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Soil Survey of ICRISAT Farm and Type Area around Patancheru Andhra Pradesh

NBSS & LUP

ICAR

National Bureau of Soil Survey & Land Use Planning
(Indian Council of Agricultural Research)
Nagpur 440 010, India

ICRISAT

International Crops Research Institute for the Semi-Arid Tropics
Patancheru, Andhra Pradesh 502 324, India

Soil Survey of ICRISAT Farm and Type Area around Patancheru, Andhra Pradesh

by

R.S. Murthy and L.D. Swindale

Revised edition edited

by

L.D. Swindale

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Patancheru, Andhra Pradesh 502 324, India

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Acknowledgements

Survey Participants

NBSS & LUP,
Regional Centre, Bangalore

Field Work and Soil Correlation

K.R. Venugopal
N.K. Barde

Coordinators

NBSS & LUP
R.S. Murthy

ICRISAT
L.D. Swindale

Initial Editors

S.B. Deshpande
L.R. Hirekerur
J.C. Bhattacharjee
B.C.G. Gunasekera

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Contents

1. Introduction

As a cooperative project between the National Bureau of Soil Survey and Land Use Planning and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, Andhra Pradesh, a reconnaissance soil survey of the Type Area around Patancheru and a detailed soil survey of the ICRISAT Farm were carried out by the Bureau's Bangalore Regional Centre, during January to June 1978. The objectives of the project were:

- To map, characterise, classify and interpret the soils of the Type Area and the Farm and know their extent for effective transfer of agro-technology developed at ICRISAT Center to similar soils, and
- To study the soil-geomorphic relationships of red soils (Alfisols) and black soils (Vertisols) occurring in the Type Area and on the Farm.

2. General Description of the Area

2.1 Location and Extent:

The Type Area is located between 17°25' to 17°40'N latitude and 78°05' to 78°20'E longitude. The ICRISAT Farm is located in the centre of the right half of the Type Area (Fig. 1). The total area surveyed was 73 537 hectares.

2.2 Geology, Geomorphology and Drainage:

2.2.1 Geology:

The geological formations of the area comprise the oldest rock formations of the earth's crust overlain by stratified deposits including Quaternary alluvium (Fig. 2). The rocks belong to the Precambrian and Upper Cretaceous to Lower Miocene periods. The rocks of the Precambrian period are generally coarse-grained granite, granite gneiss and diorite with scattered dolerite dykes. These rocks are grouped under Unclassified Crystallines. Quartz veins and amethyst crystals are commonly found in these rocks.

Coarse-grained granite, one of the major rock formations, is characterized by large blebs of feldspars and quartz grains of uniform size with flakes of biotite and muscovite micas. At places, the rocks are traversed by granitised basic materials which on weathering have given rise to calcareous veins and concretionary carbonate materials. The alteration of feldspars to pockets of kaolin is a common feature. The complex gneissic formations consist of gray granite, pink granite and granite-gneiss of fine texture. The mineralogical composition of these rocks consists of quartz, feldspars, biotite and muscovite. Gneissic formations are not so well marked in the area as is the coarse-grained granite.

Dolerite dykes (fine to medium grained) occur at places, and consist mainly of plagioclase feldspars and augite. The rocks occur as exposed boulders of varying size oriented along strike lines. In the south-west of the area, there is a thin capping of basalt. Isolated mounds of laterite occur in this basaltic region. Recent and older alluvium are confined to flood plains and filled valleys.

The basalts occur as tongues confined mainly to the south-western portion of the area and are extensions of the vast Deccan Trap to the north and the west. The maximum thickness of the basaltic flow is about 30 m at the highest point near Shankarpalli. It thins out gradually towards the granitic area. Near Indrakan and Jolki, it is barely 1 m thick and the superimposition of basalt over granite was observed. At places between the trap rocks some fluviatile or lacustrine deposits were seen. They were called Intertrappean beds.

The chronological succession of the geological formations (stratigraphy) of the Type Area is described as follows:

Recent	–	Recent alluvium
Pleistocene	–	Older alluvium
Deccan Trap	–	Basalts, fluvial and lacustrine
Archaean	–	Gneissic complex rocks, diorite, coarse-grained granite with dolerite dyke intrusions.

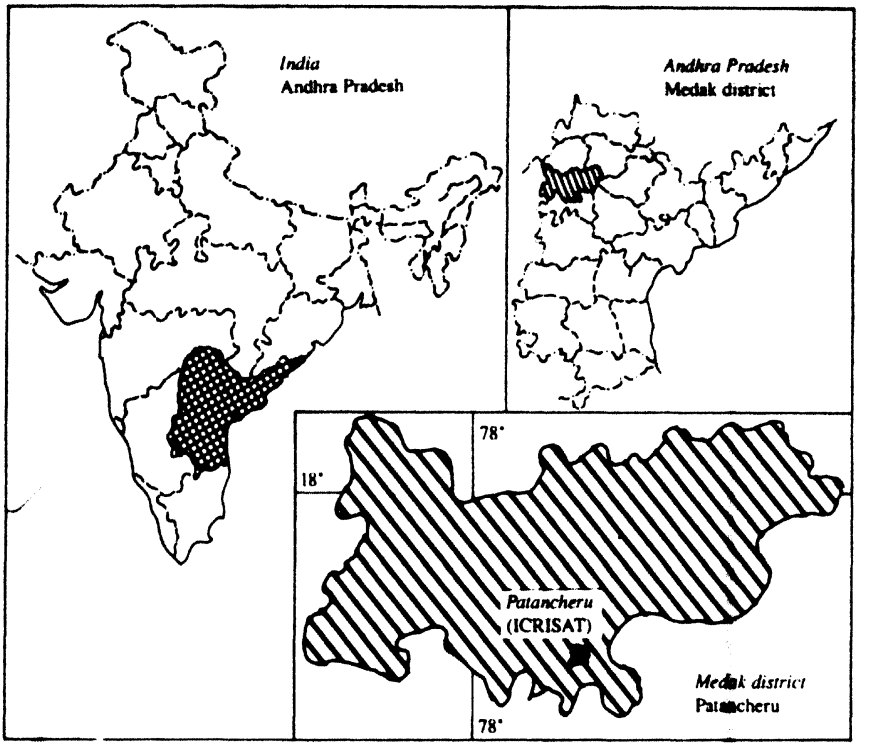

Figure 1. Location map

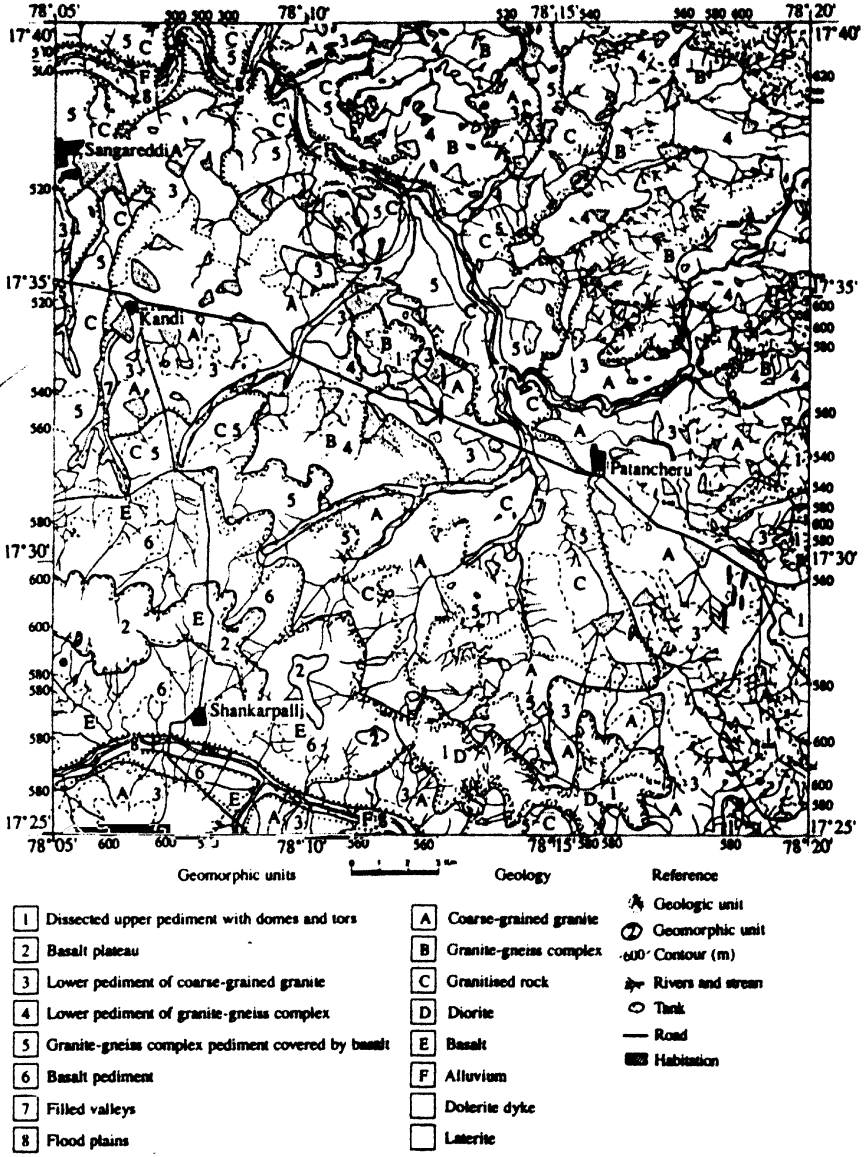

Figure 2. Geology and Geomorphology of the Type Area

2.2.2 Geomorphology and drainage:

Geomorphic study revealed that the area forms part of a peneplained surface of the ancient and stable Deccan Peninsula which had undergone several cycles of erosion, deposition and uplift. Sporadic monolithic domes and tors are also present. The general elevation ranges from 500 to 620 m above mean sea level (MSL). In the basaltic terrain in the south-west of the area, the highest point is 620 m and the lowest is 580 m above MSL and in the granite-gneiss terrain, the highest point is 610 m and the lowest is 500 m above MSL. Slope breaks in the basaltic terrain occur at 10 to 15 m intervals.

The Type Area is characterised by dendritic and parallel to sub-parallel drainage systems of different densities. The streams are mostly seasonal and active during the rainy season. The north-western part is drained by the Manjira river and the south-western part by the Musi river. The major portion drains into the Manjira river and its tributaries the Nakkavagu and the Palmavagu streams. The drainage system is most intricate in the east of the Type Area where there are several small, seasonal tanks. The drainage pattern is similar in the north-west and tanks are fewer but larger.

Eight geomorphic units were identified during the field studies (Fig. 2). Their brief descriptions are given below:

a. Dissected upper pediment with domes and tors:

The landform developed on the basement complex is dotted with domes and tors varying in height from 5 to 22 m above the pediment surface. Ephemeral streams originating from the domes and tors have dissected the upper pediment resulting in an undulating erosional surface. The upper pediment gradually merges with the lower pediment.

b. Basalt plateau:

Three flat-topped plateaus are situated in the south-western part of the area. Their heights vary from 10 to 30 m above the ground surface. The tributaries of the Manjira and the Musi rivers and the Nakkavagu stream have dissected and eroded these plateaus which merge with the granite terrain.

c. Lower pediment of coarse-grained granite:

The lower pediment of the granite terrain lies between 580 and 600 m contours in the south-west corner, between 540 and 580 m contours in south-eastern and north-eastern parts, and between 520 and 540 m contours in the north-western part. There are a few scattered, subdued dolerite dykes in the area. The drainage density is coarse.

d. Lower pediment of granite-gneiss complex:

The unit covers large areas in the north-east and small portions in the north and central parts of the Type Area. The elevation is mostly restricted to 520 to 560 m contours. It is characterized by a fine dendritic drainage system attributable to fine-grained basement rocks and colluvial deposits. It also differs from the lower pediment of coarse-grained granite in being less weathered.

e. Granite-gneiss complex pediment covered by basalt:

The landform has been developed by the deposition of outwash brought down by streams and run-off from the higher reaches of the basaltic terrain over the granite/gneiss basement complex. The landform

has average height ranging from 500 to 560 m above MSL in the area. At places, a shallow weathered mantle, calcareous in nature, occurs between the deposits and the basement rocks.

f. Basalt pediment:

This pediment surface is covered by colluvial and alluvial deposits mostly derived from the basaltic plateaus and brought down by streams and outwash. The lower reaches of this pediment surface merges with the granite/gneiss basement complex.

g. Filled valleys:

Due to the low gradient of the valleys and limited water flow the sediment carrying capacity of the streams is reduced. As a result, most of the valleys are filled by sediments. Some of the sediments are thick and consist of fine-textured materials of basaltic origin.

h. Flood plains:

Flood plains of the Manjira and the Musi rivers and the Nakkavagu stream consist of thick alluvial deposits of heterogeneous origin.

2.3 Climate:

The climate of the area is semi-arid, characterised by mild to hot summers and mild winters. According to Troll's (1965) classification the semi-arid tropics (SAT) is the region within the tropics where mean monthly rainfall exceeds mean potential evapotranspiration (PET) during 2 to 7 months of the year. Two sub-zones are recognized in the SAT. In the Dry SAT, rainfall (P) exceeds PET during 2 to 4.5 months of the year and thorny savannah vegetation is characteristic. In the Wet-Dry SAT, rainfall exceeds PET during 4.5 to 7 months and dry savannah vegetation is characteristic. The Type area around Patancheru, including the ICRISAT Farm, lies within the Wet-Dry SAT.

Generally the weather of the area is dry except during the south-west monsoon season from June to October. May is the hottest pre-monsoon month with air temperatures of 42° to 43°C. December is the coldest month with mean temperature around 20°C. The mean annual air temperature is 25.9°C. The hottest pre-monsoon month, May, is followed by stormy pre-monsoon cloud bursts in the early part of June. The regular monsoon rain occurs from the second half of June to the first week of October. The mean annual rainfall is 764.4 mm of which nearly 80% falls from June to September in most of the years. Intermittent dry spells occur occasionally during the rainy season. The pattern of rainfall is bimodal with two peaks, one in July and another in September, although there is considerable variation in rainfall from year to year.

Open pan evaporation rates (Ep) are highest in May at ICRISAT and range between 15 and 19 mm/day. The lowest Ep recorded was 1.7 mm/day in August 1975 (ICRISAT, 1976). The mean annual rainfall covers about 48% of mean annual PET in most years.

The quantum of dependable rainfall (at 75% probability) is 85 mm in the early rainy period (18 June to 15 July); 65 mm for the mid-rainy period (16 July to 12 August); 81 mm for the period 13 August to 9 September; and 72 mm from 10 September to 8 October. The total quantum of dependable annual rainfall in 1975–76 was 648 mm against the mean annual rainfall of 789 mm (ICRISAT, 1976). The meteorological data (average of 30 years) recorded at Hyderabad are presented in Table 1. The

Table 1. Climatic data of Hyderabad (1931 to 1960 average).
Latitude: 17° 27'N; Longitude: 78° 28'E; Elevation: 545 m above MSL

Months	Mean air temperature: Daily maximum (°C)	Mean air temperature: Daily minimum (°C)	Mean air temperature: Daily average (°C)	Monthly precipitation (mm)	Number of rainy days	Relative humidity: Morning 0800hrs (%)	Relative humidity: Evening 1730hrs (%)	Relative humidity: Daily average (%)	Potential evapotranspiration (PET)[1] (mm)	Actual evapotranspiration (AE)[2] (mm)
January	28.6	14.6	21.6	1.7	0.3	70	35	52.5	109.8	10.9
February	31.2	16.7	23.4	11.4	0.2	67	33	50.0	129.5	16.1
March	34.8	16.7	27.4	13.4	0.3	52	23	37.5	181.5	16.1
April	36.9	23.7	30.3	24.1	1.3	50	24	37.0	197.8	24.9
May	38.7	26.2	32.5	30.0	2.3	50	28	39.0	219.9	30.3
June	34.1	24.1	29.1	107.4	5.6	71	49	60.0	196.4	107.5
July	29.8	22.3	26.1	165.0	9.4	81	64	72.5	140.4	140.4
August	29.5	22.1	25.8	146.9	8.9	84	69	76.5	135.5	135.5
September	29.5	21.6	25.7	163.9	8.7	80	63	71.5	119.3	119.3
October	30.3	19.8	25.1	70.8	6.6	75	57	66.0	123.6	94.5
November	28.7	16.0	22.4	24.9	1.3	73	50	61.5	104.1	48.0
December	27.8	13.4	20.6	5.5	0.1	69	40	54.5	98.6	20.6
Mean annual	31.7	19.8	25.8			68.5	44.6	56.5		
Total annual				765.0	45.0				1756.4	764.1

1. Potential evapotranspiration calculated following Penman
2. Actual evapotranspiration computed following Thornthwaite and Mather (1955)

climate and soil water balance diagram for Hyderabad (Fig 3) shows monthly rainfall, temperature, deficit, recharge and utilization periods.

2.4 Natural Vegetation:

The vegetation is tropical dry deciduous type. The common trees are *Acacia sundra* (Khair), *Soymida bebrifuga* (Sonir), *Boswellia serrata* (Anduga) and *Terminalia arjuna* (Erramaddi). Some dry evergreen species like Ixora (Korivi), *Memecylon edule* (Alli) and *Mimusops hexandra* (Pala or Sapata) also occur intermixed with the dry deciduous species. The most important and valuable of all the tree species in the region is *Tectona grandis* (Teak).

The common shrubs are Cassia species, *Gymnosporia montana* (Danti), *Helicteres isora* (Gubathoda), *Holarrhena antidysenterica* (Istaripala), *Grewia* spp. (Tellajana), *Woodfordia floribunda* (Jali), and *Nyctanthes arobortristis* (Parijata).

