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Report no. 42

Characterization of Benchmark Spots of Selected Red and Black Soils in Semi-Arid Tropics of India for Identifying Systems for Carbon Sequestration and Increased Productivity in Semi-Arid Tropical Environments

ICRISAT

INTERNATIONAL CROPS RESEARCH INSTITUTE FOR THE SEMI-ARID TROPICS

Science with a human face

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Abstract

Fifty two pedons spread over 28 Benchmark (BM) spots were studied in different systems *viz*. agricultural, horticultural, forest and wasteland. The agricultural system represents dominant crops namely cereals, soybean and cotton. The horticultural system represents mandarins. The forest systems represent teak (*Tectona* sp.) and sal (*Shorea* sp.).

The selection of BM spots were limited to a mean annual rainfall (MAR) range from 1448 to 520 mm in semi-arid tropics, India and encompass various bioclimatic systems such as sub-humid (moist) (MAR >1200 mm), sub-humid (dry) (MAR 1200-1000 mm), semi-arid (dry) (1000-850 mm), semi-arid (moist) (850-550 mm) and arid (<550 mm). In order to find out the level of carbon (organic and inorganic) in soils as influenced by different land use systems, the quality and quantity of (soil) substrates require to be similar. Judging by dominantly clayey and smectitic nature of black soils (Vertisols and their intergrades) and the associated red soils, they were selected for the present study.

The soils were characterized in terms of morphological, physical and chemical properties with the data sets generated in the field and laboratory. Each profile was also characterized by the climatic data, indicating monthly potential evapotranspiration (PET), rainfall, temperature and length of growing period (LGP) data. The exact landscape situations, cropping patterns and typical soil profiles depicted through photographs further indicate the exact location of each spot studied in this project.

The present document attempts to find out various relation of morphological, physical and chemical properties of soils as far as both organic and inorganic carbon sequestration are concerned. The present document also helps in estimating carbon stock in different system under various bioclimatic zones in semi-arid tropics, India as detailed in subsequent working reports.

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Abbreviations

A	Arid
AESRS	Agroecological Subregions
BCS	Black Cotton Soils
BM	Benchmark
CCPI	Cooperating Center Principal Investigator
FM	Farmers' Management
Gg	Gigagram (10^9 g)
HM	High Management
IGP	Indo-Gangetic Plains
ITDA	Integrated Tribal Development Authority
LM	Low Management
NPK	Nitrogen Phosphorous and Pottasiun
OC	Organic Carbon
Pg	Petagram (10^{15} g)
PI	Principal Investigator
QEV	Quasi-Equilibrium Value
SA (d)	Semi-Arid (dry)
SA (m)	Semi-Arid (moist)
SAT	Semi-Arid Tropics
SCD	Surface Change Density
SH (d)	Sub-Humid (dry)
SH (m)	Sub-Humid (moist)
SIC	Soil Inorganic Carbon
SOC	Soil Organic Carbon
TC	Total Carbon

Contents

Chapter 1: Introduction

Restoration of soil health through soil organic carbon (SOC) management is a major concern for tropical soils. Besides its importance for sustainable crop production, the accelerated decomposition of SOC due to agriculture, resulting in loss of carbon to the atmosphere and its contribution to the greenhouse effect is a serious global problem. The contributions of SOC on physical, chemical and biological properties of soils in sustaining their productivity are being appreciated since the dawn of human civilization. Important factors controlling organic matter levels include climate, hydrology, parent material, soil fertility, biological activity, vegetation pattern and landuse (Jenny, 1941). The SOC is sensitive to impact of human activities, such as deforestation, biomass burning, landuse changes and environmental pollution. It has been estimated that the landuse change resulted in the transfer of 1-2 Pg carbon/year from terrestrial ecosystem to the atmosphere, of which 15-17% carbon is contributed by decomposition of SOC.

Recent studies on forest soils indicate that organic carbon (SOC) content in soils sharply declines due to cultivation. Reduction of SOC level is significant even in 5-15 years of cultivation (Saikh *et al*, 1998). It was hypothesized that irrespective of initial organic carbon levels of these forest soils (Alfisols), there is a tendency to reach a quasi-equilibrium value of 1-2% of SOC. Since such studies are specific to geographic regions, a generalised view about carbon carrying capacity of soils may not be advisable because quality of soil substrate and its surface charge density (SCD) may be different in different soils.

It has been reported that increase in SOC increases the SCD of soils and the ratio of internal/external exchange sites (Poonia and Neiderbudde, 1990). It may be mentioned that the dominant soils in the semi-arid tropics (SAT) are black (Vertisols and their intergrades) and associated red. All these soils are dominated by smectites (Bhattacharyya *et al*., 1993; Pal and Deshpande, 1987a; 1987b; Pal *et al*., 1989; 2000). Presence of smectite also increases the SCD of soils, which offer more surface for more carbon sequestration in these soils. Therefore, black soils may reach a higher quasi-equilibrium value than red soils, dominated by kaolinites.

Bhattacharyya and Pal (1998) reported 2-3% of SOC in the black soils from Madhya Pradesh. More recently, Dalal and Conter (2000) also indicated the scope of higher SOC content in the Vertisols of Australia. Earlier, Velayutham *et al.* (2000) reported a lower limit of the quasi-equilibrium value of SOC by 1% to delineate sufficient and deficient zones of SOC in the country. In view of higher SCD of the dominant soils of SAT, considering a QEV value of 2% of SOC in the first 30 cm depth of soils, the SOC stock of 116.4 m ha in SAT could be 10.5 Pg. This value is more than three times of the existing SOC stock of SAT (Bhattacharyya *et al*., 2000). Therefore, it appears that effective sequestration processes can increase the SOC stock, suggesting that the SAT could be fruitfully prioritised for carbon management in Indian soils.

After prioritising the semi-arid tropics of India for carbon sequestration, the present project finally aims at identifying various systems that may reduce CO_2 concentration in the atmosphere and increase SOC stock and can thus, maintain or increase the overall productivity of the systems.

In view of above, the study area was chosen in the SAT as well as in relatively dry sub-humid agro-ecosubregions (AESRs 9.1, 9.2, 10.1, 10.2, 10.3 and 10.4) (Velayutham *et al*., 1999). The vast plains of subhumid, semi-arid and arid ecosystems cover 150.9 M ha area in Indian subcontinent. While

selecting the soil sites, specific bioclimatic systems were identified, keeping in view the mean annual rainfall as shown in Table 1.1.

Table 1.1. Classification of bioclimatic zone according to MAR

Sl. No.	Bioclimatic zone	MAR (mm)
1.	Sub-humid (moist)	>1100
2.	Sub-humid (dry)	1100-1000 mm
3.	Semi-arid (moist)	1000-850 mm
4.	Semi-arid (dry)	850-550 mm
5.	Arid	<550 mm

The soils for the present study are selected from the benchmark sites. The reason is that each soil covers a widely extensive area in the landscape and represents either an established or a tentative soil series (Soil Survey Division Staff, 1995) (Tables 1.2 and 1.3).

Table 1.2. Benchmark spots and their site characteristics in order of decreasing rainfall from sub-humid to arid bioclimatic system

Sl. No.	BM Spot	District/State	Series	System	Mean Annual Rainfall (mm)	Profile No.
BLACK SOILS						
Sub-Humid (Moist) Mean Annual Rainfall >1100 mm						
1	13	Jabalpur/Madhya Pradesh	KHERI	Agriculture(HM) *Paddy-Wheat*	1448	P27
2	13	Jabalpur/Madhya Pradesh	KHERI	Agriculture(LM) *Soybean/Paddy-Wheat*	1448	P28
3	7	Nagpur/Maharashtra	BORIPANI	Forest *(Teak)*	1279	P15
4	3	Bhopal/ Madhya Pradesh	NABIBAGH	Agriculture(HM) *Soybean-Wheat*	1209	P5
5	3	Bhopal/ Madhya Pradesh	NABIBAGH	Agriculture(FM) *Soybean-Wheat*	1209	P6
6	2	Nagpur/Maharashtra	PANJRI	Agriculture(HM) *Cotton*	1127	P4
Sub-Humid (Dry) Mean Annual Rainfall 1100 – 1000 mm						
7	26	Adilabad/Andhra Pradesh	NIPANI	Agriculture(FM) *Cotton+Pigeonpea*	1071	P48
8	27	Adilabad/Andhra Pradesh	PANGIDI	Agriculture(FM1) *Cotton+Pigeonpea*	1071	P49

Continued

Table 1.2 *Continued*

Sl. No.	BM Spot	District/State	Series	System	Mean Annual Rainfall (mm)	Profile No.
0	27	Adilabad/Andhra Pradesh	PANGIDI 1	Agriculture(ITDA) *Soybean*	1071	P50
10	4	Indore/Madhya Pradesh	SAROL	Agriculture(HM) *Soybean-Wheat*	1053	P7
11	4	Indore/Madhya Pradesh	SAROL	Agriculture(FM) *Soybean-Wheat*	1053	P8
12	4	Indore/Madhya Pradesh	SAROL	Agri-horticulture(HM) Soybean-Gram in Mango Orchard	1053	P9
13	1	Nagpur/Maharashtra	LINGA	Horticulture(HM) *Citrus*	1011	P1
14	1	Nagpur/Maharashtra	LINGA	Horticulture(LM)* *Citrus*	1011	P3
15	1	Nagpur/Maharashtra	LINGA	Agriculture(FM) *Soybean-Gram/ Wheat*	1011	P2
Semi-Arid (Moist) Mean Annual Rainfall 1000 – 850 mm						
16	22	Bidar/Karnataka	BHATUMBRA	Agriculture(FM) *Sorghum+Pigeonpea/ Blackgram-Chickpea*	977	P42
17	5	Amravati/Maharashtra	ASRA	Agriculture(FM)* *Cotton/Green gram+Pigeonpea*	975	P10
18	5	Amravati/Maharashtra	ASRA	Agriculture(FM) *Soybean+Pigeonpea*	975	P11
19	5	Amravati/Maharashtra	ASRA	Agriculture(HM) *Cotton+Pigeonpea/ Soybean+Gram*	975	P12
Semi-Arid (Dry) Mean Annual Rainfall 850 - 550 mm						
20	16	Kota/Rajasthan	JHALIPURA	Agriculture(FM/1) *Soybean-Wheat*	842	P32
21	16	Kota/Rajasthan	JHALIPURA	Agriculture(FM2) *Paddy-Wheat*	842	P33
22	6	Akola/Maharashtra	PARAL	Agriculture(HM) *Cotton+Pigeonpea/ Sorghum*	793	P13
23	6	Akola/Maharashtra	PARAL	Agriculture(HM) *Cotton+Pigeonpea/ Sorghum*	793	P14
24	18	Mehboobnagar/Andhra Pradesh	JAJAPUR	Agriculture(FM/1) *Sorghum/ Pigeonpea+Green-gram*	792	P35

Continued

Table 1.2 *Continued*

Sl. No.	BM Spot	District/State	Series	System	Mean Annual Rainfall (mm)	Profile No.
25	18	Mehboobnagar/Andhra Pradesh	JAJAPUR 1	Agriculture(FM/2) *Paddy-Paddy*	792	P36
26	20	Medak/Andhra Pradesh	KASIREDDIPALLI	Agriculture(HM) *Soybean+Pigeonpea*	764	P39
27	20	Medak/Andhra Pradesh	KASIREDDIPALLI	Agriculture(TM) *Fallow-Chickpea*	764	P40
28	24	Solapur/Maharashtra	KONHERI	Agriculture(FM) *Pigeonpea/Sunflower-Sorghum*	742	P45
29	24	Solapur/Maharashtra	KONHERI 1	Agriculture(LM) *Fallow-Sorghum+ Safflower*	742	P46
30	25	Nasik/Maharashtra	KALWAN	Agriculture(FM) *Sugarcane/Jowar-Wheat/Gram*	692	P47
31	9	Tuticorin/Tamil Nadu	KOVILPATTI	Agriculture *Sorghum/Sunflower/ Cotton*	660	P19
32	9	Tuticorin/Tamil Nadu	KOVILPATTI 1	Waste land	660	P20
33	9	Tuticorin/Tamil Nadu	KOVILPATTI	Agriculture(HM) *Cotton + Black gram*	660	P21
34	14	Rajkot/Gujarat	SEMLA	Agriculture (ORG) *Cotton/Groundnut-Wheat*	635	P29
35	23	Bellary/Karnataka	TELIGI	Agriculture(LM) *Paddy-Paddy*	632	P43
36	23	Bellary/Karnataka	TELIGI	Agriculture(HM) *Paddy-Paddy*	632	P44
		Arid Mean Annual Rainfall < 550 mm				
37	15	Rajkot/Gujarat	SOKHDA	Agriculture(FM1) *Cotton-Bajra*	533	P30
38	15	Rajkot/Gujarat	SOKHDA 1	Agriculture(FM2) Cotton- Bajra/ Linseed	533	P31
39	28	Ahmednagar/Maharashtra	NIMONE	Agriculture (HM) Cotton-Wheat/ Chickpea	520	P51
40	28	Ahmednagar/Maharashtra	NIMONE	Agriculture (FM) Sugarcane –Soybean/ Wheat/Chickpea	520	P52

Continued

Table 1.2 *Continued*

Sl. No.	BM Spot	District/State	Series	System	Mean Annual Rainfall (mm)	Profile No.
			RED SOILS			
			Sub-Humid (Moist) Mean Annual Rainfall >1100 mm			
41	11	Dindori/ Madhya Pradesh	DADARGHUGRI	Agriculture(FM) Maize/Mustard	1420	P23
42	11	Dindori/ Madhya Pradesh	DADARGHUGRI	Forest (Teak)	1420	P24
43	12	Umeria/ Madhya Pradesh	KARKELI	Forest (Sal)	1352	P25
44	12	Umeria/ Madhya Pradesh	KARKELI 1	Agriculure (LM) *Minor millet/Sweet potato*	1352	P26
			Semi-Arid (Moist) Mean Annual Rainfall 1000 - 850 mm			
45	8	Bangalore/Karnataka	VIJAYPURA	Agriculture(FM) *Finger millet*	924	P16
46	8	Bangalore/Karnataka	VIJAYPURA 1	Agriculture* *Finger millet/ Pigeonpea/Red gram/ Groundnut*	924	P17
47	8	Bangalore/Karnataka	VIJAYPURA 1	Agriculture(HM) *Finger millet*	924	P18
			Semi-Arid (Dry) Mean Annual Rainfall 1000 - 850 mm			
48	19	Rangareddy/ Andhra Pradesh	HAYATNAGAR	Agriculture(HM) *Sorghum-Castor*	764	P37
49	19	Rangareddy/ Andhra Pradesh	HAYATNAGAR	Agriculture(LM) *Sorghum-Castor*	764	P38
50	21	Medak/Andhra Pradesh	PATANCHERU	Permanent Fallow	764	P41
51	17	Mehboobnagar/Andhra Pradesh	KAUKUNTALA	Agriculture(FM) *Castor+Pigeonpea*	674	P34
52	10	Coimbatore/Tamil Nadu	PALATHURAI	Agriculture (ORG) *Horsegram/ Vegetables*	612	P22

* Original BM Spots

Ranges of Rainfall in:
Subhumid (moist) Ecosystem = >1100 mm
Subhumid (dry) Ecosystem = 1100mm -1000 mm
Semi-arid (moist) Ecosystem = 1000mm - 850 mm
Semi-arid (dry) Ecosystem = 850 mm – 550 mm
Arid Ecosystem = <550 mm

Table 1.3. BM Spots : A few important points

Pedon No.	Physiography	Series	Latitude	Longitude	Distance from hills
P1	Lower Maharashtra Deccan Plateau	Linga	21°15'14"N	78°38'50"E	~40 km
P2	Lower Maharashtra Deccan Plateau	Linga	21°14'49"N	78°37'11"E	~40 km
P3	Lower Maharashtra Deccan Plateau	Linga	21°15'18"N	78°36'40"E	~40 km
P4	Lower Maharashtra Deccan Plateau	Panjri	21°02'14"N	79°03'33"E	~40 km
P5	Central Highland Vindhyan Ranges	Nabibagh	23°18'55"N	79°24'34"E	10 km
P6	Central Highland Vindhyan Ranges	Nabibagh	23°20'31"N	79°24'50"E	10 km
P7	Central Highland Malva Plateau	Sarol	22°36'52"N	75°41'17"E	~80 km
P8	Central Highland Malva Plateau	Sarol	22°54'54"N	75°43'07"E	~80 km
P9	Central Highland Malva Plateau	Sarol	22°36'52"N	75°41'17"E	~80 km
P10	Lower Maharashtra Deccan Plateau	Asra	20°52'42"N	77°29'12"E	~125 km
P11	Lower Maharashtra Deccan Plateau	Asra	20°52'41"N	77°24'16"E	~125 km
P12	Lower Maharashtra Deccan Plateau	Asra	21°30'N	77°42'E	~125 km
P13	Lower Maharashtra Deccan Plateau	Paral	20°57'04"N	76°57'05"E	~100 km
P14	Lower Maharashtra Deccan Plateau	Paral	20°56'48"N	76°58'30"E	~100 km
P15	Lower Maharashtra Deccan Plateau	Bonipani	20°50'31"N	79°10'55"E	On Hills
P16	Laterite Plateau Bangalore (Granite Gneiss)	Vijaypura	13°7'54"N	77°34'41"E	1 km
P17	Laterite Plateau Bangalore (Granite Gneiss)	Vijaypura	13°5'2"N	77°34'25"E	1 km
P18	Laterite Plateau Bangalore (Granite Gneiss)	Vijaypura	13°5'3"N	77°34'23"E	1 km
P19	Riverine Landform	Kovilpatty	09°12'18"N	77°52'40"E	< 50 km (Gneissic)
P20	Riverine Landform	Kovilpatty	09°12'42"N	77°52'56"E	< 50 km
P21	Riverine Landform	Kovilpatty	09°9'9"N	77°57'26"E	< 50 km
P22	Tamil Nadu Uplands	Palathurai	10°52'36"N	76°56'56"E	On Hills

Continued...

Table 1.3. *Continued.*

Pedon No.	Physiography	Series	Latitude	Longitude	Distance from hills
P23	Deccan Plateau, Satpura Range	Dadarghugri	22°53'49"N	80°49'04"E	On Hills
P24	Deccan Plateau, Satpura Range	Dadarghugri	22°53'48"N	80°49'23"E	On Hills
P25	Eastern Plateau Baghelkhand Plateau	Karkeli	23°27'58"N	80°55'30"E	1 km
P26	Eastern Plateau Baghelkhand Plateau	Karkeli	23°28'35"N	80°55'10"E	1 km
P27	Deccan Plateau, Satpura Range	Kheri	23°10'53"N	79°51'19"E	2 km
P28	Deccan Plateau, Satpura Range	Kheri	23°10'45"N	79°55'38"E	2 km
P29	The West Coast Kathiawar Peninsula	Semla	22°01'59"N	70°48'22"E	--
P30	The West Coast Kathiawar Peninsula	Sokhda	23°01'54"N	70°47'11"E	--
P31	The West Coast Kathiawar Peninsula	Sokhda	23°02'19"N	70°47'30"E	--
P32	Pather and Bundelkhand Upland	Jhalipura	25°11'19"N	75°57'4"E	--
P33	Pather and Bundelkhand Upland	Jhalipura	25°11'15"N	75°56'57"E	--
P34	Deccan Plateau (Granite Gneiss)	Kaukuntla	16°31'42"N	77°51'11"E	4-5 km
P35	Deccan Plateau (Granite Gneiss)	Jajapur	16°43'09"N	77°32'20"E	Within 1 km (Granite Gneiss)
P36	Deccan Plateau (Granite Gneiss)	Jajapur	16°43'17"N	77°32'47"E	Within 1 km (Granite Gneiss)
P37	Deccan Plateau, Laterites, Granite and Granite Gneiss	Hayathnagar	17°20'26"N	78°35'39"E	Tillas. Turs
P38	Deccan Plateau, Laterites, Granite and Granite Gneiss	Hayathnagar	17°21'05"N	78°35'46"E	Tillas. Turs
P39	Deccan Plateau, Granite, Granite Gneiss and Basalt	Kasireddypalli	17°30'13"N	78°16'7"E	Tillas 2 km
P40	Deccan Plateau, Granite, Granite Gneiss and Basalt	Kasireddypalli	17°30'38"N	78°15'49"E	Tillas 2 km
P41	Deccan Plateau, Granite, Granite Gneiss and Basalt	Patancheru	17°28'36"N	78°16'54"E	Tillas 2 km
P42	South Deccan Plateau – Basalt	Bhatumbra	18°3'25"N	77°09'06"E	~25 km

Continued...

Table 1.3. *Continued.*

Pedon No.	Physiography	Series	Latitude	Longitude	Distance from hills
P43	South Deccan Plateau – Granite Gneiss	Teligi	15°37'4"N	76°54'35"E	~ 25 km
P44	South Deccan Plateau – Granite Gneiss	Teligi	15°37'44'N	76°54'41"E	~ 25 km
P45	Upper Maharashtra Deccan Plateau	Konheri	17°48'24"N	75°30'05"E	5-10 km
P46	Upper Maharashtra Deccan Plateau	Konheri	17°48'374"N	75°29'59"E	5-10 km
P47	Upper Maharashtra Deccan Plateau	Kalwal	20°29'25.5"N	74°2'52"E	<1 km
P48	Deccan Plateau Basalt	Nipani	19°45'3.6"N	78°26'49.8"E	1-2 km
P49	Deccan Plateau Basalt	Pangidi	19°21'31"N	79°0'19.5"E	< 1 km
P50	Deccan Plateau Basalt	Pangidi	19°21'09"N	71°00'14.2"E	< 1 km
P51	Upper Maharashtra Deccan Plateau	Nimone	19°22'1.4"N	74°39'25"E	< 1 km
P52	Upper Maharashtra Deccan Plateau	Nirmal - Pimpri	19°39'15.6"N	74°29'40.3"E	~ 10 km

The selection of benchmark spots are also decided in view of different landuse systems such as agriculture, horticulture, forest and wastelands. By far, agriculture dominates the chosen *BM Spot*s (Figures 1.1, 1.2). The soil samples are selected in such a way that in agricultural system under a particular cropping pattern, two representative pedons (under the same soil series) show the farmers' management (FM/LM) and the higher management (HM), respectively. The level of management describing high and low level is shown in Table 1.4.

Table 1.4. Level of management in different BM sites

Sl. No.	High management	Low management
1.	Higher NPK	Lower NPK
2.	Regular application of manures	Rare
3.	Intercropping with legumes	Sole crop
4.	Incorporation of residues	Removal of residues and biomass
5.	Soil moisture conservation	Nil

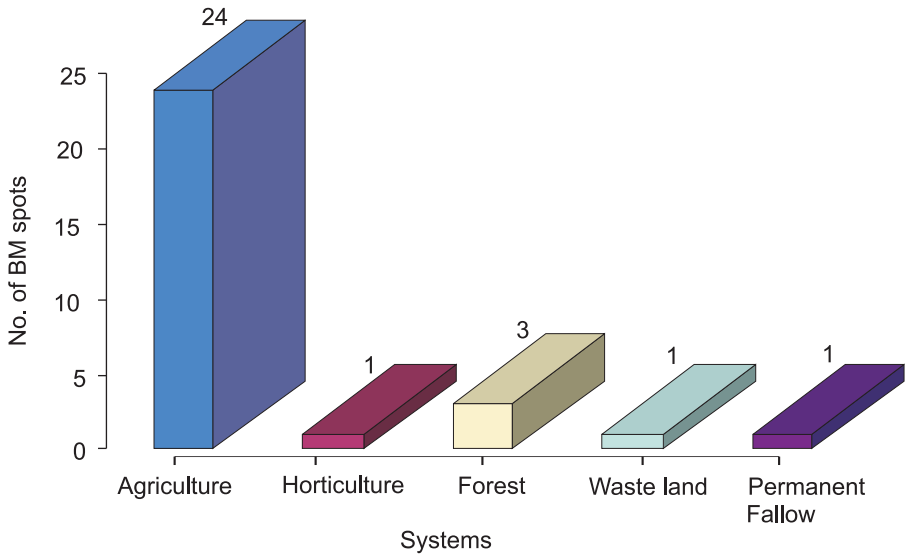


Fig. 1.1. Distribution of BM Spots in different systems.

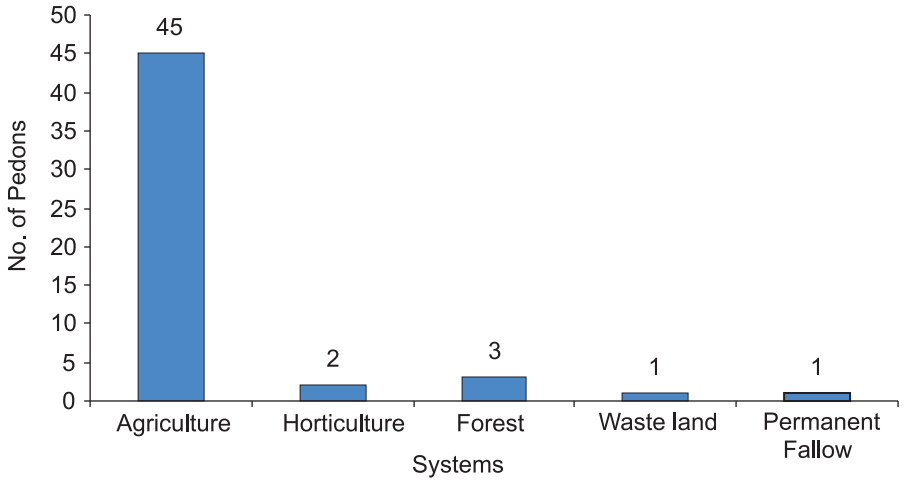


Fig. 1.2. Distribution of pedons in different systems.

Within the agricultural system, three major dominant cropping patterns such as cotton, soybean and cereals are observed (Tables 1.5, 1.6, 1.7).

Table 1.5. Agricultural system for cotton as dominant crop covering total twelve pedons

Cropping pattern	Pedons
Cotton	P4
Cotton + Pigonpea	P48, P49
Cotton + Pigeonpea / Soybean - Gram	P12
Cotton + Pigeonpea / Sorghum	P13, P14
Cotton / Greengram + Pigeonpea	P10
Cotton + Black gram	P21
Cotton / Groundnut - Wheat	P29
Cotton – Bajra	P30
Cotton - Bajra / Linseed	P31
Cotton - Wheat Chickpea	P51

Table 1.6. Agriculture system for soybean as dominant crop covering total eleven pedons

Cropping pattern	Pedons
Soybean / Paddy - Wheat	P28
Soybean - Wheat	P5, P6, P7, P8, P32
Soybean	P50
Soybean - Gram	P9
Soybean - Gram / Wheat	P2
Soybean + Pigeonpea	P11, P39

Table 1.7. Agriculture system for cereals under total fifteen pedons

	Cropping pattern	Pedons
Paddy	Paddy – Wheat	P27, P33
	Paddy - Paddy	P36, P44
Millets	Finger Millets	P16
	Finger millets / Pigeonpea / Redgram / Groundnut	P17
	Finger millet	P18
	Minor Millet / Sweet Potato	P26
Sorghum	Sorghum + Pigonpea/ Blackgram - Chickpea	P42
	Sorghum / Pigeonpea + Greengram	P35
	Sorghum / Sunflower / Cotton	P19
	Sorghum – Castor	P37, P38
Horsegram	Horsegram / Vegetables	P22
Maize	Maize / Mustard	P23

Chapter 2: Methods

Methods

The profiles are examined following standard methods (Soil Survey Division Staff, 1995). The concept of bioclimatic system is adopted from Bhattacharjee *et al*. (1982). The soils are classified following soil taxonomy (Soil Survey Staff, 1999). The morphological properties are being developed by standard procedures (Soil Survey Manual 1970; Soil Survey Division Staff, 1995 and Soil Survey Staff, 1999).

The international pipette method is applied for particle size analysis after sand, silt and clay fractions are separated according to the procedure of Jackson's (1979). Coefficient of Linear Extensibility (COLE) is determined according to Schafer and Singer (1976). Bulk density is determined by field moist method using core sample (diameter 50 mm) of known volume (100 ml) ((McIntyre, 1974; Klute, 1986).

The water dispersible clay is determined by taking 10g of soil and then shaking on an end to end shaker for eight hours. Suspension aliquots are drawn by following the international pipette method (USDA, 1972). Hydraulic conductivity is measured by taking 200g of soil, uniformly tapped and saturated overnight. It is measured by taking an hourly observations thrice. It is measured in cm/hr (Richard, 1954). The chemical characteristics of soils are determined by standard procedure (Jackson, 1973).

Characterization of Landuse Types of Benchmark Sites of RNPS-25

Landuse in a particular area can be described as Landuse Type (LuT) and production system (FAO, 1999). It is the use of land in terms of products, production system, inputs used and operations performed to produce these products and the socio-economic setting in which the production is carried out (FAO, 1976).

The characterization of LUTs of 28 benchmark spots is carried out on the following attributes.

Besides soil and climatic parameters, the above attributes directly or indirectly influence the nutrient mining, C stock build up or depletion. The information on the above attributes is gathered based on formal interviews with farmers (or proforma received from research institutes), physical assessment of sites and discussions with villagers (including laborers) almost in all 52 spots shown in Figure 2.1.

The specific information of each benchmark spot has been described in the following chapter.

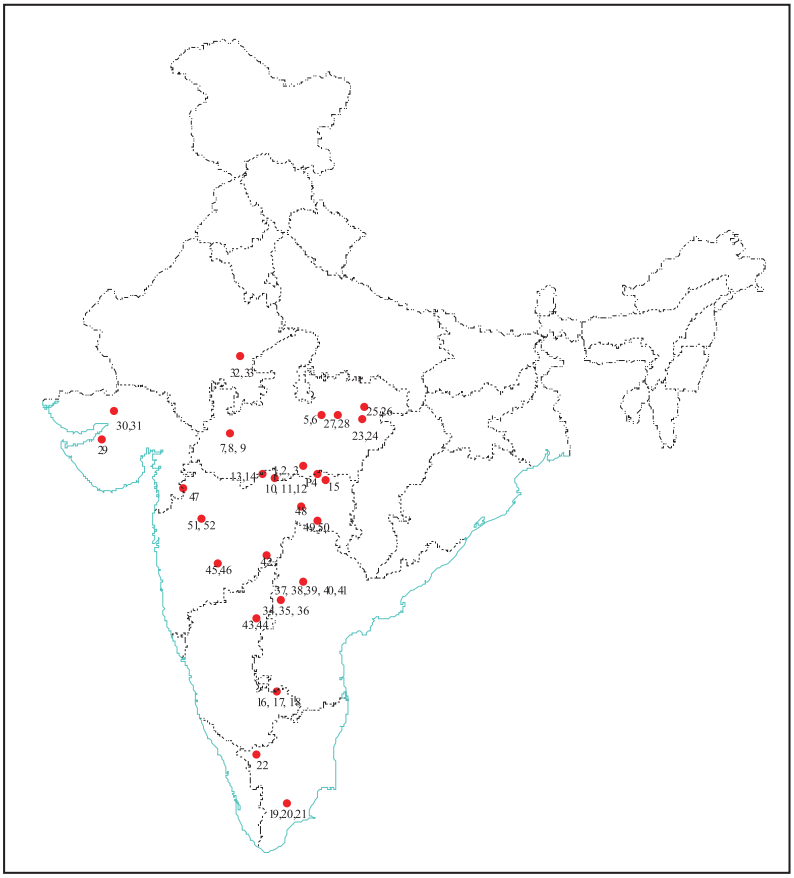


Fig. 2.1. Pedon Sites (1-52) in the semi-arid tropics, India (Please also see Table 1.3).

Table 2.1. Description of landuse types

Sl. No.	Attribute	Details
1.	Production system	(a) Rain-fed/irrigated; (b) Annual/perennial; (c) *Kharif* and/or *rabi*; (d) Length of fallow period; (e) Mono, double, multiple or intercropping system; (f) Crops (g) Crop-livestock, crop livestock-garden based farming system; (h) Component crops; (i) Yield range
2.	Management level	(a) Use of fertilizers, organics, pesticides (rare, frequent or occasional) (b) Soil water conservation and residue management
3.	Power source	Human, animal and mechanical (manual labor with hand tools, animal traction with traditional/improved implements, partial/complete mechanization)
4.	Market orientation	Subsistence, commercial, intermediate, R&D
5.	Capital intensity	Low, intermediate or high (including access to credit)
6.	Labor intensity	Low, intermediate or high (including costed or uncosted family labor)
7.	Land holding	Small, medium, large. Consolidated or fragmented
8.	Income level	Low, medium, high. Supplemental income if any

Chapter 3: Results and Discussion

The profile sites under various benchmark spots are characterized in terms of numerous site characteristics, which include physiography, geology, parent material, climate, slope, erosion, natural vegetation, landuse and cropping pattern. Each soil profile is examined in the field and the characteristics of all these profiles are described in the following paragraphs.

Horizon-wise soil samples are analysed for physical and chemical properties. The climatic data showing MAR, MAT, PET, ½ PET and LGP are indicated to characterize each profile site. The characterization of each site is further explained by addition of typical landscape situation, landuse systems, dominant crops and typical soil profiles.

Since the entire effort to characterize system for carbon sequestration is intimately linked to climate-soil interaction, soils are being described in order of decreasing rainfall, such as sub-humid (moist), sub-humid (dry), semi-arid (moist), semi-arid (dry) and arid (also see Table 1.2). Black soils are described first, followed by red soils.

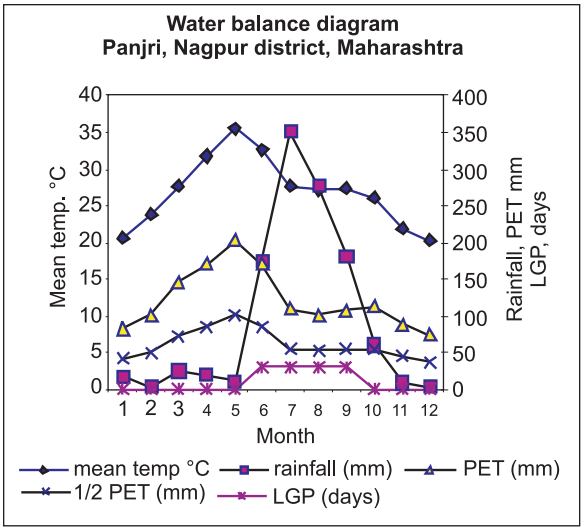
3A. BLACK SOILS

3Aa. Black soils of sub-humid (moist) bioclimatic system

(MAR > 1100 mm)

- **Benchmark Spots: 2, 3 , 7, 13**
- **No. of Pedons: 6 (P4, P5, P6, P15, P27, P28)**

BM Spot 2 : PANJRI – Agriculture (HM) (Cotton) P4



Classification : Very fine, smectitic, hyperthermic, *Typic Haplusterts*

Location : 50 m south of threshing floor, CICR Farm, Nagpur Maharashtra
Lat -21° 02'14"N, Long -79° 03'33"E

Physiographic position : Lower Maharashtra Deccan Plateau

Topography and Slope : Level to very gently sloping; 1-3% (50-150)

Drainage : Moderately well drained

Landuse : Cotton

Vegetation : Acacia, mango, *mahuva*, *dub*

Parent material : Basaltic alluvium

Sampled by: M. Venugopalan, S.K. Ray, S.L. Durge, S.R. Bhuse, R. Naitam

Date of collection: 30-11-2000

Remarks : Samples were also collected for ICRISAT, CRIDA and IISS.
Cracks 2.3-3.0 cm, wide up to 13 cm and 0.5 cm wide up to 30 cm.

Ap	0-13 cm	Dark greyish brown to very dark greyish brown (10 YR 3.5/2D); very dark greyish brown (10YR 3/2M) clay; medium, moderate subangular blocky structure; hard, friable, sticky and plastic; common very fine, a few fine roots; common very fine, a few fine and medium lime nodules; many very fine and fine pores; moderately alkaline (pH 8.0); clear, smooth boundary.
Bw1	13-38 cm	Very dark greyish brown (10 YR 3/2 M) clay; medium strong subangular blocky structure with pressure faces on ped surface; friable, sticky and plastic; a few very fine and fine roots; common very fine, fine and medium lime nodules; moderately alkaline (pH 7.9); clear, smooth boundary.
Bss1	38-60 cm	Dark greyish brown (10 YR 4/2 M) clay; medium strong, weak angular blocky to medium strong subangular blocky structure with slickensides and wedge-shaped aggregates; friable, sticky and plastic; a few very fine and fine roots; many very fine, common fine and medium lime nodules; moderately alkaline (pH 8.1); gradual smooth boundary.
Bss2	60-89 cm	Very dark greyish brown (10 YR 3/2 M) clay; coarse, strong angular blocky structure with well developed slickensides and wedge-shaped aggregates that break into small angular peds; friable, very sticky and very plastic; a few very fine and fine roots; common very fine and fine lime nodules; moderately alkaline (pH 8.1); gradual smooth boundary.
Bss3	69-131 cm	Brown (10 YR 4/3 M) clay; coarse, strong angular and blocky structure with well developed slickensides and wedge-shaped aggregates that break into small angular peds; friable, very sticky and very plastic; a few very fine and fine roots; mildly alkaline (pH 7.8); clear, wavy boundary.
Bss4	131-150+ cm	Brown to dark yellowish brown (10 YR 4/3.5 R) clay; medium strong angular blocky structure with slickensides and wedge-shaped aggregates; friable, very sticky and very plastic; a few very fine roots; many very fine and fine, common medium lime nodules; mildly alkaline (pH 7.8); slightly effervescent.

Series: PANJRI **BM Spot: 2 (BLACK SOILS)**

Profile No: P4 ***System: Agriculture (Cotton*) (HM)**

CLIMATE: SUB-HUMID (MOIST) RAINFALL: 1127 mm	Classification: Very fine, smectitic, hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location : Panjri, CICR Farm, Nagpur, Maharashtra		Sampling Date : 30.11.2000

Morphological Properties of Profile No. 4 (Panjri, Katol, Nagpur)

Horizon	Depth (cm)	Boundary		Matrix color		Texture	Coarse fragments (%) (fg and cg)	Structure		
		D	T	Dry	Moist			Size	Grade	Type
Ap	0-13	c	s	10YR3.5/2	10YR3/2	c	fg 3--5	m	2	sbk
Bw1	13-38	c	s	-	10YR3/2	c	3--5	m	3	sbk
Bss1	38-60	g	w	-	10YR4/2	c	5--8	m	3	abk(w)
Bss2	60-89	g	w	-	10YR3/2	c	3--5	c	3	abk
Bss3	89-131	c	w	-	10YR4/3* 10YR3.5/2	c	1--3	c	3	abk
Bss4	131-150	-	-	-	10YR4/3.5	c	5--8	m	3	abk

Depth (cm)	Consistence			Porosity		Nodules (conca)		Roots		Effervescence	Other features	Cracks
	Dry	Moist	Wet	S	Q	Size	Quantity	Size	Quantity	Dil HCl		
0-13	h	fr	sp	vf, f	m	vf ; f,m	c ; f	vf; f	c; f	e	-	1-2 cm
13-38	-	fr	sp	-	-	vf ; f,m	C	vf,f	f	e	Pressure faces	
38-60	-	fr	sp	-	-	vf m	m; c	vf,f	f	e	Slickensides (weak)	
60-89	-	fr	vsvp	-	-	vf,f	C	vf,f	f	e	Slickensides	
89-131	-	fr	vsvp	-	-	vf,f	F	vf,f	f	e	Slickensides	
131-150	-	fr	vsvp	-	-	vf,f; m	m; c	vf,	f	e	Slickensides	

** The first colour dominates and is about 80% by area, the other one is about 20%*

Please refer Appendix I for the abbreviations.

Series: PANJRI **BM Spot: 2 (BLACK SOILS)**

Profile No: P4 ***System: Agriculture (Cotton*) (HM)**

CLIMATE: SUB-HUMID (MOIST) RAINFALL: 1127 mm	Classification: Very fine, smectitic, hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location : Panjri, CICR Farm, Nagpur, Maharashtra		Sampling Date : 30.11.2000

Physical Properties of Profile No. 4 (Panjri, CICR Farm, Nagpur)

Laboratory No	Horizon	Depth (cm)	Size class and particle diameter (mm)			Fine clay (%) (<0.0002)	Fine clay/ total clay (%)
			Total				
			Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)		
			←----------(% of <2 mm) ----------→				
3070	Ap	0-13	0.6	44.0	55.4	42.0	75.8
3071	Bw1	13-38	0.4	42.1	57.5	49.5	86.0
3072	Bss1	38-60	0.3	31.7	68.0	53.0	77.8
3073	Bss2	60-89	0.3	32.5	67.2	54.3	80.8
3074	Bss3	89-131	0.3	43.7	56.0	49.2	87.8
3075	Bss4	131-150	0.2	31.2	68.6	54.0	78.7

Depth (cm)	BD (Mgm^{-3})	COLE	HC ($cm\ hr^{-1}$)	WDC (%)
0-13	-	0.3	0.7	9.7
13-38	1.6	0.3	1.0	14.3
38-60	1.4	0.3	1.8	11.4
60-89	1.5	0.3	1.1	12.6
89-131	1.4	0.3	1.1	9.9
131-150	1.5	0.3	1.4	13.4

Series: PANJRI BM Spot: 2 (BLACK SOILS)

Profile No: P4 *System: Agriculture (Cotton*) (HM)

CLIMATE: SUB-HUMID (MOIST) RAINFALL: 1127 mm	Classification: Very fine, smectitic, hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location : Panjri, CICR Farm, Nagpur, Maharashtra		Sampling Date : 30.11.2000

Chemical Properties of Profile No. 4 (Panjri, CICR Farm, Nagpur)

Depth (cm)	pH (1:2)		EC (1:2) (dSm^{-1})	OC (%)	$CaCO_3$ (%)	Clay CO_3* (%)
	H_2O	1*N* KCl				
0-13	8.0	6.5	0.14	0.7	4.8	2.6
13-38	7.9	6.5	0.18	0.6	5.8	3.1
38-60	8.1	6.5	0.10	0.5	6.8	2.4
60-89	8.1	6.7	0.18	0.5	7.3	2.5
89-131	7.8	6.6	0.20	0.4	7.2	2.2
131-150	7.8	6.6	0.14	0.3	7.4	2.4

Depth (cm)	Extractable bases				CEC	BS (%)	ESP
	Ca	Mg	Na	K			
	←----------[cmol(p+)kg^{-1}]----------→						
0-13	45.8	8.9	0.7	1.0	63.0	90	1.1
13-38	45.1	9.5	0.5	0.7	57.6	97	0.9
38-60	43.8	11.3	0.7	0.7	64.1	88	1.1
60-89	38.4	13.3	0.6	0.7	59.8	89	1.0
89-131	37.6	15.5	0.5	0.7	61.8	88	0.8
131-150	35.6	18.9	0.5	0.7	64.5	86	0.8

* *Percent of water dispersible clay size carbonate*

Series: PANJRI **BM Spot: 2 (BLACK SOILS)**

Profile No: P4 ***System: Agriculture (Cotton*) (HM)**

CLIMATE: SUB-HUMID (MOIST) RAINFALL: 1127 mm	Classification: Very fine, smectitic, hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location : Panjri, CICR Farm, Nagpur, Maharashtra		Sampling Date : 30.11.2000

Saturation Extract Properties of Profile No. 4 (Panjri, Nagpur)

Depth (cm)	Sat (%)	ECe (dS/m)	Soluble cations ($mmol_c\ l^{-1}$)				Sum of cations
			Ca	Mg	Na	K	
0-13	69.76	0.30	1.70	0.45	3.80	0.01	5.96
13-38	69.73	0.24	0.83	0.62	8.15	0.03	9.63
38-60	74.50	0.76	1.89	0.78	11.96	0.01	14.64
60-89	79.39	0.82	7.46	2.79	1.30	0.05	11.60
89-131	75.83	0.79	4.20	2.10	0.65	0.03	6.98
131-150+	78.58	0.72	4.22	2.64	0.44	0.06	7.36

Depth (cm)	Soluble anions ($mmol_c\ l^{-1}$)				Sum of anions
	CO_3	HCO_3	Cl	SO_4	
0-13	-	2.65	0.60	2.76	6.01
13-38	-	1.59	0.50	7.54	9.63
38-60	-	2.12	0.90	11.67	14.69
60-89	-	9.55	1.00	1.05	11.60
89-131	-	5.90	0.60	0.50	7.00
131-150+	-	6.30	0.60	0.50	7.40

Series: PANJRI **BM Spot: 2 (BLACK SOILS)**

Profile No: P4 ***System: Agriculture (Cotton*) (HM)**

CLIMATE: SUB-HUMID (MOIST) RAINFALL: 1127 mm	Classification: Very fine, smectitic, hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location : Panjri, CICR Farm, Nagpur, Maharashtra		Sampling Date : 30.11.2000

Characterization of Landuse Types

S. No.	Attribute		Description
1	Production system	:	Rain-fed cotton monocropping system. Yield range: 700 – 1500 kg ha^{-1} during the last 10 years, with 4-5 months of fallow period during summer, crop and livestock based farming system
2	Management level	:	• Seeds: Improved varieties • Fertilizers: 60-90 kg N, 30-45 kg P_2O_5 and 30-45 kg K_2O /ha per year • Organic manure: 5 tonnes per ha once in 3-4 years • Pesticides- herbicides: Occasional • Insecticides: Frequent. • Residue management: Cotton residues are being burnt on bunds initially and ploughed back after final picking in the the last 4 years. • Soil conservation measures: Leveling with very gentle slope. • Sowing time: Last week of June. • Seed rate: Hybrids 2-2 ½ kg ha^{-1}
3	Power source	:	Mechanical (tractor) with improved implements, bullocks with improved implements and human labor
4	Market orientation	:	R&D
5	Capital intensity	:	High with credit not a constraint
6	Labor intensity	:	High
7	Land holding	:	Not relevant
8	Income level	:	Not relevant

Climatic Datasets of Panjri, Nagpur District, Maharashtra

Month	Mean temp (^oC)	Rainfall (mm)	PET (mm)	½ PET (mm)	LGP (days)
January	20.60	15.40	81.00	40.50	0.00
February	23.80	1.90	100.20	50.10	0.00
March	27.80	24.50	144.60	72.30	0.00
April	31.80	20.20	170.90	85.45	0.00
May	35.60	9.90	201.70	100.85	0.00
June	32.60	174.30	169.60	84.80	30.00
July	27.60	351.50	110.30	55.15	31.00
August	27.00	277.10	102.10	51.05	31.00
September	27.30	180.50	107.00	53.50	30.00
October	25.90	61.60	112.20	56.10	0.00
November	22.00	8.70	86.70	43.35	0.00
December	20.40	1.70	73.20	36.60	0.00
Average	26.86				
Total		1127.30	1459.50	729.75	122.00

Landscape, Landuse and Soils in Benchmark Spot 2 (Panjri, Nagpur)

Benchmark spot No. 2 at Central Institute of Cotton Research, Nagpur, Maharashtra

Benchmark spot at Panjri village under agricultural system (high management) with cotton as single crop

Typical deep black soils of Panjri series (Typic Haplusterts)

BM Spot 3 : NABIBABH – Agriculture (HM) (Soybean – Wheat) P5

Classification: Fine, montmorillonitic hyperthermic, *Typic Haplusterts*

Location: IISS Farm, Field No. 6B, Nabibagh, Bhopal, M.P. Lat -23°18'55"N, Long -79°24'34"E

Physiographic position: Central Highland, Vindhyan Ranges

Topography and Slope : Plain to very gently sloping, 1-3% (50-150 m)

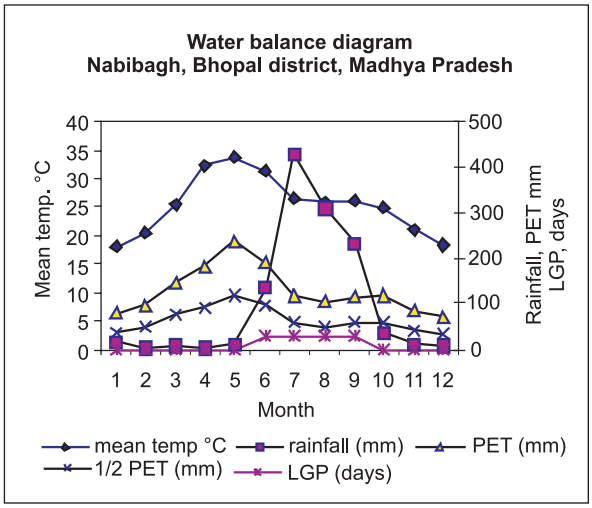
Drainage : Moderately well drained

Vegetation : Acacia, a*rabi*ca, mango, *neem*, grasses

Parent material : Basaltic alluvium

Sampled by: P. Chandran, T. Bhattacharyya, S.K. Ray, S.L. Durge, S.R. Bhuse

Date of collection: 05-02-2000



Remarks : Slickensides are not that well developed; Depth of first occurrence of slickensides is about 69 cm. The field is irrigated. Cracks are 1-2 cm wide up to 15 cm depth and <0.5 cm wide cracks up to 35 cm depth.

Ap	0-15 cm	Very dark greyish brown (10 YR 3/2 D&M) silty clay; medium, moderate subangular blocky structure; hard, very friable, sticky and plastic; a few, very fine and fine roots; many very fine, fine and a few medium lime nodules; many very fine and fine pores; moderately alkaline (pH 7.9); clear, smooth boundary.
Bw1	15-42 cm	Very dark greyish brown (10 YR 3/2 M) silty clay; medium strong subangular blocky structure with pressure faces; very friable, sticky and plastic; a few, very fine and fine roots; many very fine, fine and few medium lime nodules; many very fine and fine pores; moderately alkaline (pH 7.9); clear, smooth boundary.
Bw2	42-69 cm	Very dark greyish brown (10 YR 3/2 M) silty clay; medium strong, weak angular and blocky structures with weak development of slickensides; very friable, sticky and plastic; a few very fine roots; many very fine and a few medium lime nodules; moderately alkaline (pH 7.9); gradual smooth boundary.
Bss2	69-107 cm	Very dark greyish brown (10 YR 3/2 M) silty clay; medium strong angular and blocky structures with slickensides and wedge-shaped aggregates, which break into small angular peds; very friable, sticky and plastic; a few very fine roots; very fine many, common fine, a few medium lime nodules; moderately alkaline (pH 7.9); gradual smooth boundary.
Bss3	107-135 cm	Very dark greyish brown (10 YR 3/2 M) mixed with dark greyish brown (10 YR 4/2 M) silty clay; medium, strong, angular and blocky structure with slickensides and wedge-shaped aggregates, which break into small angular peds; very friable, sticky and plastic; a few very fine roots; many very fine, common fine, a few medium lime nodules; moderately alkaline (pH 8.0); gradual smooth boundary.
Bss4	135-150+ cm	Very dark greyish brown (10 YR 3/2 M) mixed with dark greyish brown (10 YR 4/1M) silty clay; medium strong angular blocky structure with slickensides and wedge-shaped aggregates, which break into small angular peds; very friable, sticky and plastic; a few very fine roots; many very fine, common fine, a few medium lime nodules; moderately alkaline (pH 8.1).

Series: NABIBAGH **BM Spot: 3 (BLACK SOILS)**

Profile No: P5 ***System: Agriculture (Soybeans-Wheat*) (HM)**

CLIMATE: SUB-HUMID (MOIST) RAINFALL: 1209 mm	Classification: Fine, smectitic, hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location : Nabibagh, Bhopal, Madhya Pradesh		Sampling Date : 5.12.2000

Morphological Properties of Profile No. 5 (Nabibagh, Bhopal)

Horizon	Depth (cm)	Boundary		Matrix color		Texture	Coarse fragments (%) (fg and cg)	Structure		
		D	T	Dry	Moist			Size	Grade	Type
Ap	0-13	c	s	10YR3.5/2	10YR3/2	c	fg 3--5	m	2	sbk
Bw1	13-38	c	s	-	10YR3/2	c	3--5	m	3	sbk
Bss1	38-60	g	w	-	10YR4/2	c	5--8	m	3	abk(weak)
Bss2	60-89	g	w	-	10YR3/2	c	3--5	c	3	abk
Bss3	89-131	c	w	-	10YR4/3* 10YR3.5/2	c	1--3	c	3	abk
Bss4	131-150	-	-	-	10YR4/3.5	c	5--8	m	3	abk

Depth (cm)	Consistence			Porosity		Nodules(conca)		Roots		Effervescence	Other Features	Cracks
	Dry	Moist	Wet	S	Q	Size	Quantity	Size	Quantity	dil HCl		
0-13	h	fr	sp	vf, f	m	vf ; f,m	c ; f	vf; f	c; f	e	-	1-2 cm
13-38	-	fr	sp	-	-	vf ; f,m	c	vf,f	f	e	Pressure faces	
38-60	-	fr	sp	-	-	vf m	m; c	vf,f	f	e	Slickensides (weak)	
60-89	-	fr	vsvp	-	-	vf,f	c	vf,f	f	e	Slickensides	
89-131	-	fr	vsvp	-	-	vf,f	f	vf,f	f	e	Slickensides	
131-150	-	fr	vsvp	-	-	vf,f; m	m; c	vf,	f	e	Slickensides	

Cracks 1-2 cm wide up to 15 cm and <0.5 mm cracks up to 35 cm.

Please refer Appendix I for the abbreviations.

Series: NABIBAGH **BM Spot: 3 (BLACK SOILS)**

Profile No: P5 ***System: Agriculture (Soybeans-Wheat*) (HM)**

CLIMATE: SUB-HUMID (MOIST) RAINFALL: 1209 mm	Classification: Fine, smectitic, hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location : Nabibagh, Bhopal, Madhya Pradesh		Sampling Date : 5.12.2000

Physical Properties of Profile No. 5 (Nabibagh, Bhopal)

Laboratory No	Horizon	Depth (cm)	Size class and particle diameter (mm)			Fine clay (%) (<0.0002)	Fine clay/ total clay (%)
			Total				
			Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)		
			←----------(% of <2 mm) ----------→				
3084	Ap	0-15	1.6	47.7	50.7	23.1	45.5
3085	Bw1	15-42	1.5	43.5	55.0	32.4	58.9
3086	Bw2	42-69	1.4	43.2	55.4	36.8	66.4
3087	Bss1	69-107	1.1	45.7	53.2	38.7	72.7
3088	Bss2	107-135	1.1	43.8	55.1	35.2	63.9
3089	Bss3	135-150	2.3	40.6	57.1	39.5	69.2

Depth (cm)	BD (Mgm^{-3})	COLE	HC ($cmhr^{-1}$)	WDC (%)
0-15	-	0.2	0.5	10.1
15-42	1.3	0.2	2.0	12.6
42-69	1.3	0.2	1.7	11.1
69-107	1.4	0.2	0.8	12.0
107-135	1.4	0.2	0.8	9.5
135-150	1.4	0.2	0.8	7.7

Series: NABIBAGH BM Spot: 3 (BLACK SOILS)

Profile No: P5 *System: Agriculture (Soybean-Wheat*) (HM)

CLIMATE: SUB-HUMID (MOIST) RAINFALL: 1209 mm	Classification: Fine, smectitic, hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location : Nabibagh, Bhopal, Madhya Pradesh		Sampling Date : 5.12.2000

Chemical Properties of Profile No. 5 (Nabibagh, Bhopal)

Depth (cm)	pH (1:2)		EC (1:2) (dSm^{-1})	OC (%)	$CaCO_3$ (%)	Clay CO_3* (%)
	H_2O	1*N* KCl				
0-15	7.9	6.7	0.18	0.8	5.1	1.7
15-42	7.9	6.5	0.13	0.7	5.9	1.6
42-69	7.9	6.5	0.12	0.6	5.5	1.7
69-107	7.9	6.5	0.12	0.6	5.0	2.1
107-135	8.0	6.6	0.13	0.6	5.3	1.8
135-150	8.1	6.7	0.13	0.5	5.6	1.6

Depth (cm)	Extractable bases				CEC	Clay CEC	BS (%)	ESP
	Ca	Mg	Na	K				
	←----------[cmol(p+)kg^{-1}]----------→							
0-15	36.8	5.4	0.3	0.5	45.9	90	93	0.7
15-42	36.4	6.3	0.3	0.4	45.7	83	95	0.7
42-69	37.7	8.3	0.3	0.4	46.7	84	100	0.7
69-107	35.8	9.5	0.3	0.4	47.8	90	96	0.6
107-135	33.9	10.4	0.3	0.4	45.7	83	98	0.7
135-150	33.9	12.8	0.3	0.4	47.8	84	99	0.7

* *Percent of water dispersible clay size carbonate*

Series: NABIBAGH **BM Spot: 3 (BLACK SOILS)**

Profile No: P5 ***System: Agriculture (Soybean-Wheat*) (HM)**

CLIMATE: SUB-HUMID (MOIST) RAINFALL: 1209 mm	Classification: Fine, smectitic, hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location : Nabibagh, Bhopal, Madhya Pradesh		Sampling Date : 5.12.2000

Saturation Extract Properties of Profile No. 5 (Nabibagh, Bhopal)

Depth (cm)	Sat (%)	ECe (dS/m)	Soluble cations ($mmol_c\ l^{-1}$)				SUM
			Ca	Mg	Na	K	
0-15	54.93	0.57	4.35	1.03	1.09	0.09	6.56
15-42	54.14	0.49	2.66	0.67	0.22	0.05	3.60
42-69	60.26	4.69	33.54	6.26	20.87	0.07	60.74
69-107	58.14	0.69	5.10	1.60	1.09	0.06	7.85
107-135	62.41	3.53	26.45	7.33	17.17	0.19	51.14
135-150+	56.97	3.72	23.89	8.04	15.44	0.18	47.55

Depth (cm)	Soluble anions ($mmol_c\ l^{-1}$)				SUM
	CO_3	HCO_3	Cl	SO_4	
0-15	-	5.26	1.00	0.45	6.71
15-42	1.01	1.49	0.60	0.50	3.60
42-69	1.01	6.90	0.50	52.33	60.74
69-107	-	7.00	0.60	0.25	7.85
107-135	-	50.24	0.40	0.50	51.14
135-150+	-	46.05	0.50	1.00	47.55

- *Nil or not determined (whatever applicable)*

Series: NABIBAGH BM Spot: 3 (BLACK SOILS)

Profile No: P5 *System: Agriculture (Soybean-Wheat*) (HM)

CLIMATE: SUB-HUMID (MOIST) RAINFALL: 1209 mm	Classification: Fine, smectitic, hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location : Nabibagh, Bhopal, Madhya Pradesh		Sampling Date : 5.12.2000

Characterization of Landuse Types

S. No.	Attribute		Description
1	Production system	:	Double cropping of soybean-wheat under irrigated conditions with 1-2 months fallow (summer). Yield range: Soybean 1900–2230 kg $ha^{-1}$and Wheat- 3380–3940 kg ha^{-1}.
2	Management level	:	• Improved varieties, • Organic manures: 3-4 tonnes/ha per year, • Fertilizer: Soybean- 25:60:20 and wheat- 120:60:40, weedicide losses • Pesticide losses, Pesticides: Endosulphan and Lindane. • Residues :Burnt • Soil conservation measures : None • Sowing time: Soybean- 1st week of July Wheat-last week of November • Seed rate: Soybean 80 kg ha^{-1} Wheat 100-120 kg ha^{-1}
3	Power source	:	Mechanical only
4	Market orientation	:	R& D purpose only
5	Capital intensity	:	High
6	Labor intensity	:	Low
7	Land holding	:	NA
8	Income level	:	NA

Climatic Datasets of Nabibagh, Bhopal District, Madhya Pradesh

Month	Mean temp (^oC)	Rainfall (mm)	PET (mm)	½ PET (mm)	LGP (days)
January	18.00	16.80	79.60	39.80	0.00
February	20.50	4.50	99.40	49.70	0.00
March	25.40	9.80	149.00	74.50	0.00
April	32.20	3.30	183.10	91.55	0.00
May	33.60	11.10	236.00	118.00	0.00
June	31.20	136.60	191.50	95.75	30.00
July	26.60	428.50	118.40	59.20	31.00
August	25.60	307.70	104.90	52.45	31.00
September	26.00	232.00	115.30	57.65	30.00
October	24.70	36.90	119.60	59.80	0.00
November	20.90	14.70	85.50	42.75	0.00
December	18.30	7.00	70.50	35.25	0.00
Average	25.25				
Total		1208.90	1552.80	776.40	122.00

Landscape, Landuse and Soils in Benchmark Spot 3 (Nabibagh, Bhopal)


BM Spot No. 3 at Indian Institute of Soil Science, Bhopal, Madhya Pradesh.


Typical Nabibagh soil series under agricultural system with high management practice, having soybean-wheat crop rotation (Typic Haplusterts)

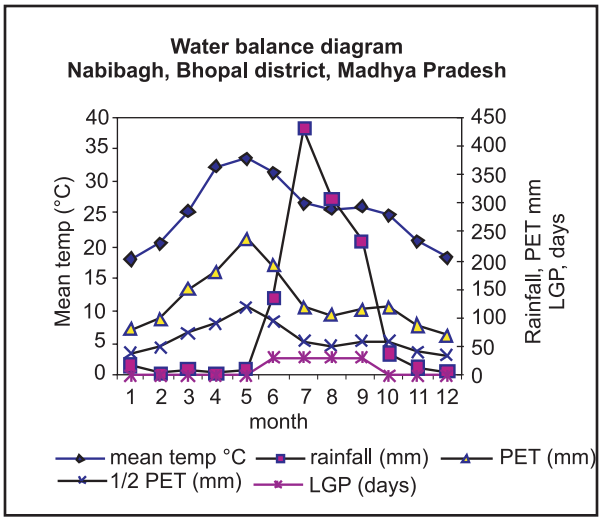
BM Spot 3 : NABIBAGH – Agriculture (LM) (Soybean-Wheat) P6

Classification : Fine, smectitic, hyperthermic, *Typic Haplusterts*

Location : Islamnagar (about 3 km from Nabibagh, IISS Farm and behind St. D.C. High School, Islamnagar, Bhopal, Madhya Pradesh. Lat. 23°20'31" N, Long. 79°24'50"E

Physiographic position : Central Highland, Vindhyan Ranges

Topography and slope: Level to very gently sloping, 1-3% (50-150 cm)



Drainage : Moderately well drained

Vegetation : Acacia, mango, *pipal*, *kans*, *dub*, parthenium

Parent material : Basaltic alluvium

Sampled by : T. Bhattacharyya, P. Chandran, S.K. Ray, S.L. Durge, S.R. Bhuse

Date of collection : 05.12.2000

Remarks : Poor resource farmer

Ap	0-23 cm	Greyish brown (10 YR 5/2D), dark greyish brown (10YR 4/2M) silty clay; medium moderate subangular blocky to strong, coarse, angular and blocky structure; hard, friable, sticky and plastic; common, very fine, a few fine roots; many very fine and fine, a few medium lime nodules; many very fine and fine pores; mildly alkaline (pH 7.8); clear, smooth boundary.
Bw1	23-42 cm	Very dark greyish brown to dark greyish brown (10YR 3.5/2M) silty clay; moderate coarse angular blocky structure; pressure faces on ped surfaces; friable, sticky and plastic; common, very fine, a few fine roots; many very fine and fine, a few medium lime nodules; many very fine and fine pores; moderately alkaline (pH 7.9); gradual smooth boundary.
Bss1	42-81 cm	Very dark greyish brown to dark greyish brown (10YR 3.5/2M) silty clay; moderate, coarse, angular and blocky structure with slickensides and wedge-shaped aggregates that break into small angular peds; friable, sticky and plastic; common very fine, a few fine roots; many very fine and fine, a few medium lime nodules; moderately alkaline (pH 8.0); slightly effervescent; gradual smooth boundary.
Bss2	81-122 cm	Very dark greyish brown (10YR 3/2M) silty clay; moderate coarse angular, and blocky structure with slickensides and wedge-shaped aggregates that break into small angular peds; friable, sticky and plastic; common very fine, few fine roots; common very fine and fine, a few medium lime nodules; moderately alkaline (pH 8.0); slightly effervescent; clear, smooth boundary.
Bss3	122-150 cm	Very dark greyish brown (10YR 3/2M) silty clay; coarse, strong angular blocky structure with slickensides and wedge-shaped aggregates that break into small angular peds; friable, sticky and plastic; common very fine and fine lime nodules; moderately alkaline (pH 8.0); slightly effervescent.

Series: NABIBAGH BM Spot: 3 (BLACK SOILS)

Profile No: P6 ***System: Agriculture (Soybean-Wheat*) (FM)**

CLIMATE: SUB-HUMID (MOIST) RAINFALL: 1209 mm	Classification: Fine, smectitic, hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location : Islamnagar, Bhopal, Madhya Pradesh		Sampling Date : 5.12.2000

Morphological Properties of Profile No. 6 (Nabibagh, Bhopal)

Horizon	Depth (cm)	Boundary		Matrix color		Texture	Coarse fragments (%) (fg and cg)	Structure		
		D	T	Dry	Moist			Size	Grade	Type
Ap	0-23	c	s	10YR5/2	10YR4/2	c	3--5	m	2	sbk
Bw1	23-42	g	s	-	10YR3.5/2	c	3--5	c	2	abk
Bss1	42-81	g	s	-	10YR3.5/2	c	3--5	c	2	abk
Bss2	81-122	c	s	-	10YR3/2	c	3--5	c	2	abk
Bss3	122-150	-	-	-	10YR3/2	c	3--5	c	3	abk

Depth (cm)	Consistence			Porosity		Nodules(conca)		Roots		Effervescence*	Other Features	Cracks
	Dry	Moist	Wet	S	Q	Size	Quantity	Size	Quantity	dil HCl		
0-23	h	fr	sp	vf, f	m	vf,f; m	m; f	vf; f	c; f	e	-	0.5 cm
23-42	-	fr	sp	vf, f	m	vf,f; m	m; f	vf; f	c; f	e	Pressure faces	
42-81	-	fr	sp	-	-	vf,f; m	m; f	vf; f	c; f	e	Slickensides	
81-122	-	fr	sp	-	-	vf,f; m	c; f	vf; f	c; f	e	Slickensides	
122-150	-	fr	sp	-	-	f,vf	c	-	-	e	Slickensides	

Cracks ~ 0.5 mm wide up to 20 cm.
**Matrix effervescence observed in 42-150 cm*

Please refer Appendix I for the abbreviations.

Series: NABIBAGH **BM Spot: 3 (BLACK SOILS)**

Profile No: P6 ***System: Agriculture (Soybean-Wheat*) (FM)**

CLIMATE: SUB-HUMID (MOIST) RAINFALL: 1209 mm	Classification: Fine, smectitic, hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location : Islamnagar, Bhopal, Madhya Pradesh		Sampling Date : 5.12.2000

Physical Properties of Profile No. 6 (Nabibagh, Bhopal)

Laboratory No.	Horizon	Depth (cm)	Size class and particle diameter (mm)			Fine clay (%) (<0.0002)	Fine clay/ total clay (%)
			Total				
			Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)		
			←----------(% of <2 mm) ----------→				
3090	Ap	0-23	2.1	49.0	48.9	31.3	64.0
3091	Bw1	23-42	1.8	46.9	51.4	34.4	67.0
3092	Bss1	42-81	1.8	42.5	55.7	38.2	68.6
3093	Bss2	81-122	1.8	45.2	53.0	35.5	67.0
3094	Bss3	122-150	1.6	42.5	55.9	38.2	68.3

Depth (cm)	BD (Mgm^{-3})	COLE	HC ($cmhr^{-1}$)	WDC (%)
0-23	-	0.2	1.5	8.3
23-42	1.3	0.2	2.9	9.5
42-81	1.5	0.2	2.1	12.1
81-122	1.5	0.2	1.7	11.6
122-150	1.4	0.2	1.1	11.4

Series: NABIBAGH BM Spot: 3 (BLACK SOILS)

Profile No: P6 *System: Agriculture (Soybean-Wheat)* (FM)

CLIMATE: SUB-HUMID (MOIST) RAINFALL: 1209 mm	Classification: Fine, smectitic, hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location : Islamnagar, Bhopal, Madhya Pradesh		Sampling Date : 5.12.2000

Chemical Properties of Profile No. 6 (Nabibagh, Bhopal)

Depth (cm)	pH (1:2)		EC (1:2) (dSm^{-1})	OC (%)	$CaCO_3$ (%)	Clay CO_3* (%)
	H_2O	1*N* KCl				
0-23	7.8	6.5	0.18	0.7	3.8	1.6
23-42	7.9	6.6	0.11	0.5	4.5	2.0
42-81	8.0	6.6	0.13	0.5	4.2	2.7
81-122	8.0	6.5	0.12	0.5	4.1	2.4
122-150	8.0	6.7	0.18	0.4	5.3	2.7

Depth (cm)	Extractable bases				CEC	Clay CEC	BS (%)	ESP
	Ca	Mg	Na	K				
	←----------[cmol(p+)kg^{-1}]----------→							
0-23	39.2	7.8	0.3	0.5	46.7	95	102	0.6
23-42	38.4	5.6	0.3	0.5	51.8	101	86	0.6
42-81	37.9	7.8	0.4	0.6	45.7	82	102	0.9
81-122	37.7	7.1	0.4	0.6	44.3	84	103	0.9
122-150	36.6	8.2	0.4	0.7	45.7	82	100	0.9

* *Percent of water dispersible clay size carbonate*

Series: NABIBAGH BM Spot: 3 (BLACK SOILS)

Profile No: P6 *System: Agriculture (Soybean-Wheat*) (FM)

CLIMATE: SUB-HUMID (MOIST) RAINFALL: 1209 mm	Classification: Fine, smectitic, hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location : Islamnagar, Bhopal, Madhya Pradesh		Sampling Date : 5.12.2000

Saturation Extract Properties of Profile No. 6 (Nabibagh, Bhopal)

Depth (cm)	Sat (%)	ECe (dS/m)	Soluble cations ($mmol_c\ l^{-1}$)				Sum of cations
			Ca	Mg	Na	K	
0-23	61.99	0.36	1.44	0.53	2.76	0.18	4.91
23-42	55.43	0.23	0.81	0.40	15.76	0.08	17.05
42-81	58.74	0.24	1.25	0.40	23.91	0.02	25.58
81-122	57.55	0.23	0.75	0.32	17.39	0.04	18.50
122-150	58.83	0.38	2.00	0.77	28.80	0.04	31.61

Depth (cm)	Soluble anions ($mmol_c\ l^{-1}$)				Sum of anions
	CO_3	HCO_3	Cl	SO_4	
0-23	-	4.01	0.90	-	4.91
23-42	-	3.18	0.50	13.31	17.00
42-81	-	3.18	0.50	21.92	25.60
81-122	-	2.65	1.70	14.15	18.50
122-150	-	4.24	2.00	25.38	31.62

- *nil or not determined (wherever applicable)*

Series: NABIBAGH BM Spot: 3 (BLACK SOILS)

Profile No: P6 *System: Agriculture (Soybean-Wheat*) (FM)

CLIMATE: SUB-HUMID (MOIST) RAINFALL: 1209 mm	Classification: Fine, smectitic, hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location : Islamnagar, Bhopal, Madhya Pradesh		Sampling Date : 5.12.2000

Characterization of Landuse Types

S. No.	Attribute		Description
1	Production system	:	Irrigated double cropping of soybean-wheat Yield ranges: Soybean (rainfed) -12-15 q/ha Wheat yield - 30-35 q/ha
2	Management level	:	• Improved seeds • Manures: Nil • Fertilizer- 20 kg N/ha and 45 kg P2O5/ha for soybean and 100 kg N : 50 kg P2O5 /ha for wheat • Herbicides: Occasional • Residues: Removed • Sowing time: Soybean- 1st week of July Wheat- 1st fortnight of December • Seed rate: Soybean 70-80 kg ha^{-1} Wheat 80-100 kg ha^{-1}
3	Power source	:	
4	Market orientation	:	Subsistence and commercial
5	Capital intensity	:	Medium with low access to institutional credit
6	Labor intensity	:	Low
7	Land holding	:	NA
8	Income level	:	NA

Climatic Datasets of Nabibagh, Bhopal District, Madhya Pradesh

Month	Mean temp (ºC)	Rainfall (mm)	PET (mm)	½ PET (mm)	LGP (days)
January	18.00	16.80	79.60	39.80	0.00
February	20.50	4.50	99.40	49.70	0.00
March	25.40	9.80	149.00	74.50	0.00
April	32.20	3.30	183.10	91.55	0.00
May	33.60	11.10	236.00	118.00	0.00
June	31.20	136.60	191.50	95.75	30.00
July	26.60	428.50	118.40	59.20	31.00
August	25.60	307.70	104.90	52.45	31.00
September	26.00	232.00	115.30	57.65	30.00
October	24.70	36.90	119.60	59.80	0.00
November	20.90	14.70	85.50	42.75	0.00
December	18.30	7.00	70.50	35.25	0.00
Average	25.25				
Total		1208.90	1552.80	776.40	122.00

Landscape, Landuse and Soils in Benchmark Spot 3 (Islamnagar, Bhopal)

Nabibagh soil series under agricultural system with low management practice, having soybean-wheat cropping system (Typic Haplusterts)

Soil profile Nabibagh soil series (Typic Haplusterts)

BM Spot 7 : BORIPANI – Forest System (Teak) P15

Classification : Very fine, smectitic, hyperthermic *Vertic Haplustepts*

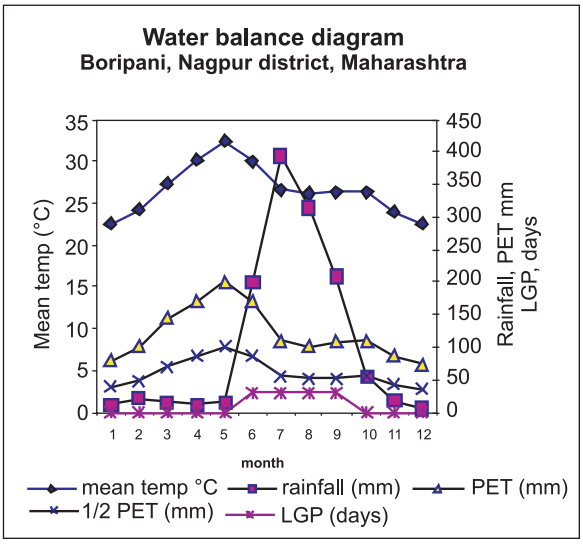
Location : 3 km east of Piperdol, Reserve Forest Area, Boripani-Sirajpur, Umred, Nagpur, Maharashtra, Lat 20°15'31" N, Long. 79°10'55" E

Physiographic position : Lower Maharashtra Deccan Plateau

Topography and slope : Very gently sloping to undulating land, 1-3% (0-50 m)

Drainage : Well drained

Vegetation : *Khair, kalamb, behada, kans, yeroni, arans, lessburni, bharati, sagwan, chilati, ain, dub, kokai, Palas, rohan, mahuwa, salai, mohair, anjan*



Landuse : Forest vegetation

Parent material : Weathered basalt

Sampled by : T. Bhattacharyya, P. Chandran, M.V. Venugopalan, S.K. Ray, S.L. Durge, S.R. Bhuse

Date of collection : 24-01-2000

Remarks : The reserve forest is near Makardhokra dam, where the main vegetation is natural teak.

A1	0-16 cm	Dark greyish brown (10YR 4/2D); very dark greyish brown (10YR 3/2M) clay; medium to weak coarse prismatic to moderate medium subangular blocky structure; hard friable, sticky and plastic; many fine and medium roots; common fine medium and coarse lime nodules; a few very fine and fine pores; neutral (pH 7.3); gradual smooth boundary.
Bw1	16-44 cm	Very dark greyish brown (10YR 3/2M) clay; medium to weak coarse prismatic to moderate medium subangular blocky structure with shiny pressure faces on ped surfaces and weak wedge-shaped aggregates; friable, very sticky and very plastic; many fine, medium and coarse roots; common fine medium and coarse lime nodules; a few very fine and fine pores; mildly alkaline (pH 7.4); gradual smooth boundary.
Bw2	44-57 cm	Very dark greyish brown (10YR 3/2M) clay; medium to weak coarse prismatic to weak moderate medium angular blocky structure with shiny pressure faces on ped surfaces and weak wedge-shaped aggregates showing initiation of slickenside formation; friable, very sticky and very plastic; common fine, medium and coarse roots; common very fine, fine medium and coarse lime nodules; a few very fine and fine pores; mildly alkaline (pH 7.6); slightly effervescent; clear, wavy boundary.
Ck1	57-94 cm	Basalt saprolite, light yellowish brown (10YR 6/4 R) clay; massive structure; very friable, sticky and non plastic; 40-50% by volume of fine and coarse fragments; common fine and medium roots; many very fine, fine medium and coarse lime nodules; mildly alkaline (pH 7.7); violent effervescent.
Ck2	94+ cm	Calcareous partially weathered basalt saprolite.

Series: BORIPANI **BM Spot: 7 (BLACK SOILS)**

Profile No: P15 ***System: Forest (Teak)***

CLIMATE: SUB-HUMID (MOIST) RAINFALL: 1279 mm	Classification: Very fine, smectitic, hyperthermic, *Vertic Haplustepts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Boripani-Sirajpur, Umred, Nagpur, Maharashtra		Sampling Date : 24.01.2001

Morphological Properties of Profile No. 15 (Boripani, Umred, Nagpur)

Horizon	Depth (cm)	Boundary		Matrix color		Texture	Coarse fragments (%) (fg and cg)	Structure		
		D	T	Dry	Moist			Size	Grade	Type
A1	0-16	g	s	10YR4/2	10YR3/2	c	2-3	c m	2/1 2	pr sbk
Bw1	16-44	g	s	10YR4/2	10YR3/2	c	2-3	m	2/1 2	sbk
Bw2	44-57	c	w	10YR4/2	10YR3/2	c	3--5	m	2/1 2	sbk-abk
Ck1	57-94	-	-	-	10 YR4/6 (R)	c	45-50	massive		

Depth (cm)	Consistence			Porosity		Nodules (conca)		Roots		Effervescence	Other features*	Cracks
	Dry	Moist	Wet	S	Q	Size	Quantity	Size	Quantity	dil HCl		
0-16	h	fr	sp	vf,f	f	f,m,c	c	f,m	m	e	-	1 cm
16-44	-	fr	sp	vf,f	f	f,m,c	c	f,m; c	c; m	e	Pressure faces	1 cm
44-57	-	fr	sp	vf,f	f	vf,f,m,c	c	f,m,c,	m	e	Pressure faces	1 cm
57-94	-	vfr	spo	-	-	vf, c	m	f,m	c	ev	-	1 cm

**Soil matrix is no- calcareous. Polygonal cracks 10-15 cm in diameter.*

Please refer Appendix I for the abbreviations.

Series: BORIPANI **BM Spot: 7 (BLACK SOILS)**

Profile No: P15 ***System: Forest (Teak)***

CLIMATE: SUB-HUMID (MOIST) RAINFALL: 1279 mm	Classification : Very fine, smectitic, hyperthermic, *Vertic Haplustepts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Boripani-Sirajpur, Umred, Nagpur, Maharashtra		Sampling Date : 24.01.2001

Physical Properties of Profile No. 15 (Boripani, Umred, Nagpur)

Laboratory No.	Horizon	Depth (cm)	Size class and particle diameter (mm)			Fine clay (%) (<0.0002)	Fine clay/ total clay (%)
			Total				
			Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)		
			←----------(% of <2 mm) ----------→				
3142	A1	0-16	1.0	29.0	70.0	42.6	60.8
3143	Bw1	16-44	1.1	31.4	67.5	43.0	63.7
3144	Bw2	44-57	1.2	24.0	74.8	51.6	69.0
3145	Ck1	57-94	35.1	16.7	48.2	36.4	75.5

Depth (cm)	BD (Mgm^{-3})	COLE	HC ($cmhr^{-1}$)	WDC (%)
0-16	1.4	0.3	1.4	15.8
16-44	1.3	0.3	1.4	18.2
44-57	1.4	0.2	1.5	16.7
57-94	1.3	0.1	1.6	8.2

Series: BORIPANI BM Spot: 7 (BLACK SOILS)

Profile No: P15 *System: Forest (Teak)*

CLIMATE: SUB-HUMID (MOIST) RAINFALL: 1279 mm	Classification : Very fine, smectitic, hyperthermic, *Vertic Haplustepts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Boripani-Sirajpur, Umred, Nagpur, Maharashtra		Sampling Date : 24.01.2001

Chemical Properties of Profile No. 15 (Boripani, Umred, Nagpur)

Depth (cm)	pH (1:2)		EC (1:2) (dSm^{-1})	OC (%)	$CaCO_3$ (%)	Clay CO_3 (%)
	H_2O	1*N* KCl				
0-16	7.3	5.6	0.90	0.9	4.0	3.0
16-44	7.4	5.7	0.12	0.7	4.0	3.0
44-57	7.6	6.0	0.14	0.7	8.0	3.4
57-94	7.7	6.1	0.15	0.1	11.0	3.3

Depth (cm)	Extractable bases				CEC	Clay CEC	BS (%)	ESP
	Ca	Mg	Na	K				
	←----------[cmol(p+)kg^{-1}]----------→							
0-16	50.2	13.1	0.3	0.6	55.5	79	94	-
16-44	46.0	9.3	0.3	0.5	64.6	96	83	-
44-57	48.8	8.0	1.9	0.3	61.0	82	87	3
57-94	55.7	16.0	1.9	0.2	67.9	140	109	3

- *Nil or not determined (wherever applicable)*

Series: BORIPANI **BM Spot: 7 (BLACK SOILS)**

Profile No: P15 ***System: Forest (Teak)***

CLIMATE: SUB-HUMID (MOIST) RAINFALL: 1279 mm	Classification: Very fine, smectitic, hyperthermic, *Vertic Haplustepts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Boripani-Sirajpur, Umred, Nagpur, Maharashtra		Sampling Date : 24.01.2001

Saturation Extract Properties of Profile No. 15 (Boripani, Nagpur)

Depth (cm)	Sat (%)	ECe (dS/m)	Soluble cations ($mmol_c\ l^{-1}$)				Sum of cations
			Ca	Mg	Na	K	
0-16	67.78	0.30	0.92	0.48	0.98	0.07	2.45
16-44	68.52	0.28	1.25	0.60	0.87	0.03	2.75
44-57	71.92	0.39	3.26	4.42	0.87	0.09	8.64
57-94	65.16	0.23	1.89	0.91	0.76	0.01	3.57

Depth (cm)	Soluble anions ($mmol_c\ l^{-1}$)				Sum of anions
	CO_3	HCO_3	Cl	SO_4	
0-16	1.06	-	0.90	0.49	2.45
16-44	1.06	0.53	0.64	0.52	2.75
44-57	1.06	0.53	0.70	6.35	8.64
57-94	2.12	-	0.50	0.95	3.57

- *Nil or not determined (wherever applicable)*

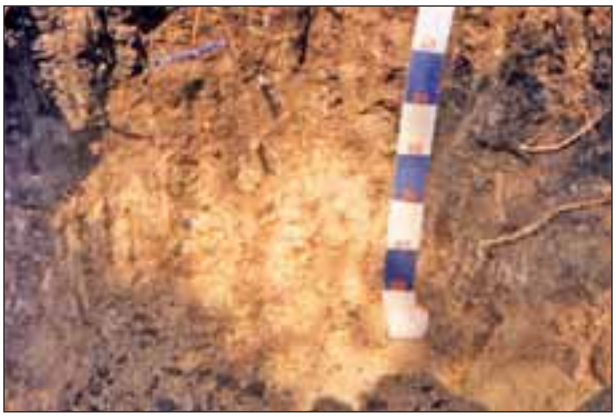
Climatic Datasets of Boripani, Nagpur District, Maharashtra

Month	Mean temp (^oC)	Rainfall (mm)	PET	½ PET	LGP (days)
January	22.60	13.20	81.00	40.50	0.00
February	24.30	21.80	100.20	50.10	0.00
March	27.40	14.70	144.60	72.30	0.00
April	30.20	13.50	170.90	85.45	0.00
May	32.30	15.20	201.70	100.85	0.00
June	29.90	199.60	169.60	84.80	30.00
July	26.70	395.50	110.30	55.15	31.00
August	26.20	314.20	102.10	51.05	31.00
September	26.40	210.10	107.00	53.50	30.00
October	26.30	54.10	112.20	56.10	0.00
November	24.00	19.80	86.70	43.35	0.00
December	22.50	7.60	73.20	36.60	0.00
Average	26.56				
Total		1279.30	1459.50	729.75	122.00

Landscape, Landuse and Soils in Benchmark Spot 7 (Boripani, Nagpur)

A teak forest site at Boripani

Typical Boripani soil profile (Vertic Haplustepts)



Closer view of the soil profile

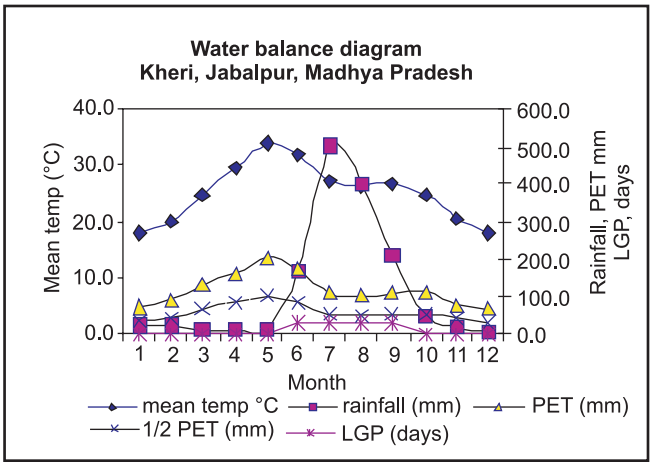
BM Spot 13: KHERI: Agricultural System (Paddy-Wheat) (HM) P27

Classification : Veryfine,smectitic,hyperthermic Typic Haplusterts

Location : Farm of National Research Centre for Weed Science, Jabalpur, Madhya Pradesh. Lat. 23°14'00" N, Long 79°58'00" E

Physiographic position : Deccan plateau – Satpura ranges

Topography and slope : Very gently sloping, 1-3% (50-150 m)



Drainage : Moderately well drained

Landuse : Paddy-wheat, maize

Vegetation : *Palas*, mango, *neem*, acacia

Parent material : Basaltic alluvium

Sampled by : P. Srivastava, S.L. Durge, G.K. Kamble

Date of collection : 17.10.2001

Remarks : Basaltic gravels (2 mm to 5 mm size) about 3 to 5% (v/v) throughout the depth

Ap	0-20 cm	Light brownish grey (2.5Y 6/2D) and greyish brown (2.5Y 5/2M) clay; moderate medium subangular blocky structure; hard, friable, sticky and plastic; common fine roots; common fine and medium pores; neutral reaction (pH 7.1); clear, smooth boundary.
Bw1	20-42 cm	Very dark greyish brown (10YR 3/2M) clay; moderate medium subangular blocky structure; friable, sticky and plastic; few fine roots; mildly alkaline (pH 7.4); clear, smooth boundary.
Bw2	42-63 cm	Very dark greyish brown (10YR 3/2M) clay; moderate medium and weak angular blocky structure with pressure faces on ped surfaces; friable, very sticky and very plastic; a few very fine and fine roots; neutral reaction (pH 7.1); slightly effervescent; gradual smooth boundary.
Bss1	63-84 cm	Very dark greyish brown (10YR 3/2M) clay; strong medium angular blocky structure with wedge-shaped aggregates and slickensides which break into small angular peds; friable, very sticky and very plastic; a few very fine roots; a few fine and medium lime nodules; neutral reaction (pH 7.2); slightly effervescent; slickensides; gradual smooth boundary.
Bss2	84-115 cm	Very dark greyish brown (10YR 3/2M) clay; strong medium angular blocky structure with well developed wedge-shaped aggregate and slickensides, which break into small angular peds; friable, very sticky and very plastic; a few very fine roots; common fine and medium lime nodules; mildly alkaline (pH 7.4); slightly effervescent; gradual smooth boundary.
Bss3	115-160 cm	Very dark greyish brown (10YR 3/2M) clay; moderate medium angular blocky structure with well developed wedge-shaped aggregates and slickensides, which break into small angular peds; firm; sticky and plastic; common fine, medium and coarse lime nodules; mildly alkaline (pH 7.5); slightly effervescent.

