The Pharma Innovation Journal 2020; 9(6): 621-628

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.03
TPI 2020; 9(6): 621-628

www.thepharmajournal.com
Received: 22-04-2020
Accepted: 24-05-2020

MR Wahane
Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Maharashtra, India

JP Sharma
National Bureau of Soil Survey and Land Use Planning, Nagpur, Maharashtra, India

NA Meshram
Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Maharashtra, India

SS More
Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Maharashtra, India

NH Khobragade
Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Maharashtra, India

Corresponding Author:
MR Wahane
Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Maharashtra, India

Evaluation of cotton based cropping system in relation to landforms and soil properties in a micro-watershed

MR Wahane, JP Sharma, NA Meshram, SS More and NH Khobragade

Abstract
The soil survey was undertaken and evaluated prominent cropping systems and soil suitability for various crops in an area of Kokarda Village in Kalmeshwar Tahsil of Nagpur District of Maharashtra and studied eight typifying pedons and belongs to Entisols, Inceptisols and Vertisols types of order. The soil chemical and physical properties are affected by the landform and the geology of the region to a larger extent. The land suitability evaluation indicated that the soils had good potential for crop production because of their better rooting depth, high clay of smectitic nature associated with high cation exchange capacity (CEC) and plant available water capacity with a high base status. The soils were placed in higher suitability class for different crops due to their physical and chemical properties. All the soil units are not equally suitable for cotton-based cropping system, whereas the summit crests and shoulder slopes are moderately suitable and foot slopes (lower) soils are marginally suitable for cotton- wheat system. The soils of foot slopes (upper) are unsuitable for any cropping system. In the toe- slopes, the soils are deep and marginally suitable for cotton-gram system. The soils occurring in main valley-side slopes are very deep and highly suitable for cotton-fallow, marginally suitable for cotton-gram and moderately suitable for cotton-wheat systems, respectively. Overall and on the basis of soil evaluations, the suitable soil and cropping management strategies may be adopted to improve the productivity of cotton-based cropping systems.

Keywords: Soil classification, characterization, watershed, soil suitability, fertility status.

Introduction
Land evaluation is the ranking of soil units on the basis of their capabilities to provide highest returns per unit area and conserving the natural resources for future use. The land suitability evaluation for field crops forms a prerequisite for land use planning (Sys *et al.* 1991). Land suitability classification is specific type of land evaluation system suitable for both qualitative and quantitative evaluation. Land suitability classification analysis for crop production becomes paramount important aspect for enhancing agricultural production and productivity at regional setting. The FAO (1976) framework is a set of principles and concepts from which land evaluation can be established to suit the local conditions. Systematic study of morphology and taxonomy of soils provides information on nature and type of soils, their constraints, potentials, capabilities and their suitability for different uses (Sehgal, 1999). Watershed management practices change the land use, vegetative cover and other non-structural and structural actions that are taken to achieve the management objectives. The information on the effect of agronomic management on different crops is available in plenty. But the same on soil intrinsic properties and landforms, on different crops and cropping systems and their suitability, which is dictated by soil properties and climate is lacking, hence the present investigation was undertaken.

Materials and methods
Study area and climate: The study area was covered 279.8 ha and situated at village Kokarda in Kalmeshwar Tahsil of Nagpur District of Maharashtra State and located at 21010'18"N latitude and 78010'28"E longitude, falls under Agro-ecological sub-region (AESR) 10.2 represented by Eastern Plateau hot sub-humid ecosystem with shallow to medium deep black soils with length of growing period (LGP) being 180-210 days. The general elevation ranges between 380 and 350 m above MSL with a relief amplitude of 30 m. The climate of the area is sub-tropical, sub-humid with well-expressed with mean annual rainfall ranges from 800 to 1200 mm which is mostly received during south-west monsoon period. The mean annual temperature varies from 18.67 to 31.29 0C and rising to 450C in summer.

Geology and geomorphology: The area was covered by layers of basaltic lavas of lower Eocene to Upper Cretaceous age commonly known as “Traps”. Geomorphologically, this area divided into summit crests, shoulder slopes, escarpments, foot slopes, toe slopes and main valley side slopes. A detailed geomorphological site analysis was measured cross-sections from the bevelled crest of the basaltic spur summits to the drainage floors for identifying different landforms.

