 \text{ cmol(p}^+\text{)kg}^{-1}$ was observed in the fifth layer and the maximum of $0.14 \text{ cmol(p}^+\text{)kg}^{-1}$ was observed in the third layer. In profile H the least and the highest values were recorded in bottom most and surface layer respectively. These were no wide variation in profile I, the least being 0.10 in all the layers except the second layer which registered $0.11 \text{ cmol(p}^+\text{)kg}^{-1}$. In profile J the least value was in the surface ($0.09 \text{ cmol(p}^+\text{)kg}^{-1}$) and the highest was in the third layer ($0.14 \text{ cmol(p}^+\text{)kg}^{-1}$). In the botanical garden the range of values was 0.69 and $0.81 \text{ cmol(p}^+\text{)kg}^{-1}$ in the third and second layer respectively. It was also interesting to observe that the CV is itself is widely varying wherein, the lease CV of 4.22 was registered in profile I and the maximum of 196.21 per cent was registered in profile F.

There were no wide variations among the different horizons with respect to exchangeable Na content in some of the profiles and in other profiles the increase (or) decrease is not following any specific trend.

The exchangeable Na content was positively related to EC (Table 13), exchangeable K (Table 14), but negatively related to CEC (Table 14).

4.1.14.4. Exchangeable potassium (Table 12)

The exchangeable potassium content of the soil samples drawn from different horizons of the profiles dug in the horticultural farm had revealed that it ranged from

0.02 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ in the penultimate layer of E horizon to 0.47 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ in the second layer of the profile A. The mean exchangeable K content was estimated to be 0.18 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ and the CV was 62.72 per cent.

Among the different profiles the values ranged from 0.27 to 0.47 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ in profile A, from 0.22 to 0.46 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ in profile B, from 0.25 to 0.38 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ in the profile C, from 0.04 to 0.20 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ in profile D, from 0.02 to 0.24 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ in profile E, from 0.07 to 0.17 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ in profile F, from 0.05 to 0.29 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ in profile G, from 0.03 to 0.34 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ in profile H, from 0.04 to 0.22 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ in profile I, from 0.04 to 0.19 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ in profile J and from 0.23 to 0.35 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ in the botanical garden. Between the profiles the least CV was recorded in profile C (16.43 per cent) and the maximum was recorded in profile H (97.30 per cent). The exchangeable K did not follow any specific trend with respect to depth.

The simple correlation studies had indicated that the exchangeable K was positively related to exchangeable Ca and Na (Table 14), total N, available N, P & K (Table 11).

The linear multiple regression analysis had indicated that the variations in the exchangeable K is not due to different soil separates (Table 6). However, between the organic matter and clay content, the content of organic matter contributed significantly towards the exchangeable K with percentage prediction of 20.7 per cent (Table 7).

4.1.15. Total Nutrients.

4.1.15.1. Total Nitrogen (Table 16)

The total N status of the profile soil samples of the horticultural farm is presented in Table 16. It is seen from the results that, the minimum values of 0.019 per cent observed in the second layer of botanical garden and the maximum value of 0.538 per cent was observed in the surface horizon of profile B. The mean total N content was found to be 0.128 per cent and the CV was 87.64 per cent.

The total N content was found to vary within the horizons of profile and between the profiles of horticultural farm as indicated by wide variations in the total N content. For example, the total N content of the profile in A block was found to be minimum in the bottom most layer (0.105 per cent) and the maximum was in the third layer (0.236 per cent). Similarly, the minimum and maximum values of total N content in the rest of the profile were 0.032 and 0.538 per cent in profile B, 0.051 and 0.259 per cent profile C, 0.025 and 0.325 per cent in profile D, 0.033 and 0.453 per cent in profile E, 0.032 and 0.361 per cent in profile F, 0.061 and 0.348 per cent in profile G, 0.035 and 0.331 per cent in profile H, 0.061 and 0.301 per cent in profile I, 0.021 and 0.0187 per cent in profile J and 0.019 and 0.238 per cent in the botanical gardens. Among the different blocks the variation within the horizons were least in profile A (36.18 per cent) whereas, it was the highest in profile B (132.41 per cent).

As for as the variations in the total N content with depth, these was a decline in the total N content as the depth increases.

The total N content was found to be positively related to organic carbon ($r = 0.786^{**}$), electrical conductivity ($r = 0.506^{**}$) (Table 13), Loss on Ignition ($r = 0.328^{**}$), moisture content ($r = 0.302^*$), total porosity ($r = 0.297^*$), percent clay ($r = 0.259^*$), exchangeable calcium ($r = 0.391^{**}$), exchangeable magnesium ($r = 0.294^*$), exch. K ($r = 0.495^{**}$), organic matter ($r = 0.610^{**}$), total P ($r = 0.495^{**}$), organic matter ($r = 0.610^{**}$), total p ($r = 0.284^*$), total K ($r = 0.630^{**}$), total Na ($r = 0.0499^{**}$), available N ($r = 0.696^{**}$), available P ($r = 0.692^{**}$) and available K ($r = 0.789^{**}$) (Table 11). However, it was negatively related to pH ($r = -0.619^{**}$).

Though the multiple regression analysis showed that the different soil separates could not contribute to the total N content (Table 6), it was found that the organic matter could significantly contribute to this pool of nitrogen by explaining the variation to the tune of 40 per cent (Table 7).

4.1.15.2. Total phosphorus (Table 16)

The total P content ranged from 0.023 per cent in the bottom most layer of the profile E to 0.206 per cent in the surface layer of profile I. The mean total P content of the PAJANCOA and Horticultural farm soils was 0.054 per cent and the CV was 59.19 per cent.

The variations in the total P content in the different horizons of profile had indicated that it ranged from 0.033 to 0.060 per cent in profile A, from 0.025 to 0.060 per cent in profile B, from 0.026 to 0.046 per cent in profile C, from 0.029 to 0.059 per cent in profile D, from 0.023 to 0.066 per cent in profile E, 0.048 to 0.082 per cent in profile F, from 0.023 to 0.082 per cent in profile G, from 0.040 to 0.164 per cent in profile H, from 0.034 to 0.206 per cent in profile I, from 0.030 to 0.052 per cent in profile J and from 0.027 to 0.144 per cent in botanical gardens. The CV was found to be least in profile A (21.06 per cent) and maximum in profile I (88.20 per cent).

In all most all the profiles the total P content did not show any specific trend with the depth of profile.

The total P content was found to be positively related to total N content ($r = 0.284^*$) and available N ($r = 0.357^{**}$) (Table 11) and it was found to be negatively related to soil pH ($r = -0.388^{**}$) (Table 13).

The multiple regression analysis had shown that the variation in total P content was neither related to soil separates nor to organic matter content (Table 6 &7).

4.1.15.3. Total Potassium (Table 16)

The total K content had ranged from 0.003 in the bottom most layer of profile D to 0.229 per cent in the surface soil of profile J with a mean of 0.085 per cent and the CV of 60.02 per cent.

Within the profile the total K content was found to be varying from 0.083 to 0.118 per cent in profile A, from 0.018 to 0.110 in profile B, from 0.036 to 0.169 per cent in profile C, 0.003 to 0.207 in profile D, 0.031 to 0.185 per cent in profile E, from 0.018 to 0.127 per cent in profile F, from 0.024 to 0.149 per cent in profile G,

from 0.023 to 0.177 per cent in profile H, from 0.031 to 0.142 per cent in profile I, from 0.021 to 0.229 per cent in profile J and from 0.029 to 0.099 per cent in botanical garden. The CV was also found to be highly varying with least value being recorded in profile A and highest in profile H.

In majority of the profiles the total K tended to decrease with the increase in the depth of the profile.

The simple correlation studies had shown that the total K content was positively correlated to organic carbon ($r = 0.331^{**}$) (Table 13), CEC ($r = 0.376^{**}$), exchangeable Ca ($r = 0.587^{**}$), exchangeable Mg ($r = 0.459^{**}$) (Table 14), total N ($r = 0.630^{**}$), total Ca ($r = 0.546^{**}$), total Mg ($r = 0.548^{**}$) available N ($r = 0.576^{**}$) and available K ($r = 0.631^{**}$) (Tables 11 and 15).

The multiple linear regression had shown the non contribution of the different soil separates towards variations in total K content (Table 6). However, the clay and organic matter content had contributed to the total K to the tune of 11.5 per cent (Table 7).

4.1.15.4. Total Calcium (Table 16)

The total calcium content of the soil samples ranged from 0.150 per cent in the fourth layer of botanical gardens to 0.841 per cent in the second layer of J block. The mean total Ca content was estimated to be 0.341 and the CV was 40.53 per cent.

The distribution of calcium within the horizons was found to be varying between the CV of 25.13 per cent in the botanical garden to 85.14 per cent in the profile G. In the case of profile A the range was between 0.205 to 0.458 per cent, in profile B it was between 0.202 to 0.459 per cent, in profile C it was 0.202 to 0.413 per cent, in profile D it was 0.206 to 0.675 per cent, in profile E it was 0.253 to 0.575 per cent, in profile F it was 0.207 to 0.520 per cent, in profile G it was 0.154 to 0.518 per cent, in profile H it was 0.152 to 0.626 per cent, in profile I it was from 0.202 to 0.411

per cent, in profile J it was 0.158 to 0.841 per cent and in botanical garden it was from 0.150 to 0.306 per cent.

As regards the variation in total calcium content, these were not much differences within the horizons of the profile or between the horizons.

It was further seen that the total calcium content was found to be positively and significantly related with loss on ignition ($r = 0.533^{**}$), moisture content ($r = 0.417^{**}$), exchangeable calcium ($r = 0.425^{**}$), exchangeable Mg ($r = 0.332^{**}$), total N ($r = 0.339^{**}$), total K ($r = 0.546^{**}$) and total Na ($r = 0.596^{**}$) (Table 15).

From the multiple regression analysis it was seen that variation in the total Ca content was neither explained by different soil separates nor the clay and organic matter content (Table 6 & 7).

4.1.15.5. Total Magnesium (Table 16)

The total magnesium content of profile soil samples ranged from nil to 0.348 per cent with a mean value of 0.136 per cent and the CV of 67.41 per cent. The least value was observed in the bottom most layer of the profile C and the highest value was observed in the surface layer of profile H.

The variation within the horizons of different profiles had shown that it ranged from 0.031 to 0.274 per cent in profile A, from 0.30 to 0.214 per cent in profile B, from nil to 0.186 per cent in profile C, from 0.030 to 0.278 per cent in profile D, from 0.030 to 0.345 per cent in profile E, from 0.062 to 0.311 per cent in profile F, from 0.031 to 0.308 per cent in profile G, from 0.061 to 0.348 per cent in profile H, from 0.061 to 0.216 per cent in profile I, from 0.030 to 0.126 per cent in profile J and from 0.031 to 0.092 in botanical gardens. The least CV was observed in the botanical gardens (35.49 per cent) and the highest was in profile G (85.14 per cent).

The range of values of total magnesium was not influenced by the depth of profiles.

The simple correlation studies had shown that the total magnesium was positively related to loss on ignition ($r = 0.406^{**}$), soil moisture content ($r = 0.533^{**}$), clay content ($r = 0.259^{**}$), exchangeable Ca ($r = 0.562^{**}$), exchangeable Mg ($r = 0.334^{**}$), organic carbon ($r = 0.298^*$), organic matter ($r = 0.28^*$), sesquioxides ($r = 0.321^*$), total N ($r = 0.416^{**}$), total K ($r = 0.548^{**}$) and total Na ($r = 0.654^{**}$) (Table 21).

The multiple linear regression analysis had revealed that the variation in total magnesium content of soil was not explained significantly by the different soil separates. However, when the clay content and organic matter status were regressed with total magnesium it was observed that there was a significant contribution from the organic matter with an overall prediction of 12.9 per cent (Table 7).

4.1.15.6. Total sodium (Table 16)

The total sodium content of the profile samples ranged from 0.025 to 0.149 with a mean value of 0.063 per cent and the CV of 45.10 per cent. The least value was observed in the fourth layer of J block and the highest value was observed in the penultimate layer of D block.

Between the profiles, the profile A registered the lowest value of 0.044 and the highest value of 0.059 per cent. The corresponding values were 0.042 and 0.106 per cent in profile B, 0.033 and 0.086 per cent in profile C, 0.029 and 0.149 per cent in profile D, 0.040 and 0.112 per cent in profile G, 0.030 and 0.100 per cent in profile H, 0.031 and 0.075 per cent in profile I, 0.025 and 0.085 per cent in profile J and 0.032 to 0.042 per cent in the botanical gardens. It was also observed that the botanical gardens recorded the lowest variations whereas, the highest was observed in J block.

As seen in the case of other properties there is no clear cut variations between the horizons of profile.

The simple correlation had revealed that the total sodium is positively related to clay content (Table 9), organic carbon and EC (Table 13), total N, K, Ca, Mg and available N and K (Table 11).

The multiple linear regression analysis had shown the insignificant dependence of these properties on different soil separates (Table 6). However, the variations in the total sodium content to the tune of 12.4 per cent was observed when clay and organic matter were regressed with a significant contribution from the clay fraction.

4.1.16. Available Nutrients

4.1.16.1. KMnO_4 - N

The KMnO_4 oxidisable N content of the soil samples drawn from the various horizons of the profile dug in the horticultural farm soils is presented in Table 17. The results had shown a wide variation not only within the profiles as well as between the profiles dug in different blocks, as indicated by a high level of CV viz., 70.45 per cent. The minimum value of available N ($4.70 \text{ kg N ha}^{-1}$) in the penultimate layer of J block (124-152 cm) and the highest value of available N was registered in the surface layer of H block ($131.71 \text{ kg ha}^{-1}$). The mean $\text{KMnO}_4\text{-N}$ content was estimated to be 26.94 kg ha^{-1} .

The variations within the horizons of the profile was also found to be high with values ranging from 28.14 per cent in botanical garden to 91.21 per cent in profile H. In profile A, the values of $\text{KMnO}_4\text{-N}$ ranged from 12.54 to 31.36 kg ha^{-1} , in profile B it was 10.98 to 61.15 kg ha^{-1} in profile C it was from 18.82 to 42.34 kg ha^{-1} , in profile D, it was 15.68 to 454 kg ha^{-1} , in profile E it was from 10.98 to 62.72 kg ha^{-1} , in profile F it was from 10.98 to 53.31 kg ha^{-1} , in profile G it was from 15.68 to 40.77 kg ha^{-1} , in profile H it was from 10.98 to $131.71 \text{ kg ha}^{-1}$, in profile I it was from 14.11 to 50.18 kg ha^{-1} , in profile J it was from 4.70 to 36.06 kg ha^{-1} and in botanical gardens it ranged from 17.25 to 36.06 kg ha^{-1} .

The $\text{KMnO}_4\text{-N}$ content did not show much variations due to the differences in the depth in certain profiles and in certain other profiles there is no definite trend.

The simple correlation studies had shown that the $\text{KMnO}_4\text{-N}$ content was positively related to the clay content ($r = 0.446^{**}$) (Table 9), organic carbon ($r = 0.479^{**}$) (Table 13), CEC ($r = 0.281^*$), exchangeable Ca ($r = 0.451^{**}$), exchangeable

Mg ($r = 0.363^{**}$) and exchangeable K ($r = 0.339^{**}$) (Table 14), total N ($r = 0.696^{**}$), total P ($r = 0.357^{**}$), total K ($r = 0.576^{**}$), available P ($r = 0.368^{**}$) and available K ($r = 0.639^{**}$) (Table 11). However, it was negatively related to soil pH ($r = -0.562^{**}$).

The linear multiple regression had indicated the significant contribution of clay content towards the $\text{KMnO}_4\text{-N}$ with regression co-efficient of 0.260^{**} , while regressed with all other soil separates. In another multiple regression analysis, the significant contribution of both the clay and organic matter towards the $\text{KMnO}_4\text{-N}$ content was established ($R^2 = 0.283^{**}$) (Table 6 & 7).

4.1.16.2. Olsen- P

The Olsen-P status of the profile soil samples ranged from 2.64 kg ha^{-1} to 62.61 kg ha^{-1} with samples ranged from 2.64 kg ha^{-1} to 62.61 kg ha^{-1} with an average status of 15.03 kg ha^{-1} and a CV of 66.54 per cent. The lowest value was registered in the fourth layer of I block and the highest value was recorded in the surface horizon of B block.

As for as the variations within the profiles with depth, Olsen-P was ranging between 16.91 to 31.99 kg ha^{-1} in profile A, from 13.64 to 62.61 kg ha^{-1} in profile B, from 9.76 to 25.91 kg ha^{-1} in profile C, from 10.52 to 35.25 kg ha^{-1} in profile D, from 8.27 to 41.08 kg ha^{-1} in profile E, from 8.25 to 16.08 kg ha^{-1} in profile F, from 5.40 to 23.08 kg ha^{-1} in profile G, from 4.00 to 19.48 kg ha^{-1} in profile H, from 2.64 to 18.62 kg ha^{-1} in profile I, from 5.40 to 12.84 kg ha^{-1} in profile J and 9.76 to 27.88 kg ha^{-1} in the botanical gardens.

The variations between the profiles was ranging between the profiles was ranging from 26.53 per cent in profile F to 79.31 per cent in profile I as explained by the CV. As observed in the other soil properties there is no observable trend which could be established between the Olsen-P and the depth of the soil profile.

The simple correlation studies had shown that the Olsen-P is positively related to

organic carbon ($r = 0.706^{**}$), and EC ($r = 0.535^{**}$) (Table 13), Total N ($r = 0.692^{**}$), $\text{KmnO}_4\text{-N}$ ($r = 0.368^{**}$) and available K ($r = 0.494^{**}$) (Table 11).

The variations in the Olsen-P status was not explained significantly by the various soil separates, whereas it was well established that the organic matter content could contribute significantly towards the Olsen-P ($R^2 = 0.354^{**}$) (Table 6 &7).

4.1.16.3 $\text{NH}_4\text{OAc-K}$ (Table 16)

The NH_4OAc -extractable K content of the soil drawn from the different horizons of the profile of the horticultural farm had revealed that it ranged from 10.68 kg ha^{-1} in the penultimate layer of botanical garden to 272.46 kg ha^{-1} in the surface layer of B horizon. The average NH_4OAc extractable K was 93.27 kg ha^{-1} and the CV was found to be 64.12 per cent.

It was further seen that the minimum and maximum values of ammonium acetate K in profile A was 32.05 and 203.01 kg ha^{-1} , the corresponding values of minimum and maximum ammonium acetate K in the rest of the profile were 32.05 and 272.46 kg ha^{-1} , in profile B, 53.42 and 165.61 kg ha^{-1} in profile C, 26.71 and 160.27 kg ha^{-1} in profile D, 32.05 and 203.01 kg ha^{-1} in profile E, 58.77 and 154.93 kg ha^{-1} in profile F, 58.77 and 224.38 kg ha^{-1} in profile G, 32.05 and 251.09 kg ha^{-1} in profile H, 37.40 kg ha^{-1} and 181.64 kg ha^{-1} in profile I, 42.74 and 165.61 kg ha^{-1} in profile J and 10.68 kg ha^{-1} to 128.88 kg ha^{-1} in the botanical garden. Between the profiles the minimum CV of 40.67 per cent was registered in profile F and the maximum of 108.61 was registered in profile B.

As observed in the case of other nutrients there is no definite trend which could be established between the NH_4OAc . K and the depth of soil profiles.

The simple correlation studies had shown that the $\text{NH}_4\text{OAc-K}$ is positively related to clay content ($r = 0.330^{**}$) (Table 10), organic carbon ($r = 0.564^{**}$), EC ($r = 0.341^{**}$) (Table 13). It was also observed that the $\text{NH}_4\text{OAc-K}$ was positively related

to loss of ignition, soil moisture content, CEC, exchangeable Ca, Mg, K, total N, K, Na and available N and P (Table 11).

The multiple regression analysis had shown that none of the soil separates could contribute towards the $\text{NH}_4\text{OAc-K}$. However, when clay and organic matter contents, were regressed with $\text{NH}_4\text{OAc-K}$, it was found to contribute significantly to the tune of 23.4 per cent with significant contribution from both clay and organic matter.

4.1.16.4. CaCl_2 Extractable sulphur (Table 17)

The CaCl_2 extractable sulphur of the profile soil samples ranged from 1.24 mg kg^{-1} to $157.13 \text{ mg kg}^{-1}$ with a mean value of 13.54 mg kg^{-1} and a CV of 142.68 per cent. The lowest value of 1.24 mg kg^{-1} was recorded in the fourth layer of H block and the highest value of $157.13 \text{ mg kg}^{-1}$ was recorded in the surface layer of I block.

As regards the variations between the profiles in different blocks it was observed that it ranged from 7.64 to 11.64 mg kg^{-1} in profile A, from 7.64 to 13.08 mg kg^{-1} in profile B, from 7.64 to 14.38 mg kg^{-1} in profile C, from 10.29 to 27.54 mg kg^{-1} in profile D, from 1.24 to 6.33 mg kg^{-1} in profile E, from 7.64 to 20.06 mg kg^{-1} in profile F, from 8.96 to 17.19 mg kg^{-1} in profile G, from 1.24 to 11.64 mg kg^{-1} in profile H, from 8.96 to $157.13 \text{ mg kg}^{-1}$ in profile I, from 10.29 to 18.62 mg kg^{-1} in profile J and 2.49 to 18.62 mg kg^{-1} in profile J and 2.49 to 18.62 mg kg^{-1} in botanical garden. The minimum CV was observed in the A block (15.58 per cent) and the maximum was observed in I block (161.53 per cent).

The CaCl_2 extractable S did not shown any specific trend with the depth of soil profile.

The $\text{CaCl}_2 - \text{S}$ content was found to be positively correlated to total P (Total 11) but negatively correlated with pH (Table 13).

The multiple regression analysis that neither the soil separates nor the organic matter content of the soil could contribute to the variation in the $\text{CaCl}_2 - \text{S}$ content.

4.2. Surface Samples

In order to evaluate and to characterise the soils of the horticultural farms of PAJANCOA and RI, surface soil samples were collected from each of the filed boundaries in duplicate so as to arrive a detailed characterization, unlike in the profile description wherein, profiles were dug at the rate of one / block. Accordingly there were eight soil samples in A block, two in B block, four in C block, two in D block, four in E block, eight in F block, eight in G block, four each in H, I and J blocks and five in the botanical gardens. The results thus obtained are described in the following sections.

4.2.1. Percent soil moisture content (Table 18)

The results of the soil moisture content after air drying, upon oven drying is presented in Table 18, which revealed that it ranged from 1.66 per cent to 5.06 per cent with a mean value of 3.26 per cent and the CV of 23.36 per cent.

The soil moisture content in the surface soils of the further revealed that it ranged from 1.66 to 3.96 per cent in the A block, from 2.41 to 2.87 per cent in B block, from 2.30 to 2.63 per cent in C block, from 2.91 to 3.57 per cent in D block, from 2.24 to 3.81 per cent in E block, from 2.27 to 4.48 per cent in F block, from 2.55 to 4.21 per cent in G block, from 3.83 to 4.20 per cent in H block, from 3.15 to 3.90 per cent in I block, from 4.12 to 5.06 per cent in J block and from 2.36 to 2.79 per cent in the botanical gardens. Among the different blocks the least variability was observed in H block and the maximum was in the A block.

The results of the simple correlation studies had shown that the soil moisture content was positively related to bulk density (Table 17), exchangeable Ca, Mg and Na (Table 20) and available P (Table 21). It was negatively related to soil pH (Table 22).

4.2.2. Loss on Ignition. (Table 18)

The loss on Ignition in the surface soil samples had ranged from 0.31 to 7.65 per cent with a mean value of 2.66 and the CV of 51.06 per cent.

It was further noticed that it ranged from 0.31 to 6.84 per cent in the A block, from 2.99 to 4.05 per cent in the B block, from 1.59 to 7.65 per cent in C block, from 2.09 to 2.94 per cent in the D block, from 2.45 to 3.95 per cent in E block, from 2.22 to 3.16 per cent in the F block, from 2.32 to 3.08 in the G block, from 3.50 to 3.82 per cent in the H block, from 0.35 to 2.29 per cent in the I block, from 2.05 to 2.72 per cent in J block and 1.18 to 1.54 per cent in the botanical gardens. The CV was found to highly fluctuating between the blocks, with a minimum CV of 4.06 in the H block and the maximum CV of 106.15 per cent in the A block.

It was further seen from the correlation studies that the loss on ignition was positively related to CEC and Exchangeable Mg (Table 19), but negatively to bulk negatively to bulk density (Table 18).

4.2.3. Bulk density (Table 18)

The bulk density values ranged from 1.176 to 1.250 Mg m⁻³ with a mean of 1.211 Mg m⁻³ and a CV of 3.06 per cent.

It was further seen that the bulk density was found to vary from 1.176 to 1.250 Mg m⁻³ in the A, E, F, G blocks between garden and remained the same in all the samples in B, C, D, H, I and J blocks namely 1.250, 1.176, 1.250, 1.176, 1.250 and 1.250 Mg m⁻³ respectively.

The simple correlation studies had shown that the bulk density was positively related to moisture content (Table 19) and total P (Table 21).

4.2.4. Particle density (Table 17)

The particle density was ranging between 2.222 to 2.500 Mg m⁻³ in A, D, F, G, and J blocks.

In B, C and botanical garden it recorded the same value of 2.222 Mg m^{-3} in all the samples of the block whereas, in the blocks E, H and I, an uniform value of 2.500 Mg m^{-3} was observed in all the surface samples of the respective blocks. Since these were no much variations / no variations in some blocks the CV was found to ranged from 0 to 6.001 per cent.

4.2.5. Total porosity (Table 18)

The total porosity was found to be varying between 43.75 to 52.94 per cent with a mean value of 48.72 per cent and the CV of 6.41 per cent.

Among the blocks the variations were found to ranged between 43.75 to 52.94 per cent in A block, from 43.75 to 50.00 per cent in D block and J block, and from 43.75 to 47.06 per cent in botanical gardens. In the B block the porosity was found to be 43.75 per cent in both the samples whereas, in C it was 47.06 per cent. The corresponding value for H and I blocks were 52.94 and 50.00 per cent. In block E it was found to ranged between 50.00 to 52.94 per cent, in F block it was ranging between 47.06 to 52.94 per cent. In G block it was ranging between 47.06 to 50.00 per cent and in J it was between 43.75 and 50.00 per cent. In the botanical garden the values ranged between 43.75 to 47.06 per cent. The CV was as low as 0 per cent to 9.43 per cent.

The total porosity was found to be negatively related to bulk density and positively to particle density (Table 19).

4.2.6. Acid insoluble (Table 23)

The acid insoluble fraction expressed as per cent of the total soil weight was found to range between 69.02 to 92.96 per cent with a mean value of 84.67 per cent and the CV of 5.67 per cent.

A further scrutiny on this fraction in the different had shown that it was ranging between 83.14 to 92.09 per cent in A block, from 87.51 to 89.20 per cent in B block, from 87.04 to 89.09 per cent in C block, from 86.21 to 86.49 per cent in D

block, from 83.24 to 87.81 per cent in E block, from 78.10 to 87.82 per cent in F block, from 71.17 to 85.47 per cent in G block, from 74.65 to 92.96 per cent in H block, from 69.02 to 89.17 per cent in botanical garden. The minimum CV was recorded in the D block and the maximum was in I block.

4.2.7. Sesquioxides (Table 23)

The sesquioxide content of the surface soil samples in different blocks of the horticulture farm ranged from 4.68 to 23.21 per cent with a mean value of 13.96 per cent and the CV of 48.45 per cent.

It was further noticed that in the A block, the sesquioxide content was ranging between 5.65 to 15.50 per cent in B block it ranged from 8.75 to 12.81 per cent, in C block it ranged between 8.22 to 21.54 per cent, in D block it ranged between 13.39 to 19.19 per cent, in E block it ranged between 10.74 to 12.93 per cent, in F block it ranged between 13.51 to 23.21 per cent, in G block it was ranging between 5.16 to 15.28 per cent, in H block it ranged between 13.55 to 19.83 per cent, in I block it was ranging between 11.36 to 21.05 per cent, in J block it ranged between 7.31 to 15.15 per cent and in botanical garden it was ranging between 8.72 to 21.52 per cent. The CV was found to vary from 7.95 per cent in the E block to 63.70 per cent in the I block.

From the simple correlation studies the sesquioxide content was found to positively correlated with total Mg content (Table 21).

4.2.8. Organic carbon (Table 23)

The organic carbon content of the soil was found to be as low as 3.2 g kg⁻¹ to 13.6 g kg⁻¹ with a mean value of 6.80 g kg⁻¹ and the CV of 39.40 per cent.

The variations in soil organic carbon content of different blocks were significant as revealed by the CV which was as low as 10.20 in the J block to 46.73 per cent in the A block. The values ranged between 3.80 to 13.60 g Kg⁻¹ in A block, from 7.20 to 9.80 g kg⁻¹ in B block, from 8.40 to 11.50 g kg⁻¹ in C block, from 4.60

to 5.50 g kg⁻¹ in D block, from 5.80 to 8.10 g kg⁻¹ in E block, from 5.80 to 10.70 g kg⁻¹ in F block, from 3.50 to 7.80 g kg⁻¹ in G block, from 3.20 to 4.60 g kg⁻¹ in H block, from 4.60 to 7.20 g kg⁻¹ in I block, from 4.30 to 5.50 g kg⁻¹ in J block and from 3.50 to 8.10 g kg⁻¹ in botanical garden.

The simple correlation studies had revealed that the organic carbon content was positively related to total N and P, available N, P & K (Table 22).

4.2.9. Organic matter status (Table 23)

The organic matter status of the surface soil samples was ranging between 0.547 to 2.337 per cent with a mean value of 1.166 per cent and the CV of 39.40 per cent.

In different blocks there were variations as revealed by the range of values. For example, in A block it ranged from 0.647 to 2.337 per cent, in B block it ranged from 1.243 to 1.691 per cent, in C block it ranged between 1.442 to 1.989 per cent, in D block it ranged from 0.796 to 0.945 per cent, in E block it was ranging between 0.995 to 1.392 per cent, in F block it ranged between 0.995 to 1.840 per cent, in G block it ranged between 0.597 to 1.343 per cent, in H block it ranged between 0.547 to 0.796 per cent in I block it ranged between 0.796 to 1.243 per cent, in J block it was between 0.796 to 0.945 per cent and in botanical garden from 0.597 to 1.392 per cent. The range of CV value was between 12.99 per cent, in D block to 46.73 per cent in A block.

The simple correlation studies had shown that this property was positively and significantly related to total N and P and available P (Table 21).

4.2.10. Soil reaction in saturation paste extract (Table 24)

The pH of the soil samples in the saturation paste extract was found to range between 5.21 to 8.75 with an average value of 7.92 and the CV of 8.18 per cent.

In the different blocks the pH was ranging between 5.21 to 8.45 in A block, 7.59 in B block, 7.98 to 8.75 in C block, 8.57 to 8.62 in D block, 7.68 to 8.06 in E block, 7.24 to 8.28 in F block, 7.25 to 8.50 in G block, 7.39 to 8.03 in H block, 8.02 to 8.32 in I block, 7.18 to 7.96 in J block and 8.17 to 8.52 in botanical gardens. The CV was found to be very meager ranging between 0.41 in D block to 18.48 per cent in A block.

From the simple correlation studies it was concluded that the pH was positively related to available sulphur (Table 22) and negatively related to soil moisture, total N, total P and available N and K (Table 22).

4.2.11. Electrical conductivity of the saturation paste extract (Table 24)

The E_{ce} was found to range between 0.04 to 2.30 dS m⁻¹ with an average value of 0.87 dS m⁻¹ and CV of 54.96 per cent.

In A block it ranged between 0.23 to 1.09 dS m⁻¹, in B block between 0.68 to 0.69 dS m⁻¹, in C block between 1.12 to 2.30 dS m⁻¹, in D block from 2.01 to 2.04 dS m⁻¹, in E block between 0.74 to 0.82 dS m⁻¹, in F block from 0.04 to 1.18 dS m⁻¹, in G block between 0.56 to 2.12 dS m⁻¹, in H block from 0.58 to 0.63 dS m⁻¹, in I block from 0.52 to 0.68 dS m⁻¹, in J block from 0.54 to 0.83 dS m⁻¹ and in botanical gardens it ranged between 0.19 to 0.76 dS m⁻¹. The CV was found to be as low as 1.03 per cent, in B block to 59.71 per cent in G block.

The simple correlation studies had further revealed that the E_{ce} was positively related to total N and available sulphur (Table 22).

4.1.12. Cation exchange capacity (Table 24; Fig. 13)

The cation exchange capacity of the surface soil samples ranged between 5.70 to 65.20 cmol(p⁺)kg⁻¹ with a mean value of 22.82 cmol(p⁺)kg⁻¹ and the CV of 65.38 per cent.

In block A the CEC was found to vary between 6.00 to 11.60 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$, in block B it was ranging between 35.00 to 55.20 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$, in block C it was ranging between 18.40 to 65.20 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$, in block D between 57.20 to 61.50 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$, in block E from 21.90 to 29.20 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$, in block F from 16.50 to 35.20 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$, in block G from 18.80 to 28.60 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$, in block H from 20.10 to 30.60 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$, in block I from 17.30 to 19.60 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$, in block J from 10.60 to 11.80 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ and in botanical garden it was ranging between 5.70 to 8.90 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$. The CV was found to be 5.12 per cent in block D to 43.26 per cent in block C.

The CEC was found to be positively correlated to loss on ignition (Table 19), EC (Table 22), Exchangeable Na (Table 19).

4.2.13. Exchangeable cations (Table 24)

4.2.13.1. Exchangeable Calcium (Table 24)

The exchangeable calcium content ranged between 5.0 to 49.50 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ with a mean value of 12.04 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ and the CV of 29.28 per cent.

In the different blocks of horticultural farm soils the exchangeable Ca ranged from 6.50 to 2.50 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ in A block, from 8.00 to 28.20 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ in block B, from 8.50 to 41.00 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ in block C, from 42.50 to 49.50 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ in block D, from 9.00 to 13.00 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ in block E, from 8.50 to 16.00 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ in block F, from 10.00 to 14.00 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ in block G, from 14.00 to 16.00 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ in block H, from 13.00 to 17.00 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ in block I, from 12.00 to 17.00 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ in block J and from 5.00 to 9.00 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ in botanical garden.

From the simple correlation studies it was inferred that the exchangeable Ca was positively related to soil moisture and exchangeable Na (Table 20) and total Ca (Table 21) but negatively related to available N (Table 21).

4.2.13.2. Exchangeable Magnesium (Table 24)

The exchangeable Mg content was ranging from 0.0 to 8.00 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ with a mean value of 4.72 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ and a CV of 39.74 per cent.

The exchangeable Mg was ranging between 2.00 to 5.00 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ in A block and 4.00 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ in both the horizons of B block. In C block it ranged between 2.00 to 4.50 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ and in D block it was from 3.00 to 4.00 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$. In the rest of the blocks it ranged from 3.00 to 7.00 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ in block E, from 0.00 to 7.50 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ in block F, from 5.00 to 7.50 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ in block G, from 4.50 to 8.00 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ in block H, from 3.00 to 5.00 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ in block I, from 3.00 to 8.00 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ in block J and from 1.50 to 3.50 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ in the botanical gardens.

The simple correlation studies had its negative relationship with available K (Table 21) and it was positively related to loss on ignition and soil moisture content (Table 20).

4.2.13.3. Exchangeable potassium (Table 24)

The results of the exchangeable Potassium in the surface soil samples ranged from 0.27 to 0.58 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ with a mean value of 0.39 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ and the CV of 18.65 per cent.

It was further noticed that in the surface soils of A block the exchangeable potassium ranged from 0.45 to 0.58 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$, in B block it ranged from 0.33 to 0.37 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$, in C block it ranged from 0.39 to 0.46 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$, in D block it range from 0.33 to 0.36 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$, in block E it ranged from 0.29 to 0.36 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$, in block F it ranged from 0.38 to 0.51 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$, in block G it ranged from 0.27 to 0.36 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$, in block H it ranged from 0.36 to 0.43 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$, in block I it ranged from 0.33 to 0.38 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$, in bock J it ranged from 0.28 to 0.40 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ and in botanical garden 0.33 to 0.43 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$.

The simple correlation studies had further revealed that this property was positively related to total K and available N (Table 20), total N, and P and available N, P, K (Table 21).

4.2.13.4. Exchangeable sodium (Table 24)

The exchangeable sodium content of the surface soil samples ranged between 1.17 to 3.82 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ with a mean value of 2.74 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ and the CV of 24.98 per cent.

In block A the exchangeable sodium content was ranged between 1.17 to 1.36 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$, in block B it ranged between 3.06 to 3.34 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$, in block C it ranged from 2.68 to 3.11 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$, in block D it ranged from 2.48 to 3.01 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$, in block E it ranged from 2.63 to 2.91 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$, in block F it ranged from 2.87 to 3.15 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$, in block G it ranged from 2.53 to 3.87 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$, in block H it ranged from 2.82 to 3.01 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$, in block I it ranged from 3.15 to 3.30 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$, I block J it ranged from 2.63 to 3.25 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ and in botanical garden it ranged from 2.68 to 3.34 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$.

The results of simple correlation studies had revealed that it was positively related to soil moisture content, exchangeable Ca and total K (Table 20). It was negatively related to organic carbon (Table 22), exchangeable K (Table 20), total N, P, K and available N and K (Table 21).

4.2.14. Total Nutrients. (Table 25)

4.2.14.1. Total Nitrogen (Table 25)

The total N content of the surface soil samples of the different blocks on the horticultural farm soils of PAJANCOA and RI was ranging between 0.016 to 0.800 per cent with a mean value of 0.395 per cent and the CV of 38.05 per cent.

Among the blocks the total N content was ranging from 0.220 to 0.800 per cent in a block, from 0.192 to 0.502 per cent in B block, from 0.367 to 0.555 per cent in C block, from 0.258 to 0.2791 per cent in D block, from 0.393 to 0.540 per cent in E block, from 0.451 to 0.644 per cent in F block, from 0.016 to 0.418 per cent in G block, from 0.269 to 0.341 per cent in H block, from 0.310 to 0.468 per cent in I block, from 0.305 to 0.454 per cent in J block and from 0.175 to 0.399 per cent in the botanical garden.

From the simple correlation studies it was inferred that the total N was positively and significantly related to organic carbon (Table 22), total P and available N, P, K (Table 21).

4.2.14.2. Total Phosphorus (Table 25)

The total P content of the surface soil samples ranged from 0.025 to 0.220 per cent with a mean value of 0.069 per cent and the CV of 50.55 per cent.