Series: KHERI **BM Spot: 13 (BLACK SOILS)**

Profile No: P27 ***System: Agriculture (Paddy-Wheat)* (HM)**

CLIMATE : SUB-HUMID (MOIST) RAINFALL: 1448 mm	Classification: Very fine, smectitic, hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: N R C for Weed Science Farm, Jabalpur, Madhya Pradesh.		Sampling Date: 17.10.2001

Morphological Properties of Profile No. 27 (Kheri, Jabalpur)

Horizon	Depth (cm)	Boundary		Matrix color		Mottle color	Texture	Coarse fragments (%) (fg %)	Structure		
		D	T	Dry	Moist				Size	Grade	Type
Ap	0-20	c	s	-	2.5Y5/2	Very faint	c	-	m	2	sbk
Bw1	20-42	c	s	-	10YR3/2	roots mottles	c	-	m	2	sbk
Bw2	42-63	g	s	-	10YR3/2	7.5YR5/6	c	-	m	2	abk
Bss1	63-84	g	s	-	10YR3/2	-	c	-	m	2	abk
Bss2	84-115	g	s	-	10YR3/2	-	c	-	m	2	abk
Bss3	115-160	-	-	-	10YR3/2	-	c	3 -5	m	2	abk

Depth (cm)	Consistence			Porosity		Nodules (conca)		Roots		Effervescence	Other features	Cracks
	Dry	Moist	Wet	S	Q	Size	Quantity	Size	Quantity	dil HCl		
0-20	h	f r	sp	f, m	m	-	-	f	c	e	-	1-2 cm
20-42	-	fr	sp	-	-	-	-	f	f	e	-	1-2 cm
42-63	-	fr	sp	-	-	-	-	-	-	e	Pressure faces	1 m
63-84	-	fr	sp	-	-	vf,f	f	-	-	e	Slickensides	
84-115	-	f i	vsvp	-	-	vf,f	f	-	-	e	*Slickensides	
115-160	-	f i	vsvp	-	-	vf,f	f	-	-	e	*Slickensides	

** Intersecting slickensides, which increase down the depth*

Please refer Appendix I for the abbreviations

Series: KHERI **BM Spot: 13 (BLACK SOILS)**

Profile No: P27 ***System: Agriculture (Paddy-Wheat)* (HM)**

CLIMATE : SUB-HUMID (MOIST) RAINFALL: 1448 mm	Classification: Very fine, smectitic, hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: N R C for Weed Science Farm, Jabalpur, Madhya Pradesh.		Sampling Date: 17.10.2001

Physical Properties of Profile No. 27 (Kheri, Jabalpur)

Laboratory No.	Horizon	Depth (cm)	Size class and particle diameter (mm)			Fine clay (%) (<0.0002)	Fine clay/ total clay (%)
			Total				
			Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)		
			←----------(% of <2 mm) ----------→				
3253	Ap	0-20	13.2	33.0	53.8	32.3	60.0
3254	Bw1	20-42	4.0	31.0	65.0	32.2	49.5
3255	Bw2	42-63	3.9	33.8	62.2	39.2	63.0
3256	Bss1	63-84	3.8	35.2	61.0	36.7	60.2
3257	Bss2	84-115	3.5	36.2	60.3	34.9	57.8
3258	Bss3	115-160	12.1	31.6	56.3	37.0	65.7

Depth (cm)	BD (Mgm^{-3})	COLE	HC ($cmhr^{-1}$)	WDC (%)
0-20	1.5	0.2	1.5	11.9
20-42	1.5	0.2	2.5	12.3
42-63	1.5	0.2	2.3	13.9
63-84	1.5	0.2	2.1	14.4
84-115	1.5	0.2	2.8	9.6
115-160	1.8	0.2	1.2	9.1

Series: KHERI **BM Spot: 13 (BLACK SOILS)**

Profile No: P27 ***System: Agriculture (Paddy-Wheat)* (HM)**

CLIMATE : SUB-HUMID (MOIST) RAINFALL: 1448 mm	Classification: Very fine, smectitic, hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: N R C for Weed Science Farm, Jabalpur, Madhya Pradesh.		Sampling Date: 17.10.2001

Chemical Properties of Profile No. 27 (Kheri, Jabalpur)

Depth (cm)	pH (1:2)		EC (1:2) (dSm^{-1})	OC (%)	$CaCO_3$ (%)	Clay CO_3 (%)
	H_2O	1*N* KCl				
0-20	7.1	6.2	0.16	0.6	3.5	4.6
20-42	7.4	6.4	0.18	0.4	4.0	4.2
42-63	7.1	5.8	0.11	0.3	2.9	4.5
63-84	7.2	6.0	0.13	0.3	2.9	4.3
84-115	7.4	6.3	0.20	0.6	3.5	3.9
115-160	7.5	6.3	0.09	0.4	3.7	4.5

Depth (cm)	Extractable bases				CEC	Clay CEC	BS (%)	ESP
	Ca	Mg	Na	K				
	←----------[cmol(p+)kg^{-1}]----------→							
0-20	28.2	12.3	1.0	0.5	47.9	89	88	2
20-42	36.3	12.4	0.8	0.7	52.1	80	96	2
42-63	37.8	14.8	1.2	0.5	52.1	84	104	2
63-84	25.6	16.0	0.4	0.5	52.1	85	81	1
84-115	27.0	14.6	0.6	0.4	49.3	82	86	1
115-160	26.5	16.0	1.0	0.4	47.9	85	91	2

- *Nil or not determined (wherever applicable)*

Series: KHERI **BM Spot: 13 (BLACK SOILS)**

Profile No: P27 ***System: Agriculture (Paddy-Wheat)* (HM)**

CLIMATE : SUB-HUMID (MOIST) RAINFALL: 1448 mm	Classification: Very fine, smectitic, hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: N R C for Weed Science Farm, Jabalpur, Madhya Pradesh.		Sampling Date: 17.10.2001

Characterization of Landuse Types

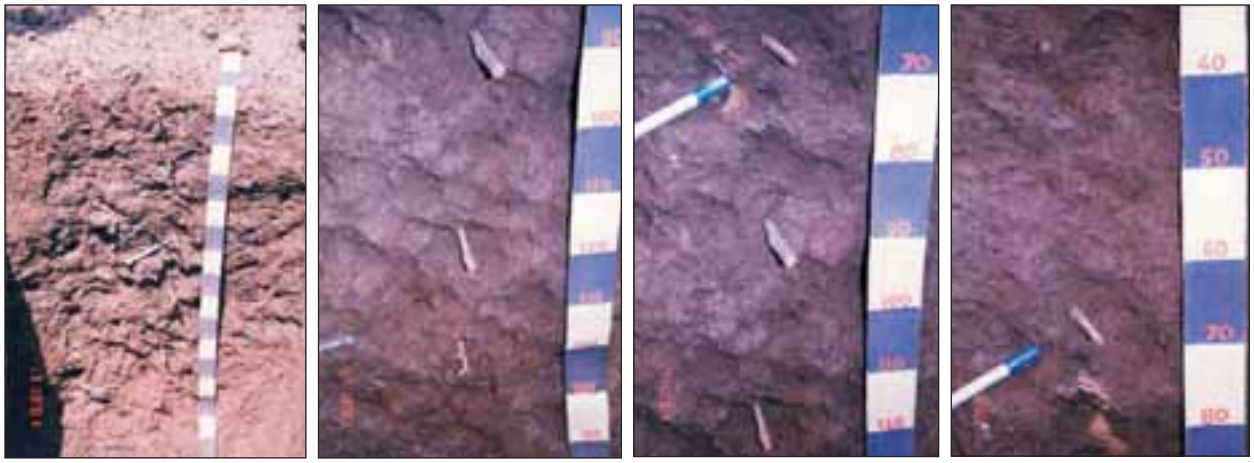
S. No.	Attribute		Description
1	Production system	:	Irrigated double cropping of soybean-wheat with 1-2 months fallow period in summer Yield ranges: Soybean-2000-2200 q/ha Wheat- 4000-4500 kg ha^{-1}
2	Management level	:	• Improved HYV • Organic manure: FYM 5t/ha once in 2years • Fertilizer dose: 25:50:50 for soybean and 120:50:50 for wheat • Crop residues: Turned down. • Soil conservation: • Sowing time: Soybean- 1st week of July • Seed rate: Soybean 80 kg ha^{-1} Wheat 100 kg ha^{-1}
3	Power source	:	Mechanical power supplemented with manual.
4	Market orientation	:	R&D
5	Capital intensity	:	NA
6	Labor intensity	:	Low
7	Land holding	:	NA
8	Income level	:	NA

Climatic Datasets of Kheri, Jabalpur, Madhya Pradesh

Month	Mean temp (^oC)	Rainfall (mm)	PET (mm)	½ PET (mm)	LGP (days)
January	17.90	26.40	69.60	34.80	0.00
February	20.10	21.50	88.80	44.40	0.00
March	24.70	14.90	134.90	67.45	0.00
April	29.50	9.40	165.00	82.50	0.00
May	33.90	15.00	203.20	101.50	0.00
June	32.00	170.40	172.60	86.30	30.00
July	27.10	505.00	105.80	52.90	31.00
August	26.50	400.70	99.30	49.65	31.00
September	26.90	212.40	107.40	53.70	30.00
October	24.90	50.10	112.70	56.35	0.00
November	20.30	16.70	78.30	39.65	0.00
December	17.90	5.00	63.20	31.60	0.00
Average	25.14				
Total		1447.50	1400.80	700.80	122.00

Landscape, Landuse and Soils in Benchmark Spot 13 under High Management (Kheri, Jabalpur)

Kheri soil under agricultural system (high management) with paddy/ wheat crop rotation.



Typical Kheri soil profile (Typic Haplusterts)

Closer view of the soil profile at different depth

BM Spot 13 : KHERI: Agricultural System (Soybean-Wheat/Paddy-Wheat) (LM) P28

Classification: Fine, smectitic, hyperthermic *Typic Haplusterts*

Location: Vill. Khajri Kheri, Jabalpur, Madhya Pradesh. Lat. 23°14'M

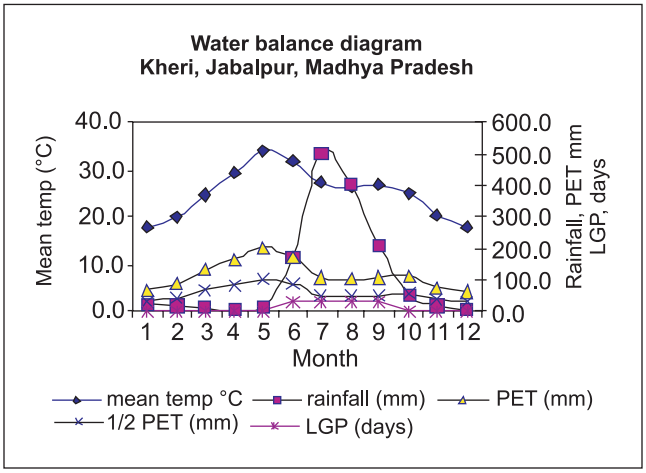
Physiographic position: Deccan Plateau – Satpura Ranges

Topography and slope: Very gently sloping, 1-3% (50-150 m)

Drainage: Moderately well drained

Vegetation: *Ber*, acacia, mango, *neem*

Landuse: Soybean-wheat/paddy-wheat/ fallow-wheat



Parent material: Basaltic alluvium

Sampled by: P. Srivastava, S.L. Durge, G.K. Kamble

Date of collection: 17.10.2001

Remarks:

Ap	0-14 cm	Greyish brown (2.5Y 5/2D) and light olive brown to olive brown (2.5Y 4.5/3M) clay; moderate medium subangular blocky structure; hard, firm, sticky and plastic; many fine and medium roots; common fine pores; many very fine and fine lime nodules; mildly alkaline (pH 7.5); strongly effervescent; clear, smooth boundary.
Bw1	14-32 cm	Very dark greyish brown (10YR 3/2M) clay; moderate medium subangular blocky structure with pressure faces on ped surfaces; firm, sticky and plastic; common fine roots; many very fine and fine lime nodules; mildly alkaline (pH 7.6); strongly effervescent; clear, smooth boundary.
Bw2	32-61 cm	Very dark greyish brown (10YR 3/2M) clay; moderate medium angular blocky structure with well developed pressure faces and small wedge-shaped aggregates; friable, sticky and plastic; common fine roots; many very fine and fine lime nodules; mildly alkaline (pH 7.6); strongly effervescent; gradual smooth boundary.
Bss1	61-82 cm	Very dark greyish brown (10YR 3/2M) clay; strong medium angular blocky structure with well developed wedge-shaped aggregates and slickensides that break into small angular peds; friable, very sticky and plastic; common fine roots; many very fine and fine lime nodules; mildly alkaline (pH 7.8); strongly effervescent; clear, smooth boundary.
Bss2	82-112 cm	Very dark greyish brown (10YR 3/2) clay; strong medium angular blocky structure with well developed wedge-shaped aggregates and slickensides that break into small angular peds; friable, very sticky and plastic; a few fine roots; many very fine and fine lime nodules; mildly alkaline (pH 7.8); violently effervescent; gradual smooth boundary.
Bss3	112-138 cm	Very dark greyish brown (10YR 3/2M) clay; strong medium angular blocky structure with weakly developed wedge shaped aggregates and slickensides that break into small angular peds; friable, very sticky and plastic; few very fine roots; many very fine and fine lime nodules; mildly alkaline (pH 7.7); violently effervescent; gradual smooth boundary.
Bss4	133-156 cm	Very dark greyish brown (10YR 3/2M) clay; strong medium angular blocky structure; with weakly developed wedge shaped aggregates and slickensides that break to weak angular peds; friable, very sticky and plastic; a few very fine roots; many very fine and fine lime nodules; moderately alkaline (pH 8.0); violently effervescent.

Series: KHERI **BM Spot: 13 (BLACK SOILS)**

Profile No: P28 ***System: Agriculture (Soybean/Paddy-Wheat)* (LM)**

CLIMATE: SUB-HUMID (MOIST) RAINFALL: 1448 mm	Classification : Fine, smectitic, hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Khajri Kheria, Jabalpur, Madhya Pradesh.		Sampling Date: 17.10.2001

Morphological Properties of Profile No. 28 (Kheri, Jabalpur)

Horizon	Depth (cm)	Boundary		Matrix color		Texture	Coarse fragments (% v/v) (fg and cg)	Structure		
		D	T	Dry	Moist			Size	Grade	Type
Ap	0-14	c	s	2.5Y5/2	2.5Y4.5/3	c	5-6	m	2	sbk
Bw1	14-32	c	s	--	10YR3/2	c	5-6	m	2	sbk
Bw2	32-61	g	s	--	10YR3/2	c	5-6	m	2	abk
Bss1	61-82	g	s	--	10YR3/2	c	5-6	m	3	abk
Bss2	82-112	g	s	--	10YR3/2	c	5-6	m	3	abk
Bss3	112-133	g	s	--	10YR3/2	c	5-6	m	3	sbk
Bss4	133-156	-	-	--	10YR3/2	c	5-6	m	3	sbk

Depth (cm)	Consistence			Porosity		Nodules (conca)		Roots		Effervescence	Other features
	Dry	Moist	Wet	S	Q	Size	Quantity	Size	Quantity	dil HCl	
0-14	h	fr	sp	f	c	vf,f	m	f,m	m	es	-
14-32	-	fr	sp	-	-	vf,f	m	f	c	es	Pressure faces
32-61	-	fr	sp	-	-	vf,f	m	f	c	es	Pressure faces
61-82	-	fr	sp	-	-	vf,f	m	f	c	es	Slickensides
82-112	-	fr	sp	-	-	vf,f	m	f	f	ev	Slickensides
112-133	-	fr	sp	-	-	vf,f	m	vf	f	ev	Slickensides
133-156	-	fr	sp	-	-	vf,f	m	vf	f	ev	Slickensides

Please refer Appendix I for the abbreviations

Series: KHERI **BM Spot: 13 (BLACK SOILS)**

Profile No: P28 ***System: Agriculture (Soybean/Paddy-Wheat)* (LM)**

CLIMATE: SUB-HUMID (MOIST) RAINFALL: 1448 mm	Classification: Fine, smectitic, hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Khajri Kheria, Jabalpur, Madhya Pradesh.		Sampling Date: 17.10.2001

Physical Properties of Profile No. 28 (Kheri, Jabalpur)

Laboratory No.	Horizon	Depth (cm)	Size class and particle diameter (mm)			Fine clay (%) (<0.0002)	Fine clay/ total clay (%)
			Total				
			Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)		
			←----------(% of <2 mm) ----------→				
3259	Ap	0-14	18.4	30.5	51.1	27.3	53.4
3260	Bw1	14-32	16.6	29.7	53.7	32.2	60.0
3261	Bw2	32-61	16.8	36.9	46.3	31.0	67.0
3262	Bss1	61-82	6.0	40.4	53.6	28.7	53.4
3263	Bss2	82-112	14.8	38.6	46.6	33.7	72.3
3264	Bss3	112-133	16.4	39.0	44.6	27.0	60.5
3265	Bss4	133-156	15.9	37.4	46.7	34.8	74.5

Depth (cm)	BD (Mgm^{-3})	COLE	HC ($cmhr^{-1}$)	WDC (%)
0-14	1.4	0.2	2.3	8.1
14-32	1.4	0.2	3.2	8.0
32-61	1.4	0.2	2.2	8.3
61-82	1.4	0.3	2.1	9.8
82-112	1.5	0.2	1.6	8.0
112-133	1.5	0.2	1.0	6.5
133-156	-	0.2	2.0	6.6

- *Nil or not determined (wherever applicable)*

Series: KHERI **BM Spot: 13 (BLACK SOILS)**

Profile No: P28 ***System: Agriculture (Soybean/Paddy-Wheat)* (LM)**

CLIMATE: SUB-HUMID (MOIST) RAINFALL: 1448 mm	Classification: Fine, smectitic, hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Khajri Kheria, Jabalpur, Madhya Pradesh.		Sampling Date: 17.10.2001

Chemical Properties of Profile No. 28 (Kheri, Jabalpur)

Depth (cm)	pH (1:2)		EC (1:2) (dSm^{-1})	OC (%)	$CaCO_3$ (%)	Clay CO_3 (%)
	H_2O	1*N* KCl				
0-14	7.5	6.4	0.13	0.7	3.6	3.7
14-32	7.6	6.5	0.15	0.6	4.4	3.7
32-61	7.6	6.5	0.14	0.5	3.9	3.7
61-82	7.6	6.5	0.15	0.6	7.1	3.9
82-112	7.8	6.7	0.16	0.4	7.3	4.2
112-133	7.7	6.6	0.16	0.6	5.0	4.1
133-156	8.0	6.6	0.15	0.4	5.5	4.0

Depth (cm)	Extractable bases				CEC	Clay CEC	BS (%)	ESP
	Ca	Mg	Na	K				
	←----------[cmol(p+)kg^{-1}]----------→							
0-14	36.0	10.4	0.4	0.4	47.9	94	90	0.8
14-32	34.2	8.2	0.4	0.4	47.9	89	90	0.8
32-61	34.2	10.7	0.5	0.4	53.5	116	86	0.9
61-82	42.9	9.6	0.4	0.9	49.3	92	109	0.8
82-112	31.3	8.4	0.6	0.5	49.3	106	83	1.2
112-133	35.3	5.6	0.4	0.5	49.3	110	85	0.8
133-156	29.6	11.1	0.6	0.5	52.1	112	80	1.1

Series: KHERI **BM Spot: 13 (BLACK SOILS)**

Profile No: P28 ***System: Agriculture (Soybean/Paddy-Wheat)*** **(LM)**

CLIMATE: SUB-HUMID (MOIST) RAINFALL: 1448 mm	Classification: Fine, smectitic, hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Khajri Kheria, Jabalpur, Madhya Pradesh.		Sampling Date: 17.10.2001

Saturation Extract Properties of Profile No. 28 (Kheri, Jabalpur)

Depth (cm)	Sat (%)	ECe (dS/m)	Soluble cations ($mmol_c\ l^{-1}$)				Sum of cations
			Ca	Mg	Na	K	
0-14	49.93	0.41	2.56	0.16	1.30	0.02	4.04
14-32	51.64	0.26	0.89	0.39	1.99	0.03	3.30
32-61	49.70	0.23	1.75	0.42	1.30	0.02	3.49
61-82	68.61	0.27	1.41	1.06	1.09	0.04	3.60
82-112	57.65	0.19	1.97	0.63	1.30	0.01	3.91
112-133	51.66	0.32	1.48	0.73	0.98	0.03	3.22
133-156	45.48	0.25	1.15	0.94	0.97	0.01	3.07

Depth (cm)	Soluble anions ($mmol_c\ l^{-1}$)				Sum of anions
	CO_3	HCO_3	Cl	SO_4	
0-14	1.06	1.59	0.80	0.59	4.04
14-32	1.06	1.54	0.70	-	3.30
32-61	-	2.65	0.80	-	3.45
61-82	-	2.65	0.80	-	3.45
82-112	-	2.86	1.10	-	3.96
112-133	-	2.44	0.80	-	3.24
133-156	-	2.65	0.70	-	3.35

- *Nil or not determined (wherever applicable)*

Series: KHERI **BM Spot: 13 (BLACK SOILS)**

Profile No: P28 ***System: Agriculture (Soybean/Paddy-Wheat)*** **(LM)**

CLIMATE: SUB-HUMID (MOIST) RAINFALL: 1448 mm	Classification: Fine, smectitic, hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Khajri Kheria, Jabalpur, Madhya Pradesh.		Sampling Date: 17.10.2001

Characterization of Landuse Types

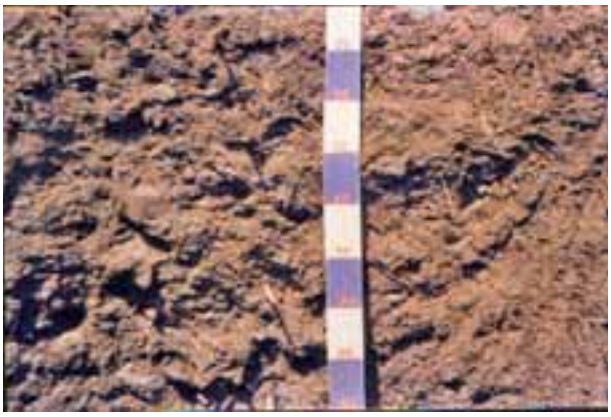
S. No.	Attribute		Description
1	Production system	:	Well irrigated double cropping of paddy (sown directly)-wheat with 1 month fallow period. Crop yield: Paddy- 2000-2500 kg ha^{-1} Wheat- 2500-3000 kg ha^{-1}
2	Management level	:	• Improved seeds • Manures: Nil • Fertilizer dose: 80:45:0 for paddy and 80:45:0 for wheat • Crop residues: Removed • Conservation measures: Nil • Sowing time: Paddy- 1st week of July Wheat- end of Nov • Seed rate: Paddy 40-50 kg ha^{-1} Wheat 80 kg ha^{-1}
3	Power source	:	Bullock and tractor
4	Market orientation	:	Mainly subsistence
5	Capital intensity	:	
6	Labor intensity	:	
7	Land holding	:	Small; consolidated
8	Income level	:	

Climatic Datasets of Kheri, Jabalpur, Madhya Pradesh

Month	Mean temp (^oC)	Rainfall (mm)	PET (mm)	½ PET (mm)	LGP (days)
January	17.90	26.40	69.60	34.80	0.00
February	20.10	21.50	88.80	44.40	0.00
March	24.70	14.90	134.90	67.45	0.00
April	29.50	9.40	165.00	82.50	0.00
May	33.90	15.00	203.20	101.50	0.00
June	32.00	170.40	172.60	86.30	30.00
July	27.10	505.00	105.80	52.90	31.00
August	26.50	400.70	99.30	49.65	31.00
September	26.90	212.40	107.40	53.70	30.00
October	24.90	50.10	112.70	56.35	0.00
November	20.30	16.70	78.30	39.65	0.00
December	17.90	5.00	63.20	31.60	0.00
Average	25.14				
Total		1447.50	1400.80	700.80	122.00

Landscape, Landuse and Soils in Benchmark Spot 13 (Kheri, Khajri-Kheria, Jabalpur)

Kheri soil under agriculture (low management) with soybean/paddy-wheat cropping system



A typical profile of Kheri soil (Typic Haplustert)

Closer view of the soil profile

3A. BLACK SOILS

3Ab. Black soils of sub-humid (dry) bioclimatic system

(MAR : > 1100 - 1000 mm)

- **Benchmark Spots: 1, 4, 26, 27**

- **No. of Pedons: 9 (P1, P2, P3, P7, P8, P9, P48, P49, P50)**

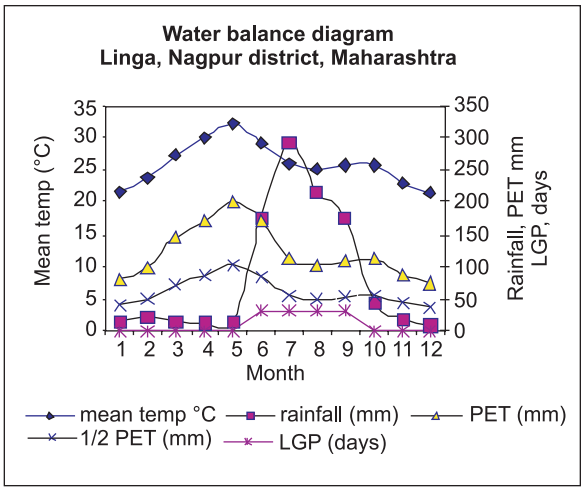
BM Spot 1 : LINGA: Horticulture (Citrus) (HM) P1

Classification : Very fine, smectitic, hyperthermic Typic Haplusterts

Location : Demonstration plot opposite Research Building at Reg. Fruit Research Station, Wandli, Katol, Nagpur, M.S. Lat - 21° 15'14"N; Long 78° 38'58"E

Physiographic position : Lower Maharashtra Deccan Plateau

Topography and slope : Plain to very gently sloping; 1-3% (300-600m)



Drainage : Moderately well drained

Vegetation : Acacia, *ber*

Landuse : Citrus (Horticulture system)

Parent material : Basaltic alluvium

Sampled by : T. Bhattacharyya, P. Chandran, S.K. Ray, S.L. Durge, R. Naitam

Date of collection : 04-11-2000

Remarks : Samples collected for ICRISAT, CRIDA and IISS. It is a demonstration plot at Regional Fruit Research Station, Wandli, Katol, Nagpur, Maharashtra, under sprinkle irrigation project for the last 7-8 years

Ap	0-15 cm	Dark greyish brown (10YR 4/2D), very dark greyish brown (10YR 3/2M) clay; medium moderate sub-angular and blocky structure; hard, friable, sticky and plastic; a few fine, medium and coarse roots; common very fine and fine, a few coarse lime nodules; many very fine and fine pores; moderately alkaline (pH 8.0); slightly effervescent; clear, smooth boundary.
Bw	15-41 cm	Dark greyish brown (10YR 4/2 D), very dark greyish brown (10YR 3/2M) clay; medium moderate sub-angular and blocky structure with pressure faces on ped surface; hard, friable, sticky and plastic, a few fine, medium and coarse roots; common very fine and fine, a few coarse lime nodules; moderately alkaline (pH 7.9); slightly effervescent; clear, smooth boundary;
Bss1	41-70 cm	Very dark greyish brown (10YR 3/2M) clay; medium strong to coarse, strong angular and blocky structure with well developed wedge-shaped aggregates and slickensides that break into small angular peds; friable, very sticky and very plastic, a few fine medium and coarse roots; common very fine, a few fine and medium lime nodules; moderately alkaline (pH 7.9); slightly effervescent; clear, smooth boundary.
Bss2	70-95 cm	Dark greyish brown to very dark greyish brown (10YR 3.5/2M) clay; coarse, strong angular and blocky structure with well developed wedge-shaped aggregates and slickensides that break into small angular peds; friable, very sticky and very plastic; a few very fine and fine roots; common very fine and a few fine lime nodules; mildly alkaline (pH 7.8); slightly effervescent; gradual smooth boundary.
Bss3	95-135 cm	Dark greyish brown (10YR 4/2M) clay; coarse, strong, angular and blocky structure with well developed wedge-shaped aggregates and slickensides that break into small angular peds; friable, very sticky and very plastic; a few very fine roots; common very fine and a few fine lime nodules; mildly alkaline (pH 7.8); clear wavy boundary.
Bss4	135-155+ cm	Brown (10YR 4/3M) clay; medium moderate subangular blocky to blocky structure with weakly developed wedge-shaped aggregates and slickensides that break into weak angular peds; friable, very sticky and very plastic; a few very fine, common fine lime nodules; strongly effervescent; moderately alkaline (pH 7.9).

Series: LINGA **BM Spot: 1 (BLACK SOILS)**

Profile No: P1 **System: Horticulture (Citrus) (HM)**

CLIMATE: SUB-HUMID(DRY) RAINFALL: 1011 mm	Classification: Very fine, smectitic, hyperthermic *Typic Haplusterts.*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Wandli, Katol, Nagpur, Maharashtra.		Sampling Date :04.11.2000

Morphological Properties of Profile No. 1 (Linga, Katol, Nagpur)

Horizon	Depth (cm)	Boundary		Matrix color		Texture	Coarse fragments (%) (fg and cg)	Structure		
		D	T	Dry	Moist			Size	Grade	Type
Ap	0-15	c	s	10YR4/2	10YR3/2	c	5--8	m	2	sbk
Bw	15-41	c	s	-	10YR3/2	c	5--8	m	3	sbk
Bss1	41-70	c	s	-	10YR3/2	c	3--5	c to m	3	abk
Bss2	70-95	g	s	-	10YR3.5/2	c	3--5	c	3	abk
Bss3	95-135	c	w	-	10YR4/2	c	1--2	c	3	abk
Bss4	135-155+	-	-	-	10YR4/3	c	1--2	m	2	abk

Depth (cm)	Consistence			Porosity		Nodules (conca)		Roots		Efferve-scence	Other features	Cracks
	Dry	Moist	Wet	S	Q	Size	Quantity	Size	Quantity	Dil HCl		
0-15	h	fr	sp	vf,f	m	vf,f ; c	c ; f	f; m; c	f	e	-	1-2 cm
15-41	h	fr	sp	-	-	vf,f ; c	c ; f	f,m, c	f	e	Pressure faces	1 cm
41-70	-	fr	vsvp	-	-	vf ; f, c	c ; f	f,m, c	f	e	Slickensides	
70-95	-	fr	vsvp	-	-	vf ; c	f ; f	vf,f	f	e	Slickensides	
95-135	-	fr	vsvp	-	-	vf ; f	c ; f	vf	f	e	Slickensides	
135-155+	-	fr	vsvp	-	-	vf ; f	f ; c	nil	nil	es	Slickensides	

Please refer Appendix I for the abbreviations

Series: LINGA **BM Spot: 1 (BLACK SOILS)**

Profile No: P1 ***System: Horticulture (Citrus*) (HM)**

CLIMATE: SUB-HUMID(DRY) RAINFALL: 1011 mm	Classification: Very fine, smectitic, hyperthermic *Typic, Haplusterts.*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Wandli, Katol, Nagpur, Maharashtra.		Sampling Date :04.11.2000

Physical Properties of Profile No. 1 (Linga, Katol, Nagpur)

Laboratory No.	Horizon	Depth (cm)	Size class and particle diameter (mm)			Fine clay (%) (<0.0002)	Fine clay/ total clay (%)
			Total				
			Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)		
			←----------(% of <2 mm) ----------→				
3038	Ap	0-15	0.9	33.4	65.7	46.0	70.0
3039	Bw	15-41	0.5	30.5	69.0	51.0	74.0
3040	Bss1	41-70	0.3	29.0	70.7	55.7	78.8
3041	Bss2	70-95	0.2	28.7	71.1	56.0	78.7
3042	Bss3	95-135	0.3	27.0	72.7	58.2	80.0
3043	Bss4	135-155+	0.2	28.8	71.0	51.0	71.8

Depth (cm)	BD (Mgm^{-3})	COLE	HC ($cmhr^{-1}$)	WDC (%)
0-15	1.5	0.2	0.6	2.1
15-41	1.5	0.2	1.0	7.1
41-70	1.3	0.2	1.5	9.0
70-95	1.3	0.2	0.5	10.2
95-135	1.4	0.2	1.0	12.3
135-155+	1.3	0.3	0.8	8.0

Series: LINGA BM Spot: 1 (BLACK SOILS)

Profile No: P1 *System: Horticulture (Citrus*) (HM)

CLIMATE: SUB-HUMID(DRY) RAINFALL: 1011 mm	Classification: Very fine, smectitic, hyperthermic *Typic Haplusterts*.	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Wandli, Katol, Nagpur, Maharashtra.		Sampling Date :04.11.2000

Chemical Properties of Profile No. 1 (Linga, Katol, Nagpur)

Depth (cm)	pH (1:2)		EC (1:2) (dSm^{-1})	OC (%)	$CaCO_3$ (%)	Clay* CO_3 (%)
	H_2O	1*N* KCl				
0-15	8.0	6.9	0.17	0.9	6.5	1.8
15-41	7.9	6.7	0.14	0.6	6.2	2.5
41-70	7.9	6.6	0.17	0.7	6.8	2.6
70-95	7.8	6.4	0.19	0.5	7.4	2.5
95-135	7.8	6.5	0.22	0.4	8.4	3.0
135-155+	7.9	6.7	0.10	0.2	10.5	2.9

Depth (cm)	Extractable bases				CEC	Clay CEC	BS (%)	ESP
	Ca	Mg	Na	K				
	←----------[cmol(p+)kg^{-1}]----------→							
0-15	36.8	10.7	0.3	1.1	48.9	74	74	0.5
15-41	37.0	9.8	0.4	0.6	47.8	69	76	0.6
41-70	38.0	9.8	0.7	0.6	49.1	69	78	1.2
70-95	38.5	13.4	1.0	0.6	53.6	75	103	1.9
95-135	38.2	16.6	1.0	0.7	56.5	78	100	1.8
135-155+	35.0	17.1	0.7	0.6	53.4	75	94	1.2

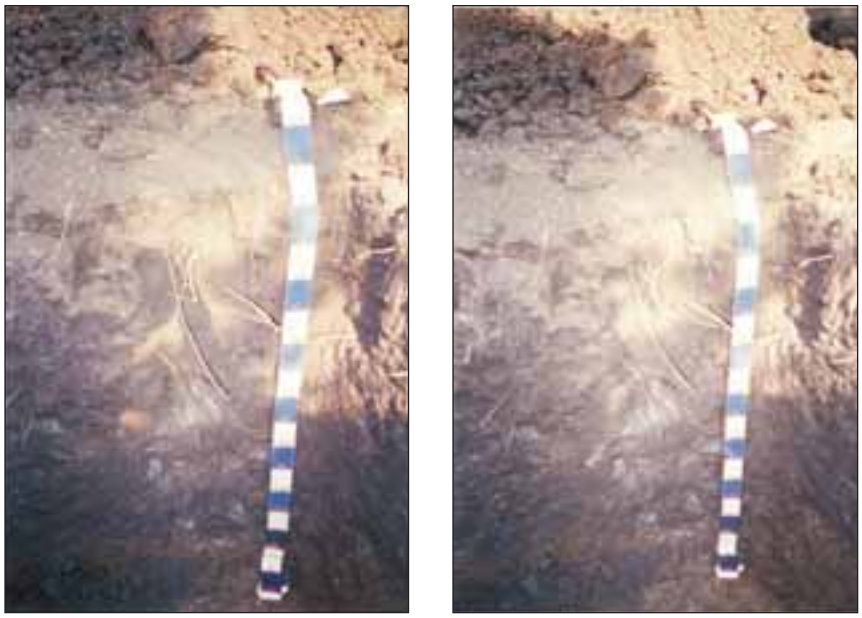
* *Percent of water dispersible clay size carbonate.*

Landscape, Landuse and Soils of Pedon P1 in Benchmark Spot (Linga, Nagpur)

Horticultural system with high management under Linga soil profile

Agriculture management practice for the last ten years in a farm under Linga soil profile

Site selection for profile examination and sample collection



Very deep black soil profile of Linga series (Typic Haplusterts)

BM Spot 1 : LINGA: Agriculture System (Soybean – Wheat) (HM) P2

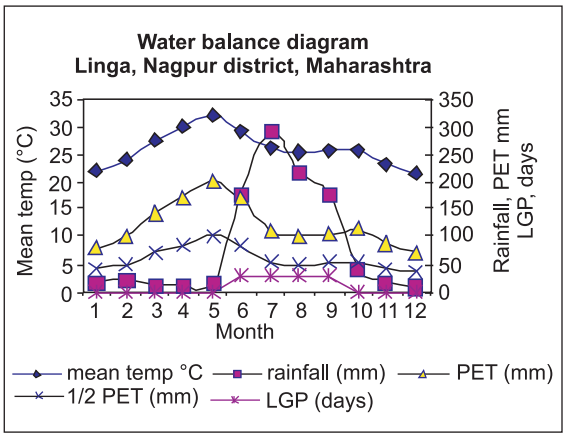
Classification : Very fine, smectitic, hyperthermic Typic (Udic) Haplusterts,

Location : 6 kms from Katol on Katol Kondhali road, 50 m away from the left side of the road, Katol, Nagpur, M.S. Lat -21° 14'49"N, Long -78° 37'11"E

Physiographic position : Lower Maharashtra Deccan Plateau

Topography and slope : Plain; 0-1% (50-150 m)

Drainage : Moderately well drained



Vegetation : Acacia, *Palas*, teak, karanji, *ber*, mango, *kans*, *dub*

Landuse : Soybean-wheat/chickpea system, citrus, pigeonpea-chickpea/wheat

Parent material : Basaltic alluvium

Sampled by : P. Chandran, S.K. Ray, S.L. Durge

Date of collection: 07-11-2000

Remarks : Cracks ≃ 0.5 mm wide up to 13 cm. Samples collected for ICRISAT, CRIDA and IISS. Soybean - gram / wheat cropping system; cultivating wheat for the first time (irrigated); adjacent crop, citrus; pigeonpea-gram/wheat.

Ap	0-13 cm	Very dark greyish brown to dark greyish brown (10YR 3.5/2D) and very dark greyish brown (10YR 3/2M) clay; moderate medium subangular blocky structure; slightly hard, friable, sticky and plastic; many very fine and few fine roots; many very fine and fine, common medium lime nodules; many very fine and fine pores; mildly alkaline (pH 7.7); slightly effervescent; clear, smooth boundary.
Bw1	13-33 cm	Very dark greyish brown (10YR 3/2M) clay; medium, strong subangular blocky structure with pressure faces; friable, sticky and plastic; very fine common, a few fine roots; many very fine and fine, a few medium lime nodules; moderately alkaline (pH 7.9); slightly effervescent; gradual smooth boundary.
Bw2	33-55 cm	Very dark greyish brown (10YR 3/2M) clay; medium, strong subangular blocky to angular blocky structure with weak development of slickensides; friable, sticky and plastic; common very fine roots; many very fine, common few lime nodules; mildly alkaline (pH 7.8); slightly effervescent; gradual smooth boundary.
Bss1	55-81 cm	Very dark greyish brown (10YR 3/2M) clay; medium, strong subangular blocky structure with well developed slickensides and wedge-shaped aggregate, which break into small angular blocks; friable, very sticky and very plastic; a few very fine roots; many very fine and common fine lime nodules; moderately alkaline (pH 7.9); nil to slightly effervescent; gradual smooth boundary.
Bss2	81-119 cm	Very dark grey to very dark greyish brown (10YR 3/1.5 M) clay; coarse, strong angular blocky structure with well developed slickensides and wedge-shaped aggregates, which break into small angular blocks; friable, very sticky and very plastic; a few, very fine roots; many very fine and common fine lime nodules; mildly alkaline (pH 7.8); nil to slightly effervescent; clear, smooth boundary.
Bss3	119-150+ cm	Dark greyish brown to brown (10YR 4/2.5M) clay; coarse, strong, angular and blocky structure with well developed slickensides and wedge-shaped aggregates, which break into small angular blocks; friable, very sticky and very plastic; many very fine, common fine, a few medium lime nodules; mildly alkaline (pH 7.8); slightly effervescent.

Series: LINGA BM Spot: 1 (BLACK SOILS)

Profile No: P2 ***System: Agriculture (Soybean- Gram/Wheat*) (FM)**

CLIMATE: SUB-HUMID (DRY) RAINFALL: 1011 mm	Classification: Very fine, smectitic, hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location : Ridhora, Katol, Nagpur, Maharashtra		Sampling Date : 07.11.2000

Morphological Properties of Profile No. 2 (Linga, Katol, Nagpur)[1]

Horizon	Depth (cm)	Boundary		Matrix color		Texture	Coarse fragments (%) (fg and cg)	Structure		
		D	T	Dry	Moist			Size	Grade	Type
Ap	0-13	c	s	10YR3.5/2	10YR3/2	c	3--5	m	2	sbk
Bw	13-33	g	s	-	10YR3/2	c	3--5	m	3	sbk
Bw1	33-55	g	s	-	10YR3/2	c	3--5	m	3	sbk-abk
Bss1	55-81	g	s	-	10YR3/2	c	2--3	m	3	abk
Bss2	81-119	c	s	-	10YR3/1.5	c	2--3	c	3	abk
Bss3	119-150+	-	-	-	10YR4/2.5	c	2--3	c	3	abk

Depth (cm)	Consistence			Porosity		Nodules (conca)		Roots		Effervescence*	Other features	Cracks
	Dry	Moist	Wet	S	Q	Size	Quantity	Size	Quantity	Dil HCl		
0-13	sh	fr	sp	vf,f	m	f,vf; m	m; c	vf; f	m; f	e	-	0.5 cm
13-33	-	fr	sp	-	-	f,vf; m	m; f	vf, f	c; f	e	Pressure faces	
33-55	-	fr	sp	-	-	vf; f	m; c	vf	c	e	Slickensides weak	
55-81	-	fr	vsvp	-	-	vf; f	m; c	vf	f	e	Slickensides	
81-119	-	fr	vsvp	-	-	vf; f; m	m; c; f	vf	f	e	Slickensides	
119-150+	-	fr	vsvp	-	-	vf f; m	m; c; f	-	-	e	Slickensides	

** Matrix effervescence was also observed*

Please refer Appendix I for the abbreviations

Series: LINGA BM Spot: 1 (BLACK SOILS)

Profile No: P2 ***System: Agriculture (Soybean-Gram/Wheat*) (FM)**

CLIMATE: SUB-HUMID (DRY) RAINFALL: 1011 mm	Classification: Very fine, smectitic, hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location : Ridhora, Katol, Nagpur, Maharashtra		Sampling Date : 07.11.2000

Physical Properties of Profile No. 2 (Linga, Katol, Nagpur)

Laboratory No.	Horizon	Depth (cm)	Size class and particle diameter (mm)			Fine clay (%) (<0.0002)	Fine clay/ total clay (%)
			Total				
			Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)		
			←----------(% of <2 mm) ----------→				
3044	Ap	0-13	0.8	35.1	64.1	46.0	71.7
3045	Bw	13-33	0.5	33.5	66.0	50.0	75.7
3046	Bw1	33-55	0.5	33.5	66.0	61.2	92.7
3047	Bss1	55-81	0.3	29.5	70.2	56.2	80.0
3048	Bss2	81-119	0.3	30.1	69.6	60.0	86.2
3049	Bss3	119-150+	0.2	28.4	71.4	62.0	86.8

Depth (cm)	BD (Mgm^{-3})	COLE	HC ($cmhr^{-1}$)	WDC (%)
0-13	-	0.2	5.0	8.0
13-33	1.5	0.2	2.7	8.7
33-55	1.5	0.2	1.2	17.2
55-81	1.5	0.3	1.6	11.3
81-119	1.4	0.3	1.4	10.2
119-150+	1.5	0.3	1.6	18.6

Series: LINGA BM Spot: 1 (BLACK SOILS)

Profile No: P2 ***System: Agriculture (Soybean-Gram/Wheat*) (FM)**

CLIMATE: SUB-HUMID (DRY) RAINFALL: 1011 mm	Classification: Very fine, smectitic, hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location : Ridhora, Katol, Nagpur, Maharashtra		Sampling Date : 07.11.2000

Chemical Properties of Profile No. 2 (Linga, Katol, Nagpur)

Depth (cm)	pH (1:2)		EC (1:2) (dSm^{-1})	OC (%)	$CaCO_3$ (%)	Clay* CO_3 (%)
	H_2O	1*N* KCl				
0-13	7.7	6.4	0.16	1.0	6.0	2.5
13-33	7.9	6.4	0.17	0.7	6.4	2.7
33-55	7.8	6.5	0.17	0.6	5.1	3.1
55-81	7.9	6.4	0.17	0.5	6.7	3.0
81-119	7.8	6.3	0.15	0.4	4.6	3.0
119-150+	7.8	6.5	0.05	0.3	6.2	2.8

Depth (cm)	Extractable bases				CEC	Clay CEC	BS (%)	ESP
	Ca	Mg	Na	K				
	← ----------[cmol(p+)kg^{-1}]----------→							
0-13	40.4	10.8	0.3	0.5	57.7	90	90	0.52
13-33	40.7	6.4	0.3	0.6	56.4	85	85	0.53
33-55	40.7	8.2	0.3	0.6	56.6	86	88	0.53
55-81	40.9	11.0	0.3	0.6	56.4	80	94	0.53
81-119	38.6	13.4	0.3	1.0	56.0	80	95	0.54
119-150+	37.8	17.3	0.3	0.7	51.7	72	109	0.58

* *Percent of water dispersible clay size carbonate*

Series: LINGA BM Spot: 1 (BLACK SOILS)

Profile No: P2 ***System: Horticulture (Soybean-Gram/Wheat*) (FM)**

CLIMATE: SUB-HUMID (DRY) RAINFALL: 1011 mm	Classification: Very fine, smectitic, hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location : Ridhora, Katol, Nagpur, Maharashtra		Sampling Date : 07.11.2000

Climatic Datasets of Linga, Nagpur District, Maharashtra

Month	Mean temp (^{o}C)	Rainfall (mm)	PET (mm)	½ PET (mm)	LGP (days)
January	21.80	15.00	81.00	40.50	0.00
February	24.00	22.60	100.20	50.10	0.00
March	27.40	14.50	144.60	72.30	0.00
April	30.00	12.20	170.90	85.45	0.00
May	32.20	15.00	201.70	100.85	0.00
June	29.20	175.30	169.60	84.80	30.00
July	26.00	292.60	110.30	55.15	31.00
August	25.10	216.40	102.10	51.05	31.00
September	25.70	176.30	107.00	53.50	30.00
October	25.70	43.90	112.20	56.10	0.00
November	23.00	18.50	86.70	43.35	0.00
December	21.50	8.40	73.20	36.60	0.00
(Average)	25.96				
Total		1010.70	1459.50	729.75	122.00

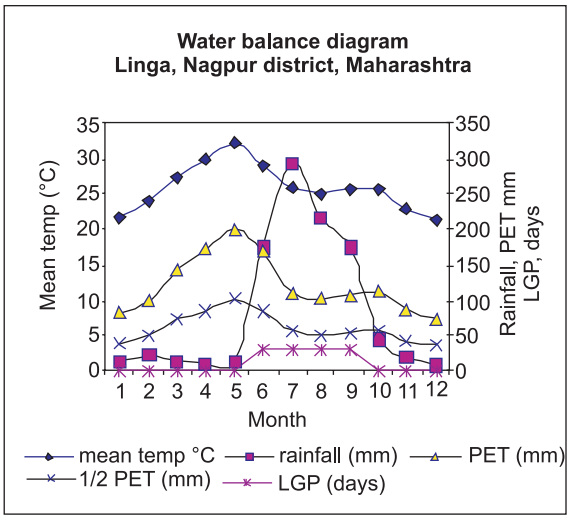
Landscape, Landuse and Soils of Pedon No.2 in Benchmark Spot Linga, Nagpur

The site of Linga soil under agricultural system

Linga soil site under agriculture system with soybean-gram/wheat cropping rotation

Very deep shrink-swell soil profile of pedon No.2 of Linga series (Typic Haplusterts).

BM Spot 1 : LINGA: Horticulture System (Citrus) (LM) P3



Classification : Very fine, smectitic, hyperthermic *Typic Haplusterts*

Location : ½ km west of Res. Farm Bldg of Reg. Fruit Res. Stn., Wandli, Katol, Nagpur, M.S. This is the original site of Linga series, Lat - 21° 15'18"N; Long -78° 36'40"E

Physiographic position : Lower Maharashtra Deccan Plateau

Topography and slope : Plain to very gently sloping; 1-3% (50-150 m)

Drainage : Moderately well drained

Vegetation : Acacia, *neem*, *Palas*, *ber*, karanji, parthenium; *kans*, *dub*

Landuse : Citrus (Horticultural System)

Geology and Parent material : Basalt; Basaltic alluvium

Sampled by : P. Chandran, S.K. Ray, S.L. Durge

Date of collection: 07-11-2000

Remarks : Cropping system of citrus under low management. Cracks ≃ 0.5 mm upto 35 cm depth. Samples collected for ICRISAT, CRIDA and IISS.

Ap	0-16 cm	Dark greyish brown to very dark greyish brown (10YR 3.5/2D) very dark greyish brown (10YR 3/2M) clay; medium moderate subangular blocky structure; slightly hard, friable, sticky and plastic; many very fine and fine, a few medium roots; many very fine and fine lime nodules; many very fine and fine pores; moderately alkaline (pH 7.9); slightly effervescent; clear smooth boundary.
Bw1	16-44 cm	Very dark greyish brown (10YR 3/2M) clay; medium strong subangular blocky structure with pressure faces; friable, sticky and plastic; common very fine and fine, a few medium roots; many very fine and fine, a few medium lime nodules; many very fine, common few pores; moderately alkaline (pH 8.0); nil to slightly effervescent; gradual smooth boundary.
Bw2	44-69 cm	Very dark greyish brown to very dark grey (10YR 3/1.5 M) clay; medium strong subangular to angular blocky structure with well developed pressure faces; friable, sticky and plastic; common very fine and fine roots; many very fine and fine, a few medium lime nodules; mildly alkaline (pH 7.8); nil to slightly effervescent; gradual smooth boundary.
Bss1	69-102 cm	Very dark greyish brown to very dark grey (10YR 3/1.5 M) clay; medium strong, subangular blocky to medium strong angular blocky structure with weak development of slickensides; friable, very sticky and very plastic; few, very fine and fine roots; common very fine and fine few medium line nodules; moderately alkaline (pH 7.9); nil to slightly effervescent; gradual smooth boundary.
Bss2	102-128 cm	Very dark greyish brown to dark brown (10YR 3/2.5M) clay; medium strong angular blocky structure with well developed slickensides and wedge-shaped aggregates, which break into small angular blocks; friable, very sticky and very plastic; a few very fine roots; common very fine and fine, few medium lime nodules; moderately alkaline (pH 8.0); gradual smooth boundary.
Bss3	128-150+ cm	Brown (10YR 4/3M) clay; coarse, strong angular blocky structure with well developed slickensides and wedge-shaped aggregates, which break into small angular blocks; friable, very sticky and very plastic; common very fine and fine, a few medium and coarse lime nodules moderately alkaline (pH 7.9); clear, smooth boundary.

Series: LINGA BM Spot: 1 (BLACK SOILS)

Profile No: P3 ***System: Horticulture (Citrus*) (LM)**

CLIMATE: SUB-HUMID (DRY) RAINFALL: 1011 mm	Classification: Very fine, smectitic, hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location : Wandli, Katol, Nagpur, Maharashtra		Sampling Date : 07.11.2000

Morphological Properties of Profile No. 3 (Linga, Katol, Nagpur)

Horizon	Depth (cm)	Boundary		Matrix color		Texture	Coarse fragments (fg and cg)	Structure		
		D	T	Dry	Moist			Size	Grade	Type
Ap	0-16	c	s	10YR3.5/2	10YR3/2	c	3--5	m	2	sbk
Bw1	16-44	g	s	-	10YR3/1.5	c	3--5	m	3	sbk
Bw2	44-69	g	s	-	10YR3/1.5	c	2--3	m	3	sbk-abk
Bss1	69-102	g	s	-	10YR3/1.5	c	2--3	m	3	abk(w)**
Bss2	102-128	g	s	-	10YR3.5/2.5	c	2--5	m	3	abk
Bss3	128-150	c	s	-	10YR4/3	c	5--8	c	3	abk

Depth (cm)	Consistence			Porosity		Nodules (conca)		Roots		Effervescence*	Other features	Cracks
	Dry	Moist	Wet	S	Q	Size	Quantity	Size	Quantity	Dil HCl		
0-16	sh	fr	sp	vf, f	m	vf,f	m	vf,f; m	m, f	e	-	0.5 cm
16-44	-	fr	sp	vf, f	m, c	vf,f; m	m; f	vf,f; m	c; f	e	Pressure faces	0.5 cm
44-69	-	fr	sp	-	-	vf,f; m	m; f	vf,f	c	e	Slickensides (weak)	
69-102	-	fr	vsvp	-	-	vf,f; m	f; c	vf,f	f	e	Slickensides (weak)	
102-128	-	fr	vsvp	-	-	vf, f c	m, f	vf	f	es	Slickensides	
128-150	-	fr	vsvp	-	-	vf,f; m,c	c; f	-		es	Slickensides	

** Matrix effervescence was also observed.*
Cracks ~ 0.5 mm wide up to 35 cm depth

Please refer Appendix I for the abbreviations

Series: LINGA BM Spot: 1 (BLACK SOILS)

Profile No: P3 ***System: Horticulture (Citrus*) (LM)**

CLIMATE: SUB-HUMID (DRY) RAINFALL: 1011 mm	Classification: Very fine, smectitic, hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location : Wandli, Katol, Nagpur, Maharashtra		Sampling Date : 07.11.2000

Physical Properties of Profile No. 3 (Linga, Katol, Nagpur)

Laboratory No.	Horizon	Depth (cm)	Size class and particle diameter (mm)			Fine clay (%) (<0.0002)	Fine clay/ total clay (%)
			Total				
			Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)		
			←----------(% of <2 mm) ----------→				
3050	Ap	0-16	1.2	33.3	65.5	42.3	64.6
3051	Bw1	16-44	0.7	32.5	66.8	46.7	69.9
3052	Bw2	44-69	0.7	32.4	66.9	51.9	77.6
3053	Bss1	69-102	0.6	28.4	71.0	50.0	70.4
3054	Bss2	102-128	0.5	28.4	71.1	48.9	68.8
3055	Bss3	128-150+	0.5	29.2	70.3	51.2	72.8

Depth (cm)	BD (Mgm^{-3})	COLE	HC ($cmhr^{-1}$)	WDC (%)
0-16	-	0.2	2.3	6.9
16-44	1.4	0.2	2.8	10.9
44-69	1.4	0.2	2.5	9.2
69-102	1.5	0.2	1.8	10.5
102-128	1.5	0.3	2.8	17.9
128-150+	1.4	0.3	2.6	12.9

Series: LINGA BM Spot: 1 (BLACK SOILS)

Profile No: P3 ***System: Horticulture (Citrus*) (LM)**

CLIMATE: SUB-HUMID (DRY) RAINFALL: 1011 mm	Classification: Very fine, smectitic, hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location : Wandli, Katol, Nagpur, Maharashtra		Sampling Date : 07.11.2000

Chemical Properties of Profile No. 3 (Linga, Katol, Nagpur)

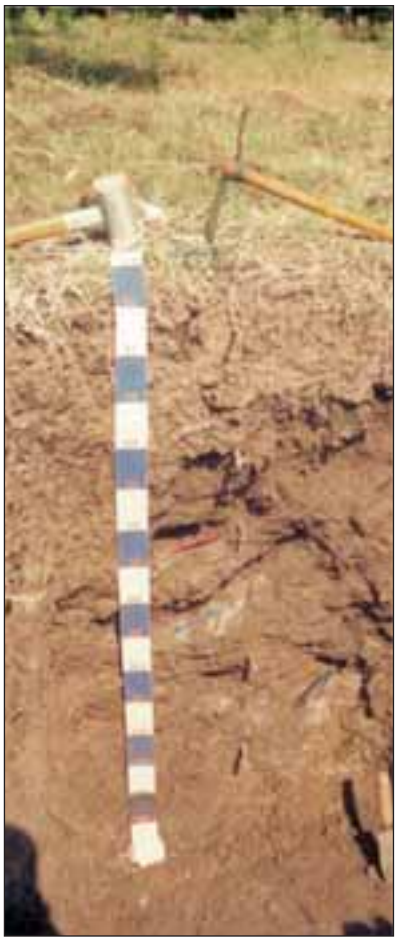
Depth (cm)	pH (1:2)		EC (1:2) (dSm^{-1})	OC (%)	$CaCO_3$ (%)	Clay CO_3* (%)
	H_2O	1*N* KCl				
0-16	7.9	6.6	0.16	1.0	6.9	2.8
16-44	8.0	6.4	0.15	0.7	7.6	3.1
44-69	7.8	6.6	0.14	0.6	7.2	2.5
69-102	7.9	6.4	0.16	0.5	9.0	3.0
102-128	8.0	4.5	0.17	0.5	9.2	2.9
128-150+	7.9	6.4	0.25	0.4	9.4	2.6

Depth (cm)	Extractable bases				CEC	Clay CEC	BS (%)	ESP
	Ca	Mg	Na	K				
	----------[cmol(p+)kg^{-1}]----------							
0-16	40.0	11.8	0.6	1.3	65.2	99	82	0.9
16-44	43.6	10.9	0.5	0.7	64.1	96	87	0.8
44-69	41.3	10.2	0.6	0.7	63.0	94	84	0.9
69-102	40.2	13.1	0.7	0.7	63.0	89	87	1.1
102-128	37.8	14.4	0.9	0.8	61.8	87	87	1.4
128-150+	40.4	19.1	0.8	0.8	63.0	90	97	1.3

* *Percent of water dispersible clay size carbonate*

Landscape, Landuse and Soils of Pedon No. 2 in Benchmark Spot Linga, Nagpur

The original benchmark spot of Linga series (pedon No. 2) under horticulture system (Citrus) under low management practice. Soil sample was last collected from this site in 1982



Very dark shrink-swell soil profile (P2) of Linga series

BM Spot 4 : SAROL: Agriculture System (Soybean-Wheat) (HM) P7

Classification : Very fine, smectitic, hyperthermic, *Typic Haplusterts*

Location : Research Farm of National Research Centre for Soybean, Indore, Madhya Pradesh; Lat. 22°36'52" N, Long. 75°41'17" E

Physiographic position : Central Highland, Malwa Plateau

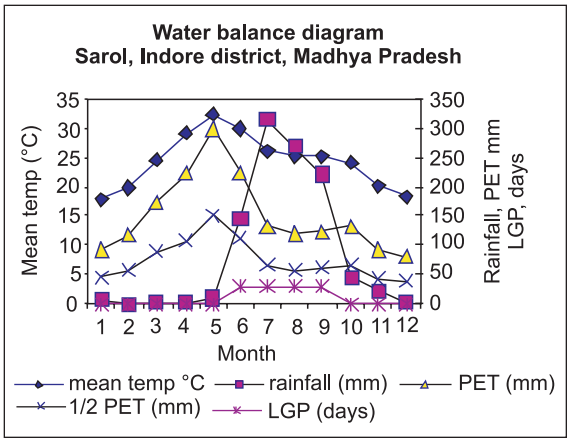
Topography and slope: Plain to very gentle sloping (300-600 m)

Drainage : Moderately well drained

Vegetation : Ipomea, corchorus sp

Landuse : Soybean – wheat

Parent material : Basaltic alluvium



Sampled by: T. Bhattacharyya, P. Chandran, S.K. Ray, S.L. Durge, M.V. Venugopalan, S.R. Bhuse

Date of collection: 07-12-2000

Remarks : Breeders field – controlled, cultivated for soybean for the last 10-15 years.

Ap	0-14 cm	Very dark greyish brown (2.5Y 3/2D&M) clay; mainly moderate medium subangular blocky and a few coarse medium prismatic structure; slightly hard, friable, very sticky and very plastic; many fine, common medium roots; common medium and coarse lime nodules; many very fine and fine pores; mildly alkaline (pH 7.8); slightly effervescent; clear, smooth boundary.
Bw1	14-28 cm	Very dark greyish brown (2.5YR 3/2M) clay; mainly medium strong subangular blocky and a few coarse medium prismatic structure; very hard, friable, very sticky and very plastic; many fine, a few medium roots; common medium and coarse lime nodules; many very fine and fine pores; moderately alkaline (pH 7.9); gradual smooth boundary.
Bw2	28-57 cm	Very dark greyish brown (2.5YR 3/2M) clay; coarse, strong, angular and blocky structure with well developed pressure faces on ped surfaces; friable, very sticky and very plastic; many fine, a few medium roots; common medium and coarse lime nodules; moderately alkaline (pH 7.9); gradual wavy boundary.
Bss2	57-85 cm	Very dark greyish brown (2.5YR 3/2M) clay; coarse, strong, angular and blocky structure with well developed slickensides and wedge-shaped aggregates that break into small angular peds; friable, very sticky and very plastic; common fine roots; common medium and coarse lime nodules; moderately alkaline (pH 7.9); gradual smooth boundary.
Bss3	85-109 cm	Very dark greyish brown (2.5YR 3/2M) clay; coarse, strong angular blocky structure with well developed slickensides and wedge-shaped aggregates that break into small angular peds; friable, very sticky and very plastic; a few fine roots; common medium and coarse lime nodules; moderately alkaline (pH 7.9); slightly effervescent; gradual smooth boundary.
Bss4	109-130 cm	Olive brown (2.5Y 4/3M) and very dark greyish brown (2.5Y 3/2M) clay; coarse strong angular blocky to medium moderate subangular blocky structure with slickensides and wedge shaped aggregates that breaks into small weak angular peds; friable, very sticky and plastic; many very fine and fine lime nodules; moderately alkaline (pH 7.9); slightly to strongly effervescent; gradual smooth boundary.
Bss5	130-155 cm	Olive brown (2.5Y 4/4M) and very dark greyish brown (2.5Y 3/2M) clay; coarse strong angular blocky to medium moderate subangular blocky structure with slickensides and wedge-shaped aggregates that break into small weak angular peds; friable, very sticky and plastic; many very fine and fine lime nodules; moderately alkaline (pH 8.0); slightly to strongly effervescent.

Series: SAROL **BM Spot: 4(BLACK SOILS)**

Profile No: P7 ***System: Agriculture (Soybean-Wheat*) (HM)**

CLIMATE: SUB-HUMID (DRY) RAINFALL: 1053 mm	Classification: Very fine, smectitic, hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: National Research Centre for Soybean (ICAR) Farm, Bhavarkuan, Indore, Indore, M.P.		Sampling Date : 7.12.2000

Morphological Properties of Profile No. 7 (Sarol, Bhavarkuan, Indore)

Horizon	Depth (cm)	Boundary		Matrix Color		Texture	Coarse Fragments (%) (fg and cg)	Structure		
		D	T	Dry	Moist			Size	Grade	Type
Ap	0-14	c	s	2.5Y3/2	2.5Y3/2	c	3--5	m	2	sbk
Bw1	14-28	g	s	-	2.5Y3/2	c	5--8	m	3	sbk
Bss1	28-57	g	w	-	2.5Y3/2	c	2--3	c	3	abk
Bss2	57-85	g	s	-	2.5Y3/2	c	5--8	c	3	abk
Bss3	85-109	g	w	-	2.5Y3/2	c	5--8	c	3	abk
Bss4	109-130	g	w	-	2.5Y4/3 & 3/2	c	8--10	c m	3 2	abk sbk
Bss5	130-155	-	-	-	2.5Y4/4 & 3/2	c	8--10	c m	3 2	abk sbk

Depth (cm)	Consistence			Porosity		Nodules (conca)		Roots		Effervesc-ence	Other features	Cracks
	Dry	Mois t	Wet	S	Q	Size	Quantity	Size	Quantity	Dil HCl		
0-14	sh,h	fr	sp	vf,f	m	m,c	c	f m	m c	e	-	2.5 –7.5 cm
14-28	vh	fr	sp	vf,f	m	m,c	c	f m	m f	**e	-	2.5 –7.5 cm
28-57	-	fr	sp	-	-	m,c	c	f m	m f	**e	Slickensides / Pressure faces	2.5 –7.5 cm
57-85	-	fr	sp	-	-	m,c	c	f	c	**e	Slickensides	2.5 –7.5 cm
85-109	-	fr	sp	-	-	m,c	c	f	f	*e	Slickensides	
109-130	-	fr	sp	-	-	vf,f	m	-	-	*e-es	Slickensides	
130-155	-	fr	sp	-	-	vf,f	m			*e-es	Slickensides	

** Matrix effervescence observed in 85-135 cm*
*** Matrix does not show any effervescence*

Please refer Appendix I for the abbreviations.

Series: SAROL **BM Spot: 4(BLACK SOILS)**

Profile No: P7 ***System: Agriculture (Soybean-Wheat*) (HM)**

CLIMATE: SUB-HUMID (DRY) RAINFALL: 1053 mm	Classification: Very fine, smectitic, hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: National Research Centre for Soybean (ICAR) Farm, Bhavarkuan, Indore, Indore, M.P.		Sampling Date : 7.12.2000

Physical Properties of Profile No. 7 (Sarol, Bhavarkuan, Indore)

Laboratory No.	Horizon	Depth (cm)	Size class and particle diameter (mm)			Fine clay (%) (<0.0002)	Fine clay/ total clay (%)
			Total				
			Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)		
			←----------(% of <2 mm) ----------→				
3095	Ap	0-14	1.9	37.0	61.1	35.2	57.6
3096	Bw1	14-28	1.9	32.8	65.3	44.5	68.1
3097	Bss1	28-57	1.8	30.0	68.2	46.3	67.9
3098	Bss2	57-85	1.7	22.6	75.7	46.2	61.0
3099	Bss3	85-109	1.7	35.5	62.8	44.4	70.7
3100	Bss4	109-130	1.6	35.4	63.0	40.4	64.1
3101	Bss5	130-155	1.5	35.5	63.0	34.4	54.6

Depth (cm)	BD (Mgm^{-3})	COLE	HC ($cmhr^{-1}$)	WDC (%)
0-14	-	0.2	2.6	12.9
14-28	1.5	0.2	2.5	10.1
28-57	1.4	0.2	2.3	13.0
57-85	1.4	0.3	1.5	13.5
85-109	1.5	0.2	1.5	12.9
109-130	1.5	0.2	1.8	17.9
130-155	1.4	0.2	0.6	7.3

Series: SAROL BM Spot: 4(BLACK SOILS)

Profile No: P7 *System: Agriculture (Soybean-Wheat*) (HM)

CLIMATE: SUB-HUMID (DRY) RAINFALL: 1053 mm	Classification: Very fine, smectitic, hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: National Research Centre for Soybean (ICAR) Farm, Bhavarkuan, Indore, Indore, M.P.		Sampling Date : 7.12.2000

Chemical Properties of Profile No.7 (Sarol, Bhavarkuan, Indore)

Depth (cm)	pH (1:2)		EC (1:2) (dSm^{-1})	OC (%)	$CaCO_3$ (%)	Clay CO_3* (%)
	H_2O	1*N* KCl				
0-14	7.8	6.5	0.19	0.7	6.5	2.6
14-28	7.9	6.6	0.18	0.4	5.7	2.6
28-57	7.9	6.6	0.22	0.4	6.5	2.2
57-85	7.9	6.5	0.21	0.4	5.9	2.5
85-109	7.9	6.5	0.17	0.3	6.1	2.7
109-130	7.9	6.6	0.20	0.3	5.1	3.0
130-155	8.0	6.7	0.25	0.2	7.5	2.7

Depth (cm)	Extractable bases				CEC	Clay CEC	BS (%)	ESP
	Ca	Mg	Na	K				
	← ----------[cmol(p+)kg^{-1}]----------→							
0-14	37.0	10.7	0.7	0.9	51.3	84	96	1.4
14-28	38.1	6.9	1.0	0.7	47.8	73	97	2.0
28-57	36.7	11.7	1.5	0.5	43.5	64	116	3.4
57-85	35.8	13.1	0.7	0.7	43.5	57	115	1.6
85-109	35.2	12.3	1.2	0.8	60.9	97	81	2.0
109-130	35.4	13.1	1.4	0.7	58.6	93	86	2.4
130-155	27.8	17.4	1.8	0.5	56.5	90	84	3.2

* *Percent of water dispersible clay size carbonate*

Series: SAROL BM Spot: 4(BLACK SOILS)

Profile No: P7 *System: Agriculture (Soybean-Wheat*) (HM)

CLIMATE: SUB-HUMID (DRY) RAINFALL: 1053 mm	Classification: Very fine, smectitic, hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: National Research Centre for Soybean (ICAR) Farm, Bhavarkuan, Indore, M.P.		Sampling Date : 7.12.2000

Characterization of Landuse Types

S. No.	Attribute		Description
1	Production system	:	Irrigated Soybean-wheat cropping system with two months of fallow period. Yield range: Soybean- 700-3350 kg ha^{-1} Wheat- 2600-4000 kg ha^{-1}
2	Management level	:	• Improved varieties (*Wheat Sujatha/Lok1*) • Chemical fertilizers (20:60:20 for soybean and 65-100 kg N, 40-60 kg P, 25-40 kg K for wheat) • Manure: Not being applied or not applied at all. • Stubbles incorporated and residues sold. • Herbicides use: Frequently • Insecticide/fungicide use: Occasional • Mechanical harvesting • Sowing time: Onset of monsoon (around 25 June) for soybean and 1st week of Nov. for gram • Seed rate: 80-100 kg ha^{-1} for Soybean, 70-80 kg ha^{-1} for Gram
3	Power source	:	Complete mechanization with improved implements.
4	Market orientation	:	R&D
5	Capital intensity	:	High
6	Labour intensity	:	Low
7	Land holding	:	Not relevant
8	Income level	:	Not relevant

Climatic Datasets of Sarol, Indore District, Madhya Pradesh

Months	Mean Temp ^{0}C	Rainfall (mm)	PET (mm)	1/2 PET (mm)	LGP (days)
January	17.80	8.40	92.80	46.40	0.00
February	19.90	1.10	116.60	58.30	0.00
March	24.50	3.50	176.80	88.40	0.00
April	29.00	3.50	219.90	109.95	0.00
May	32.30	13.20	299.70	149.85	0.00
June	30.00	147.10	224.10	112.05	30.00
July	26.00	316.00	133.80	66.90	31.00
August	25.10	266.50	119.00	59.50	31.00
September	25.10	220.90	123.10	61.55	30.00
October	24.10	48.40	132.60	66.30	0.00
November	20.40	22.10	95.10	42.55	0.00
December	18.30	2.70	80.20	40.10	0.00
Average	24.38				
Total		1053.40	1813.70	901.85	122.00

Landscape, Landuse and Soils in Benchmark Spot 4 (Sarol, Indore)

Centre for Soybean, Indore, Madhya Pradesh.

Very deep black soil of Sarol series at Indore

Profile spot at Indore, benchmark spot No. 4

Closer view of soil profile.

Soil samples collected for all the co-operating centres of the project

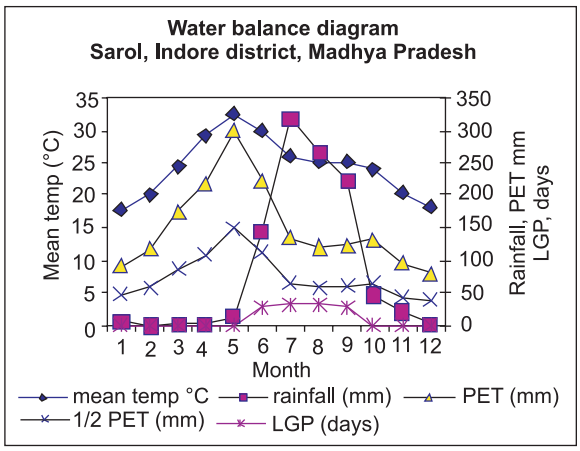
BM Spot 4 : SAROL: Agriculture System (Soybean – Wheat) (FM) P8

Classification : Very fine, smectitic, hyperthermic, Typic Haplusterts

Location : About 1.5 km from NRCS, about 6 km from Indore on Indore – Khandwa road, Indore, Madhya Pradesh; Lat. 22°54'54" N, Long. 75°43'07" E

Physiographic position : Central Highland Malwa Plateau

Topography and slope : Almost level land, 0-1% (50-150 m)



Drainage : Moderately well drained

Vegetration : Acacia, *neem*, mango, *kans*, *dub*

Landuse : Soybean-Wheat/Chickpea, Sugarcane

Parent material : Basaltic alluvium

Sampled by : T. Bhattacharyya, P. Chandran, M.V. Venugopalan, S.K. Ray, S.L. Durge, S.R. Bhuse

Date of collection: 07.12.2000

Remarks : Consecutive drought in Indore for the last 2 years.

Ap	0-18 cm	Dark greyish brown (10YR 4/2D) and very dark greyish brown (10YR 3/2M) clay; strong medium subangular blocky structure; very hard, friable, very sticky and very plastic; a few, common very fine and fine roots; common very fine, fine and medium lime nodules; common very fine and fine pores; mildly alkaline (pH 7.8); nil to slightly effervescent; gradual smooth boundary.
Bw1	18-45 cm	Very dark greyish brown to dark greyish brown (10YR 3.5/2M) clay; strong medium subangular blocky structure; friable, very sticky and very plastic; a few very fine roots; common very fine and fine lime nodules; common very fine and fine pores; moderately alkaline (pH 7.9); slightly effervescent; gradual smooth boundary.
Bw2	45-66 cm	Very dark greyish brown (10YR 3/2M) clay; strong medium angular blocky structure having weak angles of formation and pressure faces on ped surfaces; very friable, very sticky and very plastic; a few very fine roots; common very fine and fine, a few medium lime nodules; moderately alkaline (pH 7.9); slightly effervescent; clear, smooth boundary.
Bss1	66-90 cm	Very dark greyish brown to dark greyish brown (10YR 3.5/2M) clay; strong medium angular blocky structure with well developed wedge-shaped aggregates and slickensides at angle of 30-40o and which break into small angular peds; friable, very sticky and very plastic; a few very fine roots; common very fine and fine, many medium lime nodules; moderately alkaline (pH 7.9); slightly effervescent; clear, smooth boundary.
Bss2	90-124 cm	Very dark greyish brown to dark greyish brown (10YR 3.5/2M) clay; strong coarse angular blocky structure with wedge-shaped aggregates and slickensides, which break into small angular peds; friable, sticky and plastic; a few very fine roots; common very fine and fine, a few medium lime nodules; moderately alkaline (pH 7.9); slightly effervescent; diffuse boundary.
Bss3	124-159+ cm	Brown (10YR 4/3M) to dark brown (10YR 3/3M) and brown to dark yellowish brown (10YR 4/3.5M) clay; strong, coarse angular blocky structure with wedge-shaped aggregates and slickensides, which break into small angular peds; friable, sticky and plastic; common very fine and fine, few medium lime nodules; moderately alkaline (pH 8.0); slightly to strongly effervescent.

Series: SAROL **BM Spot: 4 (BLACK SOILS)**

Profile No: P8 ***System: Agriculture (Soybean-Wheat*) (FM)**

CLIMATE: SUB-HUMID (DRY) RAINFALL: 1053 mm	Classification: Very fine, smectitic, hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Limbodi, Indore, Madhya Pradesh		Sampling Date : 7.12.2000

Morphological Properties of ProfileNo. 8 (Sarol, Limbodi, Indore)

Horizon	Depth (cm)	Boundary		Matrix color		Texture	Coarse fragments (%) (fg and cg)	Structure		
		D	T	Dry	Moist			Size	Grade	Type
Ap	0-18	g	s	10YR4/2	10YR3/2	c	3-5	m	3	sbk
Bw1	18-45	g	s	-	10YR3.5/2	c	3--5	m	3	sbk
Bw2	45-66	c	s	-	10YR3/2	c	3--5	m	3	abk(w)*
Bss1	66-90	c	s	-	10YR3.5/2	c	3--5	m	3	abk
Bss2	90-124	d	s	-	10YR3.5/2	c	3--5	c	3	abk
Bss3	124-159+	-	-	-	10YR4/3 (R)	c	3--5	c	3	abk

Depth (cm)	Consistence			Porosity		Nodules(conca)		Roots		Effervescence*	Other Features	Cracks
	Dry	Mois t	Wet	S	Q	Size	Quantity	Size	Quantity	Dil HCl		
0-18	vh	fr	sp	vf,f	c	vf,f,m	c	vf,f	c	nil to e	-	0.5 cm
18-45	-	fr	sp	vf,f	c	vf,f	c	vf	f	e	-	0.5 cm
45-66	-	fr	sp	-	-	vf,f; m	c; m f	vf	f	e	Pressure faces/ Slickensides (weak)	25 cm
66-90	-	fr	sp	-	-	vf,f; m	c; m	vf	f	e	**Slickensides	
90-124	-	fr	sp	-	-	vf,f; m	c; f	vf	f	e	Slickensides	
124-159	-	fr	sp	-	-	vf,f; m	c; f	-	-	e*	Slickensides	

** Many vertical cracks ≅0.5cm wide up to 25 cm depth. ** SS: Well developed sides about 3 feet wide at an angle 35^0 to 40^0*
**** Matrix effervescence was also observed*

Please refer Appendix I for the abbreviations

Series: SAROL **BM Spot: 4(BLACK SOILS)**

Profile No: P8 ***System: Agriculture (Soybean-Wheat*) (FM)**

CLIMATE: SUB-HUMID (DRY) RAINFALL: 1053 mm	Classification: Very fine, smectitic, hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Limbodi, Indore, Madhya Pradesh		Sampling Date : 7.12.2000

Physical Properties of Profile No. 8 (Sarol, Limbodi, Indore)

Laboratory No.	Horizon	Depth (cm)	Size class and particle diameter (mm)			Fine clay (%) (<0.0002)	Fine clay/ total clay (%)
			Total				
			Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)		
			←----------(% of <2 mm) ----------→				
3102	Ap	0-18	1.7	34.2	64.1	45.2	70.5
3103	Bw1	18-45	2.3	25.7	72.1	57.8	80.3
3104	Bw2	45-66	1.6	37.2	61.2	47.7	77.9
3105	Bss1	66-90	1.7	33.9	64.5	46.3	71.8
3106	Bss2	90-124	1.6	40.9	57.5	39.9	69.4
3107	Bss3	124-159	1.2	39.2	58.9	39.6	67.2

Depth (cm)	BD (Mgm^{-3})	COLE	HC ($cmhr^{-1}$)	WDC (%)
0-18	-	0.2	0.9	13.4
18-45	-	0.2	1.3	18.5
45-66	1.4	0.2	1.3	16.2
66-90	1.4	0.2	0.9	16.4
90-124	1.4	0.2	0.7	14.9
124-159	1.4	0.2	0.9	15.9

Series: SAROL BM Spot: 4(BLACK SOILS)

Profile No: P8 *System: Agriculture (Soybean-Wheat*) (FM)

CLIMATE: SUB-HUMID (DRY) RAINFALL: 1053 mm	Classification: Very fine, smectitic, hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Limbodi, Indore, Madhya Pradesh		Sampling Date : 7.12.2000

Chemical Properties of Profile No. 8 (Sarol, Limbodi, Indore)

Depth (cm)	pH (1:2)		EC (1:2) (dSm^{-1})	OC (%)	$CaCO_3$ (%)	Clay CO_3* (%)
	H_2O	1*N* KCl				
0-18	7.8	6.6	0.15	0.8	6.6	2.9
18-45	7.9	6.6	0.14	0.7	6.3	2.5
45-66	7.9	6.6	0.14	0.5	6.6	3.1
66-90	7.9	6.6	0.16	0.5	5.6	3.1
90-124	7.9	6.7	0.16	0.4	7.5	2.4
124-159	8.0	6.7	0.13	0.3	6.9	2.7

Depth (cm)	Extractable bases				CEC	Clay CEC	BS (%)	ESP
	Ca	Mg	Na	K				
	←----------[cmol(p+)kg^{-1}]----------→							
0-18	40.0	5.1	0.4	0.7	45.7	71	101	0.9
18-45	39.1	9.6	0.4	0.6	43.5	60	114	0.9
45-66	36.4	10.7	2.1	0.6	45.7	75	109	4.6
66-90	36.4	12.0	2.1	0.7	46.7	72	110	4.5
90-124	32.9	15.5	2.0	0.6	43.5	76	117	4.6
124-159	32.6	14.0	2.1	0.7	45.7	78	108	4.6

* *Percent of water dispersible clay size carbonate*

Series: SAROL BM Spot: 4(BLACK SOILS)

Profile No: P8 *System: Agriculture (Soybean-Wheat*) (FM)

CLIMATE: SUB-HUMID (DRY) RAINFALL: 1053 mm	Classification: Very fine, smectitic, hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Limbodi, Indore, Madhya Pradesh		Sampling Date : 7.12.2000

Saturation Extract Properties of Profile No. 8 (Sarol, Indore)

Depth (cm)	Sat (%)	ECe (d Sm^{-2})	Soluble cations ($mmol_c$ l^{-1})				Sum of cations
			Ca	Mg	Na	K	
0-23	61.99	0.4	1.44	0.5	0.8	0.2	2.9
23-42	55.43	0.2	0.81	0.4	15.8	0.1	17.1
42-81	58.74	0.2	1.25	0.4	23.9	0.0	25.6
81-122	57.55	0.2	0.75	0.3	17.4	0.0	18.5
122-150	58.83	0.4	2.00	0.8	28.8	0.0	31.6

Depth (cm)	Soluble anions ($mmol_c$ l^{-1})				Sum of anions
	CO_3	HCO_3	Cl	SO_4	
0-23	-	4.2	0.9	-	5.1
23-42	-	3.2	0.5	13.3	17.0
42-81	-	3.2	0.5	21.9	25.6
81-122	-	2.7	1.7	14.2	18.5
122-150	-	4.2	2.0	25.4	31.6

- *Nil or not determined (wherever applicable)*

Series: SAROL BM Spot: 4 (BLACK SOILS)

Profile No: P8 *System: Agriculture (Soybean-Wheat*) (FM)

CLIMATE: SUB-HUMID (DRY) RAINFALL: 1053 mm	Classification: Very fine, smectitic, hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Limbodi, Indore, Madhya Pradesh		Sampling Date : 7.12.2000

Characterization of Landuse Types

S. No.	Attribute		Description
1	Production system	:	Extensive, irrigated (supplemental life sowing) soybean- wheat system. Yield: Soybean- 800-1000 kg ha^{-1} Wheat- 2000-2200 kg ha^{-1} Crop-livestock farming system.
2	Management level	:	• Improved seeds of soybean and wheat • Manures: FYM at 2 tonnes /ha per year • Chemical fertilizer: 25:60:0 for soybean 60:60:0 for wheat • Poor plant stand • Insecticides: Occasional • Sowing time: Soybean- last week of June Wheat- 1st week of Dec • Seed rate: Soybean 80 kg ha^{-1} Wheat 80-100 kg ha^{-1}
3	Power source	:	Tractor power supplemented with animal traction during monsoon season.
4	Market orientation	:	Subsistance production plus commercial sale of surplus. Dairy as subsidiary occupation.
5	Capital intensity	:	Intermediate with access to credit.
6	Labour intensity	:	Low
7	Land holding	:	Large, unconsolidated.
8	Income level	:	Moderate.

Climatic Datasets of Sarol, Indore District, Madhya Pradesh

Month	Mean temp (^{0}C)	Rainfall (mm)	PET (mm)	½PET (mm)	LGP (days)
January	17.80	8.40	92.80	46.40	0.00
February	19.90	1.10	116.60	58.30	0.00
March	24.50	3.50	176.80	88.40	0.00
April	29.00	3.50	219.90	109.95	0.00
May	32.30	13.20	299.70	149.85	0.00
June	30.00	147.10	224.10	112.05	30.00
July	26.00	316.00	133.80	66.90	31.00
August	25.10	266.50	119.00	59.50	31.00
September	25.10	220.90	123.10	61.55	30.00
October	24.10	48.40	132.60	66.30	0.00
November	20.40	22.10	95.10	42.55	0.00
December	18.30	2.70	80.20	40.10	0.00
Average	24.38				
Total		1053.40	1813.70	901.85	122.00

Landscape, Landuse and Soils in Benchmark Spot 4 (Sarol, Indore)

Very deep black soil of Sarol series under agricultural system (farmers' management) with soybean - wheat crop rotation.

Soil profile of Sarol series (Typic Haplusterts)

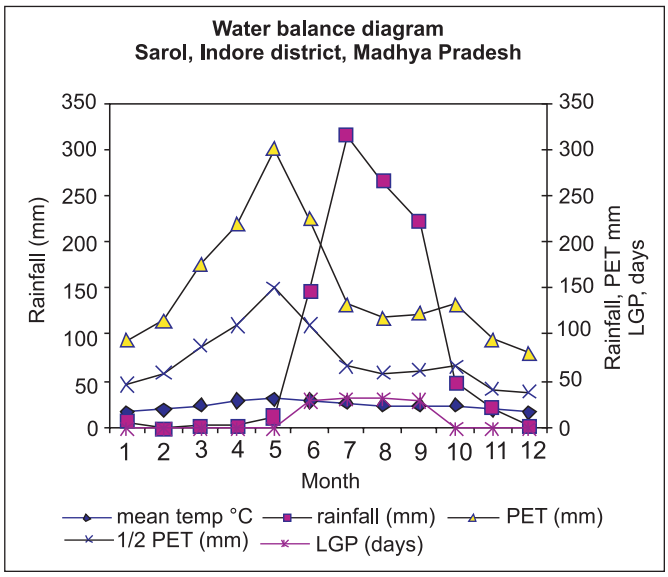
BM Spot 4 : SAROL: Agriculture or Agrihorticulture System (Soybean-Gram in Mango) (HM) P9

Classification : Very fine, smectitic, hyperthermic, *Typic Haplusterts*

Location : NRCS Farm near main gate, Indore, Madhya Pradesh; Lat. 22°36'52"N, Long.75°41'17" E

Physiographic position : Central Highland Malwa Plateau

Topography and slope: Very gently sloping and slightly undulating, 1-3% (50-150 m)



Drainage : Moderately well drained

Vegetation : Acacia, *kans*, *dub*

Landuse : Soybean-chickpea in mango orchard

Parent material : Basaltic alluvium

Sampled by : T. Bhattacharyya, P. Chandran, M.V. Venugopalan, S.K. Ray, S.L. Durge, S.R. Bhuse

Date of collection: 08.12.2000

Remarks : Agri-horticulture system having soybean-gram crop rotation in mango orchard.

Ap	0-17 cm	Dark greyish brown (10YR 4/2D) and dark greyish brown to very dark greyish brown (10YR 3.5/2M) clay; strong medium subangular blocky structure; very hard, friable, sticky and plastic; many very fine and fine roots; many very fine and fine, a few medium lime nodules; many very fine and fine pores; mildly alkaline (pH 7.7); slightly effervescent; clear, smooth boundary.
Bw	17-44 cm	Very dark greyish brown (10YR 3/2M) clay; strong medium subangular blocky structure with pressure faces on ped surfaces; slightly firm, sticky and plastic; common very fine to fine roots; many very fine and fine, a few medium lime nodules; mildly alkaline (pH 7.8); gradual smooth boundary.
Bss1	44-79 cm	Very dark greyish brown (10YR 3/2M) clay; strong medium subangular blocky to angular blocky structure with weak wedge shaped aggregates and slickensides that break into small angular peds; slightly firm, very sticky and very plastic; common very fine, a few fine roots; many very fine and fine, a few medium lime nodules; moderately alkaline (pH 7.9); gradual smooth boundary.
Bss2	79-102 cm	Very dark greyish brown (10YR 3/2M) clay; strong, coarse angular blocky structure with wedge shaped aggregates and slickensides that break into small angular peds; firm, very sticky and very plastic; a few very fine roots; many very fine and fine, a few medium lime nodules; moderately alkaline (pH 7.9); gradual smooth boundary.
Bss3	102-127 cm	Very dark greyish brown (10YR 3/2M) and brown (10YR 4/3M) clay; strong, coarse angular blocky structure with wedge shaped aggregates and slickensides that break into small angular peds; firm, very sticky and very plastic; a few very fine roots; many very fine and fine, common medium lime nodules; moderately alkaline (pH 7.9); slightly effervescent; clear, smooth boundary.
Bss4	127-152+ cm	Brown to dark yellowish brown (10YR 4/3.5) clay; strong, coarse angular blocky structure with wedge-shaped aggregates and slickensides that break into small angular peds; slightly firm, very sticky and very plastic; many very fine and fine, common medium lime nodules; moderately alkaline (pH 8.0); slightly effervescent.

Series: SAROL **BM Spot: 4 (BLACK SOILS)**

Profile No: P9 ***System: Agriculture or Agrihorticulture (Soybean-Gram in Mango Orchard*) (LM)**

CLIMATE: SUB-HIMID (DRY) RAINFALL: 1053 mm	Classification: Very fine, smectitic, hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: National Research Centre for Soybean (ICAR) Farm, Bhavarkuan, Indore, Madhya Pradesh		Sampling Date : 7.12.2000

Morphological Properties of Profile No. 9 (Sarol, Limbodi, Indore)

Horizon	Depth (cm)	Boundary		Matrix color		Texture	Coarse fragments (%) (fg and cg)	Structure		
		D	T	Dry	Moist			Size	Grade	Type
Ap	0-17	c	s	10YR4/2	10YR3.5/2	c	8-10	m	3	sbk
Bw	17-44	g	s	-	10YR3/2	c	5--8	m	3	sbk
Bss1	44-79	g	s	-	10YR3/2	c	5--8	m	3	sbk-abk
Bss2	79-102	g	s	-	10YR3/2	c	8--15	c	3	abk
Bss3	102-127	c	s	-	10YR3/2,4/3	c	8--15	c	3	abk
Bss4	127-152	-	-	-	10YR4/3.5	c	15--20	c	3	abk

Depth (cm)	Consistence			Porosity		Nodules(conca)		Roots		Effervescence**	Other Features*	Cracks
	Dry	Moist	Wet	S	Q	Size	Qty	Size	Quantity	Dil HCl		
0-17	vh	fr	sp	vf,f	m	vf,f; m	m; f	vf,f	m	e	-	10-20 cm
17-44	-	fi	sp	-	-	vf,f; m	m; f	vf,f	c	e	Pressure faces	0.5 cm
44-79	-	sfi	vs vp	-	-	vf,f; m	m; f	vf; f	c; f	e	Slickensides	
79-102	-	fi	vs vp	-	-	vf,f; m	m; f	vf	f	e	Slickensides	
102-127	-	fi	vs vp	-	-	vf,f; m	m; c	vf	f	e	Slickensides	
127-152	-	sfi	vs vp	-	-	vf,f; m	m; c	-	-	e	Slickensides	120 cm

**Cracks: 10-20 cm wide up to 20 cm depth. < 5 mm wide up to 120 cm penetrating the ss*

***Matrix effervescence also observed in 102 to 152 cm*

Please refer Appendix I for the abbreviations

Series: SAROL **BM Spot: 4 (BLACK SOILS)**

Profile No: P9 ***System: Agriculture or Agrihorticulture (Soybean-Gram in Mango Orchard*) (HM)**

CLIMATE: SUB-HIMID (DRY) RAINFALL: 1053 mm	Classification: Very fine, smectitic, hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: National Research Centre for Soybean (ICAR) Farm, Bhavarkuan, Indore, Madhya Pradesh		Sampling Date : 7.12.2000

Physical Properties of Profile No. 9 (Sarol, Bhavarkuan, Indore)

Laboratory No.	Horizon	Depth (cm)	Size class and particle diameter (mm)			Fine clay (%) (<0.0002)	Fine clay/ total clay (%)
			Total				
			Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)		
			←----------(% of <2 mm) ----------→				
3108	Ap	0-17	1.6	39.0	59.4	47.5	80.1
3109	Bw	17-44	1.4	40.7	57.9	42.5	73.4
3110	Bss1	44-79	1.1	38.8	60.1	46.3	76.9
3111	Bss2	79-102	1.2	34.8	64.0	45.1	70.6
3112	Bss3	102-127	1.1	39.2	59.7	50.4	84.4
3113	Bss4	127-152	1.0	38.5	60.5	44.4	73.5

Depth (cm)	BD (Mgm^{-3})	COLE	HC ($cmhr^{-1}$)	WDC (%)
0-17	-	0.2	1.2	6.4
17-44	1.4	0.2	2.4	8.5
44-79	1.4	0.2	1.3	10.1
79-102	1.4	0.2	1.1	5.9
102-127	1.4	0.2	0.8	9.7
127-152	-	0.2	0.8	9.0

- *Nil or not applicable (whenever applicable)*

Series: SAROL BM Spot: 4 (BLACK SOILS)

Profile No: P9 *System: Agriculture or Agrihorticulture (Soybean-Gram in Mango Orchard*) (HM)

CLIMATE: SUB-HIMID (DRY) RAINFALL: 1053 mm	Classification: Very fine, smectitic, hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: National Research Centre for Soybean (ICAR) Farm, Bhavarkuan, Indore, Madhya Pradesh		Sampling Date : 7.12.2000

Chemical Properties of Profile No. 9 (Sarol, Bhavarkuan, Indore)

Depth (cm)	pH (1:2)		EC (1:2) (dSm^{-1})	OC (%)	$CaCO_3$ (%)	Clay CO_3* (%)
	H_2O	1*N* KCl				
0-17	7.7	6.6	0.23	0.9	5.7	2.0
17-44	7.8	6.6	0.19	0.5	5.3	2.4
44-79	7.9	6.6	0.15	0.5	6.8	2.5
79-102	7.9	6.6	0.09	0.5	5.9	2.7
102-127	7.9	6.7	0.11	0.4	7.2	3.0
127-152	8.0	6.8	0.22	0.2	7.2	2.7

Depth (cm)	Extractable bases				CEC	Clay CEC	BS (%)	ESP
	Ca	Mg	Na	K				
	← ----------[cmol(p+)kg^{-1}]----------→							
0-17	36.6	9.2	0.3	0.5	42.4	71	110	0.7
17-44	37.0	12.4	0.3	0.5	45.7	79	110	0.7
44-79	35.6	15.4	0.4	0.4	43.5	72	119	0.9
79-102	37.0	19.0	0.5	0.6	49.5	77	114	1.0
102-127	34.6	22.3	0.7	0.6	47.8	80	122	1.5
127-152	34.1	23.1	1.1	0.6	47.8	79	123	2.3

**Percent of water dispersible clay size carbonate*

Series: SAROL **BM Spot: 4 (BLACK SOILS)**

Profile No: P9 ***System: Agriculture or Agrihorticulture (Soybean-Gram in Mango Orchard*) (LM)**

CLIMATE: SUB-HIMID (DRY) RAINFALL: 1053 mm	Classification: Very fine, smectitic, hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: National Research Centre for Soybean (ICAR) Farm, Bhavarkuan, Indore, Madhya Pradesh		Sampling Date : 7.12.2000

Characterization of Landuse Types

S. No.	Attribute		Description
1	Production system	:	Irrigated agro-horti system. Soybean-gram cropping system in non-bearing mango orchard. Yield range: 730 kg-2520 kg ha^{-1} of soybean and 820-1630 kg ha^{-1} of gram (last 8 years)
2	Management level	:	• Improved varieties • High density planting of mango • Chemical fertilizers: 20:60:20 for soybean and 17:30:0 for gram • Manure: Not applied • Residues: Sold • Stubbles: Incorporated • Herbicides Use: Frequent • Insecticide/fungicide: Occasional • Conservation measures: Cover crop and leveling.
3	Power source	:	Complete mechanization with improved implements.
4	Market orientation	:	R&D
5	Capital intensity	:	High
6	Labour intensity	:	Low
7	Land holding	:	Not relevant
8	Income level	:	Not relevant

Climatic Datasets of Sarol, Indore District, Madhya Pradesh

Month	Mean temp (^{0}C)	Rainfall (mm)	PET (mm)	½PET (mm)	LGP (days)
January	17.80	8.40	92.80	46.40	0.00
February	19.90	1.10	116.60	58.30	0.00
March	24.50	3.50	176.80	88.40	0.00
April	29.00	3.50	219.90	109.95	0.00
May	32.30	13.20	299.70	149.85	0.00
June	30.00	147.10	224.10	112.05	30.00
July	26.00	316.00	133.80	66.90	31.00
August	25.10	266.50	119.00	59.50	31.00
September	25.10	220.90	123.10	61.55	30.00
October	24.10	48.40	132.60	66.30	0.00
November	20.40	22.10	95.10	42.55	0.00
December	18.30	2.70	80.20	40.10	0.00
Average	24.38				
Total		1053.40	1813.70	901.85	122.00

BM Spot 26 : NIPANI: Agricultural System (Cotton + Pigeonpea) (FM) P48

Classification: Fine, smectitic (cal), hyperthermic, *Typic Haplusterts*

Location: Vill.-Nipani, Mandal-Tamsi, Adilabad, A.P.; Lat. 19°45'04"N Long. 78°26'50"E

Physiographic position: Deccan Plateau – basalt

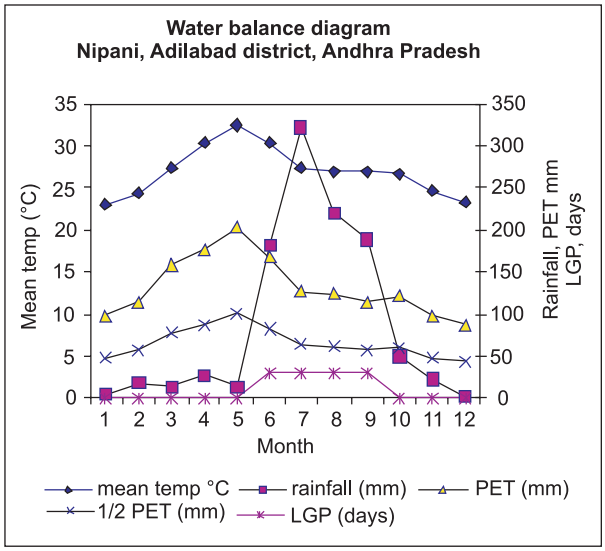
Topography and slope: Very gently sloping, 1 to 3% (50-150 m)

Drainage: Moderately well drained

Vegetation: *Babul*, *Palas*, *ber*, scrubs, grass

Landuse: Cotton+pigeonpea strip cropping and after alternate 2 to 3 years, it's sorghum and maize

Parent material: Basaltic alluvium of Cuddapah limestone & gneissic alluvium



Sampled by: T. Bhattacharyya, P. Chandran, S.K. Ray, P. Srivastava, P.N. *Dube*y, S.L. Durge

Date of collection: 04.07.2002

Remarks : About 1-2% stones of cherty limestone containing more Mn. The slickensides are weakly developed and the texture is silty clay throughout the profile.