The common grasses are *Sehima hervosum* (Canary grass), *Dochanthium annulatum* and *Chrysopogon montans*.

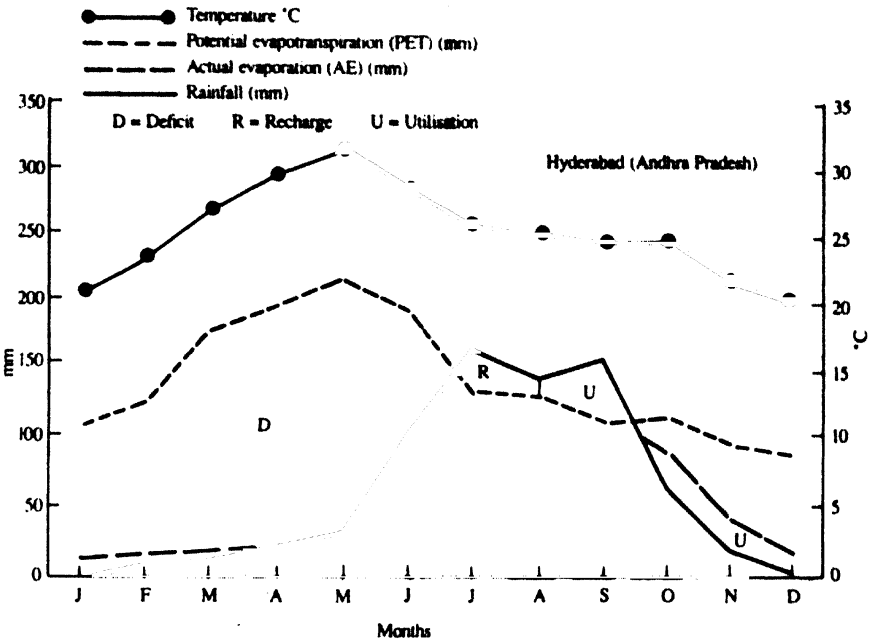

Figure 3. Climatic data and soil water balance.

2.5 Present Land Use:

The present land use of the Type Area is given in Table 2 and Fig. 4. Nearly 94% of the area is intensively cultivated mostly under dryland farming with traditional management. A small area is irrigated. The common rainy-season crops include cereals: sorghum, maize and pearl millet; pulses: pigeonpea, mungbean and blackgram; oilseeds: groundnut and safflower; and other crops, such as cotton and chillies. The common postrainy-season crops are sorghum, safflower and sunflower. Rice and sugarcane are grown under irrigation. A small percentage of the area is used for growing bananas, vegetables and grapes.

Table 2. Present land use in the Type Area.

Mapping unit numbers	Land use	Area (ha)	Percentage covered
1	Rocky and uncultivable wasteland	4 450	(6.0)
2	Rock outcrops and cultivable wasteland	1 780	(2.4)
3	Predominantly cultivated to sorghum, groundnut, safflower, pigeonpea, chickpea mostly under dryland farming; rice and vegetables under irrigation and grapevine	28 517	(38.8)
4	Predominantly cultivated to sorghum, safflower, coriander, tobacco, cotton, chillies, pigeonpea and chickpea under dryland farming with some life-saving irrigation	28 370	(38.6)
5	Predominantly cultivated to sorghum, cotton, safflower, pigeonpea, chickpea, greengram and blackgram under dryland farming	1 780	(2.4)
6	Predominantly cultivated to rice and sugarcane under irrigation	4 005	(5.4)
7	Predominantly cultivated to salt-resistant paddy under irrigation and sorghum and pulses under dryland farming	1 780	(2.4)
8	Predominantly cultivated to banana, chillies, vegetables and groundnut under irrigation	2 225	(3.1)
9	Tanks	630	(0.9)
		73 537	(100.0)

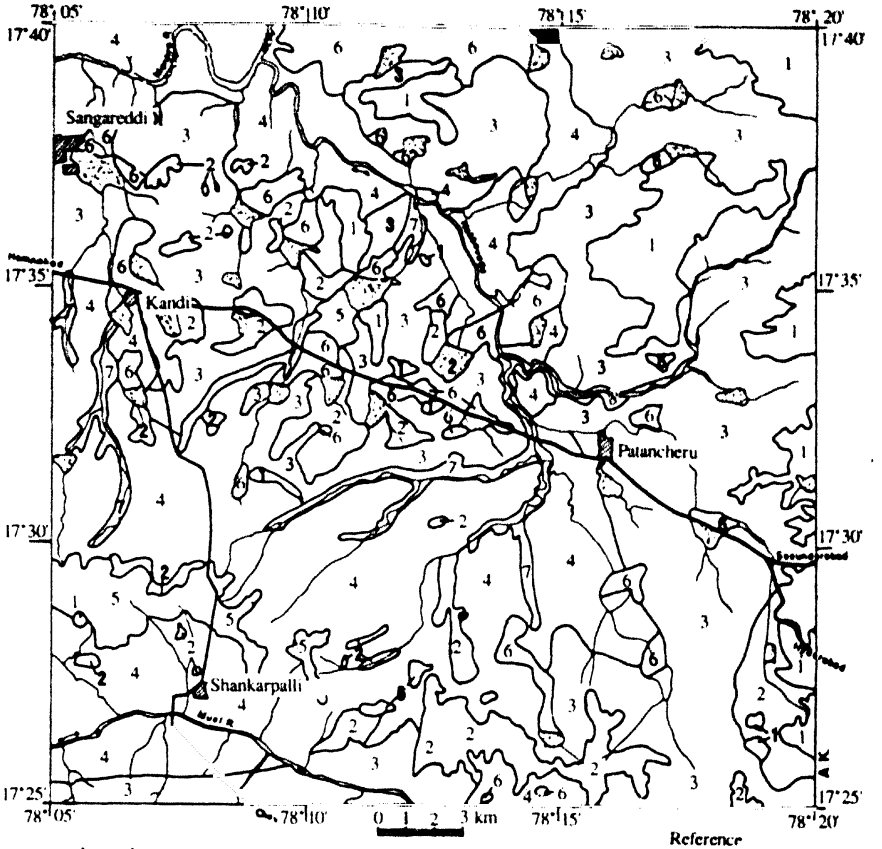

Figure 4. Present land use of the Type Area.

3. Soils of the Area

3.1 Soil Survey Technique:

Reconnaissance soil survey was carried out in the Type Area around ICRISAT and detailed survey on the ICRISAT Farm using techniques and procedures given in the Soil Survey Manuals (IARI, 1970; Soil Survey Staff, 1951).

Mapping units on a soil map are identified by names of taxa (soil series) that imply a set of soil properties. Soil series is the conceptual taxonomic unit. A soil series includes soil bodies (soil pedons) that differ only within a permissible range of morphological, physical, chemical and mineralogical properties. The soil mapping unit in a landscape unit reflects the soil pattern or the dominant soil condition of that landscape element. On a reconnaissance soil map, mapping units are associations of two or more soil series which occur in a definite pattern. Soil associations include some minor nonmappable soil entities which cover less than 15% of the mapping unit. On a detailed soil map, mapping units are combinations of phases of one identified soil series.

3.1.1 Type area:

In the reconnaissance survey, soil mapping was carried out using Survey of India toposheets in the scale of 1:50 000 as base maps. The toposheets were studied and interpreted to delineate the approximate geomorphic units in the area. Field checks during soil mapping helped in refining the geomorphic and soil boundaries. On the basis of initial traverses, auger bore samples were taken at places according to the heterogeneity indicated in the geomorphic units, and sites for studying soil pedons in detail were selected. In addition, transects were taken in a crisscross manner and additional profiles examined (Figs. 5a and 5b). On the basis of the auger bore sample studies and soil profile studies on different geomorphic units, a soil map legend was prepared for initial review and correlation. Soils were examined following normal procedures given in Soil Survey Manual (Soil Survey Staff, 1951). In all, 14 soil series were identified and mapped as soil associations.

3.1.2 ICRISAT Farm

Detailed soil survey of the ICRISAT Farm was carried out by interpretation of aerial photos. An aerial photomosaic of the ICRISAT Farm in the scale of 1:15 000 was made and certain interpretative units were delineated. A reconnaissance survey provided the key for the mapping legend of the soil mapping units encountered in the farm area. Actual mapping was done on a 1:4 000 scale cadestral maps showing village boundaries, settlement survey numbers, roads, ponds, homestead, etc. During the detailed soil survey, studies of landscape characteristics were carried out, such as microlandform units, slope breaks, surface stoniness and gravelliness, rock outcrops, past erosion, present land use and natural vegetation. Soil mapping was done by traversing the area with auger bore sample checking for soil texture and test pits were dug at frequent intervals. The phases of a soil series were differentiated either singly or in combination for texture of surface soil, slope, erosion hazard, stoniness or gravelliness and salinity/alkalinity. The combination of phases or consociations comprise the mapping units

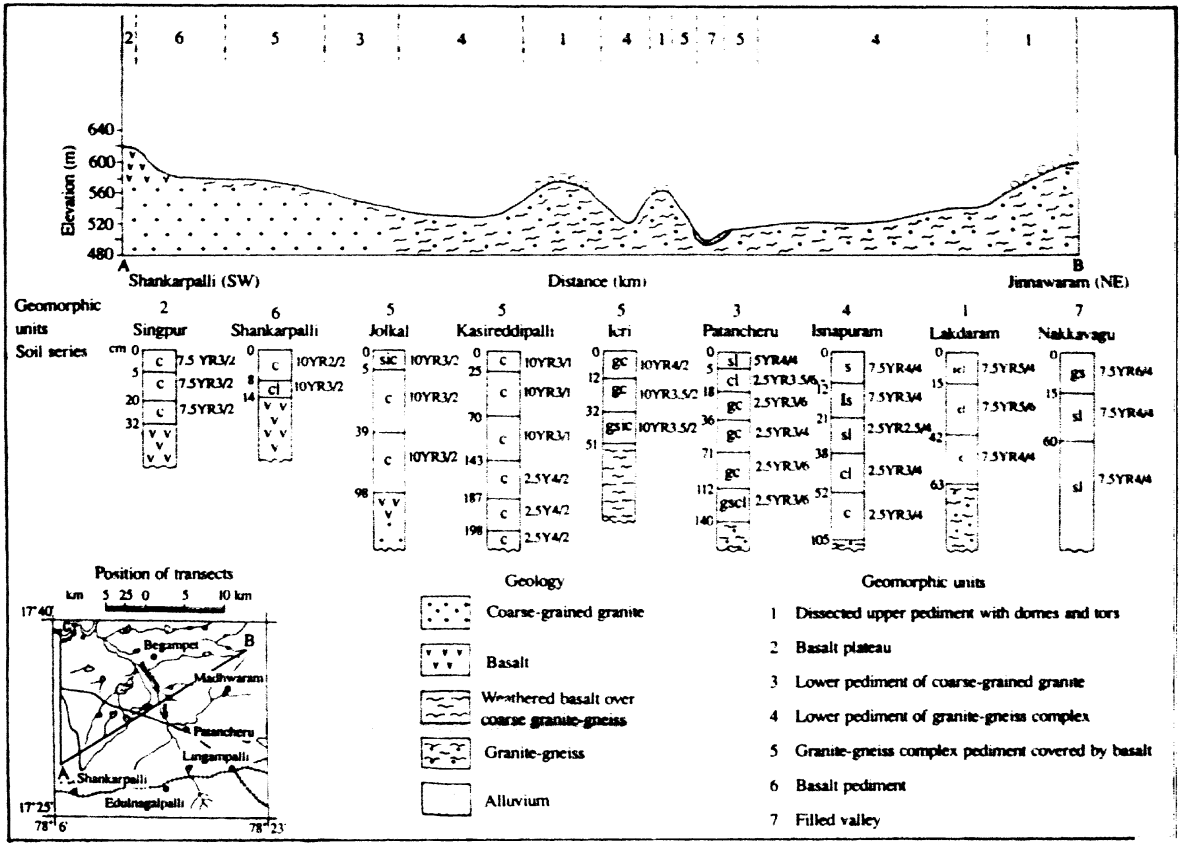

Figure 5a. Cross-section Shankarpalli to Jinnawaram.

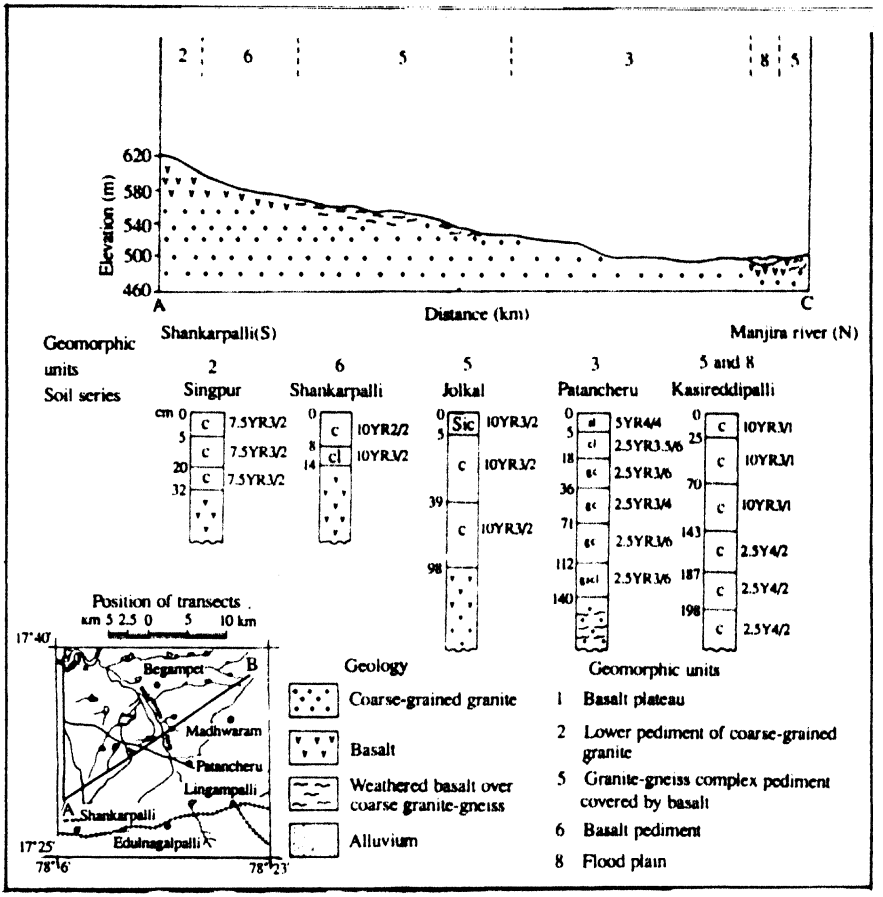

Figure 5b. Cross-section Shankarpalli to Manjira river

that were delineated on detailed soil maps. Consociation of phases are the operational units used in planning farm layouts, land treatment, land consolidation, soil conservation, land and water management and crop management for agricultural farms.

The map symbols used in delineating the consociations of phase have been described in Appendix-I. 'Explanation of map symbols'. The first capital letter of each mapping unit indicates the name of the identified series. The next small letter indicates the texture of the soil surface, the third symbol is a capital letter indicating slope class and the last one is an arabic numeral indicating the degree of past erosion. In addition, symbols for gravelliness, salinity/alkalinity could be indicated by capital letters in parentheses and stoniness and/or rockiness by suffixes to the symbol for erosion. The reconnaissance soil map of the Type Area is shown in Fig. 6. The detailed soil map of the ICRISAT Farm is shown in Fig. 7.