Soil sampling and analysis: Based on the slope analysis of Kokarda microwatershed, eight typifying pedons were selected in such a way that they will represent most of the landform units. Soil profiles were positioned in the centre of each geomorphological site and studied for their morphological characters (Soil Survey Staff, 1993) by horizon-wise. The soil samples were analysed for physical and chemical properties using the established standard analytical methods.

The studied pedons were classified tentatively using USDA system of Soil Taxonomy (Soil Survey Staff 1998). The physical and chemical properties of soils were studied by using standard procedure described by Richards (1954), Jackson (1973), Coughlan *et al.* (1986). The land evaluation was carried out following the approach of FAO (1976) and Sys *et al.* (1991). The crop requirements and its adaption information’s were collected by the farmers near by the site area. The crop requirement criteria of suitability of soil for important crops of the area were compared with the existing soil-site conditions. The criteria of limitation were determined as given by methodology of Sys *et al.* (1991).

Results and discussion

Morphological and Physical properties: The geological formation of the area mainly consists of basalt. Summit crests, shoulder slopes, escarpment slopes, foot slopes, toe slopes, interfluves slopes and entrenched valley floor are the main geomorphic units identified in the study area. The soils occurring on summit crests, shoulder slopes, escarpments, upper and lower foot slopes are very shallow to shallow having depth 10 to 40 cm, while those occurring on the toe slopes and main valley slopes were deep (150 cm). The colour of soil is varied according to their physiographic position and drainage conditions. The soil colour ranged from very dark gray (2.5 YR) to very dark greyish brown (10 YR). The soils of main-valley side slopes and shoulder slopes exhibited 10 YR hue throughout all the pedons. The chroma was low due to reduction of iron under the influence of relatively drainage and stable landform (Gaikawad *et al.* 1974). It is observed that, the soil developed on the erosive surface are shallower due to less percolation of rain water and more runoff favouring soil loss, while deep soils are found where deposition occurs (Tamgadage *et al.* 1984; Srivastava *et al.* 1991). The surface soils showed moderate, medium, sub angular blocky structure, while the sub surface horizons have developed strong, coarse, angular blocky structure due to high clay content. The soils of main-valley side slopes found well developed wedge shaped structural aggregates in the subsoil may be due to swell- shrink phenomenon of smectite clay which results in development of slickensides. The highest amount of coarse fragments observed in soils of shoulder slope shows irregular trend of increase down the profile related to topographic position. Hence, more calcium carbonate accumulated in lower layers. The texture was clay in the surface and subsurface horizon of all the pedons of Kokarda micro-watershed, being the parent material of these soils is known to produce higher amount of clay (Eswaran *et al.* 1988). The texture of summit crests, shoulder slopes and main valley-side slopes are relatively finer in texture as compared to those in the escarpments, foot slopes (upper and lower) indicating that the soils become finer and finer as one moves from higher to lower relief. The clay content increased with increasing in depth. This may be due to partly caused by beating action of fine soils from surface. The surface soil showed moderate, medium, sub angular blocky structure, while, the sub surface horizon have developed strong, coarse, angular blocky structure due to high clay content. The soils of main valley side slopes found well developed wedge shaped structural aggregates in the sub soil may be due to swell-shrink phenomenon of smectite clay which results in development of slickenside. The sand content ranges between 3 to 55 per cent in the escarpments and foot slopes (upper) whereas, the sand content was observed upto 50 per cent in the main valley side slopes and plain areas. The clay content varies from 56 to 78 per cent being highest in summit crest, shoulder slopes and main valley side slopes while lower in escarpments, foot slopes (upper and lower) varying from 26 to 33 per cent. The increase in clay content down the slope may be due to migration of finer fractions and their deposition down the slope. The bulk density of the air-dry clod ranges from 1.37 to 1.89 Mg m-3 and found to increase down the slope due to the increase in clay content (Table 1, 2). The bulk density increases with depth which may be due to overburden pressure causing compaction in the subsurface horizon, while, the surface soils are less compacted due to high amount of organic matter and plant roots (Virmani *et al.* 1982; Coughlan *et al.* 1986).