Ap	0-13 cm	Very dark grey to very dark greyish brown (10YR 31.5M) silty clay; moderate medium subangular blocky structure; very friable, sticky and plastic; many very fine, fine and medium roots; many very fine and fine lime nodules; many very fine and fine, common medium pores; moderately alkaline (pH 8.0); violently effervescent; clear, smooth boundary.
Bwk1	13-35 cm	Very dark greyish brown (10YR 3/2M) silty clay; moderate medium subangular blocky structure with pressure faces on surface of peds; friable, sticky and plastic; many very fine, fine and medium roots; common very fine and fine lime nodules; many very fine and fine, common medium pores; moderately alkaline (pH 8.0); violently effervescent; gradual smooth boundary.
Bwk2	35-62 cm	Very dark greyish brown (10YR 3/2M) silty clay; strong, medium subangular blocky to weak angular blocky structure with pressure faces on surfaces of peds and weak development of slickensides; friable, sticky and plastic; few very fine roots; common very fine and fine lime nodules; many very fine and fine, common medium pores; moderately alkaline (pH 8.1); violently effervescent; gradual smooth boundary.
Bssk1	62-88 cm	Very dark greyish brown (10YR 3/2M) silty clay; strong medium angular blocky (weak) structure with weakly developed wedge-shaped aggregates and slickensides that break into weak angular peds; friable, sticky and plastic; few very fine roots; many very fine and fine lime nodules; many very fine and fine pores; moderately alkaline (pH 8.4); violently effervescent; gradual wavy boundary.
Bssk2	88-127 cm	Dark greyish brown to very dark greyish brown (10YR 3.5/2M) silty clay; strong medium angular blocky (weak) structure with weakly developed wedge-shaped aggregates and slickensides that break into weak angular peds; friable, sticky and plastic; very fine few roots; many very fine and fine, a few medium lime nodules; moderately alkaline (pH 8.4); violently effervescent; clear wavy boundary.
Bssk3	127-155+ cm	Very dark greyish brown (10YR 3.5/2M) silty clay; strong medium angular blocky (weak) structure with weakly developed wedge shaped aggregates and slickensides that breaks into weak angular peds; friable, sticky and plastic; few very fine roots; many very fine, fine and medium, a few coarse lime nodules; strongly alkaline (pH 8.5); violently effervescent.

Series: NIPANI **BM SPOT: 26 (BLACK SOILS)**

PROFILE NO: P48 ***System: Agriculture (Cotton + Pigeonpea)*** **(FM)**

CLIMATE: SUB-HUMID (DRY) RAINFALL: 1071 mm	Classification: Fine, smectitic (cal), hyperthermic, *Typic Haplusterts.*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Nipani, Mandal-Tamsi, Adilabad, Andhra Pradesh		Sampling Date: 04.07.2002

Morphological Properties of Profile No. 48 (Nipani, Adilabad)

Horizon	Depth (cm)	Boundary		Matrix color		Texture	Coarse fragments (%)*		Structure		
		D	T	Dry	Moist		(fg , cg)	(st)	Size	Grade	Type
Ap	0-13	c	s	-	10YR3/1.5	sic	3-5	1-3	m	2	sbk
Bw1	13-35	g	s	-	10YR3/2	sic	3-5	-	m	2	sbk
Bw2	35-62	g	s	-	10YR3/2	sic	3-5	-	m	3	sbk-abk(w)***
Bss1	62-88	g	s	-	10YR3/2	sic	3-5	-	m	3	abk
Bss2	88-127	c	w	-	10YR3.5/2	sic	5-8	-	m	3	abk
Bss3	127-155+	-	-	-	10YR3.5/2	sic	8-10	-	m	3	abk

Depth (cm)	Consistence			Porosity		Nodules (conca)		Roots		Effervescence**	Other features	Cracks
	Dry	Moist	Wet	S	Q	Size	Quantity	Size	Quantity	Dil HCl		
0-13	-	vfr	sp	vf,f; m	m; c	vf,f; m	m; f	vf,f,m	f	ev	-	Not
13-35	-	fr	sp	vf,f; m	m; c	vf,f	C	vf,f,m	f	ev	Pressure faces	observed
35-62	-	fr	sp	vf,f; m	m; c	vf,f	C	vf	f	ev	Slickensides (weak)	
62-88	-	fr	sp	vf,f	m	vf,f	M	vf	f	ev	Slickensides (weak)	
88-127	-	fr	sp	-	-	vf,f; m	m; f	vf	f	ev	Slickensides (weak)	
127-155+	-	fr	sp	-	-	vf,f,m; c	m; f	vf	f	ev	Slickensides (weak)	

** A few limestone fragments*
*** Matrix effervescence was also observed*
.
Please refer Appendix I for the abbreviations.

Series: NIPANI **BM SPOT: 26 (BLACK SOILS)**

PROFILE NO: P48 ***System: Agriculture (Cotton + Pigeonpea)*** **(FM)**

CLIMATE: SUB-HUMID (DRY) RAINFALL: 1071 mm	Classification: Fine, smectitic (cal), hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Nipani, Mandal-Tamsi, Adilabad, Andhra Pradesh		Sampling Date: 04.07.2002

Physical Properties of Profile No. 48 (Nipani, Adilabad)

Laboratory No.	Horizon	Depth (cm)	Size class and particle diameter (mm)			Fine clay (%) (<0.0002)	Fine clay/ total clay (%)
			Total				
			Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)		
			←----------(% of <2 mm) ----------→				
3557	Apk	0-13	8.4	48.3	43.3	21.9	50.6
3558	Bwk1	13-35	6.7	41.3	52.0	37.1	71.3
3559	Bwk2	35-62	6.7	44.0	49.3	30.3	61.3
3560	Bssk1	62-88	5.3	43.2	51.5	37.2	72.1
3561	Bssk2	88-127	5.1	45.2	49.7	31.7	63.9
3562	Bssk3	127-155+	6.1	41.4	52.5	35.2	67.0

Depth (cm)	BD (Mgm^{-3})	COLE	HC ($cmhr^{-1}$)	WDC (%)
0-13	1.4	0.2	1.3	12.6
13-35	1.7	0.2	1.8	14.5
35-62	1.3	0.2	1.7	8.8
62-88	1.5	0.1	2.0	10.1
88-127	1.5	0.2	2.8	10.1
127-155+	1.6	0.2	1.0	13.1

Series: NIPANI **BM SPOT: 26 (BLACK SOILS)**

PROFILE NO: P48 ***System: Agriculture (Cotton + Pigeonpea)*** **(FM)**

CLIMATE: SUB-HUMID (DRY) RAINFALL: 1071 mm	Classification: Fine, smectitic (cal), hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Nipani, Mandal-Tamsi, Adilabad, Andhra Pradesh		Sampling Date: 04.07.2002

Chemical Properties of Profile No..48 (Nipani, Adilabad)

Depth (cm)	pH (1:2)		EC (1:2) (dSm^{-1})	OC (%)	$CaCO_3$ (%)	Clay CO_3 (%)
	H_2O	1*N* KCl				
0-13	8.0	7.1	0.28	1.1	24.0	4.0
13-35	8.0	7.1	0.21	0.6	26.3	4.4
35-62	8.1	7.2	0.23	0.5	24.7	3.4
62-88	8.4	7.4	0.17	0.4	25.0	3.1
88-127	8.4	7.4	0.09	0.3	24.7	3.3
127-155+	8.5	7.4	0.30	0.3	25.2	3.3

Depth (cm)	Extractable bases				CEC	Clay CEC	BS (%)	ESP
	Ca	Mg	Na	K				
	← ----------[cmol(p+)kg^{-1}]----------→							
0-13	23.2	9.6	0.9	1.0	42.2	97	82	2
13-35	19.2	17.9	0.9	0.3	40.4	78	94	2
35-62	14.3	22.2	0.8	0.3	39.5	80	95	2
62-88	9.9	27.8	0.9	0.2	43.2	84	89	2
88-127	8.3	30.1	1.3	0.2	42.2	85	94	3
127-155+	8.3	28.3	1.5	0.2	42.2	80	91	4

Series: NIPANI **BM SPOT: 26 (BLACK SOILS)**

PROFILE NO: P48 ***System: Agriculture (Cotton + Pigeonpea)* (FM)**

CLIMATE: SUB-HUMID (DRY) RAINFALL: 1071 mm	Classification: Fine, smectitic (cal), hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Nipani, Mandal-Tamsi, Adilabad, Andhra Pradesh		Sampling Date: 04.07.2002

Saturation Extract Properties of Profile No. 48 (Nipani, Adilabad)

Depth (cm)	Sat (%)	ECe (d Sm^{-1})	Soluble cations ($mmol_c\ l^{-1}$)				Sum of cations
			Ca	Mg	Na	K	
0-13	60.40	1.12	6.94	3.89	0.80	0.39	12.00
13-35	58.40	0.32	1.39	1.39	0.80	0.06	4.60
35-62	60.10	0.36	1.39	1.67	1.11	0.02	4.20
62-88	65.00	0.40	1.11	2.22	1.74	0.01	5.00
88-127	69.80	0.43	0.56	1.67	3.24	2.39	7.80
127-155+	54.80	0.37	0.67	1.00	2.24	0.02	3.90

Depth (cm)	Soluble anions ($mmol_c\ l^{-1}$)				Sum of anions
	CO_3	HCO_3	Cl	SO_4	
0-13	0.00	1.52	8.00	2.50	12.00
13-35	0.00	2.02	1.00	1.62	4.60
35-62	0.51	1.52	1.50	0.66	4.20
62-88	0.00	1.01	1.50	2.57	5.10
88-127	0.00	2.53	2.50	2.93	7.80
127-155+	0.00	2.02	1.50	0.41	3.90

- *Nil or not determined (wherever applicable)*

Series: NIPANI **BM SPOT: 26 (BLACK SOILS)**

PROFILE NO: P48 ***System: Agriculture (Cotton + Pigeonpea)*** **(FM)**

CLIMATE: SUB-HUMID (DRY) RAINFALL: 1071 mm	Classification: Fine, smectitic (cal), hyperthermic, *Typic Haplusterts*.	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Nipani, Mandal-Tamsi, Adilabad, Andhra Pradesh		Sampling Date: 04.07.2002

Characterization of Landuse Types

S. No.	Attribute		Description
1	Production system	:	Rainfed (monsoon) and irrigated (summer) crop of cotton: pigeonpea (8:1 for 3 year)-maize/sorghum system and occasional summer vegetables (irrigated). Crop - livestock farming system (1-5 months fallow). Yield range: 2000-3000 kg ha^{-1} of cotton + 100-150 kg pigeonpea/ha, 4000-5000 kg ha^{-1} maize/sorghum
2	Management level	:	• Improved seeds • Manures: FYM (4 trolley/ha once in 3 year) • Fertilizer: 110:80:80 kg ha^{-1} per crop • Pesticides: Frequently • Soil conservation measures: Nil • Residue management techniques: Nil • Sowing time: Cotton, pigeonpea, maize, sorghum- last week of Jun to 1st week of July • Seed rate: Cotton 3 kg ha^{-1} Pigeonpea 2 kg ha^{-1}(as intercrop) Sorghum 12-15 kg ha^{-1} Maize 20 kg ha^{-1}
3	Power source	:	Tractor and bullock
4	Market orientation	:	Commercial
5	Capital intensity	:	High with access to institutional credit
6	Labour intensity	:	Medium, basically hired with no farming labour involved
7	Land holding	:	High and fragmented
8	Income level	:	High

Climatic Datasets of Nipani, Adilabad District, Andhra Pradesh

Month	Mean temp (^oC)	Rainfall (mm)	PET (mm)	½PET (mm)	LGP (days)
January	23.10	5.60	99.00	49.50	0.00
February	24.50	17.50	116.00	58.00	0.00
March	27.40	13.20	158.00	79.00	0.00
April	30.30	27.90	177.00	88.50	0.00
May	32.40	13.50	202.00	101.00	0.00
June	30.30	181.60	168.00	84.00	30.00
July	27.30	323.10	127.00	63.50	31.00
August	27.00	222.00	124.00	62.00	31.00
September	27.00	189.00	115.00	57.50	30.00
October	26.80	50.80	121.00	60.50	0.00
November	24.70	23.40	98.00	49.00	0.00
December	23.20	3.30	88.00	44.00	0.00
Average	27.00				
Total		1070.90	1593.00	796.5	122.00

Landscape, Landuse and Soils in Benchmark Spot 26 (Nipani, Adilabad, A.P.)

Typical benchmark spot at Nipani, Adilabad, Andhra Pradesh, under agricultural system (farmers' management) with cotton and pigeonpea cropping system.

More than 0.5 cm polygonalcracks on the surface of Nipani soil.

Typical Nipani benchmark soil profile (Vertic Haplustepts).

BM Spot 27 : PANGIDI: Agriculture System (Cotton+Pigeonpea) (FM-I) P49

Classification: Very fine, smectitic, hyperthermic *Typic Haplusterts*

Location: Vill. Pangidi, Mandal-Jainur, Adilabad, Andhra Pradesh; Lat. 19°21'31"N, Long 79°00'20"E

Physiographic position: Deccan Plateau - Basalt

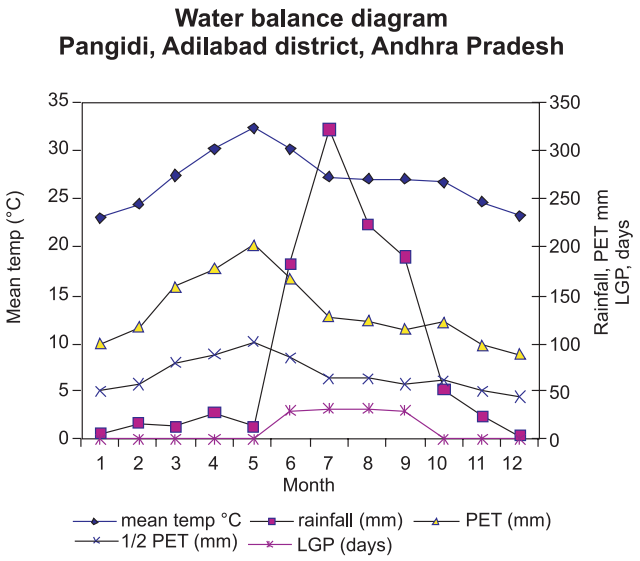
Topography: Gently sloping

Drainage: Well drained

Vegetation: *Palas*, *beshram*, *neem*, grasses

Landuse: Soybean + pigeonpea intercropping system, jowar, cotton and limestone

Parent material: Basaltic alluvium



Sampled by: T. Bhattacharyya, P. Chandran, S.K. Ray, M.V. Venugopalan, P. Srivastava, S.L. Durge

Date of collection:

Remarks : Limestone boulders throughout the area and at various depths. 0.5-1 cm wide cracks on the surface along the border of the field. Earthworm activity is throughout the profile. Soybean-pigeonpea cultivation has been since two years. Jowar-cotton (one year rotation for the previous five years).

Ap	0-14 cm	Very dark greyish brown (10YR 3/2D&M) clay; moderate medium subangular blocky structure; hard, friable, very sticky and plastic; common very fine, a few fine roots; many very fine, common fine and medium lime nodules; many very fine and fine pores; mildly alkaline (pH 7.6); clear, smooth boundary.
Bw1	14-36 cm	Very dark grey to very dark greyish brown (10YR 3/1.5M) clay; strong medium subangular blocky structure; friable, very sticky and very plastic; common very fine, a few fine roots; many very fine, common fine and medium lime nodules; many very fine and fine pores; mildly alkaline (pH 7.7); gradual smooth boundary.
Bw2	36-62 cm	Very dark greyish brown (10YR 3/2M) clay; strong medium subangular blocky to angular blocky structure with pressure faces on surface of peds; friable, very sticky and very plastic; common very fine, a few fine roots; many very fine, a few fine and medium lime nodules; many very fine and fine pores; mildly alkaline (pH 7.7); nil to slightly effervescent; gradual smooth boundary.
Bss1	62-87 cm	Very dark grey to very dark greyish brown (10YR 3/1.5M) clay; strong medium angular blocky (not uniform throughout the profile but in patches, not well developed) structure with wedge shaped aggregates and slickensides that break into small, strong angular peds; friable, very sticky and very plastic; common very fine roots; many very fine, a few fine, medium and coarse lime nodules; many very fine and fine, a few medium pores; mildly alkaline (pH 7.8); nil to slightly effervescent; clear wavy boundary.
Bss2	87-110 cm	Dark greyish brown to very dark greyish brown (10YR 3.5/2R) and brown (10YR 4/3M) clay; strong medium angular blocky structure with wedge shaped aggregates and slickensides that break into small, strong angular peds; friable, very sticky and very plastic; few very fine roots; many very fine and fine, few medium and coarse lime nodules; mildly alkaline (pH 7.8); nil to slightly effervescent.
	110+ cm	Limestone rock.

Series: PANGIDI **BM SPOT: 27 (BLACK SOILS)**

PROFILE NO: P49 ***System: Agriculture (Cotton + Pigeonpea)* (FM)**

CLIMATE: SUB-HUMID (DRY) RAINFALL: 1071 mm	Classification : Very fine, smectitic, hyperthermic, *Typic, Haplusterts.*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Pangidi, Mandal-Jainur, Adilabad, Andhra Pradesh		Sampling Date: 05.07.2002

Morphological Properties of Profile No. 49 (Pangidi, Adilabad)

Horizon	Depth (cm)	Boundary		Matrix color		Texture	Coarse fragments (%)		Structure		
		D	T	Dry	Moist		(fg, cg)	(st)	Size	Grade	Type
Ap	0-14	c	s	10YR3/2	10YR3/2	C	2-3	1-3	m	2	sbk
BW1	14-36	g	s	-	10YR3/1.5	c	2-3	-	m	3	sbk
BW2	36-62	g	s	-	10YR3/2	c	2-3	-	m	3	sbk - abk
Bss1	62-87	c	w	-	10YR3/1.5	c	3-5	-	m	3	abk
Bss2	87-110	-	-	-	10YR4/3;10YR3.5/2(R)	c	5-8	-	m	3	abk

Depth (cm)	Consistence			Porosity		Nodules (conca)		Roots		Effervescence	Other features	Cracks
	Dry	Moist	Wet	S	Q	Size	Quantity	Size	Quantity	Dil HCl		
0-14	h	fr	sp	vf,f	m	vf; f,m	m; c	vf; f	c; f	e	-	0.5 to 1 cm
14-36	-	fr	sp	vf,f	m	vf; f,m	m; c	vf; f	c; f	e	-	
36-62	-	fr	vsvp	vf,f	m	vf; f,m	m; f	vf; f	c; f	e	Pressure faces	
62-87	-	fr	vsvp	vf,f; m	m; f	vf; f,m,c	m; f	vf	c	e	Slickensides*	
87-110	-	fr	vsvp	-	-	vf,f; m,c	m; f	vf	f	e	Slickensides*	

S= In patches ; Earthworm activity is concentrated throughout the profile*

Please refer Appendix I for the abbreviations

Series: PANGIDI **BM SPOT: 27 (BLACK SOILS)**

PROFILE NO: P49 *System: Agriculture (Cotton + Pigeonpea)* (FM)

CLIMATE: SUB-HUMID (DRY) RAINFALL: 1071 mm	Classification : Very fine, smectitic, hyperthermic, *Typic, Haplusterts.*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Pangidi, Mandal-Jainur, Adilabad, Andhra Pradesh		Sampling Date: 05.07.2002

Physical Properties of Profile No. 49 (Pangidi, Adilabad)

Laboratory No.	Horizon	Depth (cm)	Size class and particle diameter (mm)			Fine clay (%) (<0.0002)	Fine clay/ total clay (%)
			Total				
			Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)		
			←----------(% of <2 mm) ----------→				
3563	Ap	0-14	2.7	27.1	70.2	54.2	77.3
3564	Bw1	14-36	2.3	22.6	75.1	59.4	79.1
3565	Bw2	36-62	1.9	23.4	74.7	61.2	81.9
3566	Bss1	62-87	1.4	20.5	78.1	64.3	82.3
3567	Bss2	87-110	1.5	19.0	79.5	65.5	82.2
-	R	110+	---------- limestone rock ----------				

Depth (cm)	BD (Mgm^{-3})	COLE	HC ($cmhr^{-1}$)	WDC (%)
0-14	1.2	0.06	0.8	12.6
14-36	1.1	0.05	1.1	12.4
36-62	1.2	0.16	0.8	11.4
62-87	1.3	0.23	1.0	11.5
87-110	1.2	0.29	1.7	11.9
110+	---------- limestone rock ----------			

Series: PANGIDI **BM SPOT: 27 (BLACK SOILS)**

PROFILE NO: P49 *System: Agriculture (Cotton + Pigeonpea)* (FM)

CLIMATE: SUB-HUMID (DRY) RAINFALL: 1071 mm	Classification : Very fine, smectitic, hyperthermic, *Typic*, *Haplusterts.*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Pangidi, Mandal-Jainur, Adilabad, Andhra Pradesh		Sampling Date: 05.07.2002

Chemical Properties of Profile No. 49 (Pangidi, Adilabad)

Depth (cm)	pH (1:2)		EC (1:2) (dSm^{-1})	OC (%)	$CaCO_3$ (%)	Clay CO_3 (%)
	H_2O	1*N* KCl				
0-14	7.6	6.5	0.07	1.1	5.8	3.1
14-36	7.7	6.6	0.14	1.0	6.8	3.3
36-62	7.7	6.6	0.07	1.0	6.2	3.2
62-87	7.8	6.6	0.12	0.9	6.3	3.0
87-110	7.8	6.7	0.13	0.6	8.0	3.1
110+	---------- limestone rock ----------					

Depth (cm)	Extractable bases				CEC	Clay CEC	BS (%)	ESP
	Ca	Mg	Na	K				
	----------[cmol(p+)kg^{-1}]----------							
0-14	48.9	12.2	0.8	1.3	66.7	95	95	1
14-36	45.5	13.1	0.9	1.2	64.0	85	95	1
36-62	46.9	12.8	1.0	1.2	65.8	88	94	2
62-87	42.0	18.0	0.8	0.9	66.8	85	92	1
87-110	39.2	18.3	1.2	1.0	64.9	82	92	1
110+	---------- limestone rock ----------							

Series: PANGIDI **BM SPOT: 27 (BLACK SOILS)**

PROFILE NO: P49 *System: Agriculture (Cotton + Pigeonpea)* (FM)

CLIMATE: SUB-HUMID (DRY) RAINFALL: 1071 mm	Classification: Very fine, smectitic, hyperthermic, *Typic*, *Haplusterts.*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Pangidi, Mandal-Jainur, Adilabad, Andhra Pradesh		Sampling Date: 05.07.2002

Characterization of Landuse Types

S. No.	Attribute		Description
1	Production system	:	Rain-fed mixed farming of soybean-pigeonpea, sorghum-cotton, along with livestock with 5-8 months fallow period. Yield range: Sorghum- 2500-3500 kg ha^{-1} Cotton- 2000 kg ha^{-1} Soybean- 2000-2500 kg ha^{-1}
2	Management level	:	• Improved seeds • Manures: FYM (adequate) • IPM technology • Soil conservation measures: Nil • Residue management: • Fertilizer: 45 kg N/ha, 45 kg P2O5/ha, 25 kg K2O/ha per crop • Sowing time: 1st week of July (all crops) • Seed rate: Soybean 60 kg ha^{-1} Pigeonpea (as intercrop) 4-5 kg ha^{-1} Cotton 2-2.5 kg ha^{-1} Sorghum 12 kg ha^{-1}
3	Power source	:	Animal
4	Market orientation	:	Turning towards commercial
5	Capital intensity	:	Medium
6	Labour intensity	:	Low, restricted to family labour
7	Land holding	:	Small
8	Income level	:	Low

Climatic Datasets of Pangidi, Adilabad District, Andhra Pradesh

Month	Mean temp (^oC)	Rainfall (mm)	PET (mm)	½PET (mm)	LGP (days)
January	23.10	5.60	99.00	49.50	0.00
February	24.50	17.50	116.00	58.00	0.00
March	27.40	13.20	158.00	79.00	0.00
April	30.30	27.90	177.00	88.50	0.00
May	32.40	13.50	202.00	101.00	0.00
June	30.30	181.60	168.00	84.00	30.00
July	27.30	323.10	127.00	63.50	31.00
August	27.00	222.00	124.00	62.00	31.00
September	27.00	189.00	115.00	57.50	30.00
October	26.80	50.80	121.00	60.50	0.00
November	24.70	23.40	98.00	49.00	0.00
December	23.20	3.30	88.00	44.00	0.00
Average	27.00				
Total		1070.90	1593.00	796.5	122.00

Landscape, Landuse and Soils in BM Spot 27 (Pangidi, FM-1, Adilabad, A.P.)

Benchmark spot at Pangidi, Adilabad, Andhra Pradesh, under agricultural system (farmers' management -1) with cotton + pigeonpea crop rotation.

Dissolution of limestone at benchmark spot Pangidi in Adilabad.

Typical benchmark profile of Pangidi soil.

BM Spot 27 : PANGIDI 1 (ITDA Plot): Agriculture System (Soybean) P50

Classification : Very fine, smectitic, hyperthermic, *Vertic Haplustepts*

Location : ITDA-ICRISAT Project Area, Vill. Pangidi, Mandal-Jainur, Adilabad, Andhra Pradesh, Lat. 19° 21'09"N, Long.71° 00'14"E

Physiographic position : Deccan Plateau - Basalt

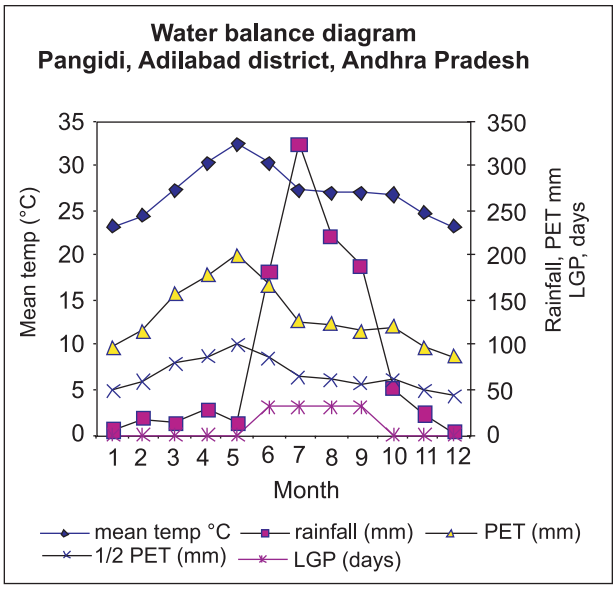
Topography and slope: Gently sloping and undulating, 3-8% (50-150 m)

Drainage : Well drained

Vegetation : *Palas*, *besharam*, grass, *neem*

Landuse : Soybean, jowar, pigeonpea

Parent material : Basaltic alluvium



Sampled by : T. Bhattacharyya, P. Chandran, S.K. Ray, M.V. Venugopalan, P. Srivastava, P.N. *Dube*y, S.L. Durge

Date of collection: 05.07.2002

Remarks : Soybean is being cultivated from this year, previously it was jowar+pigeonpea. Stones of size >2.5 cm, <7.5 cm at the surface (about 3% v/v). Substratum is of weathered limestone

Ap	0-11 cm	Very dark grey (10YR 3/1D) and very dark grey to very dark greyish brown (10YR 3/1.5M) clay; moderate medium subangular blocky structure; slightly hard, friable, very sticky and very plastic; common very fine, a few fine roots; many very fine, a few fine and medium lime nodules; many very fine and fine pores; mildly alkaline (pH 7.4); slightly effervescent; clear, smooth boundary.
Bw1	11-27 cm	Very dark grey to very dark greyish brown (10YR 3/1.5M) clay; moderate medium subangular blocky structure; friable, very sticky and very plastic; common very fine, a few fine roots; common very fine, a few fine and medium lime nodules; many very fine and fine pores; mildly alkaline (pH 7.5); slightly effervescent; clear, smooth boundary.
Bw2	27-41 cm	Very dark greyish brown (10YR 3/2M) clay; strong medium subangular blocky structure with pressure faces on surface of peds; friable, very sticky and very plastic; a few very fine roots; many very fine, a few fine and medium lime nodules; many very fine and fine pores; mildly alkaline (pH 7.5); slightly effervescent; clear, smooth boundary.
Crk1	41-55+ cm	Dark grey (10YR 4/1R) sandy clay loam; massive structure; very friable, sticky and non plastic; few very fine roots; 40 to 45% fine and coarse gravels; mildly alkaline (pH 7.8); violently effervescent.
Crk2		Weathered calcareous parent material (limestone).

Series: PANGIDI 1 BM SPOT: 27 (BLACK SOILS)

PROFILE NO: P50 *System: Agriculture (Soybean)* (ITDA)

CLIMATE: SUB-HUMID (DRY) RAINFALL: 1071 mm	Classification: Very Fine, smectitic, hyperthermic, *Vertic Haplustepts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: ITDA – ICRISAT Project Area, Pangidi, Mandal-Jainur, Adilabad, Andhra Pradesh		Sampling Date: 05.07.2002

Morphological Properties of Profile No. 50 (Pangidi, Adilabad)

Horizon	Depth (cm)	Boundary		Matrix color		Texture	Coarse fragments (%) (fg and cg %)	Structure		
		D	T	Dry	Moist			Size	Grade	Type
Ap	0-11	c	s	10YR3/1	10YR3/1.5	c	2-3	m	2	sbk
Bw1	11-27	c	s	-	10YR3/1.5	c	2-3	m	2	sbk
Bw2	27-41	c	w	-	10YR3/2	c	3-5	m	3	sbk
Crk	41-55	-	-	-	10YR4/1(R)	c	45-50	massive		

Depth (cm)	Consistence			Porosity		Nodules (conca)		Roots		Effervescence	Other features	Cracks
	Dry	Moist	Wet	S	Q	Size	Quantity	Size	Quantity	Dil HCl		
0-11	sh	fr	sp	vf,f	m	vf; f,m	m; f	vf; f	c; f	e	-	Not
11-27	-	fr	sp	vf,f	m	vf; f,m	c; f	vf; f	c; f	e	-	observed
27-41	-	fr	sp	vf,f	m	vf; f,m	m; f	vf	f	e	Pressure faces	
41-55	-	fr	sp	-	-	-	-	vf	f	ev	-	

Calcareous parent material (limestone).

Please refer Appendix I for the abbreviations.

Series: PANGIDI 1 **BM SPOT: 27 (BLACK SOILS)**

PROFILE NO: P50 *System: Agriculture (Soybean)* (ITDA)

CLIMATE: SUB-HUMID (DRY) RAINFALL: 1071 mm	Classification: Very Fine, smectitic, hyperthermic, *Vertic Haplustepts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: ITDA – ICRISAT Project Area, Pangidi, Mandal-Jainur, Adilabad, Andhra Pradesh		Sampling Date: 05.07.2002

Physical Properties of Profile No. 50 (Pangidi, Adilabad)

Laboratory No.	Horizon	Depth (cm)	Size class and particle diameter (mm)			Fine clay (%) (<0.0002)	Fine clay/ total clay (%)
			Total				
			Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)		
			←----------(% of <2 mm) ----------→				
3568	Ap	0-11	4.0	17.7	78.3	50.8	64.8
3569	Bw1	11-27	3.3	14.4	82.3	61.9	75.2
3570	Bwk1	27-41	6.2	12.7	81.1	61.0	75.2
3571	Crk	41-55	50.9	23.1	26.0	21.5	83.0

Depth (cm)	BD (Mgm^{-3})	COLE	HC ($cmhr^{-1}$)	WDC (%)
0-11	1.3	0.28	2.5	10.9
11-27	1.3	0.29	1.9	12.2
27-41	1.3	0.28	1.4	12.1
41-55	-	0.11	1.4	3.1

- *Nil or not determined (wherever applicable)*

Series: PANGIDI 1 BM SPOT: 27 (BLACK SOILS)

PROFILE NO: P50 *System: Agriculture (Soybean)* (ITDA)

CLIMATE: SUB-HUMID (DRY) RAINFALL: 1071 mm	Classification: Very Fine, smectitic, hyperthermic, *Vertic Haplustepts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: ITDA – ICRISAT Project Area, Pangidi, Mandal-Jainur, Adilabad, Andhra Pradesh		Sampling Date: 05.07.2002

Chemical Properties of Profile No. 50 (Pangidi, Adilabad)

Depth (cm)	pH (1:2)		EC (1:2) (dSm^{-1})	OC (%)	$CaCO_3$ (%)	Clay CO_3 (%)
	H_2O	1*N* KCl				
0-11	7.4	6.3	0.09	1.2	4.1	3.0
11-27	7.5	6.3	0.13	0.8	6.2	3.3
27-41	7.5	6.3	0.19	0.7	11.1	3.2
41-55	7.8	6.6	0.21	0.2	16.7	2.9

Depth (cm)	Extractable bases				CEC	Clay CEC	BS (%)	ESP
	Ca	Mg	Na	K				
	----------[cmol(p+)kg^{-1}]----------							
0-11	32.3	12.9	0.9	1.5	65.8	84	72	1
11-27	37.2	11.6	0.8	0.7	64.9	79	78	1
27-41	45.0	13.7	0.9	0.5	65.8	81	91	1
41-55	36.3	13.5	0.9	0.2	63.5	-	80	1

- *Nil or not determined (wherever applicable)*

Climatic Datasets of Pangidi, Adilabad District, Andhra Pradesh

Month	Mean temp (^oC)	Rainfall (mm)	PET (mm)	½PET (mm)	LGP (days)
January	23.10	5.60	99.00	49.50	0.00
February	24.50	17.50	116.00	58.00	0.00
March	27.40	13.20	158.00	79.00	0.00
April	30.30	27.90	177.00	88.50	0.00
May	32.40	13.50	202.00	101.00	0.00
June	30.30	181.60	168.00	84.00	30.00
July	27.30	323.10	127.00	63.50	31.00
August	27.00	222.00	124.00	62.00	31.00
September	27.00	189.00	115.00	57.50	30.00
October	26.80	50.80	121.00	60.50	0.00
November	24.70	23.40	98.00	49.00	0.00
December	23.20	3.30	88.00	44.00	0.00
Average	27.00				
Total		1070.90	1593.00	796.5	122.00

Landscape, Landuse and Soils in BM Spot 27 (Pangidi, FM-1, Adilabad, A.P.)

Benchmark spot at Pangidi, Adilabad, Andhra Pradesh, under agricultural system (Integrated Tribal Development Agency) with wheat-soybean cropping pattern

An example of Rhizobium nodules on soybean.

Typical Pangidi soil profile

3A. BLACK SOILS

3Ac. Black soils of semi-arid (moist) bioclimatic system

(MAR : > 1000 - 850 mm)

- **Benchmark Spots: 5, 22**

- **No. of Pedons: 4 (P10, P11, P12, P42)**

BM Spot 5 : ASRA: Agriculture System (Cotton/Greengram + Pigeonpea) (FM) P10

Classification : Very fine, smectitic, hyperthermic, *Typic Haplusterts*

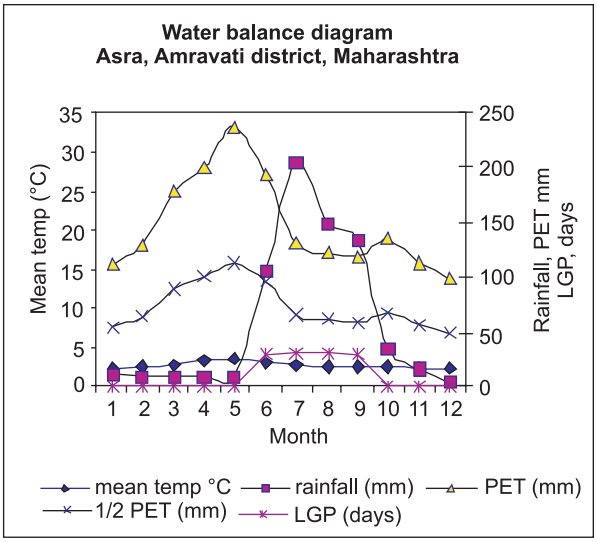
Location : Vill. Asra, Bhatkuli, Amravati, M.S. Lat. 20°52'42"N, Long. 77°29'12"E

Physiographic position : Lower Maharashtra Deccan Plateau

Topography and slope: Very gently sloping to slightly undulating, 1-3% (50-150 m)

Drainage : Moderately well drained

Vegetation : Acacia, *neem*, goghan, *ber*, *kans*, *dub*, thorny shrubs, pigeonpea



Landuse: Cotton/greengram - pigeonpea

Parent material : Basaltic alluvium

Sampled by : P. Chandran, S.K. Ray, S.L. Durge, S.R. Bhuse

Date of collection: 16-01-2001

Remarks :

Ap	0-14 cm	Very dark brown to very dark greyish brown (10YR 2.5/2 M) clay; moderate medium subangular blocky structure; friable, sticky and plastic; many very fine, common fine roots; many very fine, a few fine and medium lime nodules; many very fine and fine pores; mildly alkaline (pH 7.8); nil to slightly effervescent; clear, smooth boundary.
Bw1	14-40 cm	Very dark brown to very dark greyish brown (10YR 2.5/2M) clay; strong medium subangular blocky structure with pressure faces on ped surfaces; friable, very sticky and very plastic; many very fine common fine roots; many very fine, few fine and medium lime nodules; moderately alkaline (pH 8.0); nil to slightly effervescent; gradual smooth boundary.
Bw2	40-59 cm	Very dark brown (10YR 2/2M) clay; strong medium subangular blocky structure with well developed pressure faces on ped surfaces; friable, very sticky and very plastic; common very fine, a few fine roots; many very fine, a few fine lime nodules; moderately alkaline (pH 8.0); slightly effervescent; clear, smooth boundary.
Bss1	59-91 cm	Very dark brown to very dark greyish brown (10YR 2.5/2M) clay; strong medium angular blocky structure with well developed wedge-shaped aggregates and slickensides that break into small angular peds; slightly firm, very sticky and very plastic; common very fine, a few fine roots; many very fine, a few fine lime nodules; moderately alkaline (pH 8.1); slightly effervescent; gradual smooth boundary.
Bss2	91-125 cm	Very dark greyish brown to dark brown (10YR 3/2.5M) clay; strong, coarse angular blocky structure with well developed wedge-shaped aggregates and slickensides that break into small angular peds; slightly firm, very sticky and very plastic; common very fine, a few fine roots; many very fine and fine, a few medium lime nodules; moderately alkaline (pH 8.3); strongly effervescent; gradual smooth boundary.
Bss3	125-150 cm	Very dark greyish brown to dark brown (10YR 3/2.5M) clay; strong, coarse angular blocky structure with well developed wedge-shaped aggregates and slickensides that break into small angular peds; slightly firm, very sticky and very plastic; common very fine roots; many very fine an fine, a few medium lime nodules; moderately alkaline (pH 8.3) strongly effervescent.

Series: ASRA **BM Spot: 5 (BLACK SOILS)**

Profile No: P10 ***System: Agriculture* (*Cotton/Greengram + Pigeonpea*) (FM) (ORG)**

CLIMATE: SEMI-ARID (MOIST) RAINFALL: 975 mm	Classification: Very fine, smectitic, hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Asra, Bahtkuli, Amravati, Maharashtra		Sampling Date : 16.01.2001

Morphological Properties of Profile No. 10 (Asra, Amravati)

Horizon	Depth (cm)	Boundary		Matrix color		Texture	Coarse fragments (%) (fg and cg)	Structure		
		D	*T*	Dry	Moist			Size	Grade	Type
Ap	0-14	c	s	-	10YR2.5/2	c	3--5	m	2	sbk
Bw1	14-40	g	s	-	10YR2.5/2	c	3--5	m	3	sbk
Bw2	40-59	c	s	-	10YR2/2	c	3--5	m	3	sbk
Bss1	59-91	g	s	-	10YR2.5/2	c	3--5	m	3	abk
Bss2	91-125	g	s	-	10YR3/2.5	c	5—8	c	3	abk
Bss3	125-150	-	-	-	10YR3/2.5	c	5—8	c	3	abk

Depth (cm)	Consistence			Porosity		Nodules (conca)		Roots		Effervescence*	Other features	Cracks
	Dry	Moist	Wet	S	Q	Size	Quantity	Size	Quantity	Dil HCl		
0-14	-	fr	sp	vf, f	m	vf; f,m	m; f	vf; f	m; c	e	-	2 cm
14-40	-	fr	sp	-	-	vf; f,m	m; f	vf; f	m; c	e	Pressure faces	
40-59	-	fr	sp	-	-	vf; f	m; f	vf; f	c; f	e	Pressure faces	1 cm
59-91	-	fi	sp	-	-	vf; f	m; f	vf; f	c; f	e	Slickensides	0.5 cm
91-125	-	fi	vsvp	-	-	vf,f; m	m f	vf; f	c; f	es	Slickensides	0.2 cm
125-150	-	fi	vsvp	-	-	vf,f; m	m f	vf	c	es	Slickensides	

Cracks: 2 cm wide up to 40 cm and 1 cm wide cracks up to 60 cm and 0.5 cm wide up to 91 cm and 0.2 cm wide up to 125 cm
**Matrix effervescence was also observed*

Please refer Appendix I for the abbreviations

Series: ASRA **BM Spot: 5 (BLACK SOILS)**

Profile No: P10 ***System: Agriculture* (*Cotton/Greengram + Pigeonpea*) (FM) (ORG)**

CLIMATE: SEMI-ARID (MOIST) RAINFALL: 975 mm	Classification: Very fine, smectitic, hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Asra, Bahtkuli, Amravati, Maharashtra		Sampling Date : 16.01.2001

Physical Properties of Profile No. 10 (Asra, Amravati)

Laboratory No.	Horizon	Depth (cm)	Size class and particle diameter (mm)			Fine clay (%) (<0.0002)	Fine clay/ total clay (%)
			Total				
			Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)		
			←----------(% of <2 mm) ----------→				
3114	Ap	0-14	0.9	36.7	62.4	26.7	42.8
3115	Bw1	14-40	0.8	34.3	64.9	26.7	41.1
3116	Bw2	40-59	0.8	33.3	65.9	28.9	43.8
3117	Bss1	59-91	1.4	35.3	63.3	29.0	45.7
3118	Bss2	91-125	2.4	37.3	60.3	28.7	47.6
3119	Bss3	125-150	1.9	38.1	60.0	25.7	42.8

Depth (cm)	BD (Mgm^{-3})	COLE	HC ($cmhr^{-1}$)	WDC (%)
0-14	-	0.3	1.1	6.6
14-40	1.6	0.3	2.1	13.9
40-59	1.7	0.3	1.0	14.8
59-91	1.5	0.3	0.5	6.4
91-125	1.5	0.3	0.4	7.6
125-150	1.6	0.3	0.3	10.0

Series: ASRA BM Spot: 5 (BLACK SOILS)

Profile No: P10 ***System: Agriculture* (*Cotton/Greengram + Pigeonpea*) (FM) (ORG)**

CLIMATE: SEMI-ARID (MOIST) RAINFALL: 975 mm	Classification: Very fine, smectitic, hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Asra, Bahtkuli, Amravati, Maharashtra		Sampling Date : 16.01.2001

Chemical Properties of Profile No. 10 (Asra, Amravati)

Depth (cm)	pH (1:2)		EC (1:2) (dSm^{-1})	OC (%)	$CaCO_3$ (%)	Clay CO_3 (%)
	H_2O	1*N* KCl				
0-14	7.8	6.5	0.11	0.8	9.3	1.4
14-40	8.0	6.5	0.13	0.7	9.4	1.4
40-59	8.0	6.5	0.21	0.6	10.7	1.2
59-91	8.1	6.6	0.04	0.6	11.0	3.2
91-125	8.3	6.7	0.11	0.5	13.7	1.8
125-150	8.3	6.7	0.25	0.4	15.6	1.9

Depth (cm)	Extractable bases				CEC	Clay CEC	BS (%)	ESP
	Ca	Mg	Na	K				
	←----------[cmol(p+)kg^{-1}]----------→							
0-14	46.2	14.4	0.7	1.1	65.2	104	96	1
14-40	44.7	16.6	1.3	0.8	61.0	94	104	2
40-59	42.0	17.8	2.8	0.7	63.0	105	100	4
59-91	38.2	20.2	4.2	0.7	63.0	99	100	7
91-125	28.9	22.0	5.8	0.6	62.2	103	92	9
125-150	25.8	22.4	8.6	1.1	66.7	111	87	13

* *Percent of water dispersible clay size carbonate*

Series: ASRA **BM Spot: 5 (BLACK SOILS)**

Profile No: P10 ***System: Agriculture* (*Cotton/Greengram + Pigeonpea*)(FM)(ORG)**

CLIMATE: SEMI-ARID (MOIST) RAINFALL: 975 mm	Classification: Very fine, smectitic, hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Asra, Bahtkuli, Amravati, Maharashtra		Sampling Date : 16.01.2001

Saturation Extract Properties of Profile No. 10 (Asra, Amravati)

Depth (cm)	Sat (%)	ECe ($d\ Sm^{-1}$)	Soluble cations ($mmol_c\ l^{-1}$)				Sum of cations
			Ca	Mg	Na	K	
3114	72.81	0.34	1.43	0.76	32.06	0.10	34.35
3115	70.44	0.30	0.67	0.37	76.69	0.04	77.77
3116	73.01	-	0.46	0.32	4.09	0.05	4.92
3117	77.08	0.42	0.39	0.30	4.74	0.03	5.46
3118	63.35	4.65	0.72	0.50	5.10	1.43	7.75
3119	85.89	-	0.49	0.33	3.26	0.05	4.13

Depth (cm)	Soluble anions ($mmol_c\ l^{-1}$)				Sum of anions
	CO_3	HCO_3	Cl	SO_4	
3114	-	3.18	0.80	30.37	34.35
3115	-	5.31	0.60	71.86	77.77
3116	2.01	2.12	0.70	0.09	4.92
3117	1.01	3.18	0.90	0.37	5.46
3118	-	2.00	0.20	5.50	7.75
3119	-	1.00	0.10	3.03	4.13

- *Nil or not determined (wherever applicable)*

Series: ASRA **BM Spot: 5 (BLACK SOILS)**

Profile No: P10 ***System: Agriculture* (*Cotton/Greengram + Pigeonpea*) (FM) (ORG)**

CLIMATE: SEMI-ARID (MOIST) RAINFALL: 975 mm	Classification: Very fine, smectitic, hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Asra, Bahtkuli, Amravati, Maharashtra		Sampling Date : 16.01.2001

Characterization of Landuse Types

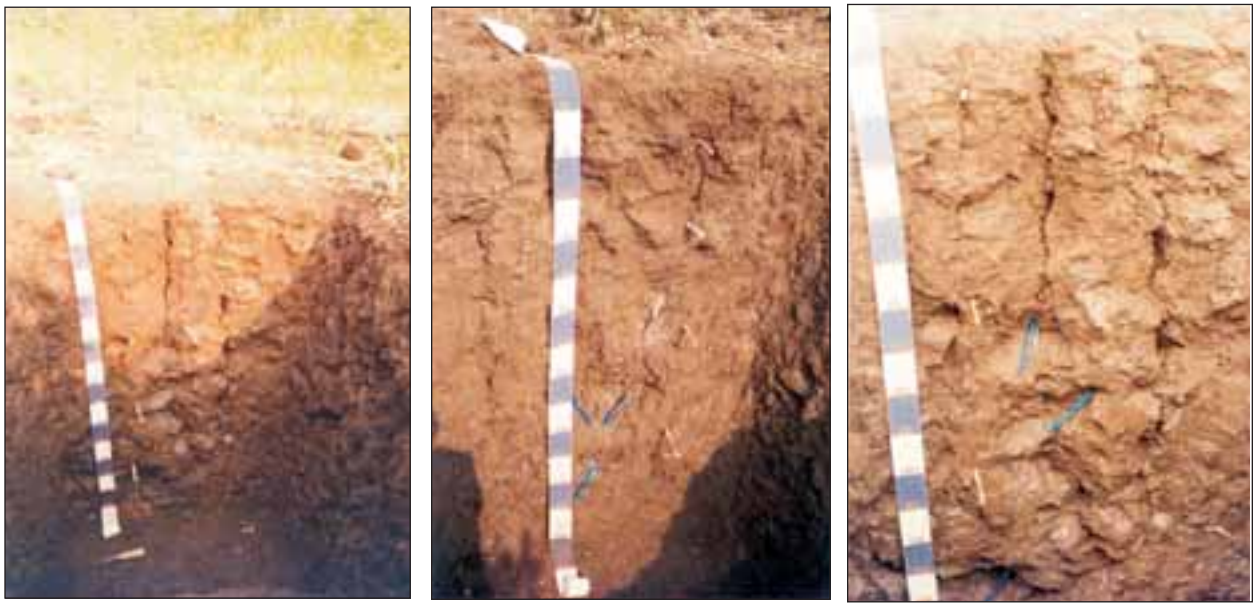
S. No.	Attribute		Description
1	Production system	:	Extensive rain-fed cotton + greengram + pigeonpea single season or sorghum.-chickpea (on residual moisture) with double cropping system. Crop- livestock farming system. Yield: 900-1000 kg green gram/ha 700-800 kg cotton/ha 1200 kg pigeonpea/ha or 3000-3500 kg ha^{-1} sorghum. Fallow period 3-6 months in summer
2	Management level	:	• Improved varieties of cotton, sorghum, pigeonpea and gram • Line sown with good plant stand • Manures: 15-20 cart load/ha per year • Chemical fertilizer: 120 kg N and 120kg P_2O_5 per year • Insecticides: Frequently used • Sowing time: *Kharif* crops 25-26th met. week Gram 1st week of Nov • Seed rate: Cotton: 2.0 kg ha^{-1} Pigeonpea: 5 kg ha^{-1} (as intercrop) Greengram: 3 kg ha^{-1}(as intercrop) Sorghum: 6-8 kg ha^{-1}
3	Power source	:	Tractor and animal traction with improved implements
4	Market orientation	:	Subsistance production plus commercial sale of surplus
5	Capital intensity	:	Intermediate
6	Labour intensity	:	High with family labour
7	Land holding	:	Large, consolidated
8	Income level	:	High

Climatic Datasets of Asra, Amravati, Maharashtra

Month	Mean temp (^oC)	Rainfall (mm)	PET	½PET	LGP (days)
January	22.20	15.00	110.60	55.30	0.00
February	24.50	12.70	129.00	64.50	0.00
March	28.70	12.30	178.20	89.10	0.00
April	32.40	13.00	200.80	100.40	0.00
May	35.00	11.90	237.60	113.80	0.00
June	31.30	149.30	193.60	96.80	30.00
July	26.90	285.70	131.20	65.60	31.00
August	26.40	209.60	122.90	61.45	31.00
September	26.70	185.90	118.10	59.05	30.00
October	26.50	49.60	134.80	67.40	0.00
November	23.80	23.90	112.60	56.30	0.00
December	21.80	5.60	99.40	49.70	0.00
Average	27.18				
Total		974.50	1768.80	879.4	122.00

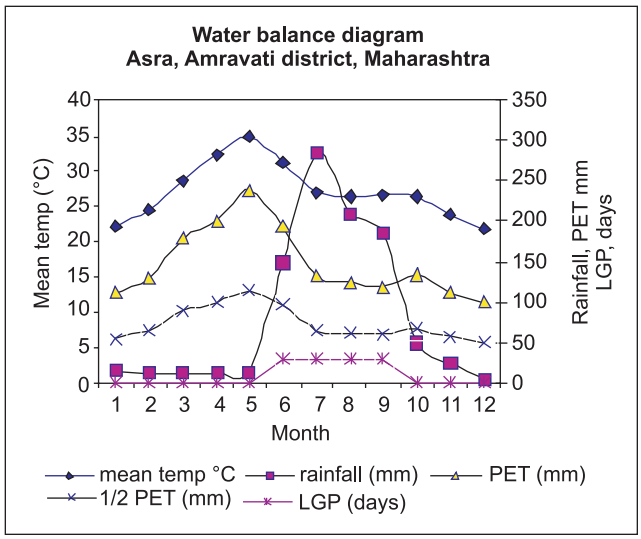
Landscape, Landuse and Soils in Benchmark Spot 5 (Asra, Amravati)

Typical black soil profile of Asra series under agricultural system (FM) with cotton/ greengram + pigeonpea crop system



Closer view of the profile showing deep and wide cracks with well developed slickensides

BM Spot 5 : ASRA: Agriculture System (Soybean + Pigeonpea) (FM) P11



Classification : Very fine, smectitic, hyperthermic, *Typic Haplusterts*

Location : Vill. Asra, Bhatukli, Amravati, M.S. Lat. 20°52'41"N, Long. 77°29'16"E

Physiographic position : Lower Maharashtra, Deccan Plateau

Topography and slope : Very gently sloping to slightly undulating, 1-3% (50-150 m)

Drainage : Moderately well drained

Vegetation : Acacia, *neem*, *pipal*, grass, shrubs

Landuse : Soybean + pigeonpea

Parent material : Basaltic alluvium

Sampled by : P. Chandran, S.K. Ray, S.L. Durge, S.R. Bhuse

Date of collection: 16-01-2001

Remarks : Cracks are 1-2 cm wide up to 18 cm and 0.5 cm wide cracks up to 107 cm.

Ap	0-14 cm	Very dark brown (10YR 2/2M) clay; moderate medium subangular blocky structure; friable, sticky and plastic; common very fine, a few fine roots; many very fine, a few fine lime nodules;many very fine and fine pores; mildly alkaline (pH 7.8); strongly effervescent; clear, smooth boundary.
Bw1	14-35 cm	Very dark brown (10YR 2/2M) clay; strong medium subangular blocky structure with pressure faces on ped surfaces; friable, very sticky and very plastic; common very fine, a few fine roots; many very fine, a few fine lime nodules; many very fine and fine pores; moderately alkaline (pH 7.9); strongly effervescent; clear, smooth boundary.
Bss1	35-69 cm	Very dark brown (10YR 2/2M) clay; strong medium angular blocky structure (weak) with not so well developed wedge-shaped aggregates and slickensides that break into small angular peds; slightly firm, very sticky and very plastic; common very fine roots; many very fine, a few fine lime nodules; mildly alkaline (pH 7.8); strongly effervescent; gradual smooth boundary.
Bss2	69-107 cm	Very dark brown (10YR 2/2M) clay; strong medium angular blocky structure with well developed wedge-shaped aggregates and slickensides that break into small angular peds; slightly firm, very sticky and very plastic; a few very fine roots; common very fine, a few fine lime nodules; moderately alkaline (pH 7.9); strongly effervescent; gradual smooth boundary.

Series: ASRA **BM Spot: 5 (BLACK SOILS)**

Profile No: P11 ***System: Agriculture (Soybean+Pigeonpea)*** **(FM)**

CLIMATE: SEMI-ARID (MOIST) RAINFALL: 975 mm	Classification: Very fine, smectitic, hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Asra, Bahtkuli, Amravati, Maharashtra		Sampling Date : 16.01.2001

Morphological Properties of Profile No. 11 (Asra, Amravati)

Horizon	Depth (cm)	Boundary		Matrix color		Texture	Coarse fragments (%) (fg and cg)	Structure		
		D	*T*	Dry	Moist			Size	Grade	Type
Ap	0-14	-	-	-	10YR2/2	c	1-3	m	3	sbk
Bw1	14-35	c	s	-	10YR2/2	c	1-3	m	2	sbk
Bss1	35-69	g	s	-	10YR2/2	c	1-3	m	3	abk(w)*
Bss2	69-107	g	w	-	10YR2/2	c	<1	m	3	abk
Bss3	107-150	g	w	-	10YR2/2	c	<1	m	3	abk

Depth (cm)	Consistence			Porosity		Nodules(conca)		Roots		Effervescence	Other Features	Cracks
	Dry	Moist	Wet	S	Q	Size	Quantit	Size	Quantity	Dil HCl		
0-14	-	fr	sp	vf, f	m	vf: f	m; f	vf; f	c; f	es	-	1-2 cm
14-35	-	fr	sp	-	-	vf: f	m; f	vf; f	c; f	es	Pressure faces	1 cm
35-69	-	fi	sp	-	-	vf: f	m; f	vf	c	es	Slickensides (Weak)	0.5 cm
69-107	-	sfi	vsvp	-	-	vf: f	c; f	vf	f	es	Slickensides	0.7 cm
107-150	-	sfi	vsvp	-	-	vf: f	c; f	vf	f	es	Slickensides	

**Cracks: 1-2 cm wide up to 18 cm and 0.5 cm up to 107 cm*
***Matrix effervescence was also observed*

Please refer Appendix I for the abbreviations

Series: ASRA **BM Spot: 5 (BLACK SOILS)**

Profile No: P11 ***System: Agriculture (Soybean+Pigeonpea)*** **(FM)**

CLIMATE: SEMI-ARID (MOIST) RAINFALL: 975 mm	Classification: Very fine, smectitic, hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Asra, Bahtkuli, Amravati, Maharashtra		Sampling Date : 16.01.2001

Physical Properties of Profile No. 11 (Asra, Amravati)

Laboratory No	Horizon	Depth (cm)	Size class and particle diameter (mm)			Fine clay (%) (<0.0002)	Fine clay/ total clay (%)
			Total				
			Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)		
			←----------(% of <2 mm) ----------→				
3120	Ap	0-14	2.8	36.1	61.1	28.9	47.5
3121	Bw1	14-35	2.7	34.6	62.7	32.5	51.8
3122	Bss1	35-69	2.7	34.8	62.5	32.4	51.8
3123	Bss2	69-107	2.6	36.1	61.3	35.0	57.1
3124	Bss3	107-150	2.1	35.8	62.1	35.3	56.8

Depth (cm)	BD (Mgm^{-3})	COLE	HC ($cmhr^{-1}$)	WDC (%)
0-14	-	0.2	1.1	2.0
14-35	1.5	0.2	1.7	6.8
35-69	1.5	0.2	1.4	12.2
69-107	1.6	0.2	1.3	7.0
107-150	1.6	0.2	0.9	10.6

- *Nil or not determined (wherever applicable)*

Series: ASRA BM Spot: 5 (BLACK SOILS)

Profile No: P11 ***System: Agriculture (Soybean+Pigeonpea)*** **(FM)**

CLIMATE: SEMI-ARID (MOIST) RAINFALL: 975 mm	Classification: Very fine, smectitic, hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Asra, Bahtkuli, Amravati, Maharashtra		Sampling Date : 16.01.2001

Chemical Properties of Profile No. 11 (Asra, Amravati)

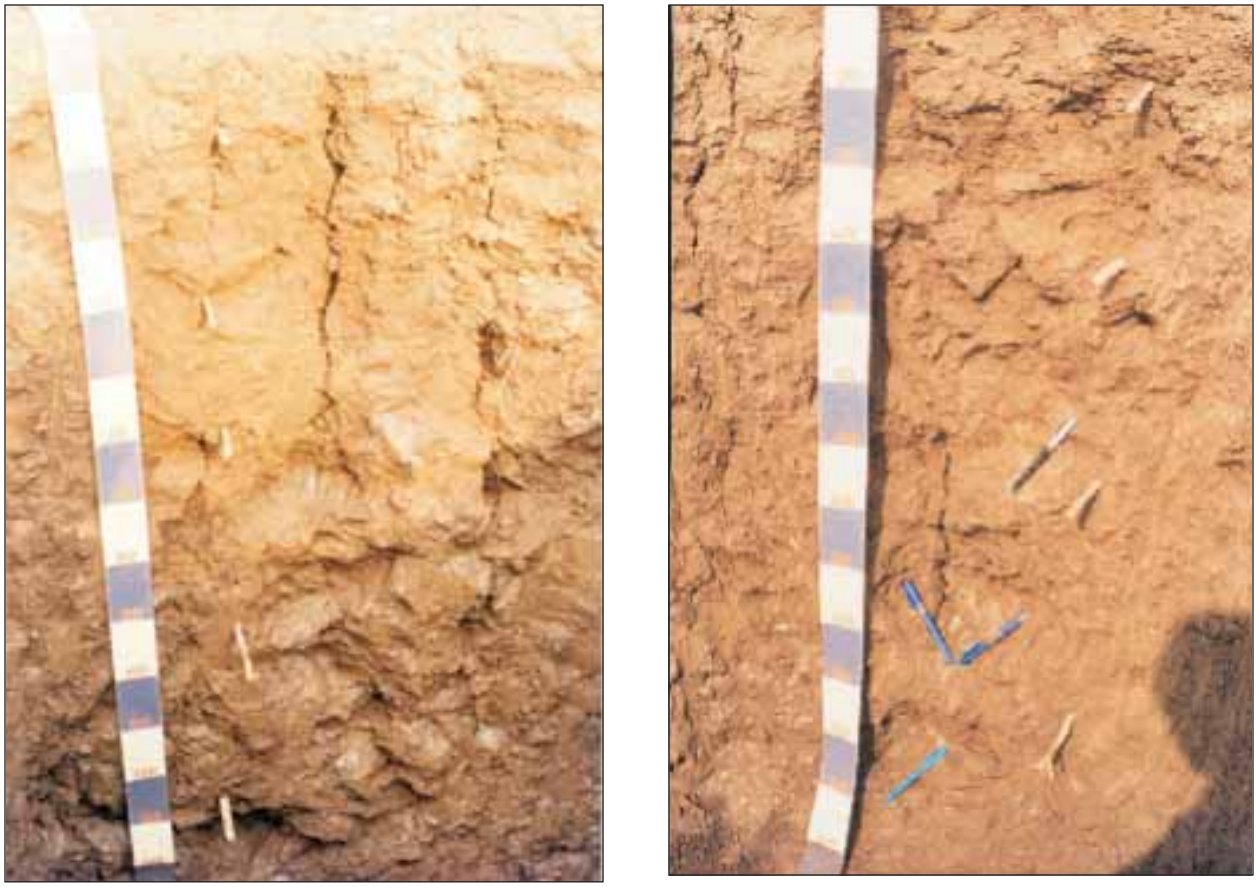
Depth (cm)	pH (1:2)		EC (1:2) (dSm^{-1})	OC (%)	$CaCO_3$ (%)	Clay CO_3* (%)
	H_2O	1*N* KCl				
0-14	7.8	6.7	0.10	0.8	8.1	1.3
14-35	7.9	6.7	0.15	0.7	9.4	1.8
35-69	7.8	6.7	0.14	0.6	9.6	1.9
69-107	7.9	6.7	0.32	0.6	9.7	1.9
107-150	8.1	6.7	0.23	0.5	10.6	2.1

Depth (cm)	Extractable bases				CEC	Clay CEC	BS (%)	ESP
	Ca	Mg	Na	K				
	----------[cmol(p+)kg^{-1}]----------							
0-14	40.1	12.2	0.4	1.1	60.9	100	88	0.6
14-35	39.0	14.9	0.6	0.8	56.5	90	97	1.0
35-69	38.0	16.9	0.8	0.8	59.8	96	94	1.3
69-107	37.8	19.0	1.7	0.8	63.0	98	94	2.8
107-150	36.2	22.2	2.6	0.8	61.9	100	100	4.2

* *Percent of water dispersible clay size carbonate*

Landscape, Landuse and Soils in Benchmark Spot 5 (Asra, Amravati)

Soil site of Asra series under agriculture system (farmers' management) with soybean + pigeonpea crops



Typical black soil profile of Asra series showing deep and wide cracks with well developed slickensides

BM Spot 5 : ASRA: Agriculture System (Cotton+Pigeonpea/Soybean+Gram) (HM) P12

Classification : Very fine, smectitic, hyperthermic, *Typic Haplusterts*

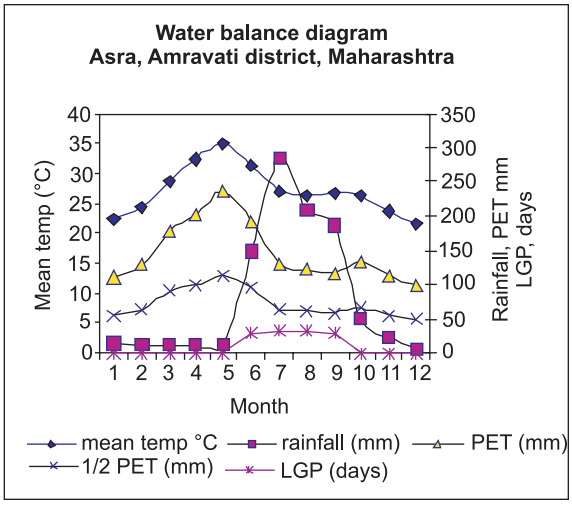
Location : Taluka Seed Multiplication Centre, Govt. of Maharashtra, Walgaon, Amravati, M.S. Lat. 21°30'N, Long. 77°42'E

Physiographic position : Lower Maharashtra Deccan Plateau

Topography and slope : Almost level land, 0-1% (50-150 m)

Drainage : Moderately well drained

Vegetation : Acacia, *ber*, mango, *neem*, *kans*, *dub*



Landuse : Cotton + Pigeonpea/soybean+gram, boru (sunhemp)

Parent material : Basaltic alluvium

Sampled by : P. Chandran, S.K. Ray, S.L. Durge, S.R. Bhuse

Date of collection : 17-01-2001

Remarks : Profile taken in plot No. 3 of 6 hectares

Yield : Soybean – 4.5-5 Q/acre; Cotton – 13 Q/ha (1999-2000)
Sunhemp (boru) is being grown for green manuring (2000-2001)

Ap	0-12 cm	Very dark greyish brown (10YR 3/2M) clay; moderate medium subangular blocky structure; friable, very sticky and very plastic; many very fine and fine, common medium roots; common very fine and fine lime nodules; many very fine and fine pores; mildly alkaline (pH 7.8); clear, smooth boundary.
Bw1	12-40 cm	Very dark greyish brown to very dark brown (10YR 2.5/2M) clay; strong medium subangular blocky structure with pressure faces on ped surfaces; friable, very sticky and very plastic; common very fine and fine, a few medium roots; common very fine and fine lime nodules; pressure faces present; moderately alkaline (pH 7.9); gradual smooth boundary.
Bss1	40-79 cm	Very dark greyish brown to very dark brown (10YR 2.5/2M) clay; strong medium angular blocky structure with well developed wedge shaped aggregates and slickensides which breaks into small angular peds; friable, very sticky and very plastic; common very fine and fine roots; common very fine and fine lime nodules; mildly alkaline (pH 7.8); gradual smooth boundary.
Bss2	79-116 cm	Very dark greyish brown to very dark brown (10YR 2.5/2M) clay; strong, coarse angular blocky structure with well developed wedge shaped aggregates and slickensides which breaks into small angular peds; friable, very sticky and very plastic; common very fine, a few fine roots; common very fine and fine lime nodules; mildly alkaline (pH 7.8); gradual smooth boundary.
Bss3	116-150 cm	Very dark greyish brown to very dark brown (10YR 2.5/2M) clay; strong medium angular blocky to medium moderate angular blocky structure with weak development of wedge-shaped aggregates and slickensides that break into small angular peds; friable, very sticky and very plastic; a few very fine roots; many very fine and fine, common medium lime nodules; moderately alkaline (pH 7.9); slightly effervescent.

Series: ASRA **BM Spot: 5 (BLACK SOILS)**

Profile No: P12 ***System: Agriculture (Cotton+Pigeonpea / Soybean-Gram*)(HM)**

CLIMATE: SEMI-ARID (MOIST) RAINFALL: 975 mm	Classification: Very fine, smectitic, hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Seed Multiplication Centre, Walgaon, Amravati(Tah), Amravati, Maharashtra		Sampling Date : 17.01.2001

Morphological Properties of Profile No. 12 (Asra, Walgaon, Amravati)

Horizon	Depth (cm)	Boundary		Matrix color		Texture	Coarse fragments (%) (fg and cg)	Structure		
		D	*T*	Dry	Moist			Size	Grade	Type
Ap	0-12	c	s	-	10YR3/2	c	1-2	m	2	sbk
Bw1	12-40	g	s	-	10YR2.5/2	c	1-2	m	3	sbk
Bss1	40-79	g	s	-	10YR2.5/2	c	1-2	m	3	abk
Bss2	79-116	g	s	-	10YR2.5/2	c	1-2	c	3	abk
Bss3	116-150	-	-	-	10YR2.5/2	c	5-8	m	3 - 2	abk

Depth (cm)	Consistence			Porosity		Nodules (conca)		Roots		Effervescence	Other features	Cracks
	Dry	Moist	Wet	S	Q	Size	Quantity	Size	Quantity	dil HCl		
0-12	-	fr	sp	vf,f	m	vf , f	c	vf,f; m	m; c	e	-	1 cm
12-40	-	fr	sp	-	-	vf , f	c	vf,f; m	c; f	e	Pressure faces	3 cm
40-79	-	fr	vsvp	-	-	vf , f	c	vf,f	c	e	Slickensides	0.5 cm
79-116	-	fr	vsvp	-	-	vf , f	c	vf; f	c; f	e	Slickensides	
116-150	-	fr	vsvp	-	-	vf ,f; m	m; c	vf	f	e	Slickensides (weak)	

**Cracks <1 cm wide up to 35 cm and <0.5 cm wide up to 50 cm*
***Matrix effervescence*

Please refer Appendix I for the abbreviations

Series: ASRA **BM Spot: 5 (BLACK SOILS)**

Profile No: P12 ***System: Agriculture (Cotton+ Pigeonpea / Soybean-Gram*) (HM)**

CLIMATE: SEMI-ARID (MOIST) RAINFALL: 975 mm	Classification: Very fine, smectitic, hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Seed Multiplication Centre, Walgaon, Amravati(Tah), Amravati, Maharashtra		Sampling Date : 17.01.2001

Physical Properties of Profile No. 12 (Asra, Walgaon, Amravati)

Laboratory No.	Horizon	Depth (cm)	Size class and particle diameter (mm)			Fine clay (%) (<0.0002)	Fine clay/ total clay (%)
			Total				
			Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)		
			←----------(% of <2 mm) ----------→				
3125	Ap	0-12	1.2	27.5	71.3	43.2	60.6
3126	Bw1	12-40	1.5	30.7	67.8	37.6	55.4
3127	Bss1	40-79	1.0	26.1	72.9	44.6	61.2
3128	Bss2	79-116	1.6	30.8	67.6	39.9	59.0
3129	Bss3	116-150	1.4	32.7	66.0	41.5	63.0

Depth (cm)	BD (Mgm^{-3})	COLE	HC ($cmhr^{-1}$)	WDC (%)
0-12	-	0.2	0.7	11.7
12-40	1.5	0.2	1.0	9.9
40-79	1.5	0.3	1.1	13.4
79-116	1.5	0.3	1.5	6.9
116-150	1.5	0.3	3.8	10.2

Series: ASRA BM Spot: 5 (BLACK SOILS)

Profile No: P12 ***System: Agriculture (Cotton+ Pigeonpea / Soybean-Gram*) (HM)**

CLIMATE: SEMI-ARID (MOIST) RAINFALL: 975 mm	Classification: Very fine, smectitic, hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Seed Multiplication Centre, Walgaon, Amravati (Tah), Amravati, Maharashtra		Sampling Date : 17.01.2001

Chemical Properties of Profile No. 12 (Asra, Walgaon, Amravati)

Depth (cm)	pH (1:2)		EC (1:2) (dSm^{-1})	OC (%)	$CaCO_3$ (%)	Clay CO_3* (%)
	H_2O	1*N* KCl				
0-12	7.8	6.5	0.13	1.1	5.2	1.8
12-40	7.9	6.5	0.24	0.8	5.4	1.7
40-79	7.8	6.3	0.19	0.7	5.6	2.0
79-116	7.8	6.4	0.18	0.6	6.5	1.8
116-150	7.9	6.4	0.18	0.6	8.5	1.4

Depth (cm)	Extractable bases				CEC	Clay CEC	BS (%)	ESP
	Ca	Mg	Na	K				
	----------[cmol(p+)kg^{-1}]----------							
0-12	49.7	12.0	1.9	1.2	69.6	98	93	3
12-40	54.5	12.7	2.6	0.9	71.7	106	99	4
40-79	52.1	14.1	1.6	0.7	76.1	104	90	2
79-116	51.2	17.2	1.2	0.8	76.1	113	92	2
116-150	47.8	14.3	1.0	0.8	69.6	105	92	1

* *Percent of water dispersible clay size carbonate*

Series: ASRA BM Spot: 5 (BLACK SOILS)

Profile No: P12 ***System: Agriculture (Cotton+Pigeonpea / Soybean-Gram*) (HM)**

CLIMATE: SEMI-ARID (MOIST) RAINFALL: 975 mm	Classification: Very fine, smectitic, hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Seed Multiplication Centre, Walgaon, Amravati(Tah), Amravati, Maharashtra		Sampling Date : 17.01.2001

Climatic Datasets of Asra, Amravati District, Maharashtra

Month	Mean temp (^{o}C)	Rainfall (mm)	PET	½ PET	LGP (days)
January	22.20	15.00	110.60	55.30	0.00
February	24.50	12.70	129.00	64.50	0.00
March	28.70	12.30	178.20	89.10	0.00
April	32.40	13.00	200.80	100.40	0.00
May	35.00	11.90	237.60	113.80	0.00
June	31.30	149.30	193.60	96.80	30.00
July	26.90	285.70	131.20	65.60	31.00
August	26.40	209.60	122.90	61.45	31.00
September	26.70	185.90	118.10	59.05	30.00
October	26.50	49.60	134.80	67.40	0.00
November	23.80	23.90	112.60	56.30	0.00
December	21.80	5.60	99.40	49.70	0.00
Average	27.18				
Total		974.50	1768.80	879.4	122.00

Landscape, Landuse and Soils in Benchmark Spot 5 (Asra, Amravati)

*Sunhemp (*Crotalaria juncea*) is a common green manuring crop in Asra soil under agriculture system with high management (with cotton + pigeonpea / soybean – gram cropping pattern)*

Pedon site for Asra soil under agriculture system (high management).

Typical black soil profile of Asra series showing cracks and slickensides

BM Spot 22 : BHATUMBRA: Agriculture System (Sorghum+Pigeonpea/Blackgram-Chickpea) (FM) P42

Classification : Very fine, smectitic, isohyperthermic, Udic Haplusterts

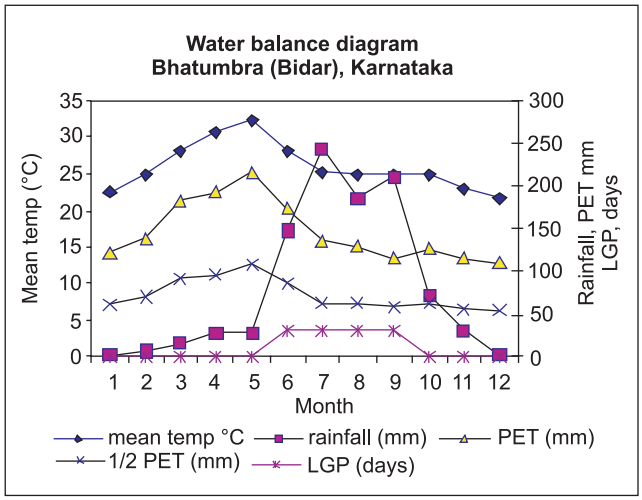
Location : Vill. Bhatumbra, Bhalki Tehsil, Bidar, Karnataka. Lat. 18°03'25"N, Long 77°09'06"E

Physiographic position : South Deccan Plateau - Basalt

Topography and slope: Very gently sloping, 1-3% (50-150 m)

Drainage : Moderately well drained

Vegetation : *Babul*, mango, cypus rotendus, *besharam*, *neem*, grass, *ber*



Landuse : Sorghum+pigeonpea/blackgram-chickpea

Parent material : Basaltic alluvium

Sampled by : P. Chandran, S.K. Ray, M.V. Venugopalan, P. Srivastava, S.L. Durge

Date of collection: 04.01.2002

Remarks : Salt encrustations are observed at the surface. Due to launch of canal, the water table has risen in this area. The seepage water is available within.

Ap	0-12 cm	Very dark greyish brown (2.5Y 3/2M) clay; medium moderate subangular blocky structure; friable, sticky and plastic; many very fine and fine roots; a few very fine, fine and medium lime nodules; many very fine and fine pores; moderately alkaline (pH 8.2); slightly to strongly effervescent; salt encrustations at the surface; clear, smooth boundary.
Bwk	12-37 cm	Dark greyish brown to very dark greyish brown (2.5Y 3.5/2M&R) clay; strong moderate subangular blocky structure with pressure faces on surface of peds; friable, sticky and plastic; many very fine and fine roots; a few very fine, fine and medium lime nodules; many very fine and fine pores; moderately alkaline (pH 8.2); slightly effervescent; clear, smooth boundary.
Bssk1	37-79 cm	Very dark greyish brown (2.5Y 3/2M) clay; strong moderate angular blocky structure with well developed wedge shaped aggregates and slickensides that break easily with slight pressure due to the wetness of the profile into small angular peds; friable, very sticky and very plastic; a few very fine roots; a few very fine and fine, common medium lime nodules; mildly alkaline (pH 7.8); slightly effervescent; gradual smooth boundary.
Bssk2	79-110 cm	Very dark grey to very dark greyish brown (2.5Y 3/1.5M) clay; strong moderate angular blocky structure with well developed wedge shaped aggregates and slickensides that break easily with slight pressure due to wetness of the profile into small angular peds; friable, very sticky and very plastic; few very fine roots; few very fine and fine, common medium lime nodules; moderately alkaline (pH 8.0); slightly effervescent.
W	110+ cm	Seepage water from nearby canal has been available since 2 years.

Series: BHATUMBRA BM SPOT: 22 (BLACK SOILS)

PROFILE NO: P42 ***System:Agriculture (Sorghum+Pigeonpea/Blackgram–Chickpea)*****(FM)**

CLIMATE: SEMI-ARID (MOIST) RAINFALL: 977 mm	Classification: Very fine, smectitic, isohyperthermic,*Udic Haplusterts*.	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Bhatumbra, Bhakli (Tah), Bidar, Karnataka		*Sampling Date: 04.01.2002*

Morphological Properties of Profile No. 42 (Bhatumbra, Bhakli, Bidar)

Horizon	Depth (cm)	Boundary		Matrix color		Texture	Coarse fragments (%) (fg and cg %)	Structure		
		D	*T*	Dry	Moist			Size	Grade	Type
Ap	0-12	c	s	-	2.5Y3/2	c	* 2-3	m	2	sbk
Bw	12-37	c	s	-	2.5Y3.5/2	c	2-3	m	3	sbk
Bss1	37-79	g	s	-	2.5Y3/2	c	3-5	m	3	abk
Bss2^{+}	79-110+	a	s	-	2.5Y3/1.5	c	3-5	m	3	abk

Depth (cm)	Consistence			Porosity		Nodules (conca)		Roots		Effervescence	Other features	Cracks
	Dry	Moist	Wet	S	Q	Size	Quantity	Size	Quantity	Dil HCl		
0-12	-	fr	sp	vf f	m	vf,f; m	f; f	vf,f	m	es-e**	-	Not
12-37	-	fr	sp	vf,f	m	vf,f,m	f	vf,f	m	e	Pressure faces	observed
37-79	-	fr	vsvp	vf,f	m	vf,f; m	f; c	-	-	e	Slickensides	
79-110+	-	fr	vsvp	-	-	vf,f; m	f; c	-	-	e	Slickensides	

cg - are mainly basaltic gravels and stones*
*** Matrix effervescence was also observed. Salt encrustations at the surface*
+ Water below 110 cm depth due to irrigation
(++) *Due to moistness of the profile, the sizes and grades are lower, may be higher when dry*

Please refer Appendix I for the abbreviations

Series: BHATUMBRA BM SPOT: 22 (BLACK SOILS)

PROFILE NO: P42 ***System:Agriculture (Sorghum+Pigeonpea/Blackgram–Chickpea)*****(FM)**

CLIMATE: SEMI-ARID (MOIST) RAINFALL: 977 mm	Classification: Very fine, smectitic, isohyperthermic,*Udic Haplusterts*.	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Bhatumbra, Bhakli (Tah), Bidar, Karnataka		*Sampling Date: 04.01.2002*

Physical Properties of Profile No. 42 (Bhatumbra, Bhakli, Bidar)

Laboratory No.	Horizon	Depth (cm)	Size class and particle diameter (mm)			Fine clay (%) (<0.0002)	Fine clay/ total clay (%)
			Total				
			Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)		
			←----------(% of <2 mm) ----------→				
3402	Ap	0-12	3.6	36.3	60.1	25.3	42.1
3403	Bw	12-37	5.2	35.8	59.0	27.4	46.4
3404	Bssk1	37-79	5.6	33.8	60.6	34.6	57.1
3405	Bssk2	79-110	4.5	25.9	69.6	45.3	65.1

Depth (cm)	BD (Mgm^{-3})	COLE	HC ($cmhr^{-1}$)	WDC (%)
0-12	1.3	0.3	1.3	13.3
12-37	1.4	0.2	0.7	14.0
37-79	1.3	0.2	0.5	12.3
79-110	1.3	0.3	0.6	16.6

Series: BHATUMBRA BM Spot: 5 (BLACK SOILS)

Profile No: P42 ***System: Agriculture (Sorghum+Pigeonpea/Blackgram/Chickpea*)(FM)**

CLIMATE: SEMI-ARID (MOIST) RAINFALL: 977 mm	Classification: Very fine, smectitic, isohyperthermic,*Udic Haplusterts*.	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Bhatumbra, Bhakli (Tah), Bidar, Karnataka		*Sampling Date: 04.01.2002*

Chemical Properties of Profile No. 42

Depth (cm)	pH (1:2)		EC (1:2) (dSm^{-1})	OC (%)	$CaCO_3$ (%)	Clay CO_3 (%)
	H_2O	1*N* KCl				
0-12	8.2	6.8	0.40	1.0	9.0	3.4
12-37	8.2	6.6	0.20	0.8	10.2	3.3
37-79	7.8	6.5	0.26	0.9	10.0	3.3
79-110	8.0	6.8	0.13	0.6	10.8	3.8

Depth (cm)	Extractable bases				CEC	Clay CEC	BS (%)	ESP
	Ca	Mg	Na	K				
	----------[cmol(p+)kg^{-1}]----------							
0-12	29.1	24.8	2.6	0.8	58.6	97	98	4
12-37	33.7	21.4	2.3	0.3	58.6	99	98	4
37-79	20.7	24.4	2.0	0.3	49.8	82	95	4
79-110	20.1	38.8	2.0	0.4	63.0	90	97	3

- *Nil or not determined (wherever applicable)*

Series: BHATUMBRA BM SPOT: 22 (BLACK SOILS)

PROFILE NO: P42 ***System:Agriculture (Sorghum+Pigeonpea/Blackgram–Chickpea)*****(FM)**

CLIMATE: SEMI-ARID (MOIST) RAINFALL: 977 mm	Classification: Very fine, smectitic, isohyperthermic,*Udic Haplusterts*.	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Bhatumbra, Bhakli (Tah), Bidar, Karnataka		*Sampling Date: 04.01.2002*

Saturation Extract Properties of Profile No. 42 (Bhatumbra, Bidar)

Depth (cm)	Sat (%)	ECe (d Sm^{-1})	Soluble cations ($mmol_c$ l^{-1})				Sum of cations
			Ca	Mg	Na	K	
0-12	54.50	0.40	2.20	1.50	8.90	0.08	12.70
12-7	89.40	0.70	1.10	0.60	3.60	0.09	5.40
37-79	97.00	0.40	1.10	0.80	4.00	0.07	6.00
79-110	68.44	0.30	0.70	0.90	1.00	0.03	2.60

Depth (cm)	Soluble anions ($mmol_c$ l^{-1})				Sum of anions
	CO_3	HCO_3	Cl	SO_4	
0-12	-	1.50	5.00	6.20	12.70
12-7	-	1.50	2.50	1.40	5.40
37-79	0.50	1.50	2.50	1.50	6.00
79-110	-	1.80	0.80	-	2.60

- *Nil or not determined (wherever applicable)*

Series: BHATUMBRA BM SPOT: 22 (BLACK SOILS)

PROFILE NO: P42 *System: Agriculture (Sorghum+Pigeonpea/Blackgram–Chickpea)*(FM)

CLIMATE: SEMI-ARID (MOIST) RAINFALL: 977 mm	Classification: Very Fine, smectitic, isohyperthermic,*Udic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Bhatumbra, Bhakli (Tah), Bidar, Karnataka		*Sampling Date: 04.01.2002*

Characterization of Landuse Types

S. No.	Attribute		Description
1	Production system	:	Irrigated (canal) multiple cropping of blackgram (*kharif*) – chickpea (*rabi*) – sorghum + pigeonpea (intercropping) (2-year rotation) with 3-5 months fallow. Crop-based farming system. Yield range: Blackgram- 1000 kg ha^{-1} Chickpea- 600 –700 kg ha^{-1} Sorghum -1000 kg (as intercrop) Pigeonpea 600-700 kg ha^{-1} as intercrop
2	Management level	:	• Improved seeds • Chemical fertilizer, pesticides or organic manures: Nil (although manures & fertilizers were regularly applied till 6-7 year ago) • Conservation or residue management: Nil • Insecticides • Sowing time: Blackgram/sorghum/pigeonpea-1st week of July, chickpea- 1st fortnight of November • Seed rate: Blackgram 18-20 kg ha^{-1} Chickpea 60-70 kg ha^{-1} Sorghum 6-8 kg ha^{-1} Pigeonpea (as intercrop) 4-5 kg ha^{-1}
3	Power source	:	Animal drawn implements
4	Market orientation	:	Subsistence + commercial (intermediate)
5	Capital intensity	:	Low with no access to institutional credit
6	Labour intensity	:	Low, limited to family labour
7	Land holding	:	Small, consolidated (additional area of 3 acres leased out)
8	Income level	:	Low

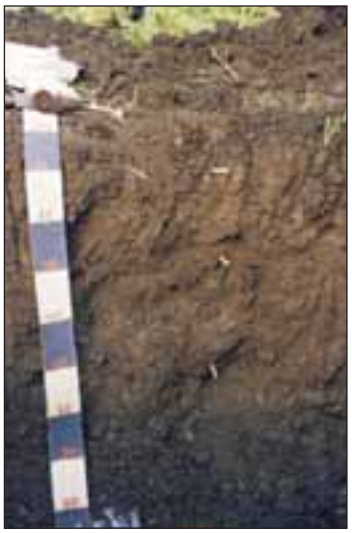
Climatic Datasets of Bhatumbra, Bidar District, Karnataka

Month	Mean temp (^oC)	Rainfall (mm)	PET (mm)	½PET (mm)	LGP (days)
January	22.40	2.00	121.60	60.80	0.00
February	24.90	7.20	138.40	69.20	0.00
March	28.20	16.70	183.70	91.85	0.00
April	30.70	27.30	191.70	95.85	0.00
May	32.30	29.20	216.70	108.35	0.00
June	28.10	146.60	172.60	86.30	30.00
July	25.10	243.30	135.10	62.55	31.00
August	24.80	186.30	127.80	63.90	31.00
September	24.90	211.50	115.80	57.90	30.00
October	25.00	73.60	126.80	63.40	0.00
November	22.90	29.90	113.90	56.95	0.00
December	21.60	3.40	109.00	54.50	0.00
Average	25.90				
Total		977.00	1753.10	871.55	*122.00*

Landscape, Landuse and Soils in BM Spot 22 (Bhatumbra, Bidar, Karnataka)




Benchmark spot at Bhatumbra, Bidar, Karnataka, under agricultural system (farmers' management) with sorghum + pigeonpea/blackgram-chickpea crop rotation



Typical Bhatumbra profile (Typic Haplusterts). Closer view of the profile Seepage water at 110 cm depth

Closer view of the profile

3A. BLACK SOILS

3Ad. Black soils of semi-arid (dry) bioclimatic system

(MAR : 850 - 550 mm)

- **Benchmark Spots: 6, 9, 14, 16, 18, 20, 23, 24, 25**

- **No. of Pedons: 17 (P13, P14, P19, P20, P21, P29, P32, P33, P35, P36, P39, P40, P43, P44, P45, P46, P47)**

BM Spot 6 : PARAL: Agriculture System (Cotton+Pigeonpea/Sorghum) (LM) P13

Classification : Very fine, smectitic, hyperthermic, *Sodic Haplusterts*

Location : Vill. Parala (Paral), Akot, Akola, M.S. Lat. 20°57'04"N, Long 76°57'05"E

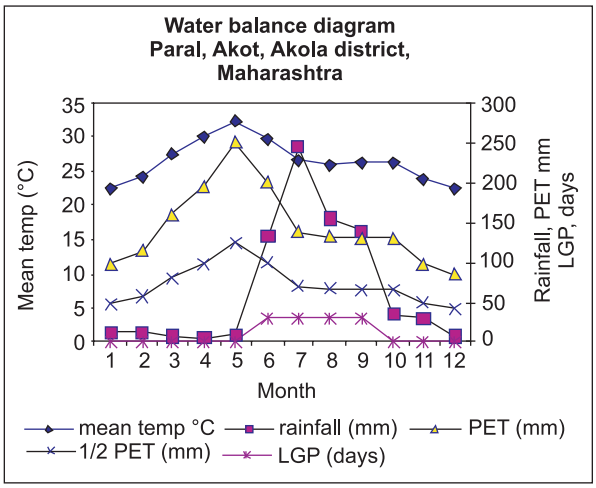
Physiographic position : Lower Maharashtra Deccan Plateau

Topography and slope : Nearly level to very gently sloping, 0-1% (50-150 m)

Drainage : Imperfectly drained

Vegetation : Acacia, *neem*, *ber*, *kans*, *dub*

Landuse : Cotton+pigeonpea, sorghum



Parent material : Basaltic alluvium

Sampled by : D.K. Pal, P. Chandran, S.K. Ray, M.V. Venugopalan, S.L. Durge, S.R. Bhuse

Date of collection: 19-01-2001

Remarks : This field represents farmers' practice with a low management. Vertical cracks are ~6 cm wide up to 15 cm, ~4 cm wide up to 70 cm, 0.5 to 1 cm wide up to 130 cm and <0.5 cm wide up to 145 cm depth

Ap	0-9 cm	Dark brown (7.5YR 3/2M) clay; moderate medium subangular blocky structure; friable, sticky and plastic; common very fine and fine, a few medium and coarse roots; common very fine and fine lime nodules; many very fine and fine pores; moderately alkaline (pH 8.0); strongly effervescent; clear, smooth boundary.
Bw1	9-35 cm	Very dark brown (7.5YR 2.5/2M) clay; moderate medium subangular blocky structure in pressure faces on ped surfaces; friable, sticky and plastic; common very fine and fine, a few medium roots; common very fine and fine lime nodules; moderately alkaline (pH 8.2); strongly effervescent; gradual smooth boundary.
Bss1	35-69 cm	Very dark brown (7.5YR 2.5/2M) clay; strong medium angular blocky structure with weakly developed wedge-shaped aggregates and slickensides that break into small angular peds; slightly firm, sticky and plastic; common very fine and fine, a few medium roots; common very fine and fine lime nodules; moderately alkaline (pH 8.4); strongly effervescent; gradual smooth boundary.
Bss2	69-105 cm	Very dark brown (7.5YR 2.5/2M) clay; strong, coarse angular blocky and columnar structure with well developed wedge-shaped aggregates and slickensides that break into small angular peds; firm, very sticky and very plastic; common very fine and fine roots; common very fine and fine lime nodules; moderately alkaline (pH 8.4); strongly effervescent; gradual wavy boundary.
Bss3	105-132 cm	Very dark brown (7.5YR 2.5/2M) clay; strong, coarse angular blocky and columnar structure with well developed wedge-shaped aggregates and slickensides that break into small angular peds; firm, very sticky and very plastic; common very fine and fine roots; common very fine and fine lime nodules; strongly alkaline (pH 8.5); strongly effervescent; gradual wavy boundary.
Bss4	132-150+ cm	Very dark brown (7.5YR 2.5/2M) clay; strong, coarse angular blocky and columnar structure with well developed wedge-shaped aggregates and slickensides that break into small angular peds; firm, sticky and plastic; few very fine and fine roots; many very fine and fine lime nodules; strongly alkaline (pH 8.5); strongly effervescent.