Legend for Soil map of the Type Area (Figure 6)

Map symbol	Soil association	Soil classification
1.	Lingampalli soils - Rock outcrops	Fine-loamy mixed isohyperthermic Lithic Rhodustalfs
2.	Lingampalli-Patancheru soils	Fine-loamy mixed isohyperthermic Lithic Rhodustalfs Clayey-skeletal mixed isohyperthermic Udic Rhodustalfs
3.	Patancheru-Lingampalli soils	Clayey-skeletal mixed isohyperthermic Udic Rhodustalfs Fine-loamy mixed isohyperthermic Lithic Rhodustalfs
4.	Rudravaram-Manmool soils	Fine-loamy mixed isohyperthermic Typic Ustropepts Fine mixed isohyperthermic Fluventic Ustropepts
5.	Lakdaram-Isnapuram soils	Fine-loamy mixed isohyperthermic Udic Haplustalfs Fine-loamy mixed isohyperthermic Udic Rhodustalfs
6.	Isnapuram-Lakdaram soils	Fine-loamy mixed isohyperthermic Udic Rhodustalfs Fine-loamy mixed isohyperthermic Udic Haplustalfs
7.	Patancheru-Isnapuram soils	Clayey-skeletal mixed isohyperthermic Udic Rhodustalfs Fine-loamy mixed isohyperthermic Udic Rhodustalfs
8.	Kasireddipalli-Icri soils	Very fine montmorillonitic isohyperthermic Typic Pellusterts Fine montmorillonitic isohyperthermic Paralithic Vertic Ustropepts
9.	Kasireddipalli-Yamkunta soils	Very fine montmorillonitic isohyperthermic Typic Pellusterts Fine montmorillonitic isohyperthermic Vertic Halaquepts
10.	Yamkunta-Manmool soils	Fine montmorillonitic isohyperthermic Vertic Halaquepts Fine mixed isohyperthermic Fluventic Ustropepts
11.	Singpur-Shankarpalli soils	Fine montmorillonitic isohyperthermic Paralithic Vertic Ustropepts Fine-loamy mixed isohyperthermic Lithic Ustorthents
12.	Shankarpalli-Jolkal soils	Fine-loamy mixed isohyperthermic Lithic Ustorthents Very fine montmorillonitic isohyperthermic Typic Chromusterts
13.	Palmavagu-Nakkavagu soils	Mixed isohyperthermic Typic Ustipsamments Coarse-loamy mixed isohyperthermic Typic Ustifluvents
14.	Nakkavagu-Rudravaram soils	Coarse-loamy mixed isohyperthermic Typic Ustifluvents Fine-loamy mixed isohyperthermic Typic Ustropepts

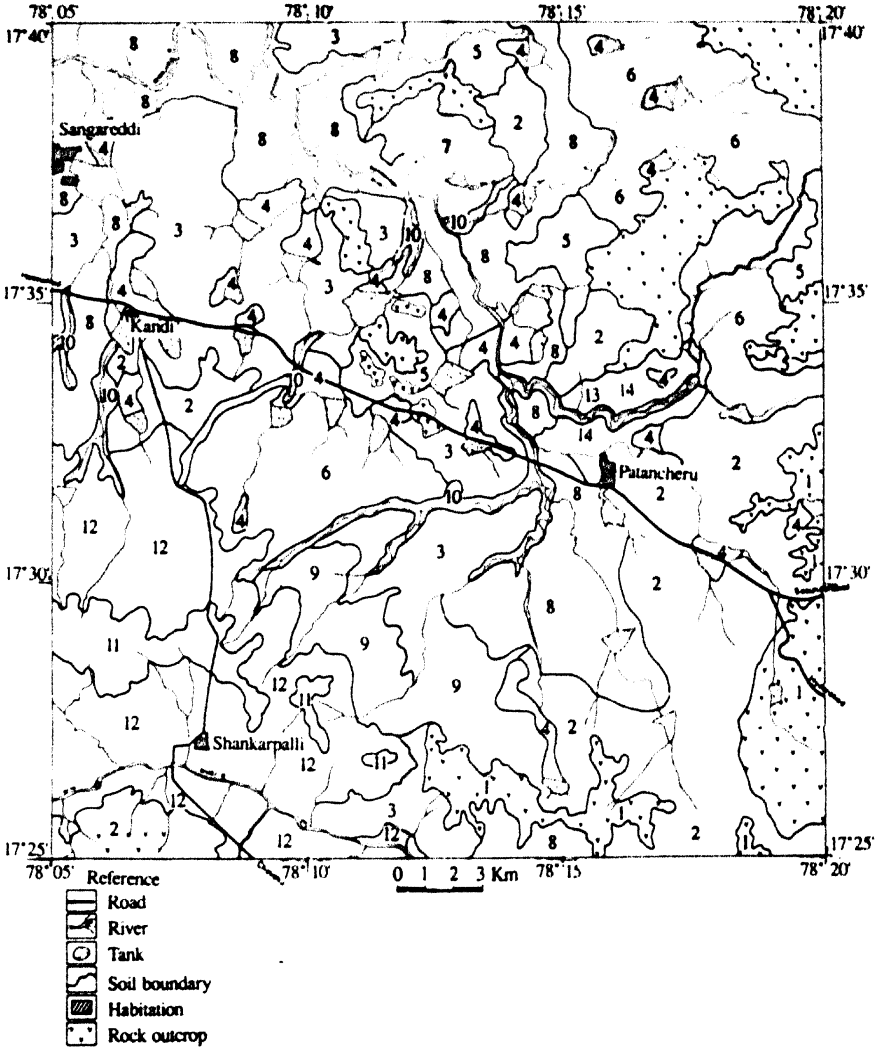

Figure 6. Soil map of the Type Area

Legend for Soil Map of the ICRISAT Farm (Figure 7)

Map symbol			Description
I. Icri Series: Fine montmorillonitic isohyperthermic Paralithic Vertic Ustropept			
IkC2	Silty clay surface	3-5%	moderate erosion
I(g)kC2	Gravelly silty clay surface	3-5%	moderate erosion
I(g)kC3	Gravelly silty clay surface	3-5%	severe erosion
ImB1	Clay surface	1-3% slope	none to slight erosion
ImB2	Clay surface	1-3% slope	moderate erosion
ImC2	Clay surface	3-5%	moderate erosion
K. Kasireddipalli series: Very fine montmorillonitic isohyperthermic Typic Pellustert			
KkC2	Silty clay surface	3-5%	moderate erosion
KMA1	Clay surface	0-1%	none to slight erosion
KMB1	Clay surface	1-3%	none to slight erosion
KMB2	Clay surface	1-3%	moderate erosion
KMC1	Clay surfce	3-5%	none to slight erosion
L. Lingampalli Series: Fine-loamy mixed isohyperthermic Lithic Rhodustalf			
LcB1	Sandy loam surface	1-3%	none to slight erosion
LcB2	Sandy loam surface	1-3%	moderate erosion
L(g)cB1	Gravelly sandy loam surface	1-3%	none to slight erosion
L(g)cB2	Gravelly sandy loam surface	1-3%	moderate erosion
LcC1	Sandy loam surface	3-5%	none to slight erosion
L(g)cC1	Gravelly sandy loam surface	3-5%	none to slight erosion
LcC2	Sandy loam surface	3-5%	moderate erosion
L(g)hA1	Gravelly sandy clay loam surface	0-1%	none to slight erosion
LhB1	Sandy clay loam surface	1-3%	none to slight erosion
LhC1	Sandy clay loam surface	3-5%	none to slight erosion
L(g)hC2	Gravelly sandy clay loam surface	3-5%	moderate erosion
M Manmool Series: Fine mixed isohyperthermic Fluventic Ustropept			
MiB1	Sandy clay surface	1-3%	none to slight erosion
MiB2	Sandy loam surface	1-3%	moderate erosion
MiC2	Sandy loam surface	3-5%	moderate erosion
MmA1	Clay surface	0-1%	none to slight erosion
MmB2	Clay surface	1-3%	none to slight erosion

Continued

Legend for Soil Map of the ICRISAT Farm (Figure 7) *continued*

Map symbol	Description			
P. Patancheru Series: Clayey-skeletal mixed isohyperthermic Udic Rhodustalf				
PbA1	Loamy sand surface	0-1%	none to slight erosion	
PcB1	Sandy loam surface	1-3%	none to slight erosion	
P(g)cB1	Gravelly sandy loam surface	1-3%	none to slight erosion	
PcB2	Sandy loam surface	1-3%	moderate erosion	
P(g)cB2	Gravelly sandy loam surface	1-3%	moderate erosion	
PcC1	Sandy loam surface	3-5%	slight erosion	
PcC2	Sandy loam surface	3-5%	moderate erosion	
P(g)cC2	Gravelly sandy loam surface	3-5%	moderate erosion	
PhA1	Sandy clay loam surface	0-1%	none to slight erosion	
P(g)hA1	Gravelly sandy clay loam surface	0-1%	none to slight erosion	
PhB1	Sandy clay loam surface	1-3%	none to slight erosion	
PhB2	Sandy clay loam surface	1-3%	moderate erosion	
P(g)hC1	Gravelly sandy clay loam surface	3-5%	none to slight erosion	
PhC2	Sandy clay loam surface	3-5%	moderate erosion	
Y. Yamkunta Series: Fine montmorillonitic isohyperthermic Vertic Halaquept				
YfC2(B)	Clay loam surface	3-5%	moderate erosion	moderate salinity/alkali hazard
YhB1	Sandy clay loam surface	1-3%	none to slight erosion	
YhB1(B)	Sandy clay loam surface	1-3%	none to slight erosion	moderate salinity/alkali hazard
YhC1	Sandy clay loam surface	3-5%	none to slight erosion	
YiA1(A)	Sandy clay surface	0-1%	none to slight erosion	strong salinity/alkali hazard
YiB1(A)	Sandy clay surface	1-3%	none to slight erosion	strong salinity/alkali hazard
YmA1(A)	Clay surface	0-1%	none to slight erosion	strong salinity/alkali hazard
YmA1(B)	Clay surface	0-1%	none to slight erosion	moderate salinity/alkali hazard
YmB1	Clay surface	1-3%	none to slight erosion	
YmB1(A)	Clay surface	1-3%	none to slight erosion	strong salinity/alkali hazard
YmB1(B)	Clay surface	1-3%	none to slight erosion	moderate salinity/alkali hazard
YmB2	Clay surface	1-3%	moderate erosion	
YmC2(B)	Clay surface	3-5%	moderate erosion	moderate salinity/alkali hazard

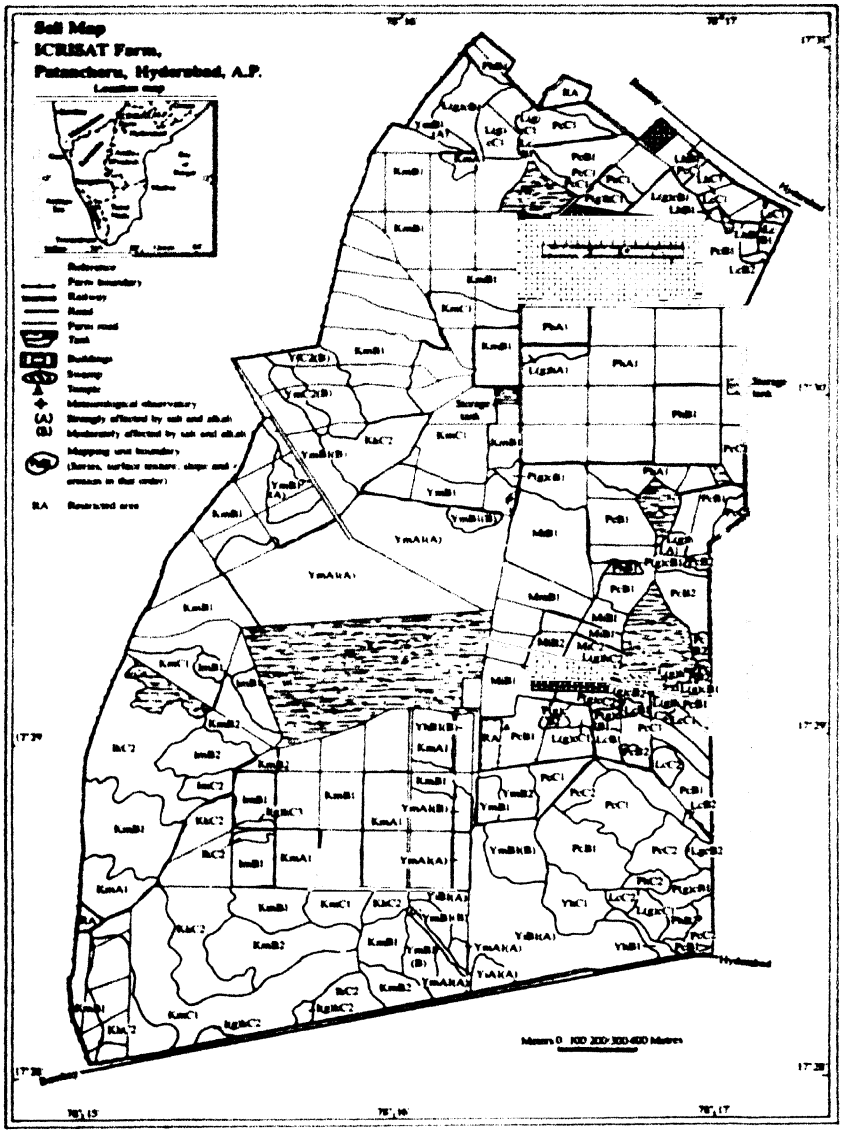

Figure 7. Detailed soil map of the ICRISAT Farm.

3.2 Soil-geomorphic Relationship

The relationship between geomorphic units and soils of the area is shown in Table 3 and Figs. 5a and 5b.

Table 3. Soil-geomorphic relationship in the Type Area.

Unit numbers	Landform unit	Soil association
1	Dissected upper pediment with domes and tors	Lingampalli soils–Rock outcrops
2	Basalt plateau	Singpur–Shankarpalli soils
3	Lower pediment of coarse-grained granite	Patancheru–Lingampalli soils
4	Lower pediment of granite-gneiss complex	Lingampalli–Patancheru soils Isnapuram–Lakdaram soils Lakdaram–Isnapuram soils Patancheru–Isnapuram soils
5	Granite-gneiss complex pediment covered by basalt	Kasireddipalli–Icri soils
6	Basalt pediment	Singpur–Shankarpalli soils Shankarpalli–Jolkal soils
7	Filled valleys	Kasireddipalli–Yamkunta soils Yamkunta–Manmool soils Nakkavagu–Rudravaram soils Rudravaram–Manmool soils
8	Flood plains	Palmavagu–Nakkavagu soils Nakkavagu–Rudravaram soils

3.3 Soils of the Type Area:

Fourteen soil series associations were mapped in the reconnaissance soil survey of the Type Area. The area under each soil association and percentage coverages are given in Table 4. The soil series are described in Appendix-II. The descriptive legend is given below.

Descriptive legend:

Mapping Unit 1: Lingampalli soils—rock outcrops.
6 615 ha, 9.0% of the total area.

The soilscape occurs on the dissected upper pediment surface which is covered by a veneer of soils of Lingampalli series. Barren domes and tors and rock outcrops occur at frequent intervals.

Lingampalli soils are the members of the fine-loamy mixed isohyperthermic family of Lithic Rhodustalfs. They are shallow, fine-loamy, reddish brown to dark reddish brown, well drained, slightly to medium acid soils on the gently sloping dissected upper pediment surface. They are underlain by partly weathered granite-gneiss. The cation exchange capacity (CEC) is between 10 to 19 me/100 g soil. Clay content increases from 17 to 19% in the surface horizons to 30 to 47% in the argillic horizon. Available water holding capacity (AWC) is comparatively low. The important limitations are shallow rooting depth to hard substrata, severe soil erodibility, and proneness to drought. Presently the soils are cultivated to sorghum and minor pulses during the rainy season. In the postrainy season Lingampalli soils are mostly left fallow./

Mapping Unit 2: Lingampalli—Patancheru soils.
630 ha, 0.9% of the total area.

The soilscape occurs on the toe slope of the dissected upper pediment where it merges gradually into the granitic lower pediment. The Lingampalli soils on the dissected upper pediment surface constitute the dominant (60–70%) component of the soil association. Patancheru soils are subordinate in this association.

Patancheru soils are the members of the clayey-skeletal mixed isohyperthermic family of Udic Rhodustalfs. They have dark brown to dark red, deep (> 1m), fine-loamy surface horizons over clayey subsurface horizons with abundant gravels. They are well drained and slightly acid to neutral. They occupy a lower position than Lingampalli soils in the soilscape. The CEC ranges from 4 to 8 me/100 g soil at the surface but varies from 10 to 15 me/100 g soil in the subsurface horizons. The AWC per meter is 160 mm. Severe erodibility, subsoil gravelliness and low to medium AWC are the main limitations for normal crop husbandry.

These soils are cultivated to sorghum, pigeonpea and maize in the rainy season under dryland farming. During the postrainy season they are mostly left fallow. Moderately high crop production is possible with irrigation.

Mapping Unit 3: Patancheru—Lingampalli soils.
16 822 ha, 23.0% of the total area.

The soilscape is more extensive than the previous one. It extends from the fringe of the dissected upper pediment to the gently sloping lower pediment on the granite/gneiss basement complex. Soils of Patancheru series occurring on the lower pediment surface dominate (60–70%).

Mapping Unit 4: Rudravaram—Manmool soils.
2 992 ha, 4.0% of the total area.

The soilscape comprises shallow depressions and valleys in the lower pediment surface filled by outwash from surrounding uplands. The multigenic outwash is of fine texture, often rich in basaltic materials and is laid over the granite/gneiss basement complex. In the soilscape very gently sloping Rudravaram soils constitute the dominant component occurring on the sides of the depressions. Level to nearly level Manmool soils occur in the bottom of depressions.

Rudravaram soils are the members of the fine-loamy mixed isohyperthermic family of Typic Ustropepts. They are grayish brown to dark grayish brown, deep, fine-loamy, slightly effervescent, and imperfectly drained with moderately alkaline reaction. The CEC of these soils ranges from 10 to 20 me/100 g soil. The weatherable mineral reserve is high and the ESP varies from 6 to 12. These are extensive soils in the shallow depressions in the Type Area mainly cultivated to rice. Imperfect drainage and slow permeability are important limitations to root zone aeration and oxygen availability to other crops.

Manmool soils are the members of the fine mixed isohyperthermic family of Fluventic Ustropepts. They are low-lying bottom land soils, deep, dark gray to very dark gray, fine, and poorly drained with moderately alkaline reaction. The soils exhibit, dusky red ferromanganese concretions 2 to 5 mm in size and a few dusky red mottlings. The CEC varies from 27 to 30 me/100 g soil. The weatherable mineral reserve is high. These soils are of limited extent in the Type Area. They are mainly cultivated to rice during the rainy season under rainfed conditions.

Mapping Unit 5: Lakdaram—Isnapuram soils.
865 ha, 1.2% of the total area.

The soilscape occurs on the gently sloping lower pediment surface of granite/gneiss basement complex.

Lakdaram soils are the members of the fine-loamy mixed isohyperthermic family of Udic Haplustalfs. They are moderately deep, brown to dark brown, fine-loamy, moderately well drained with neutral soil reaction. The CEC ranges from 5 to 12 me/100 g soil with depth; base saturation is 80% or more. Quartz dominates in the coarse fraction. Weatherable minerals range from 5 to 10%. The AWC is low (96 mm/m). Low AWC, less than optimum effective depth, and severe erodibility are the main limitations that determine the selection of adaptable crops and suitable cropping system. Presently these soils are cultivated to sorghum and pigeonpea, intercropping or sole cropped in the rainy season under rainfed conditions.