It was further revealed that the total P content in A block ranged from 0.038 to 0.220 per cent, in B block it was ranged from 0.068 to 0.132 per cent, in C block from 0.056 to 0.078 per cent, in D block from 0.045 to 0.048 per cent, in E block from 0.029 to 0.083 per cent, in F block from 0.053 to 0.117 per cent, in G block from 0.025 to 0.092 per cent, in H block from 0.046 to 0.064 per cent, in I block from 0.049 to 0.080 per cent, in J block from 0.039 to 0.070 per cent and in botanical gardens from 0.030 to 0.072 per cent.

In correlation studies it was found that the total P was positively related to bulk density, exchangeable K, organic carbon, total N and K and available N, P, K (Table 21).

4.2.14.3. Total Potassium (Table 25)

The total K content of the surface soil samples ranged from 0.024 to 0.264 per cent with an average of 0.169 per cent and the CV of 34.39 per cent.

It was further revealed that in the A block the total K content ranged from 0.109 to 0.259 per cent, in B block it ranged from 0.121 to 0.184 per cent, in C block it ranged from 0.166 to 0.205 per cent, in D block it ranged from 0.208 to 0.218 per cent, in E block it ranged from 0.024 to 0.173 per cent, in F block it ranged from 0.104 to 0.259 per cent, in G block it ranged from 0.135 to 0.256 per cent, in H block it ranged from 0.152 to 0.264 per cent, in I block it ranged from 0.098 to 0.205 per cent, in J block it ranged from 0.119 to 0.158 per cent and in botanical garden from 0.110 to 0.213 per cent.

The total K was found to be positively and significantly related to exchangeable K, total Ca and Na and available N, P and K (Total 21).

4.2.14.4. Total Calcium (Table 25)

The total calcium content of the surface soil samples of different blocks ranged between 0.205 to 1.080 per cent with a mean value of 0.448 and the CV of 35.08 per cent.

It was further revealed that the total calcium content ranged from 0.254 to 0.517 per cent in A block, from 0.359 to 0.360 per cent in B block, from 0.409 to 0.513 per cent in C block, from 0.258 to 0.363 per cent in D block, from 0.310 to 0.624 per cent in E block, from 0.208 to 0.567 per cent in F block, from 0.361 to 0.770 per cent in G block, from 0.417 to 0.730 per cent in H block, from 0.416 to 0.832 per cent in I block, from 0.314 to 0.421 per cent in J block and from 0.205 to 1.080 per cent in botanical garden.

The simple correlation studies had also shown that the total calcium was positively and significantly related to exchangeable Ca and total K (Table 21).

4.2.14.5. Total Magnesium (Table 25)

The total Mg content of the surface soil samples of different blocks ranged between 0.020 to 0.348 per cent with a mean value of 0.136 per cent and the CV of 67.41 per cent.

In A block, the total Mg^{2+} ranged between 0.031 to 0.274 per cent, in B block it varied from 0.030 to 0.214 per cent, in C block it ranged between 0.0 to 0.186 per cent, in D block it varied between 0.030 to 0.278 per cent, in E block it ranged between 0.030 to 0.345 per cent, in F block it ranged from 0.062 to 0.311 per cent, in G block it ranged from 0.031 to 0.308 per cent in H block it ranged from 0.061 to 0.348 per cent, in I block it ranged from 0.061 to 0.216 per cent, in J block from 0.030 to 0.126 per cent and in botanical gardens it ranged from 0.031 to 0.092 per cent. The total Mg content was positively correlated to sesquioxide content (Table 21).

4.2.14.6. Total sodium (Table 25)

The total sodium content of the surface soils ranged from 0.044 to 0.124 per cent with the mean value of 0.086 per cent a CV of 26.73 per cent.

In the different blocks the total sodium ranged between 0.057 to 0.086 per cent in A block, from 0.074 to 0.086 per cent in B block, from 0.105 to 0.123 per cent in C block, from 0.119 to 0.124 per cent in D block, from 0.086 to 0.118 per cent in E block, from 0.059 to 0.116 per cent in F block, from 0.054 to 0.122 per cent in G block, from 0.057 to 0.103 per cent in H block, from 0.059 to 0.093 per cent in I block, from 0.066 to 0.081 in J block and from 0.044 to 0.066 per cent in botanical gardens.

The total sodium content was found to be positively related to total K (Table 20) and EC (Table 22).

4.2.15. Available nutrients (Table 26)

4.2.5.1 $\text{kMnO}_4\text{-N}$ (Table 26)

The $\text{KMnO}_4\text{-N}$ status of the surface soils collected from different blocks of the horticultural farms had revealed that it ranged from 56.45 to 189.73 kg ha^{-1} with a mean value of 11.07 kg ha^{-1} and CV of 22.64 per cent.

Among the different blocks there were variations. In A block it ranged from 108.19 to 189.73 kg ha^{-1} , in B block it ranged from 134.85 to 139.85 kg ha^{-1} , in C block it ranged from 12.01 to 156.80 kg ha^{-1} , in D block it ranged from 108.19 to 114.46 kg ha^{-1} , in E block it ranged from 98.78 to 137.98 kg ha^{-1} , in F block it varied from 105.06 to 148.96 kg ha^{-1} , in G block it ranged from 89.38 to 109.76 kg ha^{-1} , in H block it ranged from 86.24 to 109.76 kg ha^{-1} , in I block it ranged from 94.08 to 108.19 kg ha^{-1} , in J block it varied from 95.65 to 122.30 kg ha^{-1} and in botanical garden it ranged from 56.45 to 86.24 kg ha^{-1} .

The available N was found to be positively related to organic carbon (Table 22), exchangeable K (Table 20), total N, P, K and available K (Table 21). It was

negatively related to pH (Table 22), exchangeable Ca and exchangeable Na (Table 20).

4.2.15.2. Olsen-P (Table 25)

The Olsen-P status of the surface soil samples ranged from 12.84 to 77.91 kg ha⁻¹ in A block, from 16.91 to 24.96 kg ha⁻¹ in B block, from 24.96 to 69.81 kg ha⁻¹ in C block, from 31.99 to 33.06 kg ha⁻¹ in D block, from 24.96 to 31.99 kg ha⁻¹ in E block, from 24.01 to 53.13 kg ha⁻¹ in F block, from 24.96 to 53.13 kg ha⁻¹ in G block, from 21.26 to 37.52 kg ha⁻¹ in H block, from 25.91 to 42.32 kg ha⁻¹ in I block from 37.52 to 69.81 kg ha⁻¹ in J block and from 12.84 to 34.14 kg ha⁻¹ in botanical gardens.

The simple correlation studies had further revealed that Olsen- P was positively related to organic carbon (Table 22) total N, P, K and available N and K (Table 21).

4.2.15.3. NH₄O Ac -K (Table 26)

The NH₄OAc- K in A block ranged from 261.78 to 496.84 kg ha⁻¹, in B block it ranged from 229.72 to 240.41 kg ha⁻¹, in C block it ranged from 261.78 to 368.63 kg ha⁻¹, in D block it ranged from 203.01 to 235.07 kg ha⁻¹, in E block it ranged from 170.96 to 203.01 kg ha⁻¹, in F block it ranged from 256.44 to 341.91 kg ha⁻¹, in G block it ranged from 181.64 to 240.41 kg ha⁻¹, in H block it ranged from 240.41 to 293.83 kg ha⁻¹, in I block it ranged from 208.35 to 251.09 kg ha⁻¹, in J block it ranged from 181.64 to 277.80 kg ha⁻¹ and in botanical garden it was from 235.07 to 299.17 kg ha⁻¹.

It was further noticed that the ammonium acetate K was positively related to organic carbon (Table 22), total N, P and K and available N and P (Table 21).

4.2.15.4. CaCl₂ - S. (Table 25)

The CaCl₂ - S content of the surface samples was widely varying with a very low value of 6.33 to 29.10 mg kg⁻¹. The average CaCl₂-S content was 17.14 mg kg⁻¹ and the CV was 30.84 per cent.

The CaCl₂ extractable S content of the surface sample ranged from 8.96 to 21.52 mg kg⁻¹ in A block, from 6.33 to 10.29 mg kg⁻¹ in B block, from 14.38 to 21.52 mg kg⁻¹ in C block, from 24.50 mg kg⁻¹ to 27.54 mg kg⁻¹ in D block, from 11.64 to 15.78 mg kg⁻¹ in E block, from 17.19 to 20.06 mg kg⁻¹ in F block, from 13.01 to 23.00 mg kg⁻¹ in G block, from 10.29 to 18.62 mg kg⁻¹ in H block, from 14.38 to 20.06 mg kg⁻¹ in I block, from 15.78 to 29.10 mg kg⁻¹ in J block and from 13.01 to 29.10 mg kg⁻¹ in botanical gardens. It was further seen that the CaCl₂ -S was positively related to pH and EC (Table 22).

Chapter 5

DISCUSSION

Soil is the most important natural resource upon which the life on earth depends. This is due to the fact that it acts as a medium for plant growth; plants being the only living organisms which produce their own food and all other organisms depending either on plants or on plant eating animals. Hence, the sustenance of life on this globe depends on the plants and the plants depend on soils. Prior to the civilization, the human beings were leading a nomadic life, wherein, the available food resources, which were natural, were being equally shared among the living organisms. However, once the civilization started flourishing on the river belts, the agriculture came into existence and people produce their own food in their place where they settled.

The civilization had resulted in development of communities and societies, thereby leading to growth of human kind. Such an increase in the population had demanded more production, necessitating either enhanced productivity in the same place or shifting cultivation to a new area. All these things have happened and can happen only to a certain extent, beyond which no more land is available for such deserting and newer cultivation. Hence, continued efforts were put in to enhance the productivity in this settlement with the available knowledge. However, when the productivity is not enhanced to the expected level, the science of agriculture had come into play a vital role.

The advent of green revolution in 1960's is aimed at bridging the gap between the potential productivity and the actual productivity. In addition to this, the green revolution also aimed at integrating the different components of crop production viz., crop improvement, crop management and crop protection. These include introduction of high yielding varieties/hybrids, improved fertilizer packages, advanced crop management strategies like weed management, irrigation water management etc, and timely crop protection measures. Though, all the above had resulted in enhanced production even to the extent of 2-3 times higher yield, the improper balance between the conventional agriculture and the modern system of cultivation had resulted in slow decline in the yield of crops after the 1980's. The major reason for the above trend,

though many fold, can be narrowed down to the decline in soil fertility and exploitation of the genetic potential over the past few decades. As has been conceived in the science of soil, the yield projected could not be achieved unless otherwise that particular limitation that restricts the crop growth is removed. Under this context, the soil related constraints became very significant since the post green revolution era had created an imbalanced nutrient supply from the soil to the crop plants.

Hence, it was perceived that to attain the targets in food grain production which is estimated to be around 300 million tones in 2020, requiring an additional food grain production of 5-7 million tones/annum from the present production, an in depth diagnosis of the soil related problems is a pre-requisite. This can be achieved, only by a detailed and a systematic characterization of the soils at different levels viz., field wise, region wise, series wise, state wise and national wise is undertaken. Though, this has been done earlier in the soil survey programme, the purpose of soil survey is mainly for the classification of soils coupled with certain interpretation which can be used for both agriculture and non-agricultural purposes. In the present era of precision agriculture, wherein, a set of packages need to be developed at individual level, a detailed characterization is absolutely essential.

In this regard, the present investigation was undertaken to characterize the horticultural farm soils of PAJANCOA and RI, mainly for the purpose of describing the soil properties with a view to identify the factors limiting the crop production. To meet the above objective eleven profiles were dug, one in each block of the horticultural farm and soil samples collected for laboratory analysis. Similarly surface soil samples from each of the field boundaries in duplicate were collected and subjected to similar kind of analyses. The data obtained were tabulated and subjected to descriptive statistics. Further more the simple correlation and multiple regression analysis were also done to identify the strength of relationship between a set of soil properties and to quantify the relative contribution of certain properties by other properties. The results thus obtained are described in chapter four and are discussed in this chapter.

5.1. Profile description

The soil of the horticultural farm of PAJANCOA and RI contains two soil series viz., Thirunallar, and Kottucherry, taxonomically, Typic Chromustert and Ustic Quartzipsammand respectively (Valliammal, 2004). Among the eleven profiles dug except the profiles dug in old botanical gardens, all other profiles were in Thirunallar soil series and that of the profile in botanical gardens comes under Kottucherry soil series. On a whole, 62 profile soil samples and 53 surface samples were collected.

A brief description of the above profiles had shown that the profiles dug in the orchard soils belonged to Thirunallar soil series which occur in the old plains of Karaikal region on a very gentle sloping land to almost flat lands. They are very deep, clayey, moderately well drained to imperfectly drained with moderately slow to slow permeability. They are generally normal soils and are very rarely saline alkaline in the subsurface horizons. Though there were variations in the number of horizons and the depth of horizons in the different profiles dug, all those profiles belonged to Thirunallar soil series with a dark brown clayey surface soils and almost a very dark grayish brown layers extending beyond 2 meters. The perusal of morphological data had indicated that the soils exhibit the swell and shrink properties which are very characteristic to the Vertisol. The occurrence of mottles had also been seen which clearly indicates that the soils belonging to this soil series in the horticultural farm were subjected to impeded drainage in one or other part of an year. The occurrence of mottles can be taken as an index of water stagnation also which is quite frequently occurring in orchard soils. It was reported by Khan *et al.* (1998a) that the prolonged submergence may result in reduced condition exhibiting the soil colour value of 4 to 5 and chroma is 1. Similar observations of soil colour relating to drainage condition were also reported by Gerrad (1981) and Sharma *et al.*, (1999).

The Kottucherry soil series, Ustic Quartzipsamments were found to possess sandy to sandy clay loam texture. They occur in gentle sloping land with sand dunes. The profile dug in the botanical gardens belonged to this soil series. Though, the Kottucherry soil series is light in texture, they also showed the presence of mottles which can again be related to poor drainage condition. The impeded drainage in a sandy to sandy clay loam soil type might be due to the reason that the soils are occurring in a flat plain or the ground water is shallow so as to prevent the free flow

of water by gravity or can be due to the reason that the macropores are plugged in by clay migration.

5.2. Soil physical characterization

The soil physical properties are the king pin for soil fertility. Conventionally, the term fertility is used to define the ability of soil to supply nutrients in proper proportion. However, of late it is realised that so called fertility is not alone sufficient for crop production, since the processes which are responsible for the nutrient uptake by the plant roots is not only the quantity of nutrients at the vicinity of the root hairs but also the ability of the soil to renew the depleted nutrients, which are controlled by the soil physical properties. Hence, the term chemical fertility and physical fertility is now being used which stresses the importance of soil physical environment like optimum bulk density, infiltration, water movement, drainage, heat transmission, aeration etc.

The soil moisture content after air drying is ranging between 0.26 to 7.03 per cent in the profile soils and from 1.66 to 5.06 per cent in the surface soil. The variations in the amount of water retained by an air dried soil can be directly linked to the relative humidity of the atmosphere in which the samples are being dried and the ability of the soil to resist the low loss of moisture due to the presence of clay and organic matter. The above statement is very well confirmed by the positive and significant correlation with clay content ($r = 0.428^{**}$). It was further noticed that the organic matter is not significantly related which confirms the positive role of clay content on this property. From the multiple regression analysis it was further reaffirmed that between clay and organic matter, the clay content could significantly contribute to soil moisture content after air drying. Similar inferences were also drawn by Khan *et al.*(1998b), Ramesh (2001) and Valliammal (2004).

The loss on ignition (LOI) is an index of the organic matter status of the soil (Spain *et al.*, 1982). In the present study the loss on ignition had ranged from 0.05 to 2.24 per cent in the case of profile soil samples and in the case of surface samples, it ranged from 0.31 to 7.65 per cent. The variations in the loss on ignition among the profile and surface soil samples can be linked to the organic matter content or

carbonates of Ca and Mg, which can get oxidized at a higher temperature. However, in the present study, it was revealed that the organic matter content is not related to the loss on ignition, which can be attributed to the insignificant contribution of this proportion towards to loss on ignition. Further, it was seen that the loss on ignition is positively related to the clay content, and negatively to coarse sand content ($r = -0.298^*$). Such a relationship could be explained based on the fact that the loss in weight that occurs during ignition is directly related to the moisture held by the clay particle at a very high potential, which are evaporated at high temperature. Though this inference is confirmed by the simple correlation studies, in multiple regression analysis it was seen that 11.4 per cent of the variations alone could be explained by the clay and organic matter content with the significant contributions from the clay content. Such a relationship is also established by Khan *et al.*, (1998b), Ramesh (2001) and Valliammal (2004).

The Bulk density of the soil is a true index of the extent up to which the soil is compacted or porous, since the bulk density reflects the mineral composition coupled with the arrangement of the soil particle which is essential for the proper proportion of the pores which holds the soil air and soil water. Furthermore, it also determines the root proliferation and the volume of soil which the roots can feed upon. It also gives an indication upon the anchorage that can be given to the roots of the plants. In other words the values of bulk density should be sufficiently low enough to permit the root proliferation and maintaining proper ratio of soil air and soil water and sufficiently high enough to provide anchorage to the growing plants. This means that there should be an optimum bulk density value below which or above which the plants will suffer. The available literature suggests that a bulk density values of 1.2 to 1.6 Mg m⁻³ will be optimum for most of the plants and a bulk density value of less than 1.0 Mg m⁻³ is considered to be a loose soil which cannot give required anchorage and a bulk density value of more than 1.6 Mg m⁻³ is said to be a compact soil which results in poor aeration and root proliferation.

In the present study, the bulk density values of profile soil samples ranged between 1.176 to 1.538 Mg m⁻³ and in surface soil, it ranged between 1.156 to 1.250 Mg m⁻³. The above results suggests that except in some layers in the profile study and in some surface soil samples, the bulk density values did not show extreme conditions so as to

limit the crop production. However, the lower bulk density values in certain situations can be related to their clay content and the higher bulk density can be related to higher sand fraction. Similar inferences were drawn by Bharambe *et al.*, (1999) relating the clay content to the bulk density and by Agarwal *et al.*, (1974) and Mathan *et al.*, (1991a) relating the sand fraction to higher bulk density. The significant and negative correlation between bulk density and clay content confirms the above inferences. Furthermore, the different soil fractions are capable of explaining the variations in the bulk density with significant contribution from the clay fractions. It was also seen that between the clay and organic matter contents, the organic matter is more related to bulk density than clay content as confirmed by linear multiple regression analysis.

In general, the bulk density values of the surface soils were lower which can be ascribed to the organic matter content of the surface soil (Varadan and Mammen 1999). In the present study, the above inference was very well confirmed both in the simple correlation and in multiple regression analysis, wherein the bulk density is negatively related to organic matter content of the profile soil samples. However, in the surface soil samples, such a relationship was not established which can be ascribed to the minimum variations in the organic matter content of the surface soil samples. In certain soils the bulk density values increased with depth which may be due to dispersion and migration of the clay and clogging of pores (Khan *et al.*, 1998b) and also may be due to the development of hard pan.

The particle density of a given soil sample is directly related to the density of the parent rock/mineral from which the soils have developed. It is needless to mention that the source of rocks and minerals for weathering might vary from place to place, and the weatherability also depends upon the case with which they can undergo the physical weathering. For instance, the soils could have originated from the most denser haematite or to the most lighter Pumice. Hence, the resultant soil is a mixture of different rocks and minerals of varying densities and finally resulting in a soil of particle density ranging from 2.5 to 2.8 Mg m⁻³.

In the present study, the particle density value ranged from 2.0 to 3.33 Mg m⁻³ in the profile soil samples and from 2.222 to 2.500 Mg m⁻³ in the case of surface

samples. In general, the variations in the particle density can be directly related to the parent rock and can be indirectly related to organic matter content of soil samples. It was opined by Khan *et al.*, (1998b), that the higher particle density of the certain layers can be related to the lower organic matter content. The higher particle density of 3.33 Mg m^{-3} in the bottom most layer of the profile dug in H block can be attributed to the predominant proportions of sand fractions in that layer.

The total porosity of the soil is an important physical property which determines the soil air and soil water relationships. Though, the total porosity can indicate only the relative voids space available within the soil as compared to the total volume of the soil, the ratio of micropores to macropores is rather more important. This is because of the reason that the soil water is retained in the micropores by the forces of capillarity and the macropores is the volume available for soil air. If the ratio between micro and macropores is not optimum (which is normally 15 per cent of the porespace for micropores and the remaining for the macropores), the soil may prove to be either possessing low water holding capacity or may pose poor drainage conditions. Hence, the soil pore volume along with a proper proportion of micro to macropores play a vital role in providing a favourable physical environment with respect to availability of soil water and aeration. In the present study, only the total porosity was determined which was found to vary between 37.50 to 60.00 per cent in the case of profile soil samples. The variations in the total porosity among the different horizons of profile dug in the different blocks of horticultural farm and within the surface soil sample can very well be correlated to the difference in the textural composition of soil samples. In fact, the bulk density value reflects this proportions of total volume of soil vis-a-vis volume of soil pores. Hence, it is expected that the bulk density should have a negative relationship with a total porosity as has been observed in the present study ($r = -0.505^{**}$) in the case of profile sample and surface samples ($r = -0.295^*$). It was further noticed that the different textural group could also determine the total porosity, the sand fraction contributing to macropores and the clay fractions to that of micropores. A significant and positive contribution of the clay content towards total porosity was established in the multiple linear regression analysis which further adds support to the above conclusions. It is also seen that the total porosity can be influenced by the arrangement of soil particles viz., soil structure. For instance, the ultimate unit of soil structure is the peds which

contain micropores within itself and macropores among the peds. Hence, an optimum structure in terms of size, shape and grade will ultimately determines the porosity and as well as the proportion of micropores to macropores. In general, a granular and crumby soil structure is supposed to have a proper proportion of the micropores to macropores, whereas a blocky or prismatic structure may have more of micropores than macropores. Such a situation, wherein the blocky or columnar structure may occur in subsoil horizons resulting from the migration of clay to the lower layers. This might be the reason why the sub soil may possess more porosity with less proportions of macropores resulting in impeded drainage. This is in accordance with the findings of Satyavathi (1996).

The soil texture is yet another important soil physical property, which is found to control almost all soil physical processes occurring in the soil. The different proportions of sand, silt and clay influences the soil properties like bulk density, soil structure, soil fertility, water movement, aeration, heat transmission etc. Though all the three proportions of soil separates are important in their own way by influencing the crop growth, the clay fraction is absolutely essential for all physical and physico chemical reactions that occur in the soil. In the present study, the soil textural analysis is done only in the profile soils and it was seen that the clay content ranged from 2.40 to 53.90 per cent, silt content ranging from 1.25 to 29.35 per cent , the coarse sand content from 5.24 to 71.80 per cent and the fine sand content from 2.84 to 81.75 per cent. The above data clearly indicates that there were wide variations in the distribution of the different soil separate among the different horizons of same profile and between profiles dug in different blocks. In general, the relative dominance of a particular soil separates is mostly related to parent material, the type of weathering and the management strategies adopted over years. However, soils of horticultural farm are not formed insitu, being located in the deltaic region were of transported in origin thereby do not follow the patterns of pedogenesis which is expected in insitu soils. Hence there were wide variations in the textural composition due to pedoturbation, which had happened naturally during the alluvial deposition and artificially during the layout of the horticultural farm blocks. This is further seen within the horizons wherein, there is no clear cut trend in terms of clay migration thereby confirming the fact that the profiles of horticultural farm soils underwent major disturbance during the layout. It was reported by Khangarot and Mehra (1977),

Ramesh (2001) and Valliammal (2004) who had all opined that in the transported soils there cannot be a definite trend of particle size distribution with depth.

5.3. Soil Reaction and salinity

The soil reaction as measured by the pH values of the soil water suspension is a significant property, since it regulates the nutrient availability at the optimum proportions. The soil pH, as defined, is the negative logarithm of hydrogen ion activity in soil solution and hence actively participate in the exchange reactions viz., adsorption and desorption. Since the activity of hydrogen ion is stronger as compared to other monovalent followed by di and trivalent ions, the hydrogen ion in soil solution is capable of relating the other cations. Furthermore, it also plays a vital role in enhancing or decreasing the net negative charges under the variable charge density. In the present study the pH of the profile soil samples ranged from 7.54 to 8.98 and that of the surface samples from 5.21 to 8.75. Such a variation between the profiles and within the profiles can be related to the leaching and/ or the accumulation of bases of soil horizons. Similar reasons of increased pH in the sub soil, relating to leaching from the surface and the deposition of bases in the lower layers was also reported by Sujatha *et al.* (1999). Furthermore, the soils of Karaikal being in the coastal region undergoes the process of salinisation during the summer periods and desalinisation during rainy season thereby resulting in a complex situations wherein, the soils are rich in sulphate ion, which upon drying reduces the soil pH. This phenomena is quite often observed both in the farmers field and in the research farms, acidic pH of around 5 during drier seasons and the release of hydrogen sulphide during paddy cultivation. This may be the reason for a narrow range of pH values among the horizons of profile (CV = 3.31 per cent) and a wider variations among the surface soils of different fields (CV = 8.18 per cent).

The soil salinity is measured by the electrical conductivity in the soil water suspension. In general, the electrical conductivity is measured in a soil water suspension of 1:2 or 1:2.5 to get an indication whether the soil solution is having the electrolytes above the critical limits, beyond which the plants may not be able to absorb the nutrients. Though the above methodology is adopted under normal soil conditions, it may not be a true reflection of the salt concentration in the soil- water-

root interface. In other words, majority of the crops are grown at or below the saturation point so as to permit proper aeration and as well solubilise the nutrient elements for better absorption. However, for the purpose of delineating a soil as saline/ non saline, the electrical conductivity in the saturation paste extract (EC_e) is recommended. It is reported by IRRI scientists during the period of Tsunami that there are wide variations in the relationship between the EC measured in 1:2 soil water suspension and EC measured in saturation paste extract. It was quoted that the EC_e is at least 6 times higher in clayey soils, 9 times higher in medium textured soil and 13 times in the coarse textured soils. This means that an EC of 1 dS m⁻¹ in EC (1:2 ratio) is 6 in clayey soil, 9 in medium textured soil and 3 in sandy soil, making all these soils as saline as per the classification of USSL (1954). But under normal course of analyses the EC of 1 in 1:2 ratio is reported to be non-saline. Hence, in the present investigation, the saturation paste extract was undertaken to have true reflection of soil salinity in the root soil solution interface. The EC_e of the profile soil sample in the present investigation was ranging between 0.15 to 2.02 dS m⁻¹ and in the surface soil it ranged from 0.04 to 2.30 dS m⁻¹. This indicates that the soils of horticultural farms are non saline in nature. This trend of results might be due to the possible reason that the horticultural farm soils are provided with trenches in certain fields and with drip irrigation in certain other areas. In the case of fields provided with trenches to a depth of about 2 feet, the drained water were evacuated through a main drainage trench which discharges into a local pond. This might be the probable reason for the low EC values in the soils of horticultural farm. Yet another reason might be that the horticultural farms are grown with perennial orchard crops which absorbs and accumulates large quantity of electrolytes in the different parts of the plants. In other areas where drip irrigation was provided the salts were pushed beyond the wetting zone there by registering low EC_e values. Furthermore, there is no clear cut trend observed in the case of profile soil samples wherein, there can be increase, decrease of EC_e. It might be due to the fact that when precipitation exceeds the evaporation, the salts are washed down the profile there by showing a trend of increase in EC_e with depth. On the other hand if evaporation exceeds precipitation, the salts move up in the profile by capillary thereby registering a trend of decreasing EC_e with depth. In the present study, no such trend was observed possibly due to differential washing and capillary movement within the profile and thereby not following any specific trend. It can also be reasoned out that the horticultural farm

soils are having 4 ponds at a shallow depth and hence, the water table is highly fluctuating in the soil profile which might also influence the salinity status of different horizons of profile. Similar observations of increase in EC with depth was reported by Mayalagu and Peer Mohamed (1992) and Sekar (1994). The decrease in EC with depth was reported by Balasubramanian (1987). However, in the studies of Ramesh (2001) and Valliammal (2004) no specific trend was observed with depth as that of present study.

5.4. Organic Carbon Status

The organic carbon content of soil is an index of the organic matter status of the soils. It is understood that most of the carbon (\approx 60 per cent) in the soils, is in organic form and hence taken as an index of organic matter status. Furthermore, the organic carbon is a source of energy for soil microbes and thereby there is a continuous recycling of soil nutrients through mineralization and immobilization. In recent times, the organic carbon status of soils is also notified as an index of soil health, since it supports the huge population of soil organisms. However, in a tropical situation like India, the organic carbon status can never be increased, but can be sustained through continuous application of organic manures and recycling of crop residues. Since the soil carbon is an indication of the biological load of the soil it can also be taken as an index of soil fertility and hence the breakdown of the organic carbon results in the release of other nutrient elements, specifically N, P and S and in general most of the micronutrients.

The organic carbon status of profile samples of horticultural farm soils was ranging between 0.30 to 10.40 g kg⁻¹, and in the surface soil samples it ranged between 3.20 to 13.60 g kg⁻¹. The perusal of data had shown that the organic carbon content of most of soil samples is in the medium or high status which is not that commonly observed in the farm soils of Agronomy (Valliammal, 2004). The possible reason for the above trend of results might be due to the fact, that the horticultural farm soils are subjected to minimum tillage operations thereby decrease in the mineralization rate of the added residues. Furthermore, the horticultural crops have the tendency to shed their leaves during off season and hence the addition of litter can build up the organic matter content of soil.

As discussed earlier, the organic carbon content can be taken as an index of soil fertility, since the nutrients like N, P and S are also forming the part of organic matter. This is clearly established by the positive and significant relationship of this property with total N ($r = 0.786^{**}$), total K ($r = 0.331^{**}$), total Na ($r = 0.294^{**}$), available N ($r=0.479^{**}$), available P ($r=0.06^{**}$) and available K ($r=0.564^{**}$). It is also established that a soil with medium to high organic carbon can directly influence the bulk density of the soil by facilitating better soil structural arrangement. This is very well confirmed by significant and negative correlation between organic carbon and bulk density ($r=-0.418^{**}$) indicating the fact that higher the organic matter content, lower is the bulk density. The linear multiple regression analysis further supports above conclusion by significantly contributing towards the bulk density ($R^2=0.193^{**}$), total N ($R^2=0.400^{**}$), available N ($R^2=0.283^*$), available P ($R^2=0.354^{**}$), available K ($R^2= 0.234^{**}$) and total Mg ($R^2=0.129^*$).

5.5. Cation exchange properties

The cation exchange capacity is considered to be the single most important physico chemical property, as it helps in retaining the soil and fertilizer nutrient elements, when these nutrients in solution are in excess and release when they are a deficient. In other words, the cation exchange capacity acts both as a sink and source between the soil solution and the clay complex. This capacity of retaining the cations on the exchange sites is due to the generation of negative charges on the clay complex by either isomorphous substitution or by the broken edges. The organic matter can also contribute towards the CEC by the dissociation of H^+ or OH^- from their hydroxyl or carboxyl groups depending on the soil pH. Hence, it can be inferred that the silicate clay minerals could contribute to the permanent negative charges which are pH independent and the organic colloids could contribute to CEC by variable charges in accordance with the variations in soil pH.

The CEC of the soil samples collected from different horizons of soil profile ranged between 3.50 to 31.70 $cmol(p^+) kg^{-1}$. The wide variations in the CEC values was observed in the profile soil samples with a CV of 51.81 per cent and in the surface samples it was 65.38 per cent. As discussed earlier, the variations in the CEC

values of the profile samples and surface samples can be directly related to quantity and quality of clay minerals. It is also to be understood that in a tropical climate like Karaikal the major contribution towards the CEC might be from the clay minerals with little contribution of from the organic matter. This is clearly established by the positive and significant relationship of CEC with clay content ($r=0.429^{**}$) and a negative relation with coarse sand content ($r= -0.331^{**}$). The linear multiple regression is also confirming the above fact with contribution of 24.8 per cent by the soil separates, though none of the soil separates could significantly explains the variability in CEC. It was further confirmed by an another multiple regression analysis wherein, the variations in the CEC was significantly determined by the clay content rather than the organic matter status ($R^2=0.180^{**}$). Similar inferences of higher CEC values relating with the clay minerals was reported by Khangarot and Mehra (1977) and Ramesh (2001). It was further established that the CEC values were not only related to the amount of clay minerals but also on the type of clay minerals. This means that the variations in the CEC in the present study can also be related to type of clay minerals, wherein the Sorakody soil series is coming under the soil order Inceptisol, which are dominated by mostly Kaolinite and Illite (Ramesh, 2001) and that of the Thirunallar soil series is classified under Vertisol, which are dominated by Montmorilliite and /or Vermiculite type. It was inferred by Ramesh (2001) that the Thirunallar soil series coming under the Vertisols recorded the highest CEC among the soil series of Karaikal, which was attributed to the presence of Montmorillonite and Vermiculite and lower CEC values relating to the presence of Kaolinite and Illite was reported by Khangarot and Mehra (1977) and Reddy and Shiva Prasad (1999) respectively. It can further be explained that there were variations in the CEC values among the horizons of same profiles, though there is no clearcut trend, can be attributed to the migration of clay from the surface horizons to the lower layers in such of those soils, were the pedoturbation is not significant. In other cases wherein, the removal and deposition of foreign soil materials for the purpose of laying out the horticultural farm, the variations can be directly linked to characteristic features of the materials which are deposited or the layers which are exposed after excavation. Similar findings of no definite trend of CEC with depth was reported by Maji *et al.* (1998), Ramesh (2001) and Valliammal (2004).

The nature and the quantity of exchangeable cations on the clay complex and in soil solution is a dynamic phenomena wherein, there is always shift in equilibrium between the soil solution and the clay complex. This equilibrium is considered to be a double layer, one on the clay complex which is negative and the other in close proximity by a swarm of cations. This results in a differential electrical kinetic potential which is sensitive for any change that occurs on the clay complex and in the soil solution. Though, this physico-chemical reaction of cation exchange is said to be attaining equilibrium at any point of time in real sense, it can never be attained, since the ionic activity in the soil solution is undergoing a continuous change through plant uptake, fertilizer additions, release from the ion exchangeable and mineral sources, microbial immobilization, mineralization of organic matter etc. However, the presence of different cations on the clay complex is determined by the relative ionic strength and activity in the soil solution thereby indicating the fact that such of those ions which have higher ionic activity has the preference to occupy the exchange sites. In a tropical climate like India most of the soils contained major proportions of bases viz., Ca, Mg, Na and K in that order. In the present study the exchangeable Ca ranged between 2.00 to 23.50 cmol (p⁺) kg⁻¹, exchangeable Mg ranged between 0.00 to 16.50 cmol (p⁺) kg⁻¹, exchangeable K ranging between 0.02 to 0.47 cmol (p⁺) kg⁻¹, exchangeable Na was ranging between 0.08 to 3.11 cmol (p⁺) kg⁻¹ in the profile soil samples. In the case of surface soil samples exchangeable Ca was ranging from 5.00 to 49.50 cmol (p⁺) kg⁻¹, the exchangeable Mg from 0.0 to 8.00 cmol (p⁺) kg⁻¹, the exchangeable K from 0.27 to 0.58 cmol (p⁺) kg⁻¹ and the exchangeable Na from 1.17 to 3.87 cmol (p⁺) kg⁻¹. The variations in the extent of different cations on the clay complex is quite expected due to the reason that the soils are of mostly alluvial in nature which are deposited by the river Cauvery and are found to contain calcium dominated minerals. This was reflected in the quantity of exchangeable cations wherein, in almost all the soil samples drawn from the different horizons and in al the surface samples Ca was the dominant cation followed by Mg, Na and K. This result is in line with Chakraborty and Sinha (1983), Das *et al.* (1997), Das and Sharma (1997), More *et al.* (1998), Singh *et al.* (2000). In a few samples, Mg dominated over calcium which could be ascribed to the irrigation of soils with Mg rich water. Such a trend of results was also noticed by Sahu *et al.* (1986), Maji *et al.* (1998) and Patil and Dasog (1999). The predominance of Ca and Mg on the exchangeable complex could be attributed to preferential adsorption of these cations on the exchange sites

depending on type of clay mineral and the ionic activity. The positive and significant correlation of exchangeable calcium and magnesium with clay content adds support for the above trend of results. It was further seen that the variations in exchangeable calcium and magnesium can be significantly explained by the clay content rather than the organic matter content, as revealed by the simple linear multiple regression.

5.6. Total Nutrients

Soil is a natural product resulting from the weathering of rocks and minerals. The composition of the soil at the end of the weathering or during the process of weathering mainly depends on composition of rocks and minerals from which the soils are derived. During the process of soil formation, the rocks and minerals undergo physical, chemical and biological weathering which results in reduction in the size of soil particles followed by addition and removal of chemical constituents, because of which the resultant soil is completely different from the parent rock. Furthermore, the soil contains the primary minerals which upon decomposition results in the synthesis of secondary minerals. Based on the nature of the parent material and the type of reaction that the soil undergoes during the time of weathering, the elemental composition of the soil varies coupled with variable degree of solubility/bioavailability. In other words, almost all the nutrients exist in different states of availability, a part which can be readily available for the plants, another part which may be made available over a season, yet another proportion which may be available over a decade and another part which should be weathered over centuries before it is made available to crops. In a nutshell, every nutrient present in the soil need not necessarily be available to crops, if time is specified, but will be made available over a period of time by different modes of availability viz., weathering or mineralization.

Once the soil is formed, the vegetation that comes up over the soil either naturally or artificially adds the biosphere to the soil. Though the nutrients that are taken up by vegetation had been derived from the soil, it attains a different chemical composition within the plant according to the part in which the nutrients are assimilated. During the process of rock becoming soil with all the processes of soil formation, the soil undergoes major transformation and at any point of time, the soil contains nutrients at different levels of bioavailability. It is pertinent to mention here that though the

nutrients that are in the form in which the plants take is the matter of concern, it is also important that there should be reserve storage which supplies the readily available pool as and when depleted. Hence, it is important to assess the total nutrient status in a given soil so as to determine the ability of that soil to renew the nutrients in soil solution, whenever there is a depletion.