Series: PARAL **BM Spot: 6 (BLACK SOILS)**

Profile No: P13 ***System: Agriculture (Cotton+Pigeonpea / Sorghum*) (LM)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 793 mm	Classification : Very fine, smectitic hyperthermic, *Sodic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Paral (Parala), Akot, Akola, Maharashtra		Sampling Date : 19.01.2001

Morphological Properties of Profile No. 13 (Paral, Akola)

Horizon	Depth (cm)	Boundary		Matrix color		Texture	Coarse fragments (%) (fg and cg)	Structure		
		D	T	Dry	Moist			Size	Grade	Type
Ap	0-9	c	s	-	7.5YR3/2	c	5-8	m	2	sbk
Bw1	9-35	g	s	-	7.5YR2.5/2	c	5-8	m	3	sbk
Bss1	35-69	g	s	-	7.5YR2.5/2	c	5-8	m	3	abk
Bss2	69-105	g	w	-	7.5YR2.5/2	c	5-8	c	3	abk
Bss3	105-132	g	w	-	7.5YR2.5/2	c	5-8	c	3	abk
Bss4	132-150	-	-	-	7.5YR2.5/2	c	8-10	c	3	abk

Depth (cm)	Consistence			Porosity		Nodules (conca)		Roots		Effervescence	Other features	Cracks
	Dry	Moist	Wet	S	Q	Size	Quantity	Size	Quantity	dil HCl		
0-9	-	fr	sp	v f,f	m	vf,f	c	vf,f; m, c	c; f	es	-	6 cm
9-35	-	fr	sp	-	-	vf,f	c	vf,f; m	c; f	es	Pressure faces	4 cm
35-69	-	fi	svp	-	-	vf,f	c	vf,f; m	c; f	es	Slickensides (Weak)	
69-105	-	fi	vsvp	-	-	vf,f	c	vf,f	c	es	Slickensides	1 cm
105-132	-	fi	vsvp	-	-	vf,f	c	vf,f	c	es	Slickensides	
132-150	-	fi	vsvp	-	-	vf,f	m	vf ,f	f	es	Slickensides	0.5 cm

**Cracks <1 cm wide up to 35 cm and <0.5 cm wide up to 50 cm*
***Matrix effervescence*

Please refer Appendix I for the abbreviations

Series: PARAL **BM Spot: 6 (BLACK SOILS)**

Profile No: P13 ***System: Agriculture (Cotton+Pigeonpea / Sorghum*) (LM)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 793 mm	Classification : Very fine, smectitic hyperthermic, *Sodic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Paral (Parala), Akot, Akola, Maharashtra		Sampling Date : 19.01.2001

Physical Properties of Profile No. 13 (Paral, Akola)

Laboratory No.	Horizon	Depth (cm)	Size class and particle diameter (mm)			Fine clay (%) (<0.0002)	Fine clay/ total clay (%)
			Total				
			Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)		
			←----------(% of <2 mm) ----------→				
3130	Ap	0-9	2.5	42.2	55.3	22.6	40.9
3131	Bw1	9-35	0.9	40.2	58.9	30.7	52.1
3132	Bss1	35-69	2.6	40.5	56.9	29.5	51.8
3133	Bss2	69-105	1.6	35.7	62.6	35.6	56.9
3134	Bss3	105-132	1.0	37.3	61.8	37.6	60.8
3135	Bss4	132-150	0.5	43.1	56.3	37.6	66.8

Depth (cm)	BD (Mgm^{-3})	COLE	HC ($cmhr^{-1}$)	WDC (%)
0-9	-	0.2	1.7	4.1
9-35	1.6	0.2	0.5	4.0
35-69	1.5	0.2	0.2	6.1
69-105	-	0.2	0.1	7.2
105-132	1.5	0.2	0.1	8.6
132-150	1.5	0.2	0.1	6.2

- *Nil or not determined (wherever applicable)*

Series: PARAL BM Spot: 6 (BLACK SOILS)

Profile No: P13 ***System: Agriculture (Cotton+Pigeonpea / Sorghum*) (LM)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 793 mm	Classification : Very fine, smectitic hyperthermic, *Sodic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Paral (Parala), Akot, Akola, Maharashtra		Sampling Date : 19.01.2001

Chemical Properties of Profile No. 13 (Paral, Akola)

Depth (cm)	pH (1:2)		EC (1:2) (dSm^{-1})	OC (%)	$CaCO_3$ (%)	Clay CO_3* (%)
	H_2O	1*N* KCl				
0-9	8.0	6.7	0.18	0.7	9.7	1.9
9-35	8.2	6.7	0.21	0.6	10.0	2.3
35-69	8.4	6.7	0.30	0.6	10.2	3.0
69-105	8.4	6.8	0.39	0.6	10.4	2.8
105-132	8.5	6.8	0.25	0.6	10.2	3.9
132-150	8.5	6.8	0.62	0.5	11.8	2.9

Depth (cm)	Extractable bases				CEC	Clay CEC	BS (%)	ESP
	Ca	Mg	Na	K				
	← ----------[cmol(p+)kg^{-1}]----------→							
0-9	36.3	7.6	0.7	1.2	54.4	98	84	1
9-35	32.2	9.2	2.3	0.9	56.5	96	79	4
35-69	28.5	11.0	3.9	0.9	47.8	84	92	8
69-105	28.2	13.9	7.4	0.9	51.8	83	97	14
105-132	23.7	14.6	8.8	0.9	52.5	85	91	17
132-150	18.9	14.5	9.1	0.8	43.3	77	100	21

* *Percent of water dispersible clay size carbonate*

Series: PARAL **BM Spot: 6 (BLACK SOILS)**

Profile No: P13 ***System: Agriculture (Cotton+Pigeonpea / Sorghum*) (LM)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 793 mm	Classification : Very fine, smectitic hyperthermic, *Sodic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Paral (Parala), Akot, Akola, Maharashtra		Sampling Date : 19.01.2001

Saturation Extract Properties of Profile No. 13 (Paral, Akola)

Depth (cm)	Sat (%)	ECe ($d\ Sm^{-1}$)	Soluble cations ($mmol_c\ l^{-1}$)				Sum of cations
			Ca	Mg	Na	K	
0-9	61.00	0.38	1.08	0.62	0.87	0.12	2.69
9-35	65.55	0.41	0.48	0.74	1.74	0.02	2.98
35-69	73.56	2.89	0.65	0.86	73.04	0.18	74.73
69-105	75.26	4.04	0.57	0.48	202.17	0.35	203.57
105-132	-	-	-	-	-	-	-
132-150	-	-	-	-	-	-	-

Depth (cm)	Soluble anions ($mmol_c\ l^{-1}$)				Sum of anions
	CO_3	HCO_3	Cl	SO_4	
0-9	-	1.75	0.50	0.44	2.69
9-35	-	2.12	0.40	0.46	2.98
35-69	-	74.00	0.40	0.30	74.70
69-105	-	202.29	0.50	0.78	203.57
105-132	-	-	-	-	-
132-150	-	-	-	-	-

- *Nil or not determined (wherever applicable)*

Series: PARAL **BM Spot: 6 (BLACK SOILS)**

Profile No: P13 ***System: Agriculture (Cotton+Pigeonpea / Sorghum*) (LM)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 794 mm	Classification : Very fine, smectitic hyperthermic, *Sodic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Paral (Parala), Akot, Akola, Maharashtra		Sampling Date : 19.01.2001

Characterization of Landuse Types

S. No.	Attribute		Description
1	Production system	:	Rainfed intercropping system of cotton (8R) + sorghum (2R) + pigeonpea (1R), crop livestock farming system, 5-6 months of fallow period (summer) Yield range: Cotton (hybrid) 200-250 kg ha^{-1} Sorghum 150-200 kg ha^{-1} Pigeonpea 50 kg ha^{-1}
2	Management level	:	• Improved varieties of cash crop only • Organic manure: Nil • Fertilizer: 40-60 kg N/ha and 30-40 kg P_2O_5/ha with no amendments • Conservation measures: Nil • Insecticides: Regular • Sowing time: 26^{th} met. week • Seed rate: Cotton 1 kg ha^{-1} Sorghum 3-5 kg ha^{-1} Pigeonpea (as intercrop) 2-2.5 kg ha^{-1}
3	Power source	:	Borrowed animal traction and implements
4	Market orientation	:	Primarily subsistence, commercial limited to sale of cotton
5	Capital intensity	:	Low with low risk taking ability
6	Labor intensity	:	Low, limited to family labor
7	Land holding	:	Small, consolidated
8	Income level	:	Low

Climatic Datasets of Paral, Akola District, Maharashtra

Month	Mean temp (^oC)	Rainfall (mm)	PET (mm)	½ PET (mm)	LGP (days)
January	22.50	12.70	97.00	48.50	0.00
February	24.20	11.90	114.00	57.00	0.00
March	27.40	7.10	161.00	80.50	0.00
April	30.10	4.60	194.00	97.00	0.00
May	32.30	10.40	250.00	125.00	0.00
June	29.80	132.60	200.00	100.00	30.00
July	26.60	246.10	138.00	69.00	31.00
August	26.00	156.10	133.00	66.50	31.00
September	26.30	139.10	129.00	64.50	30.00
October	26.20	34.50	130.00	65.00	0.00
November	23.80	29.20	98.00	49.00	0.00
December	22.40	8.40	86.00	43.00	0.00
Average	26.46				
Total		792.70	1730.00	865	122.00

Landscape, Landuse and Soils in Benchmark Spot 6 (Paral, Akola)

Site for Paral soil under agricultural system (low management) with cotton + pigeonpea/sorghum crop rotation

Typical degraded black soil of Paral profile (Sodic Haplusterts)

BM Spot 6 : PARAL: Agriculture System (Cotton, Greengram+ Pigeonpea/Sorghum) (HM) P14

Classification : Very fine, smectitic, hyperthermic, *Sodic Haplusterts*

Location : Vill. Parala (Paral), Akot, Akola, M.S. Lat. 20°56'48"N, Long 76°58'30"E

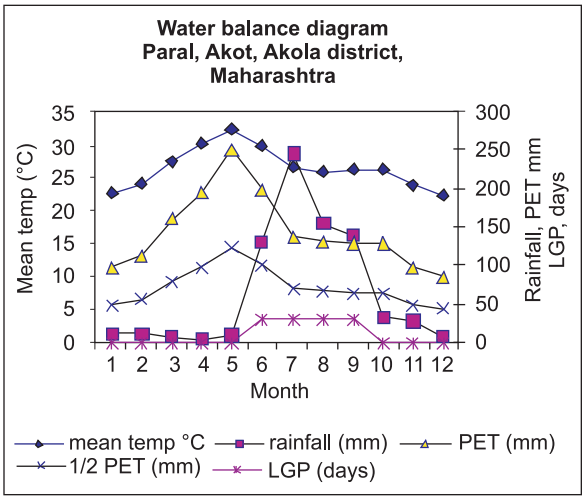
Physiographic position : Lower Maharashtra Deccan Plateau

Topography and slope: Nearly level, 0-1% (50-150 m)

Drainage : Imperfectly drained

Vegetation : Acacia, *neem*, *godan*, *kans*, *dub*

Landuse : Cotton + pigeonpea/sorghum



Parent material : Basaltic alluvium

Sampled by : D.K. Pal, P. Chandran, S.K. Ray, M.V. Venugopalan, S.L. Durge, S.R. Bhuse

Date of collection : 19-01-2002

Remarks : No irrigation due to strongly alkaline nature of well water. Vertical cracks are 5-6 cm wide up to 40 cm, 2-3 cm wide up to 70 cm, 1-2 cm wide up to 100 cm and <1 cm wide cracks up to 148 cm depth.

Ap	0-8 cm	Very dark grey (7.5YR 3/1M) clay; moderate medium subangular blocky structure; friable, sticky and plastic; common very fine and fine, a few medium roots; common very fine and fine lime nodules; many very fine and fine pores; moderately alkaline (pH 7.9); strongly effervescent; clear, smooth boundary.
Bw1	8-35 cm	Very dark grey to dark brown (7.5YR 3/1.5M) clay; strong medium subangular blocky structure with pressure faces on ped surfaces; friable, very sticky and very plastic; common very fine and fine, a few medium roots; common very fine and fine lime nodules; many very fine and fine pores; moderately alkaline (pH 8.3); strongly effervescent; gradual smooth boundary.
Bss1	35-68 cm	Very dark grey to dark brown (7.5YR 3/1.5M) clay; strong medium angular blocky and columnar structure with well developed wedge-shaped aggregates and slickensides that break into small angular peds; firm, very sticky and very plastic; common very fine and fine roots; common very fine and fine lime nodules; moderately alkaline (pH 8.4); strongly effervescent; gradual smooth boundary.
Bss2	68-97 cm	Very dark grey to dark brown (7.5YR 3/1.5M) clay; strong, coarse angular blocky and columnar structure with well developed wedge-shaped aggregates and slickensides at angles of 40-45o from the horizontal and that break into small angular peds; firm, very sticky and very plastic; common very fine and fine roots; common very fine and fine lime nodules; strongly alkaline (pH 8.5); strongly effervescent; gradual wavy boundary.
Bss3	97-129 cm	Dark brown (7.5YR 3/2M) and very dark brown (7.5YR 2.5/2) clay; strong, coarse angular blocky and columnar structure with well developed wedge-shaped aggregates and slickensides at angles of 40-45 degree from horizontal and that break into small angular peds; firm, very sticky and very plastic; a few very fine and fine roots; strongly alkaline (pH 8.5); strongly effervescent; gradual wavy boundary.
Bss4	129-150 cm	Dark brown (7.5YR 3/2M) clay; strong, coarse angular and columnar blocky structure with well developed wedge-shaped aggregates and slickensides at angles of 40-45 degree from horizontal and that breaks into small angular peds; slightly firm, very sticky and very plastic; a few very fine and fine roots; slightly alkaline (pH 8.6); strongly effervescent.

Series: PARAL **BM Spot: 6 (BLACK SOILS)**

Profile No: P14 ***System: Agriculture (Cotton+Pigeonpea / Sorghum*) (HM)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 793 mm	Classification: Very fine, smectitic, hyperthermic, *Sodic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Paral (Parala), Akot, Akola, Maharashtra		Sampling Date : 19.01.2001

Morphological Properties of Profile No. 14 (Paral, Akola)

Horizon	Depth (cm)	Boundary		Matrix Color		Texture	Coarse fragments (%) (fg and cg)	Structure		
		D	T	Dry	Moist			Size	Grade	Type
Ap	0-8	c	s	-	7.5YR3/1	c	5-8	m	2	sbk
Bw	8-35	g	s	-	7.5YR3/1.5	c	5-8	m	3	sbk
Bss1	35-68	g	s	-	7.5YR3/1.5	c	5-8	m	3	abk
Bss2	68-97	g	w	-	7.5YR3/1.5	c	5-8	c	3	abk
Bss3	97-129	g	w	-	7.5YR3/2	c	5-8	c	3	abk
Bss4	129-150	-	-	-	7.5YR3/2	c	8-10	c	3	abk

Depth (cm)	Consistence			Porosity		Nodules (conca)		Roots		Effervescence	Other features	Cracks
	Dry	Moist	Wet	S	Q	Size	Quantity	Size	Quantity	dil HCl		
0-8	-	fr	sp	vf,f	m	vf,f	c	vf,f; m	c; f	es	-	5-6 cm
8-35	-	fr	sp	-	-	vf,f	c	vf,f; m	c; f	es	Pressure faces	40 cm
35-68	-	fi	vsvp	-	-	vf,f	c	vf,f	c	es	Slickensides	2-3 cm
68-97	-	fi	vsvp	-	-	vf,f	c	vf,f	c	es	Slickensides	1-2 cm
97-129	-	fi	vsvp	-	-	vf,f	c	vf,f	f	es	Slickensides	1 cm
129-150	-	fi	sp	-	-	vf,f	m	vf,f	f	es	Slickensides	

**Cracks 5-6 cm wide up to 40 cm,2-3 cm wide up to 70 cm, 1-2 cm wide upto 100 cm and <1 cm wide upto 148 cm*
***Matrix effervescence*

Please refer Appendix 1 for the abbreviations

Series: PARAL **BM Spot: 6 (BLACK SOILS)**

Profile No: P14 ***System: Agriculture (Cotton+Pigeonpea / Sorghum*) (HM)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 793 mm	Classification: Very fine, smectitic, hyperthermic, *Sodic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Paral (Parala), Akot, Akola, Maharashtra		Sampling Date : 19.01.2001

Physical Properties of Profile No. 14 (Paral, Akola)

Laboratory No.	Horizon	Depth (cm)	Size class and particle diameter (mm)			Fine clay (%) (<0.0002)	Fine clay/ total clay (%)
			Total				
			Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)		
			←----------(% of <2 mm) ----------→				
3136	Ap	0-8	1.7	39.3	59.0	19.9	33.7
3137	Bw1	8-35	0.5	35.6	63.9	36.0	56.3
3138	Bss1	35-68	0.6	35.0	64.4	37.6	58.3
3139	Bss2	68-97	0.5	36.1	63.4	40.2	63.4
3140	Bss3	97-129	0.6	36.1	63.3	43.4	68.6
3141	Bss4	129-150	0.5	37.7	61.8	39.3	63.6

Depth (cm)	BD (Mgm^{-3})	COLE	HC ($cmhr^{-1}$)	WDC (%)
0-8	-	0.2	1.3	3.8
8-35	1.6	0.2	0.6	5.1
35-68	1.6	0.2	0.2	7.4
68-97	1.6	0.2	0.1	17.6
97-129	1.6	0.2	0.1	15.0
129-150	-	0.2	0.1	12.6

- *Nil or not determined (wherever applicable)*

Series: PARAL BM Spot: 6 (BLACK SOILS)

Profile No: P14 ***System: Agriculture (Cotton+Pigeonpea / Sorghum*) (HM)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 793 mm	Classification: Very fine, smectitic, hyperthermic, *Sodic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Paral (Parala), Akot, Akola, Maharashtra		Sampling Date : 19.01.2001

Chemical Properties of Profile No. 14 (Paral, Akola)

Depth (cm)	pH (1:2)		EC (1:2) (dSm^{-1})	OC (%)	$CaCO_3$ (%)	Clay CO_3* (%)
	H_2O	1*N* KCl				
0-8	7.9	6.7	0.18	0.6	9.5	2.8
8-35	8.3	6.7	0.21	0.6	12.8	3.0
35-68	8.4	6.7	0.28	0.5	13.2	3.6
68-97	8.5	6.7	0.23	0.5	12.0	3.7
97-129	8.5	6.8	0.41	0.3	14.3	3.8
129-150	8.6	6.9	0.61	0.3	16.7	3.0

Depth (cm)	Extractable bases				CEC	Clay CEC	BS (%)	ESP
	Ca	Mg	Na	K				
	← ----------[cmol(p+)kg^{-1}]----------→							
0-8	36.4	8.7	0.5	1.3	48.4	82	97	1
8-35	30.8	12.4	2.1	0.8	47.5	74	97	4
35-68	29.0	13.4	3.6	0.9	48.4	75	97	7
68-97	27.1	14.3	3.8	0.9	48.1	76	96	8
97-129	22.6	15.6	4.3	0.9	43.8	69	99	10
129-150	19.3	16.1	8.5	0.8	44.8	73	99	19

* *Percent of water dispersible clay size carbonate*

Series: PARAL BM Spot: 6 (BLACK SOILS)

Profile No: P14 ***System: Agriculture (Cotton+Pigeonpea / Sorghum*) (HM)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 794 mm	Classification: Very fine, smectitic, hyperthermic, *Sodic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Paral (Parala), Akot, Akola, Maharashtra		Sampling Date : 19.01.2001

Characterization of Landuse Types

S. No.	Attribute		Description
1	Production system	:	Rain-fed intercropping system of cotton (1) + greengram (1): pigeonpea (8:1) single season (*kharif*), extensive, crop livestock farming system, 5-6 months fallow (summer) Yield range: 900-1000 kg ha^{-1} cotton 300-400 kg ha^{-1} green gram 200-250 kg pigeonpea
2	Management level	:	• Improved varieties of cotton, green gram and pigeonpea • Manures: 12-15 tonnes FYM/ha once in 4 year • Chemical fertilizer: N-70 kg ha^{-1}, P_2O_5 50 kg ha^{-1} per year • Amendments: Nil • Conservation measures: Limited to leveling and bunding • Residues: Burnt (on field bunds or used as fuel) • Insecticides: Frequently used • Sowing time: 26^{th} met. week • Seed rate: Cotton: 2 kg ha^{-1} Green gram: 4-5 kg ha^{-1} Pigeonpea: 2-3 kg ha^{-1}
3	Power source	:	Mechanical tractor supplemented with bullock (animal) traction and usage of improved implements
4	Market orientation	:	Cotton for commercial and pulses for home consumption
5	Capital intensity	:	High with easy access to credit
6	Labor intensity	:	Medium and includes family labor
7	Land holding	:	Large, unconsolidated
8	Income level	:	High

Climatic Datasets of Paral, Akola District, Maharashtra

Month	Mean temp (^oC)	Rainfall (mm)	PET (mm)	½PET (mm)	LGP (days)
January	22.50	12.70	97.00	48.50	0.00
February	24.20	11.90	114.00	57.00	0.00
March	27.40	7.10	161.00	80.50	0.00
April	30.10	4.60	194.00	97.00	0.00
May	32.30	10.40	250.00	125.00	0.00
June	29.80	132.60	200.00	100.00	30.00
July	26.60	246.10	138.00	69.00	31.00
August	26.00	156.10	133.00	66.50	31.00
September	26.30	139.10	129.00	64.50	30.00
October	26.20	34.50	130.00	65.00	0.00
November	23.80	29.20	98.00	49.00	0.00
December	22.40	8.40	86.00	43.00	0.00
Average	26.46				
Total		792.70	1730.00	865	122.00

Landscape, Landuse and Soils in Benchmark Spot 6 (Paral, Akola)

Land (under cotton cultivation) in Paral soil under agricultural system with high management

Typical black soil profile of Paral series (Sodic Haplusterts)

A closer view of the soil profile

Huge chunk of soil clod showing slickensided surface in Paral series

BM Spot 9 : KOVILPATTI: Agriculture System (Sorghum-Cotton, 2 year rotation) (ORG) P19

Classification: Very fine, smectitic, isohyperthermic, Gypsic Haplusterts

Location: TNAU farm area, Kovilpatti, Toothokudi, Tamil Nadu, Lat 09°12'18"N, Long 77°52'40"E

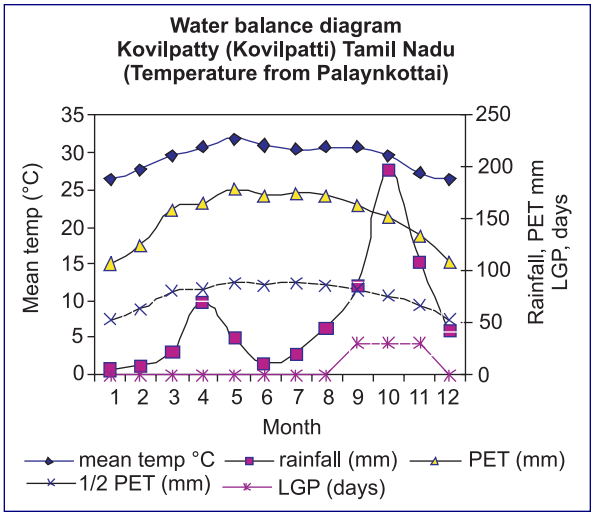
Physiographic position: Riverine landform

Topography and slope: Very gently sloping, 1-3% (50-150 m)

Drainage: Moderately well drained

Vegetation: *Neem*, prosopis, tamarind, parthenium grasses and shrubs

Landuse : Sorghum/cotton (2 yr rotation), sunflower, soybean, blackgram



Parent material: Granites-gnesisses and mixed alluvium

Sampled by: T. Bhattacharyya, P. Chandran, S.K. Ray, M. V. Venugopalan, S.L. Durge, S.R. Bhuse

Date of collection: 14.02.2001

Remarks : Very fine cracks on the surface of the pedon which are polygonal and vertical. 128-140 cm layer and underlying layer have well crystallized gypsum conglomerated with lime. Can be cut with a spade and breakable with pressure by hand but hard when moist.

Ap1	0-6 cm	Very dark greyish brown (10YR 3/2R) clay; structureless fine granular structure; very friable sticky and plastic; many very fine and fine, a few medium roots; common very fine, a few fine lime nodules; many very fine and fine, common medium pores; moderately alkaline (pH 8.0); slightly effervescent; clear, smooth boundary.
Ap2	6-20 cm	Very dark greyish brown (10YR 3/2M) clay; moderate fine subangular blocky structure; very friable, sticky and plastic, many very fine and fine, a few medium roots; common very fine, a few fine lime nodules; moderately alkaline (pH 8.0); slightly effervescent; clear, smooth boundary.
Bw1	20-41 cm	Very dark grey to very dark greyish brown (10YR 3/1.5M) clay; weak medium subangular blocky structure with pressure faces on surface of peds; friable, very sticky and very plastic; common very fine and fine, a few medium roots; common very fine, a few fine lime nodules; moderately alkaline (pH 7.9); slightly effervescent; clear, smooth boundary.
Bw2	41-74 cm	Very dark grey to very dark greyish brown (10YR 3/1.5M) clay; weak medium subangular blocky to angular blocky structure with well developed pressure faces and weakly developed wedge-shaped aggregates and slickensides that break into small weak angular blocky peds; slightly friable; very moist; sticky and very plastic; common very fine and fine, common very fine and fine lime nodules; moderately alkaline (pH 8.0); slightly effervescent; gradual smooth boundary.

Bss1	74-104 cm	Very dark grey (10Y/R 3/1M) clay; strong, medium angular blocky (weak) structure with weak development of wedge-shaped aggregates and slickensides that break into small weak angular peds; slightly friable, very sticky and very plastic; few very fine, fine and medium roots; common very fine and fine, a few medium roots; moderately alkaline (pH 7.9); strongly effervescent; clear smooth boundary.
Bss2	104-118 cm	Very dark grey to very dark greyish brown (10YR 3/1.5M) clay; strong moderate angular blocky structure with wedge-shaped aggregates and slickensides that break into small angular peds; slightly friable, very sticky and very plastic; a few very fine roots; common very fine, fine and medium lime nodules; moderately alkaline (pH 7.9); violently effervescent; clear, smooth boundary.
BCky	118-128 cm	Greyish brown to dark greyish brown (10YR 4.5/2R) clay; weak medium subangular blocky structure; friable, very sticky and very plastic; a few very fine roots; mildly alkaline (pH 7.4); violently effervescent; abruptly smooth boundary.
2Cky	128-140+ cm	Light brownish grey (10YR 6/2R) silt loam; layer of gypsum and lime with very little soil; massive structure; mildly alkaline (pH 7.5); violently effervescent.

Series: KOVILPATTI BM Spot: 9 (BLACK SOILS)

Profile No: P19 ***System: Agriculture (Sorghum/Sunflower/Cotton-2 year Rotation)*** **(ORG)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 660 mm	Classification: Very Fine, smectitic, isohyperthermic, *Gypsic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: TNAU Res. Stn. Farm, Kovilpatti, Thoothukudi, Tamil Nadu		Sampling Date : 14.02.2001

Morphological Properties of Profile No. 19 (Kovilpatti, Thoothukudi)

Horizon	Depth (cm)	Boundary		Matrix color		Texture	Coarse fragments (%) (fg and cg)	Structure		
		D	T	Dry	Moist			Size	Grade	Type
Ap1	0-6	c	s		10YR3/2 (R)	c	3-5	F	0	gr
Ap2	6-20	c	s	-	10YR3/2	c	3-5	f	2	sbk
Bw1	20-41	c	s	-	10YR3/1.5	c	3-5	m	1	sbk
Bw2	41-74	g	s	-	10YR3/1.5	c	3-5	m	2	sbk
Bss1	74-104	c	s	-	10YR3/1	c	1-3	m	3	abk
Bss2	104-118	c	s	-	10YR3/1.5	c	5-8	m	3	abk
BCky	118-128	a	s	-	10YR4.5/2 (R)	c	5-8	m	1	sbk
2Cky	128-140	Gypsum + Carbonate			10YR4.6/2 (R)	-	-	massive		

Depth (cm)	Consistence			Porosity		Nodules (conca)		Roots		Effervescence*	Other Features	Cracks
	Dry	Moist	Wet	S	Q	Size	Quantity	Size	Quantity	dil HCl		
0-6	-	vfr	sp	vf,f; m	m; c	vf; f	c; f	vf,f; m	m; f	e	-	0.1-0.2 cm
6-20	-	fr	sp	-	-	vf; f	c; f	vf,f; m	m; f	e	-	10 cm
20-41	-	fr	sp	-	-	vf; f	c; f	vf,f; m	c; f	e	Pressure faces	
41-74	-	fr	vsvp	-	-	vf,f	c	vf,f	c	e	Slickensides (Weak)	
74-104	-	fr	vsvp	-	-	vf,f; m	c; f	vf,f,m	f	es	Slickensides	
104-118	-	fr	sp	-	-	vf,f; m	c	vf	f	ev	-	
118-128	-	-	-	-	-	-	-	-	-	ev	-	
128-140	Layer of gypsum and lime with very little soil											

Please refer Appendix I for the abbreviations

Series: KOVILPATTI BM Spot: 9 (BLACK SOILS)

Profile No: P19 ***System: Agriculture (Sorghum/Sunflower/Cotton-2 year Rotation)*** **(ORG)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 660 mm	Classification: Very Fine, smectitic, isohyperthermic, *Gypsic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: TNAU Res. Stn. Farm, Kovilpatti, Thoothukudi, Tamil Nadu		Sampling Date : 14.02.2001

Physical Properties of Profile No. 19 (Kovilpatti, Thoothukudi)

Laboratory No.	Horizon	Depth (cm)	Size class and particle diameter (mm)			Fine clay (%) (<0.0002)	Fine clay/ total clay (%)
			Total				
			Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)		
			←----------(% of <2 mm) ----------→				
3166	Ap1	0-6	22.8	21.0	56.2	31.9	56.8
3167	Ap2	6-20	17.6	20.8	61.6	44.3	72.0
3168	Bw1	20-41	15.6	19.3	65.1	46.3	71.0
3169	Bw2	41-74	15.0	19.3	65.7	50.3	76.5
3170	Bss1	74-104	13.0	20.1	66.9	50.8	76.0
3171	Bss2	104-118	10.2	17.7	72.1	60.0	83.2
3172	BCky	118-128	9.8	19.9	70.3	54.8	78.0
3173	2Cky	128-140+	22.9	52.4	24.7	10.2	41.3

Depth (cm)	BD (Mgm^{-3})	COLE	HC ($cmhr^{-1}$)	WDC (%)
0-6	-	0.2	1.9	11.5
6-20	1.2	0.2	2.2	12.0
20-41	1.4	0.2	4.5	16.5
41-74	1.5	0.2	3.0	12.3
74-104	1.4	0.2	3.8	20.7
104-118	1.4	0.3	3.5	20.1
118-128	-	0.2	3.2	12.8
128-140+	-	0.1	4.8	7.1

- *Nil or not determined (whenever applicable)*

Series: KOVILPATTI **BM Spot: 9 (BLACK SOILS)**

Profile No: P19 ***System: Agriculture (Sorghum/Cotton-2year rotation)*** **(ORG)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 660 mm	Classification: Very Fine, smectitic, isohyperthermic, *Gypsic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: TNAU Res. Stn. Farm, Kovilpatti, Thoothukudi, Tamil Nadu		Sampling Date : 14.02.2001

Chemical Properties of Profile No. 19 (Kovilpatti, Thoothukudi)

Depth (cm)	pH (1:2)		EC (1:2) ($d\ Sm^{-1}$)	OC (%)	$CaCO_3$ (%)	Clay CO_3* (%)
	H_2O	1*N* KCl				
0-6	8.0	6.7	0.10	0.3	5.4	2.7
6-20	8.0	6.7	0.13	0.4	4.3	2.5
20-41	7.9	6.6	0.16	0.4	5.3	2.7
41-74	8.0	6.5	0.16	0.3	7.9	2.8
74-104	7.9	6.5	0.17	0.3	12.5	3.4
104-118	7.9	6.6	0.11	0.3	12.8	3.2
118-128	7.4	6.7	1.86	0.3	15.6	3.1
128-140+	7.5	6.8	1.97	0.1	17.4	4.5

Depth (cm)	Extractable bases				CEC	Clay CEC	BS (%)	ESP
	Ca	Mg	Na	K				
	← ----------[cmol(p+)kg^{-1}]----------→							
0-6	47.3	11.3	0.3	0.7	60.9	108	98	0.6
6-20	48.2	13.1	0.3	0.6	56.7	92	110	0.5
20-41	50.8	14.2	0.4	0.4	65.2	100	101	0.6
41-74	50.6	18.0	0.6	0.4	63.0	96	110	1.0
74-104	53.7	15.3	0.8	0.4	71.7	107	98	1.1
104-118	55.5	14.0	0.9	0.5	65.2	90	109	1.4
118-128	57.2	12.3	1.0	0.5	54.4	77	131	1.9
128-140+	47.9	8.1	0.1	0.2	32.6	132	173	0.3

- *Nil or not determined (wherever applicable)*

Series: KOVILPATTI **BM Spot: 9 (BLACK SOILS)**

Profile No: P19 ***System: Agriculture (Sorghum/Sunflower/Cotton*) (ORG)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 660 mm	Classification: Very Fine, smectitic, isohyperthermic, *Gypsic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: TNAU Res. Stn. Farm, Kovilpatti, Thoothokodi, Tamil Nadu		Sampling Date : 14.02.2001

Saturation Extract Properties of Profile No. 19 (Kovilpatti, Thoothukudi)

Depth (cm)	Sat (%)	ECe ($d\ Sm^{-1}$)	Soluble cations ($mmol_c\ l^{-1}$)				Sum of cations
			Ca	Mg	Na	K	
0-6	65.17	0.25	3.27	3.52	0.76	0.01	7.56
6-20	65.59	0.31	1.43	0.53	0.87	0.07	2.90
20-41	72.62	0.47	2.39	1.64	1.96	0.07	6.06
41-74	76.52	0.36	1.48	0.72	1.09	0.02	3.31
74-104	73.71	0.25	0.92	0.58	1.09	0.02	2.61
104-118	69.88	0.63	3.16	1.51	2.16	0.02	6.85
118-128	83.78	2.72	3.22	3.77	4.10	0.07	11.16
128-140	-	-	-	-	-	-	-

Depth (cm)	Soluble anions ($mmol_c\ l^{-1}$)				Sum of anions
	CO_3	HCO_3	Cl	SO_4	
0-6	1.06	0.85	0.46	5.19	7.56
6-20	1.49	0.63	0.50	0.28	2.90
20-41	3.82	0.53	0.50	1.21	6.06
41-74	1.61	0.53	0.70	0.47	3.31
74-104	1.06	0.53	0.40	0.62	2.61
104-118	1.06	0.53	0.50	4.76	6.85
118-128	1.06	0.53	0.49	9.08	11.16
128-140	-	-	-	-	-

- *Nil or not determined (wherever applicable)*

Series: KOVILPATTI **BM Spot: 9 (BLACK SOILS)**

Profile No: P19 ***System: Agriculture (Sorghum/Sunflower/Cotton*) (ORG)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 660 mm	Classification: Very fine, smectitic, isohyperthermic, *Gypsic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: TNAU Res. Stn. Farm, Kovilpatti, Thoothukudi, Tamil Nadu		Sampling Date : 14.02.2001

Characterization of Landuse Types

S. No.	Attribute		Description
1	Production system	:	Rain-fed cotton-sorghum (2 year rotation) during winter (NE monsoon) season and 5-6 months of summer fallow Yield range: 75-200 kg cotton/ha 700-1000 kg sorghum/ha
2	Management level	:	• Improved varieties of cotton and sorghum • Moderate chemical fertilizer: 40:20:20 per year • Manure: Nil • Stubbles: Incorporated, other residues fed to cattle • Conservation measure: Leveling • Herbicides: Not applied • Insecticides: Frequent • Sowing time: Cotton 39^{th} – 40^{th} Met Sorghum –do- • Seed rate: Cotton 15 kg ha^{-1} Sorghum 15-20 kg ha^{-1}
3	Power source	:	Complete mechanization with improved implements
4	Market orientation	:	Research and Development
5	Capital intensity	:	High
6	Labor intensity	:	High
7	Land holding	:	Not relevant
8	Income level	:	Not relevant

Climatic Datasets of Kovilpatti, Thoothukudi District, Tamil Nadu (Temperature from Palayankottai)

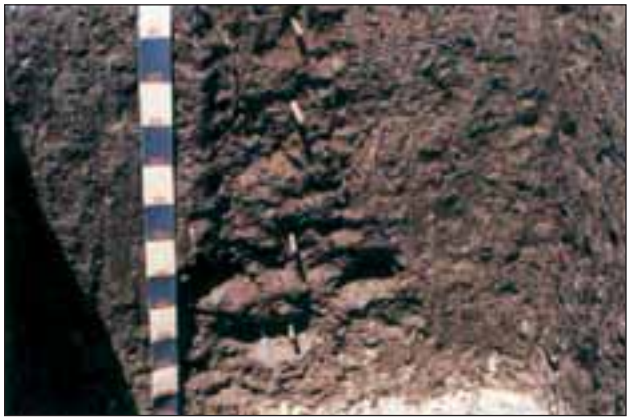
Month	Mean temp (°C)	Rainfall (mm)	PET (mm)	½PET (mm)	LGP (days)
January	26.50	6.40	107.60	53.80	0.00
February	27.70	9.20	125.60	62.80	0.00
March	29.70	23.00	160.10	80.05	0.00
April	30.70	71.60	165.30	82.65	0.00
May	31.80	36.50	178.10	89.05	0.00
June	31.00	12.20	173.00	86.50	0.00
July	30.40	20.90	175.10	87.55	0.00
August	30.60	45.50	173.50	86.75	0.00
September	30.70	86.30	163.70	81.85	30.00
October	29.50	197.30	152.20	76.10	31.00
November	27.20	108.80	133.70	66.85	30.00
December	26.40	42.00	109.60	54.80	0.00
Average	29.35				
Total		659.70	1817.50	908.75	*91.00*

Landscape, Landuse and Soils in Benchmark Spot 9 (Kovilpatti, Tamil Nadu)

Agricultural Research Station, a site for benchmark spot No. 9 at Kovilpatti, Tuticorin, Tamil Nadu

Typical landuse under agricultural system (sorghum and cotton)

Soil-site for Kovilpatti series



Closer view of slickenside in the profile

Typical black soil profile of Kovilpatti series showing accumulation of gypsum in the lowermost horizon

BM Spot 9 : KOVILPATTI 1 P20

Classification: Fine, smectitic, isohyperthermic, Leptic Gypsiusterts

Location: At 93 km stone (to Madurai), just outside of TNAU (RRS) Campus, Village Avalnatham, Kovilpatti, Tuticorin, T.N. Lat 09°12'42"N, Long 77°52'56"E.

Physiographic position: Riverine landform

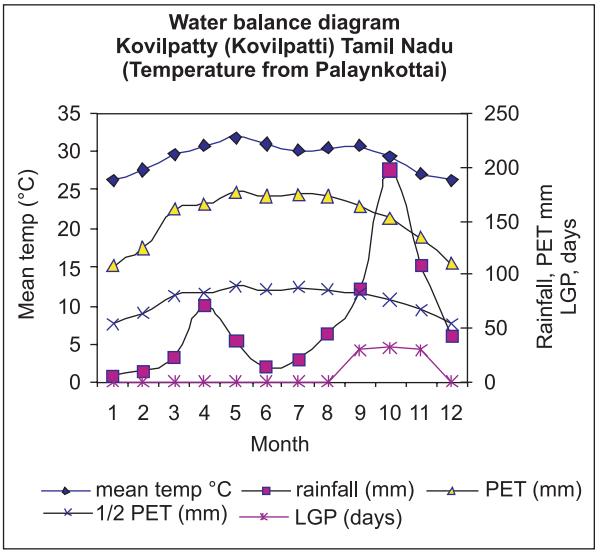
Topography and slope: Very gently sloping, 1-3% (150-300 m)

Drainage: Well drained

Vegetation: Mainly prosopis spp, parthenium grasses and shrubs

Landuse : Wasteland

Parent material: Granites and gnesisses and mixed alluvium



Sampled by : T. Bhattacharyya, P. Chandran, M.V. Venugopalan, S.K. Ray, S.L. Durge, S.R. Bhuse

Date of collection: 14.02.2001

Remarks : 79-105+ cm horizons contain large amounts of gypsum crystals, which increase downwards with medium and coarse-sized lime nodules as well as small amounts of powdery lime. This profile does not represent the original Kovilpatti. However, it has been taken because of its close proximity with Kovilpatti series and has wasteland vegetation classified as Leptic Haplusterts.

Ap	0-11 cm	Very dark greyish brown (10YR 3/2M) clay; weak medium subangular blocky structure; soft, very friable, sticky and plastic; common, very fine, fine and medium, a few coarse roots; many very fine and fine; common medium lime nodules; many very fine and fine, a few medium lime nodules; mildly alkaline (pH 7.8); slightly effervescent; clear, smooth boundary.
Bw1	11-31 cm	Very dark grey to very dark greyish brown (10YR 3/1.5M) clay; weak medium subangular blocky structure; very friable, sticky and plastic; common very fine and fine roots; many very fine, common fine and medium lime nodules; moderately alkaline (pH 7.9); slightly effervescent; clear, smooth boundary.
Bw2	31-55 cm	Very dark grey to very dark greyish brown (10YR 3/1.5M) clay; moderate medium subangular blocky structure with pressure faces on ped surfaces; friable, very sticky and very plastic; common very fine and fine roots; many very fine, common fine and medium, a few coarse lime nodules; moderately alkaline (pH 7.9); strongly effervescent;; gradual smooth boundary.
Bss	55-79 cm	Very dark grey to very dark greyish brown (10YR 3/1.5M) clay; moderate medium angular blocky structure (not well developed) with weakly developed wedge-shaped aggregates and slickensides that break into small weak angular peds; friable, very sticky and very plastic; a few very fine roots; many very fine and fine, common medium, a few coarse lime nodules; a few very fine roots; many medium and coarse lime nodules; moderately alkaline (pH 7.9); clear, smooth boundary.
2C1y	79-91 cm	Very dark grey (10YR 3/1M) clay; massive; friable, very sticky and nonplastic; many gypsum crystals; a few very fine roots; many medium and coarse lime nodules; moderately alkaline (pH 8.0); 60-80% fine and coarse gravels; strongly effervescent abruptly smooth boundary.
2C2y	91-105 cm	Greyish brown (10YR 5/2M) clay massive structure; very sticky and nonplastic; many gypsum crystals; many medium and coarse lime nodules; moderately alkaline (pH 8.0); 85-90% fine and coarse gravels; strongly effervescent.

Series: KOVILPATTI 1 **BM Spot: 9 (BLACK SOILS)**

Profile No: P20 ***System: Waste Land***

CLIMATE: SEMI-ARID (DRY) RAINFALL: 660 mm	Classification: Fine, smectitic, isohyperthermic, *Leptic Gypsiusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Avalnatham, Behind TNAU Farm, Kovilpatti, Thoothukudi, Tamil Nadu		Sampling Date : 14.02.2001

Morphological Properties of Profile No. 20 (Kovilpatti, Thoothukudi)

Horizon	Depth (cm)	Boundary		Matrix color		Texture	Coarse fragments (%) (fg and cg)	Structure		
		D	T	Dry	Moist			Size	Grade	Type
Ap	0-11	c	s	-	10YR3/2	C	3-5	m	1	sbk
Bw1	11-31	c	s	-	10YR3/1.5	C	3-5	m	1	sbk
Bw2	31-55	g	s	-	10YR3/1.5	C	3-5	m	2	sbk
Bss	55-79	c	s	-	10YR3/1.5	c	5-10	m	2	abk
2C1y	79-91	a	s	-	10YR 3/1	c	60-80	massive		
2C2y	91-105	-	-	-	10YR5/2	c	85-90	massive		

Depth (cm)	Consistence			Porosity		Nodules(conca)		Roots		Effervescence*	Other Features	Cracks
	Dry	Moist	Size	S	Q	Size	Quantity	Size	Quantity	Dil HCl		
0-11	s	vfr	sp	vf,f; m	m; f	vf,f; m	m c	vf,f,m; c	c; f	e	-	Not
11-31	-	vfr	sp	-	-	vf; f,m	m; c	vf,f	c	e	-	observed
31-55	-	fr	vsvp	-	-	vf; f,m; c	m; c; f	vf,f	c	es	Pressure faces	
55-79	-	fr	vsvp	-	-	vf,f; m; c	m; c; f	vf	f	es	Slickensides (Weak)	
79-91	-	fr	vsvp	-	-	m,c	m	vf	f	es	-	
91-105	-	-	spo	-	-	m,c	m	-	-	e	-	

**Matrix effervescence was also observed*

Please refer Appendix 1 for the abbreviations.

Series: KOVILPATTI 1 **BM Spot: 9 (BLACK SOILS)**

Profile No: P20 ***System: Waste Land***

CLIMATE: SEMI-ARID (DRY) RAINFALL: 660 mm	Classification: Fine, smectitic, isohyperthermic, *Leptic Gypsiusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Avalnatham, Behind TNAU Farm, Kovilpatti, Thoothukudi, Tamil Nadu		Sampling Date : 14.02.2001

Physical Properties of Profile No. 20 (Kovilpatti, Thoothukudi)

Laboratory No.	Horizon	Depth (cm)	Size class and particle diameter (mm)			Fine clay (%) (<0.0002)	Fine clay/ total clay (%)
			Total				
			Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)		
			←----------(% of <2 mm) ----------→				
3174	Ap	0-11	29.2	16.9	53.9	36.1	67.0
3175	Bw1	11-31	22.4	17.1	60.6	47.0	77.6
3176	Bw2	31-55	19.3	23.2	57.5	53.5	93.0
3177	Bss	55-79	12.7	29.6	57.7	51.9	89.0
3178	2C1y	79-91	10.3	20.4	69.3	57.0	82.2
3179	2C2y	91-105	17.6	17.2	65.2	53.6	82.2

Depth (cm)	BD (Mgm^{-3})	COLE	HC ($cmhr^{-1}$)	WDC (%)
0-11	-	0.2	1.2	16.9
11-31	1.4	0.1	2.7	20.4
31-55	1.4	0.2	2.1	20.4
55-79	1.3	0.1	2.8	21.1
79-91	-	0.1	3.3	18.8
91-105	-	0.1	4.8	15.8

- *Nil or not determined (wherever applicable)*

Series: KOVILPATTI 1 **BM Spot: 9 (BLACK SOILS)**

Profile No: P20 ***System: Waste Land***

CLIMATE: SEMI-ARID (DRY) RAINFALL: 660 mm	Classification: Fine, smectitic, isohyperthermic, *Leptic Gypsiusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Avalnatham, Behind TNAU Farm, Kovilpatti, Thoothukudi, Tamil Nadu		Sampling Date : 14.02.2001

Chemical Properties of Profile No. 20 (Kovilpatti, Thoothukudi)

Depth (cm)	pH (1:2)		EC (1:2) (dSm^{-1})	OC (%)	$CaCO_3$ (%)	Clay CO_3 (%)
	H_2O	1*N* KCl				
0-11	7.8	6.6	0.15	0.6	8.8	2.2
11-31	7.9	6.6	0.13	0.4	5.2	2.9
31-55	7.9	6.5	0.13	0.5	14.5	2.7
55-79	7.9	6.6	0.13	0.4	10.6	3.3
79-91	8.0	6.7	0.15	0.4	10.6	3.2
91-105	8.0	6.7	0.16	0.3	6.0	2.7

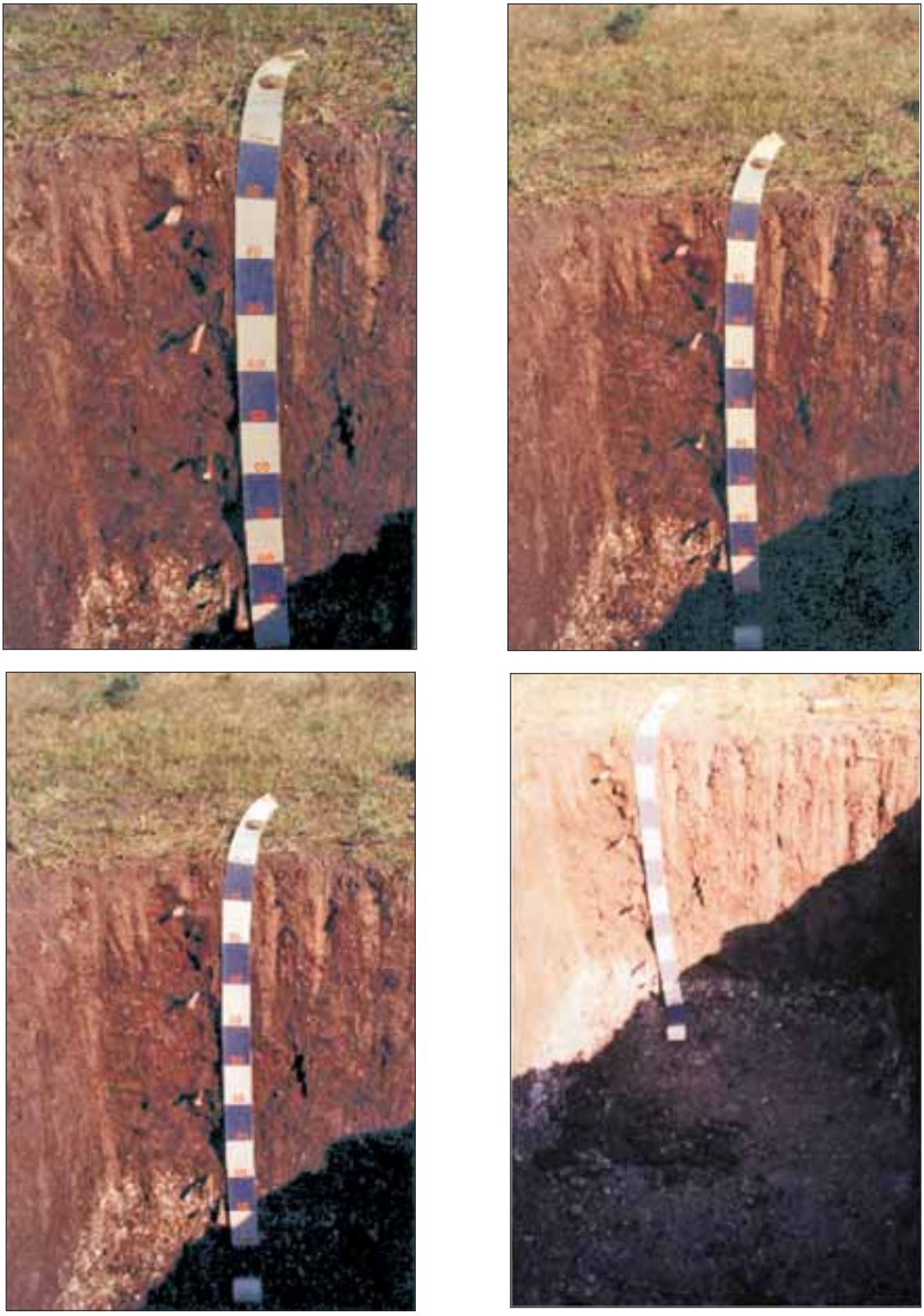
Depth (cm)	Extractable bases				CEC	Clay CEC	BS (%)	ESP
	Ca	Mg	Na	K				
	←-- ----------[cmol(p+)kg^{-1}]----------→							
0-11	39.9	8.5	0.4	0.6	50.0	93	99	1
11-31	43.2	12.4	0.5	0.4	56.7	94	99	1
31-55	45.9	11.4	0.5	0.4	58.5	102	100	1
55-79	46.8	12.5	0.5	0.4	65.2	113	92	1
79-91	38.4	12.0	0.5	0.4	54.4	79	94	1
91-105	40.0	12.6	0.5	0.4	58.7	90	91	1

- *Nil or not determined (wherever applicable)*

Landscape, Landuse and Soils in Benchmark Spot 9 (Kovilpatti, Tamil Nadu)

Kovilpatti soil site under wasteland

Clear view of natural vegetation



Typical Kovilpatti soil under wasteland (Leptic Haplusterts)

BM Spot 9 : KOVILPATTI: Agriculture System (Cotton+Blackgram) (HM) P21

Classification : Very fine, smectitic, isohyperthermic, *Gypsic Haplusterts*

Location : Vill. Kumargiri, Ettayapuram, Kovilpatti, Tuticorin, T.N. Lat 09°09'09"N, Long 77°57'26"E

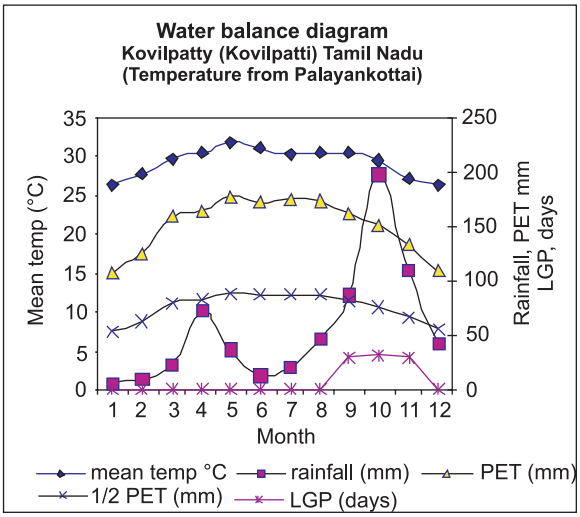
Physiographic position : Riverine landform

Topography and slope : Very gently sloping, 1-3% (50-150 m)

Drainage : Moderately well drained

Vegetation : Acacia, palm, prosopis

Landuse : Cotton+blackgram



Parent material : Granites & gnesisses with mixed alluvium

Sampled by : T. Bhattacharyya, P. Chandran, M.V. Venugopalan, S.L. Durge, S.R. Bhuse

Date of collection : 15.2.2001

Remarks : These soils are locally called Punnackukarisal. Rainfall of 25 mm in January end and 25 mm in February make the soil moist for another 30 days. Total rainfall is 660 mm of which 75% is contributed by NE monsoon and 20% by SW monsoon. Profile is moist/cracks are not visible/recent rain made the profile moist. Gypsum crystals are found especially towards the lowermost part of the profile. Soil is moist, porosity could not be seen. Porous drainage is not a problem. Soil matrix is non-calcareous. Contains some materials with clay loam like clay texture. *Punnacku* (Tamil) means cake of caster i.e. Black Karisal

Ap	0-9 cm	Very dark, greyish brown (10YR 3/2M) clay; moderate fine granular to weak fine subangular blocky structure; very friable sticky and plastic; common very fine, fine roots; many very fine and fine lime nodules; moderately alkaline (pH 8.0); slightly effervescent; gradual smooth boundary.
Ap2	9-20 cm	Very dark greyish brown (10YR 3/2M) clay; moderate fine granular to weak medium subangular blocky structure with a few pressure faces on ped surfaces; very friable, sticky and plastic; common very fine, fine roots, many very fine and fine lime nodules; moderately alkaline (pH 8.0: slightly effervescent; clear smooth boundary.
Bw1	20-58 cm	Very dark grey to very dark greyish brown (10YR 3/1.5M) clay; moderate medium subangular blocky to weak, coarse, angular, blocky structure with well developed pressure faces and weak wedge-shaped aggregates; very friable, very sticky and very plastic; a few very fine, common fine roots; many very fine and fine, common medium lime nodules; moderately alkaline (pH 8.0: slightly effervescent; gradual smooth boundary.
Bss1	58-100 cm	Very dark grey to very dark greyish brown (10YR 3/1.5M) clay; moderate coarse angular blocky structurewith wedge-shaped aggregates and slickensides that break into small angular peds; friable, very sticky and very plastic; a few very fine, common fine roots; many very fine and fine, common medium lime nodules; moderately alkaline (pH 7.9); slightly effervescent; abruptly smooth boundary.
2Cky1	100-126 cm	Greyish brown to brown (10YR 5/2.5R) silty clay; massive structure; many gypsum crystals; many few very fine roots; many very fine, fine, medium and coarse lime nodules; mildly alkaline (pH 7.5); ~80% gravels and stones; violently effervescent; gradual smooth boundary.
2Cky2	126-155+ cm	Greyish brown to brown (10YR 5/2.5R) clay; massive structure; many gypsum crystals; few very fine roots; many very fine, fine, medium and coarse lime nodules; mildly alkaline (pH 7.5); ~90% gravels and stones; violently effervescent.

Series: KOVILPATTI **BM Spot: 9 (BLACK SOILS)**

Profile No: P21 ***System: Agriculture (Cotton + Blackgram) (*HM)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 660 mm	Classification: Very Fine, smectitic, isohyperthermic, *Gypsic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Kumaragiri, Ettayapuram (Kovilpatti), Thoothukudi, Tamil Nadu		Sampling Date: 15.02.2001

Morphological Properties of Profile No. 21 (Kovilpatti, Thoothukudi)

Horizon	Depth (cm)	Boundary		Matrix color		Texture	Coarse fragments (%) (fg and cg)	Structure		
		D	T	Dry	Moist			Size	Grade	Type
Ap1	0-9	g	s	-	10YR3/2	c	3-5	f f	2 1	gr sbk
Ap2	9-20	c	s	-	10YR3/2	c	3-5	f m	2 1	sbk sbk
Bw1	20-58	g	s	-	10YR3/1.5	c	3-5	m c	2 1	sbk abk
Bss1	58-100	a	w	-	10YR3/1.5	c	3-5	c	2	abk
2Cky1	100-126	g	s	-	10YR5/2.5 (R)	sic	80***	-	-	-
2Cky2	126-155	-	-	-	10YR5/2.5 (R)	c	90***	-	-	-

Depth (cm)	Consistence			Porosity		Nodules (conca)		Roots		Effervescence	Other features	Cracks
	Dry	Moist	Wet	S	Q*	Size	Quanti	Size	Quantity	Dil HCl		
0-9	-	vfr	sp	-	-	vf,f	m	vf,f	c	e**	-	Not
9-20	-	vfr	sp	-	-	vf,f	m	vf,f	c	e**	Pressure faces	observed
20-58	-	fr	sp	-	-	vf,f; m	m; c	vf,f	f c	e**	Pressure faces Slickensides	
58-100	-	fr	vsvp	-	-	vf,f; m	m; c	vf,f	f c	e	Slickensides	
100-126		fr	sp	-	-	vf,f,m,c	m	vf	f	ev	-	
126-155		fr	sp	-	-	vf,f,m,c	m	vf	f	ev	-	

**Soil is moist; porosity not seen; it is relatively porous*
*e** Soil matrix is non calcareous.*
(+) *Cracks are not visible due to moist profile*

Please refer Appendix I for the abbreviations.

Series: KOVILPATTI **BM Spot: 9 (BLACK SOILS)**

Profile No: P21 ***System: Agriculture (Cotton + Blackgram) (*HM)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 660 mm	Classification: Very Fine, smectitic, isohyperthermic, *Gypsic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Kumaragiri, Ettayapuram (Kovilpatti), Thoothukudi, Tamil Nadu		Sampling Date: 15.02.2001

Physical Properties of Profile No. 21 (Kovilpatti, Thoothukudi)

Laboratory No.	Horizon	Depth (cm)	Size class and particle diameter (mm)			Fine clay (%) (<0.0002)	Fine clay/ total clay (%)
			Total				
			Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)		
			←----------(% of <2 mm) ----------→				
3180	Ap1	0-9	28.1	19.1	52.8	37.7	71.4
3181	Ap2	9-20	23.7	17.0	59.3	43.5	73.3
3182	Bw1	20-58	17.8	17.6	64.7	49.2	76.0
3183	Bss1	58-100	15.2	18.9	66.0	43.4	65.8
3184	2Cky1	100-126	15.3	44.4	40.3	25.2	62.5
3185	2Cky2	126-155	33.4	13.6	53.0	46.0	86.8

Depth (cm)	BD (Mgm^{-3})	COLE	HC ($cmhr^{-1}$)	WDC (%)
0-9	-	0.2	2.1	12.3
9-20	1.3	0.2	2.1	12.6
20-58	1.4	0.2	2.6	17.8
58-100	1.4	0.2	3.4	14.1
100-126	-	0.2	7.2	-
126-155	-	0.2	10.1	-

- *Nil or not determined (wherever applicable)*

Series: KOVILPATTI **BM Spot: 9 (BLACK SOILS)**

Profile No: P21 ***System: Agriculture (Cotton + Blackgram) (*HM)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 660 mm	Classification: Very Fine, smectitic, isohyperthermic, *Gypsic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Kumaragiri, Ettayapuram (Kovilpatti), Thoothukudi, Tamil Nadu		Sampling Date: 15.02.2001

Chemical Properties of Profile No. 21 (Kovilpatti, Thoothukudi)

Depth (cm)	pH (1:2)		EC (1:2) (d Sm^{-1})	OC (%)	$CaCO_3$ (%)	Clay CO_3 (%)
	H_2O	1*N* KCl				
0-9	8.0	6.7	0.12	0.5	7.4	2.6
9-20	8.0	6.7	0.18	0.4	6.7	2.7
20-58	8.0	6.5	0.16	0.4	7.2	2.8
58-100	7.9	6.5	0.18	0.4	8.7	2.8
100-126	7.5	6.7	1.70	0.2	25.1	-
126-155	7.5	6.7	1.96	0.1	17.8	-

Depth (cm)	Extractable bases				CEC	Clay CEC	BS (%)	ESP
	Ca	Mg	Na	K				
	←----------[cmol(p+)kg^{-1}]----------→							
0-9	39.1	7.8	0.2	0.6	52.2	99	91	0.4
9-20	41.6	8.6	0.3	0.7	52.2	88	98	0.5
20-58	46.9	9.9	0.3	0.6	57.7	89	100	0.4
58-100	47.1	9.4	0.3	0.3	60.9	92	94	0.5
100-126	50.0	6.7	0.3	0.2	63.0	156	91	0.4
126-155	47.6	5.1	0.3	0.2	53.3	101	100	0.5

- *Nil or not determined (wherever applicable)*

Series: KOVILPATTI **BM Spot: 9 (BLACK SOILS)**

Profile No: P21 ***System: Agriculture (Cotton + Blackgram) (*HM)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 660 mm	Classification: Very Fine, smectitic, isohyperthermic, *Gypsic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Kumaragiri, Ettayapuram (Kovilpatti), Thoothukudi, Tamil Nadu		Sampling Date: 15.02.2001

Characterization of Landuse Types

S. No.	Attribute		Description
1	Production system	:	Rain-fed single crop (or intercrop), winter season cropping, comprising maize/sorghum-cotton + blackgram in 2:2 ratio (2 year rotation), 6 months fallow (April-Aug), Yield range: 3500-4000 kg maize/ha or 400-500 kg cotton/ha +500 kg black gram/ha
2	Management level	:	• Improved varieties • Use of extension package • Organic manures: 10-12 tonnes/ha + 10-12 tonnes sheep manure/ha • Fertilizer: 90 kg ha^{-1}/year N + 110 kg P_2O_5/ha/year • Conservation measures: Adequate • Residues: Grazed or incorporated • Insecticides: Frequently used • Sowing time: 38-40th met. week • Seed rate: Cotton 8-10 kg ha^{-1} Black gram 4-5 kg ha^{-1} Sorghum 15 kg ha^{-1}
3	Power source	:	Mechanical (tractor) with improved implements supplemented with bullocks and Labor
4	Market orientation	:	Commercial
5	Capital intensity	:	High with easy access to credit
6	Labor intensity	:	High (family labor excluded)
7	Land holding	:	Small, consolidated
8	Income level	:	Moderate to high

Climatic Datasets of Kovilpatty (Kovilpatti) Tamil Nadu (Temperature from Palaynkottai)

Month	Mean temp (^oC)	Rainfall (mm)	PET (mm)	½ PET (mm)	LGP (days)
January	26.50	6.40	107.60	53.80	0.00
February	27.70	9.20	125.60	62.80	0.00
March	29.70	23.00	160.10	80.05	0.00
April	30.70	71.60	165.30	82.65	0.00
May	31.80	36.50	178.10	89.05	0.00
June	31.00	12.20	173.00	86.50	0.00
July	30.40	20.90	175.10	87.55	0.00
August	30.60	45.50	173.50	86.75	0.00
September	30.70	86.30	163.70	81.85	30.00
October	29.50	197.30	152.20	76.10	31.00
November	27.20	108.80	133.70	66.85	30.00
December	26.40	42.00	109.60	54.80	0.00
Average	29.35				
Total		659.70	1817.50	908.75	*91.00*

Landscape, Landuse and Soils in Benchmark Spot 9
(Kovilpatti, Tamil Nadu with Cotton + Blackgram under High Management)

Kovilpatti soil under agricultural system with cotton + blackgram crop rotation

*Typical black soil profile of Kovilpatti series (*Typic Haplusterts*)*

BM Spot 14 : SEMLA: Agriculture System (Cotton-Groundnut/Wheat) (ORG) P29

Classification: Fine, smectitic, hyperthermic, *Typic Haplusterts*

Location: ≃ 500 m SE of Semla village and ≃ 800 m E of River Gondal, Vill. Semla Gondal, Rajkot, Gujarat, Lat 22°01'59" N, Long 70°48'22" E

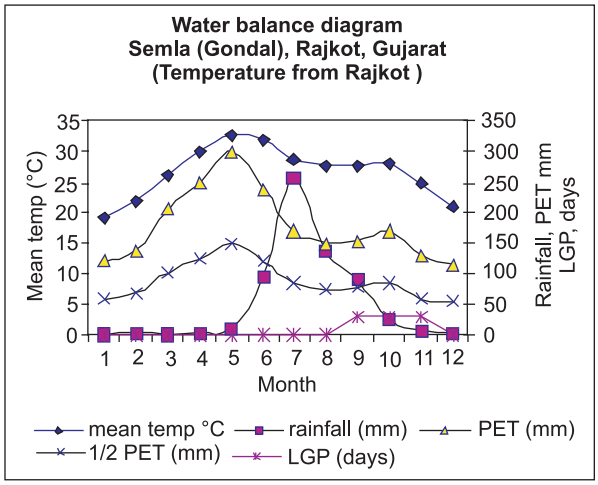
Physiographic position: West coast-Kathiawar peninsula

Topography and slope: Very gently sloping, 1-3% (50-150 m)

Drainage: Moderately well drained

Vegetation: Acacia, *ber*, *neem*, fig, su*babul*, euphorbia, hirta, grasses

Landuse : 2 years of groundnut - 1 year of cotton, fodder jowar, chickpea, wheat



Parent material : Basaltic alluvium containing zeolites

Sampled by : P. Chandran, S.K. Ray, M. V. Venugopalan, P. Srivastava, S.L. Durge

Date of collection:

Remarks : Cracks 1-2 cm wide up to 40 cm; <1 cm wide up to 60 cm. Zeolites and quartz gravels in all layers.

A1	0-17 cm	Dark greyish brown to brown (10YR 4/2.5D) and very dark brown (10YR 2/2M) clay loam; moderate, medium subangular blocky structure; slightly hard, friable, sticky and plastic; many very fine and fine roots; many very fine and fine, a few medium lime nodules; mildly alkaline (pH 7.8); many very fine and fine, a few medium pores; strongly effervescent; clear, smooth boundary.
Bw1	17-42 cm	Very dark brown (10YR 2/2M) and very dark greyish brown (10YR 3/2 R) silty clay; moderate medium subangular blocky structure with pressure faces on ped surfaces; friable, sticky and plastic; common very fine and fine roots; many very fine and fine, a few medium lime nodules; mildly alkaline (pH 7.8); many very fine and fine pores; strongly to violently effervescent; gradual smooth boundary.
Bw2	42-57 cm	Very dark brown (10YR 2/2M) clay; moderate medium angular blocky (weak) structure with well developed shiny pressure faces of ped surfaces; friable, sticky and plastic; a few very fine and fine roots; many very fine and fine, few medium lime nodules; moderately alkaline (pH 7.9); many very fine and fine pores; violently effervescent; gradual smooth boundary.
Bss1	57-86 cm	Very dark brown (10YR 2/2M) silty clay; strong medium angular blocky to strong coarse angular blocky structure with slickensides and wedge-shaped aggregates that break into small angular peds; friable, sticky and plastic; a few very fine and fine roots; many very fine, a few fine and medium lime nodules; moderately alkaline (pH 7.9); many very fine and fine pores; violently effervescent; gradual wavy boundary.

Bss2	86-115 cm	Very dark brown (10YR 2/2M) silty clay; strong coarse angular blocky structure with wedge-shaped aggregates and slickensides that break into small angular peds; friable, sticky and plastic; a few very fine roots; many very fine, a few fine and medium lime nodules; moderately alkaline (pH 8.0); many very fine and fine pores; violently effervescent; slickensides; gradual wavy boundary.
Bss3	115-144 cm	Very dark brown (lighter) (10YR 2/2M) silty clay; strong coarse angular and blocky to strong medium angular blocky to strong medium angular blocky structure with wedge-shaped aggregates and slickensides that break into small angular peds; friable, very sticky and very plastic; a few very fine roots; many very fine, few fine and medium lime nodules; moderately alkaline (pH 7.9); many very fine and fine pores; violently effervescent; clear, smooth boundary.
BC	144-155+ cm	Dark grey to dark greyish brown (10YR 4.5/2R) clay loam; weak medium subangular blocky structure; friable, sticky and plastic; many very fine, a few fine lime nodules; powdery lime present in patches; moderately alkaline (pH 8.0); violently effervescent.

Series: SEMLA **BM Spot: 14 (BLACK SOILS)**

Profile No: P29 ***System: Agriculture (Cotton / Groundnut-Wheat)*** **(ORG)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 635 mm	Classification: Fine, smectitic(cal), hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Semla, Gondal, Rajkot, Gujarat		Sampling Date: 06.11.2001

Morphological Properties of Profile No. 29 (Semla, Rajkot)

Horizon	Depth (cm)	Boundary		Matrix color		Texture	Coarse fragments (%) (fg and cg)	Structure		
		D	T	Dry	Moist			Size	Grade	Type
Ap	0-17	c	s	10YR4/2.5	10YR2/2	c	5--8	m	2	Sbk
Bw1	17-42	g	s	-	10YR2/2;3/2(R)	c	3--5	m	2	Sbk
Bw2	42-57	g	s	-	10YR2/2	c	5--10	m	2	abk(w)***
Bss1	57-86	g	w	-	10YR2/2	c	1--2	m - c	3	Abk
Bss2	86-115	g	w	-	10YR2/2	c	1--2	c	3	Abk
Bss3	115-144	c	s	-	10YR2/2	c	2--3	c - m	3	abk
BC	144-155	c	s	-	10YR4.5/2(R)	cl	2--3	m	1	Sbk

Depth (cm)	Consistence			Porosity		Nodules (conca)		Roots		Effervescence*	Other features	Cracks
	Dry	Moist	Wet	S	Q	Size	Quantity	Size	Quantity	dil HCl		
0-17	sh	fr	sp	vf,f; m	m; f	vf,f; m	m; f	vf,f	m	es	-	1-2 cm
17-42	-	fr	sp	vf,f	m	vf,f; m	m; f	vf,f	c	ev	Pressure faces	
42-57	-	fr	sp	vf,f	m	vf,f; m	m; f	vf,f	f	ev	Pressure faces	1 cm
57-86	-	fr	vsvp	vf,f	m	vf; f,m	m; f	vf,f	f	es	Slickensides	
86-115	-	fr	vsvp	vf,f	m	vf; f,m	m; f	vf	f	ev	Slickensides	
115-144	-	fr	vsvp	vf,f	m	vf; f,m	m; f	vf	f	ev	Slickensides	
144-155	-	fr	sp	-	-	vf; f	m; f	-	-	ev	Slickensides	

Cracks: 1-2cm wide up to 40 cm and <1 cm up to 60 cm
**Matrix effervescence was also observed*

Please refer Appendix I for the abbreviations

Series: SEMLA **BM Spot: 14 (BLACK SOILS)**

Profile No: P29 ***System: Agriculture (Cotton / Groundnut-Wheat)*** **(ORG)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 635 mm	Classification: Fine, smectitic(cal), hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Semla, Gondal, Rajkot, Gujarat		Sampling Date: 06.11.2001

Physical Properties of Profile No. 29 (Semla, Rajkot)

Laboratory No.	Horizon	Depth (cm)	Size class and particle diameter (mm)			Fine clay (%) (<0.0002)	Fine clay/ total clay (%)
			Total				
			Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)		
			←----------(% of <2 mm) ----------→				
3266	Ap	0-17	25.1	39.9	35.0	15.6	44.6
3267	Bw1	17-42	13.8	42.8	43.4	18.7	43.1
3268	Bw2	42-57	11.8	38.2	50.0	24.9	49.8
3269	Bss1	57-86	7.8	42.1	50.1	29.2	58.3
3270	Bss2	86-115	9.7	40.9	49.4	24.3	49.2
3271	Bss3	115-144	9.4	42.8	47.8	28.2	59.0
3272	BC	144-155	20.8	45.4	33.8	13.5	40.0

Depth (cm)	BD (Mgm^{-3})	COLE	HC ($cmhr^{-1}$)	WDC (%)
0-17	1.4	0.2	2.3	6.0
17-42	1.4	0.2	4.2	8.8
42-57	1.4	0.2	2.1	8.6
57-86	1.4	0.2	1.7	9.1
86-115	1.8	0.2	2.2	10.4
115-144	1.5	0.2	0.9	8.3
144-155	1.5	0.2	1.2	5.4

Series: SEMLA **BM Spot: 14 (BLACK SOILS)**

Profile No: P29 ***System: Agriculture (Cotton / Groundnut-Wheat)* (ORG)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 635 mm	Classification: Fine, smectitic(cal), hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Semla, Gondal, Rajkot, Gujarat		Sampling Date: 06.11.2001

Chemical Properties of Profile No. 29 (Semla, Rajkot)

Depth (cm)	pH (1:2)		EC (1:2) (d Sm^{-1})	OC (%)	$CaCO_3$ (%)	Clay CO_3 (%)
	H_2O	1*N* KCl				
0-17	7.8	6.7	0.17	0.8	15.4	4.1
17-42	7.8	6.7	0.12	0.7	18.2	4.3
42-57	7.9	6.7	0.29	0.7	18.7	4.1
57-86	7.9	6.6	0.08	0.5	14.5	3.9
86-115	8.0	6.6	0.43	0.6	17.2	4.9
115-144	7.9	6.6	0.16	0.5	17.8	4.7
144-155	8.0	6.8	0.11	0.2	23.3	3.6

Depth (cm)	Extractable bases				CEC	Clay CEC	BS (%)	ESP
	Ca	Mg	Na	K				
	← ----------[cmol(p+)kg^{-1}]----------→							
0-17	33.8	15.1	0.7	1.1	49.5	141	103	1.4
17-42	36.4	17.3	1.1	0.5	50.1	115	110	2.2
42-57	30.9	22.0	2.6	0.3	53.2	106	105	4.9
57-86	33.8	15.6	2.2	0.8	48.3	96	108	4.5
86-115	30.2	21.8	3.3	0.3	52.5	106	106	6.3
115-144	28.9	16.4	1.6	0.7	47.0	98	101	3.4
144-155	18.0	16.9	2.9	0.2	37.5	111	101	7.7

Series: SEMLA **BM Spot: 14 (BLACK SOILS)**

Profile No: P29 ***System: Agriculture (Cotton / Groundnut-Wheat)* (ORG)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 635 mm	Classification: Fine, smectitic(cal), hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Semla, Gondal, Rajkot, Gujarat		Sampling Date: 06.11.2001

Saturation Extract Properties of Profile No. 29 (Semla, Rajkot)

Depth (cm)	Sat (%)	ECe (d Sm^{-1})	Soluble cations ($mmol_c\ l^{-1}$)				Sum of cations
			Ca	Mg	Na	K	
0-17	56.87	0.41	3.27	4.03	1.52	0.15	8.97
17-42	64.18	0.36	0.82	0.70	3.04	0.05	4.61
42-57	65.50	1.41	3.26	4.56	19.13	0.04	26.99
57-86	63.05	0.70	1.56	1.24	4.56	0.08	7.44
86-115	64.41	1.01	1.51	1.62	8.70	0.01	11.84
115-144	67.45	1.16	1.84	1.69	7.17	0.05	10.75
144-155	52.29	0.54	0.74	0.64	3.90	0.02	5.30

Depth (cm)	Soluble anions ($mmol_c\ l^{-1}$)				Sum of anions
	CO_3	HCO_3	Cl	SO_4	
0-17	1.06	7.11	0.84		9.01
17-42	1.70	2.02	0.86	0.30	4.90
42-57	0.42	2.02	9.20	15.35	26.99
57-86	1.06	2.65	1.00	2.73	7.44
86-115	0.42	2.55	1.24	7.63	11.84
115-144	1.06	2.12	1.06	6.51	10.75
144-155	0.42	3.61	1.20	0.07	5.30

Series: SEMLA **BM Spot: 14 (BLACK SOILS)**

Profile No: P29 ***System: Agriculture (Cotton / Groundnut-Wheat)* (ORG)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 635 mm	Classification: Fine, smectitic(cal), hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Semla, Gondal, Rajkot, Gujarat		Sampling Date: 06.11.2001

Characterization of Landuse Types

S. No.	Attribute		Description
1	Production system	:	Irrigated, predominantly *kharif* based, cotton-groundnut (wheat after groundnut to limited extent) 2 year rotation with 4-8 months fallow period Yield range: 2000-3500 kg ha^{-1} groundnut, 2000-3000 kg ha^{-1} of cotton and 3000-3500 kg ha^{-1} of wheat Crop livestock farming system.
2	Management level	:	• Improved seeds • Organics: 30cartloads/ha • Chemical fertilizer: 40-45 kg ha^{-1}/year N, 60 kg P_2O_5/ha/year as DAP and urea for cotton-groundnut rotation, 80 kg ha^{-1}/year N and 40 kg ha^{-1}/year P_2O_5 for wheat • Insecticides: Frequent (10-12 sprays in cotton) • Residue management: Poor • Conservation measures: Ridge furrows, bunding, etc., adopted • Sowing time: Cotton and groundnut- 1st week of July Wheat (after Groundnut)- last week of November • Seed rate: Cotton- 8 kg ha^{-1} Groundnut- 100 kg ha^{-1} Wheat- 80-100 kg ha^{-1}
3	Power source	:	Mechanized (tractor) supplemented with animal traction
4	Market orientation	:	Commercial
5	Capital intensity	:	Intermediate with limited access to credit
6	Labor intensity	:	Medium. Includes family labor
7	Land holding	:	Medium, consolidated
8	Income level	:	Moderate

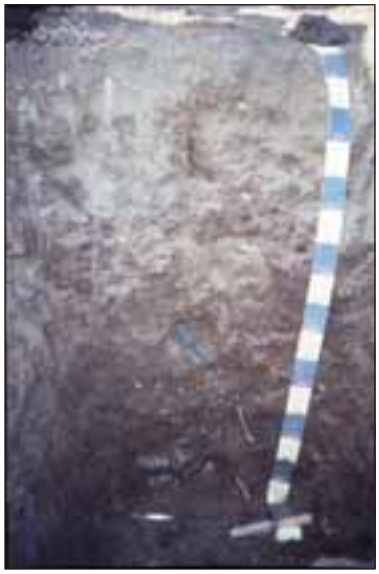
Climatic Datasets of Semla (Gondal), Rajkot District, Gujarat (Temperature from Rajkot)

Month	Mean temp (°C)	Rainfall (mm)	PET (mm)	½PET (mm)	LGP (days)
January	19.40	1.30	121.00	60.50	0.00
February	21.90	1.70	138.00	69.00	0.00
March	26.30	1.10	206.00	103.00	0.00
April	30.10	4.00	249.00	124.50	0.00
May	32.60	9.40	302.00	151.00	0.00
June	32.00	95.30	240.00	120.00	0.00
July	28.80	257.90	170.00	85.00	0.00
August	27.80	136.40	150.00	75.00	0.00
September	27.90	92.00	154.00	77.00	30.00
October	28.20	26.00	169.00	84.50	31.00
November	24.80	6.30	131.00	60.50	30.00
December	20.90	2.40	114.00	57.00	0.00
Average	26.72				
Total		633.80	2144.00	1067.00	*91.00*

Landscape, Landuse and Soils in Benchmark Spot 14 (Semla, Rajkot)

Wide cracks are common in Semla soils

Benchmark spot at Semla, Rajkot, Gujarat under agricultural system with cotton/groundnut-wheat crop rotation



Typical profile of Semla soil

Closer view of the profile

BM Spot 16 : JHALIPURA: Agriculture System (Soybean-Wheat) (FM) P32

Classification: Fine, smectitic, hyperthermic, *Typic Haplusterts*

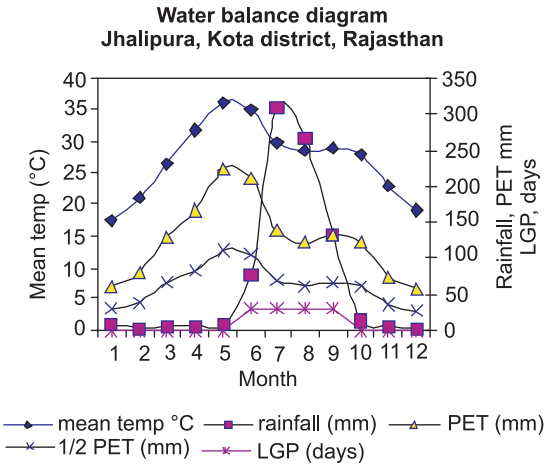
Location: Vill. Jhalipura, Kota, Rajasthan, Lat 25°11'19" N, Long 75°57'04" E

Physiographic position: Pathar & Bundelkhand Upland

Topography and slope : Very gently sloping to level, 0-3% (50-150 m)

Drainage: Moderately well drained

Vegetation: *Neem*, grass, acacia, *ber*, hypomea celotia, argentia (cock's comb)



Landuse : Soybean-wheat

Parent material : Basaltic alluvium

Sampled by : P. Chandran, S.K. Ray, M.V. Venugopalan, P. Srivastava, S.L. Durge

Date of collection: 10.11.2001

Remarks : Salt (including $CaCO_3$) encrustations are present in the form of branching channels on the surface of peds. No cracks are seen because of moist profile.

Ap	0-12 cm	Grey to dark grey (10YR 4.5/1D) and dark grey (10YR 4/1M) silty clay; moderate medium subangular blocky structure; hard, friable, slightly plastic; many very fine, common fine roots; many very fine, common fine lime nodules; many very fine, fine and medium pores; moderately alkaline (pH 8.3); slightly effervescent; clear, smooth boundary.
Bw1	12-31 cm	Very dark grey (10YR 3/1M) silty clay; strong medium subangular blocky structure with pressure faces on ped surfaces; friable, sticky and plastic; common very fine and fine roots; many very fine, a few fine lime nodules; many fine and very fine pores; moderately alkaline (pH 8.3); slightly effervescent; gradual smooth boundary.
Bw2	31-48 cm	Very dark greyish brown (10YR 3/2M) silty clay; strong medium subangular blocky to angular blocky structure with shiny pressure faces on ped surfaces and wedge-shaped aggregates; friable, sticky and plastic; a few very fine and fine roots; many very fine, a few fine lime nodules; many very fine and fine pores; mildly alkaline (pH 7.7); slightly effervescent; clear, wavy boundary.
Bss1	48-74 cm	Very dark grey (10YR 3/1M) silty clay; strong medium angular blocky structure with slickensides and wedge-shaped aggregates that break into small angular peds; friable, sticky and plastic; a few very fine and fine roots; common very fine, a few fine lime nodules; many very fine and fine pores; moderately alkaline (pH 8.1); slightly effervescent; gradual smooth boundary.
Bss2	74-110 cm	Very dark greyish brown (10YR 3/2M) silty clay; strong moderate angular blocky structure with slickensides and wedge-shaped aggregates that break into angular peds; friable, sticky and plastic; a few very fine roots; common very fine, a few fine lime nodules; many very fine and fine pores; moderately alkaline (pH 8.3); slightly effervescent; gradual smooth boundary.

Bss3	110-148 cm	Very dark greyish brown (10YR 3/2M) silty clay; strong, coarse angular and blocky structure with well developed slickensides and wedge shaped aggregates that break into strong angular peds; friable, sticky and plastic; a few very fine roots; common very fine, a few fine lime nodules; many very fine and fine pores; moderately alkaline (pH 8.1); slightly effervescent; gradual smooth boundary.
Bss4	148-165+ cm	Very dark greyish brown (10YR 3/2M) clay; strong, coarse angular and blocky structure with well developed slickensides and wedge shaped aggregates that break into strong angular peds; friable, sticky and plastic; many very fine, a few fine lime nodules; many very fine and fine pores; moderately alkaline (pH 8.4); slightly effervescent.

Series: JHALIPURA **BM Spot: 16 (BLACK SOILS)**

Profile No: P32 ***System: Agriculture (Soybean - Wheat)* (FM/1)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 842 mm	Classification : Fine, smectitic, hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Jhalipura, Kota, Rajasthan		Sampling Date: 10.11.2001

Morphological Properties of Profile No. 32 (Jhalipura, Kota)

Horizon	Depth (cm)	Boundary		Matrix color		Texture	Coarse fragments (%) (fg and cg)	Structure		
		D	T	Dry	Moist			Size	Grade	Type
Ap	0-12	c	s	10YR4.5/1	10YR4/1	C	2-5	m	2	sbk
Bw1	12-31	g	s	-	10YR3/1	C	2-5	m	3	sbk
Bw2	31-48	c	w	-	10YR3/2	C	2-5	m	3	sbk
Bss1	48-74	g	s	-	10YR3/1	C	2-5	m	3	abk
Bss2	74-110	g	s	-	10YR3/2	C	2-5	m	3	abk
Bss3	110-148	g	s	-	10YR3/2	C	2-5	c	3	abk
Bss4	148-165	-	-	-	10YR3/2	C	2-5	c	3	abk

Depth (cm)	Consistence			Porosity		Nodules (conca)		Roots		Effervescence*	Other features	Cracks
	Dry	Moist	Wet	S	Q	Size	Quantity	Size	Quantity	dil HCl		
0-12	h	fr	sp	vf,f, m	m	vf; f	m; f	vf; f	m; c	e	-	Not
12-31	-	fr	sp	vf,f	m	vf; f	m; f	vf,f	c	e	Pressure faces	observed
31-48	-	fr	vsvp	vf,f	m	vf; f	m; f	vf,f	f	e to nil	Pressure faces	
48-74	-	fr	vsvp	vf,f	m	vf; f	c; f	vf,f	f	e*	Slickensides	
74-110	-	fr	vsvp	vf,f	m	vf; f	c; f	Vf	f	es	Slickensides	
110-148	-	fr	vsvp	vf,f	m	vf; f	c; f	Vf	f	es	Slickensides	
148-165	-	fr	vsvp	vf,f	m	vf; f	m; f	-	-	es	Slickensides	

**Salt (including $CaCO_3$) encrustation in the form of channels is found branching on the surface of peds*
***Matrix effervescence was also observed.*

Please refer Appendix I for the abbreviations.