Isnapuram soils are the members of the fine-loamy mixed isohyperthermic family of Udic Rhodustalfs. They are dark brown to dark red and dark reddish brown with depth. These are very deep, well drained, fine-loamy soils with slightly acid reaction. The CEC ranges from 5 to 10 me/100 g soil in surface horizons and from 12 to 14 me/100 g soil in subsurface horizons. The base saturation is 50% in the surface layer and 80% or more in subsurface layers. The texture of the surface soil is sandy and AWC of the soil is low. Low AWC, severe erodibility and coarse texture of surface soil are some of the limitations to normal crop husbandry. The soils are cultivated to sorghum and pulses under rainfed conditions in the rainy season and are left fallow during the postrainy season.

Mapping Unit 6: Isnapuram—Lakdaram soils.
10 619 ha, 14.4% of the total area.

The soilscape occurs in gently sloping lower pediment surface of granite/gneiss basement complex. Soils of Isnapuram series cover about 60 to 70% of the soilscape.

Mapping Unit 7: Patancheru—Isnapuram soils.
472 ha, 0.6% of the total area.

The soilscape occurs on the gently sloping lower pediment surface of the granite/gneiss basement complex. Patancheru soils are dominant (>60%) in the soil association.

Both soils are susceptible to severe erosion. Less than optimum depth and low AWC are the important limitations to normal crop production. Patancheru soils are deep, but subsoil gravelliness affects the choice of crop. Both soils can be used in multiple cropping in the rainy season.

Mapping Unit 8: Kasireddipalli—Icri soils.
22 635 ha, 30.8% of the total area.

The soilscape occurs on the toe slopes of the granite-gneiss pediment surface covered with basaltic material and in filled valleys. Kasireddipalli soils are dominant in the soil association.

Kasireddipalli soils are the members of the very fine montmorillonitic isohyperthermic family of Typic Pellusterts. They are very deep, clayey soils. Colours are dominantly dark gray to very dark gray with moist chromas less than 1.5. The exchangeable complex is dominantly montmorillonitic (Pal and Deshpande, 1987a and b) and the soils have high shrink-swell potential. The CEC and AWC are high. Exchangeable sodium percentage (ESP) varies from 12 to 17, indicating possibilities of alkali hazards under inappropriate soil-water relationships. Potential soil erodibility is high. The soils are workable only over a narrow range of soil moisture. Although the soils have high AWC, plant available moisture is limited to around 30 to 40% of the total. Because the moisture retentivity of these soils is high, they can be used for rainy season multiple cropping, sequential cropping or postrainy season cropping using stored soil moisture. Imperfect internal drainage, slow to very slow subsoil permeability, high shrink-swell potential and poor workability are the important limitations to crop husbandry. The potential sodicity in subsurface horizons can be a limitation in irrigated farming without suitable subsoil drainage.

Icri soils are the members of the fine montmorillonitic isohyperthermic family of Paralithic Vertic Ustropepts. They are subordinate soils in this soil association. Icri soils are shallow, dark grayish brown, moderately well drained, and clayey with moderately alkaline reaction. The soils develop 0.5 to 1.0 cm wide vertical cracks during dry seasons. The CEC ranges from 40 to 50 me/100 g soil and divalent cations saturate more than 80% of the exchange complex. AWC is about 100 mm in the soil depth. The clay fraction is dominantly smectitic. Free calcium carbonate increases with depth. Most of the Icri soils occur under grasslands, but they can be cultivated to shallow rooted cereals and pulses during the rainy season. Moderately slow permeability, inoptimum AWC, shallow rooting depth to gravelly and pebbly substrata are the main limitations to use. With proper management, irrigated agriculture may be introduced on these soils.

Mapping Unit 9: Kasireddipalli—Yamkunta soils.
1 256 ha, 1.7% of the total area.

The soilscape covers part of the toe slope of the granite-gneiss pediment surface covered with basaltic material and intervening shallow filled valleys. Kasireddipalli soils are dominant series, occurring mostly on the toe slope of pediment surface and sides of shallow depressions. Yamkunta soils occur on bottom lands in shallow filled valleys.

Yamkunta soils are the members of the fine montmorillonitic isohyperthermic family of Vertic Halaquepts. They are very deep, dark to very dark grayish brown, imperfectly drained soils having moderately to strongly alkaline reaction. The bulk of the soil matrix between the depth of 15 and 80 cm from the surface has hues of 10 YR and 2.5 Y and a moist chroma of 2. Light gray lime nodules and

dusky red ferromanganese concretions occur at depth in the soils which are strongly effervescent. The ESP within 90 cm of the surface is about 17 and decreases thereafter with depth. The CEC varies from 27 to 37 me/100 g soil. AWC is medium to low. These soils are subject to frequent inundation. Their low location, imperfect drainage, very slow subsoil permeability, and salinity and alkali hazards pose problems for sustained cultivation. They are mostly left fallow in the rainy season. Rice cultivation perhaps would be possible.

Mapping Unit 10: Yamkunta—Manmool soils.
1 890 ha, 2.6% of the total area.

The soilscape occurs in basins. Both the soils are imperfectly drained and are subject to frequent inundation during the rainy season. Soils of Yamkunta series are more sodic. ESP in the upper part of the pedon is about 17 and decreases with depth. ESP in Manmool soils varies from 4 to 6 with depth. Yamkunta soils are mostly left fallow, but Manmool soils are cultivated to rice in the rainy season.

Mapping Unit 11: Singpur—Shankarpalli soils.
1 417 ha, 1.9% of the total area.

The soilscape occurs on nearly level to very gently sloping basalt plateaus that merge gradually to the granite-gneiss pediment surface covered by basaltic outwash. Singpur soils comprise the dominant component of the soil association.

Singpur soils are the members of the fine montmorillonitic isohyperthermic family of Paralithic Vertic Ustropepts. They are moderately well drained, shallow (30–32 cm), dark brown, clayey soils with mildly to moderately alkaline reaction. Cracks 1.0 cm wide may open and extend up to 20–25 cm vertically during dry cycles. The clay fraction is dominantly smectitic. Coarse fractions are rich in weatherable ferromagnesium minerals. AWC is low (67 mm). Divalent cations dominate in the exchange complex; base saturation is high.

Shallow depth, high clay content, low AWC and severe erodibility are the limitations to cropping. The soils are cultivated to sorghum, pulses and, at places, cotton in the rainy season. Yields are low.

Shankarpalli soils are the members of the fine-loamy mixed isohyperthermic family of Lithic Ustorthents. They occur on very gently sloping basalt pediment. They are very shallow (12–14 cm), dark brown to very dark grayish brown, moderately well drained, fine-loamy soils with mildly to moderately alkaline reaction. AWC is very low. The fine fraction is dominantly smectitic. Weatherable minerals are dominated by ferromagnesium minerals. Very shallow rooting depth to lithic contacts and severe erosion hazards are major limitations to use.

Mapping Unit 12: Shankarpalli—Jolkal soils.
5 828 ha, 7.9% of the total area.

The soilscape occurs in the basaltic pediment which slopes gradually to the granite-gneiss pediment surface covered by basaltic outwash. Shankarpalli soils occur on the upper slopes (very gently sloping edges of basalt pediment), and Jolkal soils occur on level to nearly level granite-gneiss pediment surfaces covered by basaltic outwash.

Jolkal soils are the members of the very fine montmorillonitic isohyperthermic family of Typic Chromusterts. They are deep (90–100 cm), dark grayish brown to very dark grayish brown, moderately well drained, very fine soils with moderately alkaline reaction. CEC is high and AWC ranges between

200 and 220 mm/m in the soil profile. Low permeability, high shrink-swell potential, suboptimum oxygen availability and severe erosion hazards are limitations to use in these soils. These are cultivated to sorghum, pulses and cotton in the rainy season or fallowed in the rainy season and cultivated to postrainy season crops such as a sorghum and safflower intercrop.

Mapping Unit 13: Palmavagu—Nakkavagu soils.
393 ha, 0.5% of the total area.

The soilscape occurs on recent flood plains along streams. Soils of Palmavagu series are the dominant in the association and occur along the banks of streams. Nakkavagu soils occur on inner terraces of the floodplain.

Palmavagu soils are the members of mixed isohyperthermic family of Typic Ustipsamments. They are very deep (180–185 cm), light brown to reddish yellow, sandy soils that are loose, excessively drained, and neutral to mildly alkaline in reaction. They occur in narrow patches along streams and are not usually cultivated.

Nakkavagu soils are the members of the coarse-loamy mixed isohyperthermic family of Typic Ustifluvents. They are deep, light brown to dark brown well drained soils with mildly alkaline reaction. The profile comprises coarse gravelly sandy surface layers underlain by sandy loams. AWC of the soil is very low. The soils are not usually cultivated.

Mapping Unit 14: Nakkavagu—Rudravaram soils.
945 ha, 1.3% of the total area.

The soilscape occurs on the floodplains and shallow filled valleys of streams oin the area. Nakkavagu soils developed on recent flood deposits dominate. Rudravaram soils (Typic Ustropepts) are developed on old alluvial deposits. Usually Rudravaram soils are cultivated to rice, and Nakkavagu soils are left fallow.

Table 4. Area under different soil associations in the Type Area.

Mapping unit numbers	Soil associations	Area	
		ha	Percentage of total
1	Lingampalli soils–rock outcrops	6 615	9.0
2	Lingampalli–Patancheru soils	630	0.9
3	Patancheru–Lingampalli soils	16 822	23.0
4	Rudravaram–Manmool soils	2 992	4.0
5	Lakdaram–Isnapuram soils	865	1.2
6	Isnapuram–Lakdaram soils	10 619	14.4
7	Patancheru–Isnapuram soils	472	0.6
8	Kasireddipalli–Icri soils	22 635	30.8
9	Kasireddipalli–Yamkunta soils	1 256	1.7
10	Yamkunta–Manmool soils	1 890	2.6
11	Singpur–Shankarpalli soils	1 417	1.9
12	Shankarpalli–Jolkal soils	5 828	7.9
13	Palmavagu–Nakkavagu soils	393	0.5
14	Nakkavagu–Rudravaram soils	945	1.3
	Habitation	157	0.2
		73 536	100.0

3.4 Soils of ICRISAT Farm:

Six soil series, those found to occur in the encompassing Type Area, were identified on the ICRISAT Farm covering an area of 1 394 ha. The soil mapping units (consociation of phases) and the extent of area covered by them are given in Table 5.

Icri series:

Icri soils, the principal associates of Kasireddipalli soils, are 30 to 50 cm deep to a paralithic contact. The surface texture varies from clay to silty clay, and gravelly silty clay. The content of clay in the soil varies from 53 to 57% and coarse fragments range from 22 to 23% with depth. The soils occur on very gently sloping (1 to 3%) to gently sloping (3 to 5%) lands with moderate to severe erodibility. Analytical data of the typifying pedon are given in Appendix-II.

Icri soils cover 82.4 ha or 5.91% of the farm area.

Kasireddipalli series:

Kasireddipalli soils are very deep, dark to very dark grayish, clayey soils developed in the basic and/or basaltic outwash. They show considerable homogeneity in texture and have weak horizonation but there is a striking structural change in the profile which reflects the effect of pedoturbation. The surface texture varies from clay to silty clay with clay contents varying from 45 to 57%. Kasireddipalli soils occur on nearly level to very gently sloping (1–3%) and gently sloping (3–5%) foot slopes of the pediment surface which merges gradually to shallow depressions covered by basaltic outwash. Analytical data of the typifying pedon are given in Appendix-II.

Kasireddipalli soils are the most extensive soils on the ICRISAT Farm and cover an area of 552.3 ha or 39.62% of the farm area.

Lingampalli series:

Lingampalli soils are 45–50 cm deep and are underlain by hard, partly weathered granite-gneiss. The surface soil texture can be sandy loam, gravelly sandy loam, sandy clay loam, or gravelly sandy clay loam, with clay content varying from 17 to 19% and sand varying from 73 to 77%. These are very gently (1–3%) to gently sloping (3–5%) soils with slight to moderate erosion hazards (Table 5). Analytical data of the typifying pedon are given in Appendix-II.

Lingampalli soils cover 71.6 ha or 5.17% of the farm area.

Table 5. Description of mapping units (consociation of phases) for each of the soil series on the ICRISAT farm.

Mapping Units	Description of mapping units	Area covered (ha)	Series area (%)	ICRISAT farm area (%)
Icri series (Paralithic Vertic Ustropept)		82.4	100.0	5.91
IkC2	Icri silty clay, 3-5 % slope, moderate erosion	35.5	43.1	2.55
I(g)kC2	Icri gravelly silty clay, 3-5 % slope, moderate erosion	2.4	3.0	0.20
I(g)kC3	Icri gravelly silty clay, 3-5 % slope, severe erosion	2.8	3.4	0.20
ImB1	Icri clay, 1-3 % slope, none to slight erosion	30.9	37.5	2.22
ImB2	Icri clay, 1-3 % slope, moderate erosion	8.0	9.6	0.57
ImC2	Icri clay, 3-5 % slope, moderate erosion	2.8	3.4	0.20
Kasireddipalli series (Typic Pellustert)		552.3	100.0	39.62
KkC2	Kasireddipalli silty clay, 3-5 % slope, moderate erosion	74.6	13.5	5.40
KmA1	Kasireddipalli clay, 0-1 % slope, none to slight erosion	56.6	10.2	4.06
KmB1	Kasireddipalli clay, 1-3 % slope, none to slight erosion	250.2	45.3	17.95
KmB2	Kasireddipalli clay, 1-3 % slope, moderate erosion	73.6	13.3	5.30
KmC1	Kasireddipalli clay, 3-5 % slope, none to slight erosion	97.3	17.6	7.00
Lingampalli series (Lithic Rhodustalf)		71.6	100.0	5.17
LcB1	Lingampalli sandy loam, 1-3 % slope, none to slight erosion	4.8	6.7	0.35
LcB2	Lingampalli sandy loam, 1-3 % slope, moderate erosion	4.8	6.7	0.35
L(g)cB1	Lingampalli gravelly sandy loam, 1-3 % slope, none to slight erosion	22.2	31.0	1.59
L(g)cB2	Lingampalli gravelly sandy loam, 1-3 % slope, moderate erosion	3.1	4.4	0.22
LcC1	Lingampalli sandy loam, 3-5 % slope, none to slight erosion	4.8	6.7	0.35
L(g)cC1	Lingampalli gravelly sandy loam, 3-5 % slope, none to slight erosion	13.2	18.4	0.95
LcC2	Lingampalli sandy loam, 3-5 % slope, moderate erosion	4.0	5.6	0.29
L(g)hA1	Lingampalli gravelly sandy clay loam, 0-1 % slope, none to slight erosion	1.6	2.2	0.11
LhB1	Lingampalli sandy clay loam, 1-3 % slope, none to slight erosion	2.4	3.4	0.17
LhC1	Lingampalli sandy clay loam, 3-5 % slope, none to slight erosion	5.0	7.0	0.36
L(g)hC2	Lingampalli gravelly sandy clay loam, 3-5 % slope, moderate erosion	5.7	7.9	0.40

Continued

Table 5. *continued.*

Mapping Units	Description of mapping units	Area covered (ha)	Series area (%)	ICRISAT farm area (%)
Manmool series (Fluventic Ustropept)		53.8	100.0	3.86
MiB1	Manmool sandy clay, 1-3 % slope, none to slight erosion	24.0	44.6	1.72
MiB2	Manmool sandy clay, 1-3 % slope, moderate erosion	6.0	11.2	0.43
MiC2	Manmool sandy clay, 3-5 % slope, moderate erosion	4.2	7.8	0.30
MmA1	Manmool clay, 0-1 % slope, none to slight erosion	2.8	5.2	0.20
MmB1	Manmool clay, 1-3 % slope, none to slight erosion	16.8	31.2	1.21
Patancheru series (Udic Rhodustalf)		247.7	100.0	17.77
PbA1	Patancheru sandy loam, 0-1 % slope, none to slight erosion	16.4	6.6	1.18
PcB1	Patancheru sandy loam, 1-3 % slope, none to slight erosion	80.0	32.3	5.74
P(g)cB1	Patancheru gravelly sandy loam, 1-3 % slope, none to slight erosion	10.0	4.0	0.72
PcB2	Patancheru sandy loam, 1-3 % slope, moderate erosion	15.8	6.4	1.13
P(g)cB2	Patancheru gravelly sandy loam, 1-3 % slope, moderate erosion	3.5	1.4	0.25
PcC1	Patancheru sandy loam, 3-5 % slope, none to slight erosion	33.6	13.6	2.41
PcC2	Patancheru sandy loam, 3-5 % slope, moderate erosion	12.8	5.2	0.92
P(g)cC2	Patancheru gravelly sandy loam, 3-5 % slope, moderate erosion	8.4	3.4	0.60
PhA1	Patancheru sandy clay loam, 0-1 % slope, none to slight erosion	29.6	11.9	2.12
P(g)hA1	Patancheru gravelly sandy clay loam, 0-1 % slope, none to slight erosion	1.2	0.5	0.09
PhB1	Patancheru sandy clay loam, 1-3 % slope, none to slight erosion	20.0	8.1	1.43
PhB2	Patancheru sandy clay loam, 1-3 % slope, moderate erosion	4.0	1.6	0.29
P(g)hC1	Patancheru gravelly sandy clay loam, slope, 3-5 % none to slight erosion	10.4	4.2	0.75
PhC2	Patancheru sandy clay loam, 3-5 % slope, moderate erosion	2.0	0.8	0.14
Yamkunta series (Vertic Halaquept)		177.4	100.0	12.73
YfC2(B)	Yamkunta clay loam, 3-5 % slope, moderate erosion, moderate salinity/alkali hazard	10.0	5.6	0.72
YhB1	Yamkunta sandy clay loam, 1-3 % slope, none to slight erosion	1.6	0.9	0.11
YhB1(B)	Yamkunta sandy clay loam, 1-3 % slope, none to slight erosion, moderate salinity/alkali hazard	3.8	2.1	0.27

Continued

Table 5. *continued.*

Mapping Units	Description of mapping units	Area covered (ha)	Series area (%)	ICRISAT farm area (%)
YhC1	Yamkunta sandy clay loam, 3–5 % slope, none to slight erosion	7.4	4.2	0.53
YiA1(A)	Yamkunta sandy clay, 0–1 % slope, none to slight erosion, strong salinity/alkali hazard	4.0	2.3	0.29
YiB1(A)	Yamkunta sandy clay, 1–3 % slope, none to slight erosion, strong salinity/alkali hazard	30.4	17.1	2.18
YmA1(A)	Yamkunta clay , 0–1 % slope, none to slight erosion, strong salinity/alkali hazard	29.4	16.6	2.11
YmA1(B)	Yamkunta clay, 0–1 % slope, none to slight erosion, moderate salinity/alkali hazard	0.6	0.3	0.04
YmB1	Yamkunta clay, 1–3 % slope, none to slight erosion	17.60	9.9	1.26
YmB1(A)	Yamkunta clay, 1–3 % slope, none to slight erosion, strong salinity/alkali hazard	17.3	9.7	1.24
YmB1(B)	Yamkunta clay, 1–3 % slope, none to slight erosion, moderate salinity/alkali hazard	45.5	25.7	3.27
YmB2	Yamkunta clay, 1–3 % slope, moderate erosion	4.8	2.7	0.35
YmC2(B)	Yamkunta clay, 3–5 % slope, moderate erosion, moderate salinity/alkali hazard	5.0	2.8	0.36
Building complex, gardens, recreation and non-agriculture areas		208.8	-	14.97

Manmool series:

Manmool soils occur in low-lying shallow depression in the pediment surface. They are the principal associates of Yamkunta soils on the ICRISAT Farm. Manmool soils are deep to very deep, imperfectly drained and clayey. Surface soils vary from sandy clay to clay in texture and contain 35% or more clay. Organic carbon is high in the surface soil and decreases irregularly with depth. Dull red soft Fe and Mn concretions occur between 25 and 125 cm below the surface. These soils occur on level to very gently sloping and gently sloping lands with little to moderate erosion hazard. Analytical data of the typifying pedon are given in Appendix-II.