As discussed in the previous sections the total nutrient status of soil samples collected from horticultural farm, which revealed that the total N content ranged between 0.019 to 0.53 per cent in the profile samples and from 0.06 to 0.80 per cent in the surface soil samples. The main source of N to the soil is only through the organic residues since more than 95 per cent of N is in organic form in the soil. The wide variation in the total N content between the horizons of the profile can be attributed to the organic carbon status of the soil samples in different horizons. In general, the organic carbon content of the surface samples under aerable condition will be relatively higher and tend to decrease as the depth increases corresponding to biological activity within the soil profile. In other words, the residues of crop is distributed within the top 15 to 30 cm and as the depth increases the roots cannot go beyond 30 cm in most of the annual crops, though it may not hold good for horticultural orchard crops. A significant and positive relationship in the profile soil samples between organic carbon and total N ($r = 0.786^{**}$) total Mg ($r = 0.298^*$), available N ($r = 0.479^{**}$), available P ($r = 0.706^{**}$) and available K ($r = 0.564^{**}$) further support the above conclusion. Furthermore, when the surface soil samples were subjected to similar type of correlation analysis, it was seen that organic carbon is positively correlated to total N ($r = 0.585^{**}$), total P ($r = 0.591^{**}$), available N ($r = 0.679^{**}$), available P ($r = 0.339^{**}$) and available K ($r = 0.463^{**}$) which further add supports for the earlier conclusions. Unlike nutrients like K, Ca and Mg which are more related to the mineral fractions of soil, the total N is mainly concentrated in the organic fraction of soil.

A linear multiple regression analysis undertaken to confirm this had clearly shown that none of the soil separates could contribute to total N. However, when the total N was regressed with the organic matter and clay, it was clearly proved that the organic matter could significantly contribute to total N with a regression co-efficient of 0.400^{**} . It was opined by Lahiri and Chakravarti (1989) that there is always a close

relationship between organic carbon and total N. The above finding is also in line with Ramesh (2001) and Valliammal (2004).

As regards the total P content, it is seen that it also forms a major component of soil organic matter. It was reported by Tisdale (1995), out of the total P content of soil, the organic P constitutes around 15-85 per cent with an average value of 50 per cent. Unlike N, phosphorus coexist both in organic and mineral form, the apatite being a major source of mineral P. Furthermore, the P released during the process of weathering and applied during the crop growth periods undergoes various mechanisms of fixation viz., adsorption on the positive sites of clay minerals and colloidal complex and precipitation as Fe and Al phosphates under acidic pH condition and as dicalcium and tricalcium phosphate under alkaline pH condition. In short, such of those phosphorus which forms an integral part of soil organic matter living or dead, and that proportion of P which are not soluble would constitute a major component of the total P. The total P content ranged from 0.023 to 0.206 per cent in profile soil sample. As discussed in the above section the variations in the total P content can be very well related to the organic carbon content and / or mineral composition of soil. In the present investigation it was clearly established that total P content was significantly and positively related to the organic carbon content in the case of surface soil sample only. Non-significance between of these two properties in the profile soil samples might be due to the fact that the organic carbon content decreases with increase in the depth. Similar observations of total P relating to organic carbon was also made by Poonkodi (1991), Ramesh (2001) and Valliammal (2004).

Unlike the N and P which are mostly in the organic form, the K is mainly in the inorganic form. It is also pertinent to mention that K is only nutrient element which exist in ionic form in all the ecosystem. Potassium exist in different forms viz., soil solution K, exchangeable K, non exchangeable K and mineral K, among which there is always a dynamic equilibrium. Unlike N and P, the balance between the different forms of K is highly sensitive and results in unreliable determinations while ascertaining the bioavailability. Potassium is mostly concentrated in the K bearing minerals like Orthoclase, Muscovite, Biotite etc., in which around 80 to 90 per cent of the total K is locked up. The remaining 10 to 20 per cent is distributed among the

solution, exchangeable and non-exchangeable pool, the contribution being widely varying depending on quantity and quality of clay. In the present investigation, the total K content of profile soil sample ranged from 0.003 to 0.290 per cent and in the surface soil samples it ranged from 0.024 to 0.264 per cent. The wide variability among the soil samples can be directly related to the nature of minerals present in the soil, the particle size distribution and the degree of weathering of minerals (Ranganathan and Satyanarayana, 1980), the proportion of Illite, Feldspar and Mica in the clay sized particles (Sahu and Gupta, 1987) and the presence of K bearing minerals in the coarser fraction soil (Sidhu *et al.*, 2000).

The total calcium content of the soil is mainly determined by the calcium containing parent material and the secondary precipitation of calcium with carbonates and bicarbonates of irrigation water. In most of the tropical soils, the calcium content is sufficiently high enough so that there is no limitation to the crops with respect to this nutrient. The total Ca content of profile soil samples ranged from 0.150 to 0.841 per cent and in the surface soils its ranged from 0.205 to 0.841 per cent and in the surface foils it ranged from 0.205 to 1.080 per cent. The variations in the total Ca content is mainly accomplished by the variations in the Ca bearing primary and secondary minerals. The above trend of results is in accordance with Ramesh (2001) and Valliammal (2004).

As regards to Mg content of soil these were no wide differences between Ca and Mg with respect to their forms and distributions. The source of Mg is mainly through the Mg containing parent material and irrigation with Mg rich water. In the present investigation the Mg content ranged from 0.000 to 0.348 per cent and in surface soil samples it ranged from 0.000 to 0.522 per cent. The main reason for such wide variations is mainly related to the variations in clay content and speciation. Similar result was reported by Dhaliwal *et al.*, (1993).

The total Na content in general is given least importance due to the reason that it is not an essential nutrient. However, in the present investigation the total Na content was determined with the purpose of identifying and diagnosing the Na rich layer which are developed either due to irrigation with Na rich water or with the rise in ground water table which contains appreciable amount of Na. The total Na content

ranged from 0.025 to 0.149 per cent in the profile soils and from 0.044 to 0.124 per cent in surface soil samples. The variation in the Na content might be due to the variable movement of Na in the different horizons of soil through irrigation water.

5.7. Available Nutrients

The term available nutrient is quite often used to indicate that proportion of the given nutrient element that may be available during the growth period of a plant. In other words, the nutrient elements are present in the soil in different status of bio availability ranging from instantaneously available to very difficultly available. As far as the term available nutrient status is used in the context of plant availability, every part of that soil nutrient is available one time or other depending on the stage at which the nutrient is present. In fact, the available nutrient status comprises of two fractions, one that is instantaneously available i.e. nutrient in soil solution and the other fraction which is not currently available but can be made available by a suitable mechanism during the crop growth period. The determination of available nutrient status is a prerequisite for the purpose of fertilizer prescription, since the fertilizers are to be applied by taking into consideration the instantaneous nutrient supply from the soil. While assessing the nutrient availability, the determination of instantaneously available soil nutrients is quite easy and reliable as it directly measures the nutrient in question. The difficulty arises when the so called nutrient that can be made available during the crop growth period is estimated, since it is otherwise determining the rate of release of that particular nutrient element in question by different soil mechanism over a crop growth period, which may vary according to crop. For instance, under laboratory conditions, simulations can be made by suitably using extractants which assess both the nutrient in solution plus the nutrient that can be made available over a period of time. Since the duration of crop varies, the reliability of the above determination depends on the standardization of the extractant that is being used for the purpose of available nutrient estimation. The complexity increases, resulting in decreased reliability on the laboratory data, when the extractants that is used in the laboratory do not reflect the field situation. Hence the determination of available nutrient status of the soil can only be used as a tool or a guide for assessing the nutrient availability and may not be generalized over an area.

The available N status is determined by subjecting the soil to oxidation using KMnO_4 of 0.32 per cent strength. The logic behind using this extract is that, it determines almost under all situations the amount of inorganic N present in the soil and that part of organic N that can be mineralized during the crop growth period. The amount of N thus extracted, though, may not exactly match with the amount of N taken up by the crop, it correlates well with the nutrient uptake, thus making this method universally acceptable under varied agro climatic zones. As far as the available nutrient status of the horticultural farm soils are concerned, it ranged from 4.70 to 131.70 kg ha^{-1} in the profile and from 56.45 to 189.73 kg ha^{-1} in the surface soil samples. As indicated in the earlier section the available N content is directly related to mineralization rate of the organic matter, since more than 95 per cent of N is in organic form. The above statement was clearly proved in the correlation studies wherein, the available N is positively correlated to organic carbon ($r = 0.409^{**}$). The positive relationship between organic C and total N also adds support for the above statement. It was concluded by Misra and Saithantuaanga (2000), that the organic C content can truly reflect the available N status of the soil. A significant contribution by the organic matter towards the available N in the multiple regression analysis also adds support for the above conclusion. Based on the available N status the soils, the N status can be classified as low, medium and high according to Mohr *et al.* (1965), based on which it was concluded that all the soils of horticultural farm were below the low status viz., less than 280 kg ha^{-1} , indicating the fact that this nutrient element might be the major limiting factor for attaining higher productivity from the horticultural soils (Fig 14).

The available P status as extracted by the Olsen's reagent (0.5 M NaHCO_3) is considered to be a reliable tool for assessing the quantity of phosphorus that may be accessible for the plants to take. The P exist in different forms viz., organic P, inorganic P, P locked up in the microbial tissues and the P in minerals. The form of P which the plant take up is mostly orthophosphate viz., H_2PO_4^- , HPO_4^{2-} , which should be released into the soil solution from these less or difficultly available pools of phosphorus. The management of soil phosphorus is very difficult due to the reason that the orthophosphate ions, which the plants prefers to take is subjected to all sorts of fixation and precipitation reaction thereby registering very low P use efficiency. To overcome this, management strategies are available to reduce the fixation and

precipitation reactions and as well match the plant uptake pattern. It is also important to select a suitable P supplying material in tune with soils ability to supply to the crops. For instance, a soil with high P fixing capacity may have to be first enriched with cheaper sources of P like rock phosphate and then the water soluble P source like DAP and SSP can be applied. It is also interesting to observe that most of the alluvial soils are rich in available P basically due to the reason that the P which is precipitated as ferric phosphate are solubilised as ferrous sulphate which upon dissociation can meet the crop requirement.

In the present study, the available P status of horticultural farm soil drawn from the horizons of different profiles ranged between 2.64 to 62.67 kg ha⁻¹ and in the surface soils it was ranging from 12.84 to 77.91 kg ha⁻¹ with an average value of 36.36 kg ha⁻¹. The above data clearly indicates that the P supply from the soil is sufficiently high enough to meet the crop requirement. It can also be inferred that the availability of soil P is either determined by clay or organic matter content. From the correlation analysis, it is inferred that the available P status is more related to the organic carbon content

($r = 0.706^{**}$) rather than the clay content ($r = -0.027^{NS}$). The above result is further confirmed by a positive and significant relationship of the organic carbon status and the available P status of the surface soils ($r = 0.339^*$).

The linear multiple regression undertaken for the purpose of confirmation had also clearly indicated that none of the soil separates could significantly contribute to the available pool of the soil, whereas between clay and organic matter, organic matter alone explained the variations in the available P status of soil ($R^2 = 0.354^{**}$). It was further seen that the available P is directly related to the total P in the surface soils ($r=0.597^{**}$), which once again confirms that the methodology used for the determination of available p is drawing its nutrients from the organic pool. Based on the classification given by Mohr *et al* (1965). Soils of horticultural farm are found to contain medium to high status of available P, in which 9.5 per cent of soils were medium and the remaining samples contained high to very high levels of Olsen-P (Fig 15). The above trend of results is in line with the conclusion drawn by Ramesh (2001), wherein only 7 per cent of the soils in the Thirunallar soil series was registering low status of Olsen P and the rest medium to high status. The above trend

of results further indicated that the application of P to the different fields of horticultural farm should be site specific and depending on the type of crops grown.

The available K status as determined by extracting with NH_4 OAC is an useful tool to determine that proportion of K that is made available during the crop growth period. Unlike N and P, K behave differently under field and laboratory condition making the prediction of available K unrealistic in certain cases. This is mainly because of the fact that K exist in different forms and there is a dynamic equilibrium at least between soil solution K, exchangeable K and non- exchangeable K. While the solution K constitute only 2-5 per cent of labile pool in the soil, the remaining must be contributed from either exchangeable or non-exchangeable sources. In soils which are dominated by 1:1 type of clay minerals, the contribution of K to the soil solution is only from the exchangeable pool, whereas in soils which are dominated by 2:1 type of minerals like Montmorillonite, Vermiculite and Illite, the contribution can be substantial to the labile pool. In the present investigation, the available K status of profile soil samples ranged from 10.68 to 276.46 kg ha^{-1} whereas, in surface soil samples it ranged from 170.96 to 496.84 kg ha^{-1} . The results had shown that out of the total samples drawn from the surface soils of horticultural farm, 67.92 per cent of the samples were rated as medium K status and the remaining 32.08 per cent of samples were high in K status (Fig 16). It is also to be understood that the available K is more related to mineral fraction of soil than the organic matter content. A significant and positive correlation between the available K and the clay content confirms the above conclusion. However, in the regression analysis it was inferred that both the clay and organic matter could explain the variations in the available K content.

The available sulphur as extracted by CaCl_2 is an indication of whether a soil requires sulphur addition or not. In fact, the sulphur deficiency is not that common in most part of the Indian soils except in areas where oilseeds had been grown. The reason for the above might be due to the sulphur rich irrigation water in the coastal areas, addition of gypsum especially to paddy crop and application of sulphur containing fertilizers. However, in the recent years the need for sulphur is growing due to the fact that the application of S containing fertilizers like $(\text{NH}_4)_2\text{SO}_4$, SSP and K_2SO_4 are dispensed with and the use of pesticides containing sulphur like Bordeaux

mixture is also not in practice. Hence, it is realized that the deficiency of sulphur can be anticipated very soon, if the present management strategy continue. As far as the horticultural farm soils of PAJANCOA and RI is considered, the available S ranged between 1.24 to 157.13 mg kg⁻¹ in the profile soil samples and from 6.33 to 29.10 mg kg⁻¹ in surface soil samples. According to the All India Co-ordinated research project on micro and secondary nutrients and polluted elements, the available S value of 12 mg kg⁻¹ was considered to be the critical value, below which it is deficient and above which sufficient. Accordingly 17.00 per cent of the soil samples in the horticultural farm were found to deficient and the remaining 83 per cent contained sufficient quantity of sulphur and may not require any external additions (Fig .17)

CHAPTER 6

SUMMARY AND CONCLUSION

Agriculture is the back bone of our Indian economy, constituting about 4 per cent of our Gross domestic product. It also forms the livelihood option of more than 70 per cent of our population, with the foremost objective of meeting the growing demand for food grains. To achieve this target new innovations are introduced into the Indian agriculture in the name of green revolution during 1960's which had not only resulted in enhanced crop production and productivity, but also resulted in degradation of soils. This is mainly because of the fact that the components of green revolution had to be incorporated in addition to conventional method of agriculture, instead of which only the components were practiced. This has resulted in reduced soil fertility, decreased organic carbon status, poor microbial activity, unfavorable physical environment etc, thereby the benefits of green revolution are not tapped to its fullest extend in the later parts of 1990's. The very purpose of green revolution should focus on sustainable agriculture, which can be achieved only by proper management of the natural resources like soil and water at field level. Hence, it has now become imperative that the technology should be site specific and soil characterization is a prerequisite before adopting any recent management strategies developed. Such a characterization is absolutely essential from the field level so as to develop a package of practice for a particular given farm.

With the above objectives, the horticultural farm soils of PAJANCOA and RI are characterized by digging 11 profiles in each block of horticultural farm and collecting surface soil samples in duplicate from each of the fields. The collected soils samples were subjected to various physical, chemical and physicochemical analysis and the results thus obtained were statistically scrutinized and presented in chapter 4 and discussed in chapter 5. The salient results that has emanated form this investigation are summarized in this chapter.

- The soils of the Horticultural farm comes under two soil series which are very dominant in the Karaikal region viz., Kottucherry and Thirunallar. Taxonomically the Thirunallar soil series is classified under Typic Chromustert and the Kottucherry soil series is classified under Ustic Quartzipsamment.
- The Thirunallar soil series are very deep, clayey, moderately well drained to imperfectly drained with moderately slow to slow permeability.
- The Kottucherry soil series is sandy to sandy clay loam with mottles indicating an impeded poor drainage condition.
- Both the soil series had shown mottles at lower level which are mainly Fe concretions indicating the fact that both the soil series were poorly drained due to the reason that they are located in a almost flat plain, restricting the easy flow of water either on the surface or vertically below the soil.
- The moisture content of the soil samples after equilibrating with atmospheric condition was found to range between 0.26 to 7.03 per cent in the profile samples and from 1.66 to 5.06 per cent in surface soil samples.
- The variation in the amount of water retained after air drying is mainly related to the content of clay and organic matter, the clay being significantly related to this property as revealed by simple correlation studies.
- The loss on Ignition was found to range between 0.05 to 2.24 per cent in the profile soil samples and from 0.31 to 7.65 per cent in the surface soil samples.
- The variations in loss on ignition among the soil samples can be attributed to variations in organic matter or clay content, whereas in the present investigation it was more related to clay than organic matter content as revealed by correlation and multiple regression analysis.
- The bulk density of the soil samples were found to vary from 1.176 to 1.538 Mg m^{-3} in the profile soil samples and from 1.156 to 1.250 Mg m^{-3} in the surface soil samples.
- The variation in the bulk density was more related to clay among the soil textural groups as per simple correlation studies and between organic matter and clay, organic matter significantly contributed towards the variation in bulk density as per the multiple regression analysis.

- It was further inferred that none of the soil samples had registered bulk density value which are not optimum viz., less than 1.0 or more than 1.6 Mg m⁻³ suggesting that this property is not a limiting factor in the horticultural farm soils.
- The particle density ranged from 2.00 to 3.33 Mg m⁻³ in the profile soil samples and in the surface soil samples it ranged from 2.22 to 2.50 Mg m⁻³.
- The higher bulk density in certain layers of profile was attributed to the mineralogical composition of that layer.
- The total porosity of the profile soil samples varied between 37.50 to 47.37 per cent and in the surface soil samples it ranged from 43.75 to 52.94 per cent.
- From the multiple linear regression analysis it was inferred that the clay content was the most contributing factor towards the total porosity.
- The textural analysis of the profile soil samples had shown that clay content ranged from 2.40 to 52.90, the silt content ranging from 1.25 to 29.35 per cent, the coarse sand content from 5.24 to 71.80 per cent and the fine sand content ranging from 2.84 to 81.75 per cent. The textural groups of the profile soil samples had shown that it ranged from sandy, sandy loam and loamy sand, silty clay loam to clayey indicating the fact that there were wide variations in the soil texture which might play a vital role in water transmission and drainage.
- The pH of the profile soil samples varied from 7.54 to 8.98 and from 5.21 to 8.75 in the surface samples. The results had shown that there are certain fields which had recorded acidic pH values and pH values of more than 8.5 which requires proper management.
- The acidic soil pH was related to the horizons rich in pyrites which upon oxidation produces H₂SO₄ which might have reduced the soil pH. The higher pH values are mostly related to the sodic condition, though the ESP values were not above 15 per cent.
- The EC in the saturation paste extract was ranging between 0.15 to 2.02 dS m⁻¹ in the profile soil samples and from 0.04 to 2.30 dS m⁻¹ in the surface soils.
- The E_ce values had suggested that there were no saline patches in the horticultural farm which was attributed to the cultivation of trees on the ridges with trenches which might have removed the salts during the rainy season.

- The organic carbon content of the profile soil samples ranged between 0.30 to 10.40 g kg⁻¹ and in the surface soil samples it ranged between 3.20 to 13.60 g kg⁻¹. The results had shown that in most of the surface samples the OC status is medium to high.
- The CEC of soil samples collected from different horizons of the soil profile ranged between 3.50 to 31.70 cmol (p⁺) kg⁻¹ and in the surface soil samples it ranged from 5.70 to 65.20 cmol (p⁺) kg⁻¹.
- It was clearly established that the clay content was contributing towards the CEC as revealed by simple correlation and multiple regression analysis.
- In most of the soil samples collected from profile and on the surface, the exchangeable Ca was the dominant cation followed by Mg, Na and K.
- The exchangeable Ca content ranged between 2.00 to 23.50 cmol (p⁺) kg⁻¹, the exchangeable Mg ranging between 0.00 to 16.50 cmol (p⁺) kg⁻¹, the exchangeable K ranging between 0.02 to 0.47 cmol (p⁺) kg⁻¹ and the exchangeable Na was ranging between 0.08 to 3.11 cmol (p⁺) kg⁻¹ in the profile soil samples.
- In the case of surface soil samples exchangeable Ca was ranging from 5.00 to 47.50 cmol (p⁺) kg⁻¹, the exchangeable Mg ranged between 0.00 to 8.00 cmol (p⁺) kg⁻¹, the exchangeable K ranged between 0.27 to 0.58 cmol (p⁺) kg⁻¹ and the exchangeable Na ranged between 1.17 to 3.87 cmol (p⁺) kg⁻¹.
- The total N content of the profile soil samples ranged between 0.019 to 0.53 per cent and in the surface soil samples it ranged from 0.06 to 0.80 per cent.
- The variation in the total N content was more related to the OC content rather than the clay content as revealed by simple correlation and multiple regression analysis.
- The total P content ranged between 0.023 to 0.206 per cent in profile soil samples and from 0.025 to 0.220 per cent in surface soil samples.
- The variations in the total P content was related to organic carbon content as revealed by simple correlation studies.
- The total K content ranged between 0.003 to 0.229 per cent in the profile soil samples and in the surface soil samples it ranged from 0.024 to 0.264 per cent.
- Unlike the N and P, the variations in the total K content was attributed to the soil mineral fraction rather than the organic matter.

- The total Ca content ranged from 0.150 to 0.841 per cent and in the surface soil it ranged from 0.205 to 1.080 per cent.
- With respect to total Mg, it ranged from nil to 0.348 per cent in the profile soils and from nil to 0.522 per cent in the surface soil samples.
- The total Na content was found to be varying between 0.025 to 0.149 per cent in the profile soil samples and from 0.044 to 0.124 per cent in the surface soil samples.
- The available N status in the horticultural farm soil had revealed that, it was ranging from 4.70 to 131.70 kg ha⁻¹ in the profile soil samples and from 56.45 to 189.73 kg ha⁻¹ in the surface soil samples.
- The variations in the available N was significantly and positively related to OC status of soil as revealed by simple correlation and multiple regression analysis.
- It was inferred that all the soil samples of the horticultural farm are rated as low based on the KMnO₄ extractable N.
- The available P status of the profile samples ranged between 2.64 to 62.61 kg ha⁻¹ and from 12.84 to 77.91 kg ha⁻¹ in surface soil samples.
- From the correlation and multiple regression analysis, it was inferred that the OC content was significantly explaining the variations in the available P status of the soil.
- The soils of Horticultural farm was found to contain medium P status in 9.5 per cent of the samples and the remaining samples were high in their P status.
- The available K content of profile soil samples ranged from 10.68 to 276.46 kg ha⁻¹ and in the surface soil samples it ranged from 170.96 to 496.84 kg ha⁻¹.
- It was inferred that the variations in the available K content was more related to clay content than the organic matter status as revealed by correlation and regression analysis.
- It was inferred that 67.92 per cent of the soil samples in the horticultural farm were found to possess medium status of available K and the remaining 32.08 per cent of the samples were higher in available K.
- The available S status of profile soil samples ranged from 1.24 to 157.13 mg kg⁻¹ and in the surface soils it ranged from 6.33 to 29.10 mg kg⁻¹.

- Accordingly it was inferred that 17.00 per cent of the soil samples were found to be deficient in S and remaining 83.00 per cent registered available S values above the critical level.

To conclude, the present investigation had shown that as far as the physical properties like bulk density, particle density and porosity there were no limitations which could significantly affect the crop growth. As regards the cation exchange properties, majority of the exchange sites are occupied by the bases with the dominant proportion of Ca followed by Mg, Na and K. The total nutrient status was found to be relatively higher with respect to N and P as compared to Indian soils and very low with respect to total K. However, the available nutrient status had shown that N is most limiting factor, since it was registering low status in all the soils. With respect to P, K and S, there were no major threat except that in certain fields the values of S were below the critical level, which requires addition of S or S containing fertilizers.

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*Original not seen

Table 4. Physical properties of profile soil samples of PAJANCOA and RI Horticultural farm soils

Profile	Depth (cm)	Moisture (%)	LOI (%)	BD (Mg m⁻³)	PD (Mg m⁻³)	TP (%)
	0-20	2.26	1.23	1.176	2.222	47.06
	20-49	7.03	5.87	1.176	2.500	52.94
A	49-70	2.55	1.28	1.176	2.222	47.06
	70-138	1.53	0.76	1.176	2.222	47.06
	138+	1.77	0.71	1.250	2.500	50.00
Minimum		1.53	0.71	1.176	2.222	47.06
Maximum		7.03	5.87	1.250	2.500	52.94
Mean		3.03	1.97	1.191	2.333	48.82
CV		74.98	111.38	2.761	6.521	5.388
	0-10	1.98	2.55	1.176	2.500	52.94
	10-41	2.03	2.45	1.176	2.500	52.94
B	41-84	2.82	3.09	1.176	2.500	52.94
	84-122	0.90	1.11	1.250	2.500	50.00
	122-151	1.16	1.11	1.250	2.500	50.00
	151+	1.54	0.25	1.333	2.500	46.67
Minimum		0.90	0.25	1.176	2.500	46.67
Maximum		2.82	3.09	1.333	2.500	52.94
Mean		1.74	1.76	1.227	2.500	50.92
CV		39.74	62.05	5.157	0.000	4.972
	0-21	3.15	2.79	1.250	2.222	43.75
	21-42	3.02	2.58	1.176	2.500	52.94
C	42-65	1.79	1.38	1.250	2.222	43.75
	65-84	1.71	1.58	1.250	2.222	43.75
	84-150	1.67	1.42	1.250	2.222	43.75
	150+	1.23	0.86	1.250	2.222	43.75
Minimum		1.23	0.86	1.176	2.222	43.75
Maximum		3.15	2.79	1.250	2.500	52.94
Mean		2.09	1.77	1.238	2.269	45.28
CV		37.93	42.57	2.425	4.999	8.287
	0-25	2.14	1.79	1.176	2.222	47.06
	25-44	3.73	2.54	1.176	2.222	47.06
D	44-71	2.83	2.42	1.250	2.500	50.00
	71-129	1.44	3.32	1.176	2.222	47.06
	129+	0.26	0.25	1.333	2.222	40.00
Minimum		0.26	0.25	1.176	2.222	2.22
Maximum		3.73	3.32	1.333	2.500	2.50
Mean		2.08	2.06	1.223	2.278	2.28
CV		63.54	55.71	5.696	5.454	8.03

Table 4. contd.,

Profile	Depth (cm)	Moisture (%)	LOI (%)	BD (Mg m ⁻³)	PD (Mg m ⁻³)	TP (%)
	0-20	3.35	3.41	1.176	2.500	52.94
	20-71	4.28	4.07	1.176	2.500	52.94
E	71-118	4.33	3.76	1.250	2.222	43.75
	118-126	1.34	0.25	1.333	2.500	46.67
	126+	1.23	1.21	1.333	2.222	40.00
Minimum		1.23	0.25	1.176	2.222	40.00
Maximum		4.33	4.07	1.333	2.500	52.94
Mean		2.91	2.54	1.254	2.389	47.26
CV		52.60	67.00	6.257	6.369	12.060
	0-20	3.42	3.16	1.176	2.222	47.06
	20-64	3.91	3.33	1.176	2.222	47.06
	64-91	2.56	2.21	1.250	2.500	50.00
F	91-115	2.87	2.42	1.176	2.500	52.94
	115-158	3.55	2.96	1.250	2.500	50.00
	158+	3.86	3.48	1.333	2.222	40.00
Minimum		2.56	2.21	1.176	2.222	40.00
Maximum		3.91	3.48	1.333	2.500	52.94
Mean		3.36	2.93	1.227	2.361	47.84
CV		16.09	17.46	5.157	6.444	9.26
	0-32	3.52	4.56	1.250	2.500	50.00
	32-80	2.68	3.29	1.250	2.500	50.00
G	80-101	3.79	3.53	1.250	2.500	50.00
	101-115	1.62	4.22	1.333	2.500	46.67
	115-152	2.58	2.06	1.250	2.500	50.00
	152+	2.30	2.10	1.333	2.500	46.67
Minimum		1.62	2.06	1.250	2.500	46.67
Maximum		3.79	4.56	1.333	2.500	50.00
Mean		2.75	3.29	1.278	2.500	48.89
CV		29.03	31.82	3.368	0.000	3.52
	0-29	5.20	5.91	1.176	2.222	47.06
	29-58	5.80	0.64	1.250	2.000	37.50
H	58-73	4.08	4.80	1.250	2.500	50.00
	73-88	1.30	0.56	1.538	2.500	38.46
	88-110	1.86	3.56	1.333	2.222	40.00
	110+	4.17	4.53	1.333	3.333	60.00
Minimum		1.30	0.56	1.176	2.000	37.50
Maximum		5.80	5.91	1.538	3.333	60.00
Mean		3.37	3.33	1.314	2.463	45.50
CV		48.12	67.41	9.523	18.962	19.08

Table 4. contd.,

Profile	Depth (cm)	Moisture (%)	LOI (%)	BD (Mg m ⁻³)	PD (Mg m ⁻³)	TP (%)
	0-25	2.64	2.31	1.176	2.500	52.94
	25-30	3.38	2.23	1.176	2.222	47.06
I	30-46	2.19	1.94	1.250	2.222	43.75
	46-71	1.80	1.98	1.333	2.222	40.00
	71-130	0.90	1.21	1.333	2.500	46.67
	130+	1.31	1.17	1.333	2.500	46.67
Minimum		0.90	1.17	1.176	2.222	40.00
Maximum		3.38	2.31	1.333	2.500	52.94
Mean		2.04	1.81	1.267	2.361	46.18
CV		44.30	27.63	6.101	6.444	9.24
	0-23	5.14	3.96	1.176	2.222	47.06
	23-54	4.93	3.95	1.176	2.222	47.06
J	54-72	3.32	1.86	1.250	2.222	43.75
	72-124	1.40	0.41	1.333	2.500	46.67
	124-152	1.61	0.76	1.333	2.500	46.67
	152+	4.98	3.21	1.250	2.222	43.75
Minimum		1.40	0.41	1.176	2.222	43.75
Maximum		5.14	3.96	1.333	2.500	47.06
Mean		3.56	2.36	1.253	2.315	45.83
CV		48.44	66.82	5.601	6.197	3.53
	0-26	1.24	0.41	1.176	2.500	52.94
Old Bot	26-43	1.92	0.77	1.176	2.222	47.06
	43-75	2.24	0.77	1.176	2.500	52.94
	75-152	0.28	0.05	1.250	2.500	50.00
	152+	1.53	0.56	1.333	2.222	40.00
Minimum		0.28	0.05	1.176	2.222	40.00
Maximum		2.24	0.77	1.333	2.500	52.94
Mean		1.44	0.51	1.223	2.389	48.59
CV		52.09	58.58	5.696	6.369	11.08

Descriptive statistics for overall physical properties of PAJANCOA and RI Horticultural farm profile soils

	Moisture (%)	LOI (%)	BD (Mg m ⁻³)	PD (Mg m ⁻³)	TP (%)
Minimum	0.26	0.05	1.176	2.000	37.50
Maximum	7.03	5.91	1.538	3.333	60.00
Mean	2.57	2.24	1.246	2.380	47.37
CV	54.53	64.54	5.778	8.000	9.40

Physical properties of Profile samples:

Profile	Depth (cm)	Moisture (%)	LOI (%)	BD (Mg m⁻³)	PD (Mg m⁻³)	TP (%)
	0-20	2.26	1.23	1.176	2.222	47.06
	20-49	7.03	5.87	1.176	2.500	52.94
A	49-70	2.55	1.28	1.176	2.222	47.06
	70-138	1.53	0.76	1.176	2.222	47.06
	138+	1.77	0.71	1.250	2.500	50.00
	0-10	1.98	2.55	1.176	2.500	52.94
	10-41	2.03	2.45	1.176	2.500	52.94
B	41-84	2.82	3.09	1.176	2.500	52.94
	84-122	0.90	1.11	1.250	2.500	50.00
	122-151	1.16	1.11	1.250	2.500	50.00
	151+	1.54	0.25	1.333	2.500	46.67
	0-21	3.15	2.79	1.250	2.222	43.75
	21-42	3.02	2.58	1.176	2.500	52.94
C	42-65	1.79	1.38	1.250	2.222	43.75
	65-84	1.71	1.58	1.250	2.222	43.75
	84-150	1.67	1.42	1.250	2.222	43.75
	150+	1.23	0.86	1.250	2.222	43.75
	0-25	2.14	1.79	1.176	2.222	47.06
	25-44	3.73	2.54	1.176	2.222	47.06
D	44-71	2.83	2.42	1.250	2.500	50.00
	71-129	1.44	3.32	1.176	2.222	47.06
	129+	0.26	0.25	1.333	2.222	40.00
	0-20	3.35	3.41	1.176	2.500	52.94
	20-71	4.28	4.07	1.176	2.500	52.94
E	71-118	4.33	3.76	1.250	2.222	43.75
	118-126	1.34	0.25	1.333	2.500	46.67
	126+	1.23	1.21	1.333	2.222	40.00
	0-20	3.42	3.16	1.176	2.222	47.06
	20-64	3.91	3.33	1.176	2.222	47.06
	64-91	2.56	2.21	1.250	2.500	50.00
F	91-115	2.87	2.42	1.176	2.500	52.94
	115-158	3.55	2.96	1.250	2.500	50.00
	158+	3.86	3.48	1.333	2.222	40.00
	0-32	3.52	4.56	1.250	2.500	50.00
	32-80	2.68	3.29	1.250	2.500	50.00
G	80-101	3.79	3.53	1.250	2.500	50.00
	101-115	1.62	4.22	1.333	2.500	46.67
	115-152	2.58	2.06	1.250	2.500	50.00
	152+	2.30	2.10	1.333	2.500	46.67
	0-29	5.20	5.91	1.176	2.222	47.06
	29-58	5.80	0.64	1.250	2.000	37.50
H	58-73	4.08	4.80	1.250	2.500	50.00
	73-88	1.30	0.56	1.538	2.500	38.46
	88-110	1.86	3.56	1.333	2.222	40.00
	110+	0.67	4.53	1.333	3.333	60.00

Physical properties of Profile samples:

Profile	Depth (cm)	Moisture (%)	LOI (%)	BD (Mg m⁻³)	PD (Mg m⁻³)	TP (%)
	0-25	2.64	2.31	1.176	2.500	52.94
	25-30	3.38	2.23	1.176	2.222	47.06
I	30-46	2.19	1.94	1.250	2.222	43.75
	46-71	1.80	1.98	1.333	2.222	40.00
	71-130	0.90	1.21	1.333	2.500	46.67
	130+	1.31	1.17	1.333	2.500	46.67
	0-23	5.14	3.96	1.176	2.222	47.06
	23-54	4.93	3.95	1.176	2.222	47.06
J	54-72	3.32	1.86	1.250	2.222	43.75
	72-124	1.40	0.41	1.333	2.500	46.67
	124-152	1.61	0.76	1.333	2.500	46.67
	152+	4.98	3.21	1.250	2.222	43.75
	0-26	1.24	0.41	1.176	2.500	52.94
Old Bot	26-43	1.92	0.77	1.176	2.222	47.06
	43-75	2.24	0.77	1.176	2.500	52.94
	75-152	0.28	0.05	1.250	2.500	50.00
	152+	1.53	0.56	1.333	2.222	40.00
Minimum		0.26	0.05	1.176	2.000	37.50
Maximum		7.03	5.91	1.538	3.333	60.00
Mean		2.57	2.24	1.246	2.380	47.37
CV		54.53	64.54	5.778	8.000	9.40

Table 5. Results of the correlation studies with physical properties of profile soils

Properties	LOI	Moisture	B.D	P.D	T.P
LOI	-	0.674 ^{**}	-0.297 [*]	0.139 ^{NS}	0.307 [*]
Moisture	0.674 ^{**}	-	-0.426 ^{**}	-0.272 [*]	0.043 ^{NS}
Bulk density	-0.297 [*]	-0.426 ^{**}	-	0.202 ^{NS}	-0.505 ^{**}
Total porosity	0.307 [*]	0.043 ^{NS}	-0.505 ^{**}	0.734 ^{**}	-
Clay	0.314 [*]	0.428 ^{**}	-0.268 [*]	-0.120 ^{NS}	0.052 ^{NS}
Silt	0.032 ^{NS}	-0.36 ^{NS}	0.219 ^{NS}	-0.074 ^{NS}	-0.201 ^{NS}
Coarse sand	-0.298 [*]	-0.175 ^{NS}	0.063 ^{NS}	-0.149 ^{NS}	-0.164 ^{NS}
Fine sand	0.190 ^{NS}	-0.008 ^{NS}	-0.026 ^{NS}	0.259 [*]	0.244 ^{NS}
CEC	0.585 ^{**}	0.620 ^{**}	-0.069 ^{NS}	-0.015 ^{NS}	0.037 ^{NS}
Acid insoluble	0.058 ^{NS}	-0.274 [*]	0.106 ^{NS}	0.348 ^{**}	0.172 ^{NS}
OC	0.015 ^{NS}	0.079 ^{NS}	-0.418 ^{**}	-0.094 ^{NS}	0.220 ^{NS}
OM	-0.075 ^{NS}	0.055 ^{NS}	-0.386 ^{**}	-0.120 ^{NS}	0.177 ^{NS}

Table 6. Results of Multiple Regression analysis between the soil texture and other soil properties