Series: JHALIPURA **BM Spot: 16 (BLACK SOILS)**

Profile No: P32 ***System: Agriculture (Soybean - Wheat)* (FM/1)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 842 mm	Classification : Fine, smectitic, hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Jhalipura, Kota, Rajasthan		Sampling Date: 10.11.2001

Physical Properties of Profile No. 32 (Jhalipura, Kota)

Laboratory No.	Horizon	Depth (cm)	Size class and particle diameter (mm)			Fine clay (<0.0002)	Fine clay/ total clay (%)
			Total				
			Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)		
			←----------(% of <2 mm) ----------→				
3285	Ap	0-12	9.8	45.2	45.0	25.1	55.8
3286	Bw1	12-31	7.8	44.6	47.6	27.9	58.6
3287	Bw2	31-48	6.5	41.1	52.4	31.4	60.0
3288	Bss1	48-74	8.0	41.6	49.2	31.4	61.6
3289	Bss2	74-110	8.5	41.5	50.0	31.2	62.4
3290	Bss3	110-148	8.4	40.7	50.9	32.6	64.0
3291	Bss4	148-165	8.0	39.7	52.4	29.1	55.5

Depth (cm)	BD (Mgm^{-3})	COLE	HC ($cmhr^{-1}$)	WDC (%)
0-12	-	0.2	0.8	3.9
12-31	1.7	0.2	1.5	3.7
31-48	1.4	0.2	0.7	3.2
48-74	1.7	0.2	0.6	3.3
74-110	1.7	0.2	1.3	3.1
110-148	1.7	0.2	1.4	3.1
148-165	1.7	0.2	1.0	3.0

Series: JHALIPURA **BM Spot: 16 (BLACK SOILS)**
Profile No: P32 ***System: Agriculture (Soybean - Wheat)*** **(FM/1)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 842 mm	Classification : Fine, smectitic, hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Jhalipura, Kota, Rajasthan		Sampling Date: 10.11.2001

Chemical Properties of Profile No. 32 (Jhalipura, Kota)

Depth (cm)	pH (1:2)		EC (1:2) (d Sm^{-1})	OC (%)	$CaCO_3$ (%)	Clay CO_3 (%)
	H_2O	1*N* KCl				
0-12	8.3	6.8	0.24	0.58	0.9	5.7
12-31	8.3	6.8	0.21	0.34	5.7	4.3
31-48	7.7	6.5	0.21	0.33	5.4	10.5
48-74	8.1	6.8	0.18	0.30	5.9	8.7
74-110	8.3	6.7	0.17	0.31	7.3	9.3
110-148	8.1	6.8	0.19	0.27	7.1	9.7
148-165	8.4	6.9	0.24	0.25	7.1	9.6

Depth (cm)	Extractable bases				CEC	Clay CEC	*BS (%)	ESP
	Ca	Mg	Na	K				
	← ----------[cmol(p+)kg^{-1}]----------→							
0-12	26.2	8.0	1.3	0.6	36.5	81	98	2.5
12-31	30.9	7.3	0.9	0.4	36.5	77	108	2.5
31-48	32.3	9.1	0.6	0.4	40.2	77	103	1.5
48-74	32.0	7.9	0.6	0.4	37.0	75	111	1.6
74-110	25.8	12.0	0.6	0.4	36.5	73	106	1.6
110-148	30.0	9.1	0.7	0.4	37.0	73	109	1.9
148-165	28.9	11.6	1.6	0.7	36.0	72	113	4.4

** Presence of base-rich zeolites is confirmed by XRD. These zeolites are responsible for higher BS%*

Series: JHALIPURA **BM Spot: 16 (BLACK SOILS)**

Profile No: P32 ***System: Agriculture (Soybean - Wheat)*** **(FM/1)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 842 mm	Classification : Fine, smectitic, hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Jhalipura, Kota, Rajasthan		Sampling Date: 10.11.2001

Saturation Extract Properties of Profile No. 32 (Jhalipura, Kota)

Depth (cm)	Sat (%)	ECe (d Sm^{-1})	Soluble cations ($mmol_c$ l^{-1})				Sum of cations
			Ca	Mg	Na	K	
0-12	48.47	0.84	1.96	2.59	4.89	0.11	9.55
12-31	48.36	0.42	1.80	0.93	1.99	0.04	4.76
31-48	49.46	0.42	2.84	1.43	1.34	0.06	5.67
48-74	50.00	1.14	2.78	0.28	1.64	0.02	4.70
74-110	53.27	0.33	1.49	0.84	1.18	0.08	3.59
110-148	49.55	0.37	2.15	1.02	1.35	0.01	4.53
148-165	52.63	0.43	1.46	0.95	2.72	0.07	5.20

Depth (cm)	Soluble anions ($mmol_c$ l^{-1})				Sum of anions
	CO_3	HCO_3	Cl	SO_4	
0-12	2.12	1.27	1.10	5.06	9.55
12-31	1.06	2.33	0.40	0.97	4.76
31-48	1.70	3.08	0.94	-	5.72
48-74	nil	1.52	1.50	1.70	4.70
74-110	1.06	1.14	0.80	-	3.19
110-148	1.70	1.49	0.80	0.54	4.53
148-165	1.70	1.80	1.04	0.66	5.20

Series: JHALIPURA **BM Spot: 16 (BLACK SOILS)**

Profile No: P32 ***System: Agriculture (Soybean - Wheat)* (FM/1)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 842 mm	Classification : Fine, smectitic, hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Jhalipura, Kota, Rajasthan		Sampling Date: 10.11.2001

Characterization of Landuse Types

S. No.	Attribute		Description
1	Production system	:	Irrigated (canal supplemented with tube well) soybean-wheat double cropping system with 2 months fallow period. Yield range: Soybean 1200-1500 kg ha^{-1} and Wheat 3000-4500 kg ha^{-1}. Crop livestock mixed farming system.
2	Management level	:	• Improved varieties • Seed treatment • Manures: Adequate use of FYM (6-8 cartloads/ha/year) • Chemical fertilizers: Adequate 150 kg N and 120 kg P_2O_5/ha/year (P&K) • Insecticide & fungicides: Frequent • Conservation measures: Limited to bunding • Management practice: Nil • Sowing time: Soybean- Mid July Wheat- 3rd or 4th week of Nov • Seed rate: Soybean 70-80 kg ha^{-1} Wheat 80-100 kg ha^{-1}
3	Power source	:	Tractor (mechanical) + bullocks
4	Market orientation	:	Intermediate.
5	Capital intensity	:	Intermediate with easy access to credit
6	Labour intensity	:	Low with no family labour involvement
7	Land holding	:	Large, unconsolidated.
8	Income level	:	High.

Climatic Datasets of Jhalipura, Kota District, Rajasthan

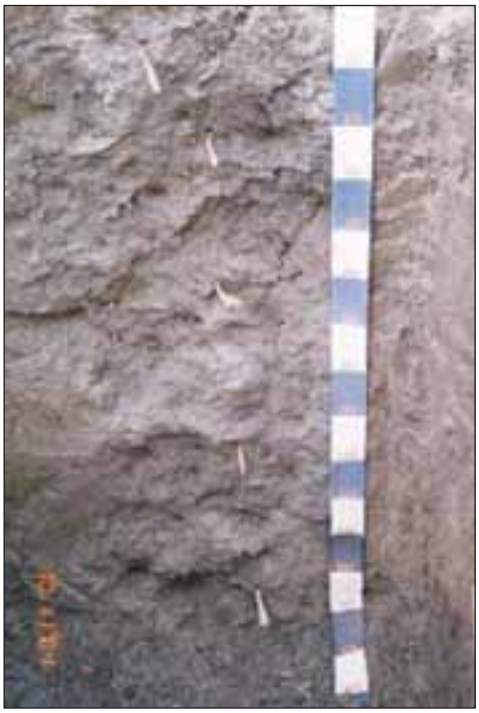
Month	Mean temp (^oC)	Rainfall (mm)	PET (mm)	½ PET (mm)	LGP (days)
January	17.60	9.00	62.00	31.00	0.00
February	20.80	4.00	80.00	40.00	0.00
March	26.30	5.00	131.00	65.50	0.00
April	31.70	5.00	167.00	83.50	0.00
May	36.20	7.00	225.00	112.50	0.00
June	34.90	79.00	210.00	105.00	30.00
July	29.80	309.00	139.00	69.50	31.00
August	28.60	268.00	121.00	60.50	31.00
September	28.90	132.00	133.00	66.50	30.00
October	27.80	15.00	122.00	61.00	0.00
November	22.80	6.00	75.00	37.50	0.00
December	19.00	3.00	58.00	29.00	0.00
Average	27.03				
Total		842.00	1523.00	761.5	122.00

Landscape, Landuse and Soils in Benchmark Spot 16 (Jhalipura, FM-1, Kota, Rajasthan)


Benchmark spot at Jhalipura, Kota, Rajasthan



Benchmark site at Jhalipura under agricultural system (farmers' management-I) with soybean-wheat crop rotation. Mustard and garlic are also grown in these soils for higher remuneration

A closer view of the profile.

BM Spot 16 : JHALIPURA: Agriculture System (Paddy-Wheat) (FM/2) P33

Classification : Fine, smectitic, hyperthermic, *Typic Haplusterts*

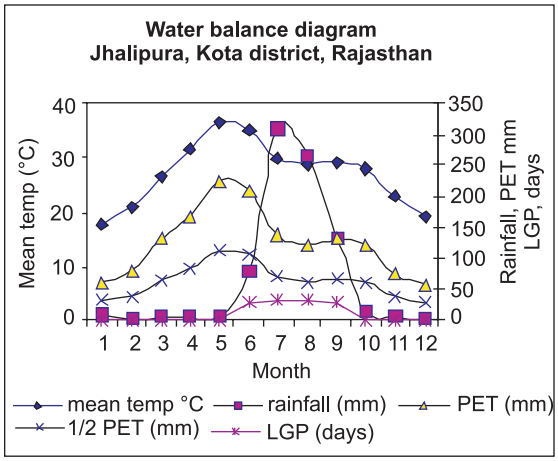
Location : Vill. Daslana (Jhalipura), Kota, Rajasthan, Lat. 25°11'15" N; Long 75°56'57" E

Physiographic position : Pathar and Bundelkhand Upland

Topography and slope: Level, 0-1% (0-50 m)

Drainage : Moderately well drained

Vegetation : *Ber*, acacia, *neem*, hypoura, grass, celotia argentia



Landuse : Paddy-wheat system, garlic

Parent material : Basaltic alluvium

Sampled by : P. Chandran, S.K. Ray, M.V. Venugopalan, P. Srivastava, S.L. Durge

Date of collection: 11.11.2001

Remarks : Recently cultivation of garlic has been taken up by farmers which is highly remunerable. $CaCO_3$ and salt encrustation are present on the surface. Dark grey (10YR 4/1) coloured thin channels (2-4 mm wide) runs vertically or obliquely down the profile. No cracks as the profile is moist. Slickensides are very well developed and as wide as 1 m.

Ap	0-13 cm	Very dark grey (2.5Y 3/1M) clay; moderate, medium subangular blocky structure; very hard, firm, sticky and plastic; many very fine, common fine roots; many very fine, common fine lime nodules; many very fine, fine and medium pores; moderately alkaline (pH 8.1); strongly effervescent; clear, smooth boundary.
Bw1	13-36 cm	Very dark greyish brown (2.5Y 3/2M) clay; strong medium subangular blocky structure with pressure faces on surface of peds; friable sticky and plastic; many very fine, common fine roots; many very fine, common fine lime nodules; many very fine and fine pores; moderately alkaline (pH 8.2); strongly effervescent; gradual smooth boundary.
Bw2	36-58 cm	Very dark greyish brown (2.5Y 3/2M) silty clay; strong medium subangular blocky and angular blocky structure with well developed shiny pressure faces on surface of peds; friable, sticky and plastic; many very fine, a few fine roots; many very fine; common fine lime nodules; many very fine and fine pores; moderately alkaline (pH 8.1); strongly effervescent; gradual wavy boundary.
Bss1	58-82 cm	Dark greyish brown (2.5Y 4/2M) clay; strong, coarse, angular and blocky structure with well developed wedge-shaped aggregates and slickensides that break into strong angular peds; friable, sticky and plastic; common very fine roots; many very fine, a few fine lime nodules; many very fine and fine pores; strongly alkaline (pH 8.5); strongly effervescent; gradual smooth boundary.
Bss2	82-107 cm	Dark greyish brown (2.5Y 4/2R) clay; strong, coarse, angular and blocky structure with well developed wedge shaped aggregates and slickensides that break into strong angular peds; friable, sticky and plastic; a few very fine roots; many very fine, common fine lime nodules; many very fine and fine pores; moderately alkaline (pH 8.4); strongly effervescent; clear, smooth boundary.

Bss3	107-132 cm	Brown (10YR 4/3R) silty clay; strong medium angular and blocky structure with wedge shaped aggregates and slickensides that break into small weak angular peds, not well developed as in the above Bss horizons; friable, sticky and plastic; a few very fine roots; many very fine and fine, common medium lime nodules; many very fine and fine pores; strongly alkaline (pH 8.6); strongly effervescent; clear, smooth boundary.
Bss4	132-156+ cm	Yellowish brown (10YR 5/4R) and dark yellowish brown (10YR 4/4M) silty clay; strong medium angular and blocky structure with wedge-shaped aggregates and slickensides that break into small weak angular peds, not well developed as in the above Bss horizons, friable, sticky and plastic; a few very fine roots; many very fine and fine, a few medium lime nodules; many very fine pores; strongly alkaline (pH 8.7); strongly to violently effervescent.

Series: JHALIPURA **BM Spot: 16 (BLACK SOILS)**

Profile No: P33 ***System: Agriculture (Paddy - Wheat)* (FM/2)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 842 mm	Classification : Fine, smectitic, hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Daslana (Jhalipura), Kota, Rajasthan		*Sampling Date: 11.11.2001*

Morphological Properties of Profile No. 33 (Jhalipura, Kota)

Horizon	Depth (cm)	Boundary		Matrix color		Texture	Coarse fragments (%) (fg and cg)	Structure		
		D	T	Dry	Moist			Size	Grade	Type
Ap	0-13	c	s	-	2.5Y3/1	c	3-5	m	2	sbk
Bw1	13-36	g	s	-	2.5Y3/2	c	3-5	m	3	sbk
Bw2	36-58	g	w	-	2.5Y3/2	c	3-5	m	3	sbk-abk
Bss1	58-82	g	s	-	2.5Y4/2 (R)	c	3-5	c	3	abk
Bss2	82-107	c	s	-	10YR4/3 (R)	c	3-5	c	3	abk
Bss3	107-132	c	s	-	10YR5/4 (R)	sicl	5-8	m	3	abk
Bss4	132-156	-	-	-	10YR4/1	sicl	5-8	m	3	abk

Depth (cm)	Consistence			Porosity		Nodules (conca)		Roots		Effervescence*	Other features	Cracks
	Dry	Moist	Wet	S	Q	Size	Quantity	Size	Quantity	Dil HCl		
0-13	vh	fi	Sp	vf,f,m	m	vf; f	m; c	vf m	f c	e	-	Not
13-36	-	fr	Sp	vf,f	m	vf; f	m; c	vf m	f c	es	Pressure faces	observed
36-58	-	fr	Sp	vf,f	m	vf; f	m; c	vf m	f f	es	Pressure faces	
58-82	-	fr	Vsvp	vf,f	m	vf; f	m; c	vf	c	es	*Slickensides	
82-107	-	fr	Vsvp	vf,f	m	vf; f	m; c	vf	f	es	Slickensides	
107-132	-	fr	Vsvp	vf,f	m	vf,f; m	m; c	vf	f	es	Slickensides	
132-156	-	fr	Sp	vf,f	m	vf,f; m	m; f	vf	f	es	Slickensides	

**Slickensides well developed and as wide as 1m.*
*** Matrix effervescence was also observed.*

Please refer Appendix I for the abbreviations.

Series: JHALIPURA **BM Spot: 16 (BLACK SOILS)**
Profile No: P33 ***System: Agriculture (Paddy - Wheat)* (FM/2)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 842 mm	Classification : Fine, smectitic, hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Daslana (Jhalipura), Kota, Rajasthan		*Sampling Date: 11.11.2001*

Physical Properties of Profile No. 33 (Jhalipura, Kota)

Laboratory No.	Horizon	Depth (cm)	Size class and particle diameter (mm)			Fine clay (%) (<0.0002)	Fine clay/ total clay (%)
			Total				
			Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)		
			←----------(% of <2 mm) ----------→				
3292	Ap	0-13	18.7	30.6	50.7	23.3	45.9
3293	Bw1	13-36	10.7	39.9	50.3	26.6	52.8
3294	Bw2	36-58	10.3	40.2	49.5	24.0	48.5
3295	Bss1	58-82	10.8	38.4	50.8	28.9	56.8
3296	Bss2	82-107	10.5	39.6	49.9	21.2	42.4
3297	Bss3	107-132	11.1	49.2	39.7	15.9	40.0
3298	Bss4	132-156	13.8	52.0	34.2	14.2	41.5

Depth (cm)	BD (Mgm^{-3})	COLE	HC ($cmhr^{-1}$)	WDC (%)
0-13	-	0.2	1.7	10.0
13-36	1.7	0.2	0.9	10.0
36-58	1.6	0.2	0.3	9.2
58-82	1.7	0.2	0.6	19.5
82-107	1.7	0.2	0.7	7.5
107-132	1.7	0.2	0.6	7.4
132-156	1.8	0.2	0.5	6.4

- *Nil or not determined (wherever applicable)*

Series: JHALIPURA **BM Spot: 16 (BLACK SOILS)**
Profile No: P33 ***System: Agriculture (Paddy - Wheat)* (FM/2)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 842 mm	Classification : Fine, smectitic, hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Daslana (Jhalipura), Kota, Rajasthan		*Sampling Date: 11.11.2001*

Chemical Properties of Profile No. 33 (Jhalipura, Kota)

Depth (cm)	pH (1:2)		EC (1:2) (dSm^{-1})	OC (%)	$CaCO_3$ (%)	Clay CO_3 (%)
	H_2O	1*N* KCl				
0-13	8.1	6.9	0.16	0.7	6.7	2.8
13-36	8.2	6.9	0.11	0.4	11.0	3.0
36-58	8.1	6.9	0.61	0.3	22.8	2.9
58-82	8.5	7.0	0.20	0.3	12.0	2.7
82-107	8.4	6.9	0.20	0.2	12.1	2.9
107-132	8.6	7.1	0.17	0.2	14.4	2.8
132-156	8.7	7.1	0.19	0.2	14.8	2.7

Depth (cm)	Extractable bases				CEC	Clay CEC	*BS (%)	ESP
	Ca	Mg	Na	K				
	----------[cmol(p+)kg^{-1}]----------							
0-13	25.5	14.9	1.5	0.5	40.2	79	105	4
13-36	28.3	10.0	1.2	0.7	37.4	74	107	3
36-58	24.2	11.4	1.6	0.4	31.3	63	120	5
58-82	24.3	9.8	1.3	0.4	34.8	68	102	4
82-107	24.6	8.5	1.6	0.4	33.7	67	104	5
107-132	21.4	11.2	1.4	0.5	32.4	82	106	4
132-156	19.0	7.9	1.7	0.5	28.3	83	103	6

** Presence of base-rich zeolites is confirmed by XRD. These zeolites are responsible for higher BS%*

Series: JHALIPURA **BM Spot: 16 (BLACK SOILS)**
Profile No: P33 ***System: Agriculture (Paddy - Wheat)* (FM/2)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 842 mm	Classification: Fine, smectitic, hyperthermic, *Typic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Daslana (Jhalipura), Kota, Rajasthan		*Sampling Date: 11.11.2001*

Characterization of Landuse Types

S. No.	Attribute		Description
1	Production system	:	Irrigated (canal + tube well) paddy-wheat double cropping system with 1-2 months fallow period. Crop livestock mixed farming system Yield: Paddy- 4000-5000 kg ha^{-1} Wheat- 4300-5000 kg ha^{-1}
2	Management level	:	• Improved seeds • Chemical fertilizers: Adequate (230-260 kg N/ha/year and 140 kg P_2O_5/ha/year) • FYM application: Nil • Pesticides: Frequently • Conservation measures: Limited to bunding • Sowing time: Paddy (transplanted)- End of July • Seed rate: Wheat 100 kg ha^{-1} Wheat- last week of November
3	Power source	:	Mechanical (tractor) + manual (weeding)
4	Market orientation	:	Largely commercial. Area devoted to high value crop like garlic, coriander, etc.
5	Capital intensity	:	High with easy access to credit
6	Labour intensity	:	Intermediate with no family labour involvement
7	Land holding	:	Large, unconsolidated
8	Income level	:	High

Climatic Datasets of Jhalipura, Kota District, Rajasthan

Month	Mean temp (^oC)	Rainfall (mm)	PET (mm)	½ PET (mm)	LGP (days)
January	17.60	9.00	62.00	31.00	0.00
February	20.80	4.00	80.00	40.00	0.00
March	26.30	5.00	131.00	65.50	0.00
April	31.70	5.00	167.00	83.50	0.00
May	36.20	7.00	225.00	112.50	0.00
June	34.90	79.00	210.00	105.00	30.00
July	29.80	309.00	139.00	69.50	31.00
August	28.60	268.00	121.00	60.50	31.00
September	28.90	132.00	133.00	66.50	30.00
October	27.80	15.00	122.00	61.00	0.00
November	22.80	6.00	75.00	37.50	0.00
December	19.00	3.00	58.00	29.00	0.00
Average	27.03				
Total		842.00	1523.00	761.5	122.00

Landscape, Landuse and Soils in Benchmark Spot 16 (Jhalipura, FM/2, Kota, Rajasthan)

Benchmark spot at Jhalipura under agricultural system (farmers' management) with paddy-wheat crop rotation

A typical Jhalipura soil profile (Typic Haplusterts)

Closer view of the profile.

BM Spot 18 : JAJAPUR: Agriculture System (Sorghum/Pigeonpea+Greengram) (FM1) P35

Classification : Fine, smectitic, isohyperthermic, *Vertic Haplustepts*

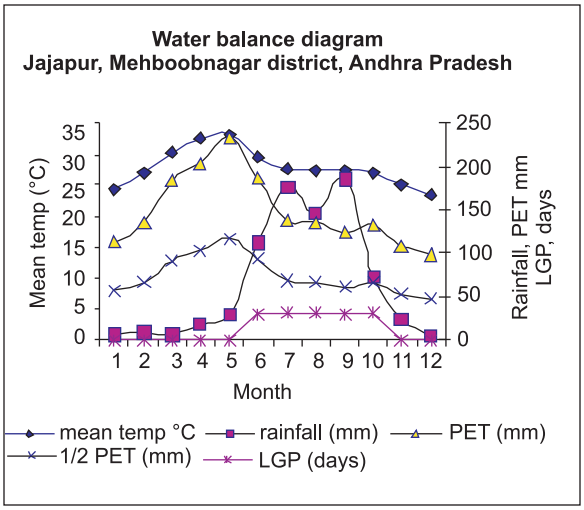
Location : Vill. Jajapur, Mandal-Narayanpet, Makthal, Mehboobnagar, Andhra Pradesh, Lat. 16°43'09"N, Long. 77°32'20"E

Physiographic position : Deccan Plateau – granite and granite-gneiss

Topography and slope : Very gently sloping, 1-3% (50-150 m)

Drainage : Moderately well drained

Vegetation : Acacia, *neem*, prosopis



Landuse : Jowar/pigeonpea+greengram

Parent material : Weathered granite-gneiss/basaltic alluvium

Sampled by : P. Chandran, S.K. Ray, M.V. Venugopalan, P. Srivastava, S.L. Durge

Date of collection : 15.12.2001

Remarks : Medium and coarse nodules are soft and can be cut easily into powdery lime. Quartz and gneissic material gravels are also found along with burnt pieces of wood. Slickensides are 0.5 mm thick without layer continuity due to sandy particles. Abk structures are not formed and have weak ped surfaces without sharp boundaries. Adjacent barren land have surface cracks about 2 cm wide.

Ap	0-12 cm	Very dark greyish brown (2.5Y 3/2M) sandy clay; moderate, medium subangular blocky structure; hard, friable, sticky and plastic; common very fine and fine, a few medium and coarse roots; common very fine, a few fine lime nodules; many very fine and fine pores; mildly alkaline (pH 7.8); slightly effervescent; clear, smooth boundary.
Bw1	12-35 cm	Very dark greyish brown (2.5Y 3/2M) sandy clay; moderate medium subangular blocky structure with pressure faces on surface of peds; friable, sticky and plastic; a few very fine, fine, medium and coarse roots; common very fine, a few fine lime nodules; many very fine and fine pores; strongly alkaline (pH 8.5); slightly effervescent; clear, smooth boundary.
Bw2	35-48 cm	Dark olive brown (2.5Y 3/3M) sandy clay; strong medium subangular blocky structure; friable, sticky and plastic; a few very fine roots; common very fine, a few fine lime nodules; strongly alkaline (pH 8.5); strongly effervescent; clear, smooth boundary.
Bw3	48-76 cm	Olive brown (2.5Y 4/3M) sandy clay; moderate medium subangular blocky structure with weakly formed wedge-shaped aggregate, which are neither stable nor continuous, angular blocky structures are not prominent and have weak ped surfaces without sharp boundaries; friable, sticky and plastic; a few very fine roots; a few very fine, fine and many lime nodules; strongly alkaline (pH 8.9); strongly effervescent; gradual smooth boundary.

Bwk1	76-96 cm	Light olive brown to olive brown (2.5Y 4.5/3M) clay; moderate medium subangular blocky structure with very weak development of slickensides and wedge-shaped aggregates having weak ped surfaces without sharp boundaries; friable, sticky and slightly plastic; a few very fine roots; a few very fine and fine, common medium lime nodules; very strongly alkaline (pH 9.1); violently effervescent; clear, smooth boundary.
Bwk2	96-126 cm	Light olive brown (2.5Y 5/3M) clay; moderate medium subangular blocky structure; friable; sticky and plastic; a few very fine roots; a few very fine and fine, common medium and coarse lime nodules; very strongly alkaline (pH 9.1); violently effervescent; gradual smooth boundary.
BCk	126-155 cm	Brown (10YR 5/3M&R) clay; moderate medium to strong subangular blocky structure; friable, sticky and plastic; a few very fine and fine, common medium and coarse lime nodules; very strongly acidic (pH 9.2); violently effervescent.

Series: JAJAPUR **BM SPOT: 18 (BLACK SOILS)**

PROFILE NO: P35 ***System: Agriculture (Sorghum/Pigeonpea+Greengram)*** **(FM1)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 792 mm	Classification : Fine, smectitic, isohyperthermic, *Vertic Haplustepts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Jajapur, Narayanpeth (Mandal), Makthal, Mehboobnagar, Andhra Pradesh		*Sampling Date: 15.12.2001*

Morphological Properties of Profile No. 35 (Jajapur, Mehboobnagar)

Horizon	Depth (cm)	Boundary		Matrix color		Texture	Coarse fragments (%) (fg and cg)	Structure		
		D	*T*	Dry	Moist			Size	Grade	Type
Ap	0-12	c	s	-	2.5Y3/2	scl	5--8	M	2	sbk
Bw1	12-35	c	s	-	2.5Y3/2	sc	5--8	M	2	sbk
Bw2	35-48	c	s	-	2.5Y3/3	sc	5--8	M	3	sbk
Bw3	48-76	g	s	-	2.5Y4/3	sc	3--5	M	2	sbk
Bwk1	76-96	c	s	-	2.5Y4.5/3	c	3--5	M	2	sbk
Bwk2	96-126	g	s	-	2.5Y5/3	c	5--8	M	2	sbk
BCk	126-155	-	-		10YR5/3 (m&R)	c	5--8	M	2 - 3	sbk

Depth (cm)	Consistence			Porosity		Nodules (conca)		Roots		Effervescence*	Other features	Cracks
	Dry	Moist	Wet	S	Q	Size	Quantity	Size	Quantity	Dil HCl		
0-12	h	fr	sp	vf, f	m	vf; f	c; f	vf,f; m, c	c; f	e	-	2 cm
12-35	-	fr	sp	vf, f	m	vf; f	c; f	vf,f; m, c	f; f	e	Pressure faces	
35-48	-	fr	sp	-	-	vf; f	c; f	vf	f	es	Thick pressure faces	
48-76	-	fr	sp	-	-	vf,f,m	f	vf	f	es	Slickensides (Weak)	
76-96	-	fr	ssp	-	-	vf,f; m	f; c	vf	f	ev	Slickensides (Weak)	
96-126	-	fr	ssp	-	-	vf,f; m,c	f; c	vf	f	ev	-	
126-155	-	fr	ssp	-	-	vf,f; m,c	f; c	-	-	ev	-	

Please refer Appendix I for the abbreviations

Series: JAJAPUR **BM SPOT: 18 (BLACK SOILS)**
PROFILE NO: P35 ***System: Agriculture (Sorghum/Pigeonpea + Greengram)*** **(FM1)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 792 mm	Classification : Fine, smectitic, isohyperthermic, *Vertic Haplustepts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Jajapur, Narayanpeth (Mandal), Makthal, Mehboobnagar, Andhra Pradesh		*Sampling Date: 15.12.2001*

Physical Properties of Profile No. 35 (Jajapur, Mehboobnagar)

Laboratory No.	Horizon	Depth (cm)	Size class and particle diameter (mm)			Fine clay (%) (<0.0002)	Fine clay / total clay (%)
			Total				
			Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)		
			←----------(% of <2 mm) ----------→				
3356	Ap	0-12	48.5	16.4	35.1	23.5	67.0
3357	Bw1	12-35	47.3	17.2	35.5	26.8	75.5
3358	Bw2	35-48	45.5	17.4	37.1	28.3	76.3
3359	Bw3	48-76	45.7	17.6	36.7	27.7	75.5
3360	Bwk1	76-96	38.7	19.3	42.0	33.0	78.4
3361	Bwk2	96-126	38.6	19.5	41.9	32.5	77.6
3362	BCk	126-155	27.4	24.1	48.5	35.5	73.2

Depth (cm)	BD (Mgm^{-3})	COLE	HC ($cmhr^{-1}$)	WDC (%)
0-12	-	0.1	1.92	2.0
12-35	1.8	0.2	1.96	2.7
35-48	1.7	0.1	1.30	2.6
48-76	1.6	0.1	0.30	2.7
76-96	1.7	0.1	<0.1	2.6
96-126	1.6	0.2	<0.1	3.1
126-155	1.6	0.2	<0.1	3.2

- *Nil or not determined (wherever applicable)*

Series: JAJAPUR **BM SPOT: 18 (BLACK SOILS)**
PROFILE NO: P35 ***System: Agriculture (Sorghum/Pigeonpea+Greengram)* (FM1)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 792 mm	Classification: Fine, smectitic, isohyperthermic, *Vertic Haplustepts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Jajapur, Narayanpeth (Mandal), Makthal, Mehboobnagar, Andhra Pradesh		*Sampling Date: 15.12.2001*

Chemical Properties of Profile No. 35 (Jajapur, Mehboobnagar)

Depth (cm)	pH (1:2)		EC (1:2) (dSm^{-1})	OC (%)	$CaCO_3$ (%)	Clay CO_3 (%)
	H_2O	1*N* KCl				
0-12	7.8	6.9	0.36	0.5	3.5	4.5
12-35	8.5	7.0	0.18	0.3	3.4	6.7
35-48	8.5	7.1	0.21	0.3	5.4	6.2
48-76	8.9	7.2	0.20	0.3	5.5	6.3
76-96	9.1	7.2	0.57	0.2	10.4	9.6
96-126	9.1	7.4	0.76	0.2	12.8	13.1
126-155	9.2	7.3	1.00	0.2	11.8	19.6

Depth (cm)	Extractable bases				CEC	Clay CEC	BS (%)	ESP
	Ca	Mg	Na	K				
	----------[cmol(p+)kg^{-1}]----------							
0-12	20.1	6.0	1.3	0.4	27.8	79	100	5
12-35	17.5	9.2	2.0	0.2	28.7	81	101	7
35-48	15.6	8.9	3.0	0.2	27.8	75	100	11
48-76	12.8	9.7	4.6	0.1	29.6	81	92	16
76-96	10.6	14.0	7.2	0.2	31.3	74	102	23
96-126	9.3	11.8	7.9	0.1	28.7	68	101	28
126-155	9.5	14.8	10.0	0.2	36.5	75	94	27

- *Nil or not determined (wherever applicable)*

Series: JAJAPUR **BM SPOT: 18 (BLACK SOILS)**

PROFILE NO: P35 ***System: Agriculture (Sorghum/Pigeonpea + Greengram)*** **(FM1)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 792 mm	Classification : Fine, smectitic, isohyperthermic, *Vertic Haplustepts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Jajapur, Narayanpeth (Mandal), Makthal, Mehboobnagar, Andhra Pradesh		*Sampling Date: 15.12.2001*

Saturation Extract Properties of Profile No. 35 (Jajapur, Mehboobnagar)

Depth (cm)	Sat (%)	*ECe* (d Sm^{-1})	Soluble cations ($mmol_c$ l^{-1})				Sum of cations
			Ca	Mg	Na	K	
0-12	33.67	0.44	0.35	0.23	2.39	0.04	3.01
12-35	37.65	0.49	1.53	0.67	4.78	0.06	7.04
35-48	40.25	0.42	0.41	0.26	9.78	0.08	10.53
48-76	46.86	0.30	2.58	1.75	12.82	0.12	17.27
76-96	66.67	0.73	0.24	0.26	13.17	0.05	13.72
96-126	65.06	0.05	4.54	3.06	12.17	13.70	19.80
126-155	86.53	1.25	0.42	0.21	11.52	0.06	12.21

Depth (cm)	Soluble anions ($mmol_c$ l^{-1})				Sum of anions
	CO_3	HCO_3	Cl	SO_4	
0-12	-	1.85	1.40	-	4.25
12-35	2.12	2.12	1.30	1.50	7.04
35-48	2.65	5.84	2.50	-	10.99
48-76	5.30	6.26	5.50	-	17.10
76-96	2.65	5.30	5.25	-	13.20
96-126	-	5.00	14.00	-	19.00
126-155	1.69	4.14	7.00	-	12.80

- *Nil or not determined (wherever applicable)*

Series: JAJAPUR **BM SPOT: 18 (BLACK SOILS)**

PROFILE NO: P35 ***System: Agriculture (Sorghum/Pigeonpea + Greengram)*** **(FM1)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 792 mm	Classification : Fine, smectitic, isohyperthermic, *Vertic Haplustepts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Jajapur, Narayanpeth (Mandal), Makthal, Mehboobnagar, Andhra Pradesh		*Sampling Date: 15.12.2001*

Characterization of Landuse Types

S. No.	Attribute		Description
1	Production system	:	Dry (rain-fed) farming of *kharif* fallow-rabi sorghum-pigeonpea + greengram (1:4) intercropping (2 year rotation). Crop livestock-farming. Yield range: Sorghum (R) 1500-2000 kg ha^{-1}, pigeonpea 1200-1500 kg ha^{-1} and greengram 750-100 kg ha^{-1} ranging from 5 to 8 months
2	Management level	:	• Improved seeds • Chemical fertilizer: 80 kg N/ha for sorghum &, 20-25 kg N/ha for pigeon pea and 58 kg P_2O_5/ha for each crop • Sowing time: *Rabi* sorghum- (October) Pigeonpea + greengram – (1^{st} fortnight of July) • Seed rate: Sorghum 7-8 kg ha^{-1} Pigeonpea 12-15 kg ha^{-1} Greengram (as winter crop) 15 kg ha^{-1}
3	Power source	:	Tractor & bullock
4	Market orientation	:	Intermediate
5	Capital intensity	:	High with limited access to credit
6	Labour intensity	:	Medium with no family labour
7	Land holding	:	Large unconsolidated
8	Income level	:	High

Climatic Datasets of Jajapur, Mehboobnagar District, Andhra Pradesh

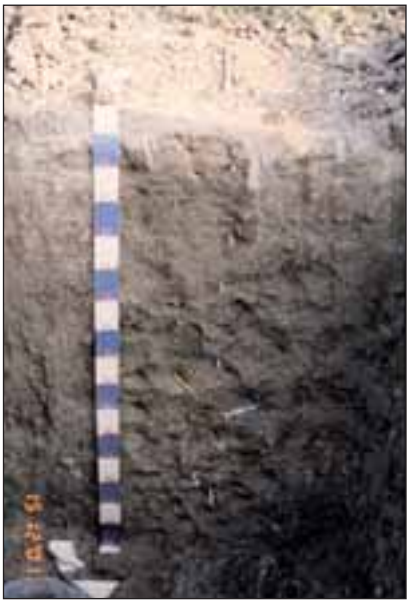
Month	Mean temp (^oC)	Rainfall (mm)	PET (mm)	½ PET (mm)	LGP (days)
January	24.40	5.80	113.00	56.50	0.00
February	26.90	9.70	135.00	67.50	0.00
March	30.20	7.10	184.00	92.00	0.00
April	32.50	17.30	205.00	102.50	0.00
May	33.10	28.70	234.00	117.00	0.00
June	29.60	112.00	186.00	93.00	30.00
July	27.50	176.30	137.00	68.50	31.00
August	27.40	146.30	135.00	67.50	31.00
September	27.20	185.20	124.00	62.00	30.00
October	27.10	74.40	132.00	66.00	31.00
November	25.00	25.70	107.00	53.50	0.00
December	23.60	3.80	98.00	49.00	0.00
Average	27.88				
Total		792.30	1790.00	895.00	153.00

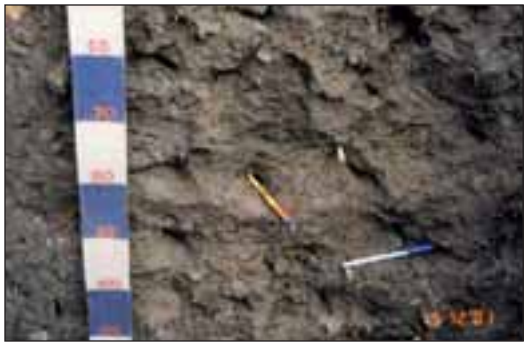
Landscape, Landuse and Soils in Benchmark Spot 18 (Jajapur, FM1, Mehboobnagar, A.P.)

Benchmark site at Jajapur, Mehboobnagar, Andhra Pradesh, under agricultural system (farmers' management-I) with sorghum/ pigeonpea+greengram cropping pattern

Interaction with farmers to collect landuse data

Wide and polygonal cracks in benchmark site at Jajapur





A closer view of the profile

BM Spot 18 : JAJAPUR 1: Agriculture System (Paddy-Paddy) (FM/2) P36

Classification: Fine-loamy, smectitic, isohyperthermic, Vertic Haplustepts

Location : Vill. Jajapur, Narayanpeth, Makthal, Mehboobnagar, Andhra Pradesh. Lat. 16°43'17"N, Long. 77°32'47"E

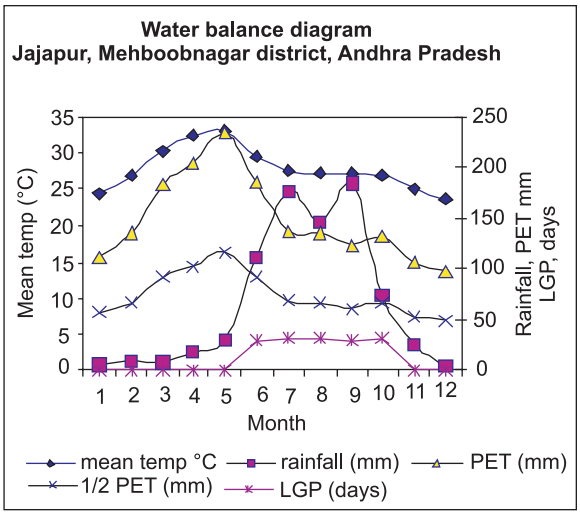
Physiographic position : Deccan Plateau – granite and granite-gneiss

Topography and slope: Almost level land, 0-1% (0-50 m)

Drainage : Imperfectly to moderately well drained

Vegetation : Acacia, prosopis, *neem*, grass

Landuse : Paddy-paddy



Parent material : Alluvium of weathered granite-gneiss

Sampled by : P. Chandran, S.K. Ray, M.V. Venugopalan, P. Srivastava, S.L. Durge

Date of collection: 15.12.2001

Remarks : Nodules from fourth horizon are soft and mainly composed of hardened (cemented) $CaCO_3$ over sand particles. Coarse fragments are mainly calcareous nodules and a few stones of gneissic material. Burnt wood and small brick pieces are throughout 10-128 cm

Ap	0-10 cm	Dark grey (10YR 4/1D) and very dark greyish brown (10YR 3/2M) sandy clay loam; strong, coarse subangular blocky structure (when dry); hard, friable, sticky and slightly plastic; many very fine, common fine roots; common very fine and fine lime nodules; many fine and very fine pores; moderately alkaline (pH 8.2); slightly effervescent; clear, smooth boundary.
Bw1	10-28 cm	Very dark grey to very dark greyish brown (10YR 3/1.5M) sandy clay loam; strong, coarse subangular blocky (when dry) structure with weak pressure faces on surface of peds; friable, sticky and slightly plastic; common very fine, a few fine roots; many very fine and fine lime nodules; many very fine and fine pores; strongly alkaline (pH 8.7); slightly effervescent; clear, smooth boundary.
Bw2	28-53 cm	Dark grey (2.5Y 4/1M) sandy clay loam; moderate medium subangular blocky structure with weak development of pressure faces on surface of peds and very weak wedge shaped aggregates; friable, sticky and slightly plastic; a few very fine and fine roots; many very fine and fine lime nodules; many very fine and fine pores; strongly alkaline (pH 8.5); slightly effervescent; clear, smooth boundary.
Bw3	53-76 cm	Dark grey to dark greyish brown (2.5Y 4.5/2M) sandy clay loam; moderate medium subangular blocky structure with weak development of pressure faces on surface of peds and very weak wedge-shaped aggregates; friable, sticky and slightly plastic; a few, fine distinct, yellowish brown (10YR 5/6) mottles; a few very fine roots; many very fine and fine lime nodules; many very fine and fine pores; 8-10% fine gravels; strongly alkaline (pH 8.8); strongly effervescent; abruptly smooth boundary.

Bwk1	76-98 cm	Light brownish grey (2.5Y 6/2R) sandy clay; weak medium subangular blocky structure; friable, sticky and slightly plastic; a few, fine, distinct, yellowish brown (10YR 4/6) mottles; a few very fine roots; many very fine and fine, common medium lime nodules; 10-15% fine and coarse gravels; strongly alkaline (pH 8.8); violently effervescent; clear, smooth boundary.
Bwk2	98-128 cm	Light brownish grey to light yellowish brown (2.5Y 6/2.5M) sandy clay loam; weak medium subangular blocky structure; friable, sticky and slightly plastic; common medium, distinct yellowish brown (10YR 4/6) mottles; a few very fine roots; many very fine, fine and medium lime nodules; 10-15% fine and coarse gravels; strongly alkaline (pH 8.5); violently effervescent; clear, smooth boundary.
BCk1	128-150 cm	Light yellowish brown (2.5Y 6/3M) sandy clay loam; weak medium subangular blocky structure; friable, sticky and slightly plastic; common medium distinct yellowish brown (10YR 4/6) mottles; many very fine, fine and medium lime nodules; 15-20% fine and coarse gravels; strongly alkaline (pH 8.6); violently effervescent; clear, smooth boundary.
BCk2	150+ cm	Light olive brown (2.5Y 5/4M) sandy clay loam; weak medium subangular blocky structure; friable, sticky and slightly plastic; many, medium, distinct yellowish brown (10YR 4/6) mottles; many very fine, fine and medium lime nodules; 15-20% fine and coarse gravels; strongly alkaline (pH 8.8); violently effervescent.

Series: JAJAPUR 1 **BM SPOT: 18 (BLACK SOILS)**

PROFILE NO: P36 ***System: Agriculture (Paddy - Paddy)*** **(FM/2)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 792 mm	Classification: Fine-loamy, smectitic, isohyperthermic, *Vertic Haplustepts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Jajapur, Narayanpeth (Mandal), Makthal, Mehboobnagar, Andhra Pradesh		*Sampling Date: 15.12.2001*

Morphological Properties of Profile No. 36 (Jajapur, Mehboobnagar)

Horizon	Depth (cm)	Boundary		Matrix color		Mottle colour*			Texture	Coarse** fragments (%) (fg, cg %)	Structure		
		D	T	Dry	Moist	A	S	C			Size	Grade	Type
Ap	0-10	c	s	10YR4/1	10YR3/2	-			scl	3--5	c	3	sbk
Bw1	10-28	c	s	-	10YR3/1.5	-			scl	3--5	c	3	sbk
Bw2	28-53	c	s	-	2.5Y4/1(R)	-			scl	5--8	m	2	sbk
Bw3	53-76	a	s	-	2.5Y4.5/2	f	10YR5/6 1	d	scl	8--10	m	2	sbk
BCK1	76-98	c	s	-	2.5Y6/2 (R)	f	10YR4/6 1	d	sc	10--15	m	1	sbk
BCK2	98-128	c	s	-	2.5Y6/2.5 (R)	c	10YR4/6 2	d	scl	10--15	m	1	sbk
BCK3	128-150	c	s	-	2.5Y6/3 (R)	c	10YR4/6 2	d	scl	15--20	m	1	sbk
BCK4	150+	-	-	-	2.5Y5/4 (R)	m	10YR4/6 2	d	scl	15--20	m	1	sbk(w)*

Depth (cm)	Consistence			Porosity		Nodules (conca)		Roots		Effervescence*	Other features	Cracks
	Dry	Moist	Wet	S	Q	Size	Quantity	Size	Quantity	Dil HCl		
0-10	h	fr	s sp	f, vf	m	vf,f	c	vf m	f c	e	-	Not
10-28	-	fr	s sp	f, vf	m	vf,f	m	vf c	f f	e	Pressure Faces (Weak)	observed
28-53	-	fr	s sp	f, vf	m	vf,f	m	vf,f	f	e	Slickensides (very weak)	
53-76	-	fr	s sp	f, vf	m	vf,f	m	vf	f	es	Slickensides (very weak)	
76-98	-	fr	s sp	-	-	vf,f m	m, c	vf	f	ev	-	
98-128	-	fr	s sp	-	-	vf, f,m	m	vf	f	ev	-	
128-150	-	fr	s sp	-	-	vf, f,m	m	-	-	ev	-	
150+	-	fr	s sp	-	-	-	-	-	-	ev	-	

***A** = Abundance, **S** = Size, **C** = Contrast of mottles **Mainly Calcareous nodules with a few stones of gneissic material*

Please refer Appendix I for the abbreviation.

Series: JAJAPUR 1 **BM SPOT: 18 (BLACK SOILS)**

PROFILE NO: P36 ***System: Agriculture (Paddy - Paddy)*** **(FM/2)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 792 mm	Classification: Fine-loamy, smectitic, isohyperthermic, *Vertic Haplustepts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Jajapur, Narayanpeth (Mandal), Makthal, Mehboobnagar, Andhra Pradesh		*Sampling Date: 15.12.2001*

Physical Properties of Profile No. 36 (Jajapur, Mehboobnagar)

Laboratory No.	Horizon	Depth (cm)	Size class and particle diameter (mm)			Fine clay (%) (<0.0002)	Fine clay/ total clay (%)
			Total				
			Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)		
			←----------(% of <2 mm) ----------→				
3363	Ap	0-10	54.2	19.4	26.4	20.6	78.0
3364	Bw1	10-28	59.4	16.8	23.8	19.5	81.9
3365	Bw2	28-53	58.1	15.6	26.3	21.5	81.7
3366	Bw3	53-76	51.2	15.4	33.4	26.1	78.1
3367	BwK1	76-98	45.6	18.5	35.9	24.7	68.8
3368	BwK2	98-128	52.9	15.8	31.4	22.0	70.3
3369	BCK1	128-150	57.4	14.2	28.4	20.1	70.8
3370	BCK2	150+	57.2	16.2	26.7	18.4	69.2

Depth (cm)	BD (Mgm^{-3})	COLE	HC ($cmhr^{-1}$)	WDC (%)
0-10	-	0.2	0.43	2.9
10-28	1.9	0.1	<0.1	2.6
28-53	1.9	0.1	<0.1	2.6
53-76	1.8	0.2	0.5	3.0
76-98	1.8	0.2	0.5	2.9
98-128	1.8	0.2	0.5	2.8
128-150	1.8	0.2	0.7	2.8
150+	1.8	0.2	0.6	3.0

- *Nil or not determined (wherever applicable)*

Series: JAJAPUR 1 **BM SPOT: 18 (BLACK SOILS)**

PROFILE NO: P36 ***System: Agriculture (Paddy - Paddy)*** **(FM/2)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 792 mm	Classification: Fine-loamy, smectitic, isohyperthermic, *Vertic Haplustepts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Jajapur, Narayanpeth (Mandal), Makthal, Mehboobnagar, Andhra Pradesh		*Sampling Date: 15.12.2001*

Chemical Properties of Profile No. 36 (Jajapur, Mehboobnagar)

Depth (cm)	pH (1:2)		EC (1:2) (d Sm^{-1})	OC (%)	$CaCO_3$ (%)	Clay CO_3 (%)
	H_2O	1*N* KCl				
0-10	8.2	7.1	0.26	1.5	2.2	4.2
10-28	8.7	7.2	0.24	0.6	2.0	4.6
28-53	8.5	7.2	0.22	0.3	3.5	5.5
53-76	8.8	7.2	0.21	0.2	8.7	7.1
76-98	8.8	7.3	0.16	0.1	16.6	8.2
98-128	8.5	7.2	0.19	0.1	12.3	7.0
128-150	8.6	7.2	0.19	0.1	10.8	6.6
150+	8.8	7.2	0.20	0.1	10.1	5.4

Depth (cm)	Extractable bases				CEC	Clay CEC	BS (%)	ESP
	Ca	Mg	Na	K				
	← ----------[cmol(p+)kg^{-1}]----------→							
0-10	10.3	8.5	2.0	0.2	18.2	69	115	11
10-28	8.8	5.5	2.0	0.2	13.9	58	119	14
28-53	8.7	8.8	2.2	0.2	17.4	66	114	12
53-76	10.0	11.4	2.3	0.2	22.2	66	107	10
76-98	9.5	10.7	1.9	0.2	22.6	63	99	8
98-128	9.9	8.4	1.7	0.2	19.1	61	105	9
128-150	10.4	8.0	1.6	0.1	17.4	61	115	9
150+	9.5	8.4	2.2	0.2	17.8	67	113	12

Series: JAJAPUR 1 **BM SPOT: 18 (BLACK SOILS)**

PROFILE NO: P36 ***System: Agriculture (Paddy - Paddy)*** **(FM/2)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 792 mm	Classification: Fine-loamy, smectitic, isohyperthermic, *Vertic Haplustepts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Jajapur, Narayanpeth (Mandal), Makthal, Mehboobnagar, Andhra Pradesh		*Sampling Date: 15.12.2001*

Characterization of Landuse Types

S. No.	Attribute		Description
1	Production system	:	Irrigated (tube well & tank) paddy-paddy double cropping, low land, transplanted, bunded system (under puddling). Crop-livestock farming system with 2-3 months fallow. Yield range: Paddy (*kharif*)- 3500-4000 kg /ha and Paddy (*rabi*): 4500 kg ha^{-1}.
2	Management level	:	• Improved seeds • Chemical fertilizer: 160-200 kg N/ha and 110-120 kg P_2O_5/ha for main crop/year • Additional DAP for paddy in nursery & organics (FYM 12 cartloads/ha) • Pesticides: Used • Conservation measures adopted: Bunding • Stubble: Incorporated • Sowing (transplanting) time: July and December.
3	Power source	:	Bullock
4	Market orientation	:	Intermediate to commercial
5	Capital intensity	:	High with access to credit
6	Labour intensity	:	High with no family labour involvement
7	Land holding	:	Medium, unconsolidated
8	Income level	:	High

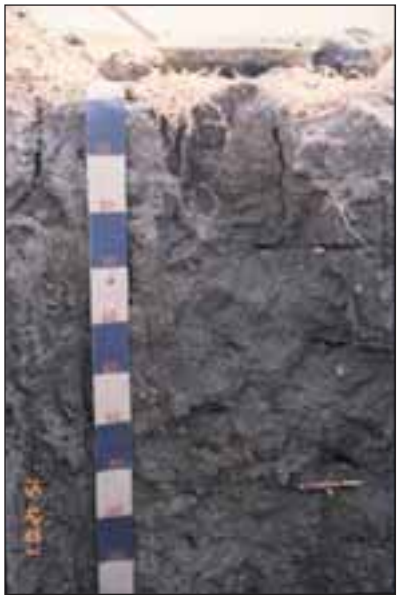
Climatic Datasets of Jajapur, Mehboobnagar District, Andhra Pradesh

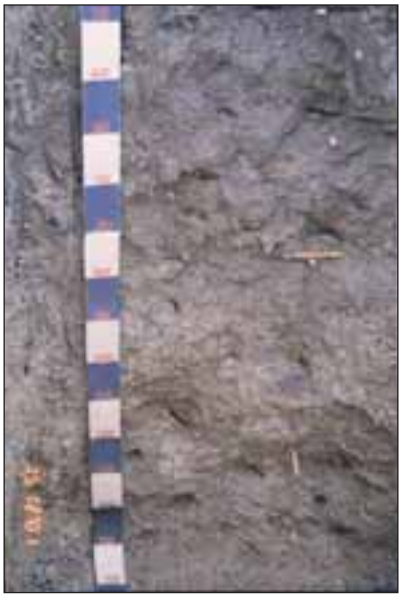
Month	Mean temp (^oC)	Rainfall (mm)	PET (mm)	½ PET (mm)	LGP (days)
January	24.40	5.80	113.00	56.50	0.00
February	26.90	9.70	135.00	67.50	0.00
March	30.20	7.10	184.00	92.00	0.00
April	32.50	17.30	205.00	102.50	0.00
May	33.10	28.70	234.00	117.00	0.00
June	29.60	112.00	186.00	93.00	30.00
July	27.50	176.30	137.00	68.50	31.00
August	27.40	146.30	135.00	67.50	31.00
September	27.20	185.20	124.00	62.00	30.00
October	27.10	74.40	132.00	66.00	31.00
November	25.00	25.70	107.00	53.50	0.00
December	23.60	3.80	98.00	49.00	0.00
Average	27.88				
Total		792.30	1790.00	895.00	153.00

Landscape, Landuse and Soils in Benchmark Spot 18 (FM/2, Jajapur, Mehboobnagar, A.P.)

Benchmark spot at Jajapur, Mehboobnagar, Andhra Pradesh, under agricultural system (farmers' management-II) with paddy-paddy cropping system

Closer view of the profile





Typical Jajapur profile (Vertic Haplustepts)

Still closer view of the profile

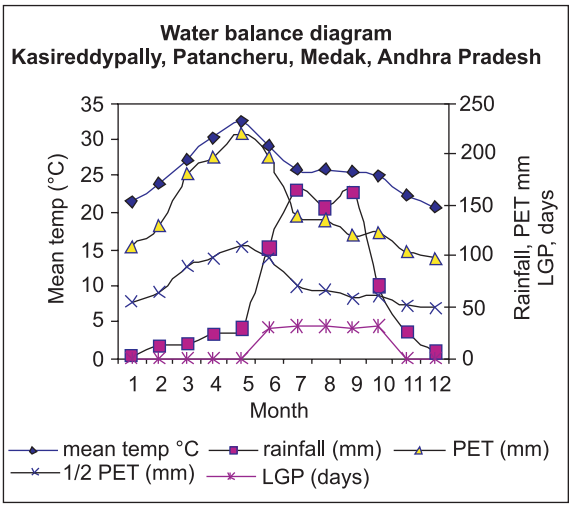
BM Spot 20 : KASIREDDYPALLI: Agriculture System (Soybean+Pigeonpea) (HM) P39

Classification: Fine, smectitic, isohyperthermic, *Sodic Haplusterts*

Location : ICRISAT Farm BW7, Patancheru, Ramchandrapuram, Medak, Andhra Pradesh. Lat. 17°30'13"N, Long 78°16'07"E

Physiographic position : Deccan plateau – boarder of granite and granite-gneiss and basalt

Topography and slope: Gently sloping and undulating, 3-8% (50-150 m)



Drainage : Moderately well drained

Vegetation : Acacia, palm, turmeric

Landuse : Soybean+pigeonpea intercropping, sorghum, gram

Parent material : Basaltic gneissic alluvium

Sampled by : P. Chandran, S.K. Ray, M.V. Venugopalan, S.L. Durge

Date of collection:

Remarks : Fine gravels of basalt. Cracks do not reach continuously vertically downwards, polygonal cracks appear on the surface of slickensides only after exposure for 3-4 days. 3-5 mm wide cracks from 12-60 cm. First 12 cm soil has no cracks due to ridge. Cracks are present along the sides of the field by 2-3 cm wide up to 30 cm. In 0-84 cm depth, effervescence may be partly due to very fine nodules. Otherwise, all the horizons are slightly effervesce in the matrix. Soybean-pigeonpea intercropping is being done on broad bed ridge and furrow system.

Ap	0-12 cm	Very dark gray to dark gray (10YR 3.5/1D) and very dark grayish brown (10YR 3/2M) clay; weak, medium subangular blocky structure; soft, very friable, sticky and plastic; common very fine and fine, a few medium and coarse roots; many very fine, common fine lime nodules; many fine and medium pores; mildly alkaline (pH 7.5); slightly effervescent; clear, smooth boundary.
Bw1	12-31 cm	Very dark gray (10YR 3/1M) clay; moderate medium subangular blocky structure with pressure faces on surface of peds; friable, sticky and plastic; common very fine and fine, few medium roots; many very fine, a few fine and medium lime nodules; many very fine and fine, a few medium pores; mildly alkaline (pH 7.8); slightly effervescent; clear, smooth boundary.
Bss1	31-54 cm	Very dark grey (10YR 3/1M) clay; strong medium angular blocky structure with shiny pressure faces on surface of peds and wedge shaped aggregates and slickensides (not well developed) that break into weak angular peds; friable, sticky and plastic; a few very fine and fine, medium roots; common very fine and fine, a few medium lime nodules; many very fine and fine pores; mildly alkaline (pH 7.8); slightly effervescent; gradual smooth boundary.

Bss2	54-84 cm	Very dark greyish brown (10YR 3/2M) clay; strong medium angular blocky structure with well developed wedge shaped aggregates and slickensides that break into small angular peds; slightly firm, sticky and plastic; a few very fine and fine roots; common very fine, a few fine and medium lime nodules; many very fine and fine pores; moderately alkaline (pH 8.2); slightly effervescent; gradual smooth boundary.
Bss3	84-118 cm	Very dark greyish brown (10YR 3/2M) clay; strong medium angular blocky structure with well developed wedge-shaped aggregates and slickensides that break into small angular peds; slightly firm, sticky and plastic (very hard when dry); a few very fine and fine roots; common very fine and fine, a few medium and coarse lime nodules; moderately alkaline (pH 8.1); slightly effervescent; clear, smooth boundary.
Bss4	118-146 cm	Olive brown (2.5Y 4/3M) and dark greyish brown (2.5Y 4/2R) clay; strong medium angular blocky structure with moderately well developed wedge-shaped aggregates and slickensides that break into small, weak angular peds; slightly firm, sticky and plastic (very hard when dry); a few very fine roots; many very fine and fine common medium and coarse lime nodules; moderately alkaline (pH 8.2); slightly effervescent; clear, smooth boundary.
BC	146-157 cm	Light olive brown (2.5Y 5/4M) clay; strong medium subangular blocky structure with weak development of wedge-shaped aggregates and angular blocky structure; firm, sticky and plastic (very hard when dry); a few very fine roots; many very fine, common fine, medium and coarse lime nodules; moderately alkaline (pH 8.2); slightly efferves cent.

Series: KASIREDDYPALLI **BM SPOT: 20 (BLACK SOILS)**

PROFILE NO: P39 ***System: Agriculture (Soybean – Pigeonpea)*** **(HM)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 764 mm	Classification: Fine, smectitic, isohyperthermic, *Sodic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: ICRISAT Farm BW7, Patancheru, Ramchandrapuram, Medak, Andhra Pradesh		*Sampling Date: 18.12.2001*

Morphological Properties of Profile No. 39 (Kasireddypalli, Medak)

Horizon	Depth (cm)	Boundary		Matrix color		Mottle color	Texture	Coarse fragments (%) (fg %)	Structure		
		D	T	Dry	Moist				Size	Grade	Type
Ap	0-12	c	s	10YR3.5/1	10YR3/2	-	c	5-8	m	1	sbk
BW1	12-31	c	s	-	10YR3/1	-	c	5-8	m	2	sbk
Bss1	31-54	g	w	-	10YR3/1	-	c	5-8	m	3	abk
Bss2	54-84	g	w	-	10YR3/2	-	c	5-8	m	3	abk
Bss3	84-118	c	s	-	10YR3/2	10YR 3/1	c	5-8**	m	3	abk
Bss4	118-146	c	s	-	2.5Y4/3,4/2 (R)	10YR 3/1	c	8-10**	m	3	abk(w)*
BssK5	146-157	-	-	-	2.5Y5/4	10YR3/1	c	8-10**	m	3	sbk

Depth (cm)	Consistence			Porosity		Nodules(conca)		Roots		Effervescence*	Other features	Cracks
	Dry	Moist	Wet	S	Q	Size	Quantity	Size	Quantity	Dil HCl		
0-12	s	vfr	s p	f, m	m	vf; f	c	vf,f; m,c	c; f	e	-	0.3 cm
12-31	-	vf	s p	vf,f; m	m;f	vf; f,m	c; f	vf,f; m	c; f	e	Pressure faces	
31-54	-	vf	s p	vf,f	m	vf,f; m	c; f	vf,f; m	f; f	e	Slickensides (mod. Well)	60 m
54-84	-	sfi	vs vp	vf,f	m	vf; f,m	c; f	vf,f	f	e	Slickensides	
84-118	-	sfi	vs vp	-	-	vf,f; m,c	c; f	vf,f	f	es	Slickensides	
118-146	-	sfi	vs vp	-	-	vf, f; m,c	m; f	vf	f	es	Slickensides	
146-157	-	fi	s p	-	-	vf; f,m,c	m; c	vf	f	es	Slickensides (weak)	

Cracks do not reach continuously vertically downward. Polygonal cracks appear on the surface of slickensides only even after exposure for 3-4 days.

** Verticle patches of dark colour.*

***Matrix effervescence was also observed.*

Please refer Annexure I for the abbreviations

Series: KASIREDDYPALLI **BM SPOT: 20 (BLACK SOILS)**

PROFILE NO: P39 ***System: Agriculture (Soybean – Pigeonpea)*** **(HM)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 764 mm	Classification: Fine, smectitic, isohyperthermic, *Sodic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: ICRISAT Farm BW7, Patancheru, Ramchandrapuram, Medak, Andhra Pradesh		*Sampling Date: 18.12.2001*

Physical Properties of Profile No. 39 (Kasireddypalli, Medak)

Laboratory No.	Horizon	Depth (cm)	Size class and particle diameter (mm)			Fine clay (%) (<0.0002)	Fine clay/ total clay (%)
			Total				
			Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)		
			←----------(% of <2 mm) ----------→				
3381	Ap	0-12	21.5	26.4	52.1	28.8	55.3
3382	Bw1	12-31	20.4	28.1	51.5	28.1	54.6
3383	Bss1	31-54	16.7	29.1	54.2	34.0	62.7
3384	Bss2	54-84	13.9	28.8	57.3	40.0	69.8
3385	Bss3	84-118	10.9	32.6	56.5	26.0	46.0
3386	Bss4	118-146	3.6	37.1	59.3	31.7	53.4
3387	BC	146-157	9.9	30.1	60.0	41.5	69.2

Depth (cm)	BD (Mgm^{-3})	COLE	HC ($cmhr^{-1}$)	WDC (%)
0-12	-	0.2	1.7	3.2
12-31	1.6	0.2	1.6	3.5
31-54	1.6	0.2	1.0	3.7
54-84	1.5	0.3	0.9	3.7
84-118	1.6	0.3	0.7	3.2
118-146	1.4	0.3	0.3	3.2
146-157	1.4	0.3	-	3.4

- *Nil or not determined (wherever applicable)*

Series: KASIREDDYPALLI **BM SPOT: 20 (BLACK SOILS)**

PROFILE NO: P39 ***System: Agriculture (Soybean – Pigeonpea)*** **(HM)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 764 mm	Classification: Fine, smectitic, isohyperthermic, *Sodic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: ICRISAT Farm BW7, Patancheru, Ramchandrapuram, Medak, Andhra Pradesh		*Sampling Date: 18.12.2001*

Chemical Properties of Profile No. 39 (Kasireddypalli, Medak)

Depth (cm)	pH (1:2)		EC (1:2) (d Sm^{-1})	OC (%)	$CaCO_3$ (%)	Clay CO_3 (%)
	H_2O	1*N* KCl				
0-12	7.5	6.4	0.14	1.0	4.2	7.9
12-31	7.8	6.6	0.15	0.6	4.5	9.6
31-54	7.8	6.5	0.22	0.4	6.2	10.8
54-84	8.2	6.7	0.31	0.4	5.1	12.0
84-118	8.1	6.6	0.23	0.5	8.6	7.5
118-146	8.2	6.6	0.30	0.5	8.4	7.9
146-157	8.2	6.8	0.62	0.3	7.4	11.3

Depth (cm)	Extractable bases				CEC	Clay CEC	BS (%)	ESP
	Ca	Mg	Na	K				
	←----------[cmol(p+)kg^{-1}]----------→							
0-12	36.5	12.5	1.0	0.5	50.4	97	100	2
12-31	34.7	14.4	1.0	0.4	54.3	105	93	2
31-54	31.9	19.0	1.8	0.4	55.6	103	95	3
54-84	28.9	15.3	3.7	0.4	56.4	98	86	7
84-118	38.7	10.2	4.2	0.7	61.6	109	87	7
118-146	34.6	16.8	4.2	0.5	58.2	98	96	7
146-157	24.4	22.8	5.1	0.7	55.2	92	96	9

Series: KASIREDDYPALLI **BM SPOT: 20 (BLACK SOILS)**

PROFILE NO: P39 ***System: Agriculture (Soybean – Pigeonpea)* (HM)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 764 mm	Classification: Fine, smectitic, isohyperthermic, *Sodic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: ICRISAT Farm BW7, Patancheru, Ramchandrapuram, Medak, Andhra Pradesh		*Sampling Date: 18.12.2001*

Characterization of Landuse Types

S. No.	Attribute		Description
1	Production system	:	Rain-fed *kharif* intercropping system with 6-7 months of fallow. Soybean + pigeonpea 4:1 intercropping system Yield range: Soybean -469-2068 kg ha^{-1} and Pigeonpea- 589-1452 kg ha^{-1}
2	Management level	:	• Improved varieties (PK432 soybean and asha-pigeonpea), • 250kg SSP/ha per year (40 kg P_2O_5/ha) • Green manuring with glyricidia loppings • Insecticides: Occasional • Weedicide: Basalin at 2 l/ha. • Broad bed (1.05 m) Ridge and furrow (0.50m) land management system.
3	Power source	:	Animal-bullock
4	Market orientation	:	Research and development
5	Capital intensity	:	Medium
6	Labour intensity	:	Low
7	Land holding	:	NA
8	Income level	:	NA

Climatic Datasets of Kasireddypalli, Medak District, Andhra Pradesh

Month	Mean temp (^oC)	Rainfall (mm)	PET (mm)	½ PET (mm)	LGP (days)
January	21.60	1.70	109.80	54.90	0.00
February	24.00	11.40	129.50	64.75	0.00
March	27.40	13.40	181.50	90.75	0.00
April	30.30	24.10	197.80	98.90	0.00
May	32.40	30.00	219.90	109.95	0.00
June	29.10	107.40	196.40	98.20	30.00
July	26.00	165.00	140.40	70.20	31.00
August	25.80	146.90	135.50	67.75	31.00
September	25.60	163.30	119.30	59.65	30.00
October	25.00	70.80	123.60	61.80	31.00
November	22.40	24.90	104.10	52.05	0.00
December	20.60	5.50	98.60	49.30	0.00
Average	25.85				
Total		764.40	1756.40	878.20	153.00

Landscape, Landuse and Soils in Benchmark Spot 20 (Kasireddypalli, HM, ICRISAT, Patancheru, Medak, A.P.)



Benchmark spot at Kasireddypalli, Medak, Andhra Pradesh, under agricultural system (high management) with soybean and pigeonpea crop rotation.

Wide polygonal cracks at the benchmark spot

Closer view of the profile



Typical Kasireddypalli soil profile (Sodic Haplusterts).

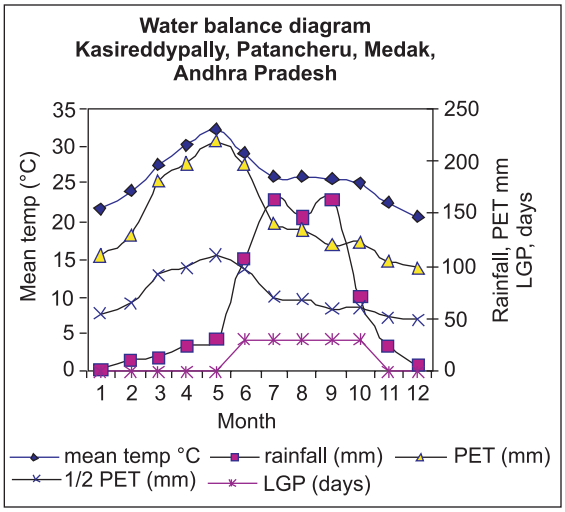
BM Spot 20 : KASIREDDYPALLI: Agriculture System (Fallow-Chickpea) (TM) P40

Classification : Fine, smectitic, isohyperthermic, Sodic Haplusterts

Location : ICRISAT Farm BW4C, Patancheru, Medak, Andhra Pradesh
Lat. 17°30'28"N Long 78°15'49"E

Physiographic position : Deccan plateau – boarder of granite and granite-gneiss and basalt

Topography and slope: Very gently sloping and undulating, 1-3% (50-150 m)



Drainage : Moderately well drained

Vegetation : Prosopis juliflora

Landuse : Fallow-chickpea

Parent material : Alluvium

Sampled by : P. Chandran, S.K. Ray, M.V. Venugopalan, S.L. Durge

Date of collection: 18.12.2001

Remarks : In this field, cultivation is done as practiced by farmers traditionally. It is *kharif* fallow followed by *rabi* chickpea. Many cracks appear on the surface; horizontal cracks are polygonal in shape; cracks are 3-4 cm wide up to 25 cm; 2-3 cm wide up to 60 cm; 1-2 cm wide up to 90 cm; <1 cm wide up to 125 cm.

Ap	0-12 cm	Dark greyish brown (10YR 4/2D) to very dark greyish brown (10YR 3.5/2M) clay; moderate medium subangular blocky structure; very hard, friable, sticky and plastic; many very fine and fine, a few medium roots; many very fine, a few fine and medium lime nodules; many very fine and fine pores; mildly alkaline (pH 7.8); slightly effervescent; clear, smooth boundary.
Bw	12-30 cm	Very dark greyish brown (10YR 3/2M) clay; strong medium subangular blocky structure with shiny pressure faces on surface of peds; friable, sticky and plastic; many very fine and a few fine roots; many very fine, a few fine and medium lime nodules; many very fine and fine pores; mildly alkaline (pH 7.8); slightly effervescent; clear, wavy boundary.
Bss1	30-59 cm	Very dark greyish brown (10YR 3/2M) clay; strong medium angular blocky structure with wedge-shaped aggregates and slickensides that break into small angular peds; slightly firm, sticky and plastic; many very fine and a few fine roots; very fine many, fine and medium common lime nodules; many very fine and fine pores; moderately alkaline (pH 8.1); slightly to strongly effervescent; gradual smooth boundary.
Bss2	59-101 cm	Very dark grey to very dark greyish brown (10YR 3/1.5M) clay; strong, coarse, angular and blocky structure with well developed wedge shaped aggregates and slickensides that break into well developed angular peds; firm, sticky and plastic; many very fine roots; many very fine, a few fine and medium lime nodules; many very fine and fine pores; moderately alkaline (pH 8.3); strongly effervescent; gradual smooth boundary.

Bss3	101-130 cm	Very dark grey and very dark greyish brown (2.5Y 3/1.5M), olive brown (2.5Y 4/3M) dark greyish brown to olive brown (2.5Y 4/2.5R) clay; strong, coarse, angular and blocky structure with well developed wedge shaped aggregates and slickensides that break into well developed angular peds; firm, sticky and plastic; common very fine roots; common very fine, medium and coarse lime nodules; a few fine iron and manganese concretions; moderately alkaline (pH 8.3); strongly effervescent; clear, smooth boundary.
BCk	130-160+ cm	Light olive brown (2.5Y 5/4M&R) clay; moderate medium subangular blocky structure; slightly firm, sticky and plastic; very fine few roots; a few very fine and fine, many medium and coarse lime nodules; 20-25% fine and coarse gravels; moderately alkaline (pH 8.2); strongly to violently effervescent.

Series: KASIREDDYPALLI **BM SPOT: 20 (BLACK SOILS)**
PROFILE NO: P40 ***System: Agriculture (Fallow – Chickpea)* (TM)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 764 mm	Classification: Fine, smectitic, isohyperthermic, *Sodic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: ICRISAT Farm, Kasireddypalli, Patancheru, Medak, Andhra Pradesh		*Sampling Date: 18.12.2001*

Morphological Properties of Profile No. 40 (Kasireddypalli, Medak)

Horizon	Depth (cm)	Boundary		Matrix color		Texture	Coarse fragments (%) (fg and cg)	Structure		
		D	*T*	Dry	Moist			Size	Grade	Type
Ap	0-12	C	s	10YR4/2	10YR3.5/2	c	8-10	m	2	sbk
Bw1	12-30	C	s	-	10YR3/2	c	5-8	m	3	sbk
Bss1	30-59	G	w	-	10YR3/2	c	3-5	m	3	abk
Bss2	59-101	G	w	-	10YR3/1.5	c	3-5	c	3	abk
Bss3	101-130	C	s	-	2.5Y3/1.5,4/2.5(R)	c	fg,cg* 8-10	c	3	abk
BCk	130-160	-	-	-	2.5Y5/4 (M & R)	c	fg,cg *20-25	m	2	sbk

Depth (cm)	Consistence			Porosity		Nodules (conca)		Roots		Effervescence	Other features	Cracks
	Dry	Moist	Wet	S	Q	Size	Quantity	Size	uantity	Dil HCl		
0-12	vh	fr	Sp	vf,f	m	vf; f, m	m; f	vf,f; m	m; f	e	-	3-4 cm
12-30	-	fr	Sp	vf,f	m	vf; f, m	m; f	vf; f	m; f	e	Pressure faces	
30-59	-	sfi	Vsvp	vf,f	m	vf; f, m	m; c	vf; f	m; f	e	Slickensides	2-3 cm
59-101	-	fi	Vsvp	vf,f	m	vf; f, m	m; f	vf	m	es	Slickensides	1-2 cm
101-130	-	fi	Vsvp	-	-	vf; m, c	c; c	vf	c	es	Slickensides	0.5 cm
130-160	-	sfi	Sp	-	-	vf,f; m,c	f; m	vf	f	es-ev	-	

** These are mainly calcareous nodules of medium and coarse sizes and small fine basaltic gravels*

Please refer Appendix I for the abbreviations

Series: KASIREDDYPALLI **BM SPOT: 20 (BLACK SOILS)**
PROFILE NO: P40 ***System: Agriculture (Fallow – Chickpea)* (TM)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 764 mm	Classification: Fine, smectitic, isohyperthermic, *Sodic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: ICRISAT Farm, Kasireddypalli, Patancheru, Medak, Andhra Pradesh		*Sampling Date: 18.12.2001*

Physical Properties of Profile No. 40 (Kasireddypalli. Medak)

Laboratory No.	Horizon	Depth (cm)	Size class and particle diameter (mm)			Fine clay (%) (<0.0002)	Fine clay/ total clay (%)
			Total				
			Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)		
			←----------(% of <2 mm) ----------→				
3388	Ap	0-12	22.5	29.6	47.9	26.4	55.1
3389	Bw1	12-30	18.7	29.9	51.4	29.7	57.7
3390	Bss1	30-59	17.9	29.6	52.5	32.5	61.9
3391	Bss2	59-101	16.6	27.8	55.6	36.4	65.5
3392	Bss3	101-130	7.2	33.4	59.4	30.8	51.8
3393	BCk	130-160	13.0	29.1	57.9	38.7	66.8

Depth (cm)	BD (Mgm^{-3})	COLE	HC ($cmhr^{-1}$)	WDC (%)
0-12	-	0.3	0.7	6.3
12-30	1.6	0.2	0.6	10.0
30-59	1.6	0.2	0.6	11.6
59-101	1.5	0.2	0.2	11.8
101-130	-	0.3	0.2	14.7
130-160	1.7	0.2	0.1	11.3

- *Nil or not determined (wherever applicable)*

Series: KASIREDDYPALLI **BM SPOT: 20 (BLACK SOILS)**
PROFILE NO: P40 ***System: Agriculture (Fallow – Chickpea)* (TM)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 764 mm	Classification: Fine, smectitic, isohyperthermic, *Sodic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: ICRISAT Farm, Kasireddypalli, Patancheru, Medak, Andhra Pradesh		*Sampling Date: 18.12.2001*

Chemical Properties of Profile No. 40 (Kasireddypalli, Medak)

Depth (cm)	pH (1:2)		EC (1:2) (dSm^{-1})	OC (%)	$CaCO_3$ (%)	Clay CO_3 (%)
	H_2O	1*N* KCl				
0-12	7.8	6.7	0.08	0.6	5.9	3.4
12-30	7.8	6.7	0.16	0.4	6.2	3.1
30-59	8.1	6.6	0.17	0.4	6.0	3.0
59-101	8.3	6.7	0.10	0.4	6.4	3.3
101-130	8.3	6.8	0.29	0.4	6.5	3.2
130-160	8.2	6.8	0.47	0.1	9.1	3.4

Depth (cm)	Extractable bases				CEC	Clay CEC	BS (%)	ESP
	Ca	Mg	Na	K				
	←----------[cmol(p+)kg^{-1}]----------→							
0-12	34.2	10.7	0.9	0.4	48.7	102	95	1.8
12-30	34.9	12.7	1.9	0.3	52.1	101	96	3.6
30-59	29.3	14.0	3.7	0.3	52.2	99	91	7.1
59-101	26.2	14.4	6.8	0.3	53.5	96	89	12.7
101-130	35.8	11.6	4.6	0.5	57.8	97	91	7.9
130-160	25.1	16.2	11.1	0.5	49.5	85	107	22.2

Series: KASIREDDYPALLI **BM SPOT: 20 (BLACK SOILS)**

PROFILE NO: P40 ***System: Agriculture (Fallow – Chickpea)* (TM)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 764 mm	Classification: Fine, smectitic, isohyperthermic, *Sodic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: ICRISAT Farm, Kasireddypalli, Patancheru, Medak, Andhra Pradesh		*Sampling Date: 18.12.2001*

Saturation Extract Properties of Profile No. 40 (Kasireddypalli, Medak)

Depth (cm)	Sat (%)	ECe (d Sm^{-1})	Soluble cations ($mmol_c$ l^{-1})				Sum of cations
			Ca	Mg	Na	K	
0-12	56.05	0.25	1.23	0.86	14.20	0.03	16.32
12-30	57.64	0.32	0.87	0.71	26.00	0.07	27.65
30-59	60.18	0.38	0.21	0.27	16.00	0.05	16.53
59-101	69.22	0.44	0.54	0.18	8.13	0.04	8.89
101-130	79.61	0.80	0.24	0.30	13.39	0.11	14.04
130-160	84.22	2.72	0.99	0.70	20.22	0.11	22.02

Depth (cm)	Soluble anions ($mmol_c$ l^{-1})				Sum of anions
	CO_3	HCO_3	Cl	SO_4	
0-12	-	12.73	3.55	-	16.28
12-30	-	22.54	4.95	-	27.49
30-59	-	14.05	2.75	-	16.80
59-101	0.42	6.74	1.30	-	8.46
101-130	2.65	7.95	4.00	-	14.60
130-160	1.06	4.24	1.50	15.22	22.02

- *Nil or not determined (wherever applicable)*

Series: KASIREDDYPALLI **BM SPOT: 20 (BLACK SOILS)**

PROFILE NO: P40 ***System: Agriculture (Fallow – Chickpea)* (TM)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 764 mm	Classification: Fine, smectitic, isohyperthermic, *Sodic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: ICRISAT Farm, Kasireddypalli, Patancheru, Medak, Andhra Pradesh		*Sampling Date: 18.12.2001*

Characterization of Landuse Types

S. No.	Attribute		Description
1	Production system	:	Rain-fed *kharif* fallow-*rabi* cropping system of chickpea-sorghum (two year rotation); with 8 months fallow period Yield range: Chickpea 1160-1550 kg $ha^{-1}$and sorghum 820-1739 kg ha^{-1}
2	Management level	:	• Improved varieties (M 35-1 sorghum and *annagiri*-chickpea) • 10 t FYM in alternate years from 1994 • Insecticides: Occasional • Chemical fertilizers: Nil
3	Power source	:	Animal-bullock
4	Market orientation	:	R&D
5	Capital intensity	:	Low
6	Labour intensity	:	Low
7	Land holding	:	NA
8	Income level	:	NA

Climatic Datasets of Kasireddypalli, Medak District, Andhra Pradesh

Month	Mean temp (^oC)	Rainfall (mm)	PET (mm)	½ PET (mm)	LGP (days)
January	21.60	1.70	109.80	54.90	0.00
February	24.00	11.40	129.50	64.75	0.00
March	27.40	13.40	181.50	90.75	0.00
April	30.30	24.10	197.80	98.90	0.00
May	32.40	30.00	219.90	109.95	0.00
June	29.10	107.40	196.40	98.20	30.00
July	26.00	165.00	140.40	70.20	31.00
August	25.80	146.90	135.50	67.75	31.00
September	25.60	163.30	119.30	59.65	30.00
October	25.00	70.80	123.60	61.80	31.00
November	22.40	24.90	104.10	52.05	0.00
December	20.60	5.50	98.60	49.30	0.00
Average	25.85				
Total		764.40	1756.40	878.20	153.00

Landscape, Landuse and Soils in Benchmark Spot 20 (Kasireddypalli, TM, ICRISAT, Patancheru, Medak, A.P.)

Benchmark spot at Kasireddypalli, Medak, Andhra Pradesh, under agricultural system (traditional management) with kharif fallow-chickpea crop rotation

Wide and polygonal surface cracks in the benchmark spot

Typically Kasireddypalli benchmark soil profile (Sodic Haplusterts)

Closer view of the profile

BM Spot 23 : TELIGI: Agricultural System (Paddy-Paddy) (LM) P43

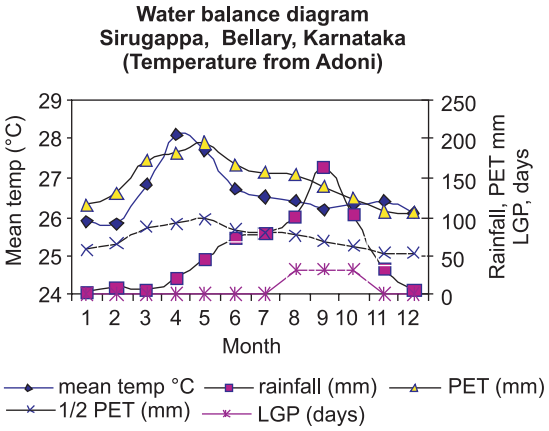
Classification : Fine, smectitic, isohyperthermic, *Sodic Haplusterts*

Location : Block No. 6 of ARS of UAS, Dharwad at Siruguppa, Bellary, Karnataka
Lat 15°37'48"N, Long 76°54'35"E

Physiographic position : South Deccan Plateau - granite-gneiss

Topography and slope : Almost level, 0-1% bunded (0-50 m)

Drainage : Imperfectly to moderately drained



Vegetation : Acacia, mango, *neem*, grass, parthenium

Land use : Paddy-paddy, cotton-jowar (7-8 years back)

Parent material : Alluvium of granite-gneiss/basalt

Sampled by : P. Chandran, S.K. Ray, M.V. Venugopalan, P. Srivastava, S.L. Durge

Date of collection : 07.01.2002

Remarks : The experimental station has observed that there is no response for K in these soils. The scientists have decided (in workshop) that farmers would be recommended to use K, atleast for paddy, lest farmers may go without K for years together. For some other crops like coriander, they have reduced the amount of K. The (ARS's) normal recommended dose is 150:75.75, but farmers added more amount of N for higher yields. Peds seems to be lighter than other Vertisols (last horizon is much lighter) which may be due to higher $CaCO_3$ per unit weight.

Apk	0-10 cm	Very dark grey (10YR 3/1 D&M) clay; moderate medium subangular blocky structure; hard, friable, sticky and plastic; many very fine and fine roots; many very fine, a few fine lime nodules; many very fine and fine, common medium pores; moderately alkaline (pH 7.9); strongly effervescent; clear, smooth boundary.
Bwk1	10-25 cm	Black to very dark grey (10YR 2.5/1M) clay; strong medium subangular blocky structure with pressure faces on surface of peds; friable, sticky and plastic; many very fine, common fine roots; many very fine, common fine lime nodules; many very fine and fine pores; moderately alkaline (pH 8.0); strongly effervescent; gradual smooth boundary.
Bwk2	25-44 cm	Very dark grey (10YR 3/1M) clay; strong medium subangular blocky structure with well developed shiny pressure faces on surface of peds; friable, sticky and plastic; many very fine, common fine roots; many very fine, a few fine lime nodules; many very fine and fine pores; moderately alkaline (pH 8.0); strongly effervescent; clear, smooth boundary.
Bssk1	44-69 cm	Very dark grey (10YR 3/1M) clay; strong medium subangular blocky to weak angular blocky structure with weakly developed wedge-shaped aggregates and slickensides that break into small weak angular peds; friable, sticky and plastic; many very fine, a few fine roots; many very fine, a few fine lime nodules; many very fine and fine pores; mildly alkaline (pH 7.8); strongly effervescent; gradual smooth boundary.

Bssk2	69-97 cm	Very dark grey (10YR 3/1M) clay; strong medium angular blocky structure with well developed shiny wedge-shaped aggregates and slickensides that break into small angular peds; friable, sticky and plastic; common very fine, and a few fine roots; many very fine, a few fine lime nodules; mildly alkaline (pH 7.6); strongly effervescent; gradual smooth boundary.
Bssk3	97-123 cm	Very dark grey (10YR 3/1M) clay; strong medium angular blocky structure with well developed shiny wedge-shaped aggregates and slickensides that break into small angular peds; friable, sticky and plastic; a few very fine roots; many very fine, a few fine lime nodules; strongly alkaline (pH 8.7); violently effervescent; clear, smooth boundary.
Bssk4	123-150+ cm	Dark grey (10YR 4/1R) clay; strong medium angular blocky to weak subangular blocky structure with weak development of wedge-shaped aggregates and slickensides that break into weak angular and subangular peds; friable, sticky and plastic; a few very fine roots; many very fine, fine and medium lime nodules (medium-sized nodules are soft and powdery); strongly alkaline (pH 8.5); violently effervescent; weak slickensides.