Manmool soils cover a total area of 53.8 ha or 3.86% of the farm area.

Patancheru series:

Patancheru soils are 1.0 m or more deep. They have fine-loamy surface horizons 18 to 20 cm thick with 14 to 28% clay and 67 to 79% sand which change abruptly to dense, clayey argillic Bhorizons with 20% or more clay than in the surface horizons. Such strongly contrasting textures within the solum may seriously affect the movement and retention of water in the soil. These soils occur on nearly level

to very gently sloping (1–3%) and gently sloping (3–5%) lands. Gravels and rock fragments increase in amounts from 36 to 65% with depth. Analytical data of the typifying pedon are given in Appendix-II.

Patancheru soils cover an area of 247.7 ha or 17.77% of the farm area.

Yamkunta series:

Soils of Yamkunta series are very deep, dark to very dark grayish brown, imperfectly drained, and moderately to strongly alkaline. They are the soils of low-lying situations affected by salinity and alkalinity. ESP in the surface layers is high, ranging from 16 to 18 and decreases with depth to 14. Organic carbon decreases regularly with depth. EC is high in the surface layers. The texture of the surface soils vary from sandy clay loam, to clay loam, to sandy clay and to clay. The content of clay in the surface soils varies from 35 to 38% while in subsoil layers it varies from 44 to 47%. Analytical data of the typifying pedon are given in Appendix-II.

Soils of Yamkunta series cover 177.4 ha or 12.73% of the farm area.

4. Soil Survey Interpretation

Soil surveys and the resulting soil maps are designed according to the purposes for which they are to be interpreted (Johnson, 1978). The soil map indicates the extent of kinds of soils having typical characteristics and of groups of soils having differing characteristics but occurring in a definite geoclimatic setting. It locates the kinds of soils with reference to interpretations that are important in their proposed use.

4.1 Land Capability Classification:

The Land Capability Classification (Klingebiel and Montgomery, 1961) is an interpretive grouping made primarily for agricultural purposes. Cultivable soils are grouped according to their potential and limitations for sustained production of the commonly cultivated crops. Lands suited to cultivation are grouped in class I to class IV according to the degree of limitations. Lands in class V to class VII are suited to silviculture and pasture. Class VIII lands are suited neither to agriculture nor forestry.

Land capability classes are divided into subclasses that represent groups of soils having the same kind of dominant limitation for agricultural use. Four kinds of limitation are recognized at subclass level: 'e' for water or wind erosion; 'w' for drainage problems, wetness, or overflow; 's' for soil limitations affecting plant growth; and 'c' for limitation due to climate.

The influence of climate in land classification has to be considered when soil conditions are favourable. Arable soils of the semi-arid region are generally classified into class III and IV lands because of climatic limitations during long periods of the year. But in the study area rainfall during the main growing season i.e., from June to October is nearly 700 mm received in about 50 days. This may be considered adequate to raise good rainy-season crops if soil conditions are favourable. Hence better soils of the area may be classified in class II.

The objectives of reconnaissance soil survey were to identify different soils, classify them and delineate associations of soil series but not to make a detailed inventory of soils. Therefore, the data collected may only be broadly interpreted. Detailed interpretations made on the ICRISAT Farm or other research centres can be used, however, for transfer of technology to similar soil units in the Type Area.

4.2 Type Area:

Brief descriptions of the soil series encountered and mapped in associations, and the common cropping patterns have been given in Chapter 3. The general interpretations are given below:

Lingampalli soils occur on the higher pediments of granite-gneiss and are shallow, droughty, and susceptible to erosion. The AWC is low. Sorghum and minor pulses are grown. The soils are expected to respond to application of manures and fertilizers. The soils are grouped under land capability subclass IIIS and irrigability class 3 or 4.

Patancheru and Isnapuram soils occur on middle and lower pediment surfaces of the granite-gneiss and have favourable depths and textures. Gravel and erosion are the major limitations. The crops raised on these soils are expected to respond well to application of manures and fertilizers both under dryland

and irrigated farming. The land capability class ranges from II to III depending upon the extent of the limitations. Irrigability class is 2 or 3 with some additional limitations due to slope or gravelliness. Isnapuram soils also have limitations due to coarse surface textures.

Lakdaram soils have an additional limitation of shallow depth as compared to Patancheru and Isnapuram soils. They are placed in capability class III and irrigability class 3 due to this limitation of depth.

Rudravaram soils occur on pediments covered with weathered basalt and in filled valleys, and are deep, fine-loamy with high base saturation. Imperfect drainage is the main limitation. The soils are grouped in land capability classes II and III and irrigability class 3. Yamkunta soils occur in the same geomorphic position and are deep, clayey and imperfectly drained. Yamkunta soils are affected by different degrees of salinity and alkali thus restricting normal crop husbandry. Although the soils are deep, effective depth is only about 20 to 25 cm due to high water-table and frequent inundation. Therefore they are grouped in class IV. With provision for suitable drainage and suitable reclamation they may qualify for class III lands.

Icri soils occur on granite-gneiss pediment surfaces covered with weathered basalt and are shallow, clayey and slowly permeable. They are grouped in land capability classes III and IV and irrigability classes 3 and 4.

Kasireddipalli soils on granite-gneiss pediment surfaces covered with weathered basalt and in filled valleys are very deep, clayey and imperfectly drained. They have a favourable AWC but show potential sodicity in the subsoil below 90 cm. They are grouped in land capability classes II and III with limitations due to fine texture and slow permeability. Drainage may pose problems with these soils and irrigation is not generally recommended. The soils are capable of supporting a wide range of crops with judicious fertilisation under rainfed conditions.

Jolkal soils occur on the lower pediment of basalt in conjunction with weathered granite-gneiss and are deep, clayey and moderately well drained. Slow permeability and erosion are the limitations. They can be brought under irrigation under proper management including the provision of drainage. They are grouped in land capability classes II and III and irrigability classes 2 and 3.

Shankarpalli and Singpur soils occupying the basalt plateau and pediment are very shallow to shallow with varying proportion of gravel. Depth, gravelliness, fine texture and erosion are the limitations. The soils are grouped in land capability classes III and IV and irrigability classes 3 and 4. The subsoils, containing weathered basaltic murrum, are permeable so that despite the depth limitations, the lands can be brought under irrigation.

Palmavagu and Nakkavagu soils occur in association along stream banks and in flood plains. Palmavagu soils are predominantly sandy and droughty; hence they are placed in capability classes IV and VI. Nakkavagu soils, on the other hand, are coarse-loamy and deep. They are grouped in land capability classes III and IV. Nakkavagu soils may be developed for irrigated agriculture without any salinity and alkali hazards by tapping the underground water, and are grouped in irrigability class 3.

4.3 ICRISAT Farm:

Detailed mapping of the ICRISAT Farm at the level of soil phases allows precise interpretation of the land capability and land irrigability classification of each unit delineated (Table 6).

Table 6. Interpretative groupings of mapping units shown on the soil map of the ICRISAT Farm.

Mapping units (consociations of phases) (1)	Area Covered (ha) (2)	Land capability subclass (3)	Land irrigability subclass (4)
Icri series (Paralithic Vertic Ustropepts)			
ImB1	30.88	IIIs	3s
ImB2	8.00	IIIs	3s
ImC2	2.80	IIIs	4st
IkC2	35.50	IVs	4st
I(g)kC2	2.40	IVs	4st
I(g)kC3	2.80	IVs	4st
Kasireddipalli series (Typic Pellusterts)			
KmA1	56.60	IIs	2s
KmB1	250.24	IIs	2s
KmB2	73.60	IIs	2s
KkC2	74.60	IIs	3st
KmC1	97.30	IIs	3st
Lingampalli series (Lithic Rhodustalfs)			
LcB1	4.80	IIIs	3s
LcB2	4.80	IIIs	3s
L(g)cB1	22.20	IIIs	3s
L(g)cB2	3.12	IIIs	3s
LcC1	4.80	IIIs	4st
L(g)cC1	13.20	IIIs	4st
LcC2	4.00	IIIs	4st
L(g)hA1	1.60	IIIs	3s
LhB1	2.40	IIIs	3s
LhC1	5.00	IIIs	4st
L(g)hC2	5.65	IIIs	4st
Manmool series (Fluventic Ustropepts)			
MiB1	24.00	IIIw	3d
MiB2	6.00	IIIw	3d
MiC2	4.20	IIIw	3d
MmA1	2.80	IIIw	3d
MmB1	16.80	IIIw	3d
Patancheru series (Udic Rhodustalfs)			
PcB1	80.0	IIe	2s
PcC1	33.6	IIe	3t
PhB1	20.0	IIe	2s
PbA1	16.4	IIs	2s

Continued

Table 6. *Continued*

Mapping units (consociations of phases) (1)	Area Covered (ha) (2)	Land capability subclass (3)	Land irrigability subclass (4)
PhA1	29.6	IIe	2s
PcC2	12.8	IIIe	3t
PhB2	4.0	IIIe	2s
PhC2	2.0	IIIe	3t
P(g)cC2	8.4	IIIe	3t
P(g)cB2	3.5	IIIe	2s
P(g)hC1	10.4	IIIe	3t
P(g)cB1	10.0	IIIs	2s
PcB2	15.8	IIIs	2s
P(g)hA1	1.2	IIIs	2s
Yamkunta series (Vertic Halaquepts)			
YhB1	1.60	IVw	4sd
YhC1	7.40	IVw	4sd
YmB1	17.60	IVw	4sd
YmB2	4.81	IVw	4sd
YfC2(B)	10.00	IVsw	4sd
YhB1(B)	3.80	IVsw	4sd
YmA1(B)	0.60	IVsw	4sd
YmB1(B)	45.52	IVsw	4sd
YmC2(B)	5.00	IVsw	4sd
YiA1(A)	4.00	IVsw	4sd
YiB1(A)	30.40	IVsw	4sd
YmA1(A)	29.40	IVsw	4sd
YmB1(A)	17.28	IVsw	4sd

Capability subclass IIe:

This subclass includes very deep, clayey-skeletal soils with medium texture at the surface. The lands are gently sloping and susceptible to erosion. The AWC is medium and productivity potential is high. The soils can support major climatically adapted crops of the region. The mapping units included in the subclass belong to Patancheru series. They are PhA1, PcB1, PcC1, and PhB1.

Capability subclass IIs:

The soils of this subclass are fine textured in the control section. Surface texture is also fine in most of the soils. The slope varies from 1 to 5%. The AWC is medium to high. Limitations of lands in this class are caused by fine texture, erodibility and slow permeability. Coarse texture in the surface is the main soil limitation in many Patancheru soils. The mapping units in this class belong largely to the Kasireddipalli series and one unit of the Patancheru series. They are KkC2, KmA1, KmB1, KmB2, KmC1 and PbA1.

Capability subclass IIIe:

The soils of IIIe subclass are clayey-skeletal in the control section with sandy loam or sandy clay loam at the surface. The lands have a slope of 1 to 5% and are moderately eroded. They require soil conservation measures for successful crop husbandry. The AWC is medium. The soils can support climatically adapted crops of the region. The mapping units included in the subclass belong to the Patancheru series and are PcC2, PhB2, PhC2, P(g)cC2, P(g)cB2 and P(g)hC1.

- The interpretive groupings may not be valid as massive earth moving operations and land levelling have already taken place.

Capability subclass IIIs:

The IIIs soils are moderately deep to deep, fine textured, and have root zone limitations. The slope ranges from 1 to 5%. Some soils although deep have excessive gravel in the subsurface horizon restricting the effective rooting depth. Depth, gravelliness and erosion are the major limitations. The AWC is low; the soils can support shallow rooted, short duration minor millets and pulses. Mapped units belonging to Lingampalli and Icri series and a few units of Patancheru series come into this subclass. Soil conservation measures are necessary to check erosion. The units included are P(g)cB1, PcB2, P(g)hA1, LcB1, LcB2, L(g)cB1, L(g)cB2, LcC1, L(g)cC1, LcC2, L(g)hA1, LhB1, LhC1, L(g)hC2, ImB1, ImB2 and ImC2.

Capability subclass IIIw:

The soils of IIIw subclass are fine in texture, deep to very deep and somewhat poorly drained. They occupy lower reaches of the pediment covered by outwash deposits and hence the moisture status is high. The soils occur on 1 to 5% slope and suffer from moderate erosion hazard. Slow permeability and gravelliness are the major limitations. They are generally cultivated to rice. The units included are MiB1, MiB2, MiC2, MmA1, and MmB1 all belonging to the Manmool series.

Capability subclass IVs:

The soils of IVs are shallow, occur on 3 to 5% slope, and are moderately to severely eroded. They are somewhat poorly drained and occupy the upper pediment covered by basaltic outwash. They can occasionally be cultivated to shallow rooted millets and pulses in the rainy season. They require suitable soil conservation measures. The units included in this subclass are IkC2, I(g)kC2 and I(g)kC3.

Capability subclass IVw:

The soils of this subclass are deep, clayey in the control section, imperfectly drained, and occur in lower situations on slope varying from 1 to 5%. The soils are slowly permeable. These limitations and the difficulties encountered in reclamation rendered them practically as waste lands. During the rainy season the lands are frequently inundated. With some reclamation it could be possible to cultivate rice on these soils. The units included are YhB1, YhC1, YmB1 and YmB2 all belonging to the Yamkunta series.

Capability subclass IVsw:

In addition to the limitations mentioned in the IVw subclass, the lands under IVsw have the additional

limitation of salinity and alkalinity rendering these soils still more difficult for reclamation. Units in this subclass belong to the Yamkunta series. They are YhB1(B), YmA1(B), YmB1(B), YfC2(B), YmC2(B), YmA1(A), YiA1(A), YiB1(A) and YmB1(A).

4.4 Irrigability Classification:

Soils with properties suited to sustained use under irrigation are further classified in land irrigability classes according to physical factors and socio-economic considerations.

Lands from class 1 to 4 generally are irrigable but limitations in their use for sustained irrigation increase from class 1 to 4. Class 5 lands are usually not suited for irrigation. However, special and detailed investigations are necessary to assign irrigability class to class 5 lands on a permanent basis. Class 6 lands are not suited to sustained use under irrigation.

Land irrigability subclasses are assigned based on the dominant limitations for sustained use under irrigation. The subclasses recognised relate to soil deficiencies (s), topography (t) and drainage (d). On the ICRISAT Farm, the mapping units have been assigned the land irrigability subclasses described below:

Irrigability subclass 2s:

This subclass includes deep soils which are clayey in the control section. Surface textures vary from loamy sand to clay. The lands have slopes of less than 3%. They are slightly to moderately eroded. The AWC is medium to high. In some soils, gravel increases with depth. Fine texture and/or gravelliness and susceptibility to erosion are the limitations. The soils are productive when well managed. Provision of drainage especially in black clayey soils is necessary. The mapping units in this subclass include phases of Patancheru and Kasireddipalli series. The units are PbA1, PeB1, PhB2, P(g)cB1, PcB2, P(g)cB2, PhA1, P(g)hA1, PhB1, KmA1, KmB1 and KmB2.

Irrigability subclass 3s:

This subclass includes shallow to moderately deep and occasionally deep, fine textured soils. Surface textures vary from sandy loam to silty clay loam. The lands have predominant 1 to 3% slopes. They are slightly to moderately eroded. The effective rooting depth is suboptimum either due to shallow soil depth or due to heavy subsoil texture and moderate surface erosion. The AWC in the effective rooting depth is low to medium. Soil conservation measures in the shallow soils and provision of drainage in deep soils will improve the productivity of these soils. The mapping units included in this subclass largely belong to Lingampalli series. A few units of Icri and Kasireddipalli series are also included. They are LcB1, LcB2, L(g)cB1, L(g)cB2, L(g)hA1, LhB1, ImB1 and ImB2.

