International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
www.chemijournal.com
IJCS 2020; 8(6): 1112-1119

Received: 08-09-2020
Accepted: 22-10-2020

**Raghu RS**
Department of Soil Science and Agricultural Chemistry, Agricultural College, Bapatla, Andhra Pradesh, India

**PRK Prasad**
Department of Soil Science and Agricultural Chemistry, Agricultural College, Bapatla, Andhra Pradesh, India

**KV Ramana**
Department of Soil Science and Agricultural Chemistry, NRSC, Hyderabad, Telangana, India

**Ch. Sujani Rao**
Department of Soil Science and Agricultural Chemistry, Agricultural College, Bapatla, Andhra Pradesh, India

**B Venkateswarlu**
Department of Agronomy, Agricultural College, Bapatla, Andhra Pradesh, India

**V Srinivasa Rao**
Department of Statistics and Computer Applications, Agricultural College, Bapatla, Andhra Pradesh, India

**MVS Naidu**
Department of Soil Science and Agricultural Chemistry, S V Agricultural College, Tirupati, Andhra Pradesh, India

**Corresponding Author:**
**Raghu RS**
Department of Soil Science and Agricultural Chemistry, Agricultural College, Bapatla, Andhra Pradesh, India

# Genesis and classification of rice-maize-sorghum growing Vertisols in semi-arid tropical region of Chinnapalem village of Guntur district in Andhra Pradesh

**Raghu RS, PRK Prasad, KV Ramana, Ch. Sujani Rao, B Venkateswarlu, V Srinivasa Rao and MVS Naidu**

**DOI:** https://doi.org/10.22271/chemi.2020.v8.i6p.10911

**Abstract**
The study was carried out in semi-arid tropical ecosystem of Chinnapalem Village of Guntur District. This study was an embodiment with an objective of genesis and classification of some black soils in semi-arid tropical region of Andhra Pradesh. The black soils of Chinnapalem Village, Duggirala mandal were formed at nearly level to plain topography with river alluvium parent material. All the pedons exhibited clear and smooth boundary in surface horizons and diffuse and wavy boundary in the sub-surface horizons and A horizon was designated as Ap horizon while B horizon was Bss due to the presence of well-formed distinct slickensides. The soil colour varied from from very dark gray to black. Textural class of fine earth was clayey with medium to coarse, moderate to strong and angular to subangular blocky in structure. The consistence varied from very hard to extremely hard, firm to extremly firm and sticky to very-sticky and plastic to very-plastic in dry, moist and wet conditions, respectively. Due to the presence of vertic features like slickensides, pressure faces, cracks and presence of more than 30 % clay in all the horizons were grouped under Vertisols and classified as *Typic Haplusterts* and ideal for cultivation of rice, sorghum, and maize.

**Keywords:** Genesis, classification, slickenslides, typic haplustert and vertisols

## Introduction
Andhra Pradesh under being a semi-arid tropical monsoon climate has a number of soil types found. Soil is one of the most important natural resources, maintaining it in good health is necessary for meeting the increasing demand of food, fibre, fodder and fuel. Characterization, classification and evaluation of soils are the first milestones to develop database for formulating land use models. Systematic study of morphology and taxonomy of soils provides information on nature and type of soils, their constraints, potentials, capabilities and their suitability for various uses (Sehgal, 2005) [25]. Characterization helps in determining the soil potentials and identifying the constraints in crop production besides giving detailed information about different soil properties (Khan and Kamalakar, 2012) [8]. Soil classification, on the other hand, helps to organize our knowledge, facilitates the transfer of experience and technology from one place to another and helps to compare soil properties. No information is available especially on classification and genesis of soils of Chinnapalem Village of Duggirala mandal in Guntur district. Hence, present study was taken to classify and evaluate the soils in Chinnapalem village.

## Materials and Methods
### Study Area
The study area lies in between 16$^0$ 23’ 22.773” to 16$^0$ 20’ 47.612” N latitudes and 80$^0$ 38’ 38.892” to 80$^0$ 41’ 54.958 E longitudes with an average elevation of 16 m mean sea level (Table 1). The soils were formed at nearly level to plain topography with river alluvium parent material (Table 2). The study area was confined to semi-arid tropical monsoonic climate with distinct summer, winter and rainy seasons. The mean annual atmospheric temperature was 29.54°C and the mean annual rainfall was 828.19 mm. with distinct summer (April to June), rainy (July to November) and winter (December to March) seasons. It experiences mean annual precipitation of 828.19 mm during May to November.

The mean annual temperature is 29.5°C with a mean summer temperature of 34.42°C and mean winter temperature of 29.94°C. The maximum temperature recorded for last 10 years is 41.9°C in the month of May and the minimum temperature is 18.34°C in the month of January (Table 3). The study area receives rainfall only during south-west monsoon period and rainfall received during the winter and hot weather periods was negligible. The overall climate of the study area is characterised by hot summer and mild winter. The soil moisture regime has been computed as ustic and temperature regime as *isohyperthermic*. The natural vegetation of the study area were *Cyprus rotundus*, *Cynadondactylon*, *Acacia nilotica*, *Azadirachtaindica*, *Phoenix dactylifera*, Sishophoraspp, *Prosopisjuliflora*, *Lantana Camera*, *Calotropisprocera*, *Mimosa pudica etc*., (Table 4).

**Methodology**

A Semi-detailed soil survey was conducted in Chinnapalm village of Guntur district located in semi-arid agro-ecological region using 1:50,000 base map as per the procedure outlined by AIS&LUS (1970) [1] and selected eight pedons in Rice-Maize-Sorghum growing areas. These pedons were studied in detail and the morphological characteristics were presented in Table1. The detailed morphological description of these pedons was studied in the field as per the procedure outlined in Soil Survey Manual (Soil Survey Staff, 2014) [32]. Later, horizon-wise samples were collected. The soils were classified taxonomically (Soil Survey Staff, 2014) [32].