Chemical properties: The soil reaction ranges from 5.5 to 8.6 which are moderately acidic to moderately alkaline in nature. The pH increases from soils of summit crest to lower sections of main valley side slopes in all soils due to the removal of bases and calcium carbonate form the upslope position and its deposition to the down slope (Sharma *et al*. 1996). It is also observed that the pH increases in soil with depth due to accumulation of calcium carbonate and bases in the lower horizons. Electrical conductivity of the soils found in low range 0.05-0.11 d Sm-1 within the safe limit for growing of crops. Organic carbon content of the soils ranges from 0.23 to 0.75 per cent. In surface layer of pedon 5, organic carbon was observed high i.e., 1.05 per cent which might be because of the soils only occasionally cultivated which favours more addition of organic matter and less oxidation of carbon due to tillage operations. Calcium carbonate content of the soils ranges from 10.66 to 21.46 per cent. It was higher in lower horizons which might be due to the leaching of soluble salts and process of calcification prevailing in the subsurface.

Cation exchange capacity (CEC) showed variation in all the soil profiles and ranged from 29.76 to 63.36 cmol (p+) kg-1. The CEC values largely influenced by the high clay content in black soils are attributed to their smectite clay mineralogy (Pal and Deshpande, 1987). The dominance of exchangeable Ca++ and Mg++ followed by Na+ and K+ was found in all profiles. In plain area exchangeable calcium decrease whereas the exchangeable magnesium content increases possibly due to free lime in the sub soils. Base saturation ranges from 32.49 to 99.27 per cent which was found to increase down the slope as well as showed increasing trend with depth.

Table 1: Morphological characteristics of the soils of study area

Horizon	Depth (cm)	Boundary		Martixcolour (Munsell notation)		Texture	Structure			Consistence			Porosity		Roots		Nodules		Effervences	Other features
		D	T	D	M		S	G	Ty	D	M	W	S	Q	S	Q	S	Q		
Typifying Pedon 1-Shoulder Slopes																				
A	0-5	a	s	5YR3/3	5YR3/3	C	f	1	sbk	s	fr	sp	vf-f	m	vf	f	-	-	-	-
Bw1	5-20	a	w	10YR3/2	10YR3/3	C	c	3	abk	h	fi	vsvp	f	c	vf	f	-	-	-	-
Bw2	20-42	a	w	10YR3/2	10YR3/3	C	c	3	abk	h	fi	vsvp	f	c	vf	f	-	-	-	-
Cr	42-65	-------------------Weathered basalt------------------																		