S.No	Y variables	X	R ²	Regression Equation
1	Moisture	Clay(x ₁),Silt(x ₂), C.Sand(x ₃),F.sand (x ₄)	0.194*	Y= 5.21 + 0.02 ^{NS} - 6.04 ^{NS} - 0.04 ^{NS} - 0.04 ^{NS}
2	LOI		0.180 ^{NS}	Y= -5.92 ^{NS} + 0.11 + 0.09 ^{NS} + 0.07 ^{NS} + 0.08 ^{NS}
3	BD		0.149 ^{NS}	Y= 1.70 - 0.006* -0.002 ^{NS} - 0.005 ^{NS} - 0.005 ^{NS}
4	TP		0.213**	Y= 1.58 + 0.48** + 0.32 ^{NS} + 0.47** + 0.52**
4a	PD		0.129 ^{NS}	Y= 1.11 + 0.01 ^{NS} + 0.01 ^{NS} + 0.01 ^{NS} + 0.02 ^{NS}
5	pH		0.131 ^{NS}	Y= 10.77 - 0.029 ^{NS} - 0.011 ^{NS} - 0.025 ^{NS}
6	EC		0.034 ^{NS}	Y= 1.622 - 0.007 ^{NS} - 0.023 ^{NS} - 0.008 ^{NS} - 0.008 ^{NS}
7	CEC		0.248**	Y= 11.03 + 0.204 ^{NS} + 0.104 ^{NS} -0.085 ^{NS} - 0.032 ^{NS}
8	Exch.Ca		0.104 ^{NS}	Y= 5.11 + 0.010 ^{NS} - 0.003 ^{NS} + 0.003 ^{NS} - 0.005 ^{NS}
9	Exch. Mg		0.098 ^{NS}	Y= 5.23 + 0.061 ^{NS} -0.008 ^{NS} - 0.030 ^{NS} - 0.37 ^{NS}
10	Exch. K		0.077 ^{NS}	Y= 0.066 + 0.002 ^{NS} - 0.004 ^{NS} + 0.002 ^{NS} + 0.001 ^{NS}
11	Exch. Na		0.097 ^{NS}	Y= -0.158 + 0.002 ^{NS} - 0.016 ^{NS} + 0.009 ^{NS} + 0.010 ^{NS}
12	Acid insoluble		0.044 ^{NS}	Y= 15.91 + 0.52 ^{NS} + 0.83 ^{NS} + 0.76 ^{NS} + 0.77 ^{NS}
13	R ₂ O ₃		0.024 ^{NS}	Y= -12.96 + 0.41 ^{NS} + 0.26 ^{NS} + 0.28 ^{NS} + 0.25 ^{NS}
14	O.C		0.146 ^{NS}	Y= 0.198 + 0.005 ^{NS} + 0.001 ^{NS} + 0.002 - 0.001 ^{NS}
15	O.M		0.130 ^{NS}	Y= 1.11 + 0.001 ^{NS} - 0.009 ^{NS} - 0.002 ^{NS} - 0.008 ^{NS}
16	Total N		0.121 ^{NS}	Y= 0.351 + 0.007 ^{NS} + 0.004 ^{NS} + 0.005 ^{NS} + 0.004 ^{NS}
17	Total P		0.104 ^{NS}	Y= 0.023 + 0.001 ^{NS} - 0.0004 ^{NS} + 0.0007 ^{NS} + 0.0009 ^{NS}
18	Total K		0.095 ^{NS}	Y= - 0.129 + 0.003 ^{NS} + 0.003 ^{NS} + 0.002 ^{NS} + 0.002 ^{NS}
19	Avail. N		0.260**	Y= - 69.67 + 1.59* + 0.95 ^{NS} + 0.92 ^{NS} + 0.75 ^{NS}
20	Avail. P		0.093 ^{NS}	Y= 3.72 + 0.11 ^{NS} - 0.05 ^{NS} + 0.19 ^{NS} + 0.08 ^{NS}
21	Avail. K		0.118 ^{NS}	Y= -6.35 + 2.44 ^{NS} + 0.14 ^{NS} + 0.77 ^{NS} + 0.63 ^{NS}
22	Avail. S		0.064 ^{NS}	Y= -0.048 + 0.026 ^{NS} - 0.279 ^{NS} + 0.129 ^{NS} + 0.304 ^{NS}
23	Total Ca		0.060 ^{NS}	Y= -0.592 + 0.011 ^{NS} + 0.809 ^{NS} + 0.009 ^{NS} + 0.010 ^{NS}
24	Total Mg		0.677 ^{NS}	Y= 0.150 + 0.001 ^{NS} + 0.0008 ^{NS} - 0.0007 ^{NS} - 0.0008 ^{NS}
25	Total Na	0.122 ^{NS}	Y= - 0.089 + 0.002 ^{NS} + 0.001 ^{NS} + 0.001 ^{NS} + 0.0002 ^{NS}	

Table 7. Results of the Multiple regression analysis between clay and organic matter and other soil properties

S.No	y variables	X	R ²	Regression Equation
1	Moisture	Clay(x ₁),O.M (x ₂)	0.183*	Y=1.47 + 0.054** - 0.044 ^{NS}
2	LOI	„	0.114*	Y=1.68 + 0.044** - 0.471 ^{NS}
3	BD	„	0.193**	Y=1.32 - 0.001 ^{NS} - 0.065**
4	TP	„	0.032 ^{NS}	Y=45.72 + 0.010 ^{NS} + 1.98 ^{NS}
5	PD	„	0.025 ^{NS}	Y=2.45 - 0.002 ^{NS} - 0.051 ^{NS}
6	pH	„	0.044 ^{NS}	Y=8.61 - 0.006 ^{NS} - 0.076 ^{NS}
7	EC	„	0.259**	Y=0.366 - 0.001 + 0.582**
8	CEC	„	0.189**	Y=7.34 + 0.264** - 1.211 ^{NS}
9	Exch. Ca	„	0.117*	Y=4.31 + 0.093* + 1.144 ^{NS}
10	Exch. Mg	„	0.099*	Y=1.9.9 + 0.087* + 0.611 ^{NS}
11	Exch. K	„	0.207**	Y=0.066 - 0.0001 ^{NS} + 0.033**
12	Exch. Na	„	0.068 ^{NS}	Y=0.361 - 0.007 ^{NS} + 0.300 ^{NS}
13	Acid insoluble	„	0.028 ^{NS}	Y=90.82 - 0.200 ^{NS} - 2.95 ^{NS}
14	R ₂ O ₃	„	0.027 ^{NS}	Y=10.37 + 0.127 ^{NS} + 3.560 ^{NS}
15	O.C	„	0.904**	Y=-0.072 + 0.001 ^{NS} + 0.510**
16	Total N	„	0.400**	Y=-0.030 + 0.002 ^{NS} + 0.166**
17	Total P	„	0.042 ^{NS}	Y=0.038 + 0.0005 ^{NS} + 0.0059 ^{NS}
18	Total K	„	0.115*	Y=0.043 + 0.001 ^{NS} + 0.026 ^{NS}
19	Avail. N	„	0.283**	Y=2.28 + 0.681** + 14.22*
20	Avail. P	„	0.354**	Y=6.003 - 0.109 ^{NS} + 15.30**
21	Avail. K	„	0.234**	Y=22.49 + 1.48* + 54.88**
22	Avail. S	„	0.017 ^{NS}	Y=12.67 - 0.151 ^{NS} + 5.478 ^{NS}
23	Total Ca	„	0.019 ^{NS}	Y=0.294 + 0.001 ^{NS} + 0.028 ^{NS}
24	Total Mg	„	0.129*	Y=0.055 + 0.002 ^{NS} + 0.059*
25	Total Na	„	0.124*	Y=0.038 + 0.007* + 0.015 ^{NS}

Table 8. Textural analysis of the profile soil samples of PAJANCOA and RI Horticultural farm soils

Profile	Depth (cm)	Clay (%)	Silt (%)	Coarse Sand (%)	Fine Sand (%)	Texture
	0-20	27.65	8.50	51.11	8.80	scl
	20-49	21.90	6.75	49.15	14.66	scl
A	49-70	15.90	2.50	53.80	19.85	scl
	70-138	16.15	7.25	59.25	16.10	scl
	138+	23.65	2.50	14.45	58.20	scl
Minimum		15.90	2.50	14.45	8.80	
Maximum		27.65	8.50	59.25	58.20	
Mean		21.05	5.50	45.55	23.52	
CV		23.94	51.12	39.07	84.12	
	0-10	16.15	2.75	63.95	14.16	scl
	10-41	13.15	6.25	66.16	12.99	scl
B	41-84	28.65	2.75	9.45	54.80	scl
	84-122	26.15	1.25	61.65	7.70	scl
	122-151	15.15	19.25	13.05	47.05	scl
	151+	15.90	2.50	60.57	15.25	scl
Minimum		13.15	1.25	9.45	7.70	
Maximum		28.65	19.25	66.16	54.80	
Mean		19.19	5.79	45.81	25.32	
CV		33.83	117.44	58.64	79.56	
	0-21	13.65	4.50	15.96	63.46	scl
	21-42	15.15	2.25	15.27	65.71	scl
C	42-65	2.65	12.50	11.81	66.97	ls
	65-84	11.15	2.75	59.91	19.51	scl
	84-150	13.65	2.25	66.15	17.75	scl
	150+	13.40	5.00	58.06	14.66	scl
Minimum		2.65	2.25	11.81	14.66	
Maximum		15.15	12.50	66.15	66.97	
Mean		11.61	4.87	37.86	41.34	
CV		39.39	80.29	68.51	63.86	
	0-25	30.15	6.25	50.96	7.66	scl
	25-44	26.15	8.75	51.55	9.04	scl
D	44-71	2.90	1.25	10.91	81.75	s
	71-129	15.40	2.50	13.42	65.71	sl
	129+	15.15	6.75	59.74	12.90	scl
Minimum		2.90	1.25	10.91	7.66	
Maximum		30.15	8.75	59.74	81.75	
Mean		17.95	5.10	37.31	35.41	
CV		59.54	61.19	62.28	100.21	

Table 8. contd.,

Profile	Depth (cm)	Clay (%)	Silt (%)	Coarse Sand (%)	Fine Sand (%)	Texture
	0-20	16.15	2.75	65.56	14.46	scl
	20-71	13.65	6.75	66.15	12.32	scl
E	71-118	28.40	18.25	10.96	40.04	scl
	118-126	15.40	5.25	61.65	7.06	scl
	126+	15.15	19.25	13.05	47.10	scl
Minimum		13.65	2.75	10.96	7.06	
Maximum		28.40	19.25	66.15	47.10	
Mean		17.75	10.45	43.47	24.19	
CV		33.93	73.86	66.22	74.66	
	0-20	51.15	9.25	30.13	6.02	c
	20-64	28.40	2.25	8.03	55.17	scl
	64-91	26.40	1.50	9.05	60.37	scl
F	91-115	25.65	1.75	9.25	60.75	scl
	115-158	24.15	2.25	7.83	61.40	scl
	158+	22.15	1.25	10.69	46.41	scl
Minimum		22.15	1.25	7.83	6.02	
Maximum		51.15	9.25	30.13	61.40	
Mean		29.65	3.04	12.50	48.35	
CV		36.23	100.85	69.60	44.46	
	0-32	32.90	5.75	5.24	52.43	scl
	32-80	29.15	5.25	6.02	55.86	scl
G	80-101	40.15	8.75	6.79	42.19	scl
	101-115	15.40	5.75	70.41	7.88	sl
	115-152	34.65	6.50	6.61	49.76	scl
	152+	7.90	24.75	9.16	47.08	scl
Minimum		7.90	5.25	5.24	7.88	
Maximum		40.15	24.75	70.41	55.86	
Mean		26.69	9.46	17.37	42.53	
CV		46.48	80.28	149.74	41.39	
	0-29	52.90	9.50	30.11	6.43	c
	29-58	49.15	4.25	36.50	2.84	c
H	58-73	4.65	11.75	15.26	64.21	ls
	73-88	8.65	5.25	70.32	10.45	ls
	88-110	34.90	6.75	6.04	49.52	scl
	110+	23.90	2.75	12.46	60.52	scl
Minimum		4.65	2.75	6.04	2.84	
Maximum		52.90	11.75	70.32	64.21	
Mean		29.03	6.71	28.45	32.33	
CV		69.68	50.35	82.48	88.84	

Table 8. contd.,

Profile	Depth (cm)	Clay (%)	Silt (%)	Coarse Sand (%)	Fine Sand (%)	Texture
	0-25	12.40	4.25	15.76	64.25	scl
	25-30	15.65	2.75	14.55	65.09	scl
I	30-46	2.40	12.75	11.13	66.11	scl
	46-71	13.15	5.75	66.02	11.55	ls
	71-130	8.15	29.35	9.85	50.56	scl
	130+	25.90	9.62	12.21	50.18	scl
Minimum		2.40	2.75	9.85	11.55	
Maximum		25.90	29.35	66.02	66.11	
CV		24.83	37.32	41.37	16.54	
Mean		12.94	10.75	21.59	51.29	
CV		60.81	91.41	101.34	40.52	
	0-23	30.40	9.50	35.35	21.95	scl
	23-54	28.65	7.75	49.60	12.55	scl
J	54-72	15.90	5.25	70.86	6.79	scl
	72-124	8.15	4.25	71.80	10.35	ls
	124-152	15.65	6.75	60.61	12.65	scl
	152+	24.40	1.75	8.87	60.95	scl
Minimum		8.15	1.75	8.87	6.79	
Maximum		30.40	9.50	71.80	60.95	
Mean		20.52	5.87	49.51	20.87	
CV		42.30	46.60	48.88	97.08	
	0-26	13.65	2.75	68.10	10.97	ls
Old Bot	26-43	14.15	3.50	67.05	10.91	ls
	43-75	31.65	1.75	8.90	51.25	sc
	75-152	28.90	1.25	7.72	58.70	scl
	152+	15.40	5.75	63.86	10.91	scl
Minimum		13.65	1.25	7.72	10.91	
Maximum		31.65	5.75	68.10	58.70	
Mean		20.75	3.00	43.13	28.55	
CV		42.28	58.93	73.79	85.02	

Descriptive statistics for overall textural properties of PAJANCOA and RI Horticultural farm Profile soils

	Clay (%)	Silt (%)	Coarse Sand (%)	Fine Sand (%)
Minimum	2.40	1.25	5.24	2.84
Maximum	52.90	29.35	71.80	81.75
Mean	20.73	6.44	34.29	34.37
CV	53.38	87.79	73.83	69.15

Textural Analysis of Profile sample:

Profile	Depth (cm)	Clay (%)	Silt (%)	Coarse Sa (%)	Fine Sa (%)	Texture
	0-20	27.65	8.50	51.11	8.80	scl
	20-49	21.90	6.75	49.15	14.66	scl
A	49-70	15.90	2.50	53.80	19.85	scl
	70-138	16.15	7.25	59.25	16.10	scl
	138+	23.65	2.50	14.45	58.20	scl
	0-10	16.15	2.75	63.95	14.16	scl
	10-41	13.15	6.25	66.16	12.99	scl
B	41-84	28.65	2.75	9.45	54.80	scl
	84-122	26.15	1.25	61.65	7.70	scl
	122-151	15.15	19.25	13.05	47.05	scl
	151+	15.90	2.50	60.57	15.25	scl
	0-21	13.65	4.50	15.96	63.46	scl
	21-42	15.15	2.25	15.27	65.71	scl
C	42-65	2.65	12.50	11.81	66.97	ls
	65-84	11.15	2.75	59.91	19.51	scl
	84-150	13.65	2.25	66.15	17.75	scl
	150+	13.40	5.00	58.06	14.66	scl
	0-25	30.15	6.25	50.96	7.66	scl
	25-44	26.15	8.75	51.55	9.04	scl
D	44-71	2.90	1.25	10.91	81.75	s
	71-129	15.40	2.50	13.42	65.71	sl
	129+	15.15	6.75	59.74	12.90	scl
	0-20	16.15	2.75	65.56	14.46	scl
	20-71	13.65	6.75	66.15	12.32	scl
E	71-118	28.40	18.25	10.96	40.04	scl
	118-126	15.40	5.25	61.65	7.06	scl
	126+	15.15	19.25	13.05	47.10	scl
	0-20	51.15	9.25	30.13	6.02	c
	20-64	28.40	2.25	8.03	55.17	scl
	64-91	26.40	1.50	9.05	60.37	scl
F	91-115	25.65	1.75	9.25	60.75	scl
	115-158	24.15	2.25	7.83	61.40	scl
	158+	22.15	1.25	10.69	46.41	scl
	0-32	32.90	5.75	5.24	52.43	scl
	32-80	29.15	5.25	6.02	55.86	scl
G	80-101	40.15	8.75	6.79	42.19	scl
	101-115	15.40	5.75	70.41	7.88	sl
	115-152	34.65	6.50	6.61	49.76	scl
	152+	7.90	24.75	9.16	47.08	scl
	0-29	52.90	9.50	30.11	6.43	c
	29-58	49.15	4.25	36.50	2.84	c
H	58-73	4.65	11.75	15.26	64.21	ls
	73-88	8.65	5.25	70.32	10.45	ls
	88-110	34.90	6.75	6.04	49.52	scl
	110+	23.90	2.75	12.46	60.52	scl

Textural Analysis of Profile sample:

Profile	Depth (cm)	Clay (%)	Silt (%)	Coarse Sa (%)	Fine Sa (%)	Texture
	0-25	12.40	4.25	15.76	64.25	scl
	25-30	15.65	2.75	14.55	65.09	scl
I	30-46	2.40	12.75	11.13	66.11	scl
	46-71	13.15	5.75	66.02	11.55	ls
	71-130	8.15	29.35	9.85	50.56	scl
	130+	25.90	9.62	12.21	50.18	scl
	0-23	30.40	9.50	35.35	21.95	scl
	23-54	28.65	7.75	49.60	12.55	scl
J	54-72	15.90	5.25	70.86	6.79	scl
	72-124	8.15	4.25	71.80	10.35	ls
	124-152	15.65	6.75	60.61	12.65	scl
	152+	24.40	1.75	8.87	60.95	scl
	0-26	13.65	2.75	68.10	10.97	ls
Old Bot	26-43	14.15	3.50	67.05	10.91	ls
	43-75	31.65	1.75	8.90	51.25	sc
	75-152	28.90	1.25	7.72	58.70	scl
	152+	15.40	5.75	63.86	10.91	scl
Minimum		2.40	1.25	5.24	2.84	
Maximum		52.90	29.35	71.80	81.75	
Mean		20.73	6.44	34.29	34.37	
CV		53.38	87.79	73.83	69.15	

Table 9. Results of the correlation studies with soil separates of profile soils

Properties	Clay	Silt	CS	FS
LOI	0.314 [*]	0.032 ^{NS}	-0.298 [*]	0.190 ^{NS}
Moisture	0.428 ^{**}	-0.036 ^{NS}	-0.175 ^{NS}	-0.008 ^{NS}
Bulk density	-0.268 [*]	0.219 ^{NS}	0.063 ^{NS}	-0.026 ^{NS}
Total porosity	0.052 ^{NS}	-0.201 ^{NS}	-0.164 ^{NS}	0.244 ^{NS}
Silt	-0.133 ^{NS}	-	-0.213 ^{NS}	0.44 ^{NS}
Coarse sand	-0.263 [*]	-0.213 ^{NS}	-	-0.886 ^{**}
Fine sand	-0.136 ^{NS}	0.044 ^{NS}	-0.886 ^{**}	-
pH	-0.192 ^{NS}	0.234 ^{NS}	0.053 ^{NS}	-0.055 ^{NS}
CEC	0.429 ^{**}	0.107 ^{NS}	-0.331 ^{**}	0.130 ^{NS}
Exch. Ca	0.318 [*]	-0.053 ^{NS}	-0.028 ^{NS}	-0.100 ^{NS}
Exch. Mg	0.306 [*]	-0.004 ^{NS}	-0.047 ^{NS}	-0.090 ^{NS}
Exch. Na	-0.124 ^{NS}	-0.256 ^{NS}	0.068 ^{NS}	0.053 ^{NS}
Exch. K	0.061 ^{NS}	-0.264 ^{NS}	0.116 ^{NS}	-0.081 ^{NS}
R₂O₃	0.127 ^{NS}	-0.030 ^{NS}	0.029 ^{NS}	-0.072 ^{NS}
Total N	0.259 [*]	-0.112 ^{NS}	0.125 ^{NS}	-0.205 ^{NS}
Total P	0.192 ^{NS}	-0.209 ^{NS}	-0.151 ^{NS}	0.135 ^{NS}
Total K	0.276 ^{NS}	0.014 ^{NS}	-0.025 ^{NS}	-0.085 ^{NS}
Total Na	0.287 [*]	-0.052 ^{NS}	-0.175 ^{NS}	0.090 ^{NS}
Total Ca	0.113 ^{NS}	-0.025 ^{NS}	-0.056 ^{NS}	0.042 ^{NS}
Total Mg	0.259 [*]	0.058 ^{NS}	-0.066 ^{NS}	-0.063 ^{NS}
Available N	0.446 ^{**}	-0.060 ^{NS}	0.083 ^{NS}	-0.256 ^{NS}
Available P	-0.027 ^{NS}	-0.141 ^{NS}	0.292 [*]	-0.258 [*]
Available K	0.330 ^{**}	-0.105 ^{NS}	-0.015 ^{NS}	-0.10 ^{NS}
Available S	-0.069 ^{NS}	-0.103 ^{NS}	-0.149 ^{NS}	0.219 ^{NS}

Table 10. The acid insolubles, sesquioxides, organic carbon and organic matter content of the profile soil samples of PAJANCOA and RI Horticultural farm

Block	Field No	Acid insoluble (%)	R ₂ O ₃ (%)	OC (g kg ⁻¹)	OM(%)
	0-20	89.27	8.70	5.48	0.945
	20-49	87.93	12.59	4.33	1.082
A	49-70	90.15	12.05	5.77	1.442
	70-138	91.60	18.28	4.33	1.082
	138+	92.03	7.13	2.88	0.721
Minimum		87.93	7.13	2.88	0.721
Maximum		92.03	18.28	5.77	1.442
Mean		90.20	11.75	4.56	1.054
CV		1.866	36.64	25.08	24.87
	0-10	87.54	11.73	10.38	1.790
	10-41	89.32	11.23	2.31	0.577
B	41-84	88.34	13.96	0.58	0.144
	84-122	88.11	14.63	3.17	0.793
	122-151	94.65	16.69	3.75	0.938
	151+	95.42	14.88	3.46	0.865
Minimum		87.54	11.23	0.58	0.144
Maximum		95.42	16.69	10.38	1.790
Mean		90.56	13.85	3.94	0.851
CV		3.887	14.84	85.16	63.65
	0-21	86.79	12.85	1.73	0.298
	21-42	87.90	9.80	1.73	0.433
C	42-65	92.20	8.65	3.17	0.793
	65-84	92.94	7.63	6.06	1.514
	84-150	93.31	7.12	2.60	0.649
	150+	94.51	9.11	1.73	0.433
Minimum		86.79	7.12	1.73	0.298
Maximum		94.51	12.85	6.06	1.514
Mean		91.27	9.19	2.84	0.687
CV		3.45	22.17	59.44	64.39
	0-25	90.79	17.08	8.94	1.542
	25-44	81.70	8.83	5.48	1.370
D	44-71	89.33	18.82	3.75	0.938
	71-129	88.29	11.05	2.02	0.505
	129+	90.81	7.02	3.17	0.793
Minimum		81.70	7.02	2.02	0.505
Maximum		90.81	18.82	8.94	1.542
Mean		88.18	12.56	4.67	1.029
CV		4.28	41.09	57.64	41.15

soils

Table 10. contd.,

Block	Field No	Acid insoluble (%)	R ₂ O ₃ (%)	OC (g kg ⁻¹)	OM(%)
	0-20	84.22	16.04	8.37	1.442
	20-71	85.45	10.37	2.02	0.505
E	71-118	87.59	17.18	1.44	0.361
	118-126	91.28	13.55	2.02	0.505
	126+	94.72	7.59	1.44	0.361
Minimum		84.22	7.59	1.44	0.361
Maximum		94.72	17.18	8.37	1.442
Mean		88.65	12.95	3.06	0.635
CV		4.873	30.69	97.49	72.04
	0-20	86.04	14.71	7.50	1.293
	20-64	88.89	6.24	0.87	0.216
	64-91	86.91	2.57	3.17	0.793
F	91-115	81.71	19.86	3.17	0.793
	115-158	86.41	15.55	1.73	0.433
	158+	85.57	10.28	1.73	0.433
Minimum		81.71	2.57	0.87	0.216
Maximum		88.89	19.86	7.50	1.293
Mean		85.92	11.54	3.03	0.660
CV		2.75	55.58	78.25	58.13
	0-32	84.94	11.40	7.79	1.343
	32-80	82.40	12.33	4.33	1.082
G	80-101	88.46	12.99	3.75	0.938
	101-115	94.48	8.64	2.60	0.649
	115-152	87.68	2.57	3.17	0.793
	152+	91.25	8.19	2.02	0.505
Minimum		82.40	2.57	2.02	0.505
Maximum		94.48	12.99	7.79	1.343
Mean		88.20	9.35	3.94	0.885
CV		4.90	41.19	52.08	34.26
	0-29	87.64	2.64	4.62	0.796
	29-58	83.70	18.05	4.33	1.082
H	58-73	84.34	2.61	2.60	0.649
	73-88	86.19	13.19	2.02	0.505
	88-110	97.10	8.66	0.29	0.072
	110+	81.60	4.12	0.29	0.072
Minimum		81.60	2.61	0.29	0.072
Maximum		97.10	18.05	4.62	1.082
Mean		86.76	8.21	2.36	0.529
CV		6.31	77.20	79.89	76.01

Table 10. contd.,

Block	Field No	Acid insoluble (%)	R ₂ O ₃ (%)	OC (g kg ⁻¹)	OM(%)
	0-25	84.89	11.50	5.19	0.895
	25-30	87.87	15.53	1.73	0.433
I	30-46	92.47	8.69	1.73	0.433
	46-71	92.87	10.18	2.31	0.577
	71-130	88.47	12.11	2.02	0.505
	130+	95.04	11.00	2.02	0.505
	Minimum		84.89	8.69	1.73
Maximum		95.04	15.53	5.19	0.895
Mean		90.27	11.50	2.50	0.558
CV		4.21	20.00	53.46	31.162
	0-23	90.12	17.39	2.60	0.448
	23-54	83.31	17.36	2.90	0.721
J	54-72	86.39	8.79	1.40	0.361
	72-124	88.26	7.1	1.40	0.361
	124-152	92.54	13.72	0.90	0.216
	152+	84.52	6.31	0.60	0.144
	Minimum		83.31	6.31	0.60
Maximum		92.54	17.39	2.90	0.721
Mean		87.52	11.78	1.63	0.375
CV		3.97	42.81	57.64	53.874
	0-26	93.15	8.70	4.90	0.845
Old Bot	26-43	92.94	12.39	4.33	1.082
	43-75	89.97	2.05	3.75	0.938
	75-152	90.91	18.28	3.46	0.865
	152+	92.87	7.13	2.88	0.721
	Minimum		89.97	2.05	2.88
Maximum		93.15	18.28	4.90	1.082
Mean		91.97	9.71	3.87	0.890
CV		1.57	62.43	20.16	14.872

Descriptive statistics for overall the acid insoluble, sesquioxides, organic carbon and organic matter content of PAJANCOA and RI, Horticultural farm profile soils

	Acid insoluble (%)	R ₂ O ₃ (%)	OC (g kg ⁻¹)	OM(%)
Minimum	81.60	2.05	0.29	0.072
Maximum	97.10	19.86	10.38	1.790
Mean	89.00	11.09	3.26	0.731
CV	15.24	40.78	65.05	53.427

Table 11. Results of the correlation studies with major nutrients

Properties	Total N	Total P	Total K	Avail N	Avail P	Avail K
LOI	0.328 ^{**}	0.207 [*]	0.472 ^{**}	0.353 ^{**}	-0.049 ^{NS}	0.553 ^{**}
Moisture	0.302 [*]	0.061 ^{NS}	0.651 ^{**}	0.386 ^{**}	-0.116 ^{NS}	0.604 ^{**}
Bulk density	-0.509 ^{**}	-0.156 ^{NS}	-0.482 ^{**}	-0.372 ^{**}	-0.306 [*]	-0.456 ^{**}
Total porosity	0.297 [*]	0.323 [*]	0.050 ^{NS}	0.027 ^{NS}	0.260 [*]	0.219 ^{NS}
Percent clay	0.259 [*]	0.192 ^{NS}	0.276 [*]	0.446 ^{**}	-0.027 ^{NS}	0.330 [*]
Percent silt	-0.112 ^{NS}	-0.209 ^{NS}	0.014 ^{NS}	-0.606 ^{NS}	-0.141 ^{NS}	-0.106 ^{NS}
Coarse sand	0.125 ^{NS}	-0.151 ^{NS}	-0.025 ^{NS}	0.083 ^{NS}	0.292 [*]	-0.015 ^{NS}
Fine sand	-0.205 ^{NS}	0.135 ^{NS}	-0.085 ^{NS}	-0.256 ^{NS}	-0.258 [*]	0.101 ^{NS}
pH	0.609 ^{**}	-0.388 ^{**}	-0.479 ^{**}	-0.508 ^{**}	-0.214 ^{NS}	-0.562 ^{**}
CEC	0.184 ^{NS}	0.250 ^{NS}	0.376 ^{**}	0.281 [*]	-0.272 [*]	0.468 ^{**}
Ex. Ca	0.391 ^{**}	0.094 ^{NS}	0.587 ^{**}	0.451 ^{**}	0.051 ^{NS}	0.614 ^{**}
Ex. Mg	0.294 [*]	0.289 [*]	0.459 ^{**}	0.363 ^{**}	0.019 ^{NS}	0.484 ^{**}
Ex. Na	-0.009 ^{NS}	-0.124 ^{NS}	-0.162 ^{NS}	-0.123 ^{NS}	0.225 ^{NS}	-0.128 ^{NS}
Ex. K	0.495 ^{**}	0.004 ^{NS}	0.253 ^{NS}	0.339 ^{**}	0.616 ^{**}	0.444 ^{**}
Acid insoluble	0.071 ^{NS}	0.164 ^{NS}	0.077 ^{NS}	0.030 ^{NS}	0.075 ^{NS}	-0.191 ^{NS}
OC	0.786 ^{**}	0.175 ^{NS}	0.331 ^{NS}	0.479 ^{**}	0.706 ^{**}	0.564 ^{**}
R₂O₃	0.248 ^{NS}	-0.030 ^{NS}	0.171 ^{NS}	0.093 ^{NS}	0.139 ^{NS}	0.133 ^{NS}
OM	0.610 ^{**}	0.101 ^{NS}	0.238 ^{NS}	0.357 ^{**}	0.583 ^{**}	0.401 ^{**}
Total N	-	0.284 [*]	0.630 ^{**}	0.696 ^{**}	0.692 ^{**}	0.789 ^{**}
Total P	0.284 [*]	-	0.098 ^{NS}	0.357 ^{**}	0.089 ^{NS}	0.212 ^{NS}
Total K	0.630 ^{**}	0.098 ^{NS}	-	0.576 ^{**}	0.177 ^{NS}	0.631 ^{**}
Total Na	0.499 ^{**}	0.074 ^{NS}	0.712 ^{**}	0.407 ^{**}	0.104 ^{NS}	0.464 ^{**}
Available N	0.696 ^{**}	0.357 ^{**}	0.576 ^{**}	-	0.368 ^{**}	0.639 ^{**}
Available P	0.692 ^{**}	0.089 ^{NS}	0.177 ^{NS}	0.368 ^{**}	-	0.494 ^{**}
Available K	0.789 ^{**}	0.212 ^{NS}	0.631 ^{**}	0.639 ^{**}	0.494 ^{**}	-
Available S	0.234 ^{NS}	0.596 ^{**}	0.193 ^{NS}	0.171 ^{NS}	0.029 ^{NS}	0.242 ^{NS}

Table 12. pH, EC, and exchange properties of the profile soil samples of the PAJANCOA and RI Horticultural farm soils

Profile	Depth (cm)	pH	ECe (dS m ⁻¹)	CEC (cmol (p ⁺) kg ha ⁻¹)	Exchangeable cations (cmol (p ⁺) kg ⁻¹)			
					Ca ²⁺	Mg ²⁺	K ⁺	Na ⁺
	0-20	8.02	0.64	7.30	7.00	4.50	0.35	0.69
	20-49	8.77	1.08	20.00	23.50	14.00	0.47	0.79
A	49-70	8.63	1.12	7.80	7.00	3.00	0.27	0.81
	70-138	8.85	0.73	5.30	5.00	1.50	0.27	0.76
	138+	8.16	0.81	4.30	6.00	1.00	0.42	0.79
Minimum		8.02	0.64	4.30	5.00	1.00	0.27	0.69
Maximum		8.85	1.12	20.00	23.50	14.00	0.47	0.81
Mean		8.49	0.88	8.94	9.70	4.80	0.35	0.77
CV		4.40	24.38	70.99	79.99	110.88	25.02	5.97
	0-10	7.84	2.04	10.00	9.00	3.50	0.46	1.10
	10-41	8.92	1.23	9.30	7.50	4.50	0.22	1.12
B	41-84	8.4	0.28	8.60	9.50	1.00	0.26	0.81
	84-122	8.93	0.78	3.50	4.50	1.50	0.23	0.84
	122-151	8.98	0.73	4.60	4.00	2.50	0.28	0.76
	151+	8.82	0.78	5.10	5.00	1.00	0.28	0.91
Minimum		7.84	0.28	3.50	4.00	1.00	0.22	0.76
Maximum		8.98	2.04	10.00	9.50	4.50	0.46	1.12
Mean		8.65	0.97	6.85	6.58	2.33	0.29	0.92
CV		5.19	61.96	40.42	36.40	61.61	29.91	16.49
	0-21	8.26	1.08	10.70	10.00	5.50	0.38	0.74
	21-42	8.11	0.72	8.90	9.50	4.50	0.29	0.86
C	42-65	8.48	0.47	5.60	5.50	1.00	0.27	1.00
	65-84	8.32	0.98	5.30	5.50	1.50	0.28	1.12
	84-150	8.45	0.63	4.20	5.00	1.50	0.25	0.60
	150+	8.62	0.95	3.00	3.50	1.00	0.26	0.64
Minimum		8.11	0.47	3.00	3.50	1.00	0.25	0.60
Maximum		8.62	1.08	10.70	10.00	5.50	0.38	1.12
Mean		8.37	0.81	6.28	6.50	2.50	0.29	0.83
CV		2.16	29.26	46.62	40.41	78.99	16.43	24.93

Table 12. contd.,

Profile	Depth (cm)	pH	EC (dS m ⁻¹)	CEC (cmol (p ⁺) kg ha ⁻¹)	Exchangeable cations (cmol (p ⁺) kg ⁻¹)			
					Ca ²⁺	Mg ²⁺	K ⁺	Na ⁺
	0-25	8.42	1.04	6.70	5.50	3.00	0.18	0.09
	25-44	8.74	1.27	11.00	6.50	5.50	0.11	0.10
D	44-71	8.52	0.82	9.20	6.50	3.50	0.13	0.10
	71-129	8.11	1.73	10.30	7.00	4.00	0.20	1.19
	129+	8.68	0.97	11.10	3.50	16.50	0.04	0.12
Minimum		8.11	0.82	6.7	3.50	3.00	0.04	0.09
Maximum		8.74	1.73	11.1	7.00	16.50	0.20	1.19
Mean		8.49	1.17	9.66	5.80	6.50	0.13	0.32
CV		2.94	30.41	18.84	24.08	87.20	47.88	152.36
	0-20	7.83	1.85	12.10	9.50	6.00	0.24	0.13
	20-71	8.58	0.74	12.20	10.00	6.00	0.10	0.13
E	71-118	8.77	0.76	11.60	9.50	5.00	0.05	0.11
	118-126	8.91	0.68	2.20	3.00	0.00	0.02	0.09
	126+	8.85	0.69	4.40	4.00	2.50	0.04	0.09
Minimum		7.83	0.68	2.20	3.00	0.00	0.02	0.09
Maximum		8.91	1.85	12.20	10.00	6.00	0.24	0.13
Mean		8.59	0.94	8.50	7.20	3.90	0.09	0.11
CV		5.14	53.77	56.65	47.25	66.86	98.07	17.58
	0-20	7.81	1.55	25.70	9.00	6.00	0.17	0.12
	20-64	8.13	1.5	18.80	6.00	8.00	0.07	0.12
	64-91	8.43	1.47	18.50	6.50	3.50	0.07	0.13
F	91-115	8.5	1.44	6.20	6.50	3.50	0.16	3.11
	115-158	8.48	0.82	19.90	6.50	8.00	0.12	0.11
	158+	8.61	0.84	15.40	8.00	5.00	0.13	0.13
Minimum		7.81	0.82	6.20	6.00	3.50	0.07	0.11
Maximum		8.61	1.55	25.70	9.00	8.00	0.17	3.11
Mean		8.33	1.27	17.42	7.08	5.67	0.12	0.62
CV		3.60	26.99	37.01	16.35	36.02	35.32	196.21

Table 12. contd.,

Profile	Depth (cm)	pH	EC (dS m ⁻¹)	CEC (c mol (p ⁺) kg ha ⁻¹)	Exchangeable cations (cmol (p ⁺) kg ⁻¹)			
					Ca+	Mg+	K+	Na+
	0-32	7.68	1.77	17.30	7.00	8.50	0.29	0.11
	32-80	8.59	0.63	31.70	8.50	6.50	0.12	0.12
G	80-101	8.82	0.72	26.30	7.50	3.50	0.10	0.14
	101-115	8.11	0.15	11.70	8.00	0.00	0.05	0.13
	115-152	8.87	0.74	18.90	5.50	3.00	0.21	0.08
	152+	8.95	0.77	21.20	5.00	3.50	0.10	0.08
Minimum		7.68	0.15	11.70	5.00	0.00	0.05	0.08
Maximum		8.95	1.77	31.70	8.50	8.50	0.29	0.14
Mean		8.50	0.80	21.18	6.92	4.17	0.14	0.11
CV		5.94	66.49	33.18	20.15	71.06	61.82	22.46
	0-29	7.84	0.24	21.20	15.00	10.00	0.34	0.11
	29-58	8.31	0.21	21.90	15.00	9.00	0.13	0.11
H	58-73	8.47	0.18	22.00	11.00	6.50	0.13	0.11
	73-88	8.43	0.16	11.00	3.00	1.00	0.03	0.10
	88-110	8.23	0.15	13.60	3.50	2.50	0.05	0.11
	110+	8.62	0.18	9.80	2.00	3.00	0.04	0.09
Minimum		7.84	0.15	9.80	2.00	1.00	0.03	0.09
Maximum		8.62	0.24	22.00	15.00	10.00	0.34	0.11
Mean		8.32	0.19	16.58	8.25	5.33	0.12	0.11
CV		3.24	17.82	34.64	74.30	69.57	97.30	6.40
	0-25	7.62	0.54	18.90	8.00	8.00	0.22	0.10
	25-30	8.18	0.43	16.60	8.50	4.50	0.12	0.11
I	30-46	8.12	0.51	11.20	7.50	0.00	0.06	0.10
	46-71	8.53	0.58	11.40	5.50	3.00	0.07	0.10
	71-130	8.65	0.52	9.50	3.50	2.50	0.04	0.10
	130+	8.68	0.58	12.20	5.00	0.50	0.05	0.10
Minimum		7.62	0.43	9.50	3.50	0.00	0.04	0.10
Maximum		8.68	0.58	18.90	8.50	8.00	0.22	0.11
Mean		8.30	0.53	13.30	6.33	3.08	0.09	0.10
CV		4.91	10.58	27.30	31.05	94.79	70.94	4.22