**Results and Discussion**

**Soil Morphology**

The detailed morphological properties of the soils were presented in Table 5. The depth of different pedons studied from Chinnapalem village varied between 0.18 m and 1.90 m and found to have deep to very deep solum. The non-availability of adequate amount of water for prolonged period in the gently sloping soils associated with removal of finer particles and their deposition at lower pediplain have resulted in deeper soils in lower pediplain (Prakash and Rao, 2002) [17]. Furthermore, Rao *et al.,* (2004) [21] stated that Vertisols in the south coastal Andhra Pradesh were very deep, clayey, moderately well drained and were formed on nearly flat to very gently sloping uplands with a slope gradient upto 3 per cent. Based on different morphological features, pedons 1, 2, 3, 4 and 5 were differentiated into 5 horizons while pedons 6, 7 and 8 were distinguished into 6 horizons each. Similar number of horizons was observed by Kashiwar *et al.* (2009) [7] and Nasre *et al.* (2013) [12] in the soils of Salai watershed of Nagpur district in Maharashtra and Vertisols of Karanji watershed of Yavatmal district in Maharastra respectively.

The A horizon was designated as Ap by taking into consideration the change in colour and structure due to cultivation in all the profiles. The Pedons 1, 2, 3, 4, 5, 6, 7 and 8 exhibited into Ap horizon while B horizon was divided into Bss1, Bss2, Bss3 and Bss4 in 1, 2, 3, 4 and 5 pedons. Further, the B horizon in pedons6, 7 and 8 was distinguished as Bss1, Bss2, Bss3, Bss4 and Bss5 due to the presence of well-formed distinct slickensides respectively. Horizonation was the main pedogenic process in Vertisols. According to Simonson (1959) [28], the basic processes involved in soil formation were gains such as addition of water, organic and mineral matter to the soil, losses of the above materials from the soil and transformation and / or translocation. Any one of the above processes might have taken place in these pedons hence, profile development occurred with ABC horizons. All the pedons showed Bss horizon indicating development of slickensides in the B horizon which qualifies these soils to be classified under Vertisols. The Vertisols of ICRISAT production agricultural fields, India were exhibiting the sub-surface horizons of Bss1, Bss2, Bss3, Bssck1, Bssck2 and Bck (Soil Survey Staff, 1999) [31]. Similarly, Rajeshwar and Mani (2015) [18] identified ABC profiles in black cotton soils of Cotton Research station (CRS) of Peramblur district of Tamil Nadu which showed the horizon sequence of Ap, Bss1, Bss2, Bss3 and Ck. All the pedons exhibited clear and smooth boundary in surface horizons and diffuse and wavy boundary in the sub-surface horizons. Rao *et al.* (2008) [19] stated that boundary of the pedons on plains varied from clear to diffuse in distinctness and smooth to wavy in topography. The Boundary of the pedons in Banaganapallemandal of Kurnool district in Andhra Pradesh varied from clear to diffuse in distinctness and smooth to wavy in topography (Sireesha and Naidu, 2013) [29].

The colour in pedons 1, 2, 3, 4, 5, 6, 7 and 8 ranged from very dark gray to black with a hue ranged from 7.5YR to 10 YR, value of 2 to 4 and chroma ranged from 1 to 2. Vertisols developed on nearly levelled plains and alluvial plains showed very dark grayish brown colour (Sharma *et al.*, 1996) [27]. The hue varied from 7.5 to 10 YR, value ranged from 3 to 5 and chroma varied from 1 to 3 in grape growing soils of Nasik district in Maharashtra (Balpande *et al*., 2007) [2]. Clay texture was found throughout the depth in all the pedons 1, 2, 3, 4, 5, 6, 7 and 8. Some black soils of Andhra Pradesh were studied by Rao *et al.*, (1995) [20] and reported that the argillic pedoturbation was responsible for the formation of these soils. Similar results were also made by Rajeswar and Mani (2015) [18]. With regard to type of soil structure, the surface layers of pedons 1 and 3 showed coarse, strong to sub-angular blocky and sub-surface horizons exhibited coarse, strong to angular blocky. The surface layers of pedons 2, 5, 6, 7 and 8 exhibited medium, moderate to sub-angular blocky whereas in subsurface showedcoarse, strong to angular blocky structure. Pedon 4 showed medium, strong to subangular blocky in surface layers and coarse, strong to angular blocky structure in sub-surface layers. The black soils of northenTelangana region were found to have moderate, medium, sub-angular blocky structure at surface and moderate to strong, medium to very coarse angular blocky structure at sub-surface (Satyavathi and Suryanarayanreddy, 2003) [24]. Sekhar *et al.* (2014) [26] reported that structure of the black soils was medium to coarse, moderate to strong, sub-angular blocky to angular blocky.

The consistence varied from very hard to extremely hard, firm to extremly firm and sticky to very-sticky and plastic to very-plastic in dry, moist and wet conditions, respectively in different horizons of all pedons of the study area. This qualitative physical behaviour of soils, as influenced by dry, moist and wet conditions was not only due to the textural make up but also due to the type of clay minerals present in these soils. Presence of slightly hard to very hard, firm to very firm and sticky and plastic to very sticky and very plastic consistence in dry, moist and wet conditions respectively might be due to high clay content of the soils. Patil *et al.* (1999) [16] also reported hard, firm and very sticky and very plastic consistence in Vertisols whose hardness was increased with depth. Presence of extremely hard, extremely firm and slightly sticky and slightly plastic to very sticky and very plastic consistence might be due to large amount of expanding clay minerals (Satish *et al.*, 2018b) [23].

Cracks of 3 to 5 cm wide, which extend to a depth of 50 cm depth, were observed in all the pedons. These cracks were evident in summer months. The variation in volume of cracks might be attributed to the variation in contents of cementing materials and exchangeable Na+. The cementing materials like humic acid, iron and aluminium hydroxides were more; the extent of cracks will be less due to reduction in swelling property. The wide cracks of 2 to 3 cm on the surface and extending upto 55 cm depth were observed which is due to the high coefficient of swelling and shrinkage of montmorillonite clays (Kharche and Pharande, 2010) [9]. Black cotton soils of southern Tamil Nadu, showed well developed deep wide cracks in summer indicating high swell-shrink potential due to dominantly smectitic clays (Paramasivan and Jawahar, 2014) [14].