Typifying Pedon 2-Escarpments																				
A	0-12	a	w	7.5YR3.5/4	7.5YR3/3	sicl	m	2	sbk	sh	fi	sp	vf-f	m	vf	c				
Cr	12-50	-------------------Weathered basalt------------------																		
Typifying Pedon 3-Foot Slopes (Lower)																				
Ap	0-5	c	s	7.5YR3/2	7.5YR3/2	c	vf	2	sbk	sh	fr	sp	f-m	m	vf	f	vf-f	m	es	-
Bw1	5-22	c	w	10YR3/2	10YR2/2	c	m	3	sbk	h	fr	vsvp	f-m	c	vf	c	vf	c	es	-
Bw2	22-37	a	w	10YR3/1	10YR3/1	c	m	3	abk	-	fi	vsvp	vf	m	vf	f	vf	m	es	pf
Cr	37-70	-------------------Weathered basalt------------------																		
Typifying Pedon 4-Toe Slopes																				
Ap	0-15	c	s	10YR3/2	10YR3/2	C	f	1	sbk	s	fr	sp	f-m	m	vf	f	vf-f	m	es	-
Bw	15-48	c	s	10YR3/2	10YR3/2	C	m	2	sbk	h	fr	vsvp	vf	m	vf	c	vf-f	m	es	-
Bss1	48-67	a	s	10YR3/1	10YR3/1	C	m	2	abk	vh	vfr	vsvp	vf	m	vf	m	vf-f	m	es	ss
Bss2	67-93	a	s	10YR3/2	10YR3/2	C	c	3	abk	eh	vfi	vsvp	vf	m	vf	f	vf-f	m	ev	ss
Bss3	93-117	a	w	10YR3/2	10YR3/2	C	c	3	abk	eh	fi	vsvp	vf	m	-				ev	ss
Cr	117-170	-------------------Weathered basalt------------------																		
Typifying Pedon 5-Main Valley-side Slopes																				
Ap	0-24	c	s	10YR3/2	10YR3/2	C	m	2	sbk	sh	fr	sp	vf	m	m	c	vf	f	e	-
Bw1	24-42	c	s	10YR3/3	10YR3/3	C	m	2	sbk	sh	fr	sp	vf	c	-	-	vf	f	e	-
Bw2	42-67	c	s	10YR3/2	10YR3/2	C	m	2	abk	sh	fi	vsvp	vf-f	c	-	-	vf-f	c	es	-
Bw3	67-89	a	s	10YR3/2	10YR3/2	C	m	3	abk	h	fi	vsvp	vf-f	c	-	-	vf-f	c	es	-
Bss1	89-104	a	s	2.5Y3/2	2.5Y3/2	C	c	3	abk	vh	vfi	vsvp	vf	f	-	-	vf-f	c	ev	ss
Bss2	104-126	a	s	2.5Y3/2	2.5Y3/2	C	c	3	abk	vh	vfi	vsvp	vf	f	-	-	vf-f	c	ev	ss
Bss3	126-155	-	-	2.5Y3/2	2.5Y3/2	C	c	3	abk	vh	fi	vsvp	vf	f	-	-	vf-f	m	ev	ss
Cr		-------------------Weathered basalt------------------																		
Typifying Pedon 6-Shoulder Slopes																				
Ap	0-10	c	s	5YR3/2	5YR3/4	C	f	2	sbk	h	fr	vsvp	vf	m	vf	f	-	-	-	-
A2	10-25	a	w	5YR3/3	5YR3/3	C	m	2	sbk	h	fr	vsvp	vf	m	vf	-	-	-	-	-
Cr	25-35	-------------------Weathered basalt------------------																		
Typifying Pedon 7-Summit Crests																				
Ap	0-20	a	s	10YR3/2	5YR3/2	C	m	2	sbk	sh	fr	sp	f	f	vf-f	-		-	-	-
Cr	20-36	-------------------Weathered basalt------------------																		
Typifying Pedon 8-Foot Slopes (Upper)																				
Ap	0-15	a	w	10YR5/3	10YR3/3	Scl	m	1	sbk	sh	fr	sp	vf	m	vf-f	f	-	-	-	-
Cr	15-25	-------------------Weathered basalt------------------																		