Table 12. contd.,

Profile	Depth (cm)	pH	EC (dS m ⁻¹)	CEC (cmol (p ⁺) kg ha ⁻¹)	Exchangeable cations (cmol (p ⁺) kg ⁻¹)			
					Ca ²⁺	Mg ²⁺	K ⁺	Na ⁺
	0-23	7.54	0.38	16.40	12.50	8.50	0.19	0.09
	23-54	8.43	0.32	17.00	10.50	7.00	0.11	0.12
J	54-72	8.47	0.32	16.00	8.50	7.00	0.10	0.14
	72-124	8.39	0.43	12.80	3.50	1.50	0.04	0.13
	124-152	8.36	0.43	13.20	4.00	3.50	0.09	0.11
	152+	8.21	0.46	13.90	8.50	5.00	0.19	0.10
Minimum		7.54	0.32	12.80	3.50	1.50	0.04	0.09
Maximum		8.47	0.46	17.00	12.50	8.50	0.19	0.14
Mean		8.23	0.39	14.88	7.92	5.42	0.12	0.11
CV		4.26	15.38	12.08	44.91	47.93	48.68	14.47
	0-26	8.12	0.64	4.30	6.50	0.50	0.35	0.76
Old Bot	26-43	8.64	0.47	5.70	6.00	4.50	0.25	0.81
	43-75	8.71	0.66	7.70	6.00	3.00	0.24	0.69
	75-152	8.74	0.63	4.10	3.50	0.00	0.23	0.76
	152+	8.85	0.68	5.90	5.00	2.50	0.24	0.72
Minimum		8.12	0.47	4.10	3.50	0.00	0.23	0.69
Maximum		8.85	0.68	7.70	6.50	4.50	0.35	0.81
Mean		8.61	0.62	1.45	5.40	2.10	0.26	0.75
CV		3.31	13.61	26.21	22.11	88.13	17.92	6.21

Statistics for overall pH, EC and exchange properties of PAJANCOA and RI Horticultural farm profile soils

	pH	EC (dS m ⁻¹)	CEC (cmol (p ⁺) kg ha ⁻¹)	Exchangeable cations (cmol (p ⁺) kg ⁻¹)			
				Ca ²⁺	Mg ²⁺	K ⁺	Na ⁺
Minimum	7.54	0.15	2.20	2.00	0.00	0.02	0.08
Maximum	8.98	2.04	31.70	23.50	16.50	0.47	3.11
Mean	8.44	0.77	11.97	7.06	4.15	0.18	0.43
CV	4.23	57.66	54.81	48.86	78.49	62.72	117.70

pH,EC and Exchangable properties of Profile samples:

Profile	Depth (cm)	pH	EC (ds m ⁻¹)	CEC	Exchangable cations [c mol (p+) kg ⁻¹]			
					Ca ²⁺	Mg ²⁺	K ⁺	Na ⁺
	0-20	8.02	0.64	7.30	7.00	4.50	0.35	0.69
	20-49	8.77	1.08	20.00	23.50	14.00	0.47	0.79
A	49-70	8.63	1.12	7.80	7.00	3.00	0.27	0.81
	70-138	8.85	0.73	5.30	5.00	1.50	0.27	0.76
	138+	8.16	0.81	4.30	6.00	1.00	0.42	0.79
	0-10	7.84	2.04	10.00	9.00	3.50	0.46	1.10
	10-41	8.92	1.23	9.30	7.50	4.50	0.22	1.12
B	41-84	8.4	0.28	8.60	9.50	1.00	0.26	0.81
	84-122	8.93	0.78	3.50	4.50	1.50	0.23	0.84
	122-151	8.98	0.73	4.60	4.00	2.50	0.28	0.76
	151+	8.82	0.78	5.10	5.00	1.00	0.28	0.91
	0-21	8.26	1.08	10.70	10.00	5.50	0.38	0.74
	21-42	8.11	0.72	8.90	9.50	4.50	0.29	0.86
C	42-65	8.48	0.47	5.60	5.50	1.00	0.27	1.00
	65-84	8.32	0.98	5.30	5.50	1.50	0.28	1.12
	84-150	8.45	0.63	4.20	5.00	1.50	0.25	0.60
	150+	8.62	0.95	3.00	3.50	1.00	0.26	0.64
	0-25	8.42	1.04	6.70	5.50	3.00	0.18	0.09
	25-44	8.74	1.27	11.00	6.50	5.50	0.11	0.10
D	44-71	8.52	0.82	9.20	6.50	3.50	0.13	0.10
	71-129	8.11	1.73	10.30	7.00	4.00	0.20	1.19
	129+	8.68	0.97	11.10	3.50	16.50	0.04	0.12
	0-20	7.83	1.85	12.10	9.50	6.00	0.24	0.13
	20-71	8.58	0.74	12.20	10.00	6.00	0.10	0.13
E	71-118	8.77	0.76	11.60	9.50	5.00	0.05	0.11
	118-126	8.91	0.68	2.20	3.00	0.00	0.02	0.09
	126+	8.85	0.69	4.40	4.00	2.50	0.04	0.09
	0-20	7.81	1.55	25.70	9.00	6.00	0.17	0.12
	20-64	8.13	1.5	18.80	6.00	8.00	0.07	0.12
	64-91	8.43	1.47	18.50	6.50	3.50	0.07	0.13
F	91-115	8.5	1.44	6.20	6.50	3.50	0.16	3.11
	115-158	8.48	0.82	19.90	6.50	8.00	0.12	0.11
	158+	8.61	0.84	15.40	8.00	5.00	0.13	0.13
	0-32	7.68	1.77	17.30	7.00	8.50	0.29	0.11
	32-80	8.59	0.63	31.70	8.50	6.50	0.12	0.12
G	80-101	8.82	0.72	26.30	7.50	3.50	0.10	0.14
	101-115	8.11	0.15	11.70	8.00	0.00	0.05	0.13
	115-152	8.87	0.74	18.90	5.50	3.00	0.21	0.08
	152+	8.95	0.77	21.20	5.00	3.50	0.10	0.08
	0-29	7.84	0.24	21.20	15.00	10.00	0.34	0.11
	29-58	8.31	0.21	21.90	15.00	9.00	0.13	0.11
H	58-73	8.47	0.18	22.00	11.00	6.50	0.13	0.11
	73-88	8.43	0.16	11.00	3.00	1.00	0.03	0.10
	88-110	8.23	0.15	13.60	3.50	2.50	0.05	0.11
	110+	8.62	0.18	9.80	2.00	3.00	0.04	0.09

pH,EC and Exchangable properties of Profile samples:

Profile	Depth (cm)	pH	EC (ds m ⁻¹)	CEC	Exchangable cations [c mol (p+) kg ⁻¹]			
					Ca ²⁺	Mg ²⁺	K ⁺	Na ⁺
	0-25	7.62	0.54	18.90	8.00	8.00	0.22	0.10
	25-30	8.18	0.43	16.60	8.50	4.50	0.12	0.11
I	30-46	8.12	0.51	11.20	7.50	0.00	0.06	0.10
	46-71	8.53	0.58	11.40	5.50	3.00	0.07	0.10
	71-130	8.65	0.52	9.50	3.50	2.50	0.04	0.10
	130+	8.68	0.58	12.20	5.00	0.50	0.05	0.10
	0-23	7.54	0.38	16.40	12.50	8.50	0.19	0.09
	23-54	8.43	0.32	17.00	10.50	7.00	0.11	0.12
J	54-72	8.47	0.32	16.00	8.50	7.00	0.10	0.14
	72-124	8.39	0.43	12.80	3.50	1.50	0.04	0.13
	124-152	8.36	0.43	13.20	4.00	3.50	0.09	0.11
	152+	8.21	0.46	13.90	8.50	5.00	0.19	0.10
	0-26	8.12	0.64	4.30	6.50	0.50	0.35	0.76
Old Bot	26-43	8.64	0.47	5.70	6.00	4.50	0.25	0.81
	43-75	8.71	0.66	7.70	6.00	3.00	0.24	0.69
	75-152	8.74	0.63	4.10	3.50	0.00	0.23	0.76
	152+	8.85	0.68	5.90	5.00	2.50	0.24	0.72
Minimum		7.54	0.15	2.20	2.00	0.00	0.02	0.08
Maximum		8.98	2.04	31.70	23.50	16.50	0.47	3.11
Mean		8.44	0.77	11.97	7.06	4.15	0.18	0.43
CV		4.23	57.66	54.81	48.86	78.49	62.72	117.70

Table 13. Results of the correlation studies with chemical properties of profile soils

Properties	Acid insoluble	R₂O₃	OC	pH	EC
LOI	0.058 ^{NS}	0.047 ^{NS}	0.015 ^{NS}	-0.352 ^{**}	0.093 ^{NS}
Moisture	-0.274 [*]	0.120 ^{NS}	0.079 ^{NS}	-0.291 [*]	0.027 ^{NS}
Bulk density	0.106 ^{NS}	0.033 ^{NS}	-0.418 ^{**}	0.317 [*]	-0.381 ^{**}
Total porosity	0.172 ^{NS}	-0.020 ^{NS}	0.220 ^{NS}	-0.084 ^{NS}	0.249 ^{NS}
Percent clay	-0.150 ^{NS}	0.127 ^{NS}	0.212 ^{NS}	-0.192 ^{NS}	0.054 ^{NS}
Percent silt	0.038 ^{NS}	-0.030 ^{NS}	-0.111 ^{NS}	0.234 ^{NS}	-0.180 ^{NS}
Coarse sand	0.035 ^{NS}	0.029 ^{NS}	0.250 ^{NS}	0.053 ^{NS}	-0.002 ^{NS}
CEC	-0.241 ^{NS}	0.084 ^{NS}	0.037 ^{NS}	-0.264 [*]	-0.019 ^{NS}
Acid insoluble	-	0.052 ^{NS}	-0.049 ^{NS}	-0.009 ^{NS}	-0.172 ^{NS}
R₂O₃	0.052 ^{NS}	-	0.205 ^{NS}	-0.157 ^{NS}	0.175 ^{NS}
Total N	0.071 ^{NS}	0.248 ^{NS}	0.786 ^{**}	-0.619 ^{**}	0.506 ^{**}
Total P	0.164 ^{NS}	-0.030 ^{NS}	0.175 ^{NS}	-0.388 ^{**}	0.051 ^{NS}
Total K	0.077 ^{NS}	0.171 ^{NS}	0.331 ^{**}	-0.479 ^{**}	0.153 ^{NS}
Total Na	0.089 ^{NS}	0.214 ^{NS}	0.294 [*]	-0.306 [*]	0.359 ^{**}
Available N	0.030 ^{NS}	0.093 ^{NS}	0.479 ^{**}	-0.508 ^{**}	0.097 ^{NS}
Available P	0.075 ^{NS}	0.139 ^{NS}	0.706 ^{**}	-0.214 ^{NS}	0.535 ^{**}
Available K	-0.191 ^{NS}	0.133 ^{NS}	0.564 ^{**}	-0.562 ^{**}	0.341 ^{**}
Available S	-0.071 ^{NS}	0.012 ^{NS}	0.151 ^{NS}	-0.337 ^{**}	-0.001 ^{NS}
Exch. Ca	-0.208 ^{NS}	0.152 ^{NS}	0.198 ^{NS}	-0.320 [*]	0.045 ^{NS}
Exch. Mg	-0.386 ^{**}	0.022 ^{NS}	0.155 ^{NS}	-0.245 [*]	0.171 ^{NS}
Exch. Na	0.027 ^{NS}	0.046 ^{NS}	0.135 ^{NS}	0.100 ^{NS}	0.325 ^{**}

Table 14. Results of the correlation studies with exchangeable properties of soils

Properties	CEC	Exch.Ca	Exch.Mg	Exch.Na	Exch.K
LOI	0.585 ^{**}	0.628 ^{**}	0.476 ^{**}	-0.191 ^{NS}	0.025 ^{NS}
Moisture	0.620 ^{**}	0.860 ^{**}	0.614 ^{**}	-0.189 ^{NS}	0.131 ^{NS}
Bulk density	-0.069 ^{NS}	-0.484 ^{**}	-0.277 [*]	-0.320 [*]	-0.517 ^{**}
Clay	0.429 ^{**}	0.318 [*]	0.306 [*]	-0.124 ^{NS}	0.061 ^{NS}
Silt	0.107 ^{NS}	-0.053 ^{NS}	-0.004 ^{NS}	-0.256 ^{NS}	-0.264 ^{NS}
Coarse sand	-0.331 ^{**}	-0.028 ^{NS}	-0.047 ^{NS}	0.068 ^{NS}	0.116 ^{NS}
Fine sand	0.130 ^{NS}	-0.100 ^{NS}	-0.090 ^{NS}	0.053 ^{NS}	-0.081 ^{NS}
pH	-0.264 [*]	-0.320 [*]	-0.245 [*]	0.100 ^{NS}	-0.229 ^{NS}
EC	-0.019 ^{NS}	0.045 ^{NS}	0.171 ^{NS}	0.328 ^{**}	0.315 [*]
CEC	-	0.493 ^{NS}	0.569 ^{NS}	-0.476 ^{**}	-0.245 ^{NS}
Exch.Ca	0.493 ^{NS}	-	0.598 ^{**}	-0.012 ^{NS}	0.381 ^{**}
Exch.Mg	0.569 ^{NS}	0.598 ^{**}	-	-0.213 ^{NS}	0.059 ^{NS}
Exch.Na	-0.476 ^{**}	-0.012 ^{NS}	-0.213 ^{NS}	-	0.515 ^{**}
Exch.K	-0.245 ^{NS}	0.381 ^{**}	0.059 ^{NS}	0.515 ^{**}	-
R₂O₃	0.084 ^{NS}	0.152 ^{NS}	0.022 ^{NS}	0.046 ^{NS}	0.019 ^{NS}

Table 15. Results of the correlation studies with secondary nutrients

Properties	Total Ca	Total Mg
LOI	0.533 ^{**}	0.406 ^{**}
Moisture	0.417 ^{**}	0.533 ^{**}
Particle density	-0.049 ^{NS}	-0.202 ^{NS}
Clay	0.113 ^{NS}	0.259 [*]
Coarse sand	-0.056 ^{NS}	-0.066 ^{NS}
Exch. Ca	0.425 ^{**}	0.562 ^{**}
Exch. Mg	0.332 ^{**}	0.334 ^{**}
Exch. Na	-0.072 ^{NS}	-0.123 ^{NS}
Exch. K	0.044 ^{NS}	0.097 ^{NS}
Acid insoluble	0.193 ^{NS}	0.073 ^{NS}
OC	0.135 ^{NS}	0.298 [*]
OM	0.095 ^{NS}	0.287 [*]
R₂O₃	0.025 ^{NS}	0.321 [*]
Total N	0.339 ^{**}	0.416 ^{**}
Total K	0.546 ^{**}	0.548 ^{**}
Total Na	0.596 ^{**}	0.645 ^{**}

Table 16. Total N, P, K, Ca, Mg and Na status of profile soil samples of PAJANCOA and RI Horticultural farm soils

Profile	Depth (cm)	Total N (%)	Total P (%)	Total K (%)	Total Ca (%)	Total Mg (%)	Total Na (%)
	0-20	0.233	0.060	0.118	0.205	0.184	0.044
	20-49	0.170	0.046	0.094	0.323	0.258	0.059
A	49-70	0.236	0.047	0.095	0.308	0.216	0.059
	70-138	0.115	0.033	0.083	0.355	0.274	0.057
	138+	0.105	0.054	0.094	0.458	0.031	0.047
Minimum		0.105	0.033	0.083	0.205	0.031	0.044
Maximum		0.236	0.060	0.118	0.458	0.274	0.059
Mean		0.172	0.048	0.097	0.330	0.193	0.053
CV		36.18	21.059	11.826	27.68	50.51	13.533
	0-10	0.538	0.060	0.110	0.459	0.153	0.077
	10-41	0.110	0.037	0.091	0.306	0.214	0.091
B	41-84	0.088	0.034	0.079	0.412	0.154	0.106
	84-122	0.032	0.026	0.018	0.202	0.061	0.042
	122-151	0.068	0.032	0.047	0.304	0.030	0.046
	151+	0.043	0.025	0.039	0.203	0.030	0.052
Minimum		0.032	0.025	0.018	0.202	0.030	0.042
Maximum		0.538	0.060	0.110	0.459	0.214	0.106
Mean		0.147	0.036	0.064	0.314	0.107	0.069
CV		132.41	36.04	54.61	33.57	72.00	38.12
	0-21	0.259	0.046	0.169	0.413	0.186	0.081
	21-42	0.127	0.037	0.108	0.361	0.155	0.086
C	42-65	0.073	0.029	0.060	0.356	0.183	0.041
	65-84	0.117	0.046	0.057	0.407	0.122	0.046
	84-150	0.051	0.026	0.068	0.254	0.061	0.047
	150+	0.052	0.040	0.036	0.202	0.000	0.033
Minimum		0.051	0.026	0.036	0.202	0.000	0.033
Maximum		0.259	0.046	0.169	0.413	0.186	0.086
Mean		0.113	0.037	0.083	0.332	0.118	0.056
CV		69.09	22.58	58.14	25.68	62.83	39.38
	0-25	0.325	0.059	0.131	0.307	0.184	0.084
	25-44	0.275	0.029	0.207	0.312	0.187	0.126
D	44-71	0.105	0.041	0.082	0.206	0.278	0.112
	71-129	0.125	0.055	0.119	0.675	0.184	0.149
	129+	0.025	0.053	0.003	0.251	0.030	0.029
Minimum		0.025	0.029	0.003	0.206	0.030	0.029
Maximum		0.325	0.059	0.207	0.675	0.278	0.149
Mean		0.171	0.048	0.108	0.350	0.173	0.100
CV		72.80	25.62	68.96	53.43	51.71	45.92

Table 16. contd.,

Profile	Depth (cm)	Total N (%)	Total P (%)	Total K (%)	Total Ca (%)	Total Mg (%)	Total Na (%)
	0-20	0.453	0.066	0.185	0.517	0.248	0.096
	20-71	0.117	0.042	0.123	0.575	0.219	0.088
E	71-118	0.067	0.036	0.115	0.418	0.345	0.105
	118-126	0.033	0.038	0.031	0.253	0.213	0.040
	126+	0.040	0.023	0.036	0.304	0.030	0.042
Minimum		0.033	0.023	0.031	0.253	0.030	0.040
Maximum		0.453	0.066	0.185	0.575	0.345	0.105
Mean		0.142	0.041	0.098	0.413	0.211	0.074
CV		124.78	37.19	66.08	32.99	54.01	41.76
	0-20	0.361	0.056	0.095	0.362	0.311	0.090
	20-64	0.090	0.082	0.061	0.520	0.125	0.074
	64-91	0.032	0.079	0.018	0.308	0.062	0.039
F	91-115	0.055	0.056	0.042	0.257	0.062	0.045
	115-158	0.067	0.062	0.127	0.207	0.156	0.055
	158+	0.060	0.048	0.090	0.312	0.156	0.056
Minimum		0.032	0.048	0.018	0.207	0.062	0.039
Maximum		0.361	0.082	0.127	0.520	0.311	0.090
Mean		0.111	0.064	0.072	0.328	0.145	0.060
CV		112.08	21.18	54.59	32.95	63.15	31.68
	0-32	0.348	0.068	0.149	0.518	0.031	0.112
	32-80	0.104	0.082	0.095	0.411	0.308	0.104
G	80-101	0.063	0.026	0.090	0.364	0.187	0.088
	101-115	0.061	0.063	0.031	0.356	0.061	0.055
	115-152	0.069	0.046	0.024	0.154	0.031	0.044
	152+	0.062	0.023	0.097	0.256	0.154	0.060
Minimum		0.061	0.023	0.024	0.154	0.045	0.044
Maximum		0.348	0.082	0.149	0.518	0.308	0.112
Mean		0.118	0.051	0.081	0.343	0.129	0.077
CV		96.95	46.28	57.60	36.69	85.14	36.39
	0-29	0.331	0.104	0.173	0.369	0.348	0.097
	29-58	0.153	0.091	0.177	0.531	0.318	0.100
H	58-73	0.115	0.047	0.133	0.626	0.188	0.079
	73-88	0.035	0.052	0.023	0.152	0.091	0.030
	88-110	0.054	0.040	0.063	0.204	0.061	0.041
	110+	0.110	0.164	0.026	0.516	0.062	0.045
Minimum		0.035	0.040	0.023	0.152	0.061	0.030
Maximum		0.331	0.164	0.177	0.626	0.348	0.100
Mean		0.133	0.083	0.099	0.399	0.178	0.065
CV		79.59	57.15	71.251	47.80	72.54	46.55

Table 16. contd.,

Profile	Depth (cm)	Total N (%)	Total P (%)	Total K (%)	Total Ca (%)	Total Mg (%)	Total Na (%)
	0-25	0.301	0.206	0.142	0.411	0.216	0.075
	25-30	0.126	0.039	0.124	0.362	0.155	0.065
I	30-46	0.057	0.052	0.050	0.307	0.092	0.036
	46-71	0.076	0.062	0.068	0.407	0.092	0.061
	71-130	0.048	0.051	0.031	0.202	0.061	0.031
	130+	0.052	0.034	0.041	0.253	0.122	0.032
Minimum		0.048	0.034	0.031	0.202	0.061	0.031
Maximum		0.301	0.206	0.142	0.411	0.216	0.075
Mean		0.110	0.074	0.076	0.324	0.123	0.050
CV		88.78	88.20	60.75	26.28	45.31	38.42
	0-23	0.187	0.050	0.229	0.474	0.095	0.085
	23-54	0.115	0.041	0.153	0.841	0.126	0.075
J	54-72	0.085	0.030	0.101	0.362	0.031	0.047
	72-124	0.021	0.032	0.021	0.203	0.030	0.025
	124-152	0.083	0.052	0.083	0.203	0.061	0.032
	152+	0.072	0.032	0.057	0.158	0.095	0.036
Minimum		0.021	0.030	0.021	0.158	0.030	0.025
Maximum		0.187	0.052	0.229	0.841	0.126	0.085
Mean		0.094	0.040	0.107	0.374	0.073	0.050
CV		58.55	24.377	69.362	69.16	53.03	48.96
	0-26	0.238	0.041	0.054	0.253	0.061	0.042
Old Bot	26-43	0.019	0.114	0.042	0.306	0.092	0.032
	43-75	0.125	0.102	0.029	0.205	0.031	0.033
	75-152	0.034	0.038	0.049	0.150	0.060	0.037
	152+	0.073	0.027	0.099	0.254	0.061	0.042
Minimum		0.019	0.027	0.029	0.150	0.031	0.032
Maximum		0.238	0.114	0.099	0.306	0.092	0.042
Mean		0.097	0.065	0.054	0.234	0.061	0.037
CV		90.93	62.41	48.68	25.13	35.49	13.039

Descriptive statistics for overall Total N, P, K, Ca, Mg and Na status of PAJANCOA and RI Horticultural farm profile soils

	Total N (%)	Total P (%)	Total K (%)	Total Ca (%)	Total Mg (%)	Total Na (%)
Minimum	0.019	0.023	0.003	0.150	0.000	0.025
Maximum	0.538	0.206	0.229	0.841	0.348	0.149
Mean	0.128	0.054	0.085	0.341	0.136	0.063
CV	87.64	59.193	60.02	40.532	67.414	45.096

Macro Nutrient status of profile samples:

Profile	Depth (cm)	Total N (%)	Total P (%)	Total K (%)
	0-20	0.233	0.060	0.118
	20-49	0.170	0.046	0.094
A	49-70	0.236	0.047	0.095
	70-138	0.115	0.033	0.083
	138+	0.105	0.054	0.094
	0-10	0.538	0.060	0.110
	10-41	0.110	0.037	0.091
B	41-84	0.088	0.034	0.079
	84-122	0.032	0.026	0.018
	122-151	0.068	0.032	0.047
	151+	0.043	0.025	0.039
	0-21	0.259	0.046	0.169
	21-42	0.127	0.037	0.108
C	42-65	0.073	0.029	0.060
	65-84	0.117	0.046	0.057
	84-150	0.051	0.026	0.068
	150+	0.052	0.040	0.036
	0-25	0.325	0.059	0.131
	25-44	0.275	0.029	0.207
D	44-71	0.105	0.041	0.082
	71-129	0.125	0.055	0.119
	129+	0.025	0.053	0.003
	0-20	0.453	0.066	0.185
	20-71	0.117	0.042	0.123
E	71-118	0.067	0.036	0.115
	118-126	0.033	0.038	0.031
	126+	0.040	0.023	0.036
	0-20	0.361	0.056	0.095
	20-64	0.090	0.082	0.061
	64-91	0.032	0.079	0.018
F	91-115	0.055	0.056	0.042
	115-158	0.067	0.062	0.127
	158+	0.060	0.048	0.090
	0-32	0.348	0.068	0.149
G	32-80	0.104	0.082	0.095
	80-101	0.063	0.026	0.090
	101-115	0.061	0.063	0.031
	115-152	0.069	0.046	0.024
	152+	0.062	0.023	0.097
	0-29	0.331	0.104	0.173
	29-58	0.153	0.091	0.177
H	58-73	0.115	0.047	0.133
	73-88	0.035	0.052	0.023
	88-110	0.054	0.040	0.063
	110+	0.110	0.164	0.026

Macro Nutrient status of profile samples:

Profile	Depth (cm)	Total N (%)	Total P (%)	Total K (%)
	0-25	0.301	0.206	0.142
	25-30	0.126	0.039	0.124
I	30-46	0.057	0.052	0.050
	46-71	0.076	0.062	0.068
	71-130	0.048	0.051	0.031
	130+	0.052	0.034	0.041
	0-23	0.187	0.050	0.229
	23-54	0.115	0.041	0.153
J	54-72	0.085	0.030	0.101
	72-124	0.021	0.032	0.021
	124-152	0.083	0.052	0.083
	152+	0.072	0.032	0.057
	0-26	0.238	0.041	0.054
Old Bot	26-43	0.019	0.114	0.042
	43-75	0.125	0.102	0.029
	75-152	0.034	0.038	0.049
	152+	0.073	0.027	0.099
Minimum		0.019	0.023	0.003
Maximum		0.538	0.206	0.229
Mean		0.128	0.054	0.085
CV		87.64	59.193	60.02

Table 17. Available N, P, K and S status of profile soil samples of PAJANCOA and RI Horticultural farm soils

Profile	Depth (cm)	Avail.N (kg ha⁻¹)	Avail.P (kg ha⁻¹)	Avail.K (kg ha⁻¹)	Avail.S (mg kg⁻¹)
	0-20	23.52	31.99	133.56	7.64
	20-49	20.38	20.36	203.01	11.64
A	49-70	31.36	17.76	58.77	8.96
	70-138	21.95	16.91	69.45	10.29
	138+	12.54	18.62	32.05	10.29
Minimum		12.544	16.91	32.05	7.64
Maximum		31.36	31.99	203.01	11.64
Mean		21.95	21.13	99.37	9.76
CV		30.72	29.36	69.33	15.58
	0-10	61.15	62.61	272.46	13.01
	10-41	26.66	16.91	74.79	7.64
B	41-84	23.52	13.64	53.42	10.29
	84-122	10.98	16.08	37.40	11.64
	122-151	14.11	18.62	32.05	7.64
	151+	14.11	17.76	42.74	10.29
Minimum		10.98	13.64	32.05	7.64
Maximum		61.15	62.61	272.46	13.01
Mean		25.09	24.27	85.48	10.08
CV		74.48	77.72	108.61	21.28
	0-21	42.34	25.91	165.61	10.29
	21-42	20.38	9.76	90.82	13.01
C	42-65	21.95	14.44	58.77	13.01
	65-84	18.82	16.08	64.11	7.64
	84-150	31.36	14.44	69.45	11.64
	150+	21.95	18.62	53.42	14.38
Minimum		18.82	9.76	53.42	7.64
Maximum		42.34	25.91	165.61	14.38
Mean		26.13	16.54	83.70	11.66
CV		34.71	32.80	50.37	20.69
	0-25	34.50	35.25	160.27	20.06
	25-44	45.47	19.48	106.85	27.54
D	44-71	23.52	16.08	101.51	26.01
	71-129	17.25	10.52	90.82	15.78
	129+	15.68	16.08	26.71	10.29
Minimum		15.68	10.52	26.71	10.29
Maximum		45.47	35.25	160.27	27.54
Mean		27.28	19.48	97.23	19.94
CV		46.08	48.16	49.05	35.91

Table 17. contd.,

Profile	Depth (cm)	Avail.N (kg ha ⁻¹)	Avail.P (kg ha ⁻¹)	Avail.K (kg ha ⁻¹)	Avail.S (mg kg ⁻¹)
	0-20	62.72	41.08	203.01	6.33
	20-71	25.09	9.76	90.82	1.24
E	71-118	10.98	13.64	42.74	2.49
	118-126	12.54	8.27	48.08	2.49
	126+	12.54	18.62	32.05	1.24
Minimum		10.98	8.27	32.05	1.24
Maximum		62.72	41.08	203.01	6.33
Mean		24.77	18.27	83.34	2.76
CV		88.65	73.14	84.63	75.81
	0-20	53.31	16.08	154.93	7.64
	20-64	20.38	8.27	69.45	20.06
	64-91	17.25	11.28	58.77	18.62
F	91-115	10.98	9.01	64.11	10.29
	115-158	21.95	15.25	101.51	13.01
	158+	15.68	13.64	128.22	13.01
Minimum		10.98	8.27	58.77	7.64
Maximum		53.31	16.08	154.93	20.06
Mean		23.26	12.26	96.16	13.77
CV		65.42	26.53	40.67	34.67
	0-32	40.77	20.36	224.38	15.78
	32-80	20.38	5.40	101.51	14.38
G	80-101	20.38	6.10	101.51	11.64
	101-115	20.38	8.27	58.77	17.19
	115-152	15.68	23.08	186.98	8.96
	152+	17.25	8.27	96.16	13.01
Minimum		15.68	5.40	58.77	8.96
Maximum		40.77	23.08	224.38	17.19
Mean		22.47	11.91	128.22	13.49
CV		40.84	64.89	49.30	21.97
	0-29	131.71	19.48	251.09	11.64
	29-58	64.29	4.00	112.19	10.29
H	58-73	26.66	5.40	101.51	6.33
	73-88	10.98	9.76	32.05	1.24
	88-110	39.20	6.10	48.08	6.33
	110+	20.38	14.44	32.05	3.76
Minimum		10.98	4.00	32.05	1.24
Maximum		131.71	19.48	251.09	11.64
Mean		48.87	9.86	96.16	6.60
CV		91.21	61.15	86.78	59.07

Table 17. contd.,

Profile	Depth (cm)	Avail.N (kg ha ⁻¹)	Avail.P (kg ha ⁻¹)	Avail.K (kg ha ⁻¹)	Avail.S (mg kg ⁻¹)
	0-25	50.18	18.62	181.64	157.13
	25-30	29.79	4.00	112.19	13.01
I	30-46	14.11	6.10	53.42	15.78
	46-71	20.38	2.64	64.11	10.29
	71-130	18.82	6.82	37.40	8.96
	130+	18.82	5.40	42.74	14.38
Minimum		14.11	2.64	37.40	8.96
Maximum		50.18	18.62	181.64	157.13
Mean		25.35	7.26	81.92	36.59
CV		52.11	79.31	67.98	161.53
	0-23	36.06	7.54	154.93	15.78
	23-54	20.38	5.40	165.61	11.64
J	54-72	25.09	5.40	85.48	18.62
	72-124	12.54	12.84	42.74	10.29
	124-152	4.70	7.54	69.45	10.29
	152+	20.38	6.10	160.27	14.38
Minimum		4.70	5.40	42.74	10.29
Maximum		36.06	12.84	165.61	18.62
Mean		19.86	7.47	113.08	13.50
CV		53.93	37.55	47.38	24.83
	0-26	32.93	27.88	122.88	7.64
Old Bot	26-43	36.06	23.08	42.74	3.76
	43-75	23.52	9.76	48.08	18.62
	75-152	17.25	12.06	10.68	10.29
	152+	34.50	20.36	53.42	2.49
Minimum		17.25	9.76	10.68	2.49
Maximum		36.06	27.88	122.88	18.62
Mean		28.85	18.63	55.56	8.56
CV		28.14	40.72	74.04	74.99

Descriptive statistics for overall Available N, P, K and S status of PAJANCOA and RI Horticultural farm profile soils

	Avail.N (kg ha ⁻¹)	Avail.P (kg ha ⁻¹)	Avail.K (kg ha ⁻¹)	Avail.S (mg kg ⁻¹)
Minimum	4.70	2.64	10.68	1.24
Maximum	131.71	62.61	272.46	157.13
Mean	26.94	15.03	93.27	13.54
CV	70.45	66.54	64.12	142.68

Available Nutrient status of profile samples:

Profile	Depth (cm)	Ava.N (kg ha ⁻¹)	Ava.P (kg ha ⁻¹)	Ava.K (kg ha ⁻¹)	Avail.S (Mg kg ⁻¹)
	0-20	23.52	31.99	133.56	7.64
	20-49	20.38	20.36	203.01	11.64
A	49-70	31.36	17.76	58.77	8.96
	70-138	21.95	16.91	69.45	10.29
	138+	12.54	18.62	32.05	10.29
	0-10	61.15	62.61	272.46	13.01
	10-41	26.66	16.91	74.79	7.64
B	41-84	23.52	13.64	53.42	10.29
	84-122	10.98	16.08	37.40	11.64
	122-151	14.11	18.62	32.05	7.64
	151+	14.11	17.76	42.74	10.29
	0-21	42.34	25.91	165.61	10.29
	21-42	20.38	9.76	90.82	13.01
C	42-65	21.95	14.44	58.77	13.01
	65-84	18.82	16.08	64.11	7.64
	84-150	31.36	14.44	69.45	11.64
	150+	21.95	18.62	53.42	14.38
	0-25	34.50	35.25	160.27	20.06
	25-44	45.47	19.48	106.85	27.54
D	44-71	23.52	16.08	101.51	26.01
	71-129	17.25	10.52	90.82	15.78
	129+	15.68	16.08	26.71	10.29
	0-20	62.72	41.08	203.01	6.33
	20-71	25.09	9.76	90.82	1.24
E	71-118	10.98	13.64	42.74	2.49
	118-126	12.54	8.27	48.08	2.49
	126+	12.54	18.62	32.05	1.24
	0-20	53.31	16.08	154.93	7.64
	20-64	20.38	8.27	69.45	20.06
	64-91	17.25	11.28	58.77	18.62
F	91-115	10.98	9.01	64.11	10.29
	115-158	21.95	15.25	101.51	13.01
	158+	15.68	13.64	128.22	13.01
	0-32	40.77	20.36	224.38	15.78
G	32-80	20.38	5.40	101.51	14.38
	80-101	20.38	6.10	101.51	11.64
	101-115	20.38	8.27	58.77	17.19
	115-152	15.68	23.08	186.98	8.96
	152+	17.25	8.27	96.16	13.01
	0-29	131.71	19.48	251.09	11.64
	29-58	64.29	4.00	112.19	10.29
H	58-73	26.66	5.40	101.51	6.33
	73-88	10.98	9.76	32.05	1.24
	88-110	39.20	6.10	48.08	6.33
	110+	20.38	14.44	32.05	3.76

Available Nutrient status of profile samples:

Profile	Depth (cm)	Ava.N (kg ha⁻¹)	Ava.P (kg ha⁻¹)	Ava.K (kg ha⁻¹)	Avail.S (Mg kg⁻¹)
	0-25	50.18	18.62	181.64	157.13
	25-30	29.79	4.00	112.19	13.01
I	30-46	14.11	6.10	53.42	15.78
	46-71	20.38	2.64	64.11	10.29
	71-130	18.82	6.82	37.40	8.96
	130+	18.82	5.40	42.74	14.38
	0-23	36.06	7.54	154.93	15.78
	23-54	20.38	5.40	165.61	11.64
J	54-72	25.09	5.40	85.48	18.62
	72-124	12.54	12.84	42.74	10.29
	124-152	4.70	7.54	69.45	10.29
	152+	20.38	6.10	160.27	14.38
	0-26	32.93	27.88	122.88	7.64
Old Bot	26-43	36.06	23.08	42.74	3.76
	43-75	23.52	9.76	48.08	18.62
	75-152	17.25	12.06	10.68	10.29
	152+	34.50	20.36	53.42	2.49
Minimum		4.70	2.64	10.68	1.24
Maximum		131.71	62.61	272.46	157.13
Mean		26.94	15.03	93.27	13.54
CV		70.45	66.54	64.12	142.68

Table 18. Physical properties of surface soil samples of PAJANCOA and RI, Horticultural farm soils

Block	Field No	Moisture (%)	LOI (%)	BD (Mg m⁻³)	PD (Mg m⁻³)	TP (%)
	A1(a)	3.40	1.09	1.250	2.222	43.75
	A1(b)	3.24	1.03	1.250	2.222	43.75
	A2(a)	2.95	0.88	1.176	2.500	52.94
A	A2(b)	3.96	0.31	1.250	2.500	50.00
	A3(a)	1.66	0.51	1.176	2.222	47.06
	A3(b)	1.79	2.29	1.176	2.500	52.94
	A4(a)	2.66	6.84	1.176	2.500	52.94
	A4(b)	2.53	4.42	1.176	2.500	52.94
Minimum		1.66	0.31	1.176	2.222	43.75
Maximum		3.96	6.84	1.250	2.500	52.94
Mean		2.77	2.17	1.204	2.396	49.54
CV		28.38	106.15	3.161	6.001	8.35
B	B(a)	2.41	4.05	1.250	2.222	43.75
	B(b)	2.87	2.99	1.250	2.222	43.75
Minimum		2.41	2.99	1.250	2.222	43.75
Maximum		2.87	4.05	1.250	2.222	43.75
Mean		2.64	3.52	1.250	2.222	43.75
CV		12.42	21.35	0.000	0.000	0.00
	C1(a)	2.58	7.65	1.176	2.222	47.06
C	C1(b)	2.63	1.59	1.176	2.222	47.06
	C2(a)	2.52	4.41	1.176	2.222	47.06
	C2(b)	2.30	3.84	1.176	2.222	47.06
Minimum		2.30	1.59	1.176	2.222	47.06
Maximum		2.63	7.65	1.176	2.222	47.06
Mean		2.51	4.37	1.176	2.222	47.06
CV		5.93	57.16	0.000	0.000	0.00
D	D1(a)	3.57	2.09	1.250	2.500	50.00
	D1(b)	2.91	2.94	1.250	2.222	43.75
Minimum		2.91	2.09	1.250	2.222	43.75
Maximum		3.57	2.94	1.250	2.500	50.00
Mean		3.24	2.51	1.250	2.361	46.88
CV		14.37	23.89	0.000	8.319	9.43