Series: TELIGI **BM SPOT: 23 (BLACK SOILS)**

PROFILE NO: P43 ***System: Agriculture (Paddy - Paddy)* (LM)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 632 mm	Classification: Fine, smectitic, isohyperthermic, *Sodic Haplusterts*.	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: ARS (UAS Dharwad) Research Farm, Siruguppa, Bellary, Karnataka		*Sampling Date: 07.01.2002*

Morphological Properties of Profile No. 43 (Teligi, Bellary)

Horizon	Depth (cm)	Boundary		Matrix color		Texture	Coarse fragments (%) (fg and cg %)	Structure		
		D	*T*	Dry	Moist			Size	Grade	Type
Apk	0-10	c	s	10YR3/1	10YR3/1	c	8-10	m	2	sbk
Bwk1	10-25	g	s	-	10YR2.5/1	c	8-10	m	3	sbk
Bwk2	25-44	c	s	-	10YR3/1	c	8-10	m	3	sbk
Bssk1	44-69	g	s	-	10YR3/1	c	8-10	m	3	sbk
Bssk2	69-97	g	s	-	10YR3/1	c	8-10	m	3	abk
Bssk3	97-123	g	s	-	10YR3/1	c	10-12	m	3	abk
Bssk4	123-150	c	s	-	10YR4/1(R)	c	10-12	m	3	abk

Depth (cm)	Consistence			Porosity		Nodules(conca)		Roots		Effervescence	Other Features	Cracks
	Dry	Moist	Wet	S	Q	Size	Quantity	Size	Quantity	Dil HCl		
0-10	h	fr	sp	vf,f; m	m; c	vf; f	m; f	vf,f	m	es	-	Not
10-25	-	fr	sp	vf, f	m	vf; f	m; f	vf; f	m; c	es	Pressure faces	observed
25-44	-	fr	sp	vf, f	m	vf; f	m; f	vf; f	m; c	es	Pressure faces	
44-69	-	fr	vsvp	vf, f	m	vf; f	m; f	vf; f	m; f	es	Slickensides	
69-97	-	fr	vsvp	-	-	vf; f	m; f	vf; f	c; f	es	Slickensides	
97-123	-	fr	vsvp	-	-	vf; f	m; f	vf	f	ev	Slickensides	
123-150	-	fr	vsvp	-	-	vf,f; m	m; m	vf	f	ev	Slickensides	

** Consists mainly of very fine gravels of calcarious nodules, some gravels of granite greiss and quartz*
*** This layer has nodules which are very soft and powdery*
(+) The soil peds are lighter in weight may be due to pressure of higher amounts of $CaCO_3$ throughout the profile as well as having relatively lesser amount of clay

Please refer Appendix I for the abbreviations

Series: TELIGI **BM SPOT: 23 (BLACK SOILS)**

PROFILE NO: P43 ***System: Agriculture (Paddy - Paddy)* (LM)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 632 mm	Classification: Fine, smectitic, isohyperthermic, *Sodic Haplusterts*.	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: ARS (UAS Dharwad) Research Farm, Siruguppa, Bellary, Karnataka		*Sampling Date: 07.01.2002*

Physical Properties of Profile No. 43 (Teligi, Bellary)

Laboratory No.	Horizon	Depth (cm)	Size class and particle diameter (mm)			Fine clay (%) (<0.0002)	Fine clay/ total clay (%)
			Total				
			Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)		
			←----------(% of <2 mm) ----------→				
3406	Apk	0-10	19.6	24.3	56.1	30.4	54.2
3407	Bwk1	10-25	18.9	22.1	59.0	45.2	76.6
3408	Bwk2	25-44	19.4	22.4	58.2	44.0	75.6
3409	Bssk1	44-69	34.3	19.1	46.6	36.1	77.5
3410	Bssk2	69-97	29.5	21.8	48.7	34.9	71.7
3411	Bssk3	97-123	11.4	36.3	52.3	25.8	49.3
3412	Bssk4	123-150	6.3	32.4	61.3	25.9	42.2

Depth (cm)	BD (Mgm^{-3})	COLE	HC ($cmhr^{-1}$)	WDC (%)
0-10	1.2	0.24	6.2	11.5
10-25	1.5	0.26	2.7	11.4
25-44	1.6	0.22	2.9	11.5
44-69	1.5	0.20	2.1	11.5
69-97	1.4	0.18	1.1	14.8
97-123	1.4	0.21	0.3	20.4
123-150	1.4	0.22	0.1	16.0

Series: TELIGI **BM SPOT: 23 (BLACK SOILS)**

PROFILE NO: P43 ***System: Agriculture (Paddy - Paddy)*** **(LM)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 632 mm	Classification: Fine, smectitic, isohyperthermic, *Sodic Haplusterts*.	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: ARS (UAS Dharwad) Research Farm, Siruguppa, Bellary, Karnataka		*Sampling Date: 07.01.2002*

Chemical Properties of Profile No. 43 (Teligi, Bellary)

Depth (cm)	pH (1:2)		EC (1:2) (dSm^{-1})	OC (%)	$CaCO_3$ (%)	Clay CO_3 (%)
	H_2O	1*N* KCl				
0-10	7.9	6.6	0.16	1.5	10.5	3.0
10-25	8.0	6.7	0.12	0.8	10.7	3.2
25-44	8.0	6.7	0.05	0.8	12.2	3.4
44-69	7.8	6.5	0.25	0.7	10.3	3.9
69-97	7.6	6.4	0.27	0.7	5.9	3.7
97-123	8.7	6.7	0.36	0.5	15.1	4.7
123-150	8.5	6.7	0.24	0.5	16.2	3.7

Depth (cm)	Extractable bases				CEC	Clay CEC	BS (%)	ESP
	Ca	Mg	Na	K				
	←----------[cmol(p+)kg^{-1}]----------→							
0-10	42.2	9.6	0.8	0.6	51.4	92	104	1.6
10-25	44.7	12.9	0.9	0.4	52.2	88	113	1.7
25-44	43.3	14.4	1.0	0.4	54.2	93	109	1.8
44-69	34.7	12.4	1.7	0.3	42.0	90	117	4.0
69-97	32.0	10.2	1.4	0.6	40.8	100	108	3.4
97-123	37.8	15.1	9.6	0.3	57.2	109	110	16.8
123-150	37.3	15.6	9.6	0.5	55.5	91	114	17.3

Series: TELIGI **BM SPOT: 23 (BLACK SOILS)**

PROFILE NO: P43 ***System: Agriculture (Paddy - Paddy)* (LM)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 632 mm	Classification: Fine, smectitic, isohyperthermic, *Sodic Haplusterts*.	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: ARS (UAS Dharwad) Research Farm, Siruguppa, Bellary, Karnataka		*Sampling Date: 07.01.2002*

Saturation Extract Properties of Profile No. 43 (Teligi, Bellari)

Depth (cm)	Sat (%)	ECe (d Sm^{-1})	Soluble cations ($mmol_c$ l^{-1})				Sum of cations
			Ca	Mg	Na	K	
0-10	72.83	0.42	2.47	1.15	52.17	0.01	55.80
10-.25	77.87	0.27	1.51	0.57	1.87	0.02	3.90
25-44	68.86	0.35	1.30	0.92	2.69	0.02	4.90
44-69	52.22	0.39	1.23	0.71	3.15	0.02	5.10
69-97	61.61	0.33	0.49	0.38	3.22	0.05	4.10
97-123	64.00	0.43	0.83	0.00	6.09	0.03	6.90
123-150	77.20	0.42	0.83	0.00	6.57	0.02	7.40

Depth (cm)	Soluble anions ($mmol_c$ l^{-1})				Sum of anions
	CO_3	HCO_3	Cl	SO_4	
0-10	-	2.12	0.90	52.78	55.80
10-.25	-	3.71	0.20	-	3.91
25-44	-	4.77	0.40	-	5.17
44-69	-	4.24	1.20	-	5.44
69-97	-	3.18	1.10	-	4.28
97-123	-	3.03	1.50	1.56	6.10
123-150	0.57	3.03	1.00	3.03	7.60

- *Nil or not determined (wherever applicable)*

Series: TELIGI **BM SPOT: 23 (BLACK SOILS)**

PROFILE NO: P43 ***System: Agriculture (Paddy - Paddy)* (LM)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 632 mm	Classification: Fine, smectitic, isohyperthermic, *Sodic Haplusterts*.	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: ARS (UAS Dharwad) Research Farm, Siruguppa, Bellary, Karnataka		*Sampling Date: 07.01.2002*

Characterization of Landuse Types

S. No.	Attribute		Description
1	Production system	:	Mono cropping of lowland rice transplanted (single crop/year) with 7-8 months fallow period Yield range: 1880-3190 kg ha^{-1}
2	Management level	:	• Improved varieties (*sona masuri*) • Integrated pest management • Weed control: Manual • Fertilizers: 150:75:75 • Manures: Nil • Residues of paddy: Turned down. • Soil conservation measures: Field bunding • Sowing time: July
3	Power source	:	Tractor and bullock
4	Market orientation	:	R& D
5	Capital intensity	:	Not relevant
6	Labour intensity	:	High
7	Land holding	:	Not relevant
8	Income level	:	Not relevant

Climatic Datasets of Sirugappa, Bellary District, Karnataka (Temperature from Adoni)

Month	Mean temp (°C)	Rainfall (mm)	PET (mm)	½ PET (mm)	LGP (days)
January	25.90	2.30	115.00	57.50	0.00
February	25.80	7.90	129.00	64.50	0.00
March	26.80	5.60	171.00	85.50	0.00
April	28.10	19.60	181.00	90.50	0.00
May	27.70	45.20	195.00	97.50	0.00
June	26.70	72.40	167.00	83.50	0.00
July	26.50	77.50	156.00	78.00	0.00
August	26.40	100.10	153.00	76.50	30.00
September	26.20	164.90	138.00	69.00	30.00
October	26.30	101.30	123.00	61.50	31.00
November	26.40	31.00	106.00	53.00	0.00
December	26.10	4.60	104.00	52.00	0.00
Average	26.57				
Total		632.40	1738.00	869.00	91.00

Landscape, Landuse and Soils in Benchmark Spot 23 (Teligi, Siruguppa, Bellary, Karnataka)

Benchmark spot Teligi at Siruguppa, Bellary, Karnataka, under agricultural system (low management) with wheat, paddy-paddy crop rotation

Typical Teligi soil profile (Sodic Haplusterts)

Closer view of the profile

BM Spot 23 : TELIGI: Agriculture System (Paddy-Paddy) (HM) P44

Classification : Fine, smectitic, isohyperthermic, *Sodic Haplusterts*

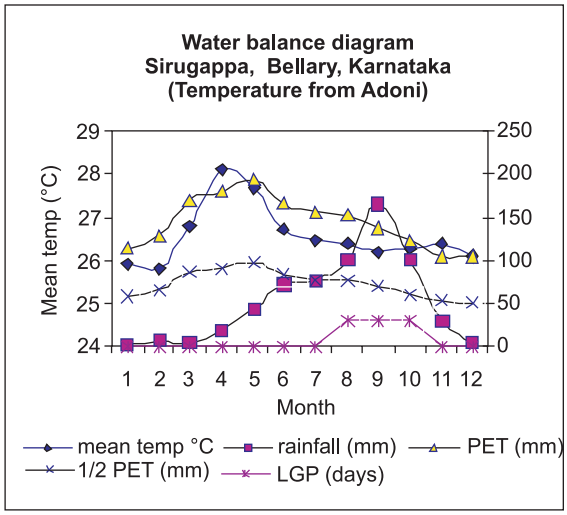
Location : Block No. 2 Plot No. 15, Farm of ARS UAS, Dharwad, Sirugappa, Bellary, Karnataka, Lat 15°37'44"N, Long 76°54'41"E

Physiographic position : South Deccan Plateau - granite-gneiss

Topography and slope : Almost level, 0-1% bunded (0-50 m)

Drainage : Imperfectly to moderately drained

Vegetation : Acacia, mango, *neem*, grass, parthenium, *basera chettu*



Land use : Paddy-paddy

Parent material : Alluvium of granite-gneiss/basalt

Sampled by : P. Chandran, S.K. Ray, M.V. Venugopalan, P. Srivastava, S.L. Durge

Date of collection:

Remarks : Cracks are 4-7 cm wide up to 14 cm, 2-4 cm wide up to 24 cm, 1-2 cm wide up to 34 cm and <1 cm wide up to 48 cm. Salt encrustations are present at the surface

Ap	0-10 cm	Black (10YR 2/1D&M) sandy clay; strong, medium subangular blocky structure; very hard, firm, sticky and plastic; many very fine and fine roots; many very fine, a few fine lime nodules; many very fine and fine pores; mildly alkaline (pH 7.4); strongly to violently effervescent; clear, smooth boundary.
Bwk1	10-34 cm	Very dark grey (10YR 3/1M) clay; strong medium subangular blocky structure with shiny pressure faces on surface of peds; very hard, firm, sticky and plastic; many very fine, common fine roots; many very fine, a few fine lime nodules; many very fine and fine pores; moderately alkaline (pH 8.0); strongly to violently effervescent; clear, smooth boundary.
Bwk2	34-54 cm	Very dark grey (10YR 3/1M) clay; strong, medium angular blocky (not very well developed) structure with shiny pressure faces on surface of peds; not well developed and discontinuous wedge-shaped aggregates and slickensides; friable, very sticky and very plastic; many very fine, common fine roots; many very fine, a few fine lime nodules; many very fine and fine pores; moderately alkaline (pH 8.2); violently effervescent; gradual smooth boundary.
Bssk1	54-89 cm	Very dark grey (10YR 3/1M) clay; strong, medium angular blocky structure with well developed shiny wedge-shaped aggregates and slickensides that break into small angular peds; friable, very sticky and very plastic; many very fine and common fine roots; many very fine, a few fine and medium lime nodules; moderately alkaline (pH 8.3); violently effervescent; gradual smooth boundary.

Bssk2	89-119 cm	Very dark grey (10YR 3/1M) clay; strong medium angular blocky structure with well developed shiny wedge-shaped aggregates and slickensides that break into small angular peds; friable, very sticky and very plastic; common very fine and a few fine roots; many very fine, common fine and medium (soft) lime nodules; moderately alkaline (pH 8.3); violently effervescent; gradual smooth boundary.
Bssk3	119-142 cm	Very dark grey to very dark greyish brown (10YR 3/1.5M) and dark grey to very dark grey (10YR 3.5/1R) clay; moderate medium angular blocky structure with shiny wedge-shaped aggregates and slickensides that break into small angular peds; very friable, very sticky and very plastic; a few very fine and fine roots; many very fine and fine, a few medium (these are soft) lime nodules; moderately alkaline (pH 8.4); violently effervescent; clear, smooth boundary.
BCk	142-160 cm	Dark grey to dark greyish brown (10YR 4/1.5M) clay; moderate medium subangular blocky structure; very friable, very sticky and plastic; a few very fine roots; many very fine, fine, medium and coarse lime nodules (medium and coarse nodules are softer); 30-35% fine gravels which are mainly soft calcareous nodules; moderately alkaline (pH 8.4); violently effervescent.

Series: TELIGI **BM SPOT: 23 (BLACK SOILS)**

PROFILE NO: P44 ***System: Agriculture (Paddy - Paddy)*** **(HM)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 632 mm	Classification: Very fine, smectitic, isohyperthermic, *Sodic Haplusterts*.	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: ARS (UAS Dharwad) Farm, Sirugappa, Bellary, Karnataka		*Sampling Date: 07.01.2002*

Morphological Properties of Profile No. 44 (Teligi, Bellary)

Horizon	Depth (cm)	Boundary		Matrix color		Texture	Coarse fragments (%) (fg and cg)	Structure		
		D	*T*	Dry	Moist			Size	Grade	Type
Apk	0-10	c	s	10 YR 2/1	10 YR 2/1	cl	* 8-10	m	3	Sbk
Bwk1	10-34	c	s	-	10 YR 3/1	c	*8-10	m	3	Sbk
Bwk2	34-54	g	w	-	10 YR 3/1	c	8-10	m	3	Abk
Bssk1	54-89	g	w	-	10 YR 3/1	c	8-10	m	3	Abk
Bssk2	89-119	g	s	-	10 YR 3/1	c	8-10**	m	3	Abk
Bssk3	119-142	c	s	-	10YR 3/1.5(m); 10 YR 3.5/1(R)	c	10-15**	m	2	Abk
BCk	142-150	-	-	-	10YR4/1.5(m & R)	c	30-35**	m	2	Sbk

Depth (cm)	Consistence			Porosity		Nodules(conca)		Roots		Effervescence*	Other Features	Cracks
	Dry	Moist	Wet	S	Q	Size	Quantity	Size	Quantity	Dil HCl		
0-10	vh	fi	s p	vf, f	m	vf; f	m; f	vf,f	m	es	-	4-7 cm
10-34	vh	fi	s p	vf, f	m	vf; f	m; f	vf; f	m; c	es	Pressure faces	2-4 cm
34-54	-	fr	vs vp	vf, f	m	vf; f	m; f	vf; f	m; c	es	Slickensides (slight)	1-2 cm
54-89	-	fr	vs vp	-	-	vf; f,m	m; f	vf; f	m; c	es	Slickensides (well)	0.5-1 cm
89-119	-	fr	vs vp	-	-	vf; f,m	m; c	vf; f	c; f	es	Slickensides (well)	
119-142	-	vfr	vs vp	-	-	vf,f,m,c	m	vf,f	f	ev	Slickensides (well)	
142-150	-	vfr	s p	-	-	vf,f,m,c	m	vf	f	ev	-	

** Calcareous nodules + quartz + granite gneiss*
*** Medium to coarse sized soft powdery calcareous nodules*
Cracksare 4-7cm wide up to 14 cm, 2-4 cm wide up to 24 cm., 1-2cm up to 34 cm, <1 cm wide up to 48 cm

Please refer Appendix I for the abbreviations

Series: TELIGI **BM SPOT: 23 (BLACK SOILS)**

PROFILE NO: P44 ***System: Agriculture (Paddy - Paddy)*** **(HM)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 632 mm	Classification: Very fine, smectitic, isohyperthermic, *Sodic Haplusterts*.	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: ARS (UAS Dharwad) Farm, Siruguppa, Bellary, Karnataka		*Sampling Date: 07.01.2002*

Physical Properties of Profile No. 44 (Teligi, Bellary)

Laboratory No.	Horizon	Depth (cm)	Size class and particle diameter (mm)			Fine clay (%) (<0.0002)	Fine clay/ total clay (%)
			Total				
			Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)		
			←----------(% of <2 mm) ----------→				
3413	Apk	0-10	45.4	15.8	38.8	32.2	83.0
3414	Bwk1	10-34	8.6	29.4	62.0	34.1	55.0
3415	Bwk2	34-54	18.2	21.1	60.7	44.0	72.5
3416	Bssk1	54-89	13.2	23.5	63.3	42.3	66.8
3417	Bssk2	89-119	8.6	27.2	64.2	41.7	65.0
3418	Bssk3	119-142	10.7	25.1	64.2	37.4	58.2
3419	BCk	142-150	8.5	27.5	64.0	51.9	81.0

Depth (cm)	BD (Mgm^{-3})	COLE	HC ($cmhr^{-1}$)	WDC (%)
0-10	1.5	0.2	1.8	6.7
10-34	1.6	0.2	0.9	8.3
34-54	1.5	0.2	0.9	14.9
54-89	1.4	0.2	0.2	10.4
89-119	1.3	0.2	0.1	19.3
119-142	1.3	0.1	0.1	18.7
142-150	1.7	0.2	1.6	12.2

Series: TELIGI **BM SPOT: 23 (BLACK SOILS)**

PROFILE NO: P44 ***System: Agriculture (Paddy - Paddy)*** **(HM)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 632 mm	Classification: Very fine, smectitic, isohyperthermic, *Sodic Haplusterts*.	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: ARS (UAS Dharwad) Farm, Siruguppa, Bellary, Karnataka		*Sampling Date: 07.01.2002*

Chemical Properties of Profile No. 44 (Teligi, Bellary)

Depth (cm)	pH (1:2)		EC (1:2) (d Sm^{-1})	OC (%)	$CaCO_3$ (%)	Clay CO_3 (%)
	H_2O	1*N* KCl				
0-10	7.4	6.5	0.24	1.0	5.4	3.2
10-34	8.0	6.6	0.19	0.7	9.3	2.9
34-54	8.2	6.7	0.19	0.5	9.9	3.3
54-89	8.3	6.7	0.33	0.5	10.6	3.3
89-119	8.3	6.7	0.44	0.5	11.5	3.8
119-142	8.4	6.7	0.25	0.4	16.2	4.6
142-150	8.4	6.8	0.64	0.2	22.0	3.8

Depth (cm)	Extractable bases				CEC	Clay CEC	BS (%)	ESP
	Ca	Mg	Na	K				
	←----------[cmol(p+)kg^{-1}]----------→							
0-10	26.2	6.3	0.8	0.3	40.1	103	89	2
10-34	40.2	17.1	1.8	0.8	60.4	97	99	3
34-54	39.7	14.1	3.3	0.3	60.4	99	95	5
54-89	37.0	12.3	7.6	0.6	62.9	99	91	12
89-119	35.1	17.1	7.6	0.6	63.8	99	95	12
119-142	31.3	15.0	13.6	0.3	63.6	99	94	21
142-150	36.1	10.2	7.1	0.1	56.8	89	94	13

Series: TELIGI **BM SPOT: 23 (BLACK SOILS)**

PROFILE NO: P44 ***System: Agriculture (Paddy - Paddy)*** **(HM)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 632 mm	Classification: Very fine, smectitic, isohyperthermic, *Sodic Haplusterts*.	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: ARS (UAS Dharwad) Farm, Siruguppa, Bellary, Karnataka		*Sampling Date: 07.01.2002*

Characterization of Landuse Types

S. No.	Attribute		Description
1	Production system	:	Mono cropping of rice lowland transplanted (single crop/year) with 7-8 months fallow period. Yield range: 6000 -7000 tonnes/ha
2	Management level	:	• Improved varieties (*sona masuri*) • Integrated pest management • Weed control: Manual • Fertilizers: 200-250 kg N/ha, 75 kg P2O5/ha and 75 kg K2O/ha • Organic manures: Not applied • Residues of paddy turned down • Soil conservation measures: Field bunding • Sowing time: (transplanting)- July
3	Power source	:	Tractor and bullock
4	Market orientation	:	R&D
5	Capital intensity	:	Not relevant
6	Labour intensity	:	High
7	Land holding	:	Not relevant
8	Income level	:	Not relevant

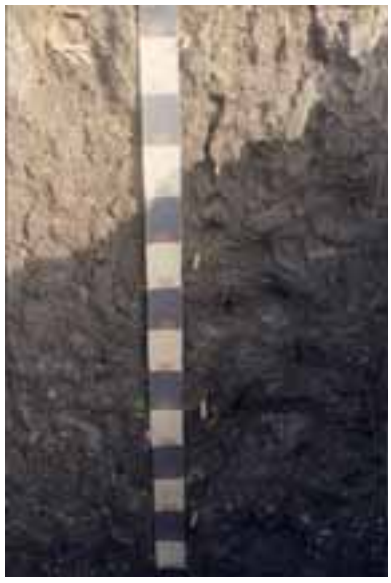
Climatic Datasets of Sirugappa, Bellary District, Karnataka (Temperature from Adoni)

Months	Mean Temp (^{o}C)	Rainfall (mm)	PET (mm)	1/2 PET (mm)	LGP (days)
January	25.90	2.30	115.00	57.50	0.00
February	25.80	7.90	129.00	64.50	0.00
March	26.80	5.60	171.00	85.50	0.00
April	28.10	19.60	181.00	90.50	0.00
May	27.70	45.20	195.00	97.50	0.00
June	26.70	72.40	167.00	83.50	0.00
July	26.50	77.50	156.00	78.00	0.00
August	26.40	100.10	153.00	76.50	30.00
September	26.20	164.90	138.00	69.00	30.00
October	26.30	101.30	123.00	61.50	31.00
November	26.40	31.00	106.00	53.00	0.00
December	26.10	4.60	104.00	52.00	0.00
Average	26.57				
Total		632.40	1738.00	869.00	91.00

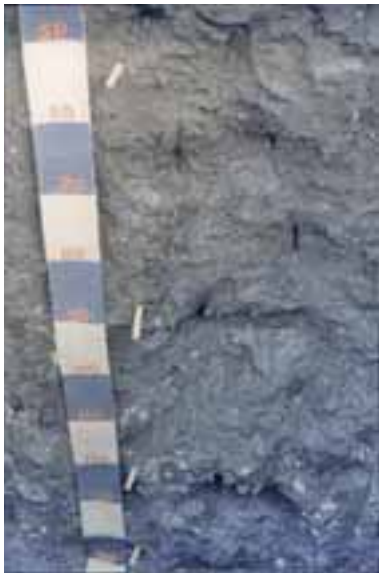
Landscape, Landuse and Soils in Benchmark Spot 23 (Teligi, HM Sirugappa, Bellary, Karnataka)

Benchmark spot at Siruguppa, Teligi, Bellary, Karnataka, under agricultural system (high management) with paddy-paddy crop rotation

Wide, polygonal cracks on the surface of Teligi soils



Typical Teligi soil profile (Sodic Haplusterts)



Closer view of the profile showing slickensides

BM Spot 24 : KONHERI: Agriculture System (Pigeonpea/Sunflower-Sorghum) (FM) P45

Classification : Fine, smectitic, hyperthermic, *Vertic Haplustepts*

Location : Konheri, Mohol, Solapur, Maharashtra, Lat. 17°48'24"N, Long 75°30'05"E

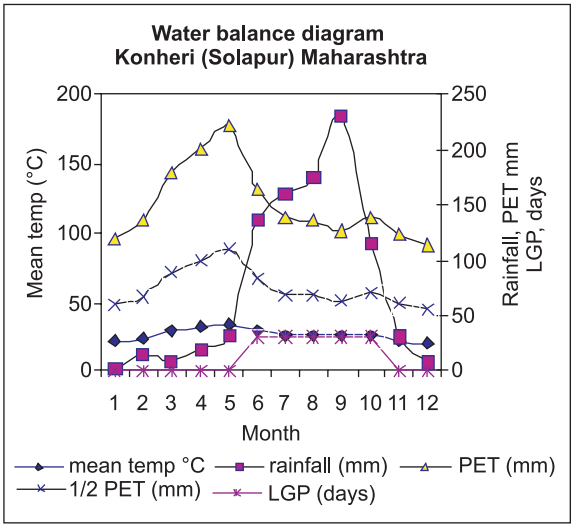
Physiographic position : Upper Maharashtra Deccan Plateau

Topography and slope : Very gently sloping and undulating, 1-3% (50-150 m)

Drainage : Moderately well drained

Vegetation : Acacia, *neem*, *ber*, casiatora, parthemium, grass, cactus spp

Land use : Pigeonpea/sunflower-sorghum or kharif fallow-sorghum (R) (system), other crops-wheat, sugarcane, onion



Parent material : Basaltic alluvium (Theolitic basalt)

Sampled by : P. Chandran, M.V. Venugopalan, S.K. Ray, P. Srivastava, S.L. Durge

Date of collection : 01.01.2002

Remarks : A few fresh water shells are found. Calcareous nodules and rounded rock fragments are also found. Cracks are 2-3 cm wide up to 13 cm; 1-2 cm wide and <0.5 cm up to 35 cm. If there is sufficient rainfall in *kharif* period, pigeonpea or sunflower crop is taken followed by *rabi* sorghum. However, if rainfall is scanty, *kharif* is kept fallow and followed by *rabi* sorghum

Ap	0-13 cm	Brown (7.5YR 4/3D) and dark brown (7.5YR 3/3M) clay loam; weak medium subangular blocky structure; slightly hard, friable, sticky and plastic; many very fine and fine, a few medium roots; a few very fine lime nodules; many very fine and fine pores; moderately alkaline (pH 8.1); strongly effervescent; clear, smooth boundary.
Bw	13-33 cm	Very dark brown (7.5YR 2.5/2M) clay; moderate medium subangular blocky (weak) structure; friable, sticky and plastic; common very fine and fine, a few medium roots; a few very fine lime nodules; many very fine and fine pores; moderately alkaline (pH 8.1); strongly effervescent; gradual smooth boundary.
Bwk1	33-69 cm	Very dark brown (7.5YR 2.5/2M) clay; moderate medium subangular blocky (weak) structure; very friable (moist), sticky and plastic; common very fine and fine, a few medium roots; a few very fine and fine lime nodules; many very fine and fine pores; moderately alkaline (pH 8.2); strongly effervescent; clear, smooth boundary.
Bwk2	69-93 cm	Dark brown (7.5YR 3/3M) clay; moderate, medium subangular blocky (weak) structure with very weak pressure faces on surface of peds; very friable, sticky and plastic; common very fine and fine, a few medium roots; a few very fine and fine lime nodules; many very fine and fine pores; moderately alkaline (pH 8.2); strongly effervescent; gradual smooth boundary.

Bwk3	93-113 cm	Very dark brown (7.5YR 2.5/2M) silty clay; moderate medium subangular blocky structure with very weak pressure faces on surface of peds; very friable, sticky and plastic; common very fine, a few fine and medium roots; common very fine and fine lime nodules; strongly alkaline (pH 8.6); strongly effervescent; abruptly smooth boundary.
BCk	113-129 cm	Very dark brown (7.5YR 2.5/2M) clay; structure less, fine granular; very friable; sticky, non plastic; common very fine, fine, and medium roots; many very fine and fine lime nodules; 40-45% fine gravels which are mainly lime nodules and rock fragments; violently effervescent; clear, smooth boundary.
Bssk	129-160 cm	Very dark brown (7.5YR 2.5/2M) clay; moderate medium angular blocky structure with shiny weak wedge shaped aggregates and slickensides (which are discontinuous) that break into weak and small angular peds; friable; sticky and plastic; weak, very fine and fine, few medium roots; few very fine lime nodules; strongly alkaline (pH 8.6); strongly effervescent.

Series: KONHERI **BM SPOT: 24 (BLACK SOILS)**

PROFILE NO: P45 ***System: Agriculture (Pigeonpea / Sunflower - Sorghum)*** **(FM)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 745 mm	Classification: Fine, smectitic, hyperthermic, *Vertic Haplustepts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Konheri, Mohol, Solapur, Maharashtra.		*Sampling Date: 09.01.2002*

Morphological Properties of Profile No. 45 (Konheri, Solapur)

Horizon	Depth (cm)	Boundary		Matrix color		Texture	Coarse fragments (%) (fg and cg %)	Structure		
		D	*T*	Dry	Moist			Size	Grade	Type
Ap	0-13	c	s	7.5YR4/3	7.5YR3/3	c	1-2	m	1	sbk
Bw	13-33	g	s	-	7.5YR2.5/2	c	1-2	m	2	sbk
Bwk1	33-69	c	s	-	7.5YR2.5/2	c	1-2	m	2	sbk
Bwk2	69-93	g	s	-	7.5YR3/3	c	1-2	m	2	sbk
Bwk3	93-113	a	s	-	7.5YR2.5/3	sic	1-2	m	2	sbk
BCk	113-129	c	s	-	7.5YR2.5/2	sic	40-45*	f	1	gr
Bssk	129-160	-	-	-	7.5YR2.5/2	c	3-5	m	2	abk

Depth (cm)	Consistence			Porosity		Nodules(conca)		Roots		Effervescence	Other Features	Cracks
	Dry	Moist	Wet	S	Q	Size	Quantity	Size	Quantity	Dil HCl		
0-13	sh	fr	s p	vf,f	m	vf	f	vf,f; m	m; f	es	-	2-3 cm
13-33	-	fr	s p	vf,f	m	vf	f	vf,f; m	c; f	es	-	1-2 cm
33-69	-	vfr	s p	vf,f	m	vf, f	f	vf,f; m	c; f	es	-	0.5 cm
69-93	-	vfr	s p	vf,f	m	vf, f	f	vf,f; m	c; f	es	Pressure faces (very weak)	
93-113	-	vfr	s p	-	-	vf, f	c	vf; f,m	c; f	es	Pressure faces (very weak)	
113-129	-	vfr	sspo	-	-	vf, f	m	vf,f,m; m	f; c	ev	-	
129-160	-	fr	s p	-	-	-	-	vf,f,m; c	c; f	es	Slickensides (weak)	

**Calcareous nodules and rock fragments (rounded)*
*** Matrix effervescence was also observed*
Cracks are 2-3cm wide up to 13 cm, 1-2cm wide & <0.5 mm up to 35cm

Please refer Appendix I for the abbreviations

Series: KONHERI **BM SPOT: 24 (BLACK SOILS)**

PROFILE NO: P45 ***System: Agriculture (Pigeonpea / Sunflower - Sorghum)*** **(FM)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 745 mm	Classification: Fine, smectitic, hyperthermic, *Vertic Haplustepts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Konheri, Mohol, Solapur, Maharashtra.		*Sampling Date: 09.01.2002*

Physical Properties of Profile No. 45 (Konheri, Solapur)

Laboratory No.	Horizon	Depth (cm)	Size class and particle diameter (mm)			Fine clay (%) (<0.0002)	Fine clay/ total clay (%)
			Total				
			Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)		
			←----------(% of <2 mm) ----------→				
3420	Ap	0-13	27.3	37.3	35.4	26.8	75.7
3421	Bw	13-33	24.8	33.8	41.4	30.7	74.1
3422	Bwk1	33-69	18.1	38.9	43.0	34.4	80.0
3423	Bwk2	69-93	22.8	33.9	43.3	32.9	76.0
3424	Bwk3	93-113	12.0	44.3	43.7	38.8	88.8
3425	BC	113-129	15.7	39.7	44.6	35.6	80.0
3426	Bss	129-160	9.8	32.3	57.9	46.4	80.1

Depth (cm)	BD (Mgm^{-3})	COLE	HC ($cmhr^{-1}$)	WDC (%)
0-13	-	0.2	2.6	4.6
13-33	1.5	0.2	2.1	4.3
33-69	1.6	0.2	3.0	6.5
69-93	1.5	0.2	3.2	5.7
93-113	1.5	0.2	1.3	7.3
113-129	1.7	0.2	1.4	6.5
129-160	1.6	0.3	1.7	14.5

- *Nil or not determined (wherever applicable)*

Series: KONHERI **BM SPOT: 24 (BLACK SOILS)**

PROFILE NO: P45 ***System: Agriculture (Pigeonpea / Sunflower - Sorghum)*** **(FM)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 745 mm	Classification: Fine, smectitic, hyperthermic, *Vertic Haplustepts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Konheri, Mohol, Solapur, Maharashtra.		*Sampling Date: 09.01.2002*

Chemical Properties of Profile No. 45 (Konheri, Solapur)

Depth (cm)	pH (1:2)		EC (1:2) (dSm^{-1})	OC (%)	$CaCO_3$ (%)	Clay CO_3 (%)
	H_2O	1*N* KCl				
0-13	8.1	6.9	0.11	0.3	9.2	1.3
13-33	8.1	6.9	0.12	0.3	8.8	1.5
33-69	8.2	6.9	0.11	0.3	10.3	1.4
69-93	8.2	6.9	0.12	0.2	10.3	1.6
93-113	8.6	6.9	0.18	0.2	12.4	1.4
113-129	8.7	7.3	0.21	0.3	24.0	3.1
129-160	8.6	7.2	0.28	0.2	16.8	3.5

Depth (cm)	Extractable bases				CEC	Clay CEC	BS (%)	ESP
	Ca	Mg	Na	K				
	←----------[cmol(p+)kg^{-1}]----------→							
0-13	32.6	10.9	0.7	0.2	48.0	136	92	1
13-33	26.4	14.6	1.0	0.1	47.2	114	89	2
33-69	25.3	15.5	1.0	0.1	49.0	114	85	2
69-93	21.9	19.9	1.2	0.1	46.2	107	93	3
93-113	20.4	20.6	3.0	0.1	47.1	108	93	6
113-129	10.8	22.5	2.7	0.1	35.0	78	103	8
129-160	16.8	15.5	3.7	0.1	42.4	73	85	7

- *Nil or not determined (wherever applicable)*

Series: KONHERI **BM SPOT: 24 (BLACK SOILS)**

PROFILE NO: P45 ***System: Agriculture (Pigeonpea / Sunflower - Sorghum)*** **(FM)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 745 mm	Classification: Fine, smectitic, hyperthermic, *Vertic Haplustepts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Konheri, Mohol, Solapur, Maharashtra.		*Sampling Date: 09.01.2002*

Characterization of Landuse Types

S. No.	Attribute		Description
1	Production system	:	Dry farming patch (although cash crop sugarcane, onion & orchard lime are irrigated using lift irrigation and drip) comprising of *kharif* fallow-*rabi* sorghum or *rabi* safflower (depending on residual moisture) or pigeonpea or sunflower in *kharif*, followed by *rabi* fallow) with 6-8 months fallow period during summer & *kharif/rabi*, crop-livestock (cattle, buffallow, goat and poultry) garden (acid lime) farming system. Yield: Sorghum (*rabi*) 1500-2500 q/ha *Kharif* pigeonpea 1200-2000 kg ha^{-1} Sunflower 1200-1500 kg ha^{-1}
2	Management level	:	• Improved seeds • Fertilizers: Moderate dose of - 45kg N/ha/crop and 30 kg P_2O_5/ha • Manures: Nil (manures applied regularly to irrigated high value onion, sugarcane and lime crops) • Residue management: Stubble & straw composted and incorporated • Soil conservation measures: Limited to field bunding • Sowing time: Sorghum (*rabi*)- last week of Sept. to 1st week of Oct., pigeonpea and Safflower- last week of June to 1st week of July • Seed rate: Sorghum 8-10 kg ha^{-1} Pigeonpea 15-20 kg ha^{-1} Sunflower 6-8 kg ha^{-1}
3	Power source	:	Animal power supplemented with tractor
4	Market orientation	:	Largely commercial
5	Capital intensity	:	High with access to institutional credit & subsidies.
6	Labour intensity	:	Low, limited to family labour.
7	Land holding	:	Large and consolidated
8	Income level	:	High

Climatic Datasets of Konheri, Solapur District, Maharashtra

Month	Mean temp (°C)	Rainfall (mm)	PET (mm)	½ PET (mm)	LGP (days)
January	21.60	1.70	120.00	60.00	0.00
February	23.90	11.40	135.00	67.50	0.00
March	29.10	7.20	179.00	89.50	0.00
April	31.90	15.80	201.00	100.50	0.00
May	32.90	26.40	221.00	110.50	0.00
June	29.20	108.70	165.00	82.50	30.00
July	26.80	127.70	139.00	69.50	31.00
August	26.60	139.90	136.00	68.00	31.00
September	26.50	183.80	127.00	63.50	30.00
October	26.40	92.30	140.00	70.00	31.00
November	22.30	24.90	124.00	62.00	0.00
December	20.60	5.50	114.00	57.00	0.00
Average	26.48				
Total		745.30	1801.00	900.50	153.00`

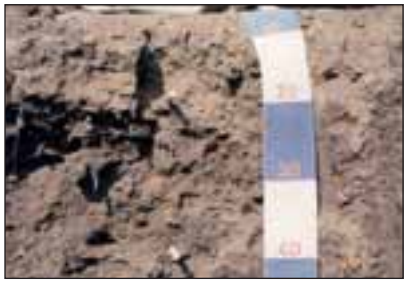
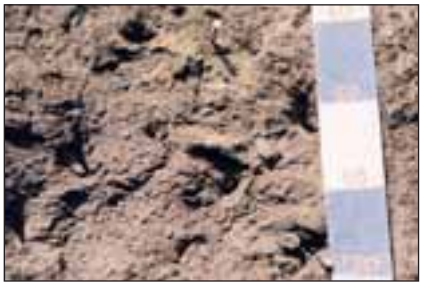
Landscape, Land soils in Benchmark Spot 24 (Konheri, Mohol, Solapur, Maharashtra)

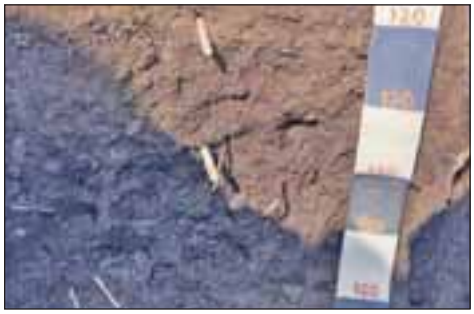

Benchmark spot at Kohneri, Solapur, Maharashtra under agricultural system (farmers' management) with pigeonpea/sunflower-sorghum crop rotatio

About 3-4 cm wide polygonal crack on the surface

Parent rock (Theolitic Basalt) responsible for the formation of Konheri black soil

Typical Konheri benchmark soil profile (Vertic Haplustepts)

Closer view of the soil profile

BM Spot 24 : KONHERI 1: Agriculture System (Pigeonpea/Sunflower-Sorghum) (LM) P46

Classification : Fine, smectitic, hyperthermic, *Leptic Haplusterts*

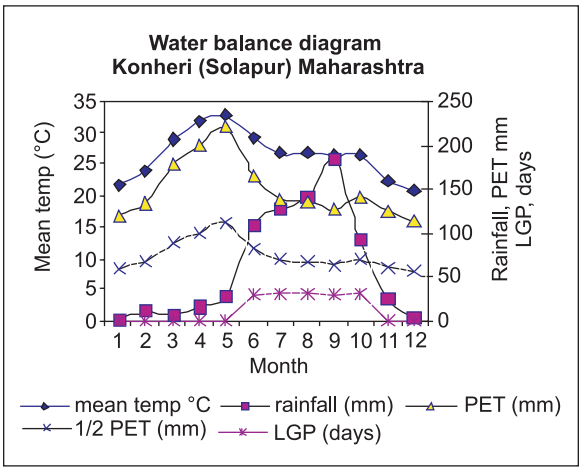
Location : Konheri, Mohol, Solapur, Maharashtra, Lat. 17°48'37"N, Long 75°29'59"E

Physiographic position : Upper Maharashtra Deccan Plateau

Topography and slope : Very gently sloping and undulating, 1-3% (50-150 m)

Drainage : Moderately well drained

Vegetation : Acacia, *neem*, *ber*, casiatora, parthenium, grass, thorny spp.



Land use : *Kharif* fallow-*Rabi* sorghum system, sunflower (sorghum-safflower stripcropping)

Parent material : Basaltic alluvium (Theolitic basalt)

Sampled by : P. Chandran, M.V. Venugopalan, S.K. Ray, P. Srivastava, S.L. Durge

Date of collection : 01.01.2002

Remarks : Most of the nodules are soft and powdery. Mainly quartz and unweathered basalt gravels as well as some hard nodules. Surface cracks have not developed may be because 2-3 cm soil of the surface is loose (due to movement of cattle) on the exposed surfaces of the profile.

Apk	0-13 cm	Very dark grey (10YR 3/1D) very dark greyish brown to very dark brown (10YR 2.5/2M) clay; moderate, medium subangular blocky (weak) structure; slightly hard, friable, very sticky and very plastic; common very fine and fine, a few medium roots; many very fine, common fine, few fine lime nodules; many very fine, fine and medium pores; moderately alkaline (pH 8.1); violently effervescent; clear, smooth boundary.
Bwk1	13-34 cm	Very dark greyish brown to very dark brown (10YR 2.5/2M) clay; moderate medium subangular blocky (well developed) structure with a few pressure faces on surface of peds; friable, very sticky and very plastic; common very fine and fine, a few medium roots; many very fine, common fine lime nodules; many very fine and fine, common medium pores; moderately alkaline (pH 8.1); violently effervescent; clear, smooth boundary.
Bssk1	34-53 cm	Very dark greyish brown to very dark brown (10YR 2.5/2M) clay; moderate medium angular blocky (not well developed) structure with weakly developed wedge-shaped aggregates and slickensides that break into weak angular peds; friable, very sticky and very plastic; common very fine and fine, a few medium roots; common very fine and fine lime nodules; many very fine and fine, common medium pores; moderately alkaline (pH 8.1); violently effervescent; clear, smooth boundary.

Bssk2	58-83 cm	Very dark greyish brown (10YR 3/2M) clay; strong medium angular blocky structure with wedge-shaped aggregates and slickensides that break into strong angular peds; friable, very sticky and very plastic; common very fine and fine, a few medium roots; common very fine and fine lime nodules; many very fine and fine, common medium pores; moderately alkaline (pH 8.0); violently effervescent; abrupt smooth boundary.
Ck1	83-117 cm	Brown(7.5YR 4/3R) clay; massive breaks into fine granular structure; loose, sticky and slightly plastic; a few very fine and fine roots; many very fine, fine, medium and coarse lime nodules; 10-15% fine gravels; moderately alkaline (pH 8.2); violently effervescent; clear, smooth boundary.
Ck2	117-155+ cm	Brown (7.5YR 4/4R) and strong brown (7.5YR 5/6M) clay; massive; breaks into fine granular structure; loose, sticky and non plastic; a few very fine and fine roots; many very fine, medium and coarse lime nodules; 35-40% fine gravels of quartz and unweathered basalt and lime nodules (which are soft and powdery); moderately alkaline (pH 8.2); violently effervescent.

Series: KONHERI 1 BM SPOT: 24 (BLACK SOILS)

PROFILE NO: P46 *System: Agriculture (Pigeonpea / Sunflower - Sorghum)* (LM)

CLIMATE: SEMI-ARID (DRY) RAINFALL: 745 mm	Classification : Very fine, smectitic, hyperthermic, *Leptic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Konheri, Mohol, Solapur, Maharashtra.		*Sampling Date: 10.01.2002*

Morphological Properties of Profile No. 46 (Konheri, Solapur)

Horizon	Depth (cm)	Boundary		Matrix color		Texture	Coarse fragments (%) (fg and cg)	Structure		
		D	*T*	Dry	Moist			Size	Grade	Type
Apk	0-13	c	s	10YR3/1	10 YR 2.5/2	c	2-3	m	2	sbk(w)$^{+}$
Bwk	13-34	c	s	-	10 YR 2.5/2	c	2-3	m	2	sbk(w)
Bssk1	34-53	c	s	-	10 YR 2.5/2	c	1-2	m	2	abk
Bssk2	53-83	a	s	-	10 YR 3/2	c	1-2	m	3	abk
Ck1	83-117	c	s	-	7.5 YR 4/3(R)	c	10-15**	massive		
Ck2	117-155	-	-	-	7.5 YR 4/4(R)	c	35-40**	massive		

Depth (cm)	Consistence			Porosity		Nodules(conca)		Roots		Effervescence*	Other Features	Cracks
	Dry	Moist	Wet	S	Q	Size	Quantity	Size	Quantity	Dil HCl		
0-13	sh	fr	s p	vf,f,m	m	vf; f; m	m; c; f	vf,f; m	c; f	ev	-	0.5 cm
13-34	-	fr	s p	vf	m c	vf; f	m; c	vf,f; m	c; f	ev	Pressure faces (few)	
34-53	-	fr	s p	vf	m c	vf; f	c	vf,f; m	c; f	ev	Slickensides (weak)	
53-83	-	fr	s p	vf	m c	vf; f	c	vf,f; m	c; f	ev	Slickensides	
83-117	-	l	spo	-	-	vf,f; m,c	m***	vf,f	f	ev	-	
117-155	-	l	spo	-	-	vf,f; m,c	m***	vf,f	f	ev	-	

**Mainly quantze gravels and unweathered basalt gravels as well as some hard nodules*
***Most of the nodules are soft and powdery*
****Matrix effervescence was also observed*

Please refer Appendix I for the abbreviations

Series: KONHERI 1 BM SPOT: 24 (BLACK SOILS)

PROFILE NO: P46 ***System: Agriculture (Pigeonpea / Sunflower - Sorghum)*** **(LM)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 745 mm	Classification : Very fine, smectitic, hyperthermic, *Leptic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Konheri, Mohol, Solapur, Maharashtra.		*Sampling Date: 10.01.2002*

Physical Properties of Profile No. 46 (Konheri, Solapur)

Laboratory No.	Horizon	Depth (cm)	Size class and particle diameter (mm)			Fine clay (%) (<0.0002)	Fine clay / total clay (%)
			Total				
			Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)		
			←----------(% of <2 mm) ----------→				
3427	Apk	0-13	2.0	19.7	78.2	54.3	69.4
3428	Bwk	13-34	1.5	19.9	78.6	59.2	75.3
3429	Bssk1	34-53	1.3	19.5	79.2	60.5	76.4
3430	Bssk2	53-83	1.1	19.8	79.2	64.6	81.6
3431	Ck1	83-117	2.8	19.7	77.5	54.5	70.3
3432	Ck2	117-155	5.6	22.7	71.6	47.4	66.2

Depth (cm)	BD (Mgm^{-3})	COLE	HC ($cmhr^{-1}$)	WDC (%)
0-13	-	0.1	1.6	15.8
13-34	1.3	0.2	3.7	18.2
34-53	1.3	0.1	1.9	19.9
53-83	1.4	0.2	1.7	20.9
83-117	1.6	0.1	1.4	7.7
117-155	-	0.1	1.2	4.1

- *Nil or not determined (wherever applicable)*

Series: KONHERI 1 **BM SPOT: 24 (BLACK SOILS)**

PROFILE NO: P46 ***System: Agriculture (Pigeonpea / Sunflower - Sorghum)*** **(LM)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 745 mm	Classification : Very fine, smectitic, hyperthermic, *Leptic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Konheri, Mohol, Solapur, Maharashtra.		*Sampling Date: 10.01.2002*

Chemical Properties of Profile No. 46 (Konheri, Solapur)

Depth (cm)	pH (1:2)		EC (1:2) (d Sm^{-1})	OC (%)	$CaCO_3$ (%)	Clay CO_3 (%)
	H_2O	1*N* KCl				
0-13	8.1	6.7	0.13	0.9	14.9	3.4
13-34	8.1	6.7	0.12	0.8	14.6	3.7
34-53	8.1	6.7	0.12	0.8	14.3	3.8
53-83	8.0	6.7	0.14	0.8	16.2	3.6
83-117	8.2	7.0	0.14	0.2	24.2	3.8
117-155	8.2	7.0	0.10	0.1	24.1	3.4

Depth (cm)	Extractable bases				CEC	Clay CEC	BS (%)	ESP
	Ca	Mg	Na	K				
	←----------[cmol(p+)kg^{-1}]----------→							
0-13	57.8	10.6	0.9	0.7	67.0	86	110	1
13-34	54.5	12.6	0.8	0.3	67.2	86	105	1
34-53	52.6	13.9	1.1	0.3	64.0	81	109	1
53-83	53.7	14.4	0.9	0.3	67.7	86	103	1
83-117	26.6	9.4	0.7	0.4	34.2	44	106	2
117-155	21.6	12.0	0.8	0.3	32.3	45	116	2

- *Nil or not determined (wherever applicable)*

Series: KONHERI 1 **BM SPOT: 24 (BLACK SOILS)**

PROFILE NO: P46 ***System: Agriculture (Pigeonpea / Sunflower - Sorghum)* (LM)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 745 mm	Classification : Very fine, smectitic, hyperthermic, *Leptic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Konheri, Mohol, Solapur, Maharashtra.		*Sampling Date: 10.01.2002*

Saturation Extract Properties of Profile No. 46 (Konheri, Solapur)

Depth (cm)	Sat (%)	ECe ($d\ Sm^{-1}$)	Soluble cations ($mmol_c\ l^{-1}$)				Sum of cations
			Ca	Mg	Na	K	
0-13	81.10	0.30	1.89	1.50	1.32	0.05	4.76
13-34	70.43	0.11	0.88	0.91	4.75	0.03	6.57
34-53	79.95	0.29	0.93	0.87	4.30	0.03	6.13
53-83	82.40	0.23	1.82	0.97	2.62	0.20	5.61
83-117	46.71	0.22	1.28	0.77	4.65	0.02	6.72
117-155	37.35	0.17	0.79	0.75	3.65	0.02	5.21

Depth (cm)	Soluble Anions ($mmol_c\ l^{-1}$)				Sum of anions
	CO_3	HCO_3	Cl	SO_4	
0-13	-	3.71	1.20	-	4.91
13-34	-	4.77	1.00	0.80	6.57
34-53	1.06	3.92	1.64	-	6.62
53-83	1.06	3.50	1.10	-	5.66
83-117	1.06	4.45	1.30	-	6.81
117-155	0.63	4.35	0.86	-	5.84

- *Nil or not determined (wherever applicable)*

Series: KONHERI 1 **BM SPOT: 24 (BLACK SOILS)**

PROFILE NO: P46 ***System: Agriculture (Pigeonpea / Sunflower - Sorghum)*** **(LM)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 745 mm	Classification : Very fine, smectitic, hyperthermic, *Leptic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Konheri, Mohol, Solapur, Maharashtra.		*Sampling Date: 10.01.2002*

Characterization of Landuse Types

S. No.	Attribute		Description
1	Production system	:	Rainfed, single post monsoon crop of *rabi* sorghum + safflower (15:2 rows) stripcropping, crop + livestock (1 buffallow + 1 cow) farming system with 8-9 months fallow period. Yield range: Sorghum - 50-100 kg ha^{-1} Safflower - 30-40 kg ha^{-1}.
2	Management level	:	• Traditional/own seeds • No fertilizer or manure • No pesticides • No soil conservation measures or residue management • Sowing time: 1st week of October • Seed rate: Sorghum 6 kg ha^{-1} Safflower (intercrop) 2-3 kg ha^{-1}
3	Power source	:	Animal power
4	Market orientation	:	Subsistence (land mostly used for grazing)
5	Capital intensity	:	Low with no access to institutional credit
6	Labour intensity	:	Low
7	Land holding	:	Small, consolidated
8	Income level	:	(of lease in) Low

Climatic Datasets of Konheri, Solapur District, Maharashtra

Month	Mean temp (°C)	Rainfall (mm)	PET (mm)	½ PET (mm)	LGP (days)
January	21.60	1.70	120.00	60.00	0.00
February	23.90	11.40	135.00	67.50	0.00
March	29.10	7.20	179.00	89.50	0.00
April	31.90	15.80	201.00	100.50	0.00
May	32.90	26.40	221.00	110.50	0.00
June	29.20	108.70	165.00	82.50	30.00
July	26.80	127.70	139.00	69.50	31.00
August	26.60	139.90	136.00	68.00	31.00
September	26.50	183.80	127.00	63.50	30.00
October	26.40	92.30	140.00	70.00	31.00
November	22.30	24.90	124.00	62.00	0.00
December	20.60	5.50	114.00	57.00	0.00
Average	26.48				
Total		745.30	1801.00	900.50	153.00`

Landscape, Landuse and Soils in Benchmark Spot 24 (Konheri, LM, Mohol, Solapur, Maharashtra)

Benchmark spot at Konheri, Solapur, Maharashtra under agricultural system

Typical benchmark profile of Konheri soils (Leptic Haplusterts)

Closer view of the soil profile

BM Spot 25 : KALWAN: Agriculture System (Sugarcane/Jowar-Wheat/Gram) (FM) P47

Classification : Fine, smectitic (cal), hyperthermic, *Typic Haplusterts*

Location : Vill. Kalwan, Kalwan, Nasik, M.S. Lat 20°29'26"N, Long 74°02'52"E

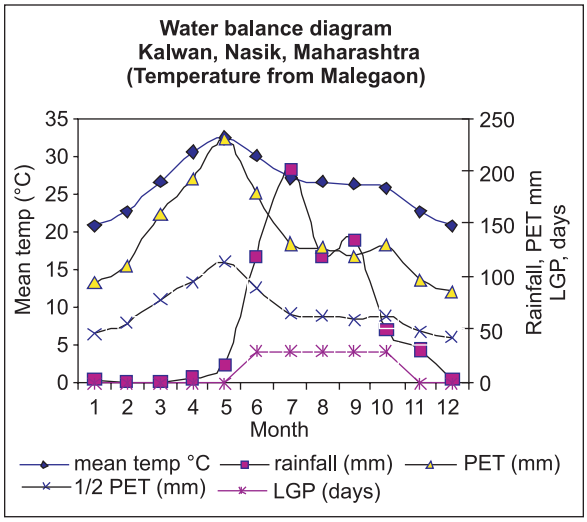
Physiographic position : Upper Maharashtra Deccan Plateau

Topography and slope : Gently sloping piedmont plains, 3-8% (50-150 m)

Drainage : Moderately well drained

Vegetation : *Neem*, mango, umber, acacia

Land use : Sugarcane, jowar, wheat, gram, onion



Parent material : Basaltic alluvium

Sampled by : D.K. Pal, T. Bhattacharyya, P. Chandran, M.V. Venugopalan, S.L. Durge, P. Srivastava

Date of collection : 21.02.2002

Remarks : Cracks are 5 cm to 7.5 cm wide up to 20 cm depth, 5 cm wide up to 48 cm, 1 cm up to 70 cm and <0.5 mm up to 88 cm depth. Class I land for sugarcane, wheat, onion, gram

Ap	0-20 cm	Dark grayish brown (10YR 4/2D) and very dark grayish brown (10YR 3/2M) clay; very coarse weak prismatic to medium and coarse moderate subangular blocky structure; hard, friable, sticky and plastic; many fine, common medium roots; many fine, a few medium lime nodules; common very fine and fine pores; moderately alkaline (pH 8.0); slightly effervescent; clear, smooth boundary.
Bw1	20-48 cm	Very dark greyish brown to very dark brown (10YR 2.5/2M) clay; coarse weak prismatic and moderate medium to coarse subangular blocky structure with pressure faces on surface of peds; firm, sticky and plastic; many fine, common medium roots; many fine, few medium lime nodules; common very fine and fine pores; mildly alkaline (pH 7.8); slightly effervescent; clear, wavy boundary.
Bssk1	48-70 cm	Very dark grey to very dark greyish brown (10YR 3/1.5M) clay; coarse strong angular blocky structure with wedge shaped aggregates and slickensides that break into strong angular peds; very firm, sticky and plastic; many fine, a few medium roots; many fine, a few medium lime nodules; common very fine and fine pores; mildly alkaline (pH 7.8); slightly effervescent; gradual smooth boundary.
Bssk2	70-88 cm	Very dark greyish brown (10YR 3/2M) silty clay; medium moderate subangular blocky and angular blocky structure with weak development of wedge-shaped aggregates and slickensides that break into weak angular peds; friable, sticky and plastic; a few fine and a few medium roots; common medium and coarse lime nodules; common very fine and fine pores; moderately alkaline (pH 7.9); slightly effervescent; clear, smooth boundary.

2BCk1	88-133 cm	Brown to strong brown (7.5YR 5/5R) loam; weak medium subangular blocky structure with slight pressure faces on surface of peds; very friable, slightly sticky and slightly plastic; a few fine roots; many medium and coarse lime nodules; many very fine and medium pores; 8-10% gravels; moderately alkaline (pH 8.1); violently effervescent; clear, smooth boundary.
2BCk2	133-154 cm	Brown (7.5YR 4/4R) loam; weak medium subangular blocky structure; very friable, slightly sticky and non plastic; many medium and coarse lime nodules; many very fine medium and coarse pores; 10-12% gravels; moderately alkaline (pH 8.3); violently effervescent.

Series: KALWAN BM SPOT: 25 (BLACK SOILS)

PROFILE NO: P47 *System: Agriculture (Sugarcane/Jowar-Wheat/Gram) (FM)*

CLIMATE: SEMI-ARID (DRY) RAINFALL: 742 mm	Classification: Fine, smectitic (Cal), hyperthermic, *Typic Haplusterts*.	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Kalwan, Kalwan, Nasik, Maharashtra.		*Sampling Date: 20.02.2002*

Morphological Properties of Profile No. 47 (Kalwan, Nasik)

Horizon	Depth (cm)	Boundary		Matrix color		Tex-ture	Coarse fragments (%) (fg and cg %)	Structure		
		D	*T*	Dry	Moist			Size	Grade	Type
Ap	0-20	c	s	10YR4/2	10YR3/2	C	3-5	vc m - c	1 2	pr sbk
Bw1	20-48	c	w	-	10YR2.5/2	c	3-5	c m	1 3	pr sbk
Bss1	48-70	g	s	-	10YR3/1.5	c	3-5	c	3	abk
Bssk1	70-88	c	s	-	10YR3/2	c	5-8	m	2	sbk
2BCk1	88-133	c	s	-	7.5YR5/5(R)	l	8-10**	m	1	sbk
2BCk2	133-154	-	-	-	7.5YR4/4(R)	l	10-12**	m	1	sbk

Depth (cm)	Consistence			Porosity		Nodules (conca)		Roots		Effervescence*	Other features	Cracks
	Dry	Moist	Wet	S	Q	Size	Quantity	Size	Quantity	Dil HCl		
0-20	h	fr	sp	vf,f	c	f; m	m; f	f; m	m; c	e	-	5-7.5cm
20-48	-	fi	vsvp	vf,f	c	f; m	m; f	f; m	m; c	e	Pressure faces	5-7.5cm
48-70	-	vfi	vsvp	vf,f	c	f; m	m; f	f; m	m; f	es	Slickensides	~5cm
70-88	-	fr	sp	vf,f	c	m, c	c	f; m	f; f	es	Slickensides	~1cm
88-133	-	vfr	ssps	vf,m	m	m, c	m	f	f	ev	Pressure faces	~0.5cm
133-154	-	vfr	sspo	vf,m, c	m	m, c	m	nil	nil	ev	-	-

**Matrix effervescence was also observed*
***fg & cg are $CaCO_3$ Nodules*

Please refer Appendix I for the abbreviations

Series: KALWAN **BM SPOT: 25 (BLACK SOILS)**

PROFILE NO: P47 ***System: Agriculture (Sugarcane/Jowar-Wheat/Gram) (FM)***

CLIMATE: SEMI-ARID (DRY) RAINFALL: 742 mm	Classification: Fine, smectitic (Cal), hyperthermic, *Typic Haplusterts*.	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Kalwan, Kalwan, Nasik, Maharashtra.		*Sampling Date: 20.02.2002*

Physical Properties of Profile No. 47 (Kalwan, Nasik)

Laboratory No.	Horizon	Depth (cm)	Size class and particle diameter (mm)			Fine clay (%) (<0.0002)	Fine clay/ total clay (%)
			Total				
			Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)		
			←----------(% of <2 mm) ----------→				
3438	Ap	0-20	14.2	37.2	48.6	26.5	54.5
3439	Bw1	20-48	27.8	25.0	47.2	31.3	66.3
3440	Bss1	48-70	16.1	32.9	51.0	32.6	63.9
3441	Bssk1	70-88	18.4	40.7	40.9	25.4	62.1
3442	2BCk1	88-133	34.5	44.1	21.4	14.7	68.7
3443	2BCk2	133-154	40.3	47.5	12.2	8.2	67.2

Depth (cm)	BD (Mgm^{-3})	COLE	HC ($cmhr^{-1}$)	WDC (%)
0-20	-	0.2	0.6	12.8
20-48	1.4	0.2	0.5	12.1
48-70	1.5	0.1	0.6	12.6
70-88	1.5	0.2	0.7	9.4
88-133	1.4	0.1	0.9	5.6
133-154	-	0.03	1.5	-

- *Nil or not determined (wherever applicable)*

Series: KALWAN BM SPOT: 25 (BLACK SOILS)

PROFILE NO: P47 *System: Agriculture (Sugarcane/Jowar-Wheat/Gram)* (FM)

CLIMATE: SEMI-ARID (DRY) RAINFALL: 742 mm	Classification: Fine, smectitic (Cal), hyperthermic, *Typic Haplusterts.*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Kalwan, Kalwan, Nasik, Maharashtra.		*Sampling Date: 20.02.2002*

Chemical Properties of Profile No. 47 (Kalwan, Nasik)

Depth (cm)	pH (1:2)		EC (1:2) (dSm^{-1})	OC (%)	$CaCO_3$ (%)	Clay CO_3 (%)
	H_2O	1*N* KCl				
0-20	8.0	6.9	0.23	1.0	2.8	3.0
20-48	7.8	6.5	0.25	0.7	3.7	3.5
48-70	7.8	6.5	0.30	0.6	7.3	4.0
70-88	7.9	6.5	0.33	0.3	12.9	4.0
88-133	8.1	6.6	0.23	0.2	14.4	4.0
133-154	8.3	6.7	0.20	0.1	13.7	-

Depth (cm)	Extractable bases				CEC	Clay CEC	BS (%)	ESP
	Ca	Mg	Na	K				
	←----------[cmol(p+)kg^{-1}]----------→							
0-20	28.2	24.7	1.9	0.5	46.9	97	118	4.0
20-48	27.6	14.0	1.6	0.4	37.8	80	115	4.2
48-70	30.9	18.2	2.1	0.5	44.5	87	116	4.7
70-88	29.6	18.7	2.3	0.5	42.3	103	121	5.4
88-133	24.7	18.2	1.8	0.5	34.6	162	131	5.2
133-154	21.3	16.0	1.5	0.5	32.3	265	122	4.6

- *Nil or not determined (wherever applicable)*

Series: KALWAN BM SPOT: 25 (BLACK SOILS)

PROFILE NO: P47 *System: Agriculture (Sugarcane/Jowar-Wheat/Gram) (FM)*

CLIMATE: SEMI-ARID (DRY) RAINFALL: 742 mm	Classification: Fine, smectitic (Cal), hyperthermic, *Typic Haplusterts.*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Kalwan, Kalwan, Nasik, Maharashtra.		*Sampling Date: 20.02.2002*

Saturation Extract Properties of Profile No. 47 (Kalwan, Nasik)

Depth (cm)	Sat (%)	ECe (d Sm^{-1})	Soluble cations ($mmol_c$ l^{-1})				Sum of cations
			Ca	Mg	Na	K	
0-20	68.58	0.82	2.54	3.69	3.8	0.06	10.09
20-48	56.74	0.53	2.46	2.50	4.72	0.07	9.70
48-70	71.79	0.63	1.74	1.59	5.72	0.04	9.10
70-88	61.89	0.73	2.16	2.27	4.35	0.06	8.80
88-133	48.70	0.58	1.39	1.11	4.39	0.04	6.90
133-154	40.60	0.57	1.39	1.11	4.37	0.06	6.93

Depth (cm)	Soluble anions ($mmol_c$ l^{-1})				Sum of anions
	CO_3	HCO_3	Cl	SO_4	
0-20	0.63	7.00	2.66	-	10.20
20-48	1.69	6.78	2.34	-	10.81
48-70	1.06	6.89	3.00	-	10.90
70-88	1.06	4.14	3.60	-	8.80
88-133	_	2.82	4.00	0.90	7.70
133-154	_	2.53	3.50	0.90	6.90

- *Nil or not determined (wherever applicable)*

Series: KALWAN BM SPOT: 25 (BLACK SOILS)

PROFILE NO: P47 *System: Agriculture (Sugarcane/Jowar-Wheat/Gram) (FM)*

CLIMATE: SEMI-ARID (DRY) RAINFALL: 742 mm	Classification: Fine, smectitic (Cal), hyperthermic, *Typic Haplusterts*.	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Kalwan, Kalwan, Nasik, Maharashtra.		*Sampling Date: 20.02.2002*

Characterization of Landuse Types

S. No.	Attribute		Description
1	Production system	:	Multiple cropping of maize-sugarcane/wheat/onion irrigated (well) with 1-2 months fallow period Yield range: Maize- 4000-5000 kg ha^{-1} Onion- 250-300 q/ha Wheat- 3500-4000 kg ha^{-1} Sugarcane- 1000-1225 q/ha
2	Management level	:	• Use of improved seeds/planting material • Organic manures: • Pesticides: • Soil conservation measures: Ridge furrow and bunding, drip irrigation • Chemical fertilizers: eg. (Sugarcane 250kg N/ha, 50kg P2O5/ha), (Wheat- 100kg N/ha & 20kg P2O5/ha). Other crops not available • Sowing time: Maize- last week of June Sugarcane- July-August Wheat/Onion- last week of November • Seed rate: Maize 20 kg ha^{-1} Sugarcane 30-35thousand setts/ha Wheat 100 kg ha^{-1}
3	Power source	:	Tractor and bullock
4	Market orientation	:	Mostly commercial and only wheat for subsistence
5	Capital intensity	:	High with easy access to credit
6	Labour intensity	:	High with no family labour involvement
7	Land holding	:	8 acre, consolidated
8	Income level	:	Moderate to high

Climatic Datasets of Kalwan, Nasik District, Maharashtra (Temperature from Malegaon)

Month	Mean temp (^oC)	Rainfall (mm)	PET (mm)	½ PET (mm)	LGP (days)
January	20.80	3.10	94.00	47.00	0.00
February	22.70	1.30	111.00	55.50	0.00
March	26.70	2.00	159.00	79.50	0.00
April	30.60	6.30	192.00	96.00	0.00
May	32.50	17.30	230.00	115.00	0.00
June	30.10	119.40	179.00	89.50	30.00
July	27.00	200.40	132.00	66.00	31.00
August	26.50	119.40	128.00	64.00	31.00
September	26.20	134.40	121.00	60.50	30.00
October	25.70	51.30	129.00	64.50	31.00
November	22.60	32.80	98.00	49.00	0.00
December	20.80	4.30	86.00	43.00	0.00
Average	26.01				
Total		692.00	1659.00	829.50	153.00

Landscape, Landuse and Soils in Benchmark Spot 25 (Kalwan, Nasik, Maharashtra)


Benchmark site at Kalwan, Nasik, Maharashtra under agricultural system (farmers' management) with sugarcane/jowar-wheat-gram/onion)








Benchmark soil profile at Kalwan (Typic Haplusterts)

3A. BLACK SOILS

3Ae. Black soils of arid bioclimatic system

(MAR: < 550 mm)

- **Benchmark Spots: 15, 28**
- **No. of Pedons: 4 (P30, P31, P51, P52)**

BM Spot 15 : SOKHDA: Agriculture System (Cotton-Bajra) (FM/1) P30

Classification: Fine, smectitic, hyperthermic, *Leptic Haplusterts*

Location : Vill. Sokhda, Morbi, Rajkot, Gujarat. Lat. 23°01'54"N, Long 70°47'11"E

Physiographic position : West Coast-Kathiawar Peninsula

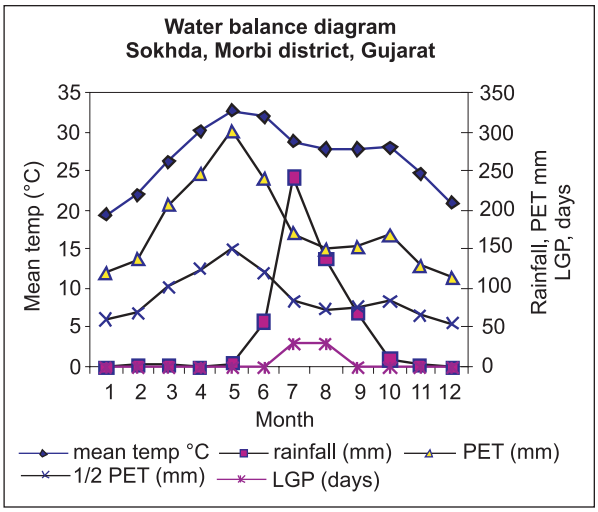
Topography and slope: Very gently sloping, 1-3% (50-150 m)

Drainage : Well drained

Vegetation : Acacia, *ber*, *neem*, prosopis, weeds solanaceous, grasses

Landuse : Cotton-bajra system

Parent material : Basaltic alluvium



Sampled by : P. Chandran, S.K. Ray, M.V. Venugopalan, P. Srivastava, S.L. Durge

Date of collection: 07.11.2001

Remarks : According to farmers, FM-I has a slightly higher yield than FM II though the crops look similar. In FM I, FYM is added every year whereas in FM II, it is added once in every 5 years. Other management factors are, however, similar. Zeolites and quartz gravels are present in all layers. Cracks are 1-1.5 wide up to 20 cm and 1-0.5 cm wide up to 60 cm.

Apk	0-11 cm	Greyish brown to dark greyish brown (10YR 4.5/2D) and dark greyish brown (10YR 4/2M) clay; weak medium subangular blocky structure; slightly hard, friable, sticky and plastic; common very fine, a few fine roots; common very fine and fine, a few medium and coarse lime nodules; many very fine and fine pores; moderately alkaline (pH 7.9); violently effervescent; clear, smooth boundary.
Bwk1	11-32 cm	Very dark greyish brown (10YR 3/2M) clay; moderate medium subangular blocky structure with pressure faces on ped surfaces; friable, sticky and plastic; common, very fine, a few fine roots; common very fine and fine, a few medium and coarse lime nodules; many very fine and fine pores; moderately alkaline (pH 8.0); violently effervescent; pressure faces; gradual smooth boundary.
Bwk2	32-57 cm	Very dark greyish brown (10YR 3/2M) clay; moderate medium subangular blocky structure with shiny pressure faces on ped surfaces; friable, sticky and plastic; common very fine few fine roots; common very fine and fine lime nodules; many very fine and fine pores; moderately alkaline (pH 7.9); violently effervescent; gradual smooth boundary.
Bssk	57-91 cm	Very dark greyish brown (10YR 3/2M) clay; strong medium angular blocky structure with weakly developed wedge-shaped aggregates and slickensides that break into weak angular peds; friable, sticky and plastic; a few very fine roots; common very fine and fine lime nodules; many very fine and fine pores; moderately alkaline (pH 7.9); violently effervescent; abruptly smooth boundary.
Ck1	91-107 cm	Brown (10YR 4/3R) clay; weak medium subangular blocky structure; very friable, sticky and slightly plastic; a few very fine roots; many very fine and fine, a few medium lime nodules; moderately alkaline (pH 8.0); violently effervescent; clear, smooth boundary.
Ck2	107-135+ cm	Very pale brown (10YR 8/2M), strong brown (7.5YR 4/6R), brown (7.5YR 4/4M) and reddish brown (5YR 4/4M) loam; weak, medium subangular blocky structure; friable, sticky and plastic; powdery lime; moderately alkaline (pH 8.0); violently effervescent.

Series: SOKHDA **BM Spot: 15 (BLACK SOILS)**

Profile No: P30 ***System: Agriculture (Cotton - Bajra)* (FM/I)**

CLIMATE: ARID RAINFALL: 533 mm	Classification : Fine, smectitic (cal), hyperthermic, *Leptic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Sokhda, Morbi, Rajkot, Gujarat		Sampling Date: 07.11.2001

Morphological Properties of Profile No 30 (Sokhda, Rajkot)

Horizon	Depth (cm)	Boundary		Matrix color		Texture	Coarse fragments (%) (fg and cg)	Structure		
		D	T	Dry	Moist			Size	Grade	Type
Apk	0-11	c	s	10YR4.5/2	10YR4/2	c	8-10	m	1	sbk
Bwk1	11-32	g	s	-	10YR3/2	c	8-10	m	2	sbk
Bwk2	32-57	g	s	-	10YR3/2	c	8-10	m	2	sbk
Bssk	57-91	a	s	-	10YR3/2	c	8-10	m	3	sbk-abk (w)**
Ck1	91-107	c	s	7.5YR4/6 (R)	10YR 4/3(R) 10YR 8/2 (M)	l	60-70	m	1	sbk
Ck2	107-135	-	-	5YR4/4 (M)	7.5YR 4/4 (M) 10YR 4/4 (M) 7.5YR 4/4 (M) 5YR 4/4 (M)	Sil	30-35	m f	1 2	sbk sbk

Depth (cm)	Consistence			Porosity		Nodules (conca)		Roots		Effervescence*	Other features	Cracks
	Dry	Moist	Wet	S	Q	Size	Quantity	Size	Quantity	Dil HCl		
0-11	sh	fr	sp	vf,f,m	m	vf,f; m,c	c; f	vf; f	c; f	Ev	-	1.5 cm
11-32	-	fr	sp	vf,f	m	vf,f; m,c	c; f	vf; f	c; f	Ev	Pressure faces	
32-57	-	fr	sp	vf,f	m	vf, f	c	vf; f	c; f	Ev	Pressure faces	0.5-1 cm
57-91	-	fr	sp	vf,f	m	vf, f	c	vf	f	Ev	Slickensides (Weak)	
91-107	-	vfr	sp	-	-	vf,f; m	m; f	vf	f	Ev	-	
107-135	-	fr	sp	-	-	powdery lime		-	-	-	-	

Cracks 1-1.5 cm wide up to 20 cm 1-0.5 cm up to 60 cm
**Matrix effervescence was also observed*

Please refer Appendix I for the abbreviations

Series: SOKHDA **BM Spot: 15 (BLACK SOILS)**

Profile No: P30 ***System: Agriculture (Cotton - Bajra)*** **(FM/I)**

CLIMATE: ARID RAINFALL: 533 mm	Classification : Fine, smectitic (cal), hyperthermic, *Leptic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Sokhda, Morbi, Rajkot, Gujarat		Sampling Date: 07.11.2001

Physical Properties of Profile No. 30 (Sokhda, Rajkot)

Laboratory No.	Horizon	Depth (cm)	Size class and particle diameter (mm)			Fine clay (%) (<0.0002)	Fine clay / total clay (%)
			Total				
			Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)		
			←----------(% of <2 mm) ----------→				
3273	Apk	0-11	24.1	34.8	41.1	14.9	36.2
3274	Bwk1	11-32	25.6	33.3	41.1	18.0	43.8
3275	Bwk2	32-57	28.8	28.5	42.7	19.6	46.0
3276	Bssk	57-91	28.7	27.1	44.2	22.0	49.7
3277	Ck1	91-107	43.5	30.2	26.3	11.9	45.0
3278	Ck2	107-135	23.7	52.1	24.2	11.7	48.3

Depth (cm)	BD (Mgm^{-3})	COLE	HC ($cmhr^{-1}$)	WDC (%)
0-11	-	0.1	1.9	4.1
11-32	1.6	0.2	2.4	5.3
32-57	1.6	0.1	2.2	5.7
57-91	1.8	0.2	3.0	5.8
91-107	1.9	0.2	2.9	3.3
107-135	-	0.2	2.6	3.3

- *Nil or not determined (wherever applicable)*

Series: SOKHDA **BM Spot: 15 (BLACK SOILS)**

Profile No: P30 ***System: Agriculture (Cotton - Bajra)*** **(FM/I)**

CLIMATE: ARID RAINFALL: 533 mm	Classification: Fine, smectitic (cal), hyperthermic, *Leptic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Sokhda, Morbi, Rajkot, Gujarat		Sampling Date: 07.11.2001

Chemical Properties of Profile No. 30 (Sokhda, Rajkot)

Depth (cm)	pH (1:2)		EC (1:2) (d Sm^{-1})	OC (%)	$CaCO_3$ (%)	Clay CO_3 (%)
	H_2O	1*N* KCl				
0-11	7.9	6.8	0.18	0.3	20.1	4.5
11-32	8.0	6.8	0.10	0.4	20.2	4.5
32-57	7.9	6.8	0.14	0.3	21.5	5.1
57-91	7.9	6.8	0.17	0.3	21.7	4.7
91-107	8.0	7.0	0.14	0.1	23.2	5.1
107-135	8.0	7.0	0.18	0.1	24.0	4.3

Depth (cm)	Extractable bases				CEC	Clay CEC	BS (%)	ESP
	Ca	Mg	Na	K				
	←----------[cmol(p+)kg^{-1}]----------→							
0-11	26.1	7.7	0.7	0.8	45.1	110	78	2
11-32	25.3	8.4	0.9	0.7	45.1	110	78	2
32-57	23.3	9.0	0.9	0.5	42.3	99	80	2
57-91	22.0	9.0	1.0	0.4	39.4	89	82	2
91-107	14.4	10.5	1.0	0.2	33.8	128	77	3
107-135	14.9	8.7	0.8	0.2	32.6	135	75	2

- *Nil or not determined (wherever applicable)*

Series: SOKHDA **BM Spot: 15 (BLACK SOILS)**

Profile No: P30 ***System: Agriculture (Cotton - Bajra)* (FM/I)**

CLIMATE: ARID RAINFALL: 533 mm	Classification: Fine, smectitic (cal), hyperthermic, *Leptic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Sokhda, Morbi, Rajkot, Gujarat		Sampling Date: 07.11.2001

Characterization of Landuse Types

S. No.	Attribute		Description
1	Production system	:	Rain-fed, predominantly *kharif* based cotton-pearl millet (2 year rotation) with 4-8 months fallow period Yield range: 1200-3000 kg ha^{-1} cotton (*desi* hybrid) and 1500-2000 kg ha^{-1} pearl millet Crop livestock system
2	Management level	:	• Improved seeds • Adequate FYM (30 cart loads per ha every year) • chemical fertilizers: Inadequate (P&K only) 40-45 kg ha^{-1}/year N and 60 kg P_2O_5/ha/year • Insecticides: Frequent • Soil-water conservation measures: Ridges and furrows • Legumes includes as intercrops (within row) to improve soil fertility • Sowing time: Cotton & pearl millet- last week of June to 1st week of July • Seed rate: Cotton 3 kg ha^{-1} Pearl millet 4-5 kg ha^{-1}, (green/blackgram 5-6 kg ha^{-1} as intercrop for green manure)
3	Power source	:	Mechanical (tractor)
4	Market orientation	:	Intermediate
5	Capital intensity	:	Intermediate with easy access to credit
6	Labor intensity	:	Medium with no family labor involvement
7	Land holding	:	Large, unconsolidated
8	Income level	:	High

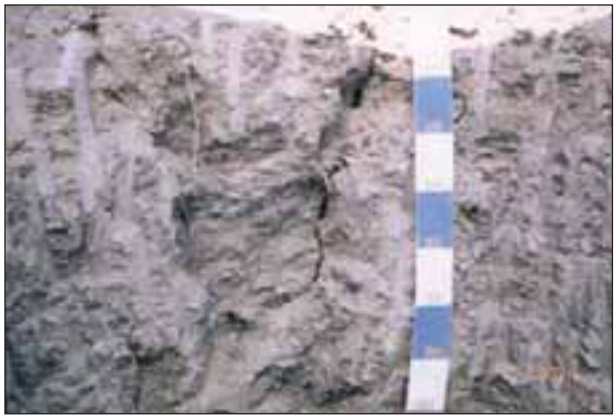
Climatic Dataset of Sokhda, Morbi District, Gujarat

Month	Mean temp (°C)	Rainfall (mm)	PET (mm)	½ PET (mm)	LGP (days)
January	19.40	0.90	121.00	60.50	0.00
February	21.90	1.40	138.00	69.00	0.00
March	26.30	2.10	206.00	103.00	0.00
April	30.10	0.30	249.00	124.50	0.00
May	32.60	4.30	302.00	151.00	0.00
June	32.00	59.80	240.00	120.00	0.00
July	28.80	243.10	170.00	85.00	31.00
August	27.80	138.50	150.00	75.00	31.00
September	27.90	68.00	154.00	77.00	0.00
October	28.20	10.90	169.00	84.50	0.00
November	24.80	3.00	131.00	65.50	0.00
December	20.90	1.00	114.00	57.00	0.00
Average	26.72				
Total		533.30	2144.00	1072.00	62.00

Landscape, Landuse and Soils in Benchmark Spot 15 (Sokhda, FM/1, Morbi, Rajkot)

Benchmark spot at Sokhda under agricultural system (farmers management I) with cotton-bajra cropping pattern

Typical Sokhda profile.



Closer view of the profile

BM Spot 15 : SOKHDA 1: Agriculture System (Cotton-Bajra/Linseed) (FM/2) P31

Classification: Fine, smectitic, hyperthermic, *Sodic Haplusterts*

Location : Vill. Sokhda, Morbi, Rajkot, Gujarat, Lat. 23°02'19"N, Long 70°47'30"E

Physiographic position : West Coast-Kathiawar Peninsula

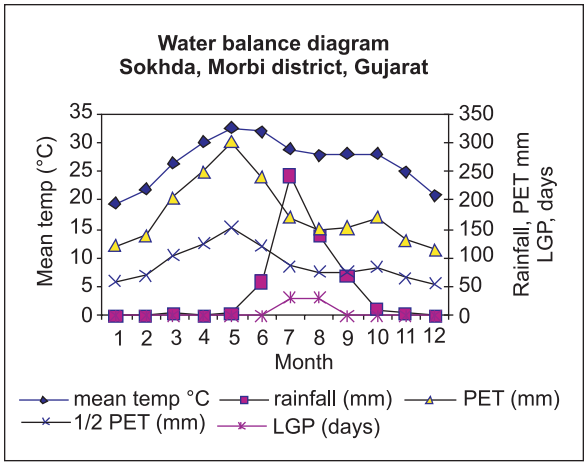
Topography and slope : Very gently sloping, 1-3% (50-150 m)

Drainage : Moderately well drained

Vegetation : Acacia, *neem*, prosopis, grass

Landuse : Cotton-bajra /linseed

Parent material : Basaltic alluvium



Sampled by : P. Chandran, S.K. Ray, M.V. Venugopalan, P. Srivastava, S.L. Durge

Date of collection: 07.11.2001

Remarks : Groundwater is turning saline after usage for about 5-6 years. It's harmful for continuous use. Farmers do not use groundwater. Zeolites and quartz gravels are throughout. Cracks : 2-3 cm wide up to 30 cm; 1-1.5 cm wide up to 75 cm; 0-5 cm wide up to 125 cm.

Apk	0-11 cm	Dark greyish brown to brown (10YR 4/2.5D) and dark greyish brown (10YR 4/2M) clay loam; weak medium subangular blocky structure; slightly hard, friable, sticky and plastic; common very fine and fine roots; common very fine and fine, a few medium lime nodules; many very fine, fine and medium pores; moderately alkaline (pH 8.2); violently effervescent; clear, smooth boundary.
Bwk1	11-37 cm	Very dark greyish brown to dark brown (10YR 3/2.5M) clay loam; moderate medium subangular blocky structure with pressure faces on ped surfaces; friable, sticky and plastic; common very fine and fine roots; common very fine and fine, a few medium lime nodules; many very fine and fine pores; moderately alkaline (pH 8.4); violently effervescent; gradual smooth boundary.
Bwk2	37-63 cm	Dark brown (10YR 3/3M) clay; strong, medium subangular blocky and weak angular blocky structure with well developed shiny pressure faces and weakly developed wedge-shaped aggregates and slickensides; friable, sticky and plastic; common very fine and a few fine roots; common very fine and fine, a few medium lime nodules; many very fine and fine pores; strongly alkaline (pH 8.7); violently effervescent; gradual wavy boundary.
Bssk1	63-98 cm	Dark brown (10YR 3/3M) clay; strong medium angular blocky (not well developed) structure with wedge-shaped aggregates and slickensides that break into weak angular peds; friable, sticky and plastic; a few very fine roots; common very fine and fine lime nodules; many very fine and fine pores; strongly alkaline (pH 8.8); violently effervescent; gradual wavy boundary.
Bssk2	98-145 cm	Dark brown (7.5YR 3/2MR & 10YR 3/3M)) clay; strong medium angular blocky structure with slickensides and wedge-shaped aggregates that break into strong angular peds; friable, sticky and plastic; a few very fine roots; common very fine and fine lime nodules; many very fine and fine pores; strongly alkaline (pH 8.6); violently effervescent; abruptly smooth boundary.
BCk	145-160+ cm	Dark reddish brown (5YR 3/4M) and (5YR 3/3R) clay; moderate medium subangular blocky structure; friable, sticky and plastic; many very fine and fine, common medium lime nodules; strongly alkaline (pH 8.5); violently effervescent.

Series: SOKHDA 1 **BM Spot: 15 (BLACK SOILS)**

Profile No: P31 ***System: Agriculture (Cotton - Bajra/Linseed)*** **(FM/2)**

CLIMATE: ARID RAINFALL: 533 mm	Classification : Fine, smectitic (cal), hyperthermic, *Sodic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Sokhda, Morbi (Tah), Rajkot, Gujarat		Sampling Date: 07.11.2001

Morphological Properties of Profile No. 31 (Sokhda, Rajkot)

Horizon	Depth (cm)	Boundary		Matrix color		Texture	Coarse fragments (%) (fg and cg)	Structure		
		D	T	Dry	Moist			Size	Grade	Type
Apk	0-11	c	s	10YR4/2.5	10 YR 4/2	c	8-10	m	1	sbk
Bwk1	11-37	g	s	-	10YR3/2.5	c	8-10	m	2	sbk
Bwk2	37-63	g	w	-	10YR3/3	c	8-10	m	3	sbk-abk
Bssk1	63-98	g	w	-	10YR3/3	c	8-10	m	3	abk
Bssk2	98-145	a	s	-	7.5YR3/2	c	8-10	m	3	abk
BCk	145-160	-	-	-	5YR3/3 (R)	c	10-15	m	2	sbk

Depth (cm)	Consistence			Porosity		Nodules(conca)		Roots		Effervescence*	Other Features	Cracks
	Dry	Moist	Wet	S	Q	Size	Quantity	Size	Quantity	Dil HCl		
0-11	sh	fr	sp	vf,f; m	m;m	vf,f; m	m; f	vf,f	c	ev	-	2-3 cm
11-37	-	fr	sp	vf,f	m	vf,f; m	c; f	vf,f	c	ev	Pressure faces	1-1.5 cm
37-63	-	fr	sp	vf,f	m	vf,f; m	c; f	vf; f	c; f	ev	Slickensides (Weak)	
63-98	-	fr	vsvp	vf,f	m	vf,f	c	vf	f	ev	Slickensides	0.5 cm
98-145	-	fr	vsvp	vf,f	m	vf,f	c	vf	f	ev	Slickensides	
145-160	-	fr	sp	-	-	vf,f; m	m; c	-	-	ev	-	

cg: Powdery lime.*
***Matrix effervescence was also observed*
Cracks: 2-3 cm wide up to 30 cm, 1-1.5 cm up to 75 cm and o.5 cm up to 125 cm

Please refer Appendix I for the abbreviations

Series: SOKHDA 1 **BM Spot: 15 (BLACK SOILS)**

Profile No: P31 ***System: Agriculture (Cotton - Bajra/Linseed)*** **(FM/2)**

CLIMATE: ARID RAINFALL: 533 mm	Classification : Fine, smectitic (cal), hyperthermic, *Sodic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Sokhda, Morbi (Tah), Rajkot, Gujarat		Sampling Date: 07.11.2001

Physical Properties of Profile No. 31 (Sokhda, Rajkot)

Laboratory No.	Horizon	Depth (cm)	Size class and particle diameter (mm)			Fine clay (<0.0002)	Fine clay/ total clay (%)
			Total				
			Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)		
			←----------(% of <2 mm) ----------→				
3279	Apk	0-11	29.9	38.4	31.7	12.6	39.7
3280	Bwk1	11-37	29.4	40.1	30.5	13.4	43.9
3281	Bwk2	37-63	26.4	33.5	40.1	17.9	44.6
3282	Bssk1	63-98	26.6	32.6	40.8	19.2	47.0
3283	Bssk2	98-145	22.8	34.5	42.7	20.4	47.7
3284	BCk	145-160	7.9	42.0	50.1	33.0	65.8

Depth (cm)	BD (Mgm-3)	COLE	HC (cmhr-1)	WDC (%)
0-11	-	0.2	3.2	1.0
11-37	1.4	0.2	3.0	4.4
37-63	1.6	0.2	1.5	3.8
63-98	1.8	0.1	0.4	3.6
98-145	1.6	0.1	0.2	3.5
145-160	1.7	0.2	0.2	3.7

- *Nil or not determined (wherever applicable)*

Series: SOKHDA 1 **BM Spot: 15 (BLACK SOILS)**

Profile No: P31 ***System: Agriculture (Cotton - Bajra/Linseed)*** **(FM/2)**

CLIMATE: ARID RAINFALL: 533 mm	Classification : Fine, smectitic (cal), hyperthermic, *Sodic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Sokhda, Morbi (Tah), Rajkot, Gujarat		Sampling Date: 07.11.2001

Chemical Properties of Profile No. 31 (Sokhda, Rajkot)

Depth (cm)	pH (1:2)		EC (1:2) (dSm^{-1})	OC (%)	$CaCO_3$ (%)	Clay CO_3 (%)
	H_2O	1*N* KCl				
0-11	8.2	7.0	0.18	0.5	21.9	5.8
11-37	8.4	7.1	0.18	0.5	21.4	5.2
37-63	8.7	7.1	0.24	0.4	21.5	6.2
63-98	8.8	7.1	0.35	0.4	22.0	5.8
98-145	8.6	7.1	0.43	0.3	21.6	8.7
145-160	8.5	6.9	0.22	0.2	11.6	4.5

Depth (cm)	Extractable bases				CEC	Clay CEC	BS (%)	ESP
	Ca	Mg	Na	K				
	←----------[cmol(p+)kg^{-1}]----------→							
0-11	21.1	9.8	1.0	0.7	40.6	128	80	2
11-37	20.4	8.9	1.2	0.6	40.6	133	74	3
37-63	18.0	13.1	2.6	0.5	42.0	105	81	6
63-98	14.4	13.8	4.7	0.5	40.6	99	82	12
98-145	12.7	15.6	8.5	0.5	42.3	99	88	20
145-160	11.8	14.0	10.1	0.5	46.5	93	78	22

Series: SOKHDA 1 **BM Spot: 15 (BLACK SOILS)**

Profile No: P31 ***System: Agriculture (Cotton - Bajra/Linseed)*** **(FM/2)**

CLIMATE: ARID RAINFALL: 533 mm	Classification : Fine, smectitic (cal), hyperthermic, *Sodic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Sokhda, Morbi (Tah), Rajkot, Gujarat		Sampling Date: 07.11.2001

Saturation Extract Properties of Profile No 31 (Sokhda, Rajkot)

Depth (cm)	Sat (%)	ECe (d Sm^{-1})	Soluble cations ($mmol_c$ l^{-1})				Sum of cations
			Ca	Mg	Na	K	
0-11	41.13	0.42	2.40	1.42	1.13	0.01	4.96
11-37	42.47	0.38	1.47	1.10	1.72	0.07	4.36
37-63	46.83	0.48	0.51	0.50	4.35	0.01	5.37
63-98	49.90	0.75	0.61	0.56	8.69	0.02	9.88
98-145	57.04	4.20	3.21	4.52	34.78	0.16	42.67
145-160	47.11	0.40	1.61	0.89	2.72	0.04	5.26

Depth (cm)	Soluble anions ($mmol_c$ l^{-1})				Sum of anions
	CO_3	HCO_3	Cl	SO_4	
0-11	1.06	2.34	1.30	0.26	4.96
11-37	1.49	1.69	1.04	0.14	4.36
37-63	1.75	2.12	1.50	-	5.37
63-98	1.06	3.93	3.56	1.33	9.88
98-145	1.70	0.97	40.00	-	42.67
145-160	1.06	2.12	0.76	1.32	5.26

-*Nil or not determined (wherever applicable)*

Series: SOKHDA 1 **BM Spot: 15 (BLACK SOILS)**

Profile No: P31 ***System: Agriculture (Cotton - Bajra/Linseed)* (FM/2)**

CLIMATE: ARID RAINFALL: 533 mm	Classification: Fine, smectitic (cal), hyperthermic, *Sodic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Sokhda, Morbi (Tah), Rajkot, Gujarat		Sampling Date: 07.11.2001

Characterization of Landuse Types

S. No.	Attribute		Description
1	Production system	:	Rain-fed, *kharif* based, cotton-pearl millet + sesamum in 2:2 ratio (2 year rotation) with 4-8 months fallow period. Yield range: Cotton 1500-2500 kg ha^{-1} and Pearl millet 1500-2000 kg ha^{-1}.
2	Management level	:	• Improved varieties of hybrids/varieties • Manures: Limited use of FYM • Fertilizers: Inadequate chemical (P&K only) 30-40 kg N and 60 kg P_2O_5/ha/year • Insecticides: Frequent • Conservation/residue management measures: Nil • Sowing time: Cotton & pearl millet- last week of June to 1st week of July • Seed rate: Pearl millet 4 kg ha^{-1} Sesamum 1.5-2 kg ha^{-1}
3	Power source	:	Tractor supplemented with animal traction
4	Market orientation	:	Intermediate
5	Capital intensity	:	Intermediate with easy access to credit
6	Labor intensity	:	Medium with no family labor involvement
7	Land holding	:	Large and unconsolidated.
8	Income level	:	High.

Climatic Dataset of Sokhda, Morbi District, Gujarat

Month	Mean temp (^oC)	Rainfall (mm)	PET (mm)	½ PET (mm)	LGP (days)
January	19.40	0.90	121.00	60.50	0.00
February	21.90	1.40	138.00	69.00	0.00
March	26.30	2.10	206.00	103.00	0.00
April	30.10	0.30	249.00	124.50	0.00
May	32.60	4.30	302.00	151.00	0.00
June	32.00	59.80	240.00	120.00	0.00
July	28.80	243.10	170.00	85.00	31.00
August	27.80	138.50	150.00	75.00	31.00
September	27.90	68.00	154.00	77.00	0.00
October	28.20	10.90	169.00	84.50	0.00
November	24.80	3.00	131.00	65.50	0.00
December	20.90	1.00	114.00	57.00	0.00
Average	26.72				
Total		533.30	2144.00	1072.00	62.00

Landscape, Landuse and Soils in Benchmark Spot 15 (Sokhda, FM/2, Rajkot, Gujarat)

Quake-hit village of Sokhda at Rajkot, Gujarat

Bullocks are important resources for farmers

Benchmark spot at Sokhda under agriculture system (farmers' management) with cotton-bajra/linseed crop rotation.