Pedons 1, 2, 3, 4, 5, 6, 7 and 8 in the study area showed distinct slickensides in deeper layers below 0.20, 0.55, 0.50, 0.42, 0.41, 0.60, 0.52 and 0.52 m depths, respectively. The formation of slickensides might be due to the presence of high amount of expanding clay minerals, alternate wetting and drying cycles and soil depth more than 0.5 m (Soil Survey Staff, 2014) [32]. The soils (Haplusterts) of Chitravathi river basin of Andhra Pradesh exhibited vertic properties and intersecting slickensides in the deeper layers and presence of wedge shaped aggregates in the second layer (Bhaskar and Nagaraju, 1998) [3]. Similar results were recorded by Nasre *et al.* (2013) [12].

There is no pores were in different layers of pedons. High porosity of these soils was due to finer texture of the soils. The pore space distribution in general revealed that most of the soils in the study area were poorly drained. The roots were few in quantity and fine in size were observed in surface layers and decreased with depth. Root distribution indicated that vegetation of the area comprises of annuals and grasses.

**Soil genesis**

Examination of soil profiles in Chinnapalem village in Duggiralamandal of Guntur district doesn't exhibited distinct horizontal layers, some of which were highly visible. Significant changes occurred as the soils were developed from relatively unconsolidated parent material. The pedons 1, 2, 3, 4, 5, 6, 7 and 8 were developed from river alluvium. Study of soil formation or soil genesis gives some notion as to how these changes occurred and why they can stimulate the development of so many types of soils. Soil genesis is brought about by series of processes, the most significant of which are:

1. Weathering and organic matter break down by which some soil constituents are modified or destroyed and others are synthesized.
2. Translocation of inorganic and organic materials up and down the soil profile, the material is being moved mostly by water but also by soil organisms.
3. Accumulation of soil materials in horizontal layers (horizons) in the soil profile, either as they are formed in place or translocated from the above or below the zone of accumulation (Brady, 1995).

Simonson (1959) [28] opined that process of soil formation includes

- Addition of organic and mineral materials to the soil as solids, liquids and gases.
- Losses of these from the soil.
- Translocation of materials from one point to another within the soil.
- Transformation of mineral and organic substances within the soil.

In the present study area, accumulation of organic matter and humus was observed on the surface soils and to certain depth of sub-soil in all the pedons. The surface horizon in all these pedons was dark in colour as compared to sub-surface horizons due to accumulation of organic matter.

For the formation of swell-shrink soils (all pedons) huge amount of smectite clay is required and such an amount cannot be produced in semi-arid climatic conditions. The smectite clay in Vertisols of central peninsular India were formed in an earlier humid climate which have been detached from the weathering process and transported downstream and deposited in the lower pediment areas or valleys (Coulombe *et al.*, 1996 and Bhattacharyya *et al.*, 1993) [6, 4]. Thus Vertisols occur in the lower pediment plain or valleys or micro depressions and the dominance of smectite clay is due to the mechanical deposition in an early humid climate (Pal and Deshpande, 1987 and Bhattacharyya *et al.*, 1993) [4]. Preservation of smectite crystallinity in black soils was achieved due to aggregation process that took place in the non-leaching environment of semi-arid climate. It is also revealed that formation of smectite occurred in all the pedons through transformation from the weathering sequence of mica-vermiculite-smectite. However, kaolinite could be formed from montmorillonite by loss of alkalies and iron.

Furthermore, the topography of the study area varied from nearly level plains. The interplay of climate, topography and vegetation acting on parent material over a period of time resulted in the development of soil *viz.,* Vertisol in Chinnapalem village of Guntur district in Andhra Pradesh.

**Soil classification**

Based on the morphological properties of soils and climatic parameters like moisture and temperature regimes the classification was done upto soil family level following the guidelines of USDA Soil Taxonomy (Soil Survey Staff, 2014) [32]. The soils are very deep and ideal for cultivation of rice, maize and sorghum. All the pedons classified under *Vertisols* because of the presence they exhibited following features. A layer 25 cm or more thick, with an upper boundary with in 100 cm of the mineral soil surface; clayey texture, more than 50 per cent clay in fine earth fraction throughout the depth; Gilgai micro-relief (microknolls and micro-ridges) on the surface; distinct intersecting slickensides in lower horizons; cracks of greater than 1 cm width which remained open and close periodically to the surface from a depth of more than 40 cm and absence of lithic or paralithic contact, duripan, petrocalcic horizon within 50 cm from the surface. Based on these characters, the soils were grouped under order *Vertisols*. Presence of cracks in normal years that are 5 mm or more wide through a thickness of 25 cm or more within 50 cm of the mineral soil surface for 90 or more cumulative days per year. The pedons 1, 2, 3, 4, 5, 6, 7 and 8 had ustic soil moisture regime. As the moisture regime is Ustic and black soil pedons were classified as Usterts at sub order level. At great group level classified as Haplusterts because the pedons did not have either salic, gypsic and petrocalcic horizons with in 100 cm depth. Surekha *et al.* (1997) [33] and Patangray *et al.* (2016) [15].

At sub group level both the pedons were further placed under the Typic Haplusterts because these pedons had deep cracks that remained open for more than 150 cumulative days most years. Similar finding was reported Surekha *et al.* (1997) [33] and Rajeshwar and Mani (2015) [18]. Pedons 2, 3, 5, 6, 7 and 8 had more than 60 per cent clay (weighted average) in the control section. Hence, the particle size class for these pedons was Very Fine. However, pedon 1 and 4 contained more than 35 per cent and less than 60 per cent weighted average clay in the control section. Hence, the particle size class for these pedon was Fine.