Irrigability subclass 3t:

The soils of subclass 3t are deep, clayey-skeletal in the control section, and occur on 3 to 5% slopes. They are moderately eroded. Gravelly phases are also common. The AWC is medium. Runoff is more than for most other irrigability subclasses because slopes are greater. Soil conservation measures are necessary to reduce the risk of excessive runoff. The soils are otherwise productive. The mapping units belong to Patancheru series and they are PcC1, PcC2, P(g)cC2, P(g)hC1 and PhC2.

Irrigability subclass 3d:

This subclass includes deep to very deep, somewhat poorly drained fine textured soils. They occur on slopes less than 3% and are slightly to moderately eroded. The AWC is medium to high. They occupy relatively lower situations while slow permeability and gravelliness are major limitations. The soils are used mostly for growing rice. With the provision of drainage soil productivity can be improved. The mapping units of this subclass belong to Manmool series. They are MiB1, MiB2, MiC2, MmA1 and MmB1.

Irrigability subclass 3st:

The soils of subclass 3st are deep, fine textured, occur on 3 to 5% slopes, and are slightly to moderately eroded. The AWC is medium to high. They are imperfectly drained with slow permeability. Soil conservation measures are necessary to check erosion; provision of drainage is necessary to improve soil-water-air relationships and increase the productivity. Two units of Kasireddipalli series, viz. KmC1 and KkC2 are included in this subclass.

Irrigability subclass 4st:

The soils of this unit are shallow to moderately deep, fine in texture, occur on 3 to 5% slopes, and are slightly to severely eroded. The AWC is low. Depth, gravelliness and in some cases slow permeability have reduced their potentiality for irrigation. Soil and moisture conservation measures are necessary to improve their productivity. The mapping units included belong to Lingampalli and Ieri series. The units are LcC1, L(g)cC1, LcC2, LhC1, L(g)hC2, ImC2, IkC2, I(g)kC2 and I(g)kC3.

Irrigability subclass 4sd:

The soils of this unit are deep, fine textured, occur on 1 to 5% slopes and are slightly to moderately eroded. They have an aquic moisture regime due to their position in the landscape. Imperfect drainage, slow permeability, salt and alkali hazards in many units are the limitations in their use for crop production. The soils suffer from frequent flooding in the rainy season. Presently the lands are left fallow but can be used occasionally for growing rice. All the units of Yamkunta series are included in this subclass.

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6. Appendices

Appendix-I. Explanation of map symbols.

Symbols: Soil series		Soil series name
I	–	Ieri
K	–	Kasireddipalli
L	–	Lingampalli
M	–	Manmool
P	–	Patancheru
Y	–	Yamkunta
Symbols: Surface texture		**Texture**
a	–	sand
b	–	loamy sand
c	–	sandy loam
f	–	clay loam
g	–	silty clay loam
h	–	sandy clay loam
i	–	sandy clay
k	–	silty clay
m	–	clay
(g)	–	gravelly
Symbols: Slope class		**Slope percentage**
A	–	0–1 per cent level to nearly level
B	–	1–3 very gently sloping
C	–	3–5 gently sloping
Symbols: Erosion classes		**Degree of erosion**
1	–	None to slight erosion
2	–	Moderate erosion
3	–	Severe to very severe erosion
Symbols: Others		**Explanatory**
(A)		Strongly affected by salinity alkali hazards
(B)		Moderately affected by salinity alkali hazards

Appendix-II. Soil series description with analytical data of the typifying pedons.

Icri series:

Icri soils are members of the fine, montmorillonitic, isohyperthermic family of Paralithic Vertic Ustropepts.

Typifying Pedon: Icri gravelly clay—grassland.

A1 0–12 cm — Dark grayish brown (10YR 4/2 D & M) gravelly clay; moderate medium subangular blocky and weak fine granular structure; hard, firm, sticky and plastic; fine to very fine imped roots; few 2–5 mm size iron concretions and common irregular lime concretions; moderate effervescence; moderately alkaline (pH 8.2); gradual smooth boundary.

B2 12–32 cm — Dark grayish brown to very dark grayish brown (10YR 3.5/2 D & M) gravelly clay; moderate medium subangular blocky peds with shiny pressure faces; firm, sticky and plastic; many fine to medium imped roots; few 2–3 mm size iron concretions and irregular lime concretions; moderate effervescence; fine to medium irregular pores; moderately alkaline (pH 8.2); diffuse boundary.

B3 32–51 cm — Dark grayish brown to very dark grayish brown (10YR 3.5/2 M) gravelly silty clay; moderate medium subangular blocky structure; firm, very sticky and plastic; few 2–5 mm size rounded iron concretions; common lime concretions; weathered basalt rock fragments (2–3 cm) in pockets strong effervescence; moderately alkaline (pH 8.1) clear smooth boundary.

IIC 51–80 cm — Weathered basalt

Type location: Village Patancheru, tehsil and district Medak, Andhra Pradesh; Block No. BW/9 of the farm area.

Setting: Occurs on weathered basalt over granite-gneiss pediment surface.

Drainage and permeability: Moderately well drained with moderately slow permeability.

Use and vegetation: Grassland.

Distribution and extent: Limited in extent.

Soil Series: Icri

Classification: Paralithic Vertic Ustropept

Horizon	Depth (cm)	Size class and particle diameter (mm)				Course fragments >2 mm (% of whole soil)	Organic carbon (%)	Carbonate as $CaCO_3$ 2mm	pH (1:2.5) H_2O	E.C. (1:2.5) H_2O	Water retention	
		Course sand 2.0-0.2	Fine sand 0.2-0.02	Silt 0.02-0.002	Clay <0.002						1/3-bar %	15-bar %
		% of <2 mm										
A1	0-12	10.4	20.3	16.1	53.2	22	1.74	0.9	8.2	0.3	33.3	19.4
B2	12-32	9.9	16.7	16.0	57.4	22	0.87	1.6	8.2	0.2	34.5	20.8
B3	32-51	11.6	16.6	19.1	52.7	23	0.75	1.3	8.1	0.5	32.9	16.6

Depth	Extractable bases				Sum	CEC NH_4O Ac	Base saturation (%)	Ratio CEC Clay	Clay fraction mineralogy (%)					Sand fraction mineralogy (%)				
	Ca	Mg	Na	K					AM	KK	MI	SM	QZ	QZ	FDM	FDP	BI	FE
	meq/100g																	
0-12	33.1	4.1	1.2	1.1	39.5	40.3	98	0.76	5	13	6	65	12	10	5	60	10	8
12-32	40.8	8.2	1.1	0.4	50.5	50.3	100	0.88	5	13	6	66	10	10	5	65	10	8
32-51	37.4	9.3	1.7	0.4	48.8	49.2	99	0.93	5	15	6	64	10	15	10	60	5	10

AM = Amphibole
KK = Kaolinite
MI = Mica
SM = Smectite
QZ = Quartz
FDM = Feldspar-microcline
FDP = Feldspar-plagioclase
BI = Biotite
FE = Magnetite

Isnapuram series:

Isnapuram soils are members of the fine-loamy, mixed, isohyperthermic family of Udic Rhodustalfs.

Typifying pedon: Isnapuram sand—cultivated.

Ap 0–12 cm — Light brown (7.5YR 6/4 D) sand, brown to dark brown (7.5YR 4/4 M); weak fine granular structure; loose and friable; common fine roots; medium acid (pH 5.8); clear smooth boundary.

A12 12–21 cm — Dark reddish brown (2.5YR 3/4 M) loamy sand; weak fine subangular blocky structure breaking to fine granular; slightly hard, friable; few fine imped roots; slightly acid (pH 6.1); gradual smooth boundary.

B21t 21–38 cm — Dark reddish brown (2.5YR 3/4 D) sandy loam, dark reddish brown (2.5YR 2.5/4 M); weak medium subangular blocky structure; slightly hard, friable and slightly sticky; common fine imped roots; few fine clay cutans; fine irregular pores; medium acid (pH 5.9); gradual smooth boundary.

B22t 38–52 cm — Dark reddish brown (2.5YR 3/4 D & M) clay loam; moderate medium subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; few fine roots; thick patchy clay cutans; fine irregular pores; medium acid (pH 6.0); gradual smooth boundary.

B23t 52–105 cm — Dark reddish brown (2.5YR 3/4 D & M) clay; moderate medium subangular blocky structure; hard, friable, slightly sticky and slightly plastic; very few very fine imped roots; few 4 to 5 mm size quartz gravels and iron concretions about 10% by volume; few weathered rock fragments; fine irregular pores; medium acid (pH 5.7); clear smooth boundary.

C 105–129 cm—Weathered granite-gneiss.

Type location: Village Patancheru, tehsil and district Medak, Andhra Pradesh; about 0.5 km north of Isnapuram.

Setting: Occurs on gently sloping pediment of granite-gneiss basement complex.

Drainage and permeability: Well drained with moderate permeability.

Use and vegetation: Mainly cultivated to sorghum and pulses.

Distribution and extent: Extensive soil.

Soil Series: Ianapuram **Classification: Udic Rhodustalf**

Horizon	Depth (cm)	Size class and particle diameter (mm): Sand 2·0–0·02 (% of <2 mm)	Silt 0·02–0·002 (% of <2 mm)	Clay <0·002 (% of <2 mm)	Coarse fragments >2 mm (% of whole soil)	Organic carbon (%)	pH (1:2·5) H_2O
Ap	0–12	90·5	2·1	7·4	1	0·21	5·8
A12	12–21	88·4	4·3	7·3	2	0·19	6·1
B21t	21–38	73·8	7·5	18·7	1	0·27	5·9
B22t	38–52	62·4	6·1	31·5	2	0·31	6·0
B23t	52–105	56·0	5·5	38·5	2	0·40	5·7

Depth	Extractable bases Ca	Mg	Na	K	Sum (meq/100g)	CEC NH_4O Ac	Base saturation (%)	Ratio CEC / Clay	Clay fraction mineralogy (%) KK	AM	MI	SM	Sand fraction mineralogy (%) QZ	FDM	FDP	FE	HE
0–12	1·7	0·2	0·3	0·2	2·4	50	0·63	9	35	9	11	32	60	35	-	5	6
12–21	1·7	0·4	0·6	0·2	2·9	88	0·45	11	37	11	10	27	55	30	5	10	-
21–38	4·4	1·3	0·4	0·4	6·5	68	0·52	10	37	10	10	28	55	30	-	5	10
38–52	9·4	0·5	0·7	0·4	11·0	88	0·42	10	37	10	10	26	45	35	5	10	5
52–105	7·0	4·5	0·4	0·4	12·3	86	0·32	10	37	10	8	31	45	34	5	10	5

AM = Amphibole
KK = Kaolinite
MI = Mica
SM = Smectite
QZ = Quartz
FDM = Feldspar-microcline
FDP = Feldspar-plagioclase
FM = Ferromagnesium minerals
FE = Magnetic
HE = Haematite

Jolkal series:

Jolkal soils are members of the very fine, montmorillonitic, isohyperthermic family of Typic Chromusterts.

Typifying pedon: Jolkal silty clay—cultivated.

Ap 0–5 cm — Very dark grayish brown (10YR 3/2 D & M) silty clay; weak fine granular structure; loose, friable, sticky and plastic; common fine roots; surface cracks 2 to 3 cm wide; few fine lime concretions; slight effervescence; moderately alkaline (pH 7.9); gradual smooth boundary.

A12 5–39 cm — Very dark grayish brown (10YR 3/2 D & M) clay; strong coarse prismatic structure breaking into moderate medium subangular blocky peds with shiny pressure faces; hard, firm, sticky and plastic; common medium and fine roots; 2 to 3 cm wide cracks; few fine lime concretions; slight effervescence; moderately alkaline (pH 7.9); diffuse boundary.

A13 39–98 cm — Very dark grayish brown (10YR 3/2 D & M) clay; well developed intersecting slickensides forming wedge-shaped structural peds inclined 60 degrees from the horizontal and breaking into strong medium angular blocky peds with shiny pressure faces; firm, sticky and plastic; very few fine roots; slight effervescence; moderately alkaline (pH 8.0); clear smooth boundary.

IIC1 98 cm+ — Weathered basalt.

Type location: Village Patancheru, tehsil and district Medak, Andhra Pradesh; about 2.5 km south of Cherial on Cherial-Jolkal cart track.

Setting: Occurs on lower basalt pediment in conjunction with gently sloping weathered granite-gneiss basement complex.

Drainage and permeability: Moderately well drained with slow permeability.

Use and vegetation: Mainly cultivated to sorghum, cotton and pulses; natural vegetation - *Acacia* spp and Tamarind.

Distribution and extent: Limited in extent.

Soil Series: Jolkal **Classification: Typic Chromustert**

Horizon	Depth (cm)	Size class and particle diameter (mm): Coarse sand 2.0-0.2 (% of <2 mm)	Fine sand 0.2-0.02 (% of <2 mm)	Silt <0.02-0.002 (% of <2 mm)	Clay 0.002 (% of <2 mm)	Coarse fragments >2 mm (% of whole soil)	Organic carbon (%)	pH (1:2.5) H_2O	E.C. (1:2.5) H_2O mmhos/cm	Water retention 1/3-bar (%)	Water retention 15-bar (%)
Ap	0-5	5.3	7.9	37.5	49.3	10	0.25	7.9	0.25	38.5	23.5
A12	5-39	6.6	9.1	20.1	64.2	11	0.16	7.9	0.20	37.6	23.2
A13	39-98	6.3	9.2	18.0	66.5	11	0.24	8.0	0.20	40.2	25.5

Depth	Extractable bases Ca (meq/100g)	Mg	Na	K	Sum	CEC NH_4OAc	Exchangeable sodium (%)	Base saturation (%)	Ratio CEC/Clay	Clay fraction mineralogy (%) AM	KK	MI	SM	QZ	Sand fraction mineralogy (%) QZ	FDM	FDP	AM	FM	FE	CA
0-5	43.8	11.8	1.0	1.3	57.9	56.6	2	100	1.15	5	16	5	68	6	25	15	25	5	15	10	5
5-39	44.1	10.8	1.1	0.6	56.6	59.1	2	96	0.92	5	14	5	67	7	40	20	15	-	10	10	5
39-98	45.2	12.9	1.1	0.7	59.9	60.1	2	99	0.90	6	17	5	68	5	35	10	20	15	5	10	5

AM = Amphibole
KK = Kaolinite
MI = Mica
SM = Smectite
QZ = Quartz
FDM = Feldspar-microcline
FDP = Feldspar-plagioclase
FM = Ferromagnesium minerals
FE = Magnetite
CA = Calcite

Kasireddipalli series:

Kasireddipalli soils are members of the very fine, montmorillonitic, isohyperthermic family of Typic Pellusterts.

Typifying pedon: Kasireddipalli clay—cultivated fallow.

Ap 0–25 cm — Very dark gray (10YR 3/1 D & M) clay; coarse strong prismatic structure separating to weak medium subangular blocky peds; common fine roots; moderately alkaline (pH 8.1); clear smooth boundary.

A12 25–70 cm — Very dark gray (10YR 3/1 D & M) clay; intersecting slickensides forming wedge-shaped structural peds inclined 45 degrees from the horizontal and breaking into strong medium angular blocky peds with shiny pressure faces; hard, firm, sticky and plastic; common fine and medium roots; slight effervescence; few medium pores; moderately alkaline (pH 8.2); diffuse boundary.

A13 70–143 cm — Very dark gray (10YR 3/1 D & M) clay; intersecting slickensides forming coarse wedge-shaped structural peds inclined 60 degrees from the horizontal and breaking into strong coarse angular blocky peds with shiny pressure faces; hard, firm, sticky and plastic; few fine roots; strong effervescence; few to very few oblique fine pores; moderately alkaline (pH 8.0); diffuse boundary.

A14 143–187 cm — Dark grayish brown (2.5Y 4/2 D & M) clay; coarse intersecting slickensides forming very coarse wedge-shaped structural peds inclined 10 to 20 degrees from the horizontal and breaking into strong coarse angular blocky peds with shiny pressure faces; sticky and plastic; few 2 to 5 mm size lime concretions; strong effervescence; moderately alkaline (pH 8.1); gradual smooth boundary.

C1 187–215 cm — Dark grayish brown (2.5YR 4/2 D & M) clay; strong medium angular blocky structure; firm, very sticky and plastic; 2 to 3 mm size iron and lime concretions 8 to 10% by volume; powdery lime in pockets; violent effervescence; moderately alkaline (pH 8.1); clear smooth boundary.

C2 215–270 cm — Olive brown (2.5Y 4/4 D & M) clay; moderate medium subangular blocky structure; firm, very sticky and very plastic; 2 to 5 mm size iron-manganese concretions 15 to 20% by volume; lime in pockets; violent effervescence; moderately alkaline (pH 8.3).

Type location: Village Patancheru, tehsil and district Medak, Andhra Pradesh; Block No. BW/11 of the farm area.

Setting: Occurs in valleys and troughs.

Drainage and permeability: Moderately to imperfectly drained with slow to very slow permeability.

Use and vegetation: Cultivated to chickpea, pigeonpea, sorghum and safflower; natural vegetation - *Acacia* spp.

Distribution and extent: Extensive soil.