Table 18. contd.,

Block	Field No	Moisture (%)	LOI (%)	BD (Mg m ⁻³)	PD (Mg m ⁻³)	TP (%)
E	E1(a)	3.81	3.85	1.176	2.500	52.94
	E1(b)	3.72	3.95	1.176	2.500	52.94
	E2(a)	3.32	2.79	1.176	2.500	52.94
	E2(b)	2.24	2.45	1.250	2.500	50.00
Minimum		2.24	2.45	1.176	2.500	50.00
Maximum		3.81	3.95	1.250	2.500	52.94
Mean		3.27	3.26	1.195	2.500	52.21
CV		22.03	23.08	3.077	0.000	2.82
F	F1(a)	3.76	2.75	1.250	2.500	50.00
	F1(b)	3.63	3.16	1.250	2.500	50.00
	F2(a)	2.27	2.69	1.250	2.500	50.00
	F2(b)	2.92	2.22	1.176	2.500	52.94
	F3(a)	4.48	2.99	1.250	2.500	50.00
	F3(b)	4.23	3.13	1.250	2.500	50.00
	F4(a)	3.82	3.12	1.176	2.222	47.06
	F4(b)	3.33	2.69	1.250	2.500	50.00
Minimum		2.27	2.22	1.176	2.222	47.06
Maximum		4.48	3.16	1.250	2.500	52.94
Mean		3.56	2.84	1.232	2.465	50.00
CV		20.04	11.36	2.764	3.984	3.14
G	G1(a)	4.21	3.08	1.176	2.222	47.06
	G1(b)	3.37	2.85	1.176	2.222	47.06
	G2(a)	2.95	2.32	1.176	2.222	47.06
	G2(b)	3.07	2.32	1.176	2.222	47.06
	G3(a)	3.24	2.48	1.176	2.222	47.06
	G3(b)	3.07	2.63	1.176	2.222	47.06
	G4(a)	2.55	2.67	1.250	2.500	50.00
	G4(b)	3.07	2.48	1.250	2.500	50.00
Minimum		2.55	2.32	1.176	2.222	47.06
Maximum		4.21	3.08	1.250	2.500	50.00
Mean		3.19	2.60	1.195	2.292	47.79
CV		14.88	10.10	2.849	5.611	2.85
H	H1(a)	4.09	3.50	1.176	2.500	52.94
	H1(b)	4.14	3.82	1.176	2.500	52.94
	H2(a)	3.83	3.51	1.176	2.500	52.94
	H2(b)	4.20	3.60	1.176	2.500	52.94
Minimum		3.83	3.50	1.176	2.500	52.94
Maximum		4.20	3.82	1.176	2.500	52.94
Mean		4.07	3.61	1.176	2.500	52.94
CV		4.00	4.06	0.000	0.000	0.00

Table 18. contd.,

Block	Field No	Moisture (%)	LOI (%)	BD (Mg m ⁻³)	PD (Mg m ⁻³)	TP (%)
	I1(a)	3.83	2.03	1.250	2.500	50.00
I	I1(b)	3.90	2.29	1.250	2.500	50.00
	I2(a)	3.77	1.87	1.250	2.500	50.00
	I2(b)	3.15	0.35	1.250	2.500	50.00
Minimum		3.15	0.35	1.250	2.500	50.00
Maximum		3.90	2.29	1.250	2.500	50.00
Mean		3.66	1.63	1.250	2.500	50.00
CV		9.43	53.54	0.000	0.000	0.00
	J1(a)	4.32	2.72	1.250	2.500	50.00
J	J1(b)	4.48	2.63	1.250	2.222	43.75
	J2(a)	5.06	2.05	1.250	2.222	43.75
	J2(b)	4.12	2.14	1.250	2.222	43.75
Minimum		4.12	2.05	1.250	2.222	43.75
Maximum		5.06	2.72	1.250	2.500	50.00
Mean		4.49	2.38	1.250	2.292	45.31
CV		8.97	14.08	0.000	6.061	6.90
	OLD1	2.52	1.39	1.176	2.222	47.06
	OLD2	2.42	1.18	1.176	2.222	47.06
Old Bot	OLD3	2.36	1.48	1.250	2.222	43.75
	OLD4	2.79	1.54	1.176	2.222	47.06
	OLD5	2.57	1.28	1.176	2.222	47.06
Minimum		2.36	1.18	1.176	2.222	43.75
Maximum		2.79	1.54	1.250	2.222	47.06
Mean		2.53	1.38	1.191	2.222	46.40
CV		6.47	10.75	2.761	0.000	3.19

Descriptive statistics for overall physical properties of PAJANCOA and RI, Horticultural farm Surface soils

	Moisture (%)	LOI (%)	BD (Mg m ⁻³)	PD (Mg m ⁻³)	TP (%)
Minimum	1.66	0.31	1.176	2.222	43.75
Maximum	5.06	7.65	1.250	2.500	52.94
Mean	3.26	2.66	1.211	2.369	48.72
CV	23.36	51.06	3.060	5.91	6.41

Physical properties of surface samples:

Block	Field No	Moisture (%)	LOI (%)	BD (Mg m⁻³)	PD (Mg m⁻³)	TP (%)
	A1(a)	3.40	1.09	1.250	2.222	43.75
	A1(b)	3.24	1.03	1.250	2.222	43.75
	A2(a)	2.95	0.88	1.176	2.500	52.94
A	A2(b)	3.96	0.31	1.250	2.500	50.00
	A3(a)	1.66	0.51	1.176	2.222	47.06
	A3(b)	1.79	2.29	1.176	2.500	52.94
	A4(a)	2.66	6.84	1.176	2.500	52.94
	A4(b)	2.53	4.42	1.176	2.500	52.94
B	B(a)	2.41	4.05	1.250	2.222	43.75
	B(b)	2.87	2.99	1.250	2.222	43.75
	C1(a)	2.58	7.65	1.176	2.222	47.06
C	C1(b)	2.63	1.59	1.176	2.222	47.06
	C2(a)	2.52	4.41	1.176	2.222	47.06
	C2(b)	2.30	3.84	1.176	2.222	47.06
D	D(a)	3.57	2.09	1.250	2.500	50.00
	D(b)	2.91	2.94	1.250	2.222	43.75
	E1(a)	3.81	3.85	1.176	2.500	52.94
E	E1(b)	3.72	3.95	1.176	2.500	52.94
	E2(a)	3.32	2.79	1.176	2.500	52.94
	E2(b)	2.24	2.45	1.250	2.500	50.00
	F1(a)	3.76	2.75	1.250	2.500	50.00
	F1(b)	3.63	3.16	1.250	2.500	50.00
	F2(a)	2.27	2.69	1.250	2.500	50.00
F	F2(b)	2.92	2.22	1.176	2.500	52.94
	F3(a)	4.48	2.99	1.250	2.500	50.00
	F3(b)	4.23	3.13	1.250	2.500	50.00
	F4(a)	3.82	3.12	1.176	2.222	47.06
	F4(b)	3.33	2.69	1.250	2.500	50.00
	G1(a)	4.21	3.08	1.176	2.222	47.06
	G1(b)	3.37	2.85	1.176	2.222	47.06
	G2(a)	2.95	2.32	1.176	2.222	47.06
G	G2(b)	3.07	2.32	1.176	2.222	47.06
	G3(a)	3.24	2.48	1.176	2.222	47.06
	G3(b)	3.07	2.63	1.176	2.222	47.06
	G4(a)	2.55	2.67	1.250	2.500	50.00
	G4(b)	3.07	2.48	1.250	2.500	50.00
	H1(a)	4.09	3.50	1.176	2.500	52.94
	H1(b)	4.14	3.82	1.176	2.500	52.94
H	H2(a)	3.83	3.51	1.176	2.500	52.94
	H2(b)	4.20	3.60	1.176	2.500	52.94

Physical properties of surface samples:

Block	Field No	Moisture (%)	LOI (%)	BD (Mg m⁻³)	PD (Mg m⁻³)	TP (%)
	I1(a)	3.83	2.03	1.250	2.500	50.00
I	I1(b)	3.90	2.29	1.250	2.500	50.00
	I2(a)	3.77	1.87	1.250	2.500	50.00
	I2(b)	3.15	0.35	1.250	2.500	50.00
	J1(a)	4.32	2.72	1.250	2.500	50.00
J	J1(b)	4.48	2.63	1.250	2.222	43.75
	J2(a)	5.06	2.05	1.250	2.222	43.75
	J2(b)	4.12	2.14	1.250	2.222	43.75
	OLD1	2.52	1.39	1.176	2.222	47.06
	OLD2	2.42	1.18	1.176	2.222	47.06
Old Bot	OLD3	2.36	1.48	1.250	2.222	43.75
	OLD4	2.79	1.54	1.176	2.222	47.06
	OLD5	2.57	1.28	1.176	2.222	47.06
Minimum		1.66	0.31	1.176	2.222	43.75
Maximum		5.06	7.65	1.250	2.500	52.94
Mean		3.26	2.66	1.211	2.369	48.72
CV		23.36	51.06	3.060	5.91	6.41

Table 19. Results of the correlation studies with physical properties of surface soil samples

Properties	LOI	Moisture	B.D	P.D	T.P
LOI	-	0.024 ^{NS}	-0.265 [*]	0.109 ^{NS}	0.235 ^{NS}
Moisture	0.024 ^{NS}	-	0.276 [*]	0.243 ^{NS}	0.095 ^{NS}
Bulk density	-0.265 [*]	0.276 [*]	-	0.211 ^{NS}	-0.295 [*]
Total porosity	0.235 ^{NS}	0.095	-0.295 [*]	0.871 ^{**}	-
CEC	0.372 ^{**}	-0.063 ^{NS}	0.022 ^{NS}	-0.082 ^{NS}	-0.090 ^{NS}
Acid insoluble	0.163 ^{NS}	-0.077 ^{NS}	-0.083 ^{NS}	-0.088 ^{NS}	-0.051 ^{NS}
OC	0.156 ^{NS}	-0.206 ^{NS}	0.114 ^{NS}	-0.069 ^{NS}	-0.124 ^{NS}
OM	0.156 ^{NS}	-0.206 ^{NS}	0.114 ^{NS}	-0.069 ^{NS}	-0.124 ^{NS}
Total Ca	0.049 ^{NS}	0.109 ^{NS}	-0.039 ^{NS}	0.150 ^{NS}	0.170 ^{NS}

Table 22. Results of the correlation studies with chemical properties of surface soils samples

Properties	Acid insoluble	R₂O₃	OC	pH	EC
LOI	0.163 ^{NS}	-0.007 ^{NS}	0.156 ^{NS}	0.209 ^{NS}	0.155 ^{NS}
Moisture	-0.077 ^{NS}	0.207 ^{NS}	-0.206 ^{NS}	-0.266 [*]	-0.066 ^{NS}
Bulk density	-0.083 ^{NS}	0.204 ^{NS}	0.114 ^{NS}	-0.083 ^{NS}	-0.089 ^{NS}
Total porosity	-0.051 ^{NS}	0.176 ^{NS}	-0.124 ^{NS}	-0.200 ^{NS}	-0.133 ^{NS}
CEC	0.110 ^{NS}	0.027 ^{NS}	0.188 ^{NS}	0.210 ^{NS}	0.481 ^{**}
Acid insoluble	-	-0.014 ^{NS}	0.116 ^{NS}	-0.099 ^{NS}	0.017 ^{NS}
R₂O₃	-0.140 ^{NS}	-	0.005 ^{NS}	-0.002 ^{NS}	0.046 ^{NS}
Total N	-0.80 ^{NS}	0.048 ^{NS}	0.585 ^{**}	-0.483 ^{**}	0.135 ^{NS}
Total P	-0.011 ^{NS}	0.071 ^{NS}	0.591 ^{**}	-0.311 [*]	-0.078 ^{NS}
Total K	0.117 ^{NS}	0.042 ^{NS}	0.197 ^{NS}	-0.083 ^{NS}	0.191 ^{NS}
Total Na	-0.187 ^{NS}	0.145 ^{NS}	0.253 ^{NS}	0.126 ^{NS}	0.532 ^{**}
Available N	0.204 ^{NS}	-0.025 ^{NS}	0.679 ^{**}	-0.495 ^{**}	0.221 ^{NS}
Available P	-0.067 ^{NS}	-0.164 ^{NS}	0.339 [*]	-0.149 ^{NS}	0.122 ^{NS}
Available K	0.121 ^{NS}	0.023 ^{NS}	0.463 ^{**}	-0.512 ^{**}	0.030 ^{NS}
Available S	-0.019 ^{NS}	0.124 ^{NS}	-0.248 ^{NS}	0.283 [*]	0.319 ^{**}
Exch. Ca	-0.144 ^{NS}	0.229 ^{NS}	-0.229 ^{NS}	0.023 ^{NS}	-0.162 ^{NS}
Exch. Mg	-0.110 ^{NS}	0.070 ^{NS}	-0.153 ^{NS}	-0.079 ^{NS}	0.073 ^{NS}
Exch. Na	-0.176 ^{NS}	0.213 ^{NS}	-0.344 ^{**}	0.202 ^{NS}	0.181 ^{NS}

Table 20. Results of the correlation studies with exchangeable properties of surface soil samples

Properties	CEC	Exch.Ca	Exch.Mg	Exch.Na	Exch.K
LOI	0.372 ^{**}	-0.097 ^{NS}	0.271 [*]	-0.096 ^{NS}	-0.021 ^{NS}
Moisture	-0.063 ^{NS}	0.447 ^{**}	0.529 ^{**}	0.271 [*]	-0.076 ^{NS}
Bulk density	0.022 ^{NS}	0.033 ^{NS}	-0.019 ^{NS}	0.086 ^{NS}	0.012 ^{NS}
pH	0.120 ^{NS}	0.023 ^{NS}	-0.079 ^{NS}	0.202 ^{NS}	-0.193 ^{NS}
EC	0.481 ^{**}	-0.162 ^{NS}	0.073 ^{NS}	0.181 ^{NS}	-0.030 ^{NS}
CEC	-	-0.164 ^{NS}	0.020 ^{NS}	-0.317 [*]	0.144 ^{NS}
Exch.Ca	-0.164 ^{NS}	-	0.015 ^{NS}	0.317 [*]	0.002 ^{NS}
Exch.Mg	0.020 ^{NS}	0.015 ^{NS}	-	0.158 ^{NS}	-0.158 ^{NS}
Exch.Na	0.317 [*]	0.317 [*]	0.158 ^{NS}	-	-0.597 ^{**}
Exch.K	-0.144 ^{NS}	0.002 ^{NS}	-0.158 ^{NS}	-0.597 ^{**}	-
R₂O₃	0.027 ^{NS}	0.229 ^{NS}	-0.070 ^{NS}	0.213 ^{NS}	-0.031 ^{NS}
Total K	0.095 ^{NS}	0.134 ^{NS}	0.195 ^{NS}	0.316 [*]	0.321 [*]
Avail N	0.096 ^{NS}	-0.353 ^{**}	-0.007 ^{NS}	-0.544 ^{**}	0.503 ^{**}

Table 21. Results of the correlation studies with major nutrients of surface soil samples

Properties	Total N	Total P	Total K	Total Ca	Total Mg	Avail. N	Avail. P	Avail. K
LOI	-0.031 ^{NS}	-0.211 ^{NS}	0.025 ^{NS}	0.049 ^{NS}	-0.107 ^{NS}	0.145 ^{NS}	-0.070 ^{NS}	-0.130 ^{NS}
Moisture	0.176 ^{NS}	-0.029 ^{NS}	0.126 ^{NS}	0.109 ^{NS}	0.191 ^{NS}	-0.046 ^{NS}	0.315 [*]	0.010 ^{NS}
Bulk density	0.119 ^{NS}	0.260 [*]	-0.047 ^{NS}	-0.039 ^{NS}	0.137 ^{NS}	0.044 ^{NS}	0.193 ^{NS}	0.066 ^{NS}
Total porosity	0.096 ^{NS}	-0.145 ^{NS}	-0.050 ^{NS}	0.170 ^{NS}	0.019 ^{NS}	0.103 ^{NS}	-0.256 ^{NS}	0.028 ^{NS}
pH	-0.483 ^{**}	-0.311 [*]	-0.083 ^{NS}	0.033 ^{NS}	-0.204 ^{NS}	-0.495 ^{**}	-0.149 ^{NS}	-0.572 ^{**}
CEC	-0.059 ^{NS}	-0.047 ^{NS}	0.095 ^{NS}	-0.042 ^{NS}	-0.135 ^{NS}	0.096 ^{NS}	0.096 ^{NS}	-0.163 ^{NS}
Ex. Ca	-0.096 ^{NS}	-0.135 ^{NS}	0.134 ^{NS}	0.533 ^{**}	0.194 ^{NS}	-0.353 ^{**}	0.033 ^{NS}	0.033 ^{NS}
Ex. Mg	0.082 ^{NS}	-0.170 ^{NS}	0.195 ^{NS}	0.255 ^{NS}	-0.015 ^{NS}	-0.007 ^{NS}	0.184 ^{NS}	-0.265 [*]
Ex. Na	-0.354 ^{**}	-0.488 ^{**}	-0.136 [*]	0.198 ^{NS}	0.158 ^{NS}	-0.544 ^{**}	-0.187 ^{NS}	-0.530 ^{**}
Ex. K	0.513 ^{**}	0.499 ^{**}	0.321 [*]	-0.064 ^{NS}	0.158 ^{NS}	0.503 ^{**}	0.272 [*]	0.811 ^{**}
Acid insoluble	-0.080 ^{NS}	-0.015 ^{NS}	-0.117 ^{NS}	-0.171 ^{NS}	-0.007 ^{NS}	0.204 ^{NS}	-0.067 ^{NS}	0.121 ^{NS}
OC	0.585 ^{**}	0.591 ^{**}	0.197 ^{NS}	0.050 ^{NS}	-0.076 ^{NS}	0.679 ^{**}	0.339 ^{**}	0.463 ^{**}
R₂O₃	0.048 ^{NS}	0.071 ^{NS}	0.042 ^{NS}	0.132 ^{NS}	0.348 ^{**}	-0.025 ^{NS}	-0.164 ^{NS}	0.023 ^{NS}
OM	0.585 ^{**}	0.591 ^{**}	0.197 ^{NS}	0.050 ^{NS}	-0.076 ^{NS}	0.679 ^{**}	0.339 [*]	0.463 ^{**}
Total N	-	0.512 ^{**}	0.252 ^{NS}	0.011 ^{NS}	0.169 ^{NS}	0.681 ^{**}	0.486 ^{**}	0.612 ^{**}
Total P	0.591 ^{**}	-	0.310 [*]	-0.023 ^{NS}	-0.014 ^{NS}	0.597 ^{**}	0.417 ^{**}	0.590 ^{**}
Total K	0.252 ^{NS}	0.310 [*]	-	0.277 [*]	-0.082 ^{NS}	0.273 [*]	0.392 ^{**}	0.367 ^{**}
Total Ca	0.011 ^{NS}	-0.023 ^{NS}	0.277 [*]	-	-0.103 ^{NS}	-0.108 ^{NS}	0.038 ^{NS}	-0.046 ^{NS}
Total Mg	0.169 ^{NS}	-0.014 ^{NS}	-0.082 ^{NS}	-0.103 ^{NS}	-	-0.087 ^{NS}	-0.155 ^{NS}	0.156 ^{NS}
Total Na	0.184 ^{NS}	0.030 ^{NS}	0.317 [*]	0.138 ^{NS}	-0.207 ^{NS}	0.209 ^{NS}	0.234 ^{NS}	-0.124 ^{NS}
Avai N	0.681 ^{**}	0.597 ^{**}	0.273 [*]	-0.108 ^{NS}	-0.087 ^{NS}	-	0.326 ^{NS}	0.573 ^{**}
Avai P	0.486 ^{**}	0.417 ^{**}	0.392 ^{**}	0.038 ^{NS}	-0.155 ^{NS}	0.326 [*]	-	0.413 ^{**}
Avai K	0.612 ^{**}	0.590 ^{**}	0.367 ^{**}	-0.046 ^{NS}	0.156 ^{NS}	0.573 ^{**}	0.413 ^{**}	-
Avail S	-0.200 ^{NS}	-0.237 ^{NS}	0.064 ^{NS}	0.055 ^{NS}	-0.215 ^{NS}	-0.258 ^{NS}	0.127 ^{NS}	-0.140 ^{NS}

Table 23. The acid insolubles, sesquioxides, organic carbon and organic matter content of the surface samples of PAJANCOA and RI Horticultural farm soils

Block	Field No	Acid insoluble (%)	R₂O₃ (%)	OC (g kg⁻¹)	OM(%)
	A1(a)	84.58	11.39	11.54	1.989
	A1(b)	83.14	15.50	13.56	2.337
	A2(a)	86.50	10.82	4.33	0.746
A	A2(b)	90.12	13.02	12.98	2.238
	A3(a)	88.83	7.12	3.75	0.647
	A3(b)	92.09	6.62	4.90	0.845
	A4(a)	87.63	5.65	7.79	1.343
	A4(b)	86.74	13.85	12.12	2.089
	Minimum	83.14	5.65	3.75	0.647
	Maximum	92.09	15.50	13.56	2.337
	Mean	87.45	10.50	8.87	1.529
	CV	3.31	34.82	46.73	46.73
B	B(a)	89.20	12.81	9.81	1.691
	B(b)	87.51	8.75	7.21	1.243
	Minimum	87.51	8.75	7.21	1.243
	Maximum	89.20	12.81	9.81	1.691
	Mean	88.35	10.78	8.51	1.467
	CV	1.35	26.61	21.57	21.57
	C1(a)	87.66	9.75	10.38	1.790
C	C1(b)	89.09	8.22	10.10	1.741
	C2(a)	87.04	21.54	8.37	1.442
	C2(b)	88.28	13.82	11.54	1.989
	Minimum	87.04	8.22	8.37	1.442
	Maximum	89.09	21.54	11.54	1.989
	Mean	88.02	13.33	10.10	1.741
	CV	1.00	44.72	12.99	12.989
D	D1(a)	86.49	19.19	4.62	0.796
	D1(b)	86.21	13.39	5.48	0.945
	Minimum	86.21	13.39	4.62	0.945
	Maximum	86.49	19.19	5.48	1.741
	Mean	86.35	16.29	5.05	0.870
	CV	0.23	25.16	12.12	12.122

Table 23. contd.,

Block	Field No	Acid insoluble (%)	R ₂ O ₃ (%)	OC (g kg ⁻¹)	OM(%)	
E	E1(a)	83.63	12.47	5.77	0.995	
	E1(b)	83.24	12.46	8.08	1.392	
	E2(a)	84.46	12.93	7.50	1.293	
	E2(b)	87.81	10.74	7.50	1.293	
Minimum		83.24	10.74	5.77	0.995	
Maximum		87.81	12.93	8.08	1.392	
Mean		84.79	12.15	7.21	1.243	
CV		2.45	7.95	13.86	13.856	
F	F1(a)	82.56	13.51	7.21	1.243	
	F1(b)	84.00	23.21	8.94	1.542	
	F2(a)	84.87	21.49	9.81	1.691	
	F2(b)	84.11	14.42	7.50	1.293	
	F3(a)	78.10	16.75	6.92	1.194	
	F3(b)	87.82	23.49	5.77	0.995	
	F4(a)	81.52	4.68	6.63	1.144	
	F4(b)	80.53	16.55	10.67	1.840	
	Minimum		78.10	4.68	5.77	0.995
	Maximum		87.82	23.49	10.67	1.840
	Mean		82.94	16.76	7.93	1.368
	CV		3.57	37.17	21.38	21.381
G	G1(a)	81.53	10.96	5.19	0.895	
	G1(b)	78.65	19.66	3.46	0.597	
	G2(a)	83.57	14.43	7.79	1.343	
	G2(b)	81.81	15.28	6.63	1.144	
	G3(a)	85.47	6.20	7.21	1.243	
	G3(b)	83.46	5.16	5.77	0.995	
	G4(a)	71.17	7.70	5.48	0.945	
	G4(b)	85.22	8.25	4.33	0.746	
	Minimum		71.17	5.16	3.46	0.597
	Maximum		85.47	19.66	7.79	1.343
	Mean		81.36	10.95	5.73	0.988
	CV		5.74	46.38	25.29	25.292

Table 23. contd.,

Block	Field No	Acid insoluble (%)	R ₂ O ₃ (%)	OC (g kg ⁻¹)	OM(%)
	H1(a)	74.65	13.55	4.04	0.696
	H1(b)	91.07	15.13	4.62	0.796
H	H2(a)	84.12	17.68	3.46	0.597
	H2(b)	92.96	19.83	3.17	0.547
Minimum		74.65	13.55	3.17	0.547
Maximum		92.96	19.83	4.62	0.796
Mean		85.70	16.55	3.82	0.659
CV		9.67	16.75	16.73	16.735
	I1(a)	86.31	13.00	5.77	0.995
I	I1(b)	89.17	20.29	7.21	1.243
	I2(a)	83.76	21.05	4.90	0.845
	I2(b)	69.02	11.36	4.62	0.796
Minimum		69.02	11.36	4.62	0.796
Maximum		89.17	21.05	7.21	1.243
Mean		82.07	21.42	5.63	0.970
CV		10.93	30.21	20.73	20.73
	J1(a)	81.52	15.15	4.62	0.796
J	J1(b)	89.66	8.38	5.48	0.945
	J2(a)	86.68	7.37	4.90	0.845
	J2(b)	87.93	11.47	4.33	0.746
Minimum		81.52	7.37	4.33	0.746
Maximum		89.66	15.15	5.48	0.945
Mean		86.45	10.59	4.83	0.833
CV		4.06	33.09	10.20	10.196
	OLD1	84.84	20.52	4.33	0.746
	OLD2	89.21	9.74	4.90	0.845
Old Bot	OLD3	82.91	11.27	3.46	0.597
	OLD4	84.46	13.37	4.04	0.696
	OLD5	74.47	8.72	8.08	1.392
Minimum		74.47	8.72	3.46	0.597
Maximum		89.21	20.52	8.08	1.392
Mean		83.18	12.72	4.96	0.855
CV		6.50	36.91	36.63	36.63

Descriptive statistics for overall the acid insoluble, sesquioxides, organic carbon and organic matter content of PAJANCOA and RI, Horticultural farm surface soils

	Acid insoluble (%)	R ₂ O ₃ (%)	OC (g kg ⁻¹)	OM(%)
Minimum	69.02	4.91	3.17	0.547
Maximum	92.96	4.68	13.56	2.337
Mean	84.67	13.20	6.77	1.166
CV	5.67	37.17	39.40	39.40

Chemical properties of surface samples:

Block	Field No	Acid Insolubles (%)	R₂O₃ (%)	OC (g kg⁻¹)	OM(%)
	A1(a)	84.58	11.39	11.54	1.989
	A1(b)	83.14	15.50	13.56	2.337
A	A2(a)	86.50	10.82	4.33	0.746
	A2(b)	90.12	13.02	12.98	2.238
	A3(a)	88.83	7.12	3.75	0.647
	A3(b)	92.09	6.62	4.90	0.845
	A4(a)	87.63	5.65	7.79	1.343
	A4(b)	86.74	13.85	12.12	2.089
B	B(a)	89.20	12.81	9.81	1.691
	B(b)	87.51	8.75	7.21	1.243
C	C1(a)	87.66	9.75	10.38	1.790
	C1(b)	89.09	8.22	10.10	1.741
	C2(a)	87.04	21.54	8.37	1.442
	C2(b)	88.28	13.82	11.54	1.989
D	D1(a)	86.49	19.19	4.62	0.796
	D2(b)	86.21	13.39	5.48	0.945
E	E1(a)	83.63	12.47	5.77	0.995
	E1(b)	83.24	12.46	8.08	1.392
	E2(a)	84.46	12.93	7.50	1.293
	E2(b)	87.81	10.74	7.50	1.293
	F1(a)	82.56	13.51	7.21	1.243
	F1(b)	84.00	23.21	8.94	1.542
F	F2(a)	84.87	21.49	9.81	1.691
	F2(b)	84.11	14.42	7.50	1.293
	F3(a)	78.10	16.75	6.92	1.194
	F3(b)	87.82	23.49	5.77	0.995
	F4(a)	81.52	4.68	6.63	1.144
	F4(b)	80.53	16.55	10.67	1.840
	G1(a)	81.53	10.96	5.19	0.895
	G1(b)	78.65	19.66	3.46	0.597
G	G2(a)	83.57	14.43	7.79	1.343
	G2(b)	81.81	15.28	6.63	1.144
	G3(a)	85.47	6.20	7.21	1.243
	G3(b)	83.46	5.16	5.77	0.995
	G4(a)	71.17	7.70	5.48	0.945
	G4(b)	85.22	8.25	4.33	0.746
H	H1(a)	74.65	13.55	4.04	0.696
	H1(b)	91.07	15.13	4.62	0.796
	H2(a)	84.12	17.68	3.46	0.597
	H2(b)	92.96	19.83	3.17	0.547

Chemical properties of surface samples:

Block	Field No	Acid Inso (%)	R₂O₃ (%)	OC (g kg-1)	OM(%)
	I1(a)	86.31	13.00	5.77	0.995
I	I1(b)	89.17	20.29	7.21	1.243
	I2(a)	83.76	21.05	4.90	0.845
	I2(b)	69.02	11.36	4.62	0.796
	J1(a)	81.52	15.15	4.62	0.796
J	J1(b)	89.66	8.38	5.48	0.945
	J2(a)	86.68	7.37	4.90	0.845
	J2(b)	87.93	11.47	4.33	0.746
	OLD1	84.84	20.52	4.33	0.746
	OLD2	89.21	9.74	4.90	0.845
Old Bot	OLD3	82.91	11.27	3.46	0.597
	OLD4	84.46	13.37	4.04	0.696
	OLD5	74.47	8.72	8.08	1.392
Minimum		69.02	4.91	3.17	0.547
Maximum		92.96	4.68	13.56	2.337
Mean		84.67	13.20	6.77	1.166
CV		5.67	37.17	39.40	39.40

Table 24. pH, EC, and exchange properties of the surface soil samples of the PAJANCOA and RI, Horticultural farm soils

Block	Field No	pH	EC (dS m ⁻¹)	CEC (cmol (p+) kg-1)	Exchangeable cations (cmol (p+) kg ⁻¹)			
					Ca ²⁺	Mg ²⁺	K ⁺	Na ⁺
	A1(a)	8.28	0.67	10.60	8.50	5.00	0.58	1.17
	A1(b)	8.17	0.68	11.60	12.50	5.00	0.57	1.19
	A2(a)	5.21	1.07	8.90	10.00	4.00	0.50	1.22
A	A2(b)	5.37	1.09	8.80	10.00	2.50	0.49	1.19
	A3(a)	8.21	0.25	7.20	7.50	3.00	0.46	1.17
	A3(b)	8.45	0.23	6.00	6.50	2.00	0.45	1.22
	A4(a)	8.37	0.58	8.70	8.50	5.00	0.50	1.29
	A4(b)	8.28	0.58	10.10	9.50	5.00	0.49	1.36
Minimum		5.21	0.23	6.00	6.50	2.00	0.45	1.17
Maximum		8.45	1.09	11.60	12.50	5.00	0.58	1.36
Mean		7.54	0.64	8.99	9.13	3.94	0.51	1.23
CV		18.48	49.72	20.13	20.05	32.15	9.45	5.40
B	B(a)	7.54	0.69	55.20	28.00	4.00	0.37	3.34
	B(b)	7.59	0.68	35.00	18.50	4.00	0.33	3.06
Minimum		7.54	0.68	35.00	18.50	4.00	0.33	3.06
Maximum		7.59	0.69	55.20	28.00	4.00	0.37	3.34
Mean		7.57	0.69	45.10	23.25	4.00	0.35	3.20
CV		0.47	1.03	31.67	28.90	0.00	6.49	6.33
	C1(a)	8.62	1.19	58.40	40.00	4.00	0.45	2.96
C	C1(b)	8.75	1.12	65.20	41.00	2.00	0.46	3.11
	C2(a)	8.01	2.3	18.40	8.50	4.50	0.41	2.68
	C2(b)	7.98	1.78	49.10	29.00	4.00	0.39	2.82
Minimum		7.98	1.12	18.40	8.50	2.00	0.39	2.68
Maximum		8.75	2.30	65.20	41.00	4.50	0.46	3.11
Mean		8.34	1.60	47.78	29.63	3.63	0.43	2.89
CV		4.82	34.68	43.26	50.96	30.58	7.21	6.40
D	D1(a)	8.62	2.04	61.50	42.50	3.00	0.36	3.01
	D2(b)	8.57	2.01	57.20	49.50	4.00	0.33	2.48
Minimum		8.57	2.01	57.20	42.50	3.00	0.33	2.48
Maximum		8.62	2.04	61.50	49.50	4.00	0.36	3.01
Mean		8.60	2.03	59.35	46.00	3.50	0.35	2.75
CV		0.41	1.05	5.12	10.76	20.20	5.24	13.53

Table 24. contd.,

Block	Field No	pH	EC (dS m ⁻¹)	CEC (p+) kg-1)	Exchangeable cations (cmol (p+) kg ⁻¹)				
					Ca ²⁺	Mg ²⁺	K ⁺	Na ⁺	
E	E1(a)	7.92	0.75	25.70	11.50	6.50	0.36	2.91	
	E1(b)	8.06	0.74	21.90	13.00	5.00	0.29	2.77	
	E2(a)	7.68	0.82	29.20	9.00	7.00	0.31	2.63	
	E2(b)	7.73	0.74	26.30	10.50	3.00	0.31	2.91	
	Minimum		7.68	0.74	21.90	9.00	3.00	0.29	2.63
Maximum		8.06	0.82	29.20	13.00	7.00	0.36	2.91	
Mean		7.85	0.76	25.78	11.00	5.38	0.32	2.81	
CV		2.235	5.07	11.65	15.30	33.43	9.58	4.89	
F	F1(a)	7.24	1.06	20.30	10.50	7.50	0.51	2.87	
	F1(b)	7.28	0.04	16.50	16.00	0.00	0.43	2.91	
	F2(a)	8.28	1.18	18.20	9.00	4.00	0.38	3.15	
	F2(b)	7.66	1.03	22.70	8.50	5.50	0.40	3.01	
	F3(a)	7.81	1.04	21.70	14.00	6.00	0.40	3.11	
	F3(b)	7.78	1.13	25.40	13.00	7.00	0.45	2.96	
	F4(a)	7.52	1.06	29.80	14.00	5.00	0.51	3.11	
	F4(b)	7.68	1.04	35.20	14.00	6.00	0.47	3.01	
	Minimum		7.24	0.04	16.50	8.50	0.00	0.38	2.87
	Maximum		8.28	1.18	35.20	16.00	7.50	0.51	3.15
	Mean		7.66	0.95	23.73	12.38	5.13	0.44	3.02
	CV		4.31	39.09	26.23	21.89	45.69	11.30	3.33
	G	G1(a)	8.25	0.89	21.30	12.50	6.00	0.30	3.15
G1(b)		8.18	0.74	24.60	12.00	7.50	0.27	3.01	
G2(a)		8.22	0.62	25.10	11.50	6.00	0.35	2.87	
G2(b)		8.28	1.65	26.10	10.00	6.00	0.34	3.11	
G3(a)		8.12	0.56	19.30	14.00	5.50	0.31	2.82	
G3(b)		7.25	2.12	18.80	12.50	5.50	0.33	3.87	
G4(a)		8.5	0.83	22.20	10.00	5.00	0.36	2.53	
G4(b)		8.02	0.62	28.60	10.50	5.50	0.31	2.77	
Minimum			7.25	0.56	18.80	10.00	5.00	0.27	2.53
Maximum			8.50	2.12	28.60	14.00	7.50	0.36	3.87
Mean		8.10	1.00	23.25	11.63	5.88	0.32	3.02	
CV		4.582	56.71	14.75	12.11	12.66	9.13	13.21	

Table 24. contd.,

Block	Field No	pH	EC (dS m ⁻¹)	CEC (cmol (p+) kg ⁻¹)	Exchangeable cations (cmol (p+) kg ⁻¹)			
					Ca ²⁺	Mg ²⁺	K ⁺	Na ⁺
H	H1(a)	7.68	0.63	25.00	14.00	7.00	0.36	2.82
	H1(b)	8.03	0.6	20.10	16.00	8.00	0.40	2.82
	H2(a)	7.39	0.58	28.50	14.00	7.00	0.40	3.01
	H2(b)	7.84	0.6	30.60	14.00	4.50	0.43	2.96
	Minimum		7.39	0.58	20.10	14.00	4.50	0.36
Maximum		8.03	0.63	30.60	16.00	8.00	0.43	3.01
Mean		7.74	0.60	26.05	14.50	6.63	0.40	2.90
CV		3.50	3.42	17.62	6.90	22.54	7.29	3.39
I	I1(a)	8.20	0.53	17.90	17.00	3.00	0.38	3.25
	I1(b)	8.32	0.68	19.60	17.00	5.50	0.33	3.20
	I2(a)	8.12	0.52	18.00	14.00	4.00	0.36	3.30
	I2(b)	8.02	0.57	17.30	13.00	4.00	0.37	3.15
	Minimum		8.02	0.52	17.30	13.00	3.00	0.33
Maximum		8.32	0.68	19.60	17.00	5.50	0.38	3.30
Mean		8.17	0.58	18.20	15.25	4.13	0.36	3.22
CV		1.55	12.74	5.40	13.52	24.99	5.50	1.91
J	J1(a)	7.83	0.62	11.80	17.00	3.00	0.37	2.63
	J1(b)	7.86	0.57	10.60	12.00	8.00	0.36	3.20
	J2(a)	7.96	0.83	11.70	12.00	7.00	0.40	3.25
	J2(b)	7.18	0.54	11.70	13.50	7.50	0.28	3.15
	Minimum		7.18	0.54	10.60	12.00	3.00	0.28
Maximum		7.96	0.83	11.80	17.00	8.00	0.40	3.25
Mean		7.71	0.64	11.45	13.63	6.38	0.35	3.06
CV		4.62	20.45	4.97	17.31	35.87	15.02	11.30
Old Bot	OLD1	8.17	0.75	5.70	5.00	1.50	0.43	3.25
	OLD2	8.31	0.66	6.90	9.00	1.50	0.35	3.15
	OLD3	8.52	0.19	6.30	7.50	3.50	0.36	3.15
	OLD4	8.23	0.76	8.90	9.00	3.00	0.42	3.34
	OLD5	8.36	0.75	7.90	8.00	1.50	0.33	2.68
Minimum		8.17	0.19	5.70	5.00	1.50	0.33	2.68
Maximum		8.52	0.76	8.90	9.00	3.50	0.43	3.34
Mean		8.32	0.62	7.14	7.70	2.20	0.38	3.11
CV		1.62	39.37	17.87	21.30	44.30	12.35	8.29

Descriptive statistics for overall pH, EC and exchange properties of PAJANCOA and RI, Horticultural farm surface soils

	pH	EC (ds m ⁻¹)	CEC (cmol (p+) kg ha ⁻¹)	Exchangeable cations (cmol (p+) kg ⁻¹)			
				Ca ²⁺	Mg ²⁺	K ⁺	Na ⁺
Minimum	5.21	0.04	5.70	5.00	0.00	0.27	1.17
Maximum	8.75	2.30	65.20	49.50	8.00	0.58	3.87
Mean	7.92	0.87	22.82	14.68	4.72	0.39	2.74
CV	8.18	54.96	65.38	63.82	39.74	18.65	24.98

pH, EC and Exchangeable properties of surface samples:

Block	Field No	pH	EC (d s m- 1)	CEC [c mol (p+) kg-1]	Exchangeable cations [c mol (p+) kg-1]			
					Ca ²⁺	Mg ²⁺	K ⁺	Na ⁺
	A1(a)	8.28	0.67	10.60	8.50	5.00	0.58	1.17
	A1(b)	8.17	0.68	11.60	12.50	5.00	0.57	1.19
	A2(a)	5.21	1.07	8.90	10.00	4.00	0.50	1.22
A	A2(b)	5.37	1.09	8.80	10.00	2.50	0.49	1.19
	A3(a)	8.21	0.25	7.20	7.50	3.00	0.46	1.17
	A3(b)	8.45	0.23	6.00	6.50	2.00	0.45	1.22
	A4(a)	8.37	0.58	8.70	8.50	5.00	0.50	1.29
	A4(b)	8.28	0.58	10.10	9.50	5.00	0.49	1.36
B	B(a)	7.54	0.69	55.20	28.00	4.00	0.37	3.34
	B(b)	7.59	0.68	35.00	18.50	4.00	0.33	3.06
	C1(a)	8.62	1.19	58.40	40.00	4.00	0.45	2.96
C	C1(b)	8.75	1.12	65.20	41.00	2.00	0.46	3.11
	C2(a)	8.01	2.30	18.40	8.50	4.50	0.41	2.68
	C2(b)	7.98	1.78	49.10	29.00	4.00	0.39	2.82
D	D1(a)	8.62	2.04	61.50	42.50	3.00	0.36	3.01
	D2(b)	8.57	2.01	57.20	49.50	4.00	0.33	2.48
	E1(a)	7.92	0.75	25.70	11.50	6.50	0.36	2.91
E	E1(b)	8.06	0.74	21.90	13.00	5.00	0.29	2.77
	E2(a)	7.68	0.82	29.20	9.00	7.00	0.31	2.63
	E2(b)	7.73	0.74	26.30	10.50	3.00	0.31	2.91
	F1(a)	7.24	1.06	20.30	10.50	7.50	0.51	2.87
	F1(b)	7.28	0.04	16.50	16.00	0.00	0.43	2.91
	F2(a)	8.28	1.18	18.20	9.00	4.00	0.38	3.15
F	F2(b)	7.66	1.03	22.70	8.50	5.50	0.40	3.01
	F3(a)	7.81	1.04	21.70	14.00	6.00	0.40	3.11
	F3(b)	7.78	1.13	25.40	13.00	7.00	0.45	2.96
	F4(a)	7.52	1.06	29.80	14.00	5.00	0.51	3.11
	F4(b)	7.68	1.04	35.20	14.00	6.00	0.47	3.01
	G1(a)	8.25	0.89	21.30	12.50	6.00	0.30	3.15
	G1(b)	8.18	0.74	24.60	12.00	7.50	0.27	3.01
	G2(a)	8.22	0.62	25.10	11.50	6.00	0.35	2.87
G	G2(b)	8.28	1.65	26.10	10.00	6.00	0.34	3.11
	G3(a)	8.12	0.56	19.30	14.00	5.50	0.31	2.82
	G3(b)	7.25	2.12	18.80	12.50	5.50	0.33	3.87
	G4(a)	8.50	0.83	22.20	10.00	5.00	0.36	2.53
	G4(b)	8.02	0.62	28.60	10.50	5.50	0.31	2.77
	H1(a)	7.68	0.63	25.00	14.00	7.00	0.36	2.82
	H1(b)	8.03	0.60	20.10	16.00	8.00	0.40	2.82
H	H2(a)	7.39	0.58	28.50	14.00	7.00	0.40	3.01
	H2(b)	7.84	0.60	30.60	14.00	4.50	0.43	2.96

pH, EC and Exchangeable properties of surface samples:

Block	Field No	pH	EC (d s m-1)	CEC [c mol (p+) kg-1]	Exchangeable cations [c mol (p+) kg-1]			
					Ca ²⁺	Mg ²⁺	K ⁺	Na ⁺
	I1(a)	8.20	0.53	17.90	17.00	3.00	0.38	3.25
I	I1(b)	8.32	0.68	19.60	17.00	5.50	0.33	3.20
	I2(a)	8.12	0.52	18.00	14.00	4.00	0.36	3.30
	I2(b)	8.02	0.57	17.30	13.00	4.00	0.37	3.15
	J1(a)	7.83	0.62	11.80	17.00	3.00	0.37	2.63
J	J1(b)	7.86	0.57	10.60	12.00	8.00	0.36	3.20
	J2(a)	7.96	0.83	11.70	12.00	7.00	0.40	3.25
	J2(b)	7.18	0.54	11.70	13.50	7.50	0.28	3.15
	OLD1	8.17	0.75	5.70	5.00	1.50	0.43	3.25
	OLD2	8.31	0.66	6.90	9.00	1.50	0.35	3.15
Old Bot	OLD3	8.52	0.19	6.30	7.50	3.50	0.36	3.15
	OLD4	8.23	0.76	8.90	9.00	3.00	0.42	3.34
	OLD5	8.36	0.75	7.90	8.00	1.50	0.33	2.68
Minimum		5.21	0.04	5.70	5.00	0.00	0.27	1.17
Maximum		8.75	2.30	65.20	49.50	8.00	0.58	3.87
Mean		7.92	0.87	22.82	14.68	4.72	0.39	2.74
CV		8.18	54.96	65.38	63.82	39.74	18.65	24.98

Table 25. Total N, P, K, Ca, Mg and Na status of surface soil samples of PAJANCOA and RI Horticultural farm soils

Block	Field No	Total N (%)	Total P (%)	Total K (%)	Total Ca (%)	Total Mg (%)	Total Na (%)
	A1(a)	0.655	0.220	0.254	0.414	0.217	0.086
	A1(b)	0.703	0.125	0.259	0.517	0.279	0.078
	A2(a)	0.697	0.090	0.232	0.361	0.278	0.068
A	A2(b)	0.800	0.185	0.258	0.416	0.219	0.071
	A3(a)	0.224	0.078	0.195	0.254	0.122	0.057
	A3(b)	0.220	0.038	0.109	0.255	0.061	0.059
	A4(a)	0.505	0.062	0.176	0.360	0.247	0.057
	A4(b)	0.323	0.082	0.186	0.513	0.185	0.073
Minimum		0.220	0.038	0.109	0.254	0.061	0.057
Maximum		0.800	0.220	0.259	0.517	0.279	0.086
Mean		0.516	0.110	0.209	0.386	0.201	0.069
CV		45.091	57.04	25.100	26.065	37.98	15.612
B	B(a)	0.192	0.132	0.121	0.359	0.246	0.074
	B(b)	0.502	0.068	0.184	0.360	0.216	0.086
Minimum		0.192	0.068	0.121	0.359	0.216	0.074
Maximum		0.502	0.132	0.184	0.360	0.246	0.086
Mean		0.347	0.100	0.153	0.359	0.231	0.080
CV		63.059	45.15	29.582	0.337	9.093	10.357
	C1(a)	0.555	0.072	0.205	0.513	0.185	0.123
C	C1(b)	0.367	0.078	0.166	0.411	0.185	0.121
	C2(a)	0.371	0.056	0.194	0.410	0.185	0.111
	C2(b)	0.384	0.062	0.199	0.409	0.184	0.105
Minimum		0.367	0.056	0.166	0.409	0.184	0.105
Maximum		0.555	0.078	0.205	0.513	0.185	0.123
Mean		0.419	0.067	0.191	0.436	0.185	0.115
CV		21.673	14.497	9.146	11.823	0.152	7.353
D	D1(a)	0.279	0.048	0.218	0.363	0.249	0.119
	D1(b)	0.258	0.045	0.208	0.258	0.031	0.124
Minimum		0.258	0.045	0.208	0.258	0.031	0.119
Maximum		0.279	0.048	0.218	0.363	0.249	0.124
Mean		0.268	0.047	0.213	0.310	0.140	0.122
CV		5.436	4.694	3.116	24.04	110.18	2.46

Table 25. contd.,

Block	Field No	Total N (%)	Total P (%)	Total K (%)	Total Ca (%)	Total Mg (%)	Total Na (%)
	E1(a)	0.409	0.029	0.130	0.624	0.187	0.088
E	E1(b)	0.393	0.083	0.173	0.467	0.125	0.095
	E2(a)	0.540	0.055	0.024	0.310	0.279	0.118
	E2(b)	0.407	0.053	0.024	0.409	0.153	0.090
Minimum		0.393	0.029	0.024	0.310	0.125	0.088
Maximum		0.540	0.083	0.173	0.624	0.279	0.118
Mean		0.437	0.055	0.088	0.453	0.186	0.098
CV		15.804	40.601	86.536	28.99	36.08	14.006
	F1(a)	0.500	0.066	0.231	0.416	0.312	0.116
	F1(b)	0.455	0.117	0.104	0.363	0.311	0.100
	F2(a)	0.503	0.078	0.115	0.512	0.153	0.085
F	F2(b)	0.581	0.069	0.174	0.567	0.247	0.067
	F3(a)	0.451	0.061	0.121	0.523	0.157	0.108
	F3(b)	0.465	0.065	0.110	0.365	0.376	0.059
	F4(a)	0.579	0.067	0.144	0.208	0.250	0.103
	F4(b)	0.644	0.053	0.259	0.517	0.248	0.103
Minimum		0.451	0.053	0.104	0.208	0.153	0.059
Maximum		0.644	0.117	0.259	0.567	0.376	0.116
Mean		0.522	0.072	0.157	0.434	0.257	0.093
CV		13.612	27.117	37.770	27.502	29.81	21.975
	G1(a)	0.316	0.025	0.256	0.365	0.282	0.096
	G1(b)	0.294	0.083	0.254	0.466	0.186	0.122
	G2(a)	0.418	0.091	0.214	0.567	0.155	0.109
G	G2(b)	0.409	0.062	0.150	0.671	0.186	0.101
	G3(a)	0.363	0.035	0.148	0.465	0.217	0.084
	G3(b)	0.345	0.051	0.143	0.464	0.186	0.110
	G4(a)	0.345	0.092	0.242	0.770	0.000	0.112
	G4(b)	0.016	0.059	0.135	0.361	0.093	0.054
Minimum		0.016	0.025	0.135	0.361	0.000	0.054
Maximum		0.418	0.092	0.256	0.770	0.282	0.122
Mean		0.313	0.062	0.193	0.516	0.163	0.098
CV		40.65	40.571	27.968	27.918	51.94	21.516
	H1(a)	0.269	0.055	0.264	0.417	0.156	0.103
	H1(b)	0.313	0.046	0.214	0.730	0.282	0.095
H	H2(a)	0.319	0.058	0.157	0.520	0.281	0.057
	H2(b)	0.341	0.064	0.152	0.418	0.219	0.058
Minimum		0.269	0.046	0.152	0.417	0.156	0.057
Maximum		0.341	0.064	0.264	0.730	0.282	0.103
Mean		0.310	0.056	0.197	0.521	0.235	0.078
CV		9.729	13.633	26.869	28.30	25.46	31.04

Table 25. contd.,

Block	Field No	Total N (%)	Total P (%)	Total K (%)	Total Ca (%)	Total Mg (%)	Total Na (%)
	I1(a)	0.323	0.067	0.176	0.520	0.343	0.087
I	I1(b)	0.310	0.049	0.184	0.832	0.125	0.088
	I2(a)	0.409	0.067	0.205	0.416	0.405	0.093
	I2(b)	0.468	0.080	0.098	0.516	0.310	0.059
Minimum		0.310	0.049	0.098	0.416	0.125	0.059
Maximum		0.468	0.080	0.205	0.832	0.405	0.093
Mean		0.378	0.066	0.165	0.571	0.296	0.082
CV		19.756	18.938	28.270	31.66	40.78	18.480
	J1(a)	0.398	0.046	0.150	0.314	0.251	0.073
J	J1(b)	0.454	0.044	0.158	0.419	0.063	0.069
	J2(a)	0.316	0.070	0.119	0.421	0.126	0.081
	J2(b)	0.305	0.039	0.123	0.365	0.313	0.066
Minimum		0.305	0.039	0.119	0.314	0.063	0.066
Maximum		0.454	0.070	0.158	0.421	0.313	0.081
Mean		0.368	0.050	0.137	0.380	0.188	0.072
CV		19.232	27.025	14.242	13.472	60.58	8.895
	OLD1	0.200	0.043	0.105	0.205	0.215	0.057
	OLD2	0.247	0.046	0.100	0.307	0.215	0.044
Old Bot	OLD3	0.175	0.030	0.102	0.307	0.522	0.049
	OLD4	0.206	0.040	0.213	1.080	0.247	0.066
	OLD5	0.399	0.072	0.129	0.359	0.154	0.055
Minimum		0.175	0.030	0.100	0.205	0.154	0.044
Maximum		0.399	0.072	0.213	1.080	0.522	0.066
Mean		0.245	0.046	0.130	0.452	0.271	0.054
CV		36.658	33.738	37.049	78.71	53.41	15.143

Descriptive statistics for overall Total N, P, K status of PAJANCOA and RI Horticultural farm surface soils

	Total N (%)	Total P (%)	Total K (%)	Total Ca (%)	Total Mg (%)	Total Na (%)
Minimum	0.016	0.025	0.024	0.205	0.000	0.044
Maximum	0.800	0.220	0.264	1.080	0.522	0.124
Mean	0.395	0.069	0.169	0.448	0.215	0.086
CV	38.046	50.547	34.389	35.076	43.118	26.726

Macro Nutrient status of surface samples:

Block	Field No	Total N (%)	Total P (%)	Total K (%)
	A1(a)	0.655	0.220	0.254
	A1(b)	0.703	0.125	0.259
	A2(a)	0.697	0.090	0.232
A	A2(b)	0.800	0.185	0.258
	A3(a)	0.224	0.078	0.195
	A3(b)	0.220	0.038	0.109
	A4(a)	0.505	0.062	0.176
	A4(b)	0.323	0.082	0.186
B	B(a)	0.192	0.132	0.121
	B(b)	0.502	0.068	0.184
	C1(a)	0.555	0.072	0.205
C	C1(b)	0.367	0.078	0.166
	C2(a)	0.371	0.056	0.194
	C2(b)	0.384	0.062	0.199
D	D1(a)	0.279	0.048	0.218
	D2(b)	0.258	0.045	0.208
	E1(a)	0.409	0.029	0.130
E	E1(b)	0.393	0.083	0.173
	E2(a)	0.540	0.055	0.024
	E2(b)	0.407	0.053	0.024
	F1(a)	0.500	0.066	0.231
	F1(b)	0.455	0.117	0.104
	F2(a)	0.503	0.078	0.115
F	F2(b)	0.581	0.069	0.174
	F3(a)	0.451	0.061	0.121
	F3(b)	0.465	0.065	0.110
	F4(a)	0.579	0.067	0.144
	F4(b)	0.644	0.053	0.259
	G1(a)	0.316	0.025	0.256
	G1(b)	0.294	0.083	0.254
	G2(a)	0.418	0.091	0.214
G	G2(b)	0.409	0.062	0.150
	G3(a)	0.363	0.035	0.148
	G3(b)	0.345	0.051	0.143
	G4(a)	0.345	0.092	0.242
	G4(b)	0.016	0.059	0.135
	H1(a)	0.269	0.055	0.264
	H1(b)	0.313	0.046	0.214
H	H2(a)	0.319	0.058	0.157
	H2(b)	0.341	0.064	0.152

Macro Nutrient status of surface samples:

Block	Field No	Total N (%)	Total P (%)	Total K (%)
	I1(a)	0.323	0.067	0.176
I	I1(b)	0.310	0.049	0.184
	I2(a)	0.409	0.067	0.205
	I2(b)	0.468	0.080	0.098
	J1(a)	0.398	0.046	0.150
J	J1(b)	0.454	0.044	0.158
	J2(a)	0.316	0.070	0.119
	J2(b)	0.305	0.039	0.123
	OLD1	0.200	0.043	0.105
	OLD2	0.247	0.046	0.100
Old Bot	OLD3	0.175	0.030	0.102
	OLD4	0.206	0.040	0.213
	OLD5	0.399	0.072	0.129
Minimum		0.016	0.025	0.024
Maximum		0.800	0.220	0.264
Mean		0.395	0.069	0.169
CV		38.046	50.547	34.389

Table 26. Available N, P, K and S status of surface soil samples of PAJANCOA and RI, Horticultural farm soils

Block	Field No	Avail.N (kg ha ⁻¹)	Avail.P (kg ha ⁻¹)	Avail.K (kg ha ⁻¹)	Avail.S (mg kg ⁻¹)
	A1(a)	156.80	77.91	373.97	21.52
	A1(b)	152.10	69.81	395.34	10.29
	A2(a)	181.89	44.85	432.73	10.29
A	A2(b)	189.73	60.93	496.84	10.29
	A3(a)	112.90	29.90	261.78	20.06
	A3(b)	108.19	20.36	272.46	18.62
	A4(a)	145.82	24.96	261.78	10.29
	A4(b)	152.10	13.64	293.83	8.96
Minimum		108.19	13.64	261.78	8.96
Maximum		189.73	77.91	496.84	21.52
Mean		149.94	42.79	348.59	13.79
CV		19.18	56.79	25.60	38.24
B	B(a)	134.85	24.96	240.41	10.29
	B(b)	139.55	16.91	229.72	6.33
Minimum		134.85	16.91	229.72	6.33
Maximum		139.55	24.96	240.41	10.29
Mean		137.20	20.93	235.07	8.31
CV		2.42	27.17	3.21	33.70
	C1(a)	133.28	69.81	368.63	14.38
C	C1(b)	127.01	53.13	261.78	14.38
	C2(a)	147.39	35.25	288.49	21.52
	C2(b)	156.80	24.96	293.83	21.52
Minimum		127.01	24.96	261.78	14.38
Maximum		156.80	69.81	368.63	21.52
Mean		141.12	45.79	303.18	17.95
CV		9.56	43.24	15.12	22.95
D	D1(a)	108.19	33.06	235.07	27.54
	D1(b)	114.46	31.99	203.01	24.50
Minimum		108.19	31.99	203.01	24.50
Maximum		114.46	33.06	235.07	27.54
Mean		111.33	32.52	219.04	26.02
CV		3.98	2.33	10.35	8.28

Table 26. contd.,

Block	Field No	Avail.N (kg ha ⁻¹)	Avail.P (kg ha ⁻¹)	Avail.K (kg ha ⁻¹)	Avail.S (mg kg ⁻¹)
	E1(a)	133.28	26.89	197.67	15.78
E	E1(b)	130.14	24.96	170.96	11.64
	E2(a)	137.98	31.99	203.01	13.01
	E2(b)	98.78	28.88	181.64	13.01
Minimum		98.78	24.96	170.96	11.64
Maximum		137.98	31.99	203.01	15.78
Mean		125.05	28.18	188.32	13.36
CV		14.24	10.65	7.81	13.01
	F1(a)	142.69	27.88	331.23	18.62
	F1(b)	148.96	33.06	341.91	17.19
	F2(a)	136.42	24.01	256.44	17.19
F	F2(b)	134.85	43.57	256.44	17.19
	F3(a)	116.03	42.32	277.80	17.19
	F3(b)	105.06	26.89	267.12	20.06
	F4(a)	106.62	38.69	320.54	18.62
	F4(b)	119.17	53.13	315.20	18.62
Minimum		105.06	24.01	256.44	17.19
Maximum		148.96	53.13	341.91	20.06
Mean		126.22	36.19	295.84	18.08
CV		13.23	27.61	11.86	5.90
	G1(a)	100.35	53.13	197.67	20.06
	G1(b)	101.92	36.37	181.64	18.62
	G2(a)	106.62	24.96	229.72	23.00
G	G2(b)	103.49	35.25	219.04	21.52
	G3(a)	109.76	53.13	213.70	18.62
	G3(b)	101.92	43.57	219.04	20.06
	G4(a)	105.06	50.25	240.41	20.06
	G4(b)	89.38	44.85	224.38	13.01
Minimum		89.38	24.96	181.64	13.01
Maximum		109.76	53.13	240.41	23.00
Mean		102.31	42.69	215.70	19.37
CV		5.89	23.26	8.57	15.23
	H1(a)	97.22	33.06	240.41	10.29
	H1(b)	86.24	21.26	256.44	18.62
H	H2(a)	109.76	37.52	293.83	15.78
	H2(b)	92.51	33.06	293.83	10.29
Minimum		86.24	21.26	240.41	10.29
Maximum		109.76	37.52	293.83	18.62
Mean		96.43	31.22	271.13	13.75
CV		10.33	22.32	9.97	30.21

Table 26. contd.,

Block	Field No	Avail.N (kg ha ⁻¹)	Avail.P (kg ha ⁻¹)	Avail.K (kg ha ⁻¹)	Avail.S (mg kg ⁻¹)
	I1(a)	106.62	42.32	251.09	17.19
I	I1(b)	97.22	30.93	208.35	20.06
	I2(a)	94.08	33.06	229.72	14.38
	I2(b)	108.19	25.91	240.41	14.38
Minimum		94.08	25.91	208.35	14.38
Maximum		108.19	42.32	251.09	20.06
Mean		101.53	33.05	232.39	16.50
CV		6.83	20.76	7.85	16.45
	J1(a)	95.65	39.87	277.80	27.54
J	J1(b)	120.74	69.81	256.44	29.10
	J2(a)	122.30	46.16	261.78	21.52
	J2(b)	98.78	37.52	181.64	15.78
Minimum		95.65	37.52	181.64	15.78
Maximum		122.30	69.81	277.80	29.10
Mean		109.37	48.34	244.41	23.49
CV		12.90	30.55	17.52	25.92
	OLD1	86.24	16.91	283.15	29.10
	OLD2	84.67	16.08	235.07	13.01
Old Bot	OLD3	56.45	12.84	240.41	13.01
	OLD4	76.83	20.36	299.17	21.52
	OLD5	81.54	34.14	288.49	13.01
Minimum		56.45	12.84	235.07	13.01
Maximum		86.24	34.14	299.17	29.10
Mean		77.15	20.07	269.26	17.93
CV		15.70	41.41	10.92	40.45

Descriptive statistics for overall Available N, P, K and S status of PAJANCOA and RI, Horticultural farm surface soils

	Avail.N (kg ha ⁻¹)	Avail.P (kg ha ⁻¹)	Avail.K (kg ha ⁻¹)	Avail.S (mg kg ⁻¹)
Minimum	56.45	12.84	170.96	6.33
Maximum	189.73	77.91	496.84	29.10
Mean	117.07	36.36	265.91	17.14
CV	22.64	41.44	23.95	30.84

Available Nutrient status of surface samples:

Block	Field No	Ava.N (kg ha ⁻¹)	Ava.P (kg ha ⁻¹)	Ava.K (kg ha ⁻¹)	Avail.S (mg kg ⁻¹)
	A1(a)	156.80	77.91	373.97	21.52
	A1(b)	152.10	69.81	395.34	10.29
	A2(a)	181.89	44.85	432.73	10.29
A	A2(b)	189.73	60.93	496.84	10.29
	A3(a)	112.90	29.90	261.78	20.06
	A3(b)	108.19	20.36	272.46	18.62
	A4(a)	145.82	24.96	261.78	10.29
	A4(b)	152.10	13.64	293.83	8.96
B	B(a)	134.85	24.96	240.41	10.29
	B(b)	139.55	16.91	229.72	6.33
	C1(a)	133.28	69.81	368.63	14.38
C	C1(b)	127.01	53.13	261.78	14.38
	C2(a)	147.39	35.25	288.49	21.52
	C2(b)	156.80	24.96	293.83	21.52
D	D1(a)	108.19	33.06	235.07	27.54
	D2(b)	114.46	31.99	203.01	24.50
	E1(a)	133.28	26.89	197.67	15.78
E	E1(b)	130.14	24.96	170.96	11.64
	E2(a)	137.98	31.99	203.01	13.01
	E2(b)	98.78	28.88	181.64	13.01
	F1(a)	142.69	27.88	331.23	18.62
	F1(b)	148.96	33.06	341.91	17.19
	F2(a)	136.42	24.01	256.44	17.19
F	F2(b)	134.85	43.57	256.44	17.19
	F3(a)	116.03	42.32	277.80	17.19
	F3(b)	105.06	26.89	267.12	20.06
	F4(a)	106.62	38.69	320.54	18.62
	F4(b)	119.17	53.13	315.20	18.62
	G1(a)	100.35	53.13	197.67	20.06
	G1(b)	101.92	36.37	181.64	18.62
	G2(a)	106.62	24.96	229.72	23.00
G	G2(b)	103.49	35.25	219.04	21.52
	G3(a)	109.76	53.13	213.70	18.62
	G3(b)	101.92	43.57	219.04	20.06
	G4(a)	105.06	50.25	240.41	20.06
	G4(b)	89.38	44.85	224.38	13.01
	H1(a)	97.22	33.06	240.41	10.29
	H1(b)	86.24	21.26	256.44	18.62
H	H2(a)	109.76	37.52	293.83	15.78
	H2(b)	92.51	33.06	293.83	10.29

Available Nutrient status of surface samples:

Block	Field No	Ava.N (kg ha⁻¹)	Ava.P (kg ha⁻¹)	Ava.K (kg ha⁻¹)	Avail.S (mg kg⁻¹)
	I1(a)	106.62	42.32	251.09	17.19
I	I1(b)	97.22	30.93	208.35	20.06
	I2(a)	94.08	33.06	229.72	14.38
	I2(b)	108.19	25.91	240.41	14.38
	J1(a)	95.65	39.87	277.80	27.54
J	J1(b)	120.74	69.81	256.44	29.10
	J2(a)	122.30	46.16	261.78	21.52
	J2(b)	98.78	37.52	181.64	15.78
	OLD1	86.24	16.91	283.15	29.10
	OLD2	84.67	16.08	235.07	13.01
Old Bot	OLD3	56.45	12.84	240.41	13.01
	OLD4	76.83	20.36	299.17	21.52
	OLD5	81.54	34.14	288.49	13.01
Minimum		56.45	12.84	170.96	6.33
Maximum		189.73	77.91	496.84	29.10
Mean		117.07	36.36	265.91	17.14
CV		22.64	41.44	23.95	30.84