Hence, the clay mineralogical class of these pedons was "smectitic". Soil Survey Staff (1998) [30] recognized March, April, May and June as summer months and November, December, January and February as winter months for the places in northern hemisphere. As per these criteria the difference between mean summer and winter temperatures was less than 6°C and mean annual temperature was more than 22°C. Therefore, the temperature regime of the study area was is ohyperthermic.

**Soil formation**

**Climate**

The study area was confined to semi-arid tropical monsoonic climate with distinct summer, winter and rainy seasons. The mean annual atmospheric temperature was 29.54°C and the mean annual rainfall was 828.19 mm (Table 3). The moisture control section is dry for >90 cumulative days or 45 consecutive days in the months of summer and pedons had ustic soil moisture regime Soil Survey Staff (1998) [30] recognized March, April, May and June as summer months and November, December, January and February as winter months for the places in northern hemisphere. As per these criteria the difference between mean summer and winter temperatures was less than 6°C and mean annual temperature was more than 22°C. Therefore, the temperature regime of the study area was isohyperthermic.

**Parent Material**

The Pedons of Chinnapalem Village in Guntur District of Andhra Pradesh were developed from river alluvium (1, 2, 3, 4, 5, 6, 7 and 8). The study area was comprised of mostly black soils. The alluvial and flood plains have alluvium as parent material (Reza *et al*., 2010) [22].

**Topography**

The topography of Chinnapalemvillage was plains (0-1%) with very slight erosion. All the Pedons were situated on buried pediplain with nearly levelled slope of 0-1 per cent. Nandy *et al.* (2012) reported that the slope of the coastal soils of Pedapuluguvaripalem village of Guntur district was less than 1 per cent with all of them falling in plain topography.

**Time**

Coulombe *et al.* (1996) [6] stated that Vertisols were developed recently even though the parent materials were found in older geological periods. Time along with topography and nature of parent material were the important soil forming factors responsible for the pedogenic differences in the soils developed on different landforms within comparable climate conditions (Kumar *et al*., 2005) [10].

**Vegetation**

The pedons studied were selected from the cultivated fields. The major crops grown in study area were rice, maize, sorghum, coconut, banana and guava. The natural vegetation of the study area were *Cyprus rotundus*, *Cynadondactylon*, *Acacia nilotica*, *Azadirachtaindica*, *Phoenix dactylifera*, Sishophoraspp, *Prosopisjuliflora*, *Lantana Camera*, *Calotropisprocera*, *Mimosa pudica* etc., (Table 4). Verma *et al.* (2012) [34] and Sekhar *et al*. (2014) [26] reported similar type of natural vegetation in soils of alluvial plains of Etawah district, Uttar Pradesh and in soils of central and eastern parts of prakasam district respectively.

**Table 1:** Details of the pedon

| Pedon No. | Village | Location | Elevation above msl (m) | Horizon | Horizon thickness (m) |
|---|---|---|---|---|---|
| 1 | Chinnapalem | 16°22'27"N | 17 | Ap | 0.00 – 0.20 |
| | | 80°40'49"E | | Bss1 | 0.20 – 0.60 |
| | | | | Bss2 | 0.60 – 0.90 |
| | | | | Bss3 | 0.90 – 1.30 |
| | | | | Bss4 | 1.30 – 1.70+ |
| 2 | Chinnapalem | 16°22'29"N | 18 | Ap | 0.00 – 0.20 |
| | | 80°40'28"E | | Bss1 | 0.20 – 0.55 |
| | | | | Bss2 | 0.55 – 0.90 |
| | | | | Bss3 | 0.90 – 1.20 |
| | | | | Bss4 | 1.20 – 1.70+ |
| 3 | Chinnapalem | 16°22'18"N | 16 | Ap | 0.00 – 0.20 |
| | | 80°39'17"E | | Bss1 | 0.20 – 0.50 |
| | | | | Bss2 | 0.50 – 0.80 |
| | | | | Bss3 | 0.80 – 1.20 |
| | | | | Bss4 | 1.20 – 1.60+ |
| 4 | Chinnapalem | 16°23'05"N | 16 | Ap | 0.00 – 0.20 |
| | | 80°39'10"E | | Bss1 | 0.20 – 0.42 |
| | | | | Bss2 | 0.42 – 0.92 |
| | | | | Bss3 | 0.92 – 1.34 |
| | | | | Bss4 | 1.34 – 1.65+ |
| 5 | Chinnapalem | 16°21'56"N | 15 | Ap | 0.00 – 0.20 |
| | | 80°49'03"E | | Bss1 | 0.20 – 0.41 |
| | | | | Bss2 | 0.41 – 0.82 |
| | | | | Bss3 | 0.82 – 1.11 |
| | | | | Bss4 | 1.11 – 1.55+ |
| 6 | Chinnapalem | 16°21'36"N | 18 | Ap | 0.00 – 0.15 |
| | | 80°40'21"E | | Bss1 | 0.15 – 0.42 |
| | | | | Bss2 | 0.42 – 0.80 |
| | | | | Bss3 | 0.80 – 1.30 |
| | | | | Bss4 | 1.30 – 1.60 |
| | | | | Bss5 | 1.60 – 1.90+ |

| Pedon No. | Village | Location | Elevation above msl (m) | Horizon | Horizon thickness (m) |
|---|---|---|---|---|---|
| 7 | Chinnapalem | 16°21'30"N | 17 | Ap | 0.00 – 0.20 |
| | | 80°40'49"E | | Bss1 | 0.20 – 0.60 |
| | | | | Bss2 | 0.60 – 1.00 |
| | | | | Bss3 | 1.00 – 1.40 |
| | | | | Bss4 | 1.40 – 1.70 |
| | | | | Bss5 | 1.70 – 1.90+ |
| 8 | Chinnapalem | 16°20'48"N | 16 | Ap | 0.00 – 0.18 |
| | | 80°40'50"E | | Bss1 | 0.18 – 0.52 |
| | | | | Bss2 | 0.52 – 0.92 |
| | | | | Bss3 | 0.92 – 1.32 |
| | | | | Bss4 | 1.32 – 1.62 |
| | | | | Bss5 | 1.62 – 1.90+ |