Soil Series: Kasireddipalli **Classification: Typic Pellustert**

Horizon	Depth (cm)	Size class and particle diameter (mm): Coarse sand 2.0-0.2 (% of <2 mm)	Fine sand 0.2-0.02 (% of <2 mm)	Silt <0.02-0.002 (% of <2 mm)	Clay 0.002 (% of <2 mm)	Coarse fragments >2 mm (% of whole soil)	Organic carbon (%)	Carbonate as $CaCo_3$ (%)	pH (1:2.5) H_2O	E.C. (1:2.5) H_2O mmhos/cm
Ap	0- 25	8.5	14.0	19.6	57.9	19	0.96	1.4	8.1	2.2
A12	25- 70	7.8	10.8	17.3	64.1	-	0.69	2.0	8.2	2.2
A13	70-143	5.6	10.3	18.1	66.0	9	0.60	2.4	8.0	0.2
A14	143-187	5.3	9.5	17.2	68.0	-	0.30	2.1	8.1	0.2

Depth	Extractable bases: Ca	Mg	Na	K	Sum (meq/100g)	CEC NH_4O Ac	Base saturation (%)	Ratio CEC / Clay	Sand fraction mineralogy (%): QZ	FDM	FDP	BI	AM	CL	FE	HE
0- 25	39.6	13.9	1.2	1.2	55.9	56.6	99	0.98	15	10	55	-	5	5	5	5
25- 70	47.7	11.8	1.1	0.6	59.2	60.8	97	0.95	10	10	50	5	5	5	10	5
70-143	40.5	12.0	1.4	0.7	54.6	54.6	99	0.83	15	5	55	5	-	5	5	10
143-187	44.8	11.2	1.4	0.7	58.1	56.1	100	0.83	10	10	50	5	-	5	10	10

QZ = Quartz
FDM = Feldspar-microcline
FDP = Feldspar-plagioclase
BI = Biotite
AM = Amphibole
CL = Chlorite
FE = Magnetite
HE = Haematite

Lakdaram series:

Lakdaram soils are members of the fine-loamy, mixed, isohyperthermic family of Udic Haplustalfs.

Typifying pedon: Lakdaram sandy clay loam—cultivated.

Ap 0–15 cm — Brown (7.5YR 5/4 D) sandy clay loam, dark brown (7.5YR 4/4 M); weak fine granular structure; loose, friable; common fine imped roots; fine irregular pores; neutral (pH 7.1); clear smooth boundary.

B1 15–42 cm — Strong brown (7.5YR 5/6 D) clay loam, dark brown, (7.5YR 4/4 M); moderate medium subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; common fine imped roots; fine irregular pores; neutral (pH 6.9); gradual smooth boundary.

B2t 42–63 cm — Brown to dark brown (7.5YR 4/4 M) clay; moderate medium subangular blocky structure; friable, slightly sticky and slightly plastic; few fine imped roots; moderately thick patchy clay cutans; iron concretions about 2 to 3% by volume; neutral (pH 6.8); gradual smooth boundary.

C 63–127 cm — Weathered granite-gneiss.

Type location: Village Lakdaram, tehsil and district Medak, Andhra Pradesh.

Setting: Occurs on granite-gneiss basement complex.

Drainage and permeability: Moderately well drained with moderate permeability.

Use and vegetation: Mainly cultivated to sorghum and pulses; natural vegetation - Tamarind, neem and *Pongamia* spp.

Distribution and extent: Limited in extent.

Soil Series: Lakderam **Classification: Udic Haplustalf**

Horizon	Depth (cm)	Size class and particle diameter (mm): Coarse sand 2.0-0.2 (% of <2 mm)	Fine sand 0.2-0.02 (% of <2 mm)	Silt <0.02-0.002 (% of <2 mm)	Clay 0.002 (% of <2 mm)	Coarse fragments >2 mm (% of whole soil)	Organic carbon (%)	pH (1:2.5) H_2O	Water retention 1/3-bar (%)	Water retention 15-bar (%)
Ap	0-15	47.1	28.4	5.0	19.5	6	0.24	7.1	5.7	2.1
B1	15-42	41.7	18.5	10.3	29.3	2	0.25	6.9	13.3	6.3
B2t	42-63	38.5	17.1	5.3	39.1	1	0.28	6.8	15.7	8.7

Depth (cm)	Extractable bases Ca	Mg	Na	K	Sum (meq/100g)	CEC NH_4O Ac (meq/100g)	Base saturation (%)	Ratio CEC Clay	Sand fraction mineralogy (%) QZ	FDM	FDP	AM	FM	FE	HE
0-15	2.6	1.3	0.2	0.2	4.3	5.3	81	0.27	40	25	10	5	5	10	5
15-42	6.3	1.3	0.4	0.3	8.3	9.3	89	0.32	45	10	15	5	10	10	5
42-63	7.8	2.5	0.3	0.3	10.9	12.0	90	0.31	45	15	10	5	5	10	5

QZ = Quartz
FDM = Feldspar-microcline
FDP = Feldspar-plagioclase
AM = Amphibole
FM = Ferromagnesium minerals
FE = Magnetite
HE = Haematite

Lingampalli series:

The Lingampalli soils are members of the fine-loamy, mixed, isohyperthermic family of Lithic Rhodustalfs.

Typifying pedon: Lingampalli sandy loam—cultivated.

Ap 0–14 cm — Yellowish red (5YR 4/6 D) sandy loam, dark reddish brown (5YR 3/3 M); moderate fine to medium subangular blocky structure; slightly hard, friable, very slightly sticky; plentiful fine roots; fine irregular pores; medium acid (pH 5.9); gradual smooth boundary.

B21t 14–40 cm — Reddish brown (2.5YR 4/4 D) clay, dark reddish brown (2.5YR 3/4 M); moderate medium subangular blocky structure; hard, friable, sticky and slightly plastic; many fine roots; patchy clay cutans; common fine tubular pores; slightly acid (pH 6.1); gradual smooth boundary.

B22t 40–50 cm — Dark red (2.5YR 3/6 D & M) clay loam; moderate medium subangular blocky structure; hard, friable, sticky and slightly plastic; many fine roots; thin patchy clay cutans; common fine tubular pores; slightly acid (pH 6.1); gradual smooth boundary.

IIC1cn 50–115 cm — Iron concretions and gravels with little soil.

IIIC2 115 cm + — Weathered coarse granite.

Type location: Village Patancheru, tehsil and district Medak, Andhra Pradesh; about 1.5 km from Gopanapalli on Gopanapalli-Vatingalapalli cart track.

Setting: Occurs on gently undulating granite-gneiss pediments in the region of domes and tors.

Drainage and permeability: Well drained with moderately rapid permeability.

Use and vegetation: Cultivated to sorghum.

Distribution and extent: Extensive soil.

Soil Series: Lingampalli **Classification: Lithic Rhodustalf**

Horizon	Depth (cm)	Size class and particle diameter (mm): Sand 2.0-0.02 (% of <2 mm)	Silt 0.02-0.002 (% of <2 mm)	Clay <0.002- (% of <2 mm)	Coarse fragments >2 mm (% of whole soil)	Organic carbon (%)	pH (1:2.5) H_2O
Ap	0-14	73.0	8.4	18.6	4	0.99	5.9
B21t	14-40	53.8	10.7	35.5	4	0.45	6.1
B22t	40-50	62.0	8.6	29.4	13	0.40	6.1

Depth (cm)	Extractable bases Ca	Mg	Na	K	Sum (meg/100g)	CEC NH_4OAc	Base saturation (%)	Ratio CEC/Clay	Sand fraction mineralogy (%) QZ	FDM	FDP	FM	RE	FE
0-14	8.7	3.0	0.5	0.7	12.9	14.9	80	0.80	45	25	10	5	5	10
14-43	6.9	2.4	0.3	0.5	10.1	13.9	73	0.39	50	25	10	5	5	10
43-50	5.4	1.3	0.4	0.4	7.5	10.0	75	0.34	40	25	20	5	5	5

QZ - Quartz
FDM - Feldspar-microcline
FDP - Feldspar-plagioclase
RE - Andalusite
FM - Ferromagnesium minerals
FE - Magnetite

Manmool series:

Manmool soils are members of the fine, mixed, isohyperthermic family of Fluventic Ustropepts.

Typifying pedon: Manmool sandy clay—cultivated.

Ap 0–12 cm — Dark gray (10YR 4/1 D) sandy clay, very dark gray (10YR 3/1 M); strong medium subangular blocky structure; hard, firm, sticky and plastic; plentiful fine and medium imped roots; fine irregular pores; moderately alkaline (pH 8.1); diffuse boundary.

B21 12–32 cm — Dark gray (10YR 4/1 D) gravelly sandy clay, very dark gray (10YR 3/1 M); strong medium subangular blocky structure; few fine roots; few 2 to 5 mm size iron-manganese concretions; fine irregular pores; moderately alkaline (pH 8.1); clear smooth boundary.

B22 32–52 cm — Grayish brown (10YR 5/2 D) sandy clay, dark grayish brown (10YR 4/2 M); strong coarse subangular blocky structure; hard, firm, sticky and plastic; very few fine roots; few 2 to 5 mm size iron-manganese concretions; moderately alkaline (pH 8.1); gradual smooth boundary.

B3 52–100 cm — Dark brown (10YR 3/3 M) sandy clay; moderate medium subangular blocky structure; firm, sticky and plastic; few 2 to 5 mm size iron-manganese concretions; common fine to medium distinct brown to dark brown and reddish brown (7.5YR 4/4 and 5YR 4/4) mottles; slight effervescence; moderately alkaline (pH 8.2); gradual smooth boundary.

C1 100–127 cm — Dark grayish brown (10YR 4/2 M) gravelly sand clay; moderate medium subangular blocky structure; friable; sticky and plastic; few 2 to 3 mm size iron-manganese concretions; common brown and reddish brown mottles; slight effervescence; moderately alkaline (pH 8.2); abrupt smooth boundary.

IIR 127–140 cm — Partly weathered granite-gneiss.

Type location: Village Patancheru, tehsil and district, Medak, Andhra Pradesh; Block no. P 5 of the farm area.

Setting: Occurs on low lands covered with weathered basalt.

Drainage and permeability: Poorly drained with poor to very poor permeability.

Use and vegetation: Mainly cultivated to rice.

Distribution and extent: Limited in extent.

Soil Series: Manmool **Classification: Fluventic Ustropept**

Horizon	Depth (cm)	Size class and particle diameter (mm): Coarse sand 2.0-0.2 (% of <2 mm)	Fine sand 0.2-0.02 (% of <2 mm)	Silt <0.02-0.002 (% of <2 mm)	Clay 0.002 (% of <2 mm)	Coarse fragments >2 mm (% of whole soil)	Organic carbon (%)	Carbonate as $CaCO_3$ (%)	pH (1:2.5) H_2O	E.C (1:2.5) H_2O mmhos/cm
Ap	0-12	35.3	24.1	5.0	35.6	17	1.26		8.1	0.2
B21	12-32	34.3	24.6	5.6	35.5	24	1.02		8.1	0.3
B22	32-52	36.4	21.3	5.2	37.1	15	0.33	0.3	8.1	0.3
B3	52-100	38.6	20.0	4.7	36.7	18	0.42	0.3	8.2	0.3
C1	100-127	36.7	21.8	5.2	36.3	25	0.52	0.2	8.2	0.3

Depth (cm)	Extractable bases: Ca (meq/100g)	Mg (meq/100g)	Na (meq/100g)	K (meq/100g)	Sum (meq/100g)	CEC NH_4OAc	Exchangable sodium (%)	Base saturation (%)	Ratio CEC/Clay	Sand fraction mineralogy (%): QZ	FDM	FDP	BI	AM	FE
0-12	18.5	5.2	1.4	0.7	25.8	27.9	5	93	0.78	10	10	50	10	2	10
12-32	19.8	6.0	1.3	0.7	27.8	29.3	4	95	0.83	10	10	50	5	5	10
32-52	20.1	6.4	1.2	0.6	28.3	30.8	4	92	0.83	10	5	50	10	3	15
52-100	28.3	7.1	1.6	0.6	27.6	29.5	6	94	0.80	15	10	40	5		15
100-127	15.7	8.6	1.6	0.7	26.6	29.3	6	91	0.81	30	10	30	5		15

QZ = Quartz
FDM = Feldspar microcline
FDP = Feldspar plagioclase
AM = Amphibole
BI = Biotite
FE = Magnetic

Nakkavagu series:

Nakkavagu soils are members of the coarse-loamy, mixed, isohyperthermic family of Typic Ustifluvents.

Typifying pedon: Nakkavagu gravelly sand—fallow.

A1 0–15 cm — Light brown (7.5YR 6/4 D) gravelly sand, dark brown (7.5YR 4/4 M); weak fine granular and single grained structure; loose; common fine roots; few fine iron concretions on the surface; mildly alkaline (pH 7.5); clear smooth boundary.

IIC1 15–60 cm — Brown (7.5YR 5/4 D) sandy loam, dark brown (7.5YR 4/4 M); weak fine granular to single grained; loose; mildly alkaline (pH 7.6); clear smooth boundary.

IIC2 60–95 cm — Brown to dark brown (7.5YR 4/4 D & M) sandy loam; moderate medium subangular blocky structure; hard, firm, slightly sticky and slightly plastic; mildly alkaline (pH 7.8).

Type location: 1 km north of village Patancheru along the bank of Nakkavagu stream, tehsil and district Medak, Andhra Pradesh.

Setting: Flood plain.

Drainage and permeability: Well drained with moderately rapid permeability.

Use and vegetation: Fallow land with local grasses.

Distribution and extent: Narrow patches along stream.

Soil Series: Nakkavagu **Classification: Typic Ustifluent**

Horizon	Depth (cm)	Size class and particle diameter (mm): Sand 2.0-0.02	Silt 0.02-0.002	Clay <0.002	Coarse fragments >2 mm (% of whole soil)	Organic carbon (%)	pH (1:2.5) H_2O	E.C. (1:2.5) H_2O mmhos/cm
		% of <2 mm						
A1	0-15	92.3	3.1	4.6	49	0.24	7.5	0.1
IIC1	15-60	81.3	4.1	14.6	6	0.16	7.6	0.1
IIC2	60-95	78.0	6.4	15.6	-	0.24	7.8	0.3

Depth	Extractable bases: Ca	Mg	Na	K	Sum	CEC NH_4OAc	Exchangeable sodium (%)	Base saturation (%)	Ratio CEC: Clay	Sand fraction mineralogy (%): QZ	FDM	FDP	AM	FE
	meq/100g													
0-15	1.4	0.3	0.1	0.1	1.9	3.1	3	61	0.67	50	30	10	-	5
15-60	3.9	0.3	0.7	0.1	5.0	4.6	14	100	0.32	35	25	20	5	10
60-95	6.8	3.6	0.1	0.2	10.7	10.8	1	99	0.69	35	25	15	10	10

QZ = Quartz
FDM = Feldspar-microcline
FDP = Feldspar-plagioclase
AM = Amphibole
FE = Magnetite

Palmavagu series:

Palmavagu soils are members of the mixed, isohyperthermic family of Typic Ustipsamments.

Typifying pedon: Palmavagu sand—fallow.

A1 0–20 cm — Light yellowish brown (10YR 6/4D) sand, yellowish brown (10YR 5/4 M); single grained; loose; few fine roots; neutral (pH 7.1); clear smooth boundary.

C 20–145 cm — Brownish yellow (10YR 6/6 D) sand, yellowish brown (10YR 5/4 M); single grained; loose; few very fine roots; mildly alkaline (pH 7.8).

Type location: Near village Patancheru, tehsil and district Medak, Andhra Pradesh; along the bank of Palmavagu stream.

Setting: Flood plain.

Drainage and permeability: Excessively well drained with rapid permeability.

Use and vegetation: Fallow land with local grasses.

Distribution and extent: Narrow patch along the stream.

Soil Series: Palmavegu **Classification: Typic Ustipsamment**

Horizon	Depth (cm)	Size class and particle diameter (mm): Sand 2.0-0.02 (% of <2 mm)	Silt 0.02-0.002 (% of <2 mm)	Clay <0.002 (% of <2 mm)	Coarse fragments >2 mm (% of whole soil)	Organic carbon (%)	pH (1:2.5) H_2O	E.C. (1:2.5) H_2O mmhos/cm
A1	0-20	92.4	3.3	4.3	8	0.41	7.1	0.3
C	20-145	90.5	3.3	6.2	23	0.06	7.8	0.2

Depth	Extractable bases Ca	Mg	Na	K (meq/100g)	Sum	CEC NH_4O Ac	Exchangeable sodium (%)	Base saturation (%)	Ratio CEC / Clay	Sand fraction mineralogy (%) QZ	FDM	FDP	AM	FE
0-20	3.0	0.3	0.3	0.4	4.0	4.0	7	100	0.94	45	30	15	5	5
20-145	4.5	0.3	0.3	0.1	5.0	5.0	6	100	0.80	45	25	20	5	5

QZ = Quartz
FDM = Feldspar-microcline
FDP = Feldspar-plagioclase
AM = Amphibole
FE = Magnetite

Patancheru series:

Patancheru soils are members of the clayey-skeletal, mixed,isohyperthermic family of Udic Rhodustalfs.

Typifying pedon: Patancheru sandy loam—culturable fallow.

Ap 0–5 cm — Yellowish red (5YR 4/6 D) sandy loam, reddish brown (5YR 4/4 M); weak fine subangular blocky structure; loose and friable; many fine imped roots; 2 to 5 mm size quartz gravels 15 to 20% by volume; fine irregular pores; neutral (pH 6.9); clear smooth boundary.

B1 5–18 cm — Dark red (2.5YR 3.5/6 D & M) clay loam; moderate medium subangular blocky structure; hard, friable, slightly sticky; many fine imped roots; fine irregular pores; neutral (pH 6.9); gradual smooth boundary.

B21t 18–36 cm — Red to dark red (2.5YR 3/6 D & M) gravelly clay; strong coarse subangular blocky structure; hard, friable and sticky; few fine roots; thin patchy clay cutans; 5 to 10 mm size quartz gravels 45 to 50% by volume; common tubular pores; neutral (pH 6.9); gradual smooth boundary.