Fig 2 Textural analysis of profile soil samples - A block

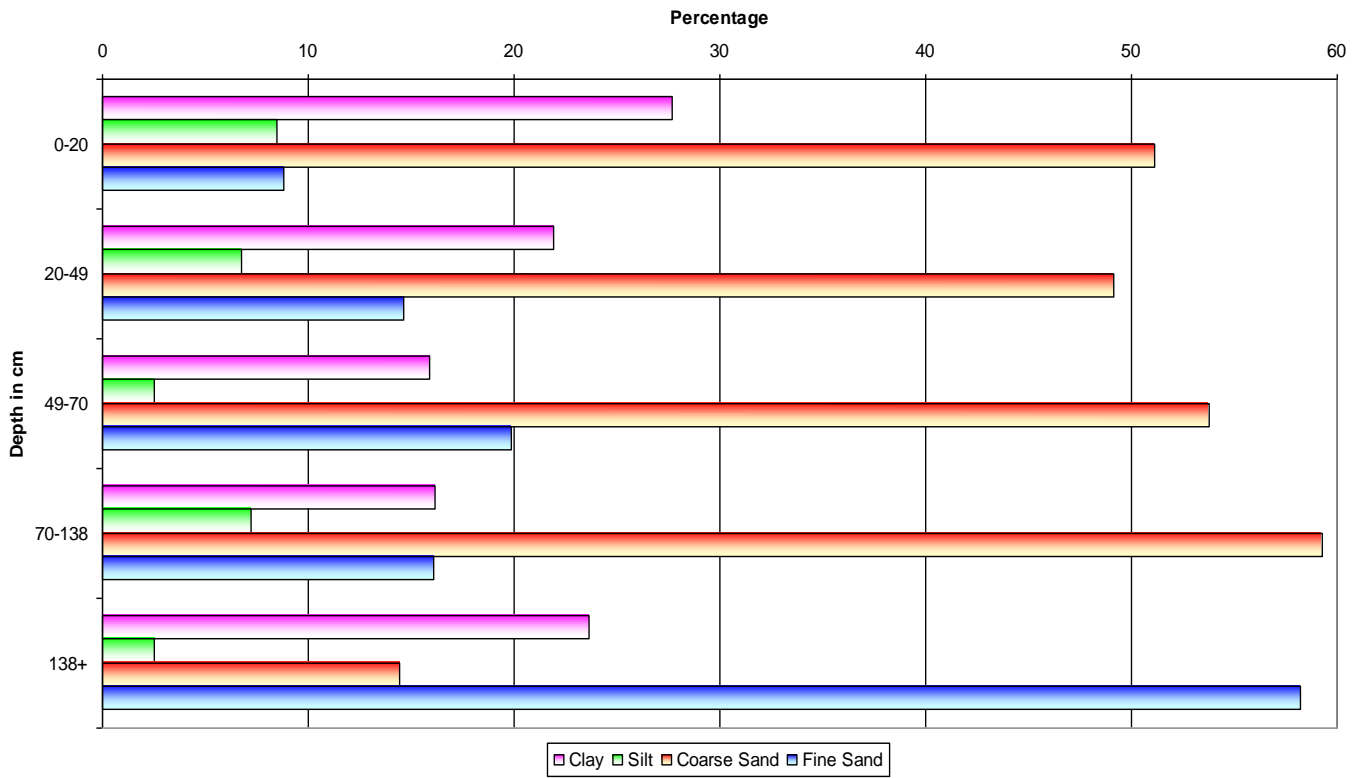


Fig 3 Textural analysis of profile soil samples - B block

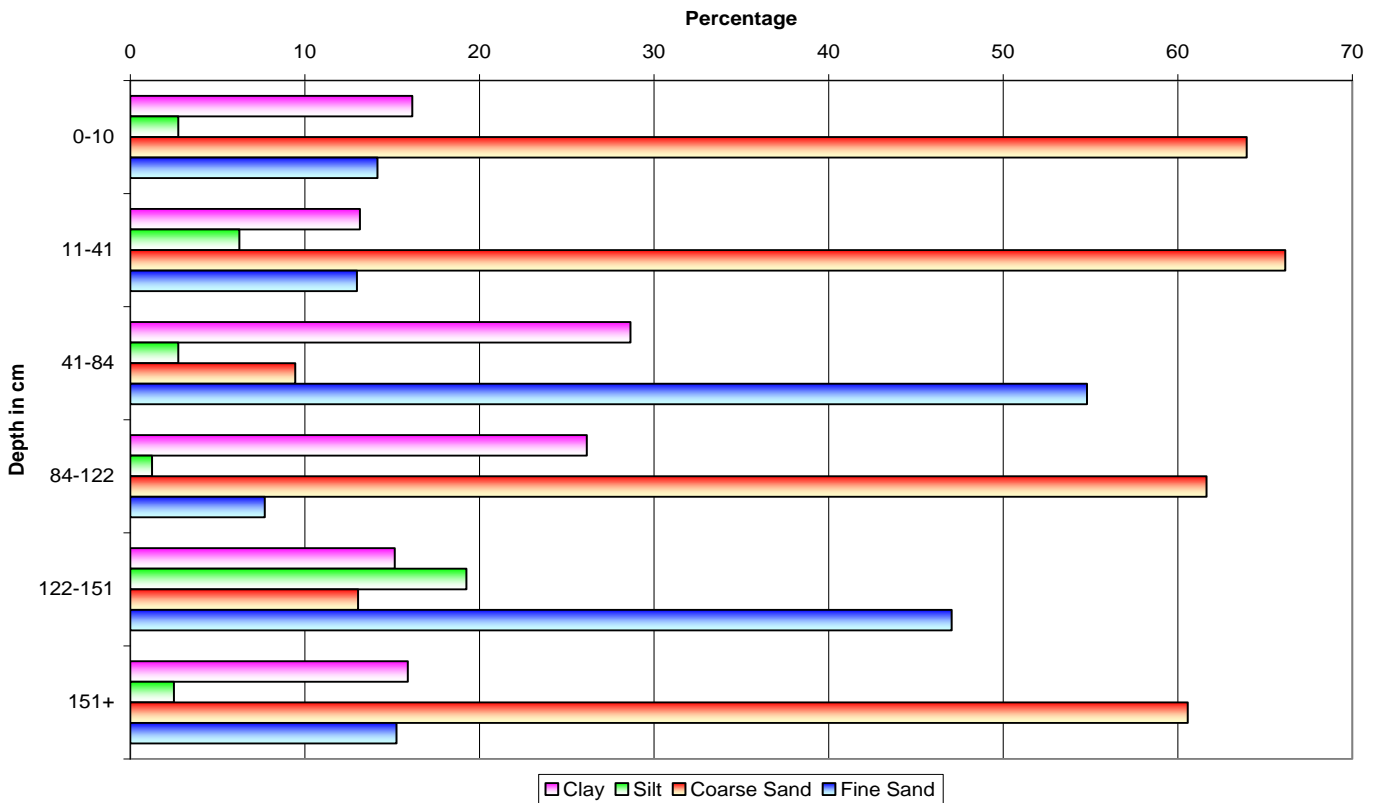


Fig 4 Textural analysis of profile soil samples - C block

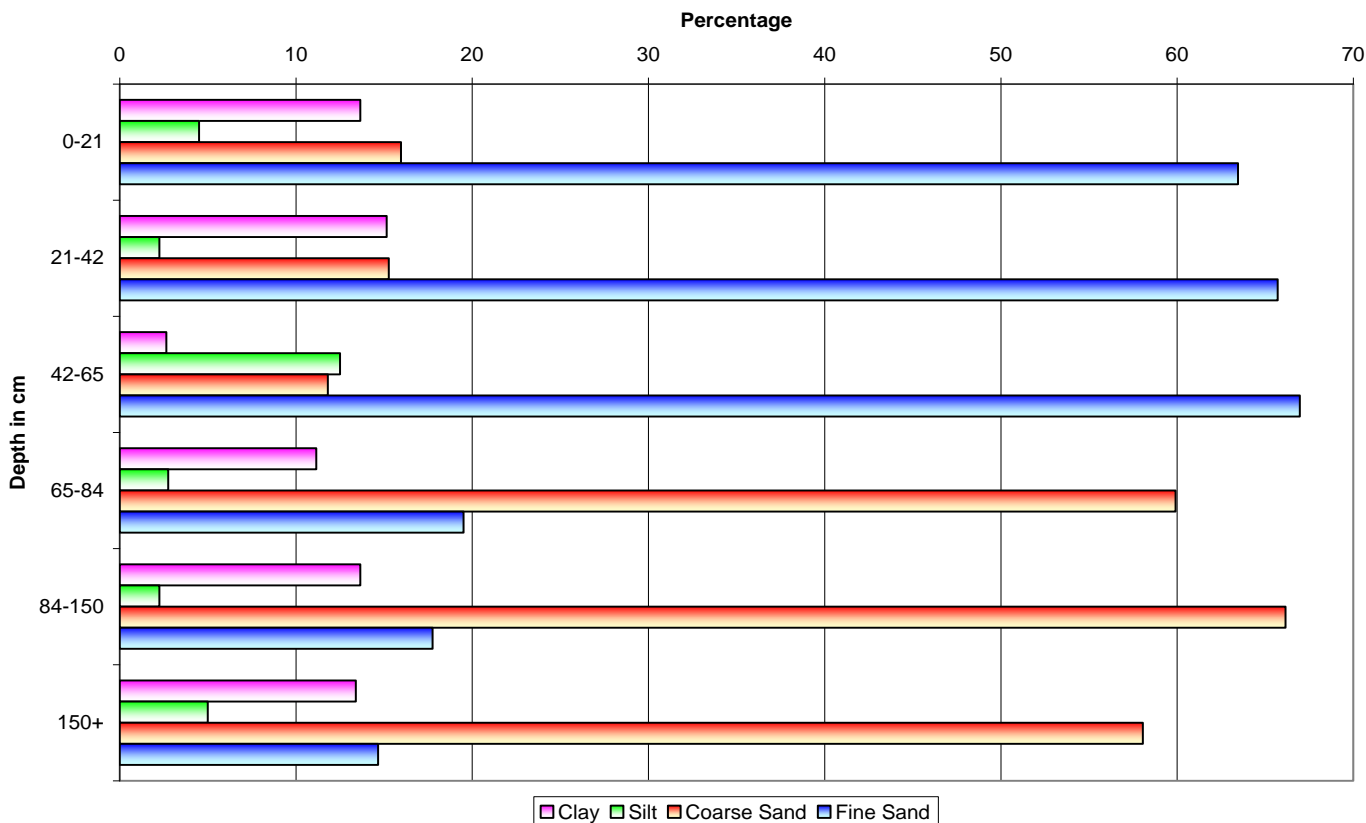


Fig 5 Textural analysis of profile soil samples - D block

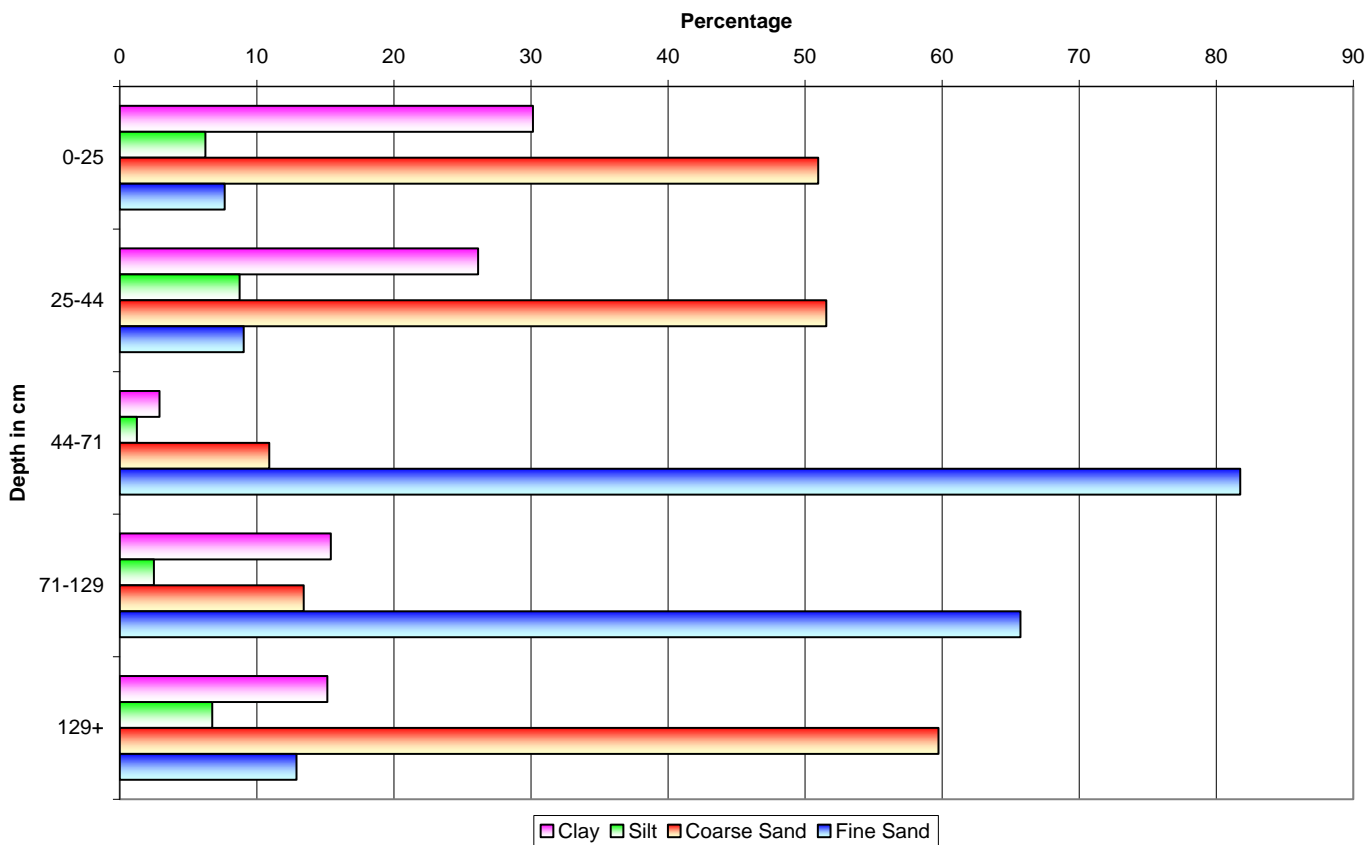


Fig 6 Textural analysis of profile soil samples - E block

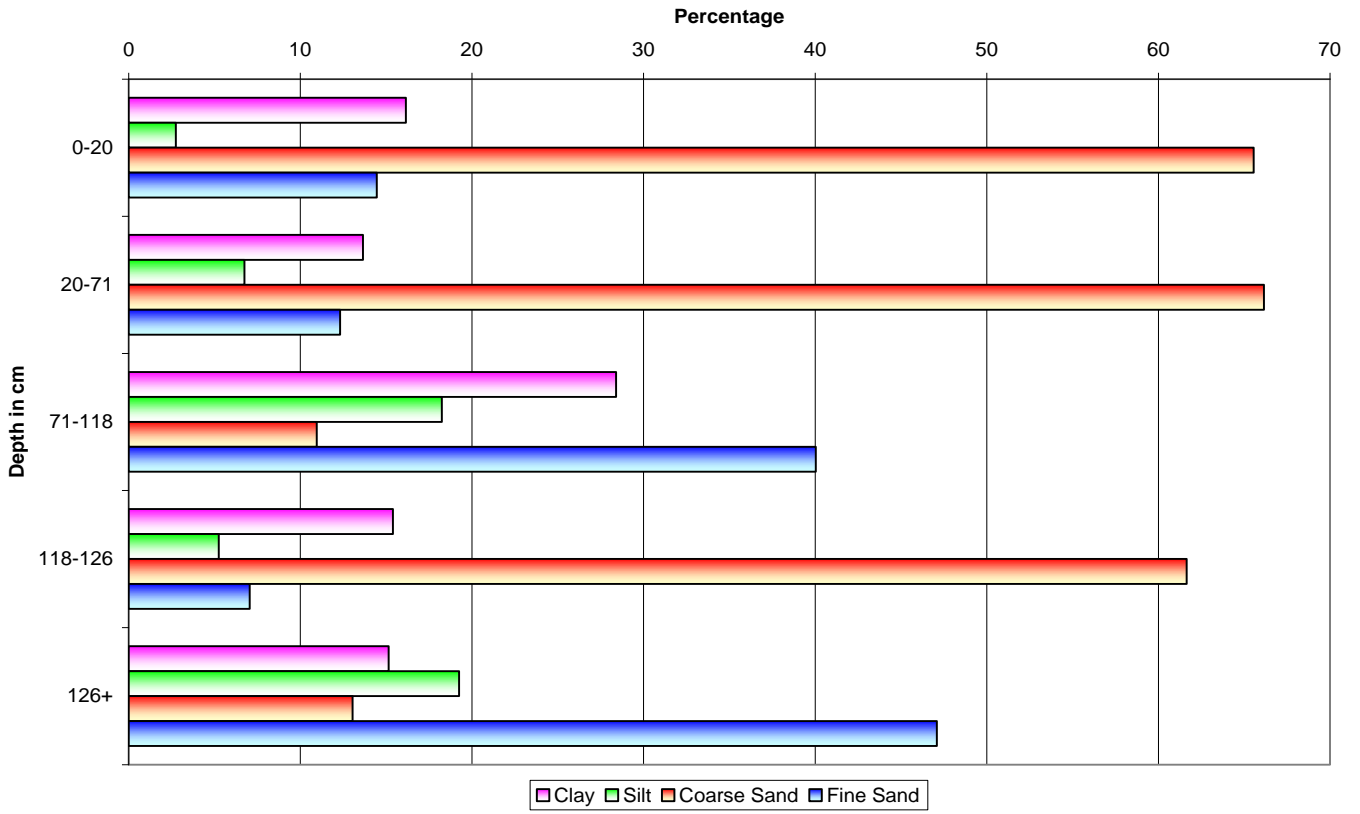


Fig 7 Textural analysis of profile soil samples - F block

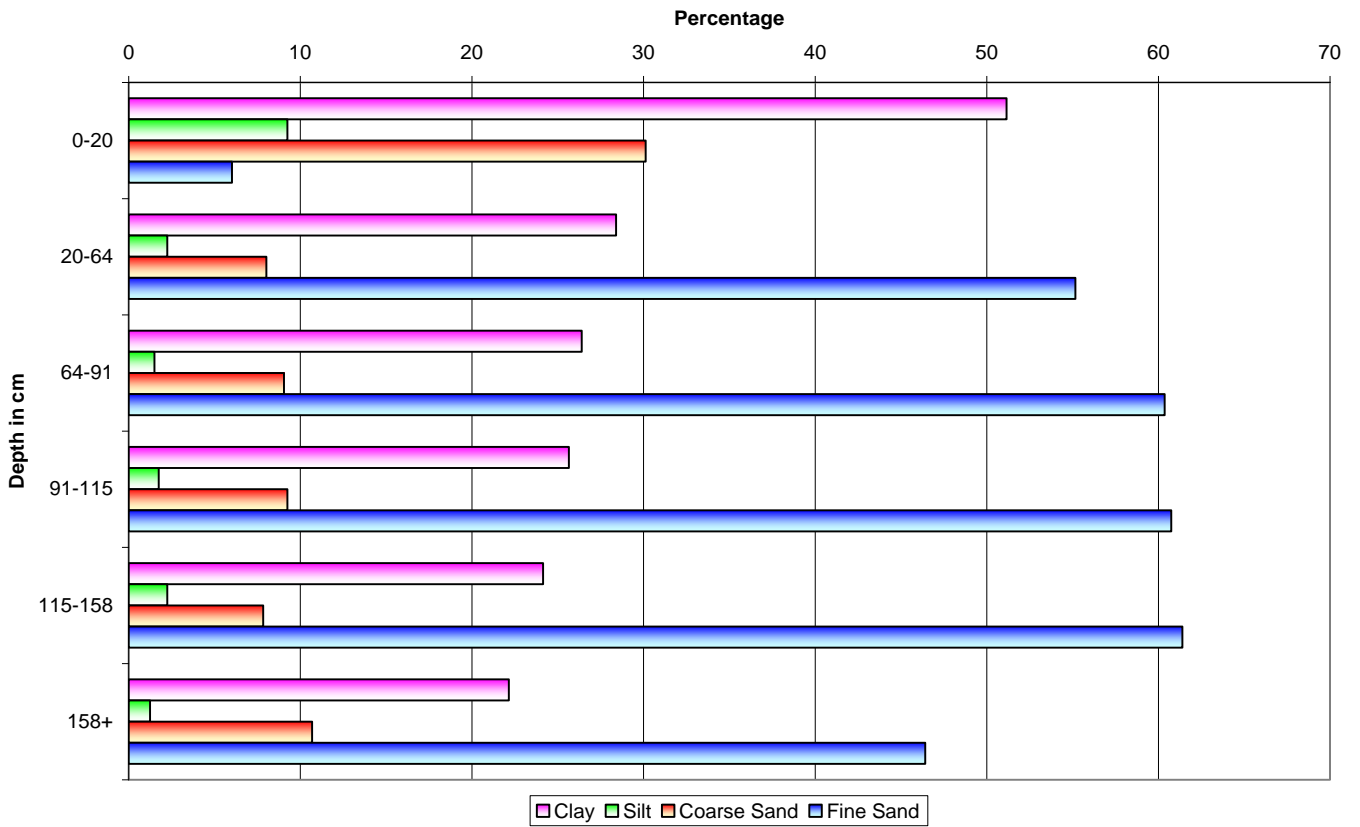


Fig 8 Textural analysis of profile soil samples - G block

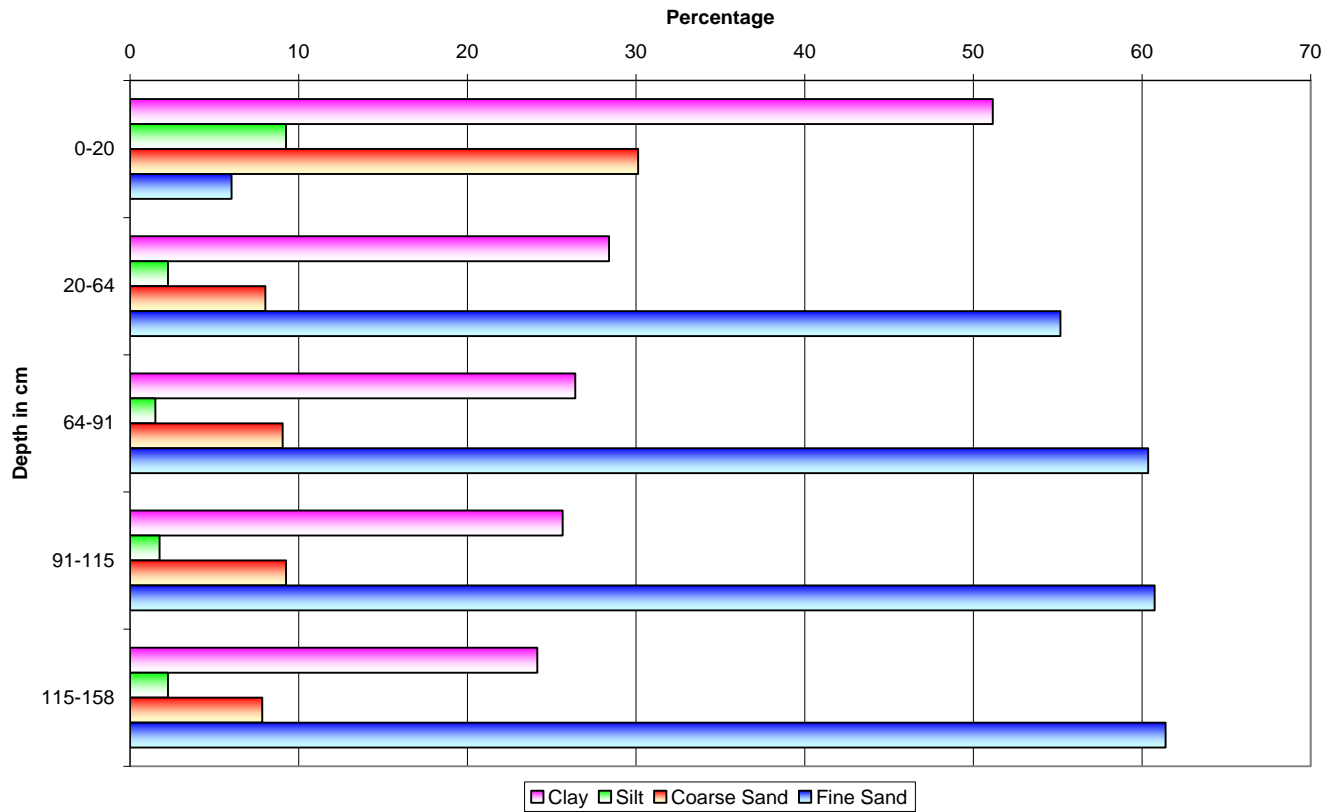


Fig 9 Textural analysis of profile soil samples - H block

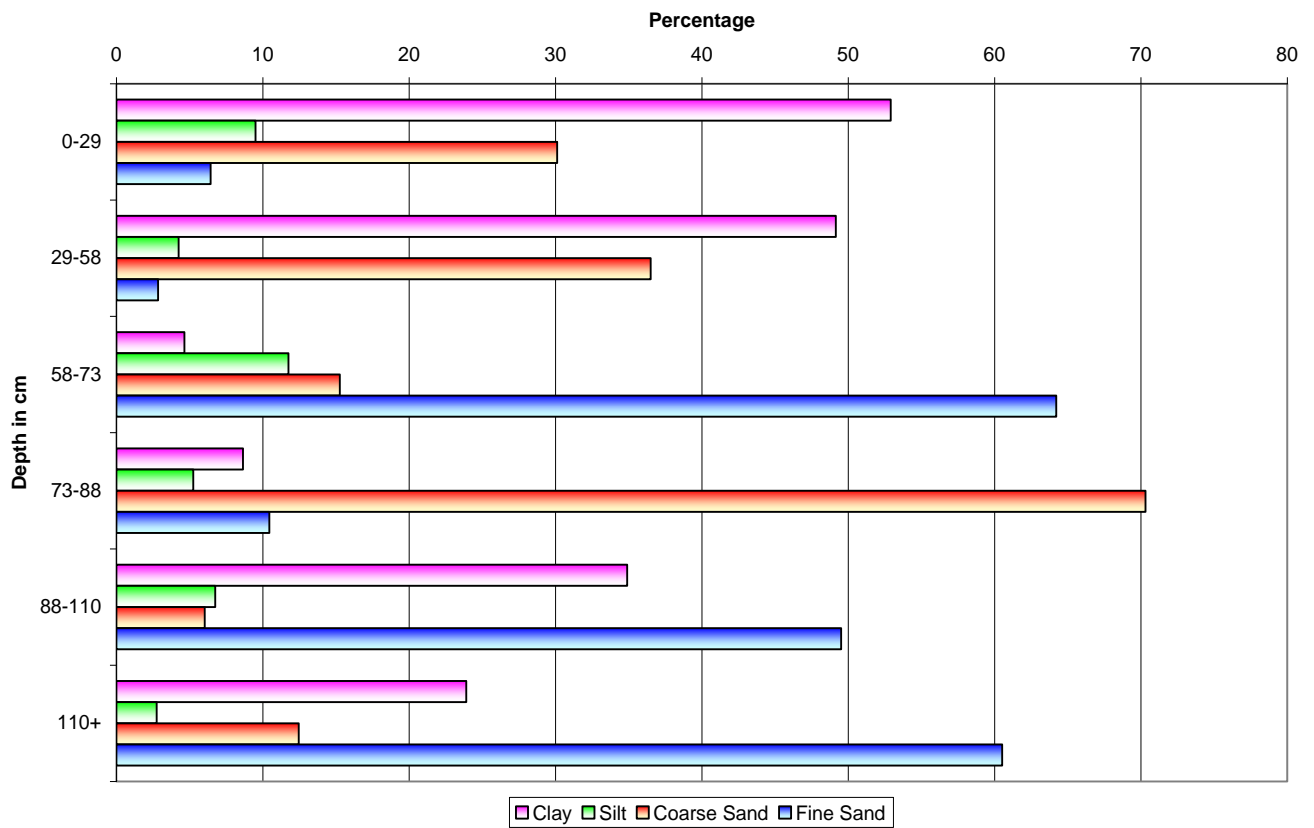


Fig 10 Textural analysis of the profile soil samples - I Block

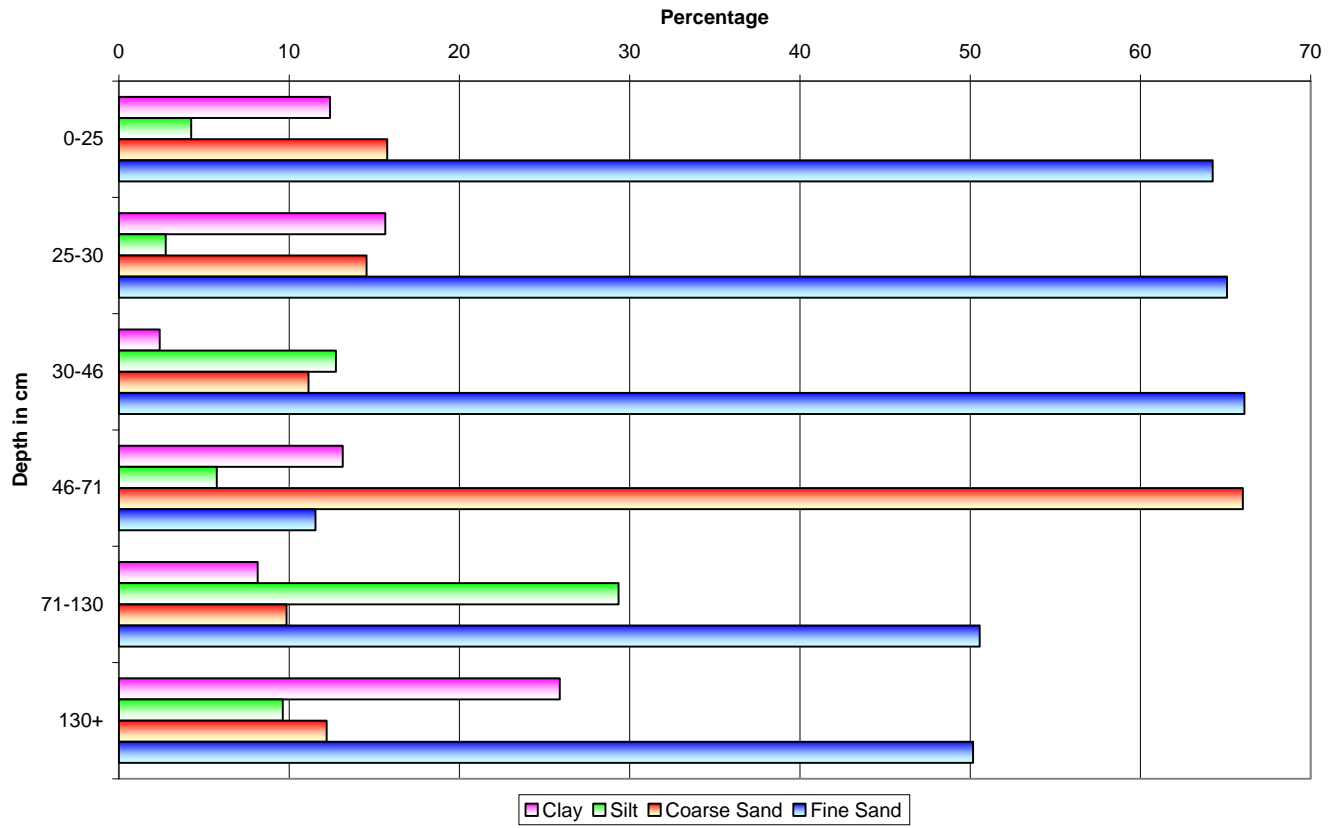


Fig 11 Textural analysis of the profile soil samples - J Block

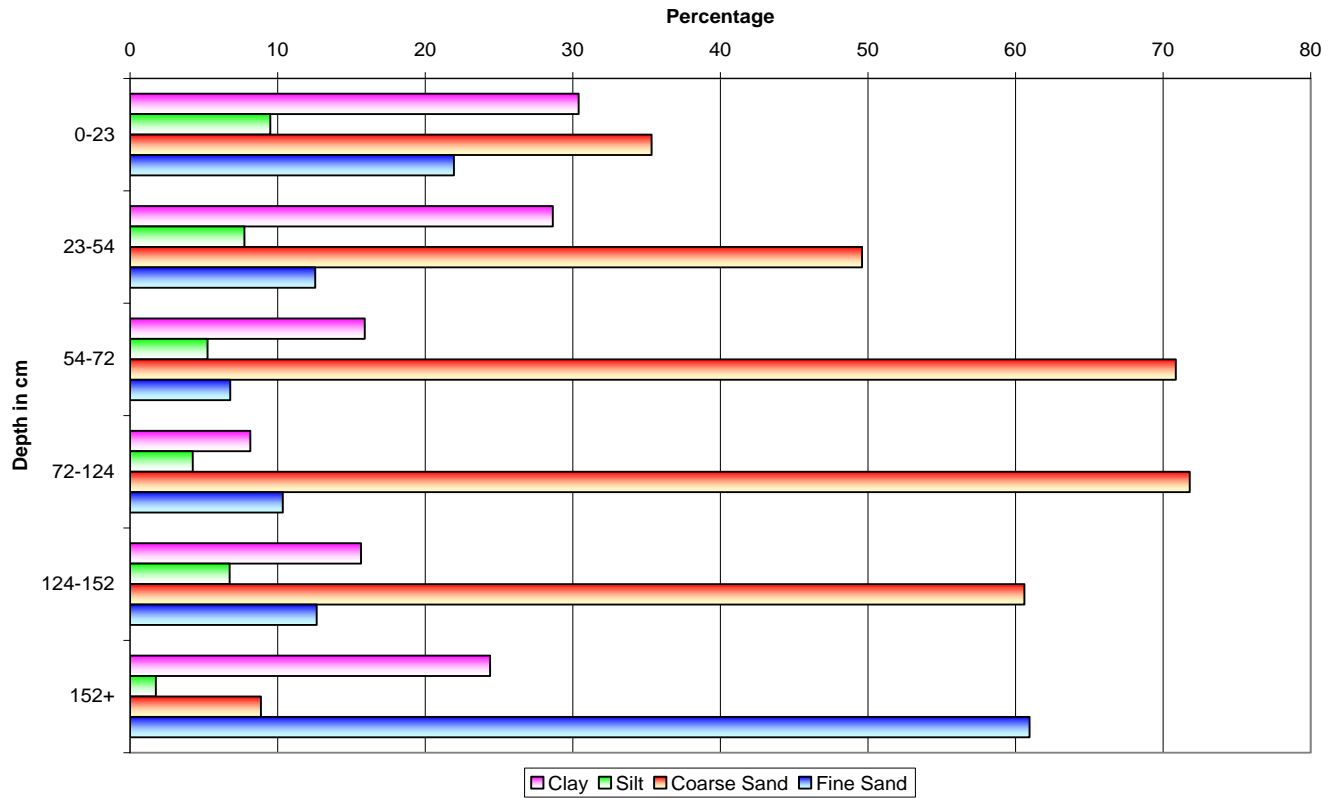


Fig 12 Textural analysis of the profile soil samples - Old Botanical gardens

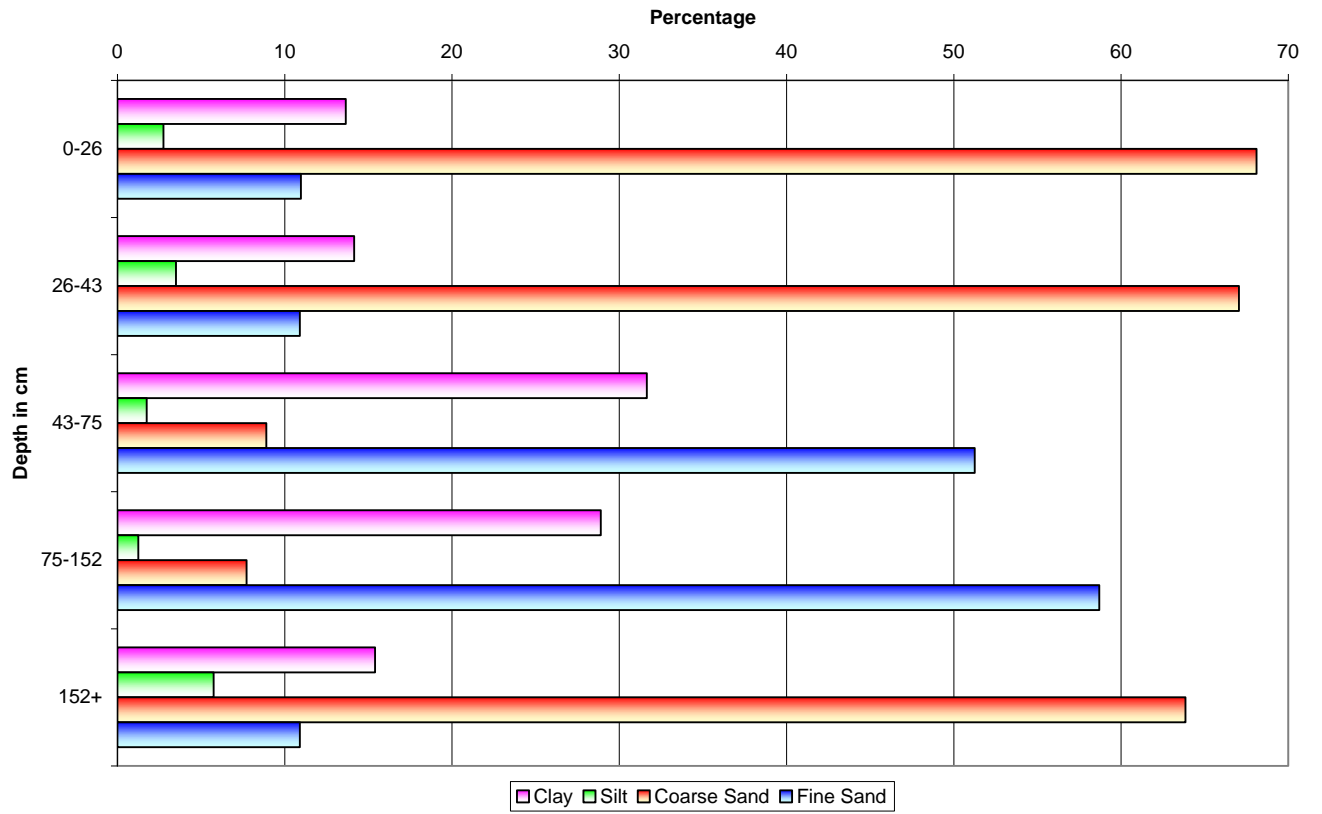


Fig 13 CEC of the Profile soil samples in different blocks of the Horticultural farm soils

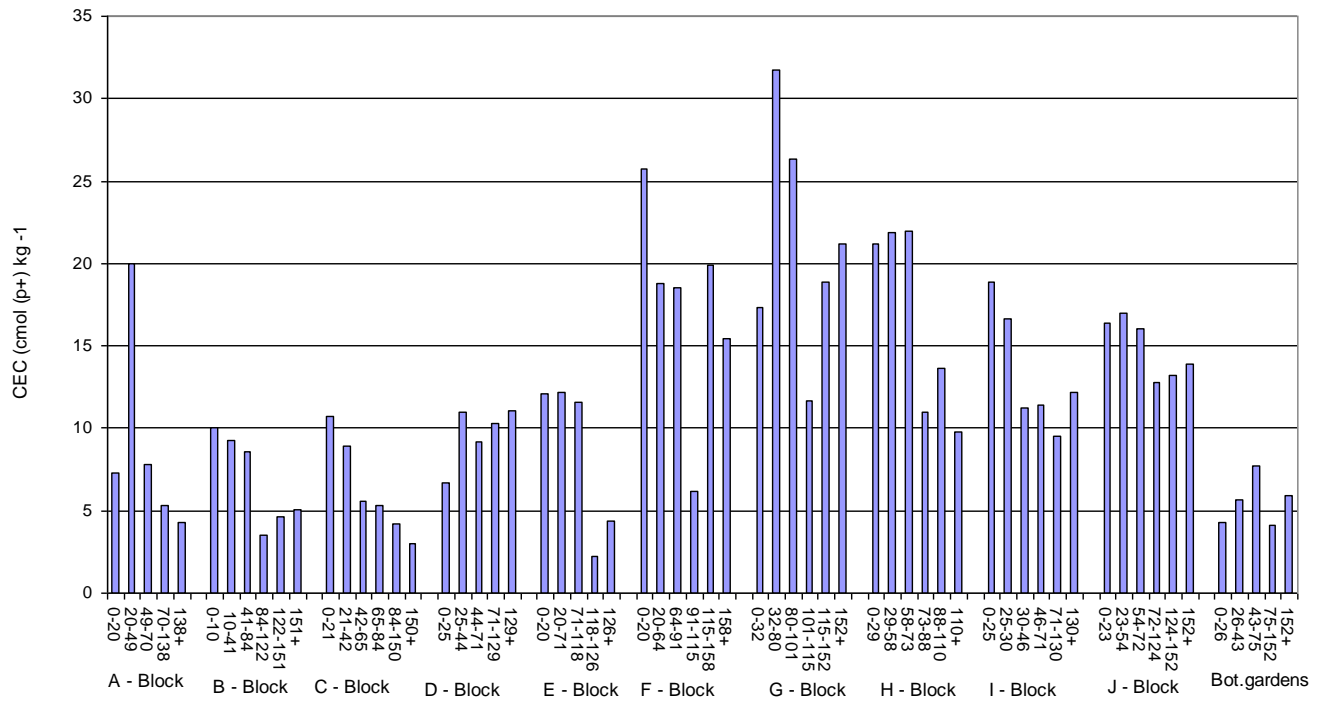


Fig 14 Available N status of the surface soil samples

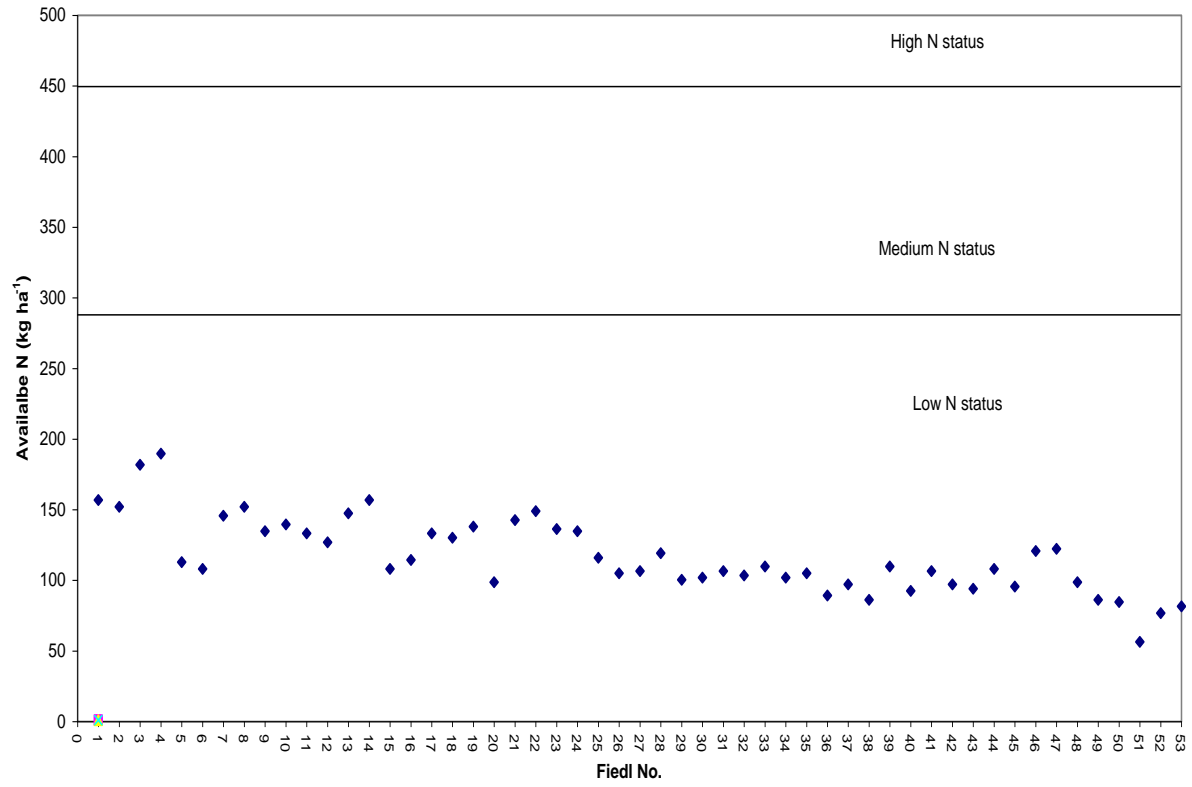


Fig 15 Available P status of the surface soil samples

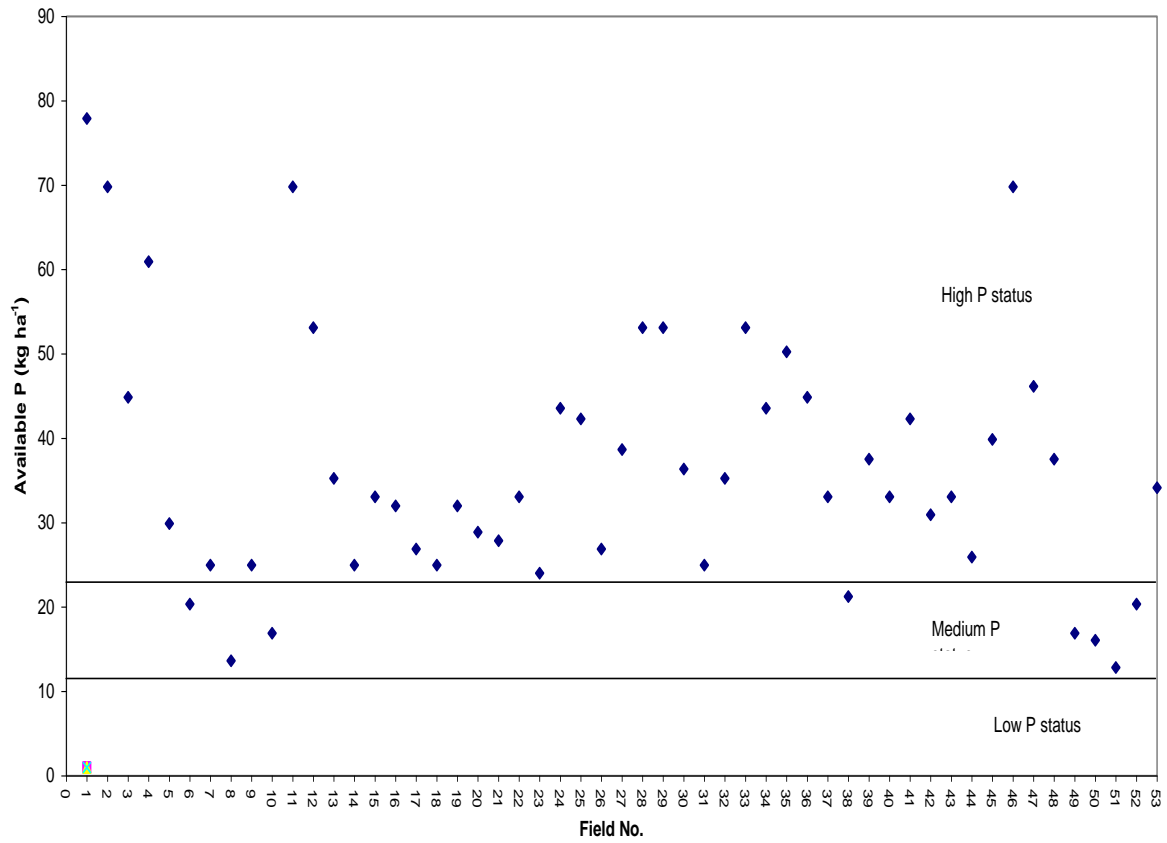


Fig 16 Available K status of the surface soil samples

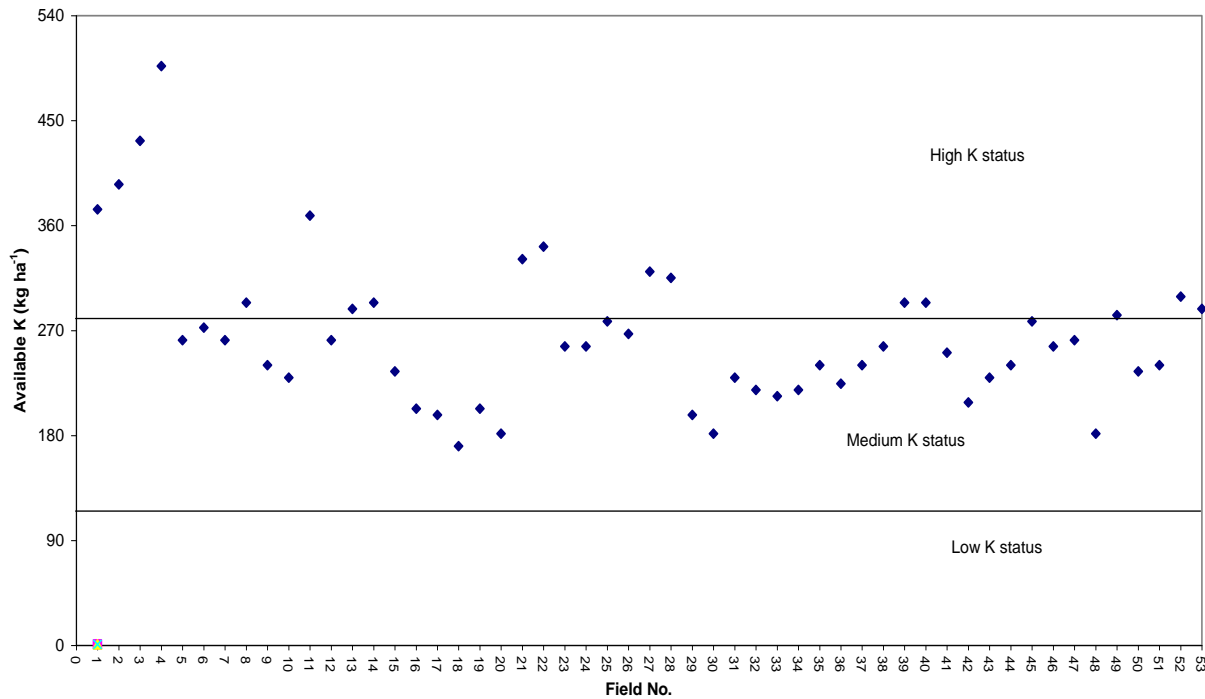


Fig 17 Available S status of the surface soil samples