Table 2: Physicochemical properties of soils of the study area

Horizon	Depth (cm)	Coarse fragments (%)	pH (1:2.5) Soil:Water	EC(1:2.5) Soil:Water	OC (%)	Particle size distribution (mm)			Textural class	Bulk density (air dry) (Mg m^{-3})	CEC cmol (p+) kg-1	BS (%)
						Sand	Silt	Clay				
Typifying Pedon 1-Shoulder Slopes												
A	0-5	30.0	7.1	0.10	0.75	2.6	19.9	77.5	c	1.87	54.72	96.76
Bw1	5-20	10.0	6.9	0.09	0.64	2.9	20.1	77.0	c	1.85	55.68	74.94
Bw2	20-42	-	7.4	0.11	0.57	5.3	16.2	78.5	c	1.89	56.64	75.79
Typifying Pedon 2-Escarpments												
A	0-12	20.0	7.0	0.06	0.70	19.6	47.4	33.0	sicl	1.42	30.72	90.26
Typifying Pedon 3-Foot Slopes (Lower)												
Ap	0-5	10.0	8.2	0.15	0.70	19.1	22.3	58.6	c	1.67	56.64	99.77
Bw1	5-22	5.0	8.2	0.13	0.57	16.1	10.4	73.5	c	1.82	62.30	98.49
Bw2	22-37	5.0	8.2	0.15	0.53	22.6	10.3	68.0	c	1.81	63.36	87.70
Typifying Pedon 4-Toe Slopes												
Ap	0-15	10.0	8.3	0.12	1.05	19.7	24.8	55.5	c	1.61	52.80	100.43
Bw	15-48	5.0	8.3	0.14	0.80	18.4	20.0	61.6	c	1.72	58.56	98.65
Bss1	48-67	10.0	8.4	0.14	0.70	20.3	20.7	59.0	c	1.72	62.40	100.86
Bss2	67-93	5.0	8.4	0.19	0.62	13.3	19.5	67.2	c	1.80	63.36	96.95
Bss3	93-117	10.0	8.4	0.19	0.55	30.6	17.4	52.0	c	1.57	47.04	98.72
Typifying Pedon 5-Main Valley-side Slopes												
Ap	0-24	15.0	8.1	0.17	0.66	11.6	32.4	56.0	c	1.49	53.76	100.48
Bw1	24-42	10.0	8.2	0.15	0.52	14.8	28.7	56.5	c	1.51	58.68	93.70
Bw2	42-67	15.0	8.3	0.16	0.46	36.9	4.1	59.0	c	1.70	56.64	94.42
Bw3	67-89	15.0	8.4	0.17	0.44	6.0	38.0	56.0	c	1.60	52.80	91.57
Bss1	89-104	10.0	8.5	0.19	0.43	17.0	21.0	62.0	c	1.77	65.64	78.64
Bss2	104-126	15.0	8.5	0.25	0.41	18.0	17.5	64.5	c	1.79	57.60	91.28
Bss3	126-155	20.0	8.6	0.24	0.33	20.9	18.5	60.5	c	1.72	68.56	94.65
Typifying Pedon 6-Shoulder Slopes												
Ap	0-10	10.0	5.8	0.16	0.77	8.5	25.0	66.5	c	1.69	45.12	87.16
A2	10-25	10.0	6.8	0.04	0.73	9.2	24.3	66.5	c	1.62	47.04	89.22
Typifying Pedon 7-Summit Crests												
Ap	0-20	30.0	7.1	0.07	0.61	15.7	25.8	58.5	c	1.58	50.58	90.42
Typifying Pedon 8-Foot Slopes (Upper)												
Ap	0-15	20.0	7.2	0.05	0.23	54.6	17.5	27.9	scl	1.37	29.76	98.42