A typical Sokhda profile

Closer view of the profiles

BM Spot 28 : NIMONE: Agriculture System (Cotton-Wheat/Chickpea) (HM) P51

Classification: Very fine, smectitic (cal), isohyperthermic, *Sodic Haplusterts*

Location: Survey No. 51C, Cotton Project Farm area of MPKV, Rahuri, Vill. Rahurikhurd, Rahuri , Ahmednagar, Maharashtra Lat. 19°22'01"N, Long 74°39'25" E

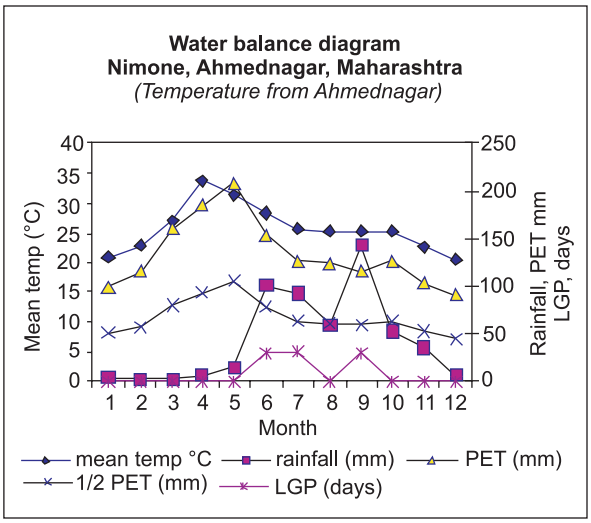
Physiography position : Upper Maharashtra Deccan Plateau

Topography and slope: Level to very gently sloping, 0-3% (50-150 m)

Drainage: Moderately well drained

Vegetation: Acacia, *neem*, grass (*Dub* S. Dactylon)

Landuse : Cotton-wheat/chickpea system, sugarcane



Parent Material: Basaltic alluvium.

Sampled by: P. Chandran, M.V. Vegnugopalan, S.K. Ray, S.L. Durge, G.K. Kamble

Date of Collection: 18/10/2002

Remarks: Medium and coarse nodules are brittle and soft in nature and softer in the last layer. A few quartz/Zeolite gravels are present at surface. Cracks are not seen due to irrigation. They do not remain open for more than 40-60 consecutive days as cotton crop cultivation begins from 15th March to 15 April. Irrigation water does not stagnate at surface.

Apk	0-13 cm	Dark brown (7.5YR3/2D) and very dark brown (2.5/2M) clay; weak to moderate medium subangular blocky structure; hard, friable very sticky and very plastic; very fine common, a few fine roots; common very fine, a few fine lime nodules; many very fine and fine pores; moderately alkaline (pH 8.4); strongly effervescent; clear, smooth boundary.
Bwk1	13-38 cm	Very dark brown (7.5YR2.5/2M) and dark brown (7.5YR3/2R); sub angular blocky structure with pressure faces on surface of peds; friable very sticky and very plastic; common very fine, a few fine roots; common very fine, a few fine lime nodules; many very fine and fine pores; strongly alkaline (pH 8.5); strongly effervescent; gradual smooth boundary.
Bwk2	38-55 cm	Very dark brown (7.5YR2.5/2M) and dark brown (7.5YR3/2R); clay; moderate medium subangular blocky structure with shiny pressure faces on surface of peds; friable, very sticky and very plastic; a few common roots; strongly effervescent; gradual wavy boundary.
Bssk1	55-94 cm	Very dark brown (7.5YR2.5/2M&R); clay; strong medium sub angular blocky to angular blocky structure with weak development of wedge-shaped aggregates and slickensides that break into weak angular peds; friable very sticky and very plastic; a few very fine roots; common very fine and fine lime nodules; strongly alkaline (pH 8.5); strongly effervescent; gradual wavy boundary.
Bssk2	94-128 cm	Very dark brown (7.5YR2.5/2M&R); clay; strong medium angular blocky structure with wedge-shaped aggregates and slickensides that break into small strong angular peds; friable, very sticky and very plastic; a few very fine roots; many very fine and fine, common medium lime nodules; strongly alkaline (pH 8.5); strongly effervescent; slickensides; clear, wavy boundary.
Bwk3	128-150+ cm	Dark reddish brown (54R3/4M, 80 to 90% v/v), very dark brown (7.5R2.5/2 10 to 20% v/v) and reddish brown (54R4/3R); clay; moderate medium subangular blocky structure with pressure faces on surface of peds; friable, very sticky and very plastic; a few very fine roots; many very fine and fine, common medium and coarse lime nodules; strongly alkaline (pH 8.5); violently effervescent.

Series: NIMONE **BM SPOT: 28 (BLACK SOILS)**

PROFILE NO: P51 ***System: Agriculture (Cotton-wheat/Chickpea[Irrigated])(*HM)**

CLIMATE: ARID RAINFALL: 520 mm	Classification: Very fine, smectitic (cal), isohyperthermic *Sodic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Cotton Project (Plot No/Survey No. 51C), area of MPKV, Village-Rahuri Khurd, Rahuri, Ahmednagar, Maharashtra.		Sampling Date: 18/12/2002

Morphological Properties of Profile No. 51 (Nimone, Rahuri)

Horizon	Depth (cm)	Boundary		Matrix color		Texture	Coarse fragments (%) (fg %)	Structure		
		D	T	Dry	Moist			Size	Grade	Type
Ap	0-13	c	s	7.5YR3/2	7.5YR2.5/2	c	5-8	m	1-2	sbk
Bwk1	13-38	g	s	-	7.5YR 2.5/2(m)/3/2(R)	c	5-8	m	2	sbk
Bwk2	38-55	g	w	-	7.5YR 2.5/2(m)/3/2(R)	c	5-8	m	2	sbk
Bssk1	55-94	g	w	-	7.5YR 2.5/2(m)/3/2(R)	c	5-8	m	3	sbk-.abk
Bssk2	94-128	c	s	-	7.5YR 2.5/2(m)/3/2(R)	c	8-10	m	3	abk
Bwk3	128-150+	-	-	-	7.5YR2.5/2(R)** 5YR3/4m	c	10-15	m	2	sbk

Depth (cm)	Consistence			Porosity		Nodules (conca)		Roots		Efferve-scence	Other Features	Cracks
	Dry	Moist	Wet	S	Q	Size	Quantity	Size	Quantity	Dil HCl		
0-13	h	fr	sp	vf,f	m	vf,f	c,f	vf,f	c,f	es	-	Not
13-38	-	fr	sp	vf,f	m	vf,f	c,f	vf,f	c,f	es	Pressure faces	observed
38-55	-	fr	sp	vf,f	m	vf,f	c,f	vf,f	f	es	Pressure faces	
55-94	-	fr	vs vp	-	-	vf,f	c	vf	f	es	Slickensides(well)	
94-128	-	fr	vs vp	-	-	vf,f,m	m*c	vf	f	es	Slickensides	
128-150+	-	fr	sp	-	-	vf,f,f,c	m*c	vf	f	ev	Pressure faces	

** fg - Few quartz/Zeolite gravels (fg/cg)*

*** 80 - 90% of colors are in 5YR lime and 10-20% are in hue of 7.5 YR*

**** The medium and coarse nodules are brittle and soft in nature; softer in the last layer*

1. Cracks are not observed during irrigation in sugarcane belt. The soils do not remain dry for >90 consecutive days. Therefore, soils are grouped under Udic subgroup inspite of 500 mm annual rainfall

Please refer Appendix I for the abbreviations

Series: NIMONE **BM SPOT: 28 (BLACK SOILS)**

PROFILE NO: P51 ***System: Agriculture (Cotton-wheat/Chickpea [Irrigated])*****(HM)**

CLIMATE: ARID RAINFALL: 520 mm	Classification: Very fine, smectitic (cal), isohyperthermic *Sodic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Cotton Project (Plot no/Survey no. 51C), area of MPKV, Village-Rahuri Khurd, Rahuri, Ahmednagar, Maharashtra.		Sampling Date: 18/12/2002

Physical Properties of Profile No. 51 (Nimone, Rahuri)

Laboratory No.	Horizon	Depth (cm)	Size class and particle diameter (mm)			Fine clay (%) (<0.0002)	Fine clay / total clay (%)
			Total				
			Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)		
			←----------(% of <2 mm) ----------→				
3574	Apk	0-13	4.0	29.6	66.4	46.0	69.3
3575	Bwk1	13-38	4.0	28.3	67.7	48.7	71.9
3576	Bwk2	38-55	4.2	29.7	66.1	47.2	71.4
3577	Bssk1	55-94	4.5	26.2	69.3	50.2	72.4
3578	Bssk2	94-128	2.7	26.6	70.7	52.4	74.1
3579	Bwk3	128-150+	2.7	26.8	70.5	53.2	75.5

Depth (cm)	BD (Mgm^{-3})	COLE	HC ($cmhr^{-1}$)	WDC (%)
0-13	-	0.2	2.6	2.3
13-38	1.4	0.3	2.0	3.8
38-55	1.4	0.3	1.5	2.8
55-94	1.3	0.3	1.5	2.8
94-128	1.4	0.3	1.5	4.5
128-150+	1.3	0.2	2.8	2.0

- *Nil or not determined (wherever applicable)*

Series: NIMONE **BM SPOT: 28 (BLACK SOILS)**

PROFILE NO: P51 ***System: Agriculture (Cotton-Wheat/Chickpea [Irrigated])*****(HM)**

CLIMATE: ARID RAINFALL: 520 mm	Classification: Very fine, smectitic (cal), isohyperthermic *Sodic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Cotton Project (Plot No/Survey No. 51C), area of MPKV, Village-Rahuri Khurd, Rahuri, Ahmednagar, Maharashtra.		Sampling Date: 18/12/2002

Chemical Properties of Profile No. 51 (Nimone, Rahuri)

Depth (cm)	pH (1:2)		EC (1:2) (dSm^{-1})	OC (%)	$CaCO_3$ (%)	Clay CO_3 (%)
	H_2O	1*N* KCl				
0-13	8.4	7.0	0.22	0.9	14.1	-
13-38	8.5	7.1	0.22	0.7	14.4	-
38-55	8.4	7.1	0.31	0.6	15.7	-
55-94	8.4	7.1	0.64	0.6	14.5	-
94-128	8.5	7.1	1.63	0.5	15.8	-
128-150+	8.5	7.1	2.34	0.4	16.3	-

Depth (cm)	Extractable bases				CEC	Clay CEC	BS (%)	ESP
	Ca	Mg	Na	K				
	←----------[cmol(p+)kg^{-1}]----------→							
0-13	37.8	15.6	1.1	0.8	50.6	76	110	2.2
13-38	36.4	15.6	1.1	0.5	48.5	72	110	2.3
38-55	33.3	20.0	2.8	0.4	48.7	74	116	5.7
55-94	31.6	20.0	4.2	0.4	48.7	70	115	8.6
94-128	31.0	23.1	5.2	0.5	48.3	68	124	10.8
128-150+	39.9	20.7	4.7	0.4	42.8	61	153	11.0

- *Nil or not determined (wherever applicable)*

Series: NIMONE **BM Spot: 28 (BLACK SOILS)**

Profile No: P51 ***System: Agriculture(Cotton-Wheat/Chickpea[Irrigated])*****(HM)**

CLIMATE: ARID RAINFALL: 520 mm	Classification: Very fine, smectitic (cal), isoryperthermic *Sodic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Cotton Project (Plot No/Survey No. 51C), area of MPKV, Village-Rahuri Khund, Rahuri, Ahmednagar, Maharashtra.		Sampling Date: 18/12/2002

Saturation Extraction Properties of Profile No. 51 (Nimone, Ahmednagar)

Lab. No.	Sat (%)	ECe (d Sm^{-1})	Soluble cations ($mmol_c$ l^{-1})				Sum of cations
			Ca	Mg	Na	K	
3574	-	0.47	1.9	1.4	1.2	0.07	4.6
3575	-	0.53	2.0	1.1	1.7	0.05	5.0
3576	-	0.73	1.9	1.2	2.7	0.05	5.9
3577	-	1.74	4.3	4.5	5.1	0.04	13.9
3578	-	0.83	18.2	16.1	13.9	0.09	48.3
3579	-	0.78	18.6	15.4	10.9	0.07	44.9

Lab. No.	Soluble anions ($mmol_c$ l^{-1})				Sum of anions
	CO_3	HCO_3	Cl	SO_4	
3574	-	2.5	2.1	-	4.6
3575	0.5	2.5	2.0	-	5.0
3576	0.5	2.5	2.9	-	5.9
3577	-	5.0	3.8	5.1	13.9
3578	-	5.8	7.5	35.0	48.3
3579	-	8.8	6.3	29.8	44.9

Series: NIMONE **BM Spot: 28 (BLACK SOILS)**

Profile No: P51 ***System: Agriculture(Cotton-Wheat/Chickpea[Irrigated])*(HM)**

CLIMATE: ARID RAINFALL: 520 mm	Classification: Very fine, smectitic (cal), isoryperthermic *Sodic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Cotton Project (Plot no/Survey no. 51C), area of MPKV, Village-Rahuri Khund, Rahuri, Ahmednagar, Maharashtra.		Sampling Date: 18/12/2002

Characterization of Landuse Types

S. No.	Attribute		Description
1	Production system	:	Irrigated, double cropping system of cotton (summer irrigated from Mar-Oct)- gram/wheat (*rabi*) with less than 1 month fallow period. Rotation of sorghum (R)- fallow or green manure with *dhaincha* (once in 3 - 4 years). Yield range: Cotton- 1800-2000 kg ha^{-1}, wheat- 4500 kg ha^{-1} and sorghum (rain-fed)- 12 kg ha^{-1}
2	Management level	:	• Improved varieties/hybrids • Optimum plant stand • Chemical fertilizers: Recommended (cotton 100:50:50, wheat 100:50:50 and sorghum 50:0:0) • Manures: Adequate FYM (10 cart loads/ha in 4 year) • Green manuring: Occasional • Soil conservation measures: Leveling and field bunding • Sowing time: Cotton-1st fortnight of April • Seed rate: 2.45-3 kg ha^{-1}
3	Power source	:	Tractor with improved implements
4	Market orientation	:	R&D
5	Capital intensity	:	High
6	Labor intensity	:	Intermediate
7	Land holding	:	NA
8	Income level	:	NA

Climatic Datasets of Nimone (Rahuri), Ahmednagar District, Maharashtra

Month	Mean temp (^oC)	Rainfall (mm)	PET (mm)	½ PET (mm)	LGP (days)
January	21.00	5.10	99.00	49.50	0.00
February	23.00	1.80	115.00	57.50	0.00
March	26.80	3.10	160.00	80.00	0.00
April	33.50	5.30	184.00	92.00	0.00
May	31.10	15.70	208.00	104.00	0.00
June	28.10	100.60	154.00	77.00	30.00
July	25.60	92.70	126.00	63.00	31.00
August	25.20	57.90	123.00	61.50	0.00
September	25.10	143.00	116.00	58.00	30.00
October	25.20	53.30	127.00	63.50	0.00
November	22.40	35.10	103.00	51.50	0.00
December	20.60	6.30	90.00	45.00	0.00
Average	25.63				
Total		519.90	1605.00	802.50	91.00

BM Spot 28 : NIMONE: Agriculture System (Sugarcane-Ratoon/Soybean-Wheat/Chickpea) (FM) P52

Classification: Fine, smectitic (cal), isohyperthermic, *Sodic Haplusterts*

Location: Vill. Nirmal Pimpri, Rahata, Ahmednagar, Maharashtra. Lat.19°39'16"N, Long 74°29'40"E

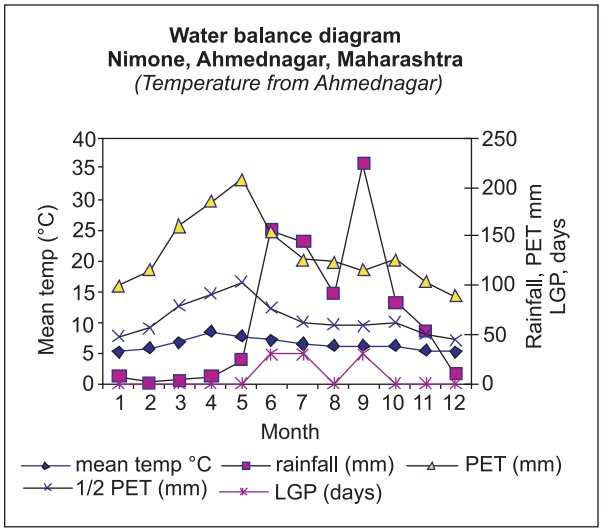
Physiography position : Upper Maharashtra Deccan Plateau

Topography and slope: Level to very gently sloping, 0-3% (50-150 m)

Drainage: Imperfectly well drained

Vegetation: Acacia, *neem*, grass (*Dub* S. Dactylon), tamarind

Landuse : Sugarcane-ratoon (1 or 2) – soybean-wheat/chickpea system



Parent Material: Basaltic alluvium.

Sampled by: P. Chandran, M.V. Vegnugopalan, S.K. Ray, S.L. Durge, G.K. Kamble

Date of Collection: 18/12/2002

Remarks: At a depth of 84 cm, there are patches of brittle, soft limy material which increases with depth and also in purity. Slickensides are also formed adjoining limy material, which are firm and very hard when dry. A few quartz and zeolite are present (more at the surface) of size fs/cs. The medium and coarse sized nodules are brittle and breaks into fine and very fine particles. Cracks are 1-2 cm wide up to 15 cm. Sometimes, it's <0.5 cm wide up to 29 cm.

Apk	0-12cm	Dark grey (10YR4/1D) and dark greyish brown (10YR4/1.5M) clay; moderate medium subangular blocky to weak medium subangular blocky structure; friable sticky and plastic, common very fine and fine roots; common very fine, a few fine lime nodules; many very fine and fine pores; strongly alkaline (pH 8.7); violently effervescent; clear, smooth boundary.
Bwk1	2-29cm	Very dark brown (10YR2/2M) and dark brown (7.5YR3/2R) clay; moderate medium subangular blocky structure with weak pressure faces on surface of peds; friable, sticky and plastic, common very fine and fine roots; common very fine, few fine lime nodules; many very fine and fine pores; strongly alkaline (pH 8.8); violently effervescent; gradual smooth boundary.
Bwk2	29-50cm	Dark brown (7.5YR3/2M&R) clay; strong medium subangular blocky structure with pressure faces on surface of peds; slightly firm, sticky and plastic; common very fine and fine roots; common very fine, a few fine lime nodules; many very fine and fine pores; strongly alkaline (pH 8.9); violently effervescent; gradual wavy boundary.

Bssk1	50-84cm	Dark brown (7.5YR3/2M&R) clay; strong medium angular blocky (weak) structure with weak wedge shaped aggregates and slickensides that break into small weak angular peds; firm, sticky and plastic; a few very fine and fine roots; common very fine, a few fine lime nodules; many very fine, fine and medium pores; very strongly alkaline (pH 9.5); violently effervescent; diffuse wavy boundary.
Bssk2	84-113 cm	Dark brown (7.5YR 3/2, 3/3M) and pink (7.5YR7/3D), brown (7.5YR 4/3 R); clay; strong medium angular blocky (soil part) with wedge-shaped aggregates and slickensides that break into strong angular peds; and weak, medium, subangular and blocky (limes part) structure; friable sticky and plastic; a few very fine, fine and medium roots; common very fine and fine, many medium and coarse lime nodules; very strongly alkaline (pH 9.7); violently effervescent; diffuse wavy boundary.
Bssk3	113-148 cm	Pink (7.5YR7/3D), brown (7.5YR4/3R) and very dark grey to dark brown (7.5YR 3/1.5 M) clay; strong, medium, angular and blocky (soil part) with weak wedge-shaped aggregates and slickensides that break into weak angular peds and weak medium subangular blocky (limes part) structure; friable sticky and plastic; a few fine and medium roots; common very fine and fine, many medium and coarse lime nodules; very strongly alkaline (pH 9.7); violently effervescent; clear, wavy boundary.
BCk	148-165+ cm	Light grey (7.5YR 7/1D), pinkish grey (7.5YR 6/2M), brown (7.5YR 4/3M) and brown to dark brown (7.5YR 3.5/3R) clay; moderate medium subangular blocky (soil part) and weak, medium, subangular and blocky (limy part) structure; friable sticky and plastic; few very fine roots; common very fine and fine, many medium and coarse lime nodules; very strongly alkaline (pH 9.7); violently effervescent.

Series: NIMONE BM SPOT: 28 (BLACK SOILS)

PROFILE NO: P52 Sy*stem: Agriculture(Sugarcane[Ratoon]-Soybean-Wheat/ Chickpea)(*FM)

CLIMATE: ARID RAINFALL: 520 mm	Classification: Fine, smectitic (cal), isohyperthermic, *Sodic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Village - Nirmal Pimpari, Rahata (Tah), Ahmednagar, Maharashtra.		Sampling Date: 18.12.2002

Morphological Properties of Profile No. 52 (Nimone, Ahmednagar)

Horizon	Depth (cm)	Boundary		Matrix color		Texture	Coarse fragments (%)* (fg %)	Structure		
		D	T	Dry	Moist			Size	Grade	Type
Apk	0-12	c	s	10YR4/1	10YR4/1.5	c	10-12%	m	2/1	sbk
Bwk1	12-29	g	s	-	10YR2/2 7.5YR3/2(R)	c	10-12%	m	2	sbk
Bwk2	29-50	g	w	-	7.5YR3/2(R)	c	10-15%	m	3	abk $(w)^{+}$
Bssk1	50-84	a	w	-	7.5YR3/2(R)	c	10-15%	m	3/1	sbk
Bssk2	84-113	a	w	7.5YR7/3	7.5YR3/2,4/3(R)	c	10-15%	m	3/1	sbk
Bssk3	113-148	c	w	7.5YR7/3	7.5YR3/1,4/3(R)	c	10-15%	m	3/1	sbk
BCk	148-165+	-	-	7.5YR7/1	7.5YR 3.5/3 7.5YR 6/2, 4/3	c	10-15%	m	2/1	sbk

Depth (cm)	Consistence			Porosity		Nodules** (conca)		Roots		Efferve-scence	Other features***	Cracks[1]
	Dry	Moist	Wet	S	Q	Size	Quantity	Size	Quantity	Dil HCl		
0-12	-	fr	sp	vf,f	m	vf,f	c,f	vf,f	c	ev	-	1-2 cm
12-29	-	fr	sp	vf,f	m	vf,f	c,f	vf,f	c	ev	Pressure faces (weak)	0.5 cm
29-50	-	sfi	vs vp	vf,f	m	vf,f	c,f	vf,f	c	ev	Pressure faces	
50-84	-	fi	vs vp	vf,m	m	vf,c	c,f	vf,f	f	ev	Slickensides (weak)	
84-113	-	fr	sp	-	-	vf,f,m,c	c,m	vf,f,m	f	ev	Slickensides	
113-148	-	fr	sp	-	-	vf,f,m,c	c,m	f,m	f	ev	Slickensides (weak)	
148-165+	-	fr	sp	-	-	vf,f,m,c	c,m	vf	f	ev	Slickensides (weak)	

**Few fg/cg gravels of quartz and zeolite also found in the pedon*

***Medium and coarse nodules of last three layers are brittle and break into fine and very fine particles*

****Cracks of 1-2 cm wide upto 15 cm and <0.5 cm wide upto 29 cm*

1. Cracks are not observed during irrigation in sugarcane belt. The soils do not remain dry for >90 consecutive days. Therefore, the soils are grouped under Udic subgroup inspite of 500 mm annual rainfall

Please refer Appendix I for the abbreviations

Series: NIMONE BM SPOT: 28 (BLACK SOILS)

PROFILE NO: P52 **Sy*stem: Agriculture (Sugarcane[Ratoon]-Soybean-Wheat/ Chickpea)(*FM)**

CLIMATE: ARID RAINFALL: 520 mm	Classification: Fine, smectitic (cal), isohyperthermic, *Sodic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Village - Nirmal Pimpari, Rahata (Tah), Ahmednagar, Maharashtra.		Sampling Date: 18.12.2002

Physical Properties of Profile No. 52 (Nimone, Ahmednagar)

Laboratory No.	Horizon	Depth (cm)	Size class and particle diameter (mm)			Fine clay (%) (<0.0002)	Fine clay/ total clay (%)
			Total				
			Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)		
			←----------(% of <2 mm) ----------→				
3580	Apk	0-12	7.6	38.4	54.0	36.1	0.7
3581	Bwk1	12-29	7.1	38.7	54.2	41.1	0.8
3582	Bwk2	29-50	5.6	38.2	56.2	43.7	0.8
3583	Bssk1	50-84	4.7	37.9	57.4	46.1	0.8
3584	Bssk2	84-113	4.2	38.2	57.6	45.1	0.8
3585	Bssk3	113-148	4.0	38.6	57.4	41.9	0.7
3586	BCk	148-165+	4.0	37.5	58.5	41.8	0.7

Depth (cm)	BD (Mgm^{-3})	COLE	HC ($cmhr^{-1}$)	WDC (%)
0-12	-	0.21	2.9	0.5
12-29	1.3	0.21	1.2	2.3
29-50	1.5	0.22	0.2	4.9
50-84	1.4	0.25	-	13.5
84-113	1.4	0.28	-	14.4
113-148	1.3	0.19	-	14.9
148-165+	1.3	0.22	-	8.8

- *Nil or not determined (wherever applicable)*

Series: NIMONE BM SPOT: 28 (BLACK SOILS)

PROFILE NO: P52 *System: Agriculture (Sugarcane[Ratoon]-Soybean/Wheat/ Chickpea)*(FM)

CLIMATE: ARID RAINFALL: 520 mm	Classification: Fine, smectitic (cal), isohyperthermic, *Sodic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Village - Nirmal Pimpari, Rahata (Tah), Ahmednagar, Maharashtra.		Sampling Date: 18.12.2002

Chemical Properties of Profile No. 52 (Nimone, Ahmednagar)

Depth (cm)	pH (1:2)		EC (1:2) (d Sm^{-1})	OC (%)	$CaCO_3$ (%)	Clay CO_3 (%)
	H_2O	1*N* KCl				
0-12	8.7	7.2	0.21	0.7	22.1	0.3
12-29	8.8	7.2	0.30	0.8	22.0	1.4
29-50	8.9	7.3	0.36	0.7	22.2	0.9
50-84	9.5	7.3	0.07	0.6	22.2	0.6
84-113	9.7	7.5	0.05	0.4	25.5	1.1
113-148	9.7	7.6	0.57	0.3	26.3	1.8
148-165+	9.7	7.6	0.56	0.3	27.4	1.2

Depth (cm)	Extractable bases				CEC	Clay CEC	BS (%)	ESP
	Ca	Mg	Na	K				
	←----------[cmol(p+)kg^{-1}]----------→							
0-12	20.4	15.2	2.2	0.4	37.3	69	102	5.8
12-29	20.6	15.6	3.0	0.3	36.2	67	109	8.4
29-50	18.2	17.4	4.9	0.3	35.8	64	114	13.6
50-84	12.5	15.6	8.4	0.3	36.4	63	101	23.2
84-113	6.6	14.2	10.1	0.4	32.1	56	110	31.4
113-148	6.0	16.0	10.1	0.3	29.4	51	110	34.3
148-165+	7.2	17.6	9.4	0.3	30.8	53	112	30.5

Series: NIMONE BM SPOT: 28 (BLACK SOILS)

PROFILE NO: P52 *System: Agriculture (Sugarcane[Ratoon]-Soybean/Wheat/ Chick pea)(*FM)

CLIMATE: ARID RAINFALL: 520 mm	Classification: Fine, smectitic (cal), isohyperthermic, *Sodic Haplusterts*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Village - Nirmal Pimpari., Rahata (Tah), Ahmednagar, Maharashtra.		Sampling Date: 18.12.2002

Characterization of Landuse Types

S. No.	Attribute		Description
1	Production system	:	Irrigated soybean based, ie sugarcane-soybean/sorghum/wheat with extended sugarcane ratooning and 2-3 months fallow period at the end of each cycle Yield range: Sugarcane (main)-1500 kg ha^{-1} (ratoon)-750-900 q/ha Crop-livestock-garden farming system with improved cattle breed.
2	Management level	:	• Improved varieties • Drip irrigation • Optimum plant stand • Chemical fertilizers: Recommended (but no K), sugarcane – 240-300 kg N, 150-170 kg P2O5/ha. • FYM: Nil • Ridge furrow planting • Weedicide and insecticide: Occasional • Crop residues: Burnt or used for feed and housing • Sowing time: Sugarcane- (no fixed time) Soybean and sorghum- 1st week of July Wheat- end of Nov. • Seed rate: Sugarcane- 35-40 thousand sets/ha Soybean 80 kg ha^{-1} Ssorghum 15 kg ha^{-1} Wheat 80-100 kg ha^{-1}
3	Power source	:	Tractor supplemented with animal power using improved farm implements
4	Market orientation	:	Commercial
5	Capital intensity	:	High with easy access to institutional credit
6	Labor intensity	:	Intermediate
7	Land holding	:	High and fragmented
8	Income level	:	High

Climatic Datasets of Nimone, Ahmednagar District, Maharashtra

Month	Mean temp (^{o}C)	Rainfall (mm)	PET (mm)	½PET (mm)	LGP (days)
January	21.00	5.10	99.00	49.50	0.00
February	23.00	1.80	115.00	57.50	0.00
March	26.80	3.10	160.00	80.00	0.00
April	33.50	5.30	184.00	92.00	0.00
May	31.10	15.70	208.00	104.00	0.00
June	28.10	100.60	154.00	77.00	30.00
July	25.60	92.70	126.00	63.00	31.00
August	25.20	57.90	123.00	61.50	0.00
September	25.10	143.00	116.00	58.00	30.00
October	25.20	53.30	127.00	63.50	0.00
November	22.40	35.10	103.00	51.50	0.00
December	20.60	6.30	90.00	45.00	0.00
Average	25.63				
Total		519.90	1605.00	802.50	91.00

3B. RED SOILS

3Ba. Red soils of sub-humid (moist) bioclimatic system

(MAR : > 1100 mm)

- **Benchmark Spots: 11, 12**
- **No. of Pedons: 4 (P23, P24, P25, P26)**

BM Spot 11 : DADARGHUGRI: Agriculture System (Maize/Mustard) (FM) P23

Classification : Clayey-skeletal, mixed, hyperthermic, *Typic Haplustalfs*

Location : Vill. Dadarghugri, Sehapura, Dindori, M.P.

Physiographic position : Deccan Plateau – Satpura Ranges

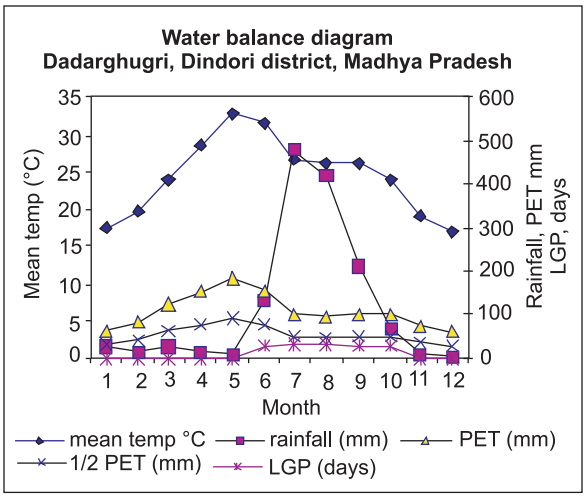
Topography: Gently sloping top of mounds, 3-8% (0-50 m)

Drainage : Well drained

Vegetation : *Sahja, herra, haldu, mahuva*, mango

Landuse : Maize/mustard

Parent material : Weathered basalt



Sampled by : T. Bhattacharyya, S.K. Ray, P. Chandran, M.V. Venugopalan, S.L. Durge, P. Srivastava

Date of collection: 11.06.2001

Remarks : Soil sampling is done on the top of mounds which are repetitive in nature as in a basaltic landscape.

Ap	0-11 cm	Brown (7.5YR 4/4D) and very dark brown (7.5YR 2.5/3M) silty clay; weak medium subangular and blocky structure; soft, very friable, sticky and plastic; many very fine and fine roots; 10-15% fine and coarse gravels; many very fine and fine pores; strongly acidic (pH 5.2); clear, smooth boundary.
Bt1	11-29 cm	Dark reddish brown (5YR 3/2M) gravelly clay; moderate, fine, subangular and blocky structure; very friable, sticky and non-plastic; thin patchy and broken clay cutans on ped surfaces; many very fine and fine roots; 25-30% fine and coarse gravels; strongly acidic (pH 5.3); clear, smooth boundary.
Bt2	29-55 cm	Dark reddish brown (5YR 3/3M) gravelly clay; weak, fine, subangular and blocky structure; very friable, sticky and non-plastic; thin patchy and broken clay cutans on ped surfaces; common very fine roots; 60-70% fine and coarse gravels and stones; strongly acidic (pH 5.3); clear wavy boundary.
C1	55-74 cm	Dark reddish brown (5YR 3/4M) gravelly clay; massive breaks-down with little pressure faces; a few very fine roots; 80-90% gravels and stones with very little soil; strongly acidic (pH 5.3); abrupt wavy boundary.
C2	74-100+ cm	Dark reddish brown (5YR 3/4M) gravelly clay; massive structure; breaks-down with little pressure faces; a few very fine roots; 90-95% gravels, stones and boulders with almost negligible soil, strongly acidic (pH 5.4).

Series: DADARGHUGRI BM Spot: 11 (RED SOILS)

Profile No: P23 *System: Agriculture (Maize/Mustard)* (FM)

CLIMATE: SUB-HUMID(MOIST) RAINFALL: 1420 mm	Classification: Clayey-skeletal, mixed, hyperthermic *Typic Haplustalfs*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur
Location: Dadarghugri, Sehapura, Dindori, Madhya Pradesh		Sampling Date: 11.06.2001

Morphological Properties of Profile No. 23 (Dadarghugri, Dindori)

Horizon	Depth (cm)	Boundary		Matrix color		Texture	Coarse fragments (%) (fg and cg)	Structure		
		D	T	Dry	Moist			Size	Grade	Type
Ap	0-11	c	s	7.5YR4/4-	7.5YR2.5/3	sicl	10-15	m	1	sbk
Bt1	11-29	c	s	-	5YR3/2	c	25-30	f	1	sbk
Bt2	29-55	c	w	-	5YR3/3	c	+st 60-70	f	1	sbk
C1	55-74	c	w	-	5YR3/4	-	+st 65-90	massive		
C2	74-100	-	-	-	5YR3/4	-	+st 90-95	massive		

Depth (cm)	Consistence			Porosity		Cutans			Roots		Effervescence	Other features
	Dry	Moist	Wet	S	Q	Type	Thickness	Quantity	Size	Quantity	Dil HCl	
0-11	s	vfr	sp	vf,f	m	-	-	-	vf,f	m	-	-
11-29	-	vfr	s p	-	-	T	tn	p	vf,f	m	-	-
29-55	-	vfr	s ps	-	-	T	tn	p	vf	c	-	-
55-74	-	-	-	-	-	-	-	-	vf	f	-	-
74-100	-	-	-	-	-	-	-	-	vf	f	-	-

Please refer Appendix I for the abbreviations.

Series: DADARGHUGRI **BM Spot: 11 (RED SOILS)**

Profile No: P23 ***System: Agriculture (Maize/Mustard)* (FM)**

CLIMATE: SUB-HUMID(MOIST) RAINFALL: 1420 mm	Classification: Clayey-skeletal, mixed, hyperthermic *Typic Haplustalfs*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur
Location: Dadarghugri, Sehapura, Dindori, Madhya Pradesh		Sampling Date: 11.06.2001

Physical Properties of Profile No. 23 (Dadarghugri, Dindori)

Laboratory No.	Horizon	Depth (cm)	Size class and particle diameter (mm)			Fine clay (%) (<0.0002)	Fine clay/ total clay (%)
			Total				
			Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)		
			←----------(% of <2 mm) ----------→				
3212	Ap	0-11	10.3	53.1	36.6	22.8	62.3
3213	Bt1	11-29	5.9	39.0	55.1	50.0	90.6
3214	Bt2	29-55	7.9	36.8	55.3	54.2	97.8
3215	C1	55-74	19.7	25.7	54.6	48.5	88.8
3216	C2	74-100	14.6	26.9	58.5	40.2	68.7

Depth (cm)	BD (Mgm^{-3})	COLE	HC ($cmhr^{-1}$)	WDC (%)
0-11	-	0.1	-	-
11-29	-	0.1	-	-
29-55	-	0.1	-	-
55-74	-	0.1	-	-
74-100	-	0.1	-	-

- *Nil or not determined (wherever applicable)*

Series: DADARGHUGRI BM Spot: 11 (RED SOILS)

Profile No: P23 ***System: Agriculture (Maize/Mustard)*** **(FM)**

CLIMATE: SUB-HUMID(MOIST) RAINFALL: 1420 mm	Classification: Clayey-skeletal, mixed, hyperthermic *Typic Haplustalfs*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur
Location: Dadarghugri, Sehapura, Dindori, Madhya Pradesh		Sampling Date: 11.06.2001

Chemical Properties of Profile No. 23 (Dadarghugri, Dindori)

Depth (cm)	pH (1:2)		EC (1:2) (dSm^{-1})	OC (%)	$CaCO_3$ (%)	Clay CO_3 (%)
	H_2O	1*N* KCl				
0-11	5.2	4.7	0.01	2.4	-	-
11-29	5.3	4.5	0.09	2.0	-	-
29-55	5.3	4.6	0.03	1.3	-	-
55-74	5.3	4.9	0.03	0.8	-	-
74-100	5.4	4.9	0.04	1.0	-	-

Depth (cm)	Extractable bases				CEC	Clay CEC	BS (%)	ESP
	Ca	Mg	Na	K				
	----------[cmol(p+)kg^{-1}]----------							
0-11	11.4	2.7	0.4	2.1	26.1	71	64	2
11-29	13.9	3.7	0.3	0.9	26.5	48	71	1
29-55	12.2	5.3	0.3	0.4	24.3	44	75	1
55-74	14.5	6.8	0.3	0.5	24.3	44	91	1
74-100	15.2	6.6	0.3	0.7	24.8	42	92	1

Series: DADARGHUGRI BM Spot: 11 (RED SOILS)

Profile No: P23 *System: Agriculture (Maize/Mustard)* (FM)

CLIMATE: SUB-HUMID(MOIST) RAINFALL: 1420 mm	Classification: Clayey-skeletal, mixed, hyperthermic *Typic Haplustalfs*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur
Location: Dadarghugri, Sehapura, Dindori, Madhya Pradesh		Sampling Date: 11.06.2001

Characterization of Landuse Types

S. No.	Attribute		Description
1	Production system	:	Dry farming (rain-fed) of maize-mustard double cropping. Crop-livestock farming system. Yield: 150-350 kg maize/ha 125-200 kg mustard/ha
2	Management level	:	• Traditional varieties • Sowing: Broadcast method • Manure at 1 tonne FYM/ha/year • Conservation & residue management: Nil • Sowing time: 3rd week of June for Maize 2nd fortnight of October for Mustard • Seed rate: Maize 10-12 kg ha^{-1} Mustard 3-4 kg ha^{-1}
3	Power source	:	Human and animal traction with traditional implements
4	Market orientation	:	Subsistence
5	Capital intensity	:	Low with no access to credit
6	Labor intensity	:	Low, limited to family labor
7	Land holding	:	Small, consolidated.
8	Income level	:	Low (alternate source is off farm income).

Climatic Datasets of Dadarghugri, Dindori District, Madhya Pradesh

Month	Mean temp (°C)	Rainfall (mm)	PET (mm)	½PET (mm)	LGP (days)
January	17.40	28.70	65.50	32.75	0.00
February	19.70	15.30	83.80	41.90	0.00
March	23.90	27.60	125.00	62.50	0.00
April	28.50	13.90	152.50	76.25	0.00
May	32.80	7.70	185.80	92.90	0.00
June	31.40	131.70	158.90	79.45	30.00
July	26.70	480.40	101.90	50.95	31.00
August	26.10	419.50	94.90	47.45	31.00
September	26.20	213.70	100.80	50.40	30.00
October	24.00	70.60	100.50	50.25	30.00
November	19.00	8.30	72.50	36.25	0.00
December	16.90	2.80	59.10	29.55	0.00
Average	24.38				
Total		1420.20	1301.20	650.6	152.00

Landscape, Landuse and Soils of Benchmark Spot 11 (Dadarghugri Series, Dindori, Madhya Pradesh)


General view of the landscape in Dindori district, Madhya Pradesh. The elevated hillocks are the actual site of Dadarghugri soil.




Closer view of Dadarghugri soil under agricultural system (low management with maize/mustard cropping pattern)

Closer view of the surface of Dadarghugri soil showing stones and bolders

Typical Dadarghugri soil profile showing bouldery spot at lower surface horizon, indicating in-situ weathering of basalt

BM Spot 11 : DADARGHUGRI: Forest System P24

Classification: Clayey-skeletal, mixed, hyperthermic, *Typic Haplustalfs*

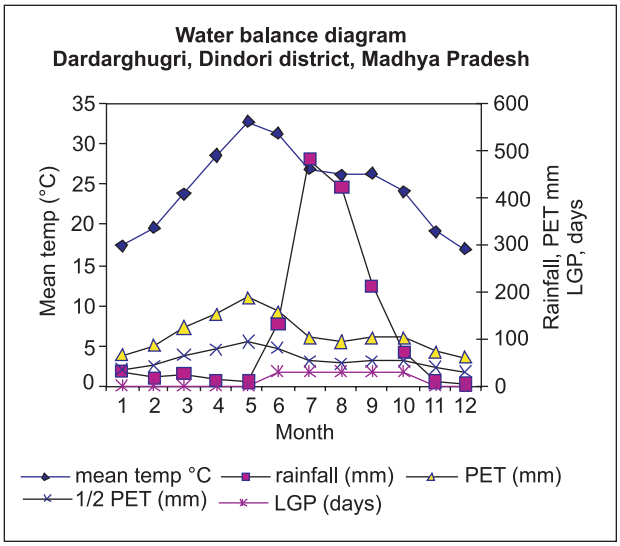
Location: Dadarghugri Forest, Sehpura, Dadarghugri, Dindori, Madhya Pradesh, Lat.22°53'48"N, Long. 80°49'23"E

Physiographic position: Deccan Plateau – Satpura Ranges

Topography: Moderately sloping on the side slopes of mound, 8-15% (0-50 m)

Drainage: Somewhat excessively drained

Vegetation: Teak, *ladia, intana, bantulsi, herra ghotia*



Landuse : Forest system

Parent material: Partially weathered basalt

Sampled by: T. Bhattacharyya, P. Chandran, S.K. Ray, M. V. Venugopalan, P. Srivastava, S.L. Durge

Date of collection: 11.06.2001

Remarks: This is a forested area similar in landscape position as Dadarghugri (FM).

A1	0-10 cm	Dark brown (7.5YR 3/2M) silty clay; weak, fine, subangular and blocky structure; very friable, sticky and slightly plastic; many very fine and fine, common medium and coarse roots; many very fine and fine pores; 10-15% fine and coarse gravels; strongly acidic (pH 5.1); clear, smooth boundary.
Bt1	10-26 cm	Very dark brown (7.5YR 2.5/2M) clay; weak, fine, subangular and blocky structure; very friable sticky and non-plastic; thin patchy and broken clay cutans; many very to fine many, common medium and coarse roots; 35-40% fine and coarse gravels; strongly acidic (pH 5.2); clear wavy boundary.
C1	26-50 cm	Very dark brown (7.5YR 2.5/3M) clay; massive (breaks-down with little pressure) structure; loose, sticky and non-plastic; many very fine and fine, few medium roots; 80-85% gravels and stones; strongly acidic (pH 5.3); clear wavy boundary.
C2	50-85+ cm	Mainly partially weathered basalt with very little soil.

Series: DADARGHUGRI BM Spot: 11 (RED SOILS)

Profile No: P24 *System: Forest (Teak)*

CLIMATE: SUB-HUMID (MOIST) RAINFALL: 1420 mm	Classification: Clayey-skeletal, mixed, hyperthermic, *Typic Haplustalfs*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Dadarghugri, Sehapura, Dindori, Madhya Pradesh		Sampling Date: 11.06.2001

Morphological Properties of Profile No. 24 (Dadarghugri, Dindori)

Horizon	Depth (cm)	Boundary		Matrix color		Texture	Coarse fragments (%) (fg and cg)	Structure		
		D	T	Dry	Moist			Size	Grade	Type
A1	0-10	c	s	7.5YR3/2	-	sic	10-15	f	1	sbk
Bt1	10-26	c	w	7.5YR2.5/2	-	c	35-40	f	1	sbk(w)*
C1	26-50	c	w	7.5YR2.5/3	-	c	cg+fg+st 80-85	massive		
C2	50-85	-	-	Partially weathered basalt		c	cg+fg+st90-95	massive		

Depth (cm)	Consistence			Porosity		Cutans			Roots		Effervescence	Other features*
	Dry	Moist	Wet	S	Q	Type	Thickness	Quantity	Size	Quantity	Dil HCl	
0-10	-	vfr	sp	vf,f	m	-	-	-	vf, f; m, c	m; c	-	-
10-26	-	vfr	sps	-	-	T	tn	p	vf, f; m, c	m; c	-	-
26-50	-	l	spo	-	-	-	-	-	vf f; m	m; f	-	-
50-85	-	-	-	-	-	-	-	-	vf f; m	m; f	-	-

Please refer Appendix I for the abbreviations

Series: DADARGHUGRI **BM Spot: 11 (RED SOILS)**

Profile No: P24 ***System: Forest (Teak)***

CLIMATE: SUB-HUMID (MOIST) RAINFALL: 1420 mm	Classification: Clayey-skeletal, mixed, hyperthermic, *Typic Haplustalfs*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Dadarghugri, Sehapura, Dindori, Madhya Pradesh		Sampling Date: 11.06.2001

Physical Properties of Profile No. 24 (Dadarghugri, Dindori)

Laboratory No.	Horizon	Depth (cm)	Size class and particle diameter (mm)			Fine clay (%) (<0.0002)	Fine clay / total clay (%)
			Total				
			Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)		
			←----------(% of <2 mm) ----------→				
3208	A1	0-10	8.1	41.2	50.7	33.3	65.6
3209	Bt1	10-26	10.7	39.6	49.7	33.3	67.0
3210	C1	26-50	32.1	14.9	53.1	46.8	88.3
3211	C2	50-85	38.9	15.2	45.9	36.9	80.4

Depth (cm)	BD (Mgm^{-3})	COLE	HC ($cmhr^{-1}$)	WDC (%)
0-10	-	0.1	-	-
10-26	-	0.1	-	-
26-50	-	0.1	-	-
50-85	-	0.1	-	-

- *Nil or not determined (wherever applicable)*

Series: DADARGHUGRI **BM Spot: 11 (RED SOILS)**

Profile No: P24 ***System: Forest (Teak)***

CLIMATE: SUB-HUMID (MOIST) RAINFALL: 1420 mm	Classification: Clayey-skeletal, mixed, hyperthermic, *Typic Haplustalfs*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Dadarghugri, Sehapura, Dindori, Madhya Pradesh		Sampling Date: 11.06.2001

Chemical Properties of Profile No. 24 (Dadarghugri, Dindori)

Depth (cm)	pH (1:2)		EC (1:2) (dSm^{-1})	OC (%)	$CaCO_3$ (%)	Clay CO_3* (%)
	H_2O	1*N* KCl				
0-10	5.1	4.9	0.08	3.3	-	-
10-26	5.2	4.2	0.04	2.1	-	-
26-50	5.3	4.4	0.04	1.5	-	-
50-85	5.6	4.4	0.03	1.2	-	-

Depth (cm)	Extractable bases				CEC	Clay CEC	BS (%)	ESP
	Ca	Mg	Na	K				
	←----------[cmol(p+)kg^{-1}]----------→							
0-10	18.4	9.0	0.3	1.4	40.8	80	71	-
10-26	16.4	9.2	0.3	0.6	35.2	71	75	-
26-50	16.0	9.6	0.4	0.7	35.2	66	76	-
50-85	15.8	12.0	0.2	0.5	35.4	77	80	-

- *Nil or not determined (wherever applicable)*

Series: DADARGHUGRI **BM Spot: 11 (RED SOILS)**

Profile No: P24 ***System: Forest (Teak)***

CLIMATE: SUB-HUMID (MOIST) RAINFALL: 1420 MM	Classification: Clayey-skeletal, mixed, hyperthermic, *Typic Haplustalfs*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Dadarghugri, Sehapura, Dindori, Madhya Pradesh		Sampling Date: 11.06.2001

Climatic Datasets of Dadarghugri, Dindori District, Madhya Pradesh

Month	Mean temp (^{o}C)	Rainfall (mm)	PET (mm)	½ PET (mm)	LGP (days)
January	17.40	28.70	65.50	32.75	0.00
February	19.70	15.30	83.80	41.90	0.00
March	23.90	27.60	125.00	62.50	0.00
April	28.50	13.90	152.50	76.25	0.00
May	32.80	7.70	185.80	92.90	0.00
June	31.40	131.70	158.90	79.45	30.00
July	26.70	480.40	101.90	50.95	31.00
August	26.10	419.50	94.90	47.45	31.00
September	26.20	213.70	100.80	50.40	30.00
October	24.00	70.60	100.50	50.25	30.00
November	19.00	8.30	72.50	36.25	0.00
December	16.90	2.80	59.10	29.55	0.00
Average	24.38				
Total		1420.20	1301.20	650.6	152.00

Landscape, Landuse and Soils of BM Spot 11, Dadarghugri Forest System, Dindori, Madhya Pradesh

Dadarghugri soil-site under forest system (with teak tectona grandis cropping pattern).

Typical soil profile of Dadarghugri soil (Typic Haplustalfs).

BM Spot 12 : KARKELI: Forest System P25

Classification : Coarse-loamy, mixed, hyperthermic, *Typic Paleustalfs*

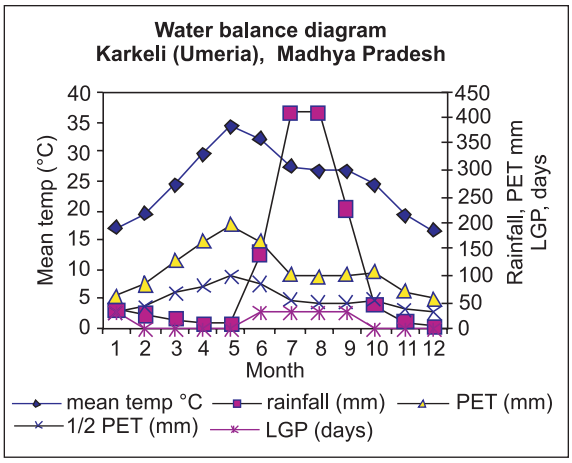
Location : Karkeli Reserve Forest, about ½ km north-east of Karkeli Railway station, Karkeli tolla, Bandhavgarh, Umeria, M.P. Lat. 23°27'58"N, Long 80°55'30"E

Physiographic position : Eastern Plateau – Baghelkhand Plateau

Topography and slope: Very gently sloping, 1-3% (50-150 m)

Drainage : Well drained

Vegetation : *Pipal*, sal, *mahuva*, date palm, grasses and shrubs



Landuse : Forest system

Parent material : Weathered sand stone

Sampled by : T. Bhattacharyya, P. Chandran, M.V. Venugopalan, S.K. Ray, P. Srivastava, S.L. Durge

Date of collection: 13.06.2001

Remarks : The profile was taken in a reserve forest having mainly sal vegetation.

A	0-11 cm	Brown to dark brown (7.5YR 3.5/3M) loamy sand; weak, medium and subangular structure; very friable, non sticky and non plastic; many very fine to fine and few medium roots; many fine and medium pores; 3-5% fine gravels; strongly acidic (pH 5.2); clear smooth boundary.
Bt1	11-23 cm	Brown to dark brown (7.5YR 3.5/4M) loamy sand; weak, medium and subangular blocky structure; very friable, sticky and non plastic; thin patchy clay cutans on ped surfaces; many very fine and fine, a few medium roots; many fine and medium pores; 2-5% fine gravels; strongly acidic (pH 5.2); clear, smooth boundary.
Bt2	23-47 cm	Light brown (7.5YR 6/4D) and yellowish red (5YR 5/7M) loamy sand; weak medium subangular blocky structure; slightly hard; very friable; non sticky and non plastic; thin patchy clay cutans on ped surfaces; a few very fine, fine, medium and coarse roots; fine many pores; 2-5% fine gravels; strongly acidic (pH 5.2); clear, smooth boundary.
Bt3	47-77 cm	Reddish yellow (5YR 6/6D) and red (2.5YR 5/8M) sandy loam; weak, medium and subangular blocky structure; slightly hard; very friable, slightly sticky and non-plastic; thin patchy clay cutans on ped surfaces; a few very fine, fine medium and coarse roots; many fine, medium and coarse pores; 2-5% fine gravels; strongly acidic (pH 5.2); gradual smooth boundary.
Bt4	77-101 cm	Light red (2.5YR 6/8D) and red (2.5YR 4/8M) sandy loam; weak, medium, subangular and blocky structure; slightly hard, very friable, slightly sticky and non-plastic; thin patchy clay cutans on ped surfaces; a few fine, medium and coarse roots; many fine and medium pores; 5-10% fine gravels; strongly acidic (pH 5.2); gradual smooth boundary.

Bt5	101-123 cm	Light red to red (2.5YR 5.5/8D) and red (2.5YR 4/8M) sandy loam; weak, medium, subangular and blocky structure; slightly hard, very friable, slightly sticky and non-plastic; thin patchy clay cutans on ped surfaces; a few fine, medium and coarse roots; common fine and medium, a few coarse pores; 5-10% fine gravels; strongly acidic (pH 5.3); clear, smooth boundary.
Bt6	123-137 cm	Light red to red (2.5YR 5.5/8D) and red (2.5YR 4/8M) sandy loam; weak, fine, subangular and blocky structure; slightly hard, very friable; slightly sticky and non-plastic; thin patchy clay cutans on ped surfaces; a few fine, medium and coarse roots; common fine and medium, a few coarse pores; 20-25% coarse and fine gravels; strongly acidic (pH 5.3); clear wavy boundary.
BC	137-152+ cm	Red (2.5YR 5/8R) sandy loam; single grain; loose, slightly sticky and non-plastic; a few fine, medium and coarse roots; many fine and medium pores; 35-40% fine and coarse gravels; strongly acidic (pH 5.2).

Series: KARKELI **BM Spot: 12 (RED SOILS)**

Profile No: P25 ***System: Reserve Forest (Sal)***

CLIMATE: SUB-HUMID (MOIST) RAINFALL: 1352 mm	Classification: Coarse-loamy, mixed, hyperthermic, *Typic Paleustalfs*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Karkeli Tolla, Bandhavgarh, Umeria, Madhya Pradesh		Sampling Date : 13.06.2001

Morphological Properties of Profile No. 25 (Karkeli, Umeria)

Horizon	Depth (cm)	Boundary		Matrix color		Texture	Coarse fragments (%) (fg and cg)	Structure		
		D	T	Dry	Moist			Size	Grade	Type
A	0-11	C	s	-	7.5YR3.5/3	ls	fg 2.5	m	1	sbk
Bt1	11-23	C	s	-	7.5YR3.5/4	ls	fg 2.5	m	1	sbk(w)*
Bt2	23-47	C	s	7.5YR6/4	5YR 5/7	ls	2.5	m	1	sbk
Bt3	47-77	G	s	5YR6/6	2.5YR5/8	sl	2.5	m	1	sbk
Bt4	77-101	G	s	2.5YR6/8	2.5YR4/8	sl	5-10	m	1	sbk
Bt5	101-123	C	s	2.5YR5.5/8	2.5YR4/8	sl	5-10	m	1	sbk
Bt6	123-137	C	w	2.5YR5.5/8	2.5YR4/8	sl	20-25	f	1	sbk
BC	137-152	-	-	-	2.5YR5/8	sl	35-40	-	-	sg

Depth (cm)	Consistence			Porosity		Cutans			Roots		Effervescence	Other features
	Dry	Moist	Wet	S	Q	Type	Thickness	Quantity	Size	Quantity	Dil HCl	
0-11	-	vfr	sopo	f,m	m	-	-	-	vf,f; m	m; f	-	-
11-23	-	vfr	sopo	f,m	m	-	-	-	vf,f; m	m; c	-	-
23-47	sh	vfr	sopo	f	m	-	-	-	vf, f, m, c	f	-	-
47-77	sh	vfr	ssps	f ,m, c	m	T	tn	p	vf, f, m, c	f	-	-
77-101	sh	vfr	ssps	f,m	m	T	tn	p	f,c,m	f	-	-
101-123	sh	vfr	ssps	f ,m; c	c; f	T	tn	p	f,c,m	f	-	-
123-137	sh	vfr	ssps	f ,m; c	c; f	T	tn	p	f,c,m	f	-	-
137-152	l	l	ssps	f,m	m	-	-	-	f,c,m	f	-	-

**Partially weathered and unweathered present in some parts of the profile*

Please refer Appendix I for the abbreviations

Series: KARKELI **BM Spot: 12 (RED SOILS)**

Profile No: P25 ***System: Reserve Forest (Sal)***

CLIMATE: SUB-HUMID (MOIST) RAINFALL: 1352 mm	Classification: Coarse-loamy, mixed, hyperthermic, *Typic Paleustalfs*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Karkeli Tolla, Bandhavgarh, Umeria, Madhya Pradesh		Sampling Date : 13.06.2001

Physical Properties of Profile No. 25 (Karkeli, Umeria)

Laboratory No.	Horizon	Depth (cm)	Size class and particle diameter (mm)			Fine clay (%) (<0.0002)	Fine clay/ total clay (%)
			Total				
			Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)		
			←----------(% of <2 mm) ----------→				
3217	A	0-11	80.3	13.1	6.6	3.1	46.3
3218	Bw1	11-23	80.0	12.4	7.6	5.2	68.4
3219	Bw2	23-47	79.6	12.7	7.7	4.8	62.3
3220	Bt1	47-77	73.9	13.6	12.5	6.1	48.8
3221	Bt2	77-101	74.8	13.0	12.2	6.6	53.6
3222	Bt3	101-123	74.0	12.5	13.5	7.0	51.4
3223	Bt4	123-137	76.4	11.6	12.0	5.9	49.2
3224	Bt5	137-152	77.2	10.7	12.1	6.1	50.4

Depth (cm)	BD (Mgm^{-3})	COLE	HC ($cmhr^{-1}$)	WDC (%)
0-11	-	0.02	-	-
11-23	-	0.01	-	-
23-47	-	0.01	-	-
47-77	-	0.02	-	-
77-101	-	0.04	-	-
101-123	-	0.02	-	-
123-137	-	0.03	-	-
137-152	-	-	-	-

- *Nil or not determined (wherever applicable)*

Series: KARKELI **BM Spot: 12 (RED SOILS)**

Profile No: P25 ***System: Reserve Forest (Sal)***

CLIMATE: SUB-HUMID (MOIST) RAINFALL: 1352 mm	Classification: Coarse-loamy, mixed, hyperthermic, *Typic Paleustalfs*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Karkeli Tolla, Bandhavgarh, Umeria, Madhya Pradesh		Sampling Date : 13.06.2001

Chemical Properties of Profile No. 25 (Karkeli, Umeria)

Depth (cm)	pH (1:2)		EC (1:2) (d Sm^{-1})	OC (%)	$CaCO_3$ (%)	Clay CO_3* (%)
	H_2O	1*N* KCl				
0-11	5.2	4.5	0.04	1.9	-	-
11-23	5.2	4.7	0.01	0.7	-	-
23-47	5.2	4.8	0.03	0.5	-	-
47-77	5.2	4.5	0.02	0.3	-	-
77-101	5.2	4.3	0.01	0.3	-	-
101-123	5.3	4.3	0.02	0.3	-	-
123-137	5.3	4.3	0.02	0.3	-	-
137-152	5.3	4.5	0.02	0.3	-	-

Depth (cm)	Extractable bases				CEC	Clay CEC	BS (%)	ESP
	Ca	Mg	Na	K				
	←----------[cmol(p+)kg^{-1}]----------→							
0-11	0.7	0.1	0.3	0.2	5.7	86	23	-
11-23	1.0	0.8	0.2	0.1	5.2	68	41	-
23-47	0.5	0.2	0.2	0.1	4.4	57	23	-
47-77	0.6	0.5	0.7	0.7	3.0	24	38	-
77-101	0.4	0.8	0.2	0.1	3.5	29	43	-
101-123	0.4	0.4	0.3	0.1	4.6	34	27	-
123-137	0.2	0.2	0.3	0.1	3.9	33	20	-
137-152	1.4	0.6	0.2	0.1	6.9	58	32	-

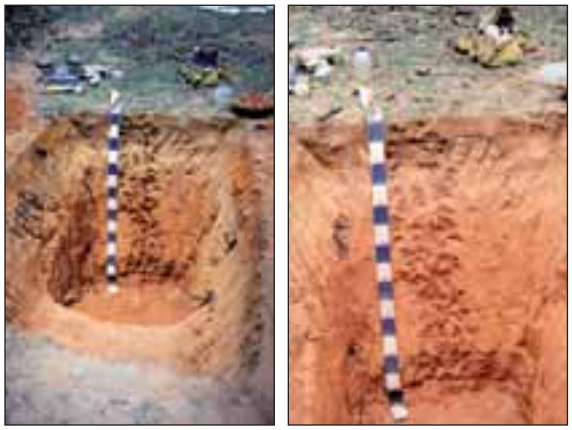
* *Percent of water dispersible clay size carbonate*

\- *Nil or not determined (wherever applicable)*

Landscape, Landuse and Soils of Benchmark Spot 12 Forest (Karkeli, Karkeli Tolla, Bandhavgarh, Umeria, Madhya Pradesh)

Karkeli soil-site in Umeria district, Madhya Pradesh, under forest (with sal, shorea, robusta cropping pattern)

Typical termite mound in Karkeli forest site



Very deep red soil profile of Karkeli series showing redder subsurface horizon (Typic Haplustalfs)

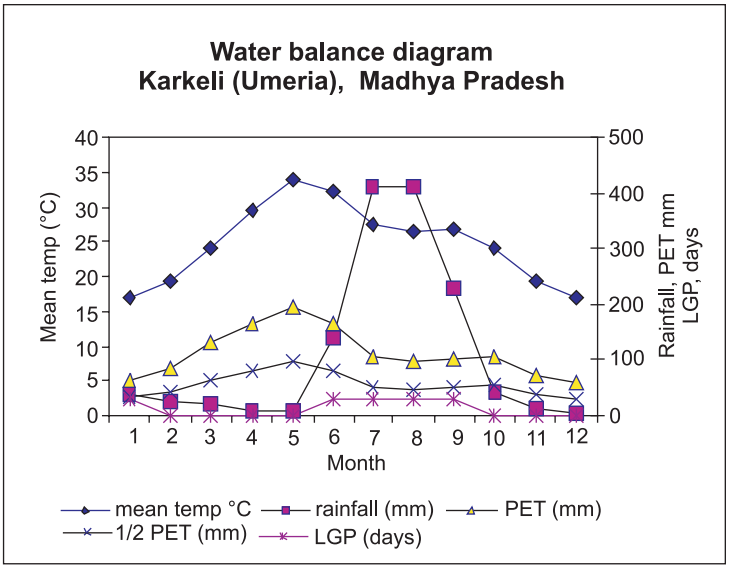
BM Spot 12 : KARKELI 1: Agriculture System (Minor Millet-Potato) (LM) P26

Classification : Fine-loamy, mixed, hyperthermic, *Typic Paleustalfs*

Location : About 600 m northeast of Karkeli Railway Station, adjacent to the Reserve Forest, Vill. Karkeli Tolla, Bandhavgarh, Umeria, M.P. Lat 23°28'35"N Long 80°55'10"E

Physiographic position : Eastern plateau – Baghelkhand Plateau

Topography and slope: Very gently sloping, 1-3% (50-150 m)



Drainage : Well drained

Vegetation : Sal, *pipal*, *mahuva*, *karanji*, date palm, grasses, shrubs

Landuse : Kodo, minormillet-sweet potato crop rotation

Parent material : Weathered sandstone

Sampled by : T. Bhattacharyya, P. Chandran, S.K. Ray, M.V. Venugopalan, P. Srivastava, S.L. Durge

Date of collection:

Remarks : Cultivation is being done on small parcels of deforested land adjacent to the forest. Kodo is cultivated alternately with sweet potato very year. Fe/Mn concretions are present.

Ap	0-15 cm	Strong brown (7.5YR 4.5/6M) loamy sand; weak moderate subangular blocky structure; very friable, non sticky and non plastic; many very fine, a few fine and medium few roots; many fine and medium pores; 1-2% fine gravels; strongly acidic (pH 5.1); gradual smooth boundary.
Bt1	15-39 cm	Brown (7.5YR 4/3.5M) sandy loam; moderate medium subangular blocky structure; very friable, slightly sticky and non-plastic; thin patchy clay cutans on ped surfaces; common very fine and a few fine to medium roots; many fine and medium pores; 1-2% fine gravels; strongly acidic (pH 5.3); clear wavy boundary.
Bt2	39-62 cm	Yellowish brown (10YR 5/6M) sandy clay loam; moderate medium subangular blocky structure; very friable, slightly sticky and non-plastic; thin patchy clay cutans on ped surfaces; common very fine and fine, few medium and coarse roots; many very fine and fine pores; 2-3% fine gravels; strongly acidic (pH 5.4); gradual smooth boundary.

Bt3	62-84 cm	Strong brown (7.5YR 5/6R) clay loam; moderate medium subangular blocky structure; very friable, sticky and plastic; thin patchy clay cutans on ped surfaces; many very fine and fine, common medium and coarse iron and manganese concretions; common very fine, a few coarse roots; many very fine and fine pores; 3-5% fine gravels; strongly acidic (pH 5.3); clear wavy boundary.
Bt4	84-127 cm	Yellowish red (5YR 4.5/6R) clay loam; moderate medium subangular blocky structure; very friable, sticky and plastic; thin patchy clay cutans on ped surfaces; many very fine and fine, a few medium and coarse iron and manganese concretions; common very fine and fine, a few medium and coarse roots; many very fine and fine pores; 5-8% fine gravels; strongly acidic (pH 5.4); gradual smooth boundary.
Bt5	127-155 cm	Yellowish red (5YR 5/6R) sandy clay loam; moderate medium subangular blocky structure; very friable, sticky and slightly plastic; thin patchy clay cutans on ped surfaces; many very fine and fine, a few medium and coarse iron and manganese concretions; a few very fine common medium roots; many very fine and fine pores; 8-10% fine gravels; strongly acidic (pH 5.5).

Series: KARKELI 1 **BM Spot: 12 (RED SOILS)**

Profile No: P26 ***System: Agriculture (Minor Millet/Sweet Potato)* (LM)**

CLIMATE: SUB-HUMID (MOIST) RAINFALL: 1352 mm	Classification: Fine-loamy, mixed, hyperthermic, *Typic Paleustalfs*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Karkeli Tolla, Bandhavgarh (Tah), Umeria, Madhya Pradesh		Sampling Date: 13.06.2001

Morphological Properties of Profile No. 26 (Karkeli, Umeria)

Horizon	Depth (cm)	Boundary		Matrix color		Texture	Coarse fragments (%) (fg and cg)	Structure		
		D	T	Dry	Moist			Size	Grade	Type
Ap	0-15	g	s	-	7.5YR4.5/6	ls	1-2	m	1	sbk
Bt1	15-39	c	w	-	7.5YR4./3.5	sl	1-2	m	2	sbk
Bt2	39-62	g	s	-	10YR5/6	scl	2-3	m	2	sbk
Bt3	62-84	c	w	-	7.5YR5/6	cl	**3-5	m	2	sbk
Bt4	84-127	g	s	-	5YR4.5/6 (R)	cl	5-8	m	2	sbk
Bt5	127-155	-	-	-	5YR5/6 (R)	scl	8-10	m	2	sbk

Depth (cm)	Consistence			Porosity		Cutans			Nodules (conir)		Roots		Efferve-scence	Other features
	Dry	Moist	Wet	S	Q	Type	Thickness	Quantity	Size	Quantity	Size	Quantity	Dil HCl	
0-15	-	vfr	sopo	f,m	m	-	-	-	-	-	vf; f,m	m; f	-	-
15-39	-	vfr	ssps	f,m	m	T	tn	p	-	-	vf; f,m	c; f	-	-
39-62	-	vfr	s p	vf,f	m	T	tn	p	-	-	vf,f; m, c	c; f	-	-
62-84	-	vfr	s p	vf,f	m	T	tn	p	vf,f; m,c	m; c	vf,c	c, f	-	-
84-127	-	vfr	s p	vf,f	m	T	tn	p	vf,f; m,c	m; c	vf,f; m, c	c; f	-	-
127-155	-	vfr	s p	vf,f	m	T	tn	p	-	-	vf; m	f; c	-	-

**Fe/Mn concretions also present*

Please refer Appendix for the abbreviations.

Series: KARKELI 1 **BM Spot: 1 (RED SOILS)**

Profile No: P26 ***System: Agriculture (Minor millet/Sweet Potato)*** **(LM)**

CLIMATE: SUB-HUMID (MOIST) RAINFALL: 1352 mm	Classification: Fine-loamy, mixed, hyperthermic, *Typic Paleustalfs*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Karkeli Tolla, Bandhavgarh (Tah), Umeria, Madhya Pradesh		Sampling Date: 13.06.2001

Physical Properties of Profile No. 26 (Karkeli, Umeria)

Laboratory No.	Horizon	Depth (cm)	Size class and particle diameter (mm)			Fine clay (%) (<0.0002)	Fine clay/ total clay (%)
			Total				
			Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)		
			←----------(% of <2 mm) ----------→				
3225	Ap	0-15	79.3	12.5	8.2	7.3	89.0
3226	Bt1	15-39	65.1	21.4	13.5	9.1	67.4
3227	Bt2	39-62	54.2	21.3	24.5	17.1	69.8
3228	Bt3	62-84	39.9	29.9	30.2	21.6	71.3
3229	Bt4	84-127	38.6	28.7	32.7	21.5	65.7
3230	Bt5	127-155	52.2	20.8	27.0	16.6	61.5

Depth (cm)	BD (Mgm^{-3})	COLE	HC ($cmhr^{-1}$)	WDC (%)
0-15	-	0.01	-	-
15-39	-	0.04	-	-
39-62	-	0.07	-	-
62-84	-	0.12	-	-
84-127	-	0.10	-	-
127-155	-	0.08	-	-

- *Nil or not determined (wherever applicable)*

Series: KARKELI 1 **BM Spot: 12 (RED SOILS)**

Profile No: P26 ***System: Agriculture (Minor Millet/Sweet Potato)*** **(LM)**

CLIMATE: SUB-HUMID (MOIST) RAINFALL: 1352 mm	Classification: Fine-loamy, mixed, hyperthermic, *Typic Paleustalfs*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Karkeli Tolla, Bandhavgarh (Tah), Umeria, Madhya Pradesh		Sampling Date: 13.06.2001

Chemical Properties of Profile No. 26 (Karkeli, Umeria)

Depth (cm)	pH (1:2)		EC (1:2) (d Sm^{-1})	OC (%)	$CaCO_3$ (%)	Clay CO_3 (%)
	H_2O	1*N* KCl				
0-15	5.1	4.6	0.04	0.7	-	-
15-39	5.3	4.2	0.04	0.5	-	-
39-62	5.4	4.4	0.03	0.7	-	-
62-84	5.3	4.4	0.02	0.5	-	-
84-127	5.4	4.5	0.01	0.3	-	-
127-155	5.5	4.6	0.01	0.2	-	-

Depth (cm)	Extractable bases				CEC	Clay CEC	BS (%)	ESP
	Ca	Mg	Na	K				
	←----------[cmol(p+)kg^{-1}]----------→							
0-15	0.6	0.2	0.2	0.2	3.2	39	30	-
15-39	2.7	1.1	0.3	0.2	5.2	38	54	-
39-62	5.0	2.6	0.3	0.4	6.1	25	98	-
62-84	7.0	3.2	0.2	0.3	4.7	16	77	-
84-127	7.5	3.6	0.2	0.3	9.7	30	84	-
127-155	5.7	2.7	0.2	0.2	7.8	29	76	-

- *Nil or not determined (wherever applicable)*

Series: KARKELI 1 **BM Spot: 12 (RED SOILS)**

Profile No: P26 ***System: Agriculture (Minor millet/Sweet Potato)*** **(LM)**

CLIMATE: SUB-HUMID (MOIST) RAINFALL: 1352 mm	Classification: Fine-loamy, mixed, hyperthermic, *Typic Paleustalfs*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Karkeli Tolla, Bandhavgarh (Tah), Umeria, Madhya Pradesh		Sampling Date: 13.06.2001

Characterization of Landuse Types

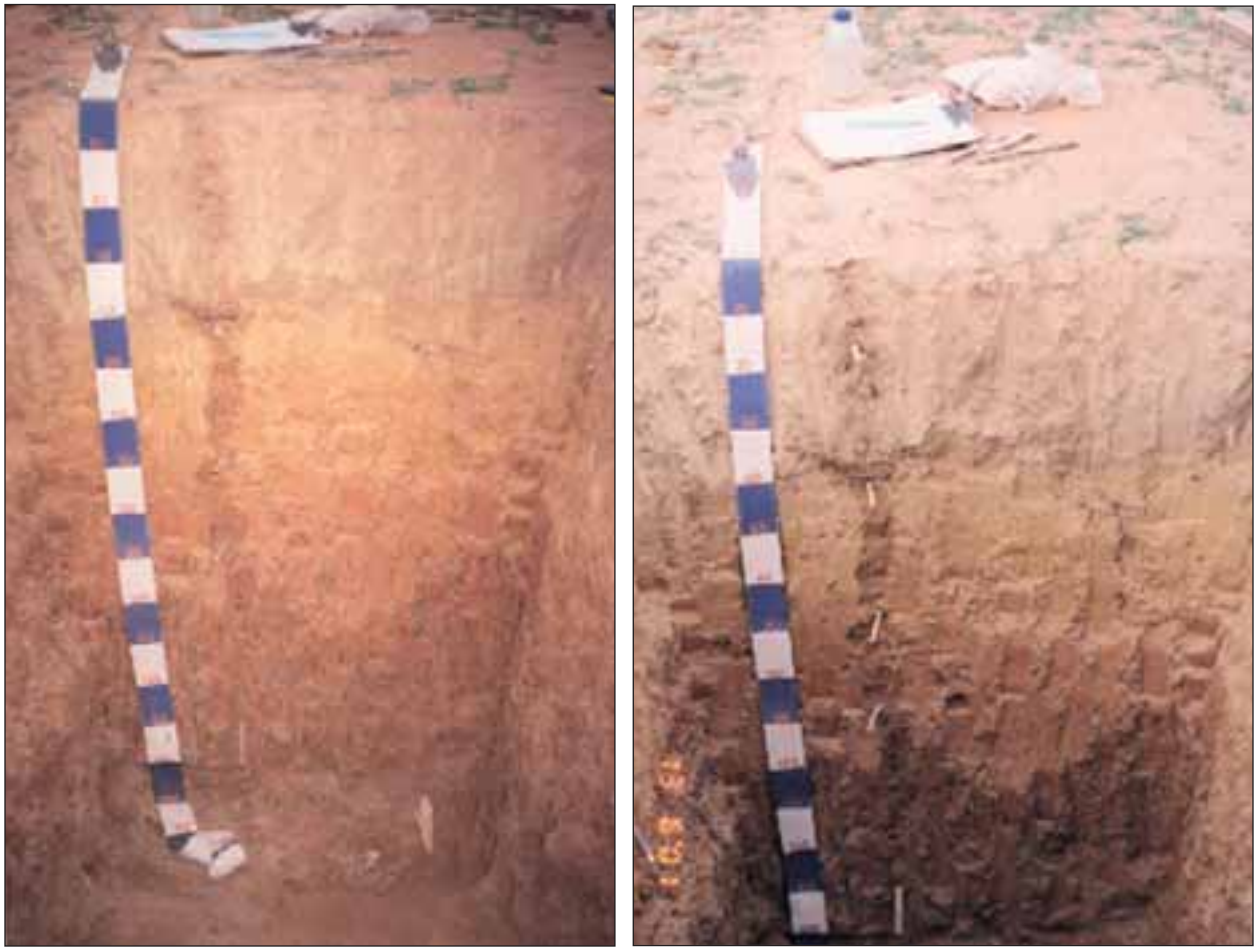
S. No.	Attribute		Description
1	Production system	:	Rain-fed double cropping (kodo millet-sweet potato), double cropping on deforested land. Six months fallow in summer Yield range: 800-1000 kg ha^{-1} kodo millet 1000-2000 kg ha^{-1} sweet potato
2	Management level	:	• Traditional varieties • Organic or inorganic fertilizer: Nil • Pesticides: Nil • Residue management: Nil • Conservation techniques: Nil • Broadcast sown (millet) • Sowing time: Kodo millet- last week of June Sweet potato- last week of October • Seed rate: Kodo millet 8-10 kg ha^{-1} (broadcast and mixed in soil)
3	Power source	:	Bullock operated
4	Market orientation	:	Subsistence plus commercial
5	Capital intensity	:	Low
6	Labor intensity	:	Low, limited to family labor
7	Land holding	:	Small, consolidated
8	Income level	:	Low (alternate source of off farm income)

Climatic Datasets of Karkeli (Umeria), Umeria District, Madhya Pradesh

Month	Mean temp (^oC)	Rainfall (mm)	PET (mm)	½PET (mm)	LGP (days)
January	17.00	36.80	64.30	32.20	31.00
February	19.30	26.40	83.80	41.90	0.00
March	24.10	19.70	129.90	65.00	0.00
April	29.50	9.20	163.80	81.90	0.00
May	34.00	8.70	195.80	97.90	0.00
June	32.20	140.60	165.10	82.60	30.00
July	27.30	409.00	104.30	52.20	31.00
August	26.50	410.30	96.20	48.10	31.00
September	26.70	227.50	101.50	50.80	30.00
October	24.10	43.30	106.20	53.10	0.00
November	19.20	14.40	73.10	36.60	0.00
December	16.80	6.00	58.30	29.20	0.00
Average	24.73	*1351.90*	*1342.30*	*671.5*	*153.00*

Landscape, Landuse and Soils in Benchmark Spot 12 (Karkeli, Umeria)

Karkeli soil under agricultural system (low management) with millet and sweet potato as main crops



Typical soil profile of Karkeli series (low management and cultivated)

3B. RED SOILS

3Bb. Red soils of semi-arid (moist) bioclimatic system

(MAR : > 1000-850 mm)

- **Benchmark Spots: 8**
- **No. of Pedons: 3 (P16, P17, P18)**

BM Spot 8 : VIJAYPURA: Agriculture System (Finger Millet) (FM) P16

Classification : Fine, kaolinitic, isohyperthermic, *Typic Haplustalfs*

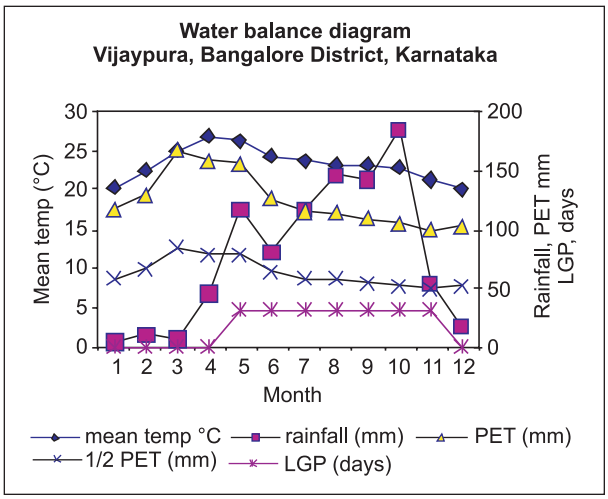
Location : Vill. Nagenehalli, Bangalore, Karnataka. Lat. 13°07'54"N, Long 77°34'41"E

Physiographic position : Laterite plateau - Bangalore

Topography and slope : Very gently sloping, 1-3%(0-50 m)

Drainage : Well drained

Vegetation : Tamarind, jackfruit, mango, palm, baniyan, parthenium, grasses



Landuse : Finger millet system, coconut, chiku, grapes, tomato, pigeonpea

Parent material : Weathered granites-gneissses

Sampled by : P. Chandran, S.K. Ray, S.L. Durge, S.R. Bhuse

Date of collection : 09.02.2001

Remarks : Adjacent plots cultivate coconut, sapota, grape, tomato, etc.

Ap	0-9 cm	Yellowish red (5YR 4/6D) and dark reddish brown (5YR 3/4M) sandy clay loam; weak medium subangular blocky (stronger when dry) structure; slightly hard, very friable, slightly sticky and slightly plastic; common very fine and fine roots; many very fine pores; less than 2% by volume of fine gravels; strongly acidic (pH 5.4); clear, smooth boundary.
Bt1	9-22 cm	Red (2.5YR 4/6D&M) sandy clay; moderate, medium, subangular and blocky (stronger when dry) structure; slightly hard, friable, sticky and slightly plastic; thin patchy clay cutans on ped surfaces; common very fine and fine roots; many fine pores; less than 2% by volume of fine gravels; medium acidic (pH 6.0); clear, smooth boundary.
Bt2	22-42 cm	Red to dark red (2.5YR 3.5/6D&M) clay; moderate, medium, subangular and blocky (stronger when dry) structure; friable, sticky and plastic; thin patchy clay cutans on ped surfaces; few very fine and fine roots; many very fine and fine pores; <2% by volume of fine gravels (part of which are lateritic); slightly acidic (pH 6.3); gradual smooth boundary.
Bt3	42-69 cm	Red (2.5YR 4/6M) clay; moderate, medium, subangular and blocky (stronger when dry) structure; friable, sticky and plastic; thin patchy clay cutans on ped surfaces; a few very fine roots; 2-5% by volume of fine and coarse gravels (most of which are lateritic); neutral (pH 6.7); gradual smooth boundary.
Bt4	69-98 cm	Yellowish red (5YR 5/6M) and reddish brown (5YR 4/4R) clay; weak, medium, subangular and blocky structure; friable, sticky and non-plastic; thin patchy clay cutans on ped surfaces; a few very fine roots; 30-35% by volume of fine and coarse gravels (most of which are lateritic); neutral (pH 6.7); gradual smooth boundary.

Bt5	98-120 cm	Yellowish red (5YR 4/6M&R), strong brown (7.5YR 5/8) and grey (7.5YR 6/1) clay; moderately fine, subangular and blocky (weak, stronger when dry) structure; friable, sticky and slightly plastic; thin patchy clay cutans on ped surfaces; a few very fine roots; 10-15% by volume of fine and coarse gravels; neutral (pH 7.3); gradual smooth boundary.
BC1	120-150+ cm	Grey (7.5YR 6/1), strong brown (7.5YR 4/6R), yellowish red (5YR 5/6) and strong brown (7.5YR 5/8) clay; fine subangular blocky (weak, stronger when dry) structure; friable, sticky and slightly plastic; 10-15% by volume of fine and coarse gravels; mildly alkaline (pH 7.4).

Series: VIJAYPURA **BM Spot: 8 (RED SOILS)**

Profile No: P16 ***System: Agriculture (Finger millet*) (FM)**

CLIMATE: SEMI-ARID (MOIST) RAINFALL: 924 mm	Classification: Fine, kaolinitic, isohyperthermic, *Typic Haplustalfs*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur
Location: Nagenehalli, Bangalore, Karnataka		Sampling Date : 09.02.2001

Morphological Properties of Profile No. 16 (Vijaypura, Bangalore)

Horizon	Depth (cm)	Boundary		Matrix color		Mottle colour	Tex-ture	Coarse fragments (%) (fg and cg)	Structure		
		D	T	Dry	Moist				Size	Grade	Type
Ap	0-9	c	s	5YR4/6	5YR3/4	-	scl	<2	m	1	sbk
Bt1	9-22	c	s	2.5YR4/6	2.5YR4/6	-	sc	<2	m	2	sbk
Bt2	22-42	g	s	2.5YR3.5/6	2.5YR3.5/6	-	c	<2	m	2	sbk
Bt3	42-69	g	s	2.5YR4/6	2.5YR4/6	-	c	<2	m	1	sbk
Bt4	69-98	g	s	-	5YR 5/6(R), 5YR 4/4	5YR4/4	c	30-35	m	1	sbk
Bt5	98-120	g	s	-	5YR5/6 (R), 7.5YR 6/1, 5/8	7.5YR6/1	c	10-15	f	2	sbk
BC1	120-150	-	-	-	7.5YR6/1, 5/8, 5YR 5/6	7.5YR6/1	c	10-15	f	2	sbk

Depth (cm)	Consistence			Porosity		Cutans		Roots		Effervescence	Other features*
	Dry	Moist	Wet	S	Q	Type	Thickness	Size	Quantity	Dil HCl	
0-9	sh	fr	sp	f	m	-	-	vf, f	c	-	-
9-22	sh	fr	sp	f	m	tn	p	vf, f	c	-	-
22-42	-	fr	sp	vf, f	m	tn	p	vf, f	f	-	-
42-69	-	fr	sp	-	-	tn	p	vf	f	-	Laterite gravels & plinthites
69-98	-	fr	spo	-	-	tn	p	vf	f	-	Laterite gravels & plinthites
98-120	-	fr	sp	-	-	tn	p	-	-	-	Laterite gravels & plinthites
120-150	-	fr	sp	-	-	-	-	-	-	-	Laterite gravels & plinthites

**Cutans are not observable in the last horizon due to disturbance*
***All the horizons become hard when dry except 69-98 cm horizon. Laterite gravels (dark coloured) & plinthites are found in last two horizons*

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Please refer Appendix I for the abbreviations.

Series: VIJAYPURA **BM Spot: 8 (RED SOILS)**

Profile No: P16 ***System: Agriculture (Finger millet*) (FM)**

CLIMATE: SEMI-ARID (MOIST) RAINFALL: 924 mm	Classification: Fine, kaolinitic, isohyperthermic, *Typic Haplustalfs*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur
Location: Nagenehalli, Bangalore, Karnataka		Sampling Date : 09.02.2001

Physical Properties of Profile No. 16 (Vijaypura, Bangalore)

Laboratory No.	Horizon	Depth (cm)	Size class and particle diameter (mm)			Fine clay (%) (<0.0002)	Fine clay / total clay (%)
			Total				
			Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)		
			←----------(% of <2 mm) ----------→				
3146	Ap	0-9	68.7	7.7	23.6	18.7	79.2
3147	Bt1	9-22	50.3	7.0	42.7	25.1	58.8
3148	Bt2	22-42	35.2	9.4	55.4	33.8	61.0
3149	Bt3	42-69	32.0	19.5	48.5	32.8	67.6
3150	Bt4	69-98	32.5	13.7	53.8	38.7	72.0
3151	Bt5	98-120	36.4	16.5	47.1	31.6	67.1
3152	BC1	120-150	25.8	21.5	52.7	35.6	67.5

Depth (cm)	BD (Mgm^{-3})	COLE	HC ($cmhr^{-1}$)	WDC (%)
0-9	-	0.02	-	-
9-22	1.7	0.07	-	-
22-42	1.6	0.10	-	-
42-69	1.6	0.08	-	-
69-98	1.5	0.10	-	-
98-120	1.5	0.08	-	-
120-150	-	0.09	-	-

- *Nil or not determined (wherever applicable)*

Series: VIJAYPURA BM Spot: 8 (RED SOILS)

Profile No: P16 ***System: Agriculture (Finger millet*) (FM)**

CLIMATE: SEMI-ARID (MOIST) RAINFALL: 924 mm	Classification: Fine, kaolinitic, isohyperthermic, *Typic Haplustalfs*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur
Location: Nagenehalli, Bangalore, Karnataka		Sampling Date : 09.02.2001

Chemical Properties of Profile No. 16 (Vijaypura, Bangalore)

Depth (cm)	pH (1:2)		EC (1:2) (d Sm^{-1})	OC (%)	$CaCO_3$ (%)	Clay CO_3* (%)
	H_2O	1*N* KCl				
0-9	5.4	4.7	0.18	1.4	-	-
9-22	6.0	5.0	0.05	0.8	-	-
22-42	6.3	5.2	0.06	0.5	-	-
42-69	6.7	5.6	0.05	0.4	-	-
69-98	6.7	5.2	0.05	0.3	-	-
98-120	7.3	6.3	0.11	0.2	-	-
120-150	7.4	6.5	0.15	0.2	-	-

Depth (cm)	Extractable bases				CEC	Clay CEC	BS (%)	ESP
	Ca	Mg	Na	K				
	←----------[cmol(p+)kg^{-1}]----------→							
0-9	2.5	0.9	0.2	0.2	5.0	21	74	-
9-22	4.4	1.3	0.3	0.1	7.2	17	83	-
22-42	7.1	1.9	0.3	0.1	10.2	18	91	-
42-69	8.0	1.8	0.3	0.1	12.6	26	81	-
69-98	8.5	1.4	0.7	0.1	12.8	24	83	-
98-120	11.3	1.0	0.3	0.1	13.0	28	97	-
120-150	11.5	1.0	0.3	0.1	13.9	26	92	-

* *Percent of water dispersible clay size carbonate*

\- *Nil or not determined (wherever applicable)*

Landscape, Landuse and Soils in Benchmark Spot 8 (Vijaypura, Bangalore)

Vijaypura soil under agricultural system (farmers' management) with finger millet as dominant crop

Vijaypura soil profile (Typic Haplustalfs)

A closer view of the profile

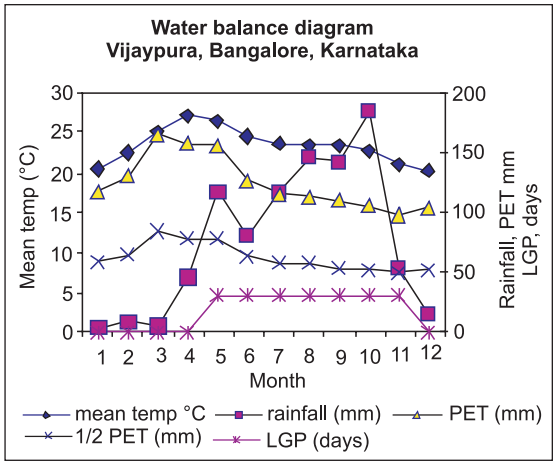
BM Spot 8 : VIJAYPURA 1: Agriculture System (Finger Millet/ Pigeonpea/Red Gram/Groundnut) (ORG) P17

Classification : Fine-loamy, kaolinitic, isohyperthermic, *Typic Haplustalfs*

Location : Plot No. 16, GKVK Farm, Bangalore, Karnataka. Lat. 13°05'02"N, Long 77°34'23"E

Physiographic position : Laterite Plateau - Bangalore

Topography and slope: Almost level land to very gently sloping, 1-3% (50-150 m)



Drainage : Well drained

Vegetation : *Neem*, tamarind, grasses, shrubs, *mahuva*

Landuse : Finger millet system, pigeonpea, redgram, groundnut

Parent material : Weathered granites-gneissses

Sampled by : P. Chandran, S.K. Ray, S.L. Durge, S.R. Bhuse

Date of collection : 09.02.2001

Remarks : As the soils are very friable and dry, it is not possible to take B.D. for all the horizons. Gravels present are mainly of quartz/feldspar except a few small laterite gravels.