**Table 2:** Site Characteristics of the Study Area

| Profile No. | Location | Slope percent | Physiography | Drainage | Parent Material |
|---|---|---|---|---|---|
| 1 | Chinnapalem | 0-1 | Plains | Poor | Alluvium |
| 2 | Chinnapalem | 0-1 | Plains | Poor | Alluvium |
| 3 | Chinnapalem | 0-1 | Plains | Poor | Alluvium |
| 4 | Chinnapalem | 0-1 | Plains | Somewhat poor | Alluvium |
| 5 | Chinnapalem | 0-1 | Plains | Poor | Alluvium |
| 6 | Chinnapalem | 0-1 | Plains | Somewhat poor | Alluvium |
| 7 | Chinnapalem | 0-1 | Plains | Somewhat poor | Alluvium |
| 8 | Chinnapalem | 0-1 | Plains | Somewhat poor | Alluvium |

**Table 3:** Meteorological data of the study area (2009-2018)*

| Month | Rainfall (mm) | Temperature ($^0$C) | | |
|---|---|---|---|---|
| | | Maximum | Minimum | Mean |
| JANUARY | 20.51 | 33.31 | 18.34 | 25.83 |
| FEBRUARY | 9.90 | 34.61 | 18.59 | 26.60 |
| MARCH | 2.27 | 36.99 | 21.56 | 29.27 |
| APRIL | 6.80 | 39.76 | 24.56 | 32.16 |
| MAY | 48.49 | 41.94 | 27.21 | 34.58 |
| JUNE | 142.94 | 37.96 | 26.81 | 32.39 |
| JULY | 151.56 | 35.40 | 25.90 | 30.65 |
| AUGUST | 133.38 | 35.23 | 25.51 | 30.37 |
| SEPTEMBER | 131.64 | 35.34 | 25.10 | 30.22 |
| OCTOBER | 119.30 | 34.90 | 23.56 | 29.23 |
| NOVEMBER | 45.36 | 33.39 | 21.17 | 27.28 |
| DECEMBER | 16.04 | 32.80 | 18.93 | 25.86 |
| Total | 828.19 | 35.97 | 23.10 | 29.54 |

Mean annual rainfall = 828.19mm
Mean annual air temperature = 29.54°C
*Mean values from 2009-2018

**Table 4:** Vegetation and land use of the study area

| Pedon No. | Village | Natural vegetation | Land use at site |
|---|---|---|---|
| 1 | Chinnapalem | *Cyprus rotundus Cynadon dactylon Acacia nilotica Azadirachta indica Phoenix dactylifera Sishophora spp* | Sorghum |
| 2 | Chinnapalem | *Phoenix dactylifera Prospis juliflora Ziziphus mauritiana Lantana camera* | Sorghum, Coconut |
| 3 | Chinnapalem | *Phoenix dactylifera Acacia nilotica Prospis juliflora Ziziphus mauritiana* | Coconut, Maize |
| 4 | Chinnapalem | *Azadirachta indica Ziziphus mauritiana Ficus benghalensis Calotropis procera Phoenix dactylifera* | Banana, Guava |
| 5 | Chinnapalem | *Acacianilotica Phoenix dactylifera Azadirachta indica Mimosa pudica Achyranthus aspera* | Sorghum |
| 6 | Chinnapalem | *Phoenix dactylifera Azadirachta indica Calotropis procera Acacia nilotica* | Rice |
| 7 | Chinnapalem | *Phoenix dactylifera Azadirachta indicaCalotropis procera Cyprus rotundus Acacianilotica Cynadon dactylon* | Maize |
| 8 | Chinnapalem | *Phoenix dactylifera Azadirachta indicaAcacianilotica Lantana camera Cyprus rotundus Cynadon dactylon Ficus benghalensis* | Maize |