The relatively higher base saturation in surface layer could be attributed to the recycling of basic cations through vegetation. The available nitrogen in the soil was observed low to medium ranges from 106.40 to 407.68 kg ha-1 and decreases with depth wise. It was found highest in the main valley side slopes (Pedon 5) i.e., 407 kg ha-1 due to continuous cropping, where the land should not keep follow. The soils were observed low to medium in available phosphorus ranging from3.56 to 24.11kg ha-1. The available potassium status of the soil was low to medium 84.63 to 689.47 kg ha-1. The available potassium was observed very low in pedon 2 which was 84.63 kg ha-1, indicated good availability of K to the crops (Table 3). The available K was found to increase with depth, which may be due to the presence of more clay in the lower horizons which fixes more K, while in the surface horizons, K was released from non-exchangeable and fixed fraction to maintain dynamic equilibrium among the different forms (Kadrekar, 1977; Das *et al.* 1993).

Table 3: Chemical properties of soils of the study area

Horizon	Depth (cm)	pH (1:2.5) soil:water	EC (1:2.5) soil:water	Org.C (%)	CaCO3 (%)	Ca++	Exchangeable cations Mg++	Na+	K+	Sum	CEC cmol(p+)kg-1	Base Saturation
------------cmol(p+)kg-1 ------------- (%)												
Pedon 1-Clayey, smectitic, hyperthermic Vertic Haplustepts												
A	0-5	7.1	0.10	0.75	3.18	37.14	14.45	0.83	0.53	52.59	54.72	96.76
Bw1	5-20	6.9	0.09	0.64	3.07	27.99	12.36	0.68	0.69	41.73	55.68	74.94
Bw2	20-42	7.4	0.11	0.57	3.42	29.81	11.81	0.55	0.75	42.93	56.64	75.79
Pedon 2-Clayey, mixed, hyperthermic Lithic Ustorthents												
A	0-12	7.0	0.06	0.70	2.49	15.88	11.46	0.23	0.15	27.73	30.72	90.26
Pedon 3- Clayey, smectitic, hyperthermicVertic Haplustepts												
Ap	0-5	8.2	0.15	0.70	12.73	48.53	6.82	0.49	0.67	56.51	56.64	99.77
Bw1	5-22	8.2	0.13	0.57	14.65	49.80	10.53	0.54	0.59	61.46	62.30	98.49
Bw2	22-37	8.2	0.15	0.53	20.04	37.95	16.44	0.52	0.67	55.57	63.36	87.70
Pedon 4- Fine, smectitic, hyperthermic (calcareous) Typic Haplusterts												
Ap	0-15	8.3	0.12	1.05	10.66	38.89	12.51	0.59	1.04	53.03	52.80	100.43
Bw	15-48	8.3	0.14	0.80	14.06	30.46	26.01	0.68	0.62	57.77	58.56	98.65
Bss1	48-67	8.4	0.14	0.70	15.04	23.56	37.87	0.91	0.59	62.94	62.40	100.86
Bss2	67-93	8.4	0.19	0.62	16.59	22.33	37.21	1.33	0.57	61.43	63.36	96.95
Bss3	93-117	8.4	0.19	0.55	17.74	17.07	27.39	1.56	0.43	46.44	47.04	98.72
Pedon 5- Fine, smectitic, hyperthermic (calcareous) Typic Haplusterts												
Ap	0-24	8.1	0.17	0.66	12.94	36.66	16.10	0.61	0.64	54.02	53.76	100.48
Bw1	24-42	8.2	0.15	0.52	13.28	30.50	20.32	0.76	0.52	52.10	58.68	93.70
Bw2	42-67	8.3	0.16	0.46	21.03	19.43	32.64	0.85	0.56	53.48	56.64	94.42
Bw3	67-89	8.4	0.17	0.44	21.16	24.75	22.03	1.03	0.53	48.35	52.80	91.57
Bss1	89-104	8.5	0.19	0.43	21.22	20.07	22.49	1.29	0.59	44.44	65.64	78.64
Bss2	104-126	8.5	0.25	0.41	21.24	17.26	33.27	1.48	0.58	52.58	57.60	91.28
Bss3	126-155	8.6	0.24	0.33	21.48	17.43	35.56	1.88	0.56	55.43	68.56	94.65
Pedon 6- Clayey, smectitic, hyperthermic Lithic Haplustepts												
Ap	0-10	5.8	0.16	0.77	2.37	23.74	15.00	0.44	0.15	39.33	45.12	87.16
A2	10-25	6.8	0.04	0.73	2.60	27.09	14.27	0.38	0.23	41.97	47.04	89.22
Pedon 7- Clayey, smectitic, hyperthermic Lithic Ustorthents												
Ap	0-20	7.1	0.07	0.61	2.83	29.90	14.78	0.54	0.79	46.01	50.58	90.42
Pedon 8- Clayey, mixed, hyperthermic Lithic Ustorthents												
Ap	0-15	7.2	0.05	0.23	2.72	17.97	10.71	0.35	0.27	29.29	29.76	98.42

Soil-landform relationship

The detailed geomorphological site analysis was carried out by measured cross-section the identification of various landform units, the processes acted / acting upon them and their evaluation (Table 4). The soils on the summit crest i.e. highest landform of the study area, shallow soils encountered. Immediately below the summit crest, the solum depth increased to about 25-40 cm with clayey texture and were classified as shoulder slope. The escarpment slope are occurring below the shoulder slopes, the upper and lower edges of this landform is marked by angular slope discontinuities and showed shallow soil development. On the foot slope, sudden changes in the slope angle are encountered. This unit is having angular discontinuity on the upper margins with escarpment slopes and a gently curved inflexion with the lower margins towards the toe-slopes. Below the foot slopes toe-slopes are occurring marked by gentle curved inflexion. The slope angles are further reduced and become shallower. The interfluves slopes are the landforms occurring in between the entrenched valley floors and as such, these are on the lowest elevation in the study area. This landform has the planner slopes with 160 cm soil depth and shows well differentiated surface and subsurface horizons (Table 1, 2).