B22t 36–71 cm — Dark reddish brown (2.5YR 3/4 D & M) gravelly clay; strong coarse subangular blocky structure; hard, friable, sticky; very few very fine roots; thick patchy clay cutans; quartz gravel and fine iron concretions 60 to 65% by volume; common fine tubular pores; neutral (pH 6.8); gradual smooth boundary.

B23t 71–112 cm — Dark red (2.5YR 3/6 M) gravelly clay; moderate medium subangular blocky structure, hard, friable, sticky; very few very fine roots; quartz gravels, larger than 2 cm size rock fragments; iron concretions 50 to 60% by volume; few patchy clay cutans, common fine tubular pores; slightly acid (pH 6.5); gradual smooth boundary.

B3 112–140 cm — Dark red (2.3YR 3/6 M) gravelly sandy clay loam; moderate medium subangular blocky structure; friable, slightly sticky; very few fine roots; slightly acid (pH 6.2); clear wavy boundary.

C 140–150 cm + — Weathered granite-gneiss.

Type location: Village Patancheru, tehsil and district Medak, Andhra Pradesh; about 3 km east of Kandi village on Kandi-Patancheru road.

Setting: Occurs on gently sloping (3 to 5%) pediment of coarse grained granite-gneiss basement complex.

Drainage and permeability: Well drained with moderate permeability.

Use and vegetation: Mainly cultivated to sorghum and pulses.

Distribution and extent: Extensive soil.

Note: There may be some pedons on very gently sloping pediment surface with lesser amount of gravel.

Soil Series: Patancheru **Classification: Udic Rhodustalf**

Horizon	Depth (cm)	Size class and particle diameter (mm): Sand 2.0-0.02 (% of <2 mm)	Silt 0.02-0.002 (% of <2 mm)	Clay <0.002 (% of <2 mm)	Coarse fragments >2 mm (% of whole soil)	Organic carbon (%)	pH (1:2.5) H_2O	E.C. (1:2.5) H_2O	Water retention: 1/3-bar %	Water retention: 15-bar %
Ap	0- 5	79.3	6.4	14.3	17	0.55	6.0	0.1	16.2	6.3
B1	5- 18	66.7	5.5	27.8	17	0.52	6.9	0.1	20.0	12.4
B21t	18- 36	41.6	6.8	51.6	36	0.63	6.9	0.1	21.9	13.9
B22t	36- 71	45.0	4.4	50.6	54	0.40	6.8	0.1	24.8	17.4
B23t	71-112	54.1	7.4	38.5	50	0.10	6.5	0.1	23.6	16.2
B3	112-140	70.6	4.1	25.3	63	0.18	6.2	0.2	18.7	11.5

Depth	Extractable bases: Ca	Mg	Na	K (meq/100g)	Sum	CEC NH_4O Ac	Base saturation (%)	Ratio CEC / Clay	Clay fraction mineralogy (%): Am	KK	MI	SM	QZ	Sand fraction mineralogy (%): QZ	FDM	FE	HE	FDP	Others
0- 5	2.6	0.5	-	0.4	3.5	4.8	74	0.34	11	37	12	17	17	35	25	10	10	5	15
5- 18	3.8	0.9	-	0.5	5.2	8.2	64	0.29	12	37	10	19	14	45	20	5	5	10	15
18- 36	5.8	3.8	-	0.6	10.2	14.8	69	0.29	14	37	10	23	14	40	30	10	-	10	10
36- 71	7.9	3.1	-	0.6	11.6	14.1	82	0.28	12	38	11	20	16	30	30	5	5	15	15
71-112	5.4	2.5	0.3	0.4	8.6	9.8	88	0.25	12	44	9	18	16	40	20	5	-	10	25
112-140	5.7	1.9	0.5	0.3	8.4	9.1	92	0.36	10	39	8	21	16	35	25	5	-	15	20

AM = Amphibole
KK = Kaolinite
MI = Mica
SM = Smectite
QZ = Quartz
FDM = Feldspar microcline
FDP = Feldspar plagioclase
HE = Haematite
FE = Magnetite

Rudravaram series:

Rudravaram soils are members of the fine-loamy, mixed, isohyperthermic family of Typic Ustropepts.

Typifying pedon: Rudravaram sandy clay loam—cultivated.

Ap 0–5 cm — Grayish brown (10YR 5/2 D) sandy clay loam, dark grayish brown (10YR 4/2 M); moderate medium subangular blocky structure; hard, friable, slightly sticky and slightly plastic; many fine imped roots; slight effervescence; moderately alkaline (pH 8.4); gradual smooth boundary.

A1 5–19 cm — Dark grayish brown (10YR 4/2 D & M) sandy clay loam; moderate medium subangular blocky structure; hard, friable, slightly sticky and slightly plastic; many fine roots; slight effervescence; moderately alkaline (pH 8.2); gradual smooth boundary.

B21 19–35 cm — Very dark grayish brown (10YR 3/2 M) clay; moderate medium subangular blocky structure; firm, sticky and plastic; few fine roots; slight effervescence; moderately alkaline (pH 8.1); gradual smooth boundary.

B22 35–85 cm — Very dark grayish brown (10YR 3/2 M) clay; moderate medium subangular blocky structure; firm, sticky and plastic; slight effervescene; moderately alkaline (pH 8.1); clear wavy boundary.

C 85–100 cm — Weathered basalt, mixed with lime concretions.

Type location: Village Patancheru, tehsil and district Medak, Andhra Pradesh; about 1.2 km east of Gangavaram on Hyderabad road.

Setting: Low lying level to very gently sloping pediment covered by basaltic outwash.

Drainage and permeability: Moderately well drained with moderate permeability.

Use and vegetation: Mainly cultivated to rice.

Distribution and extent: Extensive soil.

Soil Series: Rudraveram **Classification: Typic Ustropept**

Horizon	Depth (cm)	Size class and particle diameter (mm): Coarse sand 2.0-0.2	Fine sand 0.2-0.02	Silt <0.02-0.002	Clay 0.002	Coarse fragments >2 mm (% of whole soil)	Organic carbon (%)	Carbonate as $CaCO_3$ (%)	pH (1:2.5) H_2O	E.C. (1:2.5) H_2O mmhos/cm
		% of <2 mm								
Ap	0-5	42.2	25.8	9.2	22.8	11	0.75	0.36	8.4	0.4
A1	5-19	45.1	25.1	8.1	21.7	13	0.37	0.20	8.2	0.3
B21	19-35	31.2	25.9	8.0	34.9	11	0.22	0.20	8.1	0.5
B22	35-85	35.0	24.0	7.0	34.0	13	-	0.20	8.1	1.0

Depth	Extractable bases: Ca	Mg	Na	K	Sum	CEC NH_4OAc	Exchangeable sodium (%)	Base saturation (%)	Ratio CEC / Clay	Sand fraction mineralogy (%): QZ	FDM	FDP	FM	ZR	FE
	meq/100g														
0-5	5.9	2.5	0.7	1.4	10.5	10.9	6	96	0.48	10	10	55	10	10	5
5-19	5.4	2.9	1.3	1.1	10.7	11.1	12	97	0.50	5	10	65	5	10	5
19-35	8.2	8.2	1.1	0.7	18.2	19.0	6	96	0.51	10	20	45	5	10	-
35-85	7.4	10.6	0.7	0.4	19.1	21.6	3	88	0.64	5	25	45	5	10	5

QZ - Quartz
FDM - Feldspar microcline
FDP - Feldspar plagioclase
ZR - Zircon
FM - Ferromagnesium minerals
FE - Magnetite

Shankarpalli series:

Shankarpalli soils are members of the fine-loamy, mixed, isohyperthermic family of Lithic Ustorthents.

Typifying pedon: Shankarpalli clay—cultivated.

Ap 0–8 cm — Brown to dark brown (10YR 4/3 D) clay, very dark brown (10YR 2/2 M); weak medium angular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; few fine imped roots; few fine lime concretions; strong effervescence; mildly alkaline (pH 7.8); gradual smooth boundary.

AC 8–14 cm — Brown to dark brown (10YR 4/3 D) clay loam, very dark grayish brown (10YR 3/2 M); weak medium subangular blocky structure; slightly hard, friable, slightly sticky and plastic; common fine imped roots; few fine to medium lime concretions; strong effervescence; moderately alkaline (pH 8.1); clear wavy boundary.

R 14–30 cm — Weathered basalt.

Type location: Village Patancheru, tehsil and district Medak, Andhra Pradesh; about 1 km north of Jolkal village on Jolkal-Chorial cart track.

Setting: Occurs on very gently sloping basalt plateau and basalt pediment.

Drainage and permeability: Moderately well drained with moderately slow permeability.

Use and vegetation: Mainly cultivated to pulses.

Distribution and extent: Extensive soil.

Soil Series: Shankarpalli **Classification: Lithic Ustorthent**

Horizon	Depth (cm)	Size class and particle diameter (mm) Sand 2.0-0.02	Silt 0.02-0.002	Clay <0.002		Coarse fragments >2 mm (% of whole soil)	Organic carbon (%)	Carbonate as $CaCO_3$ 2mm	pH (1:2.5) H_2O	E.C. (1:2.5) H_2O	Water retention 1/3-bar %	15-bar %
		% of <2 mm										
Ap	0-8	21.2	38.3	5.9	34.6	15	0.30	4.4	7.8	0.2	30.5	20.9
AC	8-14	22.1	37.7	10.9	29.3	11	0.20	6.4	8.1	0.1	29.9	17.8

Depth	Extractable bases Ca	Mg	Na	K	Sum	CEC NH_4OAc	Base saturation (%)	Ratio CEC Clay	Clay fraction mineralogy (%) AM	KK	MI	SM	QZ	Sand fraction mineralogy (%) FDP	BI	FM	FE	HE
	meq/100g																	
0-8	25.9	5.6	0.9	0.8	33.2	33.7	98	0.97	6	9	3	74	7	20	15	35	20	10
8-14	26.1	4.2	1.0	0.6	31.9	31.8	100	1.08	6	17	4	67	6	15	15	40	15	5

AM = Amphibole
KK = Kaolinite
MI = Mica
HE = Haematite
SM = Smectite
QZ = Quartz
FE = Magnetite
FDP = Feldspar plagioclase
BI = Biotite
FM = Ferromagnesium minerals

Singpur series:

Singpur soils are members of the fine, montmorillonitic, isohyperthermic family of Paralithic Vertic Ustropepts.

Typifying pedon: Singpur clay—cultivated.

Ap 0–5 cm — Dark brown (7.5YR 3/2 D & M) clay; weak fine granular structure; loose, friable, sticky and plastic; common fine and medium imped roots; common fine pores; surface cracks up to 20 cm depth; mildly alkaline (pH 7.8); gradual boundary.

B21 5–20 cm — Dark brown (7.5YR 3/2 D & M) clay; strong coarse subangular blocky structure; hard, firm, sticky and plastic; common fine imped roots; moderately alkaline (pH 7.9); gradual smooth boundary.

B22 20–32 cm — Dark brown (7.5YR 3/2 D & M) clay; strong coarse angular blocky structure; firm, sticky and plastic; very few fine lime concretions; slight effervescence; moderately alkaline (pH 7.9); clear smooth boundary.

IIC 32–50 cm — Weathered basalt.

Type location: Village Patancheru, tehsil and district Medak, Andhra Pradesh; about 3 km west of Shankarpalli on Shankarpalli-Kandi road (near Microwave Station).

Setting: Occurs on nearly level basalt plateau and basalt pediment.

Drainage and permeability: Moderately well drained with moderate permeability.

Use and vegetation: Mainly cultivated to sorghum, safflower and pulses.

Distribution and extent: Extensive soil.

Soil Series: Singpur **Classification: Paralithic Vertic Ustropept**

Horizon	Depth (cm)	Size class and particle diameter (mm): Coarse sand 2.0-0.2 (% of <2 mm)	Fine sand 0.2-0.02 (% of <2 mm)	Silt <0.02-0.002 (% of <2 mm)	Clay <0.002 (% of <2 mm)	Coarse fragments >2 mm (% of whole soil)	Organic carbon (%)	pH (1:2.5) H_2O	EC (1:2.5) H_2O mmhos/cm	Water retention 1/3 bar (%)	Water retention 15 bar (%)
Ap	0-5	2.3	17.8	25.7	54.2	18	0.46	7.8	0.1	37.6	22.0
B21	5-20	3.5	11.3	23.4	61.8	16	0.35	7.9	0.1	40.0	25.1
B22	20-32	3.0	8.0	20.0	69.0	6	0.39	7.9	0.1	38.9	24.6

Depth	Extractable bases: Ca (meq/100g)	Mg	Na	K	Sum	CEC NH_4OAc	Base saturation (%)	Ratio CEC: Clay	Clay fraction mineralogy (%): AM	KK	MI	SM	QZ	Sand fraction mineralogy (%): RE	FDP	BI	FM	PE	HE
0-5	46.5	10.3	0.9	0.7	58.4	61.1	95	1.14	9	20	2	63	4	2	25	10	35	10	5
5-20	46.5	11.5	1.0	0.5	59.5	61.0	98	0.99	9	17	2	67	5	2	20	15	40	15	10
20-32	46.5	12.6	0.9	0.4	60.4	62.1	97	0.90	8	21	2	67	4	2	25	10	40	20	-

AM = Amphibole
KK = Kaolinite
MI = Mica
SM = Smectite
QZ = Quartz
RE = Anatase
FDP = Feldspar-plagioclase
BI = Biotite
FM = Ferromagnesium minerals
FE = Magnetite
HE = Haematite

Yamkunta series:

Yamkunta soils are members of the fine, montmorillonitic, isohyperthermic family of Vertic Halaquepts.

Typifying pedon: Yamkunta clay—fallow.

Ap 0–13 cm — Dark grayish brown (2.5Y 4/2 D & M) clay; moderate medium subangular blocky structure; hard, firm, sticky and plastic; few fine roots; few fine lime concretions; strong effervescence; mildly alkaline (pH 7.8); clear smooth boundary.

B21 13–60 cm — Dark grayish brown (10YR 4/2 M) clay; moderate medium subangular blocky structure; hard, firm, sticky and plastic; very few fine roots; few fine iron and lime concretions; strong effervescence; moderately alkaline (pH 8.4); gradual smooth boundary.

B22 60–89 cm — Dark grayish brown to very dark grayish brown (10YR 3.5/2 M) clay; blocky structure, firm, sticky and plastic; very few fine roots; few fine lime and iron concretions; strong effervescence; strongly alkaline (pH 8.7); gradual smooth boundary.

B23 89–120 cm — Very dark grayish brown (10YR 3/2 M) clay; blocky structure; firm, very sticky and plastic; very few lime and iron concretions; strong effervescence; strongly alkaline (pH 8.6); gradual smooth boundary.

C1 120–145 cm — Grayish brown to dark grayish brown (2.5Y 4.5/2 M) gravelly clay; massive; very sticky and plastic; 2 to 5 mm size rounded iron concretions and irregular lime concretions; strong effervescence; strongly alkaline (pH 8.7); clear wavy boundary.

C2 145–190 cm — Light yellowish brown (2.5Y 6/4 M) gravelly clay; massive; very sticky and plastic; 5 to 10 mm size rounded iron concretions and irregular lime concretions 20 to 30% by volume; strong effervescence; strongly alkaline (pH 8.6).

Type location: Village Patancheru, tehsil and district Medak, Andhra Pradesh; Block No. D/3 of the farm area.

Setting: Occurs in filled valleys.

Drainage and permeability: Imperfectly drained with very slow permeability.

Use and vegetation: Lying fallow due to frequent inundation, strong salinity and alkalinity.

Distribution and extent: Limited in extent.

Soil Series: Yamiunta **Classification: Vertic Halaquept**

Horizon	Depth (cm)	Size class and particle diameter (mm): Coarse sand 2.0-0.2 (% of <2 mm)	Fine sand 0.2-0.02 (% of <2 mm)	Silt <0.02-0.002 (% of <2 mm)	Clay 0.002 (% of <2 mm)	Coarse fragments >2 mm (% of whole soil)	Organic carbon (%)	pH (1:2.5) H_2O	E.C. (1:2.5) H_2O mmhos/cm
Ap	0-13	34.2	22.1	5.6	38.1	10	0.66	7.8	3.0
B21	13-60	27.9	17.9	7.5	46.7	17	0.48	8.4	1.3
B22	60-89	30.3	17.6	6.5	45.6	20	0.48	8.7	1.3
B23	89-120	27.2	17.5	7.4	47.9	14	0.36	8.6	1.3
C1	120-145	31.3	17.6	6.8	44.3	27	0.33	8.7	1.3

Depth	Extractable bases: Ca (meq/100g)	Mg	Na	K	Sum	CEC NH_4OAc	Exchangeable sodium (%)	Base saturation (%)	Ratio CEC/Clay	Sand fraction mineralogy (%): QZ	FDM	FDP	AM	FM	FE	CA
0-13	8.2	12.0	5.0	0.7	25.9	27.1	18	96	0.71	15	25	20	10	5	15	-
13-60	8.6	14.6	5.5	0.8	24.5	34.4	16	71	0.74	10	25	30	5	-	15	10
60-89	8.1	14.2	5.9	0.8	29.0	33.1	17	88	0.73	5	20	25	10	5	15	10
89-120	8.7	16.3	5.4	0.9	31.3	37.0	15	85	0.77	30	-	40	-	-	10	5
120-145	3.3	21.5	4.7	0.8	30.3	34.3	14	89	0.77	40		25	5	10	10	10

QZ = Quartz
FDM = Feldspar-microcline
FDP = Feldspar-plagioclase
AM = Amphibole
FM = Ferromagnesium minerals
FE = Magnetite
CA = Calcite