**Table 5:** Summary of the morphological Characters of the pedon

| Pedon No. & Horizon | Depth (m) | Colour | | Texture | Structure | | | Consistence | | | | Boundary | | Cutans | | | Pores | | Roots | | Others |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Dry | Moist | | S | G | T | D | M | S | P | D | T | TY | TH | Q | S | Q | S | Q | |
| **Pedon 1** | | | | | | | | | | | | | | | | | | | | | |
| Ap | 0.00 – 0.20 | 10 YR 3/1 | 10 YR 3/1 | c | c | s | sbk | vh | vfi | vs | vp | c | s | - | - | - | - | - | f | f | Surface Cracks |
| Bss1 | 0.20 – 0.60 | 10 YR 2/1 | 10 YR 2/1 | c | c | s | abk | vh | vfi | vs | vp | d | w | - | - | - | - | - | f | F | Slickenslides |
| Bss2 | 0.60 – 0.90 | 10 YR 2/1 | 10 YR 2/1 | c | c | s | abk | vh | vfi | vs | vp | d | w | - | - | - | - | - | - | - | Slickenslides |
| Bss3 | 0.90 – 1.30 | 10 YR 2/1 | 10 YR 2/1 | c | c | s | abk | vh | vfi | vs | vp | d | w | - | - | - | - | - | - | - | Slickenslides |
| Bss4 | 1.30 – 1.70+ | 10 YR 3/1 | 10 YR 4/2 | c | c | s | abk | vh | vfi | vs | vp | d | w | - | - | - | - | - | - | - | Slickenslides |
| **Pedon 2** | | | | | | | | | | | | | | | | | | | | | |
| Ap | 0.00 – 0.20 | 10 YR 3/1 | 10 YR 3/1 | c | m | m | sbk | vh | vfi | vs | vp | c | s | - | - | - | - | - | f | f | Surface Cracks |
| Bss1 | 0.20 – 0.55 | 10 YR 3/2 | 10 YR 3/1 | c | c | s | abk | eh | efi | vs | vp | d | w | - | - | - | - | - | f | f | Slickenslides |
| Bss2 | 0.55 – 0.90 | 10 YR 3/2 | 10 YR 3/1 | c | c | s | abk | eh | efi | vs | vp | d | w | - | - | - | - | - | - | - | Slickenslides |
| Bss3 | 0.90 – 1.20 | 10 YR 3/2 | 10 YR 2/1 | c | c | s | abk | eh | efi | vs | vp | d | w | - | - | - | - | - | - | - | Slickenslides |
| Bss4 | 1.20 – 1.70+ | 10 YR 3/2 | 10 YR 2/1 | c | c | s | abk | eh | efi | vs | vp | d | w | - | - | - | - | - | - | - | Slickenslides |
| **Pedon 3** | | | | | | | | | | | | | | | | | | | | | |
| Ap | 0.00 – 0.20 | 10 YR 3/2 | 10 YR 2/2 | c | c | s | sbk | vh | fi | s | p | c | s | - | - | - | - | - | f | f | Surface Cracks |
| Bss1 | 0.20 – 0.50 | 10 YR 3/1 | 10 YR 3/1 | c | c | s | abk | vh | vfi | vs | vp | d | w | - | - | - | - | - | f | f | Slickenslides |
| Bss2 | 0.50 – 0.80 | 10 YR 3/1 | 10 YR 3/1 | c | c | s | abk | vh | vfi | vs | vp | d | w | - | - | - | - | - | - | - | Slickenslides |
| Bss3 | 0.80 – 1.20 | 10 YR 2/2 | 10 YR 2/2 | c | c | s | abk | vh | vfi | vs | vp | d | w | - | - | - | - | - | - | - | Slickenslides |
| Bss4 | 1.20 – 1.60+ | 10 YR 3/2 | 10 YR 3/2 | c | c | s | abk | vh | vfi | vs | vp | d | w | - | - | - | - | - | - | - | Slickenslides |
| **Pedon 4** | | | | | | | | | | | | | | | | | | | | | |
| Ap | 0.00 – 0.20 | 7.5 YR 3/1 | 7.5 YR 3/1 | c | m | s | sbk | vh | fi | s | p | c | s | - | - | - | - | - | f | f | Surface Cracks |
| Bss1 | 0.20 – 0.42 | 10 YR 3/2 | 7.5 YR 3/1 | c | c | s | abk | vh | vfi | vs | vp | d | w | - | - | - | - | - | f | f | Slickenslides |
| Bss2 | 0.42 – 0.92 | 10 YR 4/2 | 7.5 YR 3/2 | c | c | s | abk | vh | vfi | vs | vp | d | w | - | - | - | - | - | - | - | Slickenslides |
| Bss3 | 0.92 – 1.34 | 10 YR 4/2 | 7.5 YR 2.5/2 | c | c | s | abk | vh | vfi | vs | vp | d | w | - | - | - | - | - | - | - | Slickenslides |
| Bss4 | 1.34 – 1.65+ | 10 YR 4/2 | 7.5 YR 3/1 | c | c | s | abk | vh | vfi | vs | vp | d | w | - | - | - | - | - | - | - | Slickenslides |