Table 4: Climatic and soil-site characteristics of mapped units

Landform characteristics	Shoulder slope (P1)	Escarpment slope (P2)	Foot slope – Lower (P3)	Toe slope (P4)	Main valley side slope (P5)	Shoulder slope (P6)	Summit crest (P7)	Foot slope – Upper (P8)
Climatic Characteristics								
Total Rainfall (mm)	1043.8	1043.8	1043.8	1043.8	1043.8	1043.8	1043.8	1043.8
Rainfall growing season (mm)	930.4	930.4	930.4	930.4	930.4	930.4	930.4	930.4
Relative humidity (%)	55.85	55.85	55.85	55.85	55.85	55.85	55.85	55.85
Length of growing season (days)	180-210	180-210	180-210	180-210	180-210	180-210	180-210	180-210
Mean temp. growing season (0C)	25.38	25.38	25.38	25.38	25.38	25.38	25.38	25.38
Mean max. temp.growing season (0C)	32.50	32.50	32.50	32.50	32.50	32.50	32.50	32.50
Mean min temp. growing season (0C)	18.25	18.25	18.25	18.25	18.25	18.25	18.25	18.25
Length of dry spells (weeks) July beginning August (end)	18.25 - -	18.25 - -	18.25 - -	18.25 - -	18.25 - -	18.25 - -	18.25 - -	18.25 - -
Site Charactseristics								
Slope (%)	3-8	15-30	1-3	1-3	0-1	1-3	0-1	3-8
Erosion	Moderate	Severe	Moderate	Very slow	None/V. slow	Moderate	Moderate	Severe
Drainage -Fine and medium -Coarse soils	M. well -	- Excessive	M. well -	Imperfect -	Well -	M. well -	Somewhat excessive -	Somewhat excessive -
Flooding	No	No	No	Occasional	No	No	No	No
PAWC (mm m-1)	31.10	36.00	117.64	254.10	237.10	41.50	30.00	4.50
Stoniness (Surface)	< 3	3-15	< 3	< 3	< 3	< 3	3-15	< 3
Soil Characteristics								
Texture	Clay	Silty clay loam	Clay	Clay	Clay	Clay	Clay	Sandy clay laom
Coarse fragments (Vol. %) -Within 50cm -Below 50 cm	13.33 -	20.00 75-80	70 80-90	6.66 -	14.28 -	10.00 -	30.00 -	20.00 -
Depth (Cm)	42	12	37	117	155	25	20	15
CaCO3 (%)	3.22	2.49	17.04	15.84	18.09	2.48	2.83	2.72
Gypsum (%)	-	-	-	-	-	-	-	-
Soil Fertility								
CEC (soil) cmol (p+) kg-1	55.68	30.72	54.48	55.84	55.95	46.08	50.88	29.76
BS (%)	82.49	90.26	93.72	99.27	92.10	88.19	90.42	98.42
OC (%) (0-15 cm)	0.69	0.70	0.63	1.05	0.66	0.75	0.61	0.23
EC (dSm-1)	0.103	0.066	0.148	0.167	0.192	0.104	0.068	0.052
pH	7.1	7.0	8.2	8.4	8.3	6.3	7.1	7.2

Statistical analysis: The effect of soil depth, nitrogen, phosphorus and potassium content for different crop yield was analysed through multivariate regression analysis. From the data, it was observed that the yield of cotton and sorghum was dependent on soil depth and nitrogen content whereas phosphorus and potassium content of soil was not influence significantly on cotton yield.

Y = 2.23 + 0.055 x1 + 0.0007 x2 - 0.0057 x3 - 0.0037 x4 (R=0.968) for cotton
Y = 6.8 + 0.0345 x1 + 0.00067 x2 - 0.0163 x3 - 0.007 x4 (R=0.977) for sorghum
Soil depth was influence on soybean yield. It indicated that as growing season of soybean experienced variability in rainfed, thereby soybean yield was directly dependent on soil depth.
Y= 10.79 + 0.0309 x1 + 0.0010 x2 – 0.0284 x3 - 0.00716 x4 (R=0.816)
Wheat is grown usually on stored moisture or with limited irrigation in the area. The soil depth and phosphorus content was deciding factor for wheat yield.
Y=8.82 + 0.0397 x1 + 0.004 x2 – 0.022 x3 – 0.00388 x4 (R=0.892) where, x1=soil depth (cm), x2= soil available nitrogen kg ha-1, x3= soil available phosphorus kg ha-1 and x4= soil available potassium kg ha-1