Ap	0-12 cm	Reddish yellow (5YR 6/8D) and yellowish red (5YR 4/6M) sandy loam; weak fine granular (stronger whey dry) structure; slightly hard, very friable, non sticky and non plastic; common very fine, fine and medium roots; many fine pores; less than 1% fine gravels; strongly acidic (pH 5.4); clear, smooth boundary.
Bt1	12-37 cm	Light red (2.5YR 6/8D) and red (2.5YR 4/6M) sandy clay loam; weak fine subangular blocky structure; slightly hard, very friable, slightly sticky and slightly plastic; thin patchy clay cutans on ped surfaces; common very fine roots; many fine pores; less than 1% fine gravels; extremely acidic (pH 4.4); clear, smooth boundary.
Bt2	37-62 cm	Light red (2.5YR 6/8D) red (2.5YR 4/6M) sandy clay loam; weak medium subangular blocky structure; slightly hard, very friable, slightly sticky and slightly plastic; thin patchy clay cutans on ped surfaces; common very fine, few fine roots; many fine pores; less than 1% fine gravels; strongly acidic (pH 5.1); gradual smooth boundary.
Bt3	62-92 cm	Red (25YR 5/8D) and red (2.5YR 4/6M) sandy clay; moderate, medium, subangular and blocky structure; slightly hard, very friable sticky and slightly plastic; thin patchy clay cutans on ped surfaces; a few very fine roots; many fine pores; less than 1% fine gravels; strongly acidic (pH 5.3); abruptly smooth boundary.
Bt4	92-116 cm	Red (2.5YR 4/7M) sandy clay; structureless fine granular structure; very friable, sticky and non plastic; thin patchy clay cutans on ped surfaces; a few very fine roots; 60-70% fine and coarse gravels; neutral (pH 6.7); clear, smooth boundary.
Bt5	116-143 cm	Red (2/5YR 4/6M) sandy clay loam; weak fine subangular blocky structure; very friable sticky and non-plastic; thin patchy clay cutans on ped surfaces; a few very fine roots; 35-40% fine gravels; medium acidic (pH 5.7); clear, smooth boundary.
Bt6	143-155+ cm	Red (2.5YR 4/8M) clay increases; weak medium subangular blocky structure; very friable, slightly sticky and non-plastic; thin patchy clay cutans on ped surfaces; a few very fine roots; 20-25% fine gravels; strongly acidic (pH 5.5).

Series: VIJAYPURA 1 **BM Spot: 8 (RED SOILS)**

Profile No: P17 ***System: Agriculture (Finger millet/Pigeonpea/Red gram/Groundnut)*****(ORG)**

CLIMATE: SEMI-ARID (MOIST) RAINFALL: 924 mm	Classification: Fine-loamy, kaolinitic, isohyperthermic, *Typic Haplustalfs*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Plot no. 16, GKVK Farm, Bangalore, Karnataka		Sampling Date : 9.02.2001

Morphological Properties of Profile No. 17 (Vijaypura, Bangalore)

Horizon	Depth (cm)	Boundary		Matrix color		Texture	Coarse fragments (%) (fg and cg)	Structure		
		D	T	Dry	Moist			Size	Grade	Type
Ap	0-12	c	S	5YR6/8	5YR4/6	sl	** <1	f	1	gr
Bt1	12-37	c	S	2.5YR6/8	5YR4/6	scl	<1	f	1	sbk
Bt2	37-62	g	S	2.5YR6/8	5YR4/6	scl	<1	m	1	sbk
Bt3	62-92	a	S	2.5YR5/8	5YR4/6	sc	<1	m	2	sbk
Bt4	92-116	c	S	-	2.5YR4/7	scl	60-70	f	0	gr
Bt5	116-143	c	S	-	2.5YR4/6	scl	35-40	f	1	sbk
Bt6	143-155	-	-	-	2.5YR4/8	scl	20-25	m	1	sbk

Depth (cm)	Consistence			Porosity		Cutans		Roots		Effervescence	Other features*
	Dry	Moist	Wet	S	Q	Type	Thickness	Size	Quantity	Dil HCl	
0-12	sh	vfr	sopo	F	m	-	-	vf f	c	-	-
12-37	sh	vfr	sp	F	m	tn	p	vf	c	-	-
37-62	sh	vfr	sp	F	m	tn	p	vf, f	f, c	-	-
62-92	sh	vfr	sp	F	m	tn	p	vf	f	-	-
92-116	-	vfr	spo	-	-	tn	p	vf	f	-	-
116-143	-	vfr	spo	-	-	tn	p	vf	f	-	-
143-155	-	vfr	ssp	-	-	tn	p	vf	f	-	-

** *Gravels are mainly quartz/ feldspars and small laterite gravels*

Please refer Appendix I for the abbreviations

Series: VIJAYPURA 1 **BM Spot: 8 (RED SOILS)**

Profile No: P17 ***System: Agriculture (Finger millet/Pigeonpea/Redgram/Groundnut)*****(ORG)**

CLIMATE: SEMI-ARID (MOIST) RAINFALL: 924 mm	Classification: Fine-loamy, kaolinitic, isohyperthermic, *Typic Haplustalfs*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Plot no. 16, GKVK Farm, Bangalore, Karnataka		Sampling Date : 9.02.2001

Physical Properties of Profile No. 17 (Vijaypura, Bangalore)

Laboratory No.	Horizon	Depth (cm)	Size class and particle diameter (mm)			Fine clay (%) (<0.0002)	Fine clay/ total clay (%)
			Total				
			Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)		
			←----------(% of <2 mm) ----------→				
3153	Ap	0-12	76.6	8.7	14.7	9.7	66.0
3154	Bt1	12-37	59.7	8.8	31.5	12.4	39.3
3155	Bt2	37-62	53.2	13.2	33.6	15.7	46.7
3156	Bt3	62-92	50.0	12.8	37.2	16.8	45.2
3157	Bt4	92-116	50.1	15.6	34.3	18.6	54.2
3158	Bt5	116-143	50.2	17.1	32.7	11.4	35.0
3159	Bt6	143-155	48.7	25.1	26.2	12.0	45.8

Depth (cm)	BD (Mgm^{-3})	COLE	HC ($cmhr^{-1}$)	WDC (%)
0-12	-	0.01	-	-
12-37	-	0.08	-	-
37-62	-	0.09	-	-
62-92	-	0.10	-	-
92-116	-	0.09	-	-
116-143	-	0.10	-	-
143-155	-	0.08	-	-

- *Nil or not determined (wherever applicable)*

Series: VIJAYPURA 1 BM Spot: 8 (RED SOILS)

Profile No: P17 ***System:Agriculture(Finger millet/Pigeonpea/Red gram/Groundnut)*****(ORG)**

CLIMATE: SEMI-ARID (MOIST) RAINFALL: 924 mm	Classification: Fine-loamy, kaolinitic, isohyperthermic, *Typic Haplustalfs*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Plot no. 16, GKVK Farm, Bangalore, Karnataka		Sampling Date : 9.02.2001

Chemical Properties of Profile No.17 (Vijaypura, Bangalore)

Depth (cm)	pH (1:2)		EC (1:2) (d Sm^{-1})	OC (%)	$CaCO_3$ (%)	Clay CO_3* (%)
	H_2O	1*N* KCl				
0-12	5.4	4.7	0.07	0.5	-	-
12-37	4.4	3.8	0.06	0.5	-	-
37-62	5.1	5.0	0.07	0.5	-	-
62-92	5.3	4.7	0.08	0.5	-	-
92-116	6.7	5.0	0.10	0.2	-	-
116-143	5.7	5.2	0.04	0.2	-	-
143-155	5.5	5.3	0.03	0.1	-	-

Depth (cm)	Extractable bases				CEC	Clay CEC	BS (%)	ESP
	Ca	Mg	Na	K				
	←----------[cmol(p+)kg^{-1}]----------→							
0-12	1.50	0.41	0.11	0.07	3.3	34	64	-
12-37	1.20	0.33	0.05	0.06	2.8	23	57	-
37-62	1.80	0.55	0.09	0.04	3.4	22	73	-
62-92	1.80	0.75	0.09	0.04	3.7	22	73	-
92-116	1.50	0.67	0.11	0.04	3.0	16	77	-
116-143	1.60	0.55	0.11	0.04	2.8	25	82	-
143-155	1.45	0.49	0.09	0.03	2.8	23	75	-

* *Percent of water dispersible clay size carbonate*

\- *Nil or not determined (wherever applicable)*

Series: VIJAYPURA 1 BM Spot: 8 (RED SOILS)

Profile No: P17 ***System: Agriculture(Finger millet/Pigeonpea/Redgram/Groundnut)*****(ORG)**

CLIMATE: SEMI-ARID (MOIST) RAINFALL: 924 mm	Classification: Fine-loamy, kaolinitic, isohyperthermic, *Typic Haplustalfs*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Plot no. 16, GKVK Farm, Bangalore, Karnataka		Sampling Date : 9.02.2001

Characterization of Landuse Types

S. No.	Attribute		Description
1	Production system	:	Rain-fed finger millet-finger millet-pigeonpea-field, bean (4 year rotation) cropped during *kharif* with 6-8 months fallow (winter-summer). Yield: Finger millet: 2000-2200 kg ha^{-1} Pigeonpea: 800-1000 kg ha^{-1} Field bean: 400 kg ha^{-1}
2	Management level	:	• Improved varieties • Optimum plant stand • Manures: FYM @ 10 tonnes/ha for finger millet • Chemical fertilizers: 25:45:25 for finger millet and 25:50:25 for pigeon pea • Stubbles: Partly incorporated • Weedicides: Occasional • Insecticides: Frequent • Conservation measure: Leveling. • Sowing time: 1st fortnight of June • Seed rate: Finger millet 6-8 kg ha^{-1} Pigeon pea 12-15 kg ha^{-1}
3	Power source	:	Tractor supplemented with animal traction with improved implements.
4	Market orientation	:	R&D
5	Capital intensity	:	Intermediate
6	Labour intensity	:	Medium
7	Land holding	:	Not relevant
8	Income level	:	Not relevant

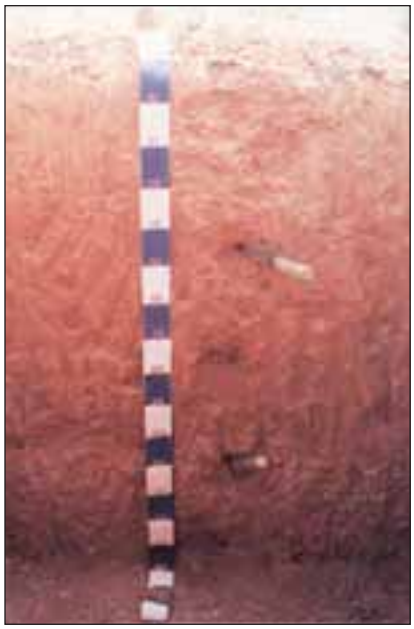
Climatic Datasets of Vijaypura, Bangalore, Karnataka

Month	Mean temp (°C)	Rainfall (mm)	PET (mm)	½ PET (mm)	LGP (days)
January	20.50	3.30	117.40	58.70	0.00
February	22.50	10.20	130.00	65.00	0.00
March	25.00	6.10	166.20	84.10	0.00
April	27.00	45.70	158.20	79.10	0.00
May	26.40	116.50	156.50	78.25	31.00
June	24.50	80.10	126.50	63.25	30.00
July	23.70	116.60	115.70	57.85	31.00
August	23.30	147.10	114.20	57.10	31.00
September	23.30	142.70	108.90	54.45	30.00
October	22.90	184.90	105.10	52.55	31.00
November	21.20	54.30	98.30	49.15	30.00
December	20.10	16.20	102.90	51.45	0.00
Average	23.37	*923.70*	*1499.90*	*750.95*	*214.00*

Landscape, Landuse and Soils in Benchmark Spot 8 (Vijaypura (Original), Bangalore)

GKVK, Dryland Agriculture Station at Bangalore

Soil-site of Vijaypura series under agricultural system (with finger millet/pigeonpea/redgram/ groundnut cropping pattern)



Typical red soil profile of Vijaypura series (Typic Haplustalfs)

A closer view of the profile (Typic Haplustalfs)

BM Spot 8 : VIJAYPURA 1: Agriculture System (Finger Millet) (HM) P18

Classification : Fine-loamy, kaolinitic, isohyperthermic, *Typic Haplustalfs*

Location : Opp. Plot No.16, GKVK Farm, Bangalore K'aka, Lat. 13°05'03"N, Long 77°34'25"E

Physiographic position : Laterite Plateau - Bangalore

Topography and slope : Almost level land to very gently sloping, 1-3% (50-150 m)

Drainage : Well drained

Vegetation : *Neem*, tamarind, grasses, shrubs, *mahuva*

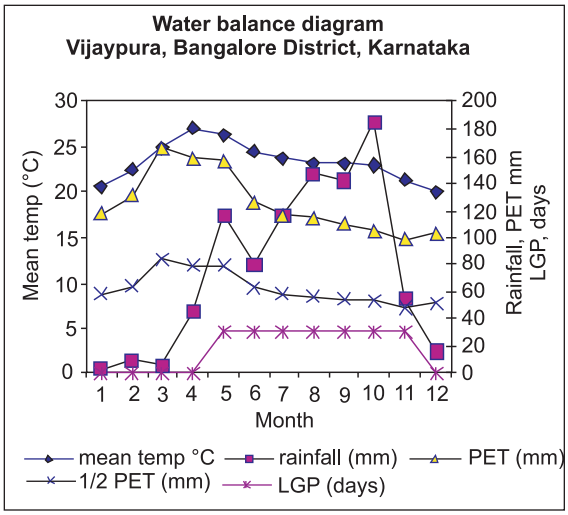
Landuse : Finger millet system,

Parent material : Granites and gneissses

Sampled by : P. Chandran, S.K. Ray, S.L. Durge, S.R. Bhuse

Date of collection : 10.02.2001

Remarks : Gravels are mainly of quartz/feldspar and laterite.



Ap	0-11 cm	Yellowish red (5YR 5/6D) and yellowish red (5YR 4/6M) sandy loam; weak medium subangular blocky structure (stronger when dry); slightly hard, very friable; non sticky and non plastic; common very fine and fine, a few medium roots; less than 1% fine gravels; many fine and a few medium pores; medium acidic (pH 5.8); clear, smooth boundary.
Bt1	11-32 cm	Yellowish red (5YR 5/8D) and yellowish red (5YR 4/6M) sandy clay loam; moderate medium, subangular and blocky (stronger when dry) structure; slightly hard, very friable; sticky and slightly plastic; thin patchy clay cutans on ped surfaces; common very fine and fine, few medium roots; less than 1% fine gravels; many fine pores; very strongly acidic (pH 4.6); gradual smooth boundary.
Bt2	32-64 cm	Yellowish red (5YR 4.5D) and yellowish red (5YR 4/6M) sandy clay; moderate medium, subangular and blocky (stronger when dry) structure; slightly hard, very friable sticky and plastic; thin patchy clay cutans on ped surfaces; common very fine and fine roots; less than 1% fine gravels; many fine pores; strongly acidic (pH 5.5); gradual smooth boundary.
Bt3	64-100 cm	Yellowish red (5YR 4.5/6D) and yellowish red (5YR 4/6M) sandy clay loam; moderate medium, subangular and blocky (stronger when dry) structure; slightly hard, very friable, sticky and slightly plastic; thin patchy clay cutans on ped surfaces; common very fine and fine roots; less than 2% fine gravels; many fine pores; medium acidic (pH 5.7); abruptly smooth boundary.
Bt4	100-130 cm	Light red (2.5YR 5.5/8R) and red (2.5YR 4/8M) sandy clay loam; weak, fine and granular structure; very friable sticky and non plastic; thin patchy clay cutans on ped surfaces; common very fine roots; 60-70% fine and coarse gravels; medium acidic (pH 6.0); clear, smooth boundary.
Bt5	130-150 cm	Red (2.5YR 5/8R) and red (2.5YR 4/8M) sandy clay loam; moderate medium, subangular and blocky structure; very friable sticky and slightly plastic; thin patchy clay cutans on ped surfaces; a few very fine roots; 20-25% fine gravels; slightly acidic (pH 6.5).

Series: VIJAYPURA 1 BM Spot: 8 (RED SOILS)

Profile No: P18 ***System: Agriculture (Finger millet*) (HM)**

CLIMATE: SEMI-ARID (MOIST) RAINFALL: 924 mm	Classification: Fine-loamy, kaolinitic, isohyperthermic, *Typic Haplustalfs*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Opp. to Plot no. 16, GKVK Farm, Bangalore, Karnataka		Sampling Date : 10.02.2001

Morphological Properties of Profile No. 18 (Vijaypura, Bangalore)

Horizon	Depth (cm)	Boundary		Matrix color		Texture	Coarse fragments (%) (fg and cg)	Structure		
		D	T	Dry	Moist			Size	Grade	Type
Ap	0-11	c	s	5YR 5/6	5YR 4/6	sl	<1	m	1	sbk
Bt1	11-32	g	s	5YR 5/8	5YR 4/6	scl	<1	m	2	sbk
Bt2	32-64	g	s	5YR 4.5/6	5YR 4/6	sc	<1	m	2	sbk
Bt3	64-100	a	s	5YR 4.5/6	5YR 4/6	scl	<2	m	2	sbk
Bt4	100-130	c	s	2.5YR 5.5/8	5YR 4/8	scl	*60 -70	f	1	gr
Bt5	130-150	-	-	2.5YR5/8	5YR 4/8	scl	20-25	m	2	sbk

Depth (cm)	Consistence			Porosity		Cutans		Roots		Effervescence	Other features*
	Dry	Moist	Wet	S	Q	Type	Thickness	Size	Quantity	Dil HCl	
0-11	sh	vfr	sopo	f; m	m;f	-	-	vf f; m	c; f	-	-
11-32	sh	vfr	sp	F	m	tn	p	vf f; m	c; f	-	-
32-64	sh	vfr	sp	F	m	tn	p	vf, f	c	-	-
64-100	sh	vfr	sp	F	m	tn	p	vf, f	c	-	-
100-130	-	vfr	spo	-	-	tn	p	vf	c	-	-
130-150	-	vfr	sps	-	-	tn	p	vf	f	-	-

**Mainly fine gravels 75 to 80 % and coarse gravels 20 to 25 %; gravels consist quartz, feldspars and laterite*

Please refer Appendix I for the abbreviations

Series: VIJAYPURA 1 **BM Spot: 8 (RED SOILS)**

Profile No: P18 ***System: Agriculture (Finger millets*) (HM)**

CLIMATE: SEMI-ARID (MOIST) RAINFALL: 924 mm	Classification: Fine-loamy, kaolinitic, isohyperthermic, *Typic Haplustalfs*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Opp. Plot no. 16, GKVK Farm, Bangalore, Karnataka		Sampling Date : 10.02.2001

Physical Properties of Profile No. 18 (Vijaypura, Bangalore)

Laboratory No.	Horizon	Depth (cm)	Size class and particle diameter (mm)			Fine clay (%) (<0.0002)	Fine clay/ total clay (%)
			Total				
			Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)		
			←----------(% of <2 mm) ----------→				
3160	Ap	0-11	73.4	8.2	18.4	11.8	64.1
3161	Bt1	11-32	61.6	11.4	27.0	13.9	51.5
3162	Bt2	32-64	49.5	12.1	38.4	24.0	62.5
3163	Bt3	64-100	52.4	15.8	31.7	13.8	43.4
3164	Bt4	100-130	52.9	15.7	31.3	15.5	49.4
3165	Bt5	130-150	48.8	20.7	30.5	13.5	44.3

Depth (cm)	BD (Mgm^{-3})	COLE	HC ($cmhr^{-1}$)	WDC (%)
0-11	-	0.08	-	-
11-32	-	0.05	-	-
32-64	-	0.07	-	-
64-100	-	0.07	-	-
100-130	-	0.07	-	-
130-150	-	0.10	-	-

- *Nil or not determined (wherever applicable)*

Series: VIJAYPURA 1 BM Spot: 8 (RED SOILS)

Profile No: P18 ***System: Agriculture (Finger millets*) (HM)**

CLIMATE: SEMI-ARID (MOIST) RAINFALL: 924 mm	Classification: Fine-loamy, kaolinitic, isohyperthermic, *Typic Haplustalfs*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Opp. Plot no. 16, GKVK Farm, Bangalore, Karnataka		Sampling Date : 10.02.2001

Chemical Properties of Profile No. 18 (Vijaypura, Bangalore)

Depth (cm)	pH (1:2)		EC (1:2) (d Sm^{-1})	OC (%)	$CaCO_3$ (%)	Clay CO_3* (%)
	H_2O	1*N* KCl				
0-11	5.8	5.3	0.11	1.0	-	-
11-32	4.6	3.9	0.09	0.7	-	-
32-64	5.5	4.9	0.08	0.6	-	-
64-100	5.7	5.1	0.03	0.4	-	-
100-130	6.0	5.4	0.06	0.2	-	-
130-150	6.5	5.6	0.05	0.1	-	-

Depth (cm)	Extractable bases				CEC	Clay CEC	BS (%)	ESP
	Ca	Mg	Na	K				
	----------[cmol(p+)kg^{-1}]----------							
0-11	1.80	0.41	0.04	0.13	4.1	22	58	-
11-32	1.50	0.37	0.10	0.06	7.0	26	29	-
32-64	2.40	0.55	0.11	0.03	5.2	13	58	-
64-100	2.40	1.22	0.17	0.07	6.3	20	60	-
100-130	2.30	1.23	0.13	0.07	4.6	14	80	-
130-150	2.30	1.08	0.17	0.06	5.2	17	69	-

* *Percent of water dispersible clay size carbonate*

\- *Nil or not determined (wherever applicable)*

Series: VIJAYPURA 1 BM Spot: 8 (RED SOILS)

Profile No: P18 ***System: Agriculture (Finger millets*) (HM)**

CLIMATE: SEMI-ARID (MOIST) RAINFALL: 924 mm	Classification: Fine-loamy, kaolinitic, isohyperthermic, *Typic Haplustalfs*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Opp. Plot no. 16, GKVK farm, Bangalore, Karnataka		Sampling Date : 10.02.2001

Characterization of Landuse Types

S. No.	Attribute		Description
1	Production system	:	Rain-fed groundnut- groundnut finger millet (3 year rotation) cropped during *kharif* with 8-9 month fallow (winter & summer) Yield range: Finger millet - 2000 kg Groundnut 700-1100 kg
2	Management level	:	• Improved varieties • Optimum plant stand • Manures: FYM @10 tonnes /ha for finger millet • Chemical fertilizer: 25:50:25 for groundnut, 25:40:25 for finger millet. • Weedicides: Occasional • Insecticides: Occasional • Conservation measure: Leveling • Sowing time: Finger millet- 1st fortnight of June Groundnut- 2nd fortnight of May • Seed rate: Finger millet- 6-8 kg ha^{-1} Groundnut- 80-100 kg ha^{-1}
3	Power source	:	Tractor supplemented with animal traction and improved implements for interculture.
4	Market orientation	:	R&D
5	Capital intensity	:	Intermediate
6	Labour intensity	:	Medium
7	Land holding	:	Not relevant
8	Income level	:	Not relevant

Climatic Datasets of Vijaypura, Bangalore District, Karnataka

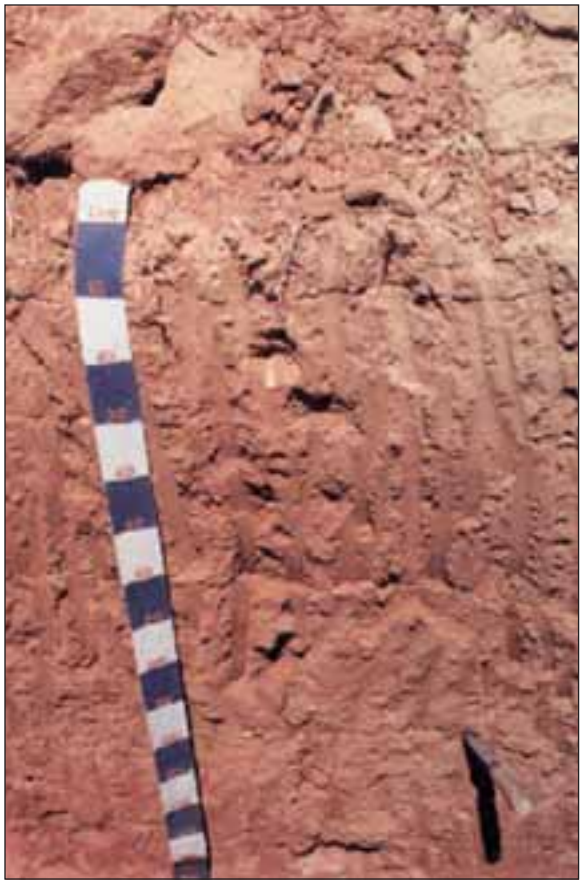
Month	Mean temp (°C)	Rainfall (mm)	PET (mm)	½ PET (mm)	LGP (days)
January	20.50	3.30	117.40	58.70	0.00
February	22.50	10.20	130.00	65.00	0.00
March	25.00	6.10	166.20	84.10	0.00
April	27.00	45.70	158.20	79.10	0.00
May	26.40	116.50	156.50	78.25	31.00
June	24.50	80.10	126.50	63.25	30.00
July	23.70	116.60	115.70	57.85	31.00
August	23.30	147.10	114.20	57.10	31.00
September	23.30	142.70	108.90	54.45	30.00
October	22.90	184.90	105.10	52.55	31.00
November	21.20	54.30	98.30	49.15	30.00
December	20.10	16.20	102.90	51.45	0.00
Average	23.37	*923.70*	*1499.90*	*750.95*	*214.00*

Landscape, Landuse and Soils in Benchmark Spot 8 (Vijaypura (HM), Bangalore)

Benchmark site of Vijaypura series under agricultural system (high management) with finger millet as dominant crop

Ragi (finger millet) staple food of benchmark spot No. 8

Collection of horizon wise soil sample



Typical red soil profile of Vijaypura series (Typic Haplustalfs)

A closer view of soil profile

3B. RED SOILS

3Bc. Red soils of semi-arid (dry) bioclimatic system

(MAR : 850-550 mm)

- **Benchmark Spots: 10, 17, 19, 21**

No. of Pedons: 5 (P22, P34, P37, P38, P41)

BM Spot 10 : PALATHURAI: Agriculture System (Horsegram/Vegetable) (ORG) P22

Classification : Fine-loamy, mixed, isohyperthermic (cal), *Typic Haplustalfs*

Location : Vill. Palathurai, Coimbatore, Tamil Nadu, Lat. 10°52'36"N, Long 76°56'56"E

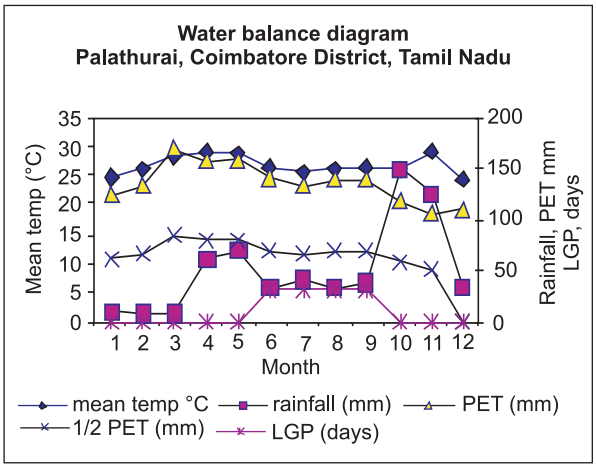
Physiographic position : Tamil Nadu Uplands

Topography and slope: Gently sloping and undulating, 3-8% (50-150 m)

Drainage : Well drained

Vegetation : Palm, cactus, *babul*

Landuse : Horsegram, pigeonpea, vegetables, jowar



Parent material : Weathered gneiss

Sampled by : T. Bhattacharyya, P. Chandran, S. Siddhamalai, M.V. Venugopalan, S.L. Durge, S.R. Bhuse

Date of collection : 17.02.2001

Remarks : These are calcareous red soils. Calcretes are present which are conglomerate of quartz, $CaCO_3$, biotite and muscovite mica. The entire 46-73 cm layer is impervious – kind of calcrete layer. C1 is harder than C2 and the latter is highly weathered and mixed with sand.

Ap	0-16 cm	Reddish brown to dark reddish brown (5YR 3.5/3D) dark reddish brown (5YR 3/2M) sandy loam; moderate fine granular to weak fine subangular blocky structure; slightly hard; very friable, non sticky and non plastic; common very fine and fine roots; common very fine, fine and medium lime nodules; common very fine and fine pores; mildly alkaline (pH 7.8); slightly effervescent (not in the matrix); clear, smooth boundary.
Bt1	16-33 cm	Dark reddish brown (5YR 3/2M) gravelly sandy clay loam; moderate, fine, subangular and blocky to moderate medium subangular blocky structure; very friable, sticky and slightly plastic; thin patchy and broken clay cutans; common very fine roots; common very fine, fine and medium lime nodules; about 15% fine and coarse gravels and stones; mildly alkaline (pH 7.8); slightly effervescent (not in matrix); gradual smooth boundary.
Bt2	33-46 cm	Dark reddish brown (5YR 3/3M) gravelly sandy loam; weak, fine, subangular and blocky structure; loose, very friable, slightly sticky and non plastic; cutans not clear; a few very fine roots; common medium and coarse limenodules; about 15-25% fine and coarse gravels and stones; mildly alkaline (pH 7.8); slightly effervescent (not in matrix); clear irregular boundary.
C1	46-73 cm	Brown (7.5YR 4/3.5M) gravelly sandy loam; hard massive structure; loose to very friable, slightly sticky and non-plastic; many medium and coarse lime nodules; type of discontinuous imperious calcrete layer; about 90% coarse gravels, stones and boulders; moderately alkaline (pH 7.9); weathered gneiss mixed with quartz, feldspar, mica; violently effervescent; gradual wavy boundary.
C2	73-95+ cm	Brown (7.5YR 4/4M) gravelly sandy loam; loose structure; many medium and coarse lime nodules; highly weathered granite mixed with mainly sand and quartz, feldspars, mica; moderately alkaline (pH 8.1); violently effervescent.

Series: PALATHURAI **BM Spot: 10 (RED SOILS)**

Profile No: P22 ***System: Agriculture (Horsegram/Vegetable)*** **(ORG)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 612 mm	Classification: Fine-loamy, mixed, isohyperthermic (cal), *Typic Haplustalfs*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Palathurai, Coimbatore, Tamil Nadu		Sampling Date : 17.02.2001

Morphological Properties of Profile No. 22 (Palathurai, Coimbatore)

Horizon	Depth (cm)	Boundary		Matrix color		Texture	Coarse fragments (%) (fg and cg)	Structure		
		D	T	Dry	Moist			Size	Grade	Type
Ap	0-16	c	s	5YR3.5/3	5YR3/2	sl	3-10	f m	2 1	gr sbk
Bt1	16-33	g	s	-	5YR3/2	scl	15	f m	2 2	sbk sbk
Bt2	33-46	c	i	-	5YR3/3	sl	15-25	f	1	sbk
Ck1	46-73	g	w	-	7.5YR4/3.5	sl	90	Hard & massive		
Ck2	73-95	-	-	-	7.5YR4/4	ls	15-45	loose		

Depth (cm)	Consistence			Porosity		Cutans			Nodules (conca)		Roots		Efferve-scence	Other features
	Dry	Moist	Wet	S	Q	Type	Thickness	Quantity	Size	Quanti ty	Size	Quantity	Dil HCl	
0-16	sh	vfr	sopo	vf,f	c	-	-	-	vf,f,m	c	vf,f	c	e*	-
16-33	-	vfr	sps	vf,f	c	-	-	-	vf,f,m	c	vf	c	e*	-
33-46	l	vfr	sspo	-	-	T	tn	p	m,c	c	vf	f	es	-
46-73	-	-	-	-	-	-	-	-	-	-	-	-	ev	-
73-95	-	-	-	-	-	-	-	-	-	-	-	-	ev	-

e = No reaction in matrix.* *46-73 cm layer is impervious - kind of calcrete layer.*

Please refer Appendix I for the abbreviations.

Series: PALATHURAI **BM Spot: 10 (RED SOILS)**

Profile No: P22 ***System: Agriculture (Horsegram/Vegetable)*** **(ORG)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 612 mm	Classification: Fine-loamy, mixed, isohyperthermic (cal), *Typic Haplustalfs*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Palathurai, Coimbatore, Tamil Nadu		Sampling Date : 17.02.2001

Physical Properties of Profile No. 22 (Palathurai, Coimbatore)

Laboratory No.	Horizon	Depth (cm)	Size class and particle diameter (mm)			Fine clay (%) (<0.0002)	Fine clay/ total clay (%)
			Total				
			Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)		
			←----------(% of <2 mm) ----------→				
3186	Ap	0-16	79.3	6.6	14.1	11.4	80.8
3187	Bt1	16-33	67.7	3.7	28.7	21.9	76.6
3188	Bt2	33-46	76.5	5.6	17.9	14.5	81.0
3189	Ck1	46-73	77.7	6.9	15.4	12.2	79.2
3190	Ck2	73-95	81.3	6.7	12.1	9.5	78.5

Depth (cm)	BD (Mgm^{-3})	COLE	HC ($cmhr^{-1}$)	WDC (%)
0-16	-	0.01	-	-
16-33	-	0.07	-	4.6
33-46	-	0.03	-	4.2
46-73	-	0.04	-	3.3
73-95	-	0.02	-	3.0

- *Nil or not determined (wherever applicable)*

Series: PALATHURAI BM Spot: 10 (RED SOILS)

Profile No: P22 ***System: Agriculture (Horsegram/Vegetable)*** **(ORG)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 612 mm	Classification: Fine-loamy, mixed, isohyperthermic (cal), *Typic Haplustalfs*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Palathurai, Coimbatore, Tamil Nadu		Sampling Date : 17.02.2001

Chemical Properties of Profile No. 22 (Palathurai, Coimbatore)

Depth (cm)	pH (1:2)		EC (1:2) (d Sm^{-1})	OC (%)	$CaCO_3$ (%)	Clay CO_3 (%)
	H_2O	1*N* KCl				
0-16	7.8	7.4	0.18	0.8	1.0	-
16-33	7.8	6.9	0.14	0.7	1.5	60.2
33-46	7.8	7.1	0.25	0.5	10.4	-
46-73	7.9	7.3	0.13	0.3	11.7	87.4
73-95	8.1	7.3	0.14	0.3	10.9	-

Depth (cm)	Extractable bases				CEC	Clay CEC	BS (%)	ESP
	Ca	Mg	Na	K				
	←----------[cmol(p+)kg^{-1}]----------→							
0-16	3.2	1.6	0.3	0.6	5.7	40	100	-
16-33	10.5	-	0.3	0.5	10.7	37	106	-
33-46	8.5	1.2	0.3	0.3	8.0	45	129	-
46-73	5.9	1.1	0.4	0.2	9.9	64	79	-
73-95	6.1	1.0	0.3	0.2	6.6	54	115	-

- *Nil or not determined (wherever applicable)*

Series: PALATHURAI BM Spot: 10 (RED SOILS)

Profile No: P22 ***System: Agriculture (Horsegram/Vegetable)*** **(ORG)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 612 mm	Classification: Fine-loamy, mixed, isohyperthermic (cal), *Typic Haplustalfs*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Palathurai, Coimbatore, Tamil Nadu		Sampling Date : 17.02.2001

Characterization of Landuse Types

S. No.	Attribute		Description
1	Production system	:	Rain-fed, irregular with no fixed pattern. Winter rainfall based; extensive but uncultivated (cultivated once but irregular rainfall reduced average) of tomato or horsegram or sorghum. Crop based farming system. Yield: 1000-1200 kg ha^{-1} sorghum or 3000-3500 kg ha^{-1} tomato Long fallow period
2	Management level	:	• Traditional varieties • Organic manure: Occasional (at 2 tonnes/ha, once in four years) • Fertilizer: 22.5:22.5:22.5 ($N:P_2O_5:K_2O$ kg ha^{-1}) • Insecticides: Occasional • Conservation measures: Nil • Residue management measure: Nil • Sowing time: No fixed pattern for tomato Sorghum- September • Seed rate: Tomato- (transplanted) Sorghum 12-15 kg ha^{-1}
3	Power source	:	Bullock (animal traction) with traditional implements.
4	Market orientation	:	Commercial.
5	Capital intensity	:	Low, credit and risk shy
6	Labor intensity	:	Low, limited to family labor
7	Land holding	:	Large, consolidated (mostly left fallow).
8	Income level	:	Low (supplemented with off farm income).

Climatic Datasets of Palathurai, Coimbatore District, Tamil Nadu

Month	Mean temp (^oC)	Rainfall (mm)	PET (mm)	½ PET (mm)	LGP (days)
January	24.50	11.40	122.20	61.10	0.00
February	26.20	7.40	132.40	66.20	0.00
March	28.40	8.90	170.40	85.20	0.00
April	29.00	61.00	156.80	78.40	0.00
May	28.60	69.10	158.00	79.00	0.00
June	26.50	34.00	140.00	70.00	30.00
July	25.50	41.70	132.10	66.10	31.00
August	26.00	33.90	139.40	69.70	31.00
September	26.40	37.30	137.50	68.80	30.00
October	26.20	148.70	118.00	59.00	0.00
November	29.20	125.30	103.90	52.00	0.00
December	24.30	33.50	110.40	-	0.00
Average	26.73	612.20	1621.10	755.5	122.00

Landscape, Landuse and Soils of Benchmark Spot 10 (Palathurai series, Palathurai, Coimbatore)

Village Palathurai in Coimbatore district

Palathurai soil under agricultural system (horsegram/ vegetables cropping pattern)

Palathurai soil under agricultural system (Horsegram/Vegetables cropping pattern)

Typical profile of Palathurai soil (Typic Haplustalfs)

BM Spot 17 : KAUKUNTLA: Agricultural System (Castor+Pigeonpea) (FM) P34

Classification : Fine, mixed, isohyperthermic, *Vertic Haplustalfs*

Location : Kaukuntla (Kaukuntala), Atmakur, Mehboobnagar, A.P. Lat 16°31'42"N, Long 77°51'19"E

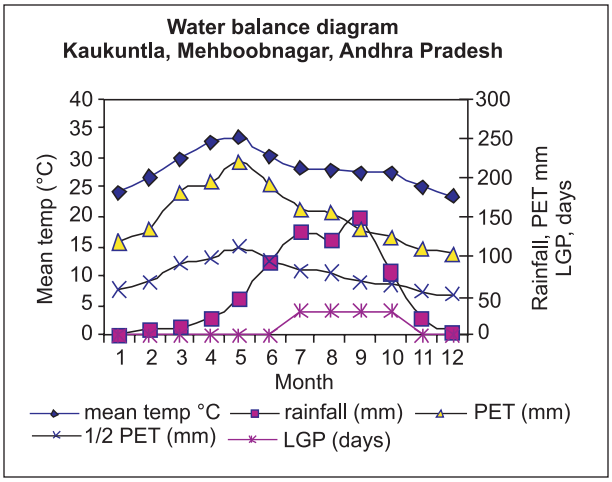
Physiographic position : Deccan Plateau – granite and granite-gneiss

Topography and slope: Very gently sloping upland, 1-3% (50-150 m)

Drainage : Well drained

Vegetation: *Babul*, mango, *pipal*, banyan, cynodon, dactylon, grass, thorny shrubs

Landuse : Castor+pigeonpea system, groundnut, cotton



Parent material : Weathered granite-gneiss

Sampled by : P. Chandran, S.K. Ray, M.V. Venugopalan, S.L. Durge

Date of collection : 14.12.2001

Remarks : Castor + pigeonpea (10 rows to one row) is the main crop with an average yield of 10-15 Q/acre for castor. Cotton is grown mainly in black soils, only small patches of cotton are grown in red soils. Paddy is grown in black soils in lowlying areas. Groundnut grows well in these red soils, but wild boars destroy the crop. On one face of the profiles, gravels are about 60-65%. There is variation with subsequent thin layers (8-10 cm), differing in clay content. Soft iron/Mn concretions are present.

Ap	0-8 cm	Reddish yellow (7.5YR 6/6D) and strong brown (7.5YR 4/6M) loamy sand; weak medium subangular blocky structure; slightly hard, friable, non sticky and non plastic; common very fine and fine roots; many fine and medium pores; slightly acidic (pH 6.3); clear, smooth boundary.
Bt1	8-27 cm	Red (2.5YR 4/6M) clay; moderate medium subangular blocky structure; friable, sticky and plastic; thin patchy clay cutans on surface of peds; a few very fine and fine roots; a few very fine soft iron and manganese concretions; many fine and medium pores; medium acidic (pH 5.7); clear, smooth boundary.
Bt2	27-43 cm	Dark red (2.5YR 3/6M) clay; strong moderate subangular blocky structure with slight pressure faces; slightly firm, sticky and plastic; moderately thick patchy clay cutans on surface of peds; a few very fine roots; a few very fine and fine soft iron and manganese concretions; many very fine and fine pores; medium acidic (pH 6.0); clear, smooth boundary.
Bt3	43-68 cm	Yellowish red (5YR 4/6M) sandy clay; strong moderate subangular blocky structure with slight pressure faces on surface of peds; slightly firm, sticky and plastic; moderately thick patchy clay cutans on surface of peds; a few very fine roots; common very fine and fine soft iron and manganese concretions; slightly acidic (pH 6.2); clear, smooth boundary.

Bt4	68-98 cm	Reddish brown (5YR 4/4R) clay; strong moderate subangular blocky structure; slightly firm, sticky and plastic; thin patchy clay cutans on surface of peds; a few very fine roots; a few very fine and fine soft iron and manganese concretions; 8-10% fine gravels; medium acidic (pH 6.2); clear, smooth boundary.
Bt5	98-121 cm	Yellowish red (5YR 4/6R) clay; weak moderate subangular blocky structure; friable, sticky and non plastic; thin patchy clay cutans on ped surface; a few very fine roots; a few very fine and fine iron and manganese concretions; 30-35% fine gravels; neutral reaction (pH 6.5); clear, smooth boundary.
Bt6	121-156 cm	Strong brown (7.5YR 4/6M) sandy clay; medium moderate subangular blocky structure; friable, slightly sticky and plastic; thin patchy clay cutans on surface of peds; a few fine soft iron and manganese concretions; 20-25% fine gravels; neutral reaction (pH 6.8); clear, smooth boundary.
BC	156+ cm	Strong brown (7.5YR 5/6M) sandy clay loam; weak medium subangular blocky structure; friable, sticky and non plastic; a few fine soft iron and manganese concretions; 25-30% fine gravels; neutral reaction (pH 6.7).

Series: KAUKUNTLA **BM SPOT: 17 (RED SOILS)**

PROFILE NO: P34 ***System: Agriculture (Castor + Pigeonpea)* (FM)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 674 mm	Classification : Fine,mixed, isohyperthermic, *Vertic Haplustalfs*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Kaukuntala, Atmakar (Tah), Mehboobnagar, Andhra Pradesh		Sampling Date: 14.12.2001

Morphological Properties* of Profile No. 34 (Kaukuntla, Mehboobnagar)

Horizon	Depth (cm)	Boundary		Matrix color		Texture	Coarse fragments (%) (fg and cg)	Structure		
		D	T	Dry	Moist			Size	Grade	Type
Ap	0-8	c	s	7.5YR6/6	7.5YR4/6	Ls	3-5	m	1	sbk
Bt1	8-27	c	s	-	2.5YR4/6	C	5-8	m	2	sbk
Bt2	27-43	c	s	-	2.5YR3/6	C	5-8	m	3	sbk
Bt3	43-68	c	s	-	5YR4/6(R)	C	5-8	m	3	sbk
Bt4	68-98	c	s	-	5YR4/4(R)	c	8-10	m	3	sbk
Bt5	98-121	c	s	-	5YR4/6(R)	c	30-35**	m	1	sbk
Bt6	121-156	c	s	-	7.5YR4/6	c	20-25	m	2	sbk
BC	156-+	-	-	-	7.5YR5/6	sc	25-30	m	1	sbk

Depth (cm)	Consistence			Porosity		Cutans			Nodules(conir)***		Roots		Other Features
	Dry	Moist	Wet	S	Q	Type	Thickness	Quantity	Size	Quantity	Size	Quantity	
0-8	sh	fr	sopo	f, m	m	-	-	-	-	-	vf, f	c	-
8-27	-	fr	sp	f, m	m	T	tn	p	vf	f	vf, f	f	-
27-43	-	sfi	sp	vf,f	m	T	mtk	p	vf,f	f	vf	f	Slight Pressure faces
43-68	-	sfi	sp	-	-	T	mtk	p	vf,f	c	vf	f	Slight Pressure faces
68-98	-	sfi	sp	-	-	T	tn	p	vf,f	f	vf	f	-
98-121	-	fr	spo	-	-	T	tn	p	f	f	-	-	-
121-156	-	fr	spo	-	-	T	tn	p	f	f	-	-	-
156-+	-	fr	spo	-	-	T	tn	p	-	-	-	-	-

***** *No effervescence with dil.HC.*
*** 0n one face gravels are about 60-65 %*
**** Soft Iron and Manganese concretions*

Please refer Appendix I for the abbreviations.

Series: KAUKUNTLA **BM SPOT: 17 (RED SOILS)**

PROFILE NO: P34 ***System: Agriculture (Castor + Pigeonpea)*** **(FM)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 674 mm	Classification: Fine,mixed, isohyperthermic, *Vertic Haplustalfs*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Kaukuntala, Atmakar (Tah), Mehboobnagar, Andhra Pradesh		Sampling Date: 14.12.2001

Physical Properties of Profile No. 34 (Kaukuntla, Mehboobnagar)

Laboratory No.	Horizon	Depth (cm)	Size class and particle diameter (mm)			Fine clay (<0.0002)	Fine clay/ total clay (%)
			Total				
			Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)		
			←----------(% of <2 mm) ----------→				
3348	Ap	0-8	81.9	6.3	11.8	18.5	89.8
3349	Bt1	8-27	40.7	7.4	51.9	45.1	82.0
3350	Bt2	27-43	43.8	9.6	46.6	45.9	84.0
3351	Bt3	43-68	45.9	6.6	47.5	33.9	71.4
3352	Bt4	68-98	41.6	8.6	49.8	38.5	77.3
3353	Bt5	98-121	43.0	7.1	49.9	36.0	72.1
3354	Bt6	121-156	47.5	7.7	44.8	32.8	73.2
3355	BC	156-+	57.0	8.6	34.4	24.8	72.1

Depth (cm)	BD (Mgm^{-3})	COLE	HC ($cmhr^{-1}$)	WDC (%)
0-8	-	0.03	-	-
8-27	1.5	0.19	-	-
27-43	1.6	0.14	-	-
43-68	1.6	0.15	-	-
68-98	1.8	0.17	-	-
98-121	-	0.14	-	-
121-156	1.8	0.14	-	-
156 - +	-	0.14	-	-

- *Nil or not determined (wherever applicable)*

Series: KAUKUNTLA **BM SPOT: 17 (RED SOILS)**

PROFILE NO: P34 ***System: Agriculture (Castor + Pigeon pea)*** **(FM)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 674 mm	Classification: Fine,mixed, isohyperthermic, *Vertic Haplustalfs*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Kaukuntala, Atmakar (Tah), Mehboobnagar, Andhra Pradesh		Sampling Date: 14.12.2001

Chemical Properties of Profile No. 34 (Kaukuntala, Mehboobnagar)

Depth (cm)	pH (1:2)		EC (1:2) (d Sm^{-1})	OC (%)	$CaCO_3$ (%)	Clay CO_3 (%)
	H_2O	1*N* KCl				
0-8	6.3	5.6	0.06	1.1	1.2	-
8-27	5.7	4.4	0.06	0.6	1.4	-
27-43	6.0	4.7	0.05	0.5	.0.4	-
43-68	6.2	4.9	0.04	0.4	0.9	-
68-98	6.0	4.9	0.31	0.3	0.6	-
98-121	6.8	5.2	0.04	0.2	0.9	-
121-156	6.8	5.2	0.04	0.2	1.1	-
156-+	6.7	5.2	0.04	0.2	1.8	-

Depth (cm)	Extractable bases				CEC	Clay CEC	BS (%)	ESP
	Ca	Mg	Na	K				
	←----------[cmol(p+)kg^{-1}]----------→							
0-8	2.5	1.9	0.9	0.3	12.2	103	45	7
8-27	6.3	2.1	0.7	0.4	17.2	33	55	4
27-43	8.3	3.0	0.9	0.3	16.4	35	76	6
43-68	9.5	3.3	0.7	0.4	17.2	36	81	4
68-98	9.9	3.4	0.9	0.4	18.2	36	80	5
98-121	11.7	2.8	0.7	0.4	19.2	38	81	4
121-156	11.1	2.8	0.9	0.4	18.2	41	84	5
156-+	11.5	2.0	0.8	0.3	15.2	44	95	5

- *Nil or not determined (wherever applicable)*

Series: KAUKUNTLA **BM SPOT: 17 (RED SOILS)**

PROFILE NO: P34 ***System: Agriculture (Castor + Pigeonpea)*** **(FM)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 674 mm	Classification: Fine, mixed, isohyperthermic, *Vertic Haplustalfs*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: Kaukuntala, Atmakar (Tah), Mehboobnagar, Andhra Pradesh		Sampling Date: 14.12.2001

Characterization of Landuse Types

S. No.	Attribute		Description
1	Production system	:	Rain-fed, castor + pigeonpea (10:1 strip cropping) system with 5-6 months fallow period, crop based farming system Yield range: Castor 400-1000 kg ha^{-1} and pigeonpea 100-200 kg ha^{-1}.
2	Management level	:	• Use of improved hybrids • Chemical fertilizers: 20-25 kg ha^{-1}/year N, 20-25 kg ha^{-1}/year P_2O_5 and 20-25 kg ha^{-1}/year K_2O • Castor hull after threshing added to soil • Insecticides • Sowing time: 1st week of July • Seed rate: Castor 10-12 kg ha^{-1} Pigeonpea 2 kg ha^{-1}
3	Power source	:	Mechanical (tractor hired).
4	Market orientation	:	Largely commercial.
5	Capital intensity	:	Low with limited access to credit
6	Labour intensity	:	Intermediate with family labour involvement
7	Land holding	:	Small and consolidated
8	Income level	:	Medium (farm income supplemented with carpentry work)

Climatic datasets of Kaukuntala, Mehboobnagar, Andhra Pradesh

Month	Mean temp (^oC)	Rainfall (mm)	PET (mm)	½ PET (mm)	LGP(days)
January	24.10	0.20	117.60	58.80	0.00
February	26.80	5.00	134.80	67.40	0.00
March	30.00	9.70	180.80	90.40	0.00
April	32.60	21.60	194.70	97.40	0.00
May	33.60	44.40	221.40	110.70	0.00
June	30.30	90.50	189.80	94.90	0.00
July	28.10	129.60	161.40	80.70	31.00
August	27.80	121.60	154.60	77.30	31.00
September	27.60	147.10	133.50	66.80	30.00
October	27.40	79.20	125.70	62.90	31.00
November	25.10	21.80	108.30	54.20	0.00
December	23.40	3.00	104.10	52.10	0.00
Average	27.88				
Total		673.70	1826.70	913.6	123.00

Landscape, Landuse and Soils in Benchmark Spot 17 (Kaukuntla, Mehboobnagar, A.P.)

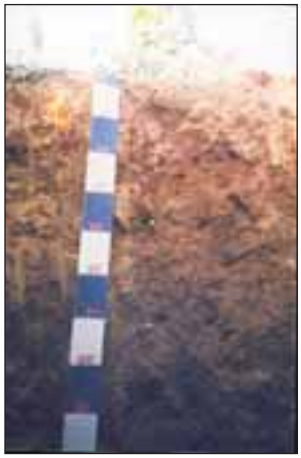


Benchmark spot at Kaukuntla, Mehboobnagar, Andhra Pradesh, under agriculture (farmers' management) with castor + pigeonpea cropping system

Cotton is also grown in Mehboobnagar

Sale of castor seeds yield profits

Soil profile examination; scientists discuss with farmers



Typical Kaukuntla soil profile


Closer view of the profile

BM Spot 19 : HAYATHNAGAR : Agriculture System (Sorghum - Castor) (HM) P37

Classification : Loamy-skeletal, mixed, isohyperthermic, *Typic Rhodustalfs*

Location : Hayathnagar farm of CRIDA, Hyderabad, Rangareddy (Ranga Reddy) district, Andhra Pradesh, Lat. 17°20'26"N, Long 78°35'39"E

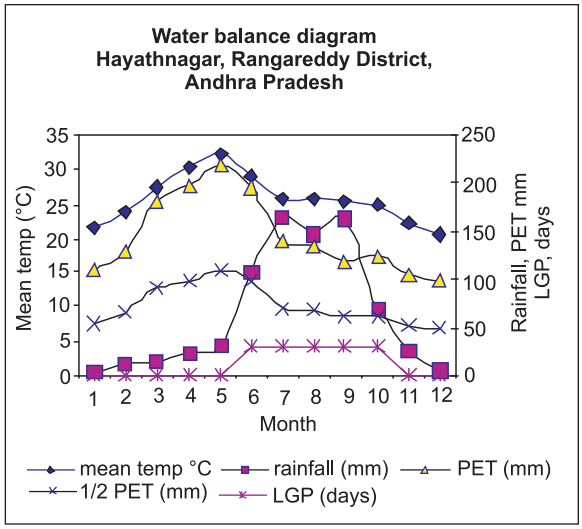
Physiographic position : Deccan Plateau – laterite and granite and granite-gneiss

Topography and slope: Gently sloping to undulating, 3-8% (50-150 m)

Drainage : Well drained

Vegetation : *Neem*, mango, grass, cock's comb, seasamum

Landuse : Sorghum – castor



Parent material : Weathered granite-gneiss

Sampled by : D.K. Pal, T. Bhattacharyya, P. Chandran, S.K. Ray, M.V. Venugopalan, P. Srivastava, S.L. Durge, K.L. Sharma

Date of collection: 16.12.2001

Remarks : Spheroidal weathering of granite-gneiss was observed. From a depth of 29 cm down the profile contains veins of weathered/unweathered feldspars in granite-gneiss complex. There is also weak development of Bt in 67-101 cm and 101+ cm horizons.

Ap	0-12 cm	Red (2.5YR 4/6D) and dark red (2.5YR 3/6M) sandy clay loam; moderate medium subangular blocky structure; hard, friable, slightly sticky and non plastic; many very fine and fine, a few medium and coarse roots; common very fine, fine and medium, a few coarse pores; 30-35% gravels and stones; medium acidic (pH 5.6); clear, smooth boundary.
Bt1	12-29 cm	Dark reddish brown (2.5YR 3/4M) sandy clay loam; moderate medium subangular blocky structure; hard, friable, slightly sticky and non-plastic; thin patchy clay cutans on surface of peds; common very fine and fine, a few coarse roots; a few very fine and fine, common medium and coarse pores; 35-45% gravels and stones; strongly acidic (pH 5.2); abruptly smooth boundary.
Bt2	29-67 cm	Dark reddish brown (2.5YR 3/4M) sandy clay loam; weak fine granular structure; friable, slightly sticky and non plastic; thin patchy clay cutans on surface of peds; common very fine and fine roots; common medium and coarse pores; about 80% gravels; stones & boulders; medium acidic (pH 5.8); clear, smooth boundary.
Bt3	67-101 cm	Dark reddish brown (2.5YR 3/4M) sandy clay loam; weak medium subangular blocky and weak fine granular structure; friable, slightly sticky and non plastic; thin patchy clay cutans on surface of peds; a few very fine and fine roots; common medium and coarse pores; 80-90% gravels; stones and boulders; slightly acidic (pH 6.1).
C	101+ cm	Highly weathered gneissic material which is soft, mixed with stones and rock fragments. The material has some clay and also has few patchy and thin clay cutans. It is moist and seems to retain some moisture.

Series: HAYATHNAGAR **BM SPOT: 19 (RED SOILS)**

PROFILE NO: P37 ***System: Agriculture (Sorghum - Castor)* (HM)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 764 mm	Classification: Loamy-skeletal, mixed, isohyperthermic, *Typic Rhodustalfs*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: CRIDA Research Farm, Hayathnagar (Mandal), Rangareddy, Andhra Pradesh		Sampling Date: 16.12.2001

Morphological Properties of Profile No. 37 (Hayathnagar, Rangareddy)

Horizon	Depth (cm)	Boundary		Matrix colour		Texture	Coarse fragments (%) (fg and cg)	Structure		
		D	T	Dry	Moist			Size	Grade	Type
Ap	0-12	c	s	2.5Yr 4/6	2.5YR3/6	scl	27-35	m	2	sbk
Bt1	12-29	a	s	_	2.5YR3/4	scl	35-45	m	2	sbk
Bt2	29-67	c	s	_	2.5YR3/4	scl	80-90	f	1	gr
Bt3	67-101	-	-	_	2.5YR3/4	scl	-	m f	1 1	sbk gr
C	101+	Highly weathered gneissic material which is soft, mixed with stone and rocks fragments. The material has some clay and a few patchy and thin clay cutans. It is moist and seems to retain some moisture.								

Depth (cm)	Consistence			Porosity		Cutans			Roots		Effervescence.	Other features
	Dry	Moist	Wet	S	Q	Type	Thickness	Quantity	Size	Quantity	Dil HCl	
0-12	h	Fr	sspo	vf,f,m; c	c; f	-	-	-	vf,f; m,c	m; f	-	-
12-29	h	Fr	ssp	m,c; vf	c; f	T	tn	p	vf,f; c	c; f	-	-
29-67	-	Fr	spo	m,c	c	T	tn	p	vf,f	c	-	-
67-101	-	Fr	spo	m,c	c	T	tn	p	vf, f	f	-	-
101+	-											

**Throughout, the profile is slightly calcareous, though not observable by dilute HCl. However, chemical analysis data confirmed its presence. The profile is truncated at the surface and thus elluvial horizon(s) does not exist*

Please refer Appendix I for the abbreviations

Series: HAYATHNAGAR **BM SPOT: 19 (RED SOILS)**

PROFILE NO: P37 ***System: Agriculture (Sorghum - Castor)* (HM)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 764 mm	Classification: Loamy-skeletal, mixed, isohyperthermic, *Typic Rhodustalfs*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: CRIDA Research Farm, Hayathnagar (Mandal), Rangareddy, Andhra Pradesh		Sampling Date: 16.12.2001

Physical Properties of Profile No. 37 (Hayathnagar, Rangareddy)

Laboratory No.	Horizon	Depth (cm)	Size class and particle diameter (mm)			Fine clay (<0.0002)	Fine clay/ total clay (%)
			Total				
			Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)		
			←----------(% of <2 mm) ----------→				
3371	Ap	0-12	73.4	3.4	23.2	21.3	91.8
3372	Bt1	12-29	66.9	7.5	25.6	21.6	84.3
3373	Bt2	29-67	69.0	8.8	22.2	18.2	82.0
3374	Bt3	67-101	66.8	10.2	23.0	18.8	81.7

Depth (cm)	BD (Mgm^{-3})	COLE	HC ($cmhr^{-1}$)	WDC (%)
0-12	-	0.1	-	-
12-29	-	0.1	-	-
29-67	-	0.1	-	-
67-101	-	0.1	-	-

- *Nil or not determined (wherever applicable)*

Series: HAYATHNAGAR **BM SPOT: 19 (RED SOILS)**

PROFILE NO: P37 ***System: Agriculture (Sorghum - Castor)* (HM)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 764 mm	Classification: Loamy-skeletal, mixed, isohyperthermic, *Typic Rhodustalfs*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: CRIDA Research Farm, Hayathnagar (Mandal), Rangareddy, Andhra Pradesh		Sampling Date: 16.12.2001

Chemical Properties of Profile No. 37 (Hayathnagar, Rangareddy)

Depth (cm)	pH (1:2)		EC (1:2) (d Sm^{-1})	OC (%)	$CaCO_3$ (%)	Clay CO_3 (%)
	H_2O	1*N* KCl				
0-12	5.6	4.4	0.05	1.0	0.3	-
12-29	5.2	4.1	0.04	0.9	0.4	-
29-67	5.8	4.6	0.06	0.6	0.4	-
67-101	6.1	4.6	0.07	0.5	0.6	-

Depth (cm)	Extractable bases				CEC	Clay CEC	BS (%)	ESP
	Ca	Mg	Na	K				
	←----------[cmol(p+)kg^{-1}]----------→							
0-12	3.1	2.1	1.0	0.2	7.0	11	256	14
12-29	5.0	1.6	0.8	0.2	8.3	33	91	10
29-67	6.3	1.2	0.9	0.2	8.3	37	104	11
67-101	7.3	3.0	0.7	0.3	10.3	45	110	7

- *Nil or not determined (wherever applicable)*

Series: HAYATHNAGAR **BM SPOT: 19 (RED SOILS)**

PROFILE NO: P37 ***System: Agriculture (Sorghum - Castor)* (HM)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 764 mm	Classification: Loamy-skeletal, mixed, isohyperthermic, *Typic Rhodustalfs*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: CRIDA Research Farm, Hayathnagar (Mandal), Rangareddy, Andhra Pradesh		Sampling Date: 16.12.2001

Characterization of Landuse Types

S. No.	Attribute		Description
1	Production system	:	Rain-fed *kharif* sorghum-castor (2 year rotation) with 5-8 months of fallow period (including summer). Yield range: Castor- 975-1263 q/ha Sorghum- 1220-1450 kg ha^{-1}
2	Management level	:	• Improved varieties/hybrid (Aruna for castor and CSH5, 6 or 9 for sorghum), • Chemical fertilizers: 60 kg ha^{-1} N + 30 kg ha^{-1} P_2O_5 + green manure (glyricidia) • Insecticides: Limited (to shoot fly control) • Residue management: Sorghum stover at 2 t/ha and Glyricidia loppergs at 2 times fresh wt/ha • Soil conservation measures: Bunding • Sowing time: Castor and sorghum- 1st week of July • Seed rate: Castor 12-15 kg ha^{-1} Sorghum 8-10 kg ha^{-1}
3	Power source	:	Mechanical (tractor)
4	Market orientation	:	Research and development
5	Capital intensity	:	High
6	Labour intensity	:	High
7	Land holding	:	Not relevant
8	Income level	:	Not relevant

Climatic Datasets of Hayathnagar (Rangareddy) , Andhra Pradesh

Month	Mean temp (^oC)	Rainfall (mm)	PET (mm)	½ PET (mm)	LGP (days)
January	21.60	1.70	109.80	54.90	0.00
February	24.00	11.40	129.50	64.75	0.00
March	27.40	13.40	181.50	90.75	0.00
April	30.30	24.10	197.80	98.90	0.00
May	32.40	30.00	219.90	109.95	0.00
June	29.10	107.40	196.40	98.20	30.00
July	26.00	165.00	140.40	70.20	31.00
August	25.80	146.90	135.50	67.75	31.00
September	25.60	163.30	119.30	59.65	30.00
October	25.00	70.80	123.60	61.80	31.00
November	22.40	24.90	104.10	52.05	0.00
December	20.60	5.50	98.60	49.30	0.00
Average	25.85				
Total LGP		764.40	1756.40	878.20	1453

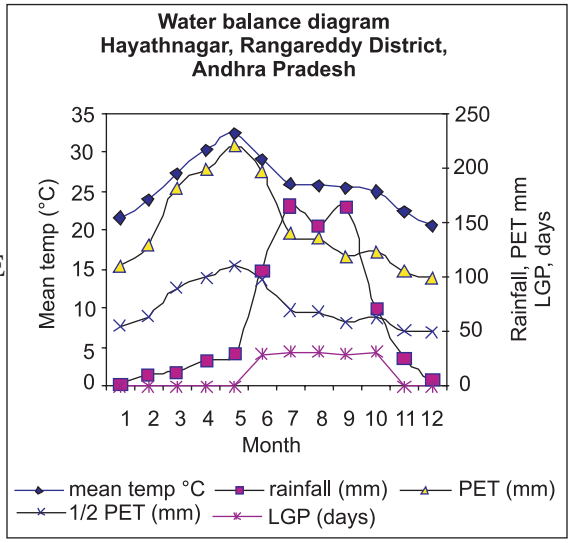
Landscape, Landuse and Soils in Benchmark Spot 19 (Hayathnagar-HM, Rangareddy, A.P.)

Benchmark spot at Hayathnagar, Hyderabad

Benchmark spot at Hayathnagar, Rangareddy, Andhra Pradesh, under agricultural system (high management) with sorghum-castor cropping pattern

Typical Hayathnagar profile (Typic Rhodustalfs).

BM Spot 19 : HAYATHNAGAR: Agriculture System (Sorghum - Castor) (LM) P38



Classification : Loamy-skeletal, mixed, isohyperthermic, *Typic Rhodustalfs*

Location : Hayathnagar farm of CRIDA, Hyderabad, Rangareddy (Ranga Reddy) district, Andhra Pradesh, Lat. 17°21'05"N, Long 78°35'46"E

Physiographic position : Deccan Plateau – Laterite and granite and granite-gneiss

Topography and slope: Gently sloping to undulating, 3-8% (50-150 m)

Drainage : Well drained

Vegetation : *Neem*, gliricidia, *deenanath* grass, cock's comb, wild *tulsi*, grasses, surubs, nielax procumbum

Landuse : Sorghum – castor

Parent material : Weathered granite-gneisses

Sampled by : D.K. Pal, T. Bhattacharyya, P. Chandran, S.K. Ray, M.V. Venugopalan, P. Srivastava, S.L. Durge, K.L. Sharma

Date of collection: 16.12.2001

Remarks : The C-horizon has CaCO3 on three walls of the profile, weathered and fragmented rock on two walls, about 90-95% of weathered rock, small amount of clay on two walls and soft CaCO3 on two walls.

Ap	0-16 cm	Yellowish red (5YR 4/6D) and dark reddish brown (5YR 3/4M) sandy loam; weak medium subangular blocky structure; hard, friable, slightly sticky and non-plastic; common very fine and fine, a few medium roots; common fine and medium pores; 10-15% gravels and stones; strongly acidic (pH 5.2); clear, smooth boundary.
Bt1	16-41 cm	Dark reddish brown (2.5YR 3/4M) sandy clay loam; weak, fine granular structure; very friable, sticky and non plastic; thin patchy and broken clay cutans on surface of peds; common very fine and fine, a few medium roots; common medium and coarse pores; 65-70% gravels and stones; medium acidic (pH 6.0); abruptly smooth boundary.
Bt2	41-62 cm	Dark red (2.5YR 3/6M) sandy clay; weak, fine subangular blocky structure; very friable, sticky and non plastic; thin patchy clay cutans on surface of peds; common very fine and fine roots; common medium and coarse pores; 55-60% gravels and stones; medium acidic (pH 6.3); gradual smooth boundary.
Bt3	62-89 cm	Dark red (2.5YR 3/6M) sandy clay loam; weak, fine subangular blocky structure; very friable, slightly sticky and non-plastic; thin patchy clay cutans on surface of peds; a few very fine and fine roots; common medium and coarse pores; 55-60% gravels and stones; neutral reaction (pH 7.2); clear, smooth boundary.
Cr	89-115 cm	Dark reddish brown (5YR 3/4M&R) sandy clay loam; massive/weak, fine subangular blocky structure; very friable, slightly sticky and non-plastic; a few very fine and fine roots; mildly alkaline (pH 7.4); 30-40% gravels and stones; violently effervescent (not in matrix).

Series: HAYATHNAGAR **BM SPOT: 19 (RED SOILS)**

PROFILE NO: P38 ***System: Agriculture (Sorghum - Castor)*** **(LM)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 764 mm	Classification: Loamy-skeletal, mixed, isohyperthermic, *Typic Rhodustalfs*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: CRIDA Research Farm, Hayathnagar (Village & Mandal), Rangareddy, Andhra Pradesh		Sampling Date: 16.12.2001

Morphological Properties of Profile No. 38 (Hayathnagar, Rangareddy)

Horizon	Depth (cm)	Boundary		Matrix color		Texture	Coarse fragments (%)		Structure		
		D	T	Dry	Moist		fg, cg	st	Size	Grade	Type
Ap	0-16	c	s	5YR4/6	5YR3/4	sl	5-8	3-5	m	1	sbk
Bt1	16-41	a	s	-	2.5YR3/4	scl	60-65	3-5	f	1	gr
Bt2	41-62	g	s	-	2.5YR3/6	c	50-55	3-5	f	1	sbk
Bt3	62-89	c	s	-	2.5YR3/6	scl	50-55	3-5	f	1	sbk
Cr	89-115	-	-	-	5YR3/4 (R)	scl	5-10	20-30	massive		

Depth (cm)	Consistence			Porosity		Cutans			Roots		Effervescence	Other Features
	Dry	Moist	Wet	S	Q	Type	Thickness	Quantity	Size	Quantity	Dil HCl	
0-16	h	fr	ss sp	f,m	C	-	-	-	vf,f; m	c; f	-	-
16-41	-	vfr	spo	m, c	C	T	tn	p(w)	vf,f; m	c; f	-	-
41-62	-	vfr	spo	m, c	C	T	tn	p	vf,f	c	-	-
62-89	-	vfr	spo	m, c	C	T	tn	p	vf,f	f	-	-
89-115	-	vfr	ssp	-	-	-	-	-	vf,f	f	ev	-

Please refer Appendix I for the abbreviations

Series: HAYATHNAGAR **BM SPOT: 19 (RED SOILS)**

PROFILE NO: P38 ***System: Agriculture (Sorghum - Castor)*** **(LM)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 764 mm	Classification: Loamy-skeletal, mixed, isohyperthermic, *Typic Rhodustalfs*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: CRIDA Research Farm, Hayathnagar (Village & Mandal), Rangareddy, Andhra Pradesh		Sampling Date: 16.12.2001

Physical Properties of Profile No. 38 (Hayathnagar, Rangareddy)

Laboratory No.	Horizon	Depth (cm)	Size class and particle diameter (mm)			Fine clay (%) (<0.0002)	Fine clay/ total clay (%)
			Total				
			Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)		
			←----------(% of <2 mm) ----------→				
3376	Ap	0-16	72.8	9.8	17.4	16.0	92.0
3377	Bt1	16-41	59.3	12.0	28.7	23.4	81.5
3378	Bt2	41-62	45.6	18.8	35.6	27.9	78.4
3379	Bt3	62-89	64.1	13.0	22.9	17.9	78.2
3380	Cr	89-115	65.2	13.6	21.2	17.5	82.5

Depth (cm)	BD (Mgm^{-3})	COLE	HC ($cmhr^{-1}$)	WDC (%)
0-16	-	0.1	-	-
16-41	-	0.1	-	-
41-62	-	0.1	-	-
62-89	-	0.1	-	4.4
89-115	-	-	-	3.7

- *Nil or not determined (wherever applicable)*

Series: HAYATHNAGAR **BM SPOT: 19 (RED SOILS)**

PROFILE NO: P38 ***System: Agriculture (Sorghum - Castor)* (LM)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 764 mm	Classification: Loamy-skeletal, mixed, isohyperthermic, *Typic Rhodustalfs*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: CRIDA Research Farm, Hayathnagar (Village & Mandal), Ranga Reddy, Andhra Pradesh		Sampling Date: 16.12.2001

Chemical Properties of Profile No.38 (Hayathnagar, Rangareddy)

Depth (cm)	pH (1:2)		EC (1:2) (d Sm^{-1})	OC (%)	$CaCO_3$ (%)	Clay CO_3 (%)
	H_2O	1*N* KCl				
0-16	5.2	4.2	0.05	1.1	0.4	-
16-41	6.0	4.8	0.07	0.8	0.6	-
41-62	6.3	5.1	0.07	0.7	0.7	-
62-89	7.2	6.5	0.17	0.5	1.5	69.5
89-115	7.4	6.7	0.19	0.4	1.5	67.6

Depth (cm)	Extractable bases				CEC	Clay CEC	BS (%)	ESP
	Ca	Mg	Na	K				
	←----------[cmol(p+)kg^{-1}]----------→							
0-16	3.2	2.7	0.7	0.2	7.5	15	272	13
16-41	7.1	3.8	0.7	0.2	10.3	36	115	7
41-62	8.1	7.3	0.6	0.2	17.2	48	94	3
62-89	15.4	7.0	0.7	0.2	21.1	92	110	3
89-115	15.0	4.5	0.8	0.2	20.1	95	102	4

- *Nil or not determined (wherever applicable)*

Series: HAYATHNAGAR **BM SPOT: 19 (RED SOILS)**

PROFILE NO: P38 ***System: Agriculture (Sorghum - Castor)*** **(LM)**

CLIMATE: SEMI-ARID (DRY) RAINFALL: 764 mm	Classification: Loamy-skeletal, mixed, isohyperthermic, *Typic Rhodustalfs*	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: CRIDA Research Farm, Hayathnagar (Village & Mandal), Rangareddy, Andhra Pradesh		Sampling Date: 16.12.2001

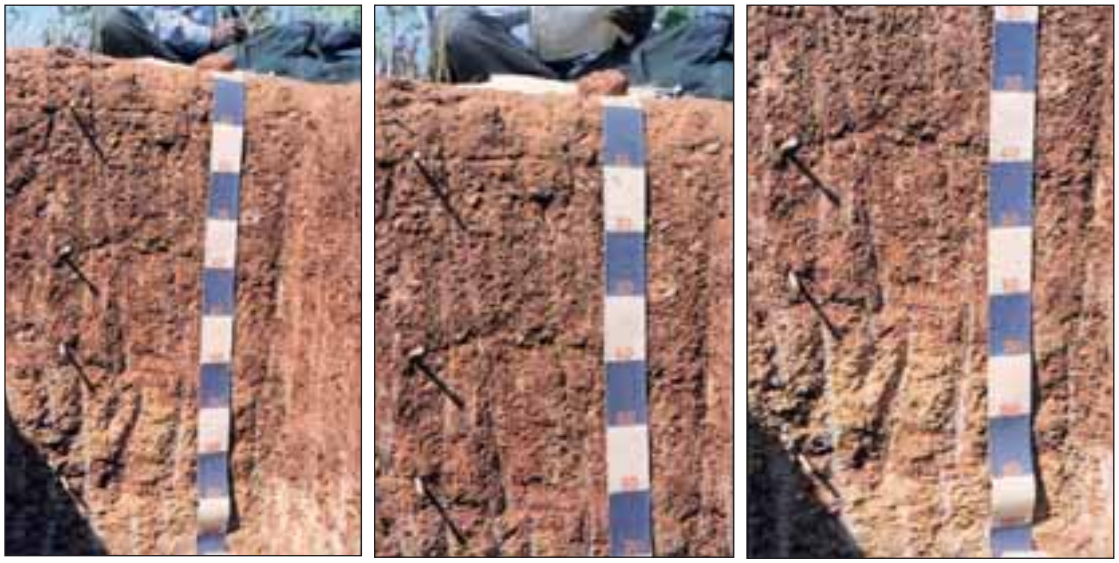
Climatic Datasets of Hayathnagar (Rangareddy), Andhra Pradesh

Month	Mean temp (^{o}C)	Rainfall (mm)	PET (mm)	½ PET (mm)	LGP (days)
January	21.60	1.70	109.80	54.90	0.00
February	24.00	11.40	129.50	64.75	0.00
March	27.40	13.40	181.50	90.75	0.00
April	30.30	24.10	197.80	98.90	0.00
May	32.40	30.00	219.90	109.95	0.00
June	29.10	107.40	196.40	98.20	30.00
July	26.00	165.00	140.40	70.20	31.00
August	25.80	146.90	135.50	67.75	31.00
September	25.60	163.30	119.30	59.65	30.00
October	25.00	70.80	123.60	61.80	31.00
November	22.40	24.90	104.10	52.05	0.00
December	20.60	5.50	98.60	49.30	0.00
Average	25.85	*764.40*	*1756.40*	*878.20*	*total LGP 1453*

Landscape, Landuse and Soils in Benchmark spot 19 (Hayathnagar, HM, Rangareddy, A.P.)

Benchmark Spot at Hyderabad and the participants.

Benchmark spot at Hayathnagar, Rangareddy, Andhra Pradesh, under agricultural system (low management) with sorghum-castor crop rotation.



Typical Hayathnagar profile (Typic Rhodustalfs).

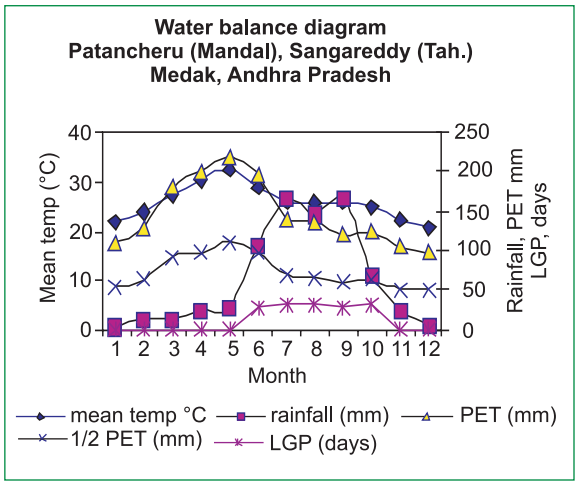
BM Spot 21 : PATANCHERU – Permanent Fallow P41

Classification : Fine, mixed, isohyperthermic *Typic Rhodustalfs*

Location : Plot No. RUS6B in ICRISAT Farm, Manmul, Patancheru, Sangareddy, Medak, A.P., Lat 17°28'36"N Long 78°16'54"E

Physiographic position : Deccan Plateau – boarder of granites and granite-gneiss and basalt

Topography and slope: Very gently sloping, 1-3% (50-150 m)



Drainage : Well drained

Vegetation : *Yerragada*, *kasigadda*, grass and *relachettu*

Landuse : Permanent fallow (grassland)

Parent material : Weathered granites and gneisses

Sampled by : P. Chandran, S.K. Ray, M.V. Venugopalan, S.L. Durge

Date of collection: 18.12.2001

Remarks : Termite activity up to 65 cm. First 4 cm of the profile consists of mainly earthworm casts (70-80% v/v). A few calcareous nodules are present which effervescence with HCl. In general, the walls of the profile do not effervesce. Usually these nodules are softer and brighter than the calcareous nodules commonly found. For the last 7-10 years, it is under grass vegetation.

A1	0-4 cm	Strong brown (7.5YR 4/6D) and dark brown (7.5YR 3/4M&R) sandy loam; earthworm casts; granular structure; hard, friable, slightly sticky and non-plastic; many very fine, common fine roots; slightly acidic (pH 6.4); 70-80% earthworm casts; 3-5% fine gravels; abruptly smooth boundary.
A2	4-11 cm	Dark reddish brown (5YR 3/4D) and reddish brown (5YR 5/4M) sandy loam; moderate medium subangular blocky structure; slightly hard, friable, slightly sticky and non-plastic; many very fine, common fine roots; many very fine, fine, medium and coarse pores; slightly acidic (pH 6.2); 3-5% fine gravels; abruptly smooth boundary.
Bt1	11-38 cm	Dark red (2.5YR 3/6M) clay; strong medium subangular blocky structure with slight pressure faces on surface of peds; friable, sticky and plastic; thin patchy clay cutans on surface of peds and channels; many very fine, a few fine roots; common very fine and fine few medium roots; slightly acidic (pH 6.1); 3-5% fine gravels; clear, smooth boundary.
Bt2	38-65 cm	Dark red to dark reddish brown (2.5YR 3/3.5M) clay; strong medium subangular blocky structure with slight pressure faces on surface of peds; friable, sticky and plastic; common very fine roots; common very fine and fine pores; slightly acidic (pH 6.1); 8-10% fine gravels; gradual smooth boundary.
Bt3	65-79 cm	Dark red to dark reddish brown (2.5YR 3/3.5M) clay; moderate medium subangular blocky structure; friable, sticky and non plastic; thin patchy clay cutans on surface of peds; common very fine roots; common very fine and fine pores; 80-85% gravels and stones, mainly vein of quartz and feldspars; medium acidic (pH 6.0); clear, smooth boundary.

BC	79-109 cm	Dark red to dark reddish brown (2.5YR 3/3.5M) sandy clay; weak medium subangular blocky structure; friable, sticky and non-plastic; very weakly developed, broken and disintegrated clay cutans; common very fine roots; common very fine and fine pores; 30-35% fine gravels; slightly acidic (pH 6.4); clear, smooth boundary.
C	109-163 cm	Strong brown (7.5YR 4/6M) weak, fine subangular blocky structure; very friable, slightly sticky and non-plastic; a few very fine roots; few fine lime nodules which are softer and brighter than the commonly found lime nodules; neutral reaction (pH 6.6); slightly to strongly effervescent due to nodules (matrix do not effervesce).

Series: PATANCHERU **BM SPOT: 21 (BLACK SOILS)**

PROFILE NO: P41 ***System: Permanent Fallow***

CLIMATE: SEMI-ARID (DRY) RAINFALL: 764 mm	Classification: Fine, mixed, isohyperthermic, *Typic Rhodustalfs*.	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: ICRISAT Research Farm (RUS6B), Manmul (Near Telapur Gate), Patancheru (Mandal), Sangareddy, Medak, Andhra Pradesh		Sampling Date: 18.12.2001

Morphological Properties of Profile No. 41 (Patancheru, Medak)

Horizon	Depth (cm)	Boundary		Matrix color		Texture	Coarse fragments (%) (fg and cg)	Structure		
		D	T	Dry	Moist			Size	Grade	Type
A1	0-4	c	s	7.5YR4/6	7.5YR3/4(M&R)	sl	3-5 (70-80)*	-	-	gr
A2	4-11	a	s	5YR3/6	5YR5/4	sl	3-5	m	2	sbk
Bt1	11-38	c	s	-	2.5YR3/6	sc	3-5	m	3	sbk
Bt2	38-65	g	s	-	2.5YR3/3.5	c	8-10	m	3	sbk
Bt3	65-79	c	s	-	2.5YR3/3.5	c	cg,st 80-85	m	2	sbk
BC	79-109	c	s	-	2.5YR3/3.5	scl	30-35	m	1	sbk
C	109-163	-	-	-	7.5YR4/6	scl	40-45	f	1	sbk

Depth (cm)	Consistence			Porosity		Cutans			Nodules (conca)		Roots		Effervescence	Other Features
	Dry	Moist	Wet	S	Q	Type	Thick-ness	Qty	Size	Qty	Size	Quantity	Dil HCl	
0-4	h	fr	sssp	-	-	-	-	-	-	-	vf; f	n;c	-	-
4-11	sh	fr	sssp	vf,f;m	n;c	-	-	-	-	-	vf; f	n;c	-	-
11-38	-	fr	sp	f,f; c	n;f	T	tn	p	-	-	vf; f	n;f	-	Slight Pressure faces
38-65	-	fr	sp	vf,f	c	T	tn	p	-	-	vf	c	-	Slight Pressure faces
65-79	-	fr	spo	vf,f	c	T	tn	p	-	-	vf	c	-	-
79-109	-	fr	ssp	vf,f	c	T	tn	p (w)	-	-	vf	c	-	-
109-163	-	vfr	sspo	-	-	-	-	-	f	f	vf	f	e-es**	-

**Mainly consists of termite activity up to 65 cm. Earthwarm cast*
*** A few soft calcareous nodules are present, which effervesces with HCL*

Please refer Appendix I for the abbreviations

Series: PATANCHERU **BM SPOT: 21 (BLACK SOILS)**

PROFILE NO: P41 ***System: Permanent Fallow***

CLIMATE: SEMI-ARID (DRY) RAINFALL: 764 mm	Classification: Fine, mixed, isohyperthermic, *Typic Rhodustalfs*.	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: ICRISAT Research Farm (RUS6B), Manmul (Near Telapur Gate), Patancheru (Mandal), Sangareddy, Medak, Andhra Pradesh		Sampling Date: 18.12.2001

Physical Properties of Profile no 41 (Patancheru, Medak)

Laboratory No.	Horizon	Depth (cm)	Size class and particle diameter (mm)			Fine clay (%) (<0.0002)	Fine clay/ total clay (%)
			Total				
			Sand (2-0.05)	Silt (0.05-0.002)	Clay (<0.002)		
			←----------(% of <2 mm) ----------→				
3394	A1	0-4	66.7	15.4	17.9	12.5	69.8
3395	A2	4-11	74.7	10.8	14.5	11.0	75.8
3396	Bt1	11-38	50.6	5.3	44.1	37.3	84.6
3397	Bt2	38-65	35.9	11.5	52.6	41.9	79.6
3398	Bt3	65-79	34.8	12.0	53.2	40.9	76.9
3399	BC	79-109	50.4	14.4	35.2	25.9	73.6
3400	C	109-163	61.1	16.4	22.5	17.5	77.8

Depth (cm)	BD (Mgm^{-3})	COLE	HC ($cmhr^{-1}$)	WDC (%)
0-4	-	0.04	-	-
4-11	-	0.03	-	-
11-38	1.6	0.11	-	-
38-65	1.7	0.16	-	-
65-79	-	0.14	-	-
79-109	1.7	0.12	-	-
109-163	1.8	0.12	-	-

- *Nil or not determined (wherever applicable)*

Series: PATANCHERU **BM SPOT: 21 (BLACK SOILS)**

PROFILE NO: P41 ***System: Permanent Fallow***

CLIMATE: SEMI-ARID (DRY) RAINFALL: 764 mm	Classification: Fine, mixed, isohyperthermic, *Typic Rhodustalfs*.	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: ICRISAT Research Farm (RUS6B), Manmul (Near Telapur Gate), Patancheru (Mandal), Sangareddy, Medak, Andhra Pradesh		Sampling Date: 18.12.2001

Chemical Properties of Profile No. 41 (Patancheru, Medak)

Depth (cm)	pH (1:2)		EC (1:2) (d Sm^{-1})	OC (%)	$CaCO_3$ (%)	Clay CO_3 (%)
	H_2O	1*N* KCl				
0-4	6.4	5.8	0.17	3.1	0.6	-
4-11	6.2	5.1	0.05	1.6	0.4	-
11-38	6.1	5.1	0.03	1.0	0.6	-
38-65	6.1	4.8	0.05	0.7	0.8	-
65-79	6.0	4.7	0.06	0.6	0.8	-
79-109	6.4	4.7	0.05	0.4	0.9	-
109-163	6.6	4.6	0.04	0.2	0.9	-

Depth (cm)	Extractable bases				CEC	Clay CEC	BS (%)	ESP
	Ca	Mg	Na	K				
	← ----------[cmol(p+)kg^{-1}]----------→							
0-4	4.2	3.8	0.8	1.2	10.0	36	120	8
4-11	3.3	3.4	0.6	0.3	10.0	24	76	6
11-38	8.3	3.3	0.7	0.3	11.3	26	111	6
38-65	12.5	5.2	0.8	0.3	18.2	35	103	4
65-79	12.4	5.9	0.7	0.4	21.1	40	92	3
79-109	14.8	5.7	0.8	0.2	23.1	66	93	4
109-163	16.3	5.0	0.9	0.3	22.2	100	101	4

- *Nil or not determined (wherever applicable)*

Series: PATANCHERU **BM SPOT: 21 (BLACK SOILS)**

PROFILE NO: P41 ***System: Permanent Fallow***

CLIMATE: SEMI-ARID (DRY) RAINFALL: 764 mm	Classification: Fine, mixed, isohyperthermic, *Typic Rhodustalfs*.	Analysis at: Division of Soil Resource Studies, NBSS&LUP, Nagpur.
Location: ICRISAT Research Farm (RUS6B), Manmul (Near Telapur Gate), Patancheru (Mandal), Sangareddy, Medak, Andhra Pradesh		Sampling Date: 18.12.2001

Climatic Datasets of Patancheru, Medak District, Andhra Pradesh

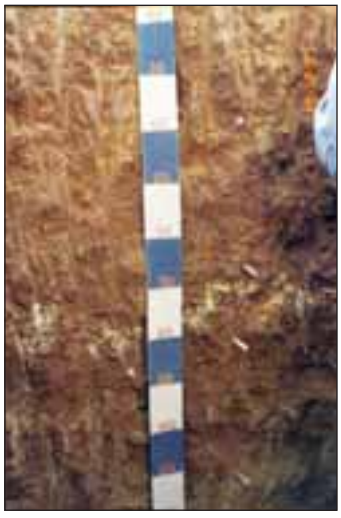
Month	Mean temp (^{o}C)	Rainfall (mm)	PET (mm)	½ PET (mm)	LGP (days)
January	21.60	1.70	109.80	54.90	0.00
February	24.00	11.40	129.50	64.75	0.00
March	27.40	13.40	181.50	90.75	0.00
April	30.30	24.10	197.80	98.90	0.00
May	32.40	30.00	219.90	109.95	0.00
June	29.10	107.40	196.40	98.20	30.00
July	26.00	165.00	140.40	70.20	31.00
August	25.80	146.90	135.50	67.75	31.00
September	25.60	163.30	119.30	59.65	30.00
October	25.00	70.80	123.60	61.80	31.00
November	22.40	24.90	104.10	52.05	0.00
December	20.60	5.50	98.60	49.30	0.00
Average	25.85	*764.40*	*1756.40*	*878.20*	*total LGP 1453*

Landscape, Landuse and Soils in Benchmark Spot 21 (Patancheru, Medak, A.P.)

Spot at Patancheru, Medak, Andhra Pradesh, under permanent fallow with grass vegetation for the last 7-10 years

Earthworm casts bigger than 4 cm are common in Patancheru soils

Closer view of the profile.



Still closer view of the profile

Typical Patancheru soil profile (Typic Rhodustalfs)

ANNEXURE-I

KEY to abbreviations

Boundary

D - Distinctness	T – Topography
a – abrupt c – clear g – gradual d – diffuse	s – smooth w – wavy i – irregular b – broken

Colour
D – dry M – moist R - rubbed

Texture	
s – sand lfs – loamy fine sand ls – loamy sand sl – sandy loam l – loam	sil – silty loam si – silt sic – silty clay c – clay scl – sandy clay loam cl – clay loam sc – sandy clay sicl – silty clay loam

Structure

Size	Grade	Type
vf – very fine f – fine m – medium c – coarse vc – very coarse	0 structurless 1 weak 2 medium 3 strong	abk – angular blocky sbk – subangular blocky gr – granular m – massive sg – single grain cpr – columnar pr – prismatic pl – platy cr - crumb

Coarse fragments
fg – fine gravel (<2.5 cm) cg – coarse gravel (2.5-7.5 cm) st – stone (7.5 – 25 cm) b – boulders (>25 cm)

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

Porosity, Nodules and Roots	
S = Size	Q = Quantity
vf – very fine f – fine m – medium c – coarse	f – few c – common m - many

Effervescence (e)
e – slight es – strong ev - violent

Cutans		
Type	Thickness	Quantity
T – Argillan Fe – Ferran Mn – Mangan O – Organ	th – thin mtk – moderately thick tk – thick	p – patches b – broken c - continuous

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The National Bureau of Soil Survey and Land Use Planning (NBSS&LUP), Nagpur, a premier Institute of the Indian Council of Agricultural Research (ICAR), was set up in the year 1976 with the objective to prepare soil resource maps at state and district level and to provide research inputs in soil resource mapping, and its applications, land evaluation, land use planning, land resource management, and database management using GIS for optimising land use on different kinds of soils in the country. The Bureau has been engaged in carrying out agro-ecological and soil degradation mapping at the country, state and district level for qualitative assessment and monitoring the soil health towards viable land use planning. The research activities have resulted in identifying the soil potentials and problems, and the various applications of the soil surveys with the ultimate objective of sustainable agricultural development. The Bureau has the mandate to correlate and classify soils of the country and maintain a National Register of all the established soil series. The Institute is also imparting in-service training to staff of the soil survey agencies in the area of soil survey and land evaluation, soil survey interpretations for land use planning. The Bureau in collaboration with Dr.Panjabrao Deshmukh Krishi Vidyapeeth, Akola is running post-graduate, teaching and research programme in land resource management, leading to M.Sc. & Ph.D. degrees. Recently the Bureau has been actively engaged in the research work under National Agricultural Technology Project (NATP).

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