**Cont…**

**Table 5.3.** Contd…

| Pedon No. & Horizon | Depth (m) | Colour | | Texture | Structure | | | Consistence | | | | Boundary | | Cutans | | | Pores | | Roots | | Others |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Dry | Moist | | S | G | T | D | M | S | P | D | T | TY | TH | Q | S | Q | S | Q | |
| **Pedon 5** | | | | | | | | | | | | | | | | | | | | | |
| Ap | 0.00 – 0.20 | 10 YR 3/1 | 10 YR 3/2 | c | m | m | sbk | sh | fi | s | p | c | s | - | - | - | - | - | f | f | Surface Cracks |
| Bss1 | 0.20 – 0.41 | 10 YR 4/2 | 10 YR 3/2 | c | vc | s | abk | vh | vf | vs | vp | d | w | - | - | - | - | - | f | f | Slickenslides |
| Bss2 | 0.41 – 0.82 | 10 YR 4/2 | 10 YR 2/2 | c | vc | s | abk | vh | vf | vs | vp | d | w | - | - | - | - | - | - | - | Slickenslides |
| Bss3 | 0.82 – 1.11 | 10 YR 4/2 | 10 YR 2/2 | c | vc | s | abk | vh | vf | vs | vp | d | w | - | - | - | - | - | - | - | Slickenslides |
| Bss4 | 1.11 – 1.55+ | 10 YR 4/2 | 10 YR 3/2 | c | vc | s | abk | vh | vf | vs | vp | d | w | - | - | - | - | - | - | - | Slickenslides |
| **Pedon 6** | | | | | | | | | | | | | | | | | | | | | |
| Ap | 0.00 – 0.20 | 10 YR 2/2 | 10 YR 3/2 | c | m | m | sbk | vh | vfi | s | p | c | s | - | - | - | - | - | f | f | Surface Cracks |
| Bss1 | 0.20 – 0.60 | 10 YR 3/2 | 10 YR 3/2 | c | c | s | abk | eh | efi | vs | vp | d | w | - | - | - | - | - | f | f | Slickenslides |
| Bss2 | 0.60 – 1.00 | 10 YR 4/1 | 10 YR 3/1 | c | c | s | abk | eh | efi | vs | vp | d | w | - | - | - | - | - | - | - | Slickenslides |
| Bss3 | 1.00 – 1.40 | 10 YR 4/2 | 10 YR 3/2 | c | c | s | abk | eh | efi | vs | vp | d | w | - | - | - | - | - | - | - | Slickenslides |
| Bss4 | 1.40 – 1.70 | 10 YR 4/1 | 10 YR 3/2 | c | c | s | abk | eh | efi | vs | vp | d | w | - | - | - | - | - | - | - | Slickenslides |
| Bss5 | 1.70 – 1.90+ | 10 YR 3/2 | 10 YR 3/1 | c | c | s | abk | eh | fi | vs | vp | d | w | - | - | - | - | - | - | - | Slickenslides |
| **Pedon 7** | | | | | | | | | | | | | | | | | | | | | |
| Ap | 0.00 – 0.18 | 10 YR 3/2 | 10 YR 3/2 | c | m | m | sbk | vh | vfi | s | p | c | s | - | - | - | - | - | f | f | Surface Cracks |
| Bss1 | 0.18 – 0.52 | 10 YR 4/2 | 10 YR 3/2 | c | c | s | abk | eh | efi | vs | vp | d | w | - | - | - | - | - | f | f | Slickenslides |
| Bss2 | 0.52 – 0.92 | 10 YR 3/2 | 10 YR 3/2 | c | c | s | abk | eh | efi | vs | vp | d | w | - | - | - | - | - | - | - | Slickenslides |
| Bss3 | 0.92 – 1.32 | 10 YR 4/1 | 10 YR 3/1 | c | c | s | abk | eh | efi | vs | vp | d | w | - | - | - | - | - | - | - | Slickenslides |
| Bss4 | 1.32 – 1.62 | 10 YR 4/1 | 10 YR 3/1 | c | c | s | abk | eh | efi | vs | vp | d | w | - | - | - | - | - | - | - | Slickenslides |
| Bss5 | 1.62 – 1.90+ | 10 YR 4/1 | 10 YR 3/1 | c | c | s | abk | eh | efi | vs | vp | d | w | - | - | - | - | - | - | - | Slickenslides |
| **Pedon 8** | | | | | | | | | | | | | | | | | | | | | |
| Ap | 0.00 – 0.18 | 10 YR 2/1 | 10 YR 3/2 | c | m | m | sbk | vh | vfi | s | p | c | s | - | - | - | - | - | f | f | Surface Cracks |
| Bss1 | 0.18 – 0.52 | 10 YR 4/2 | 10 YR 3/2 | c | c | s | abk | eh | efi | vs | vp | d | w | - | - | - | - | - | f | f | Slickenslides |
| Bss2 | 0.52 – 0.92 | 10 YR 4/1 | 10 YR 3/2 | c | c | s | abk | eh | efi | vs | vp | d | w | - | - | - | - | - | - | - | Slickenslides |
| Bss3 | 0.92 – 1.32 | 10 YR 4/2 | 10 YR 3/1 | c | c | s | abk | eh | efi | vs | vp | d | w | - | - | - | - | - | - | - | Slickenslides |
| Bss4 | 1.32 – 1.62 | 10 YR 4/2 | 10 YR 3/1 | c | c | s | abk | eh | efi | vs | vp | d | w | - | - | - | - | - | - | - | Slickenslides |
| Bss5 | 1.62 – 1.90+ | 10 YR 4/2 | 10 YR 3/2 | c | c | s | abk | eh | efi | vs | vp | d | w | - | - | - | - | - | - | - | Slickenslides |

Texture : c – clay, cl – clay loam, l – loam, s – sand, sl – sandy loam, scl – sandy clay loam, sc – sandy clay, ls – loamy sand

Structure : Size (S) – vf – very fine, f – fine, m – medium, c – coarse; Grade (G) – O – structureless, l – weak, 2 – moderate, 3 – strong; Type (T) cr – crumb, sg – single grain, abk – angular blocky,sbk – sub-angular blocky.

Consistence : Dry : s – soft, l – loose, sh – slightly hard, h – hard, vh – very hard, eh – extremely hard, Moist : l – loose, fr – friable, fi – firm, vfi – very firm, efi – extremely firm, Wet : so – non-sticky, ss – slightly sticky, s – sticky, vs – very sticky; po – non-plastic, ps – slightly plastic, p – plastic, vp – very plastic

Cutans : Ty – type – t – Argillan, Th – Thickness, tn – thin, th – thick, Quantity (Q), p – patchy, c – continuous

Pores : Size (S) f – fine, m- medium, c- coarse; Q – Quantity, f – few, c – common, m - many

Roots : Size (S) f – fine, m- medium, c- coarse; Q – Quantity, f – few, c – common, m - many

Boundary : D – Distinctness, c – clear, g – gradual, d – diffuse, T – Topography; s – smooth; w – wavy

## Conclusion

The soils of study area were formed at nearly level to plain topography with river alluvium parent material. All the pedons have deep to very deep solum exhibited clear and smooth boundary in surface horizons and diffuse and wavy boundary in the sub-surface horizons. The soil colour varied from from very dark gray to black with clayey texture. Due to the presence of vertic features like slickensies, pressure faces, cracks and presence of more than 30 % clay in all the horizons were grouped under Vertisols and classified as *Typic Haplusterts*.