Soil-site suitability evaluation: Land evaluation is ranking of soil units on the basis of their capabilities under circumstances including levels of management and socio-economic conditions to produce highest returns per unit area and at the same time conserving the natural resources for future use (Van Wambeke, 1987). The climate and soil-site characteristics of the mapped soils of the watershed area completely matched with the soil-site suitability criteria for different crops (Table 5). Based on the number and degree of limitations, the overall degree of limitation for each mapped soil unit was determined and suitability class for crop evaluated. Based upon the degree of limitation in each landform, it was observed that the soils developed in lower plain and in main valley is highly suitable (S1). The soils of upper plain *viz*. shoulder slopes, foot slopes (lower) and toe slope are marginally suitable (S3) with severe limitations of soil depth, drainage, pH and coarse fragment. The limitations of soil depth, coarse fragments are in-correctable while, those pertaining to fertility and erosion can be corrected by the application of amendments and introducing green manuring crop in crop rotation, respectively. The soils of summit crest, escarpments and foot slopes (upper) are presently and potentially unsuitable for cotton cultivation owing to severe erosion and shallow depth. Pigeonpea is an important pulse crop commonly grown as intercrop with cotton in Vidarbha region. The data showed that the soils of summit crest, shoulder slopes, foot slopes (lower), toe slopes and main valley side slope are marginally suitable (S3) and that of escarpments and foot slopes (upper) are presently and potentially unsuitable as determined by using soil-site suitability model Sehgal *et al*. (1989). The soils representing toe slopes and main valley side slopes being deep, fine and moderately well drained are moderately suitable (S2) for sorghum. The soils of summit crest, shoulder slopes, foot slopes upper and lower are marginally suitable (S3) due to limitation of soil depth. The soils of escarpment are presently and potentially unsuitable (N1) due to their severe slope, erosion, excessive drainage, limiting soil depth and low PAWC. The overall suitability class for groundnut in each landform showed that the soils developed in shoulder slopes, toe slopes and main valley side slopes are marginally suitable (S3), having limitations of soil depth and texture, limitations of soil depth, texture and pH for toe slopes and main valley side slopes respectively. Some soils of summit crests and foot slopes of upper and lower are presently unsuitable (N1) because of limiting soil depth. The soils of escarpments are unsuitable (N2) due to severe limitations of non-correctable soil site characteristics. The soils developed on toe-slopes and main valley side slopes are moderately suitable (S2) having moderate limitation of pH. Soils of shoulder slopes and foot slopes and foot slopes (lower) are marginally suitable (S3) because limitations of soil depth and organic carbon. The soils of summit crests and escarpments are presently unsuitable (N1) because of limitation of soil depth, drainage and organic carbon. The soils of foot slopes (upper) are unsuitable. Though the adoption of appropriate conservation measures in order to check soil erosion and to improve land qualities such as plant available water capacity, these soils are marginally suitable except soils of escarpments.

Table 5: Soil-suitability for different mapped unit in the micro-watershed

Pedon	Present land use	Suitability class
P1	Cotton-Fallow Cotton-Wheat	Marginally suitability (S3) Moderately suitability (S2)
P2	Forest	-
P3	Cotton-Wheat Cotton/Tur-Wheat Cotton-Gram Soybean-Wheat Sorghum-Wheat	Marginally suitable (S3) Marginally suitable (S3)- Unsuitable (N2) Marginally suitable (S3) Marginally suitable (S3) Marginally suitable (S3)
P4	Tur/Cotton-Fallow Sorghum-Wheat Soybean-Wheat Cotton-Gram	Marginally suitable (S3) Moderately suitable (S2) Moderately suitable (S2) Marginally suitable (S3)
P5	Cotton-Fallow Sorghum-Wheat Soybean-Wheat Cotton-Gram	Highly suitable (S3) Moderately suitable (S2) Moderately suitable (S2) Marginally suitable (S3)
P6	Cotton/Tur-Fallow Cotton-Wheat Gram	Marginally suitable (S3) Moderately suitable (S2) Marginally suitable (S3) Unsuitable (N2)
P7	Cotton-Fallow Cotton-Wheat Sorghum-Fallow	Presently unsuitable (N1) Presently unsuitable (N12) Moderately suitable (S2) Marginally suitable (S3)
P8	Cotton-Fallow Cotton-Wheat Groundnut-Wheat Sorghum-Fallow	Presently unsuitable (N1) Presently unsuitable (N1) Presently unsuitable (N1) Marginally suitable (S3)

Conclusion
It can be concluded that the soils of main valley side slopes are highly suitable for cotton- fallow, marginally suitable for cotton-gram and moderately suitable for cotton-wheat, soybean-wheat, and sorghum-wheat cropping systems. The soils of summit crests, shoulder slopes, escarpments and foot slopes are on eroded surfaces and shallow in depth. These soils are marginally suitable for cotton, pigeon pea, soybean, sorghum and wheat crops. The soils of foot slopes found to be deep and moderately suitable for cotton-gram, cotton-wheat, cotton/pigeon pea-wheat, sorghum- wheat, soybean-wheat cropping system, respectively. The soils