## References

1. AIS&LUS. *Soil Survey Manual*, All India Soil and Land Use Survey Organization, IARI, New Delhi 1970,1-63.
2. Balpande HS, Challa O, Prasad J. Characterization and classification of grape growing soils in Nasik district of Maharashtra. Journal of the Indian Society of Soil Science 2007;55(1):80-83.
3. Bhaskar BP, Nagaraju MSS. Characterization of some salt affected soils occurring in the Chitravati basin of Andhra Pradesh. Journal of the Indian Society of Soil Science 1998;46:416-421.
4. Bhattacharyya T, Pal DK, Deshpande SD. Genesis and transformation of minerals in the formation of red (Alfisols) and black (Inceptisols and Vertisols) soils on Deccan basalt in the Western Ghats, India. Journal of Soil Science 1993;44:159-171.
5. Brady NC. The Nature and Properties of Soils. Tenth edition, Prentice Hall of India Limited, New Delhi 1995,65.
6. Coulombe CE, Wilding LP, Dixon JB. Over view of Vertisols: characteristics and impacts on society. Advances in Agronomy 1996;56:291-372.
7. Kashiwar DY, Nagaraju MSS, Srivastava R, Prasad J, Ramamurthy Vand, Barthwal AK. Characterization, evaluation and management of Salai watershed in Nagpur district of Maharashtra using remote sensing and GIS techniques. Agropedology 2009;19(1):15-23.
8. Khan MAA, Kamalakar J. Characterisation of soils of newly established agro biodiversity park of ANGR Agricultural University, Hyderabad. Green Farming 2012;31):21-25.
9. Kharche VK, Pharande AL. Land degradation assessment and land evaluation in Mula command of irrigated agro-ecosystem of Maharashtra. Journal of the Indian Society of Soil Science 2010;58(2):221-227.
10. Kumar R, Sharma BD, Sidhu PS, Brar JS. Characteristic, classification and management of Aridisols of Punjab. Journal of the Indian Society of Soil Science 2005;53(1):21-28.
11. Nandy T, Prasunarani P, Madhuvani P, Subbaiah G. Soil fertility status of pedapuluguvaripalem village of Guntur district, Andhra Pradesh. The Andhra Agricultural Journal 2012;59(2):214-218.
12. Nasre RA, Nagaraju MSS, Srivastava R, Maji AK, Barthwal AK. Characterization, classification and evaluation of soils of Karanjiwatershed, Yavatmal district of Maharashtra for land resource management using geospatial technologies. Journal of the Indian Society of Soil Science 2013;61(4):275-286.
13. Pal DK, Deshpande SB. Genesis of clay minerals in red and black soil complex of southern India. Clay Research 1987;6:6-13.
14. Paramasivan M, Jawahar D. Characterization, classification and crop suitability of some black cotton soils of southern Tamil Nadu, Agropedology 2014;24(01):111-118.
15. Patangray AJ, Patil NG, Singh SK, Tiwari P, Mishra VN, Pagdhune AR. Soil suitability evaluation of major crops for sustainable land use planning in Kupti watershed, Yavatmal district, Maharashtra. Agropedology. 2016;26(02):117-131.
16. Patil MN, Khandare NC, Puranik RB. Evaluation of pedogenical development of orange garden soils of Akola district through field morphology rating system. Journal of the Indian Society of Soil Science 1999;47:180-182.
17. Prakash TR, Rao MS. Characterization and classification of some soils in a part of Krishna district, Andhra Pradesh. The Andhra Agricultural Journal 2002;49:228-236.
18. Rajeshwar M, Mani S. Genesis, classification and evaluation of cotton growing soils in semi-arid tropics of Tamil Nadu. An Asian Journal of Soil Science 2015;10(1):130-141.
19. Rao APVP, Naidu MVS, Ramavatharam N, Rama Rao G. Characterization, classification and evaluation of different landforms in Ramchandrapuram mandal of Chittoor district in Andhra Pradesh for sustainable land use planning. Journal of the Indian Society of Soil Science 2008;56(1):23-33.
20. Rao BRM, Venkataramaiah K, Sharma SK. Genesis morphology and classification of soils in: soils of Andhra Pradesh, A monograph edited by Subba Rao IV published by Andhra Pradesh Agricultural University and Hyderabad chapter of Indian Society of Soil Science 1995,1-115.
21. Rao MS, Prasunarani P, Ramesh K, Vikram D. Morphology and classification of southern coastal agro-eco- sub-region soils of Andhra Pradesh. The Andhra Agricultural Journal 2004;51:71-76.
22. Reza SK, Nayan Ahmed, Sharmistha Pal. Characterization, classification and mapping of soils of Panja–Rao watershed, Saharanpur, Uttar Pradesh. Agropedology 2010;20(2):124-132.
23. Satish S, Naidu MVS, Ramana KV, Munaswamy V, Reddy GP, Sudhakar P. Characterization and classification of the soils of Brahmanakotkur watershed in Kurnool district of Andhra Pradesh. Journal of Indian Society of soil science 2018b;66(4):35-361.
24. Satyavathi PLA, Reddy MS. Characterization and classification of shallow, medium deep and deep red and black soils of northern Telangana zone in Andhra Pradesh. Journal of Tropical Agriculture 2003;41:23-29.
25. Sehgal JL. *Pedology – Concepts and Applications.* Second Revised and Expanded Edition, 2005. Kalyani Publishers, New Delhi 2005,176-185.
26. Sekhar CHC, Balaguravaiah D, Naidu MVS. Studies on genesis, characterization, and classification of soils in central and eastern parts of Prakasam district in Andhra Pradesh. Agropedology 2014;24(2):125-137.
27. Sharma SS, Totawat KL, Shyampura RL. Characterisation and classification of soils of toposequence over basaltic tarrain. Journal of the Indian Society of Soil Science 1996;45:480-485.
28. Simonson RW. Outline of a generalized theory of soil genesis. Soil Science Society of American Proceedings 1959;23:152-156.

29. Sireesha PVG, Naidu MVS. Studies on genesis, characterization and classification of soils in semi-arid Agro-ecological region: A case study in Banaganapalle mandal of Kurnool district, Andhra Pradesh. Journal of the Indian Society of Soil Science 2013;61(3):167-178.
30. Soil Survey Staff. Keys to Soil Taxonomy (Eighth edition), Natural Resource Conservation Service, USDA, Blacksburg, Virginia 1998.
31. Soil Survey Staff. *Soil Taxonomy* (Second edition.) Agriculture Hand Book No. 436, USDA, Natural Resources Conservation Service, Washington, DC 1999,1-782.
32. Soil Survey Staff. Keys to Soil Taxonomy (Twelveth edition). USDA Natural Resource Conservation Service, Washington, DC 2014.
33. Surekha K, Subbarao IV, Prasadrao A, Sankaram MV. Characterization of some Vertisols of Andhra Pradesh. Journal of the Indian Society of Soil Science 1997;45:338-343.
34. Verma TP, Singh SP, Ramgopal RP, Dhankar Rao RVS, Lal T. Characterization and evaluation of soils of Trans Yamuna area in Etawah district, Uttar Pradesh for sustainable land use. Agropedology 2012;22(1):26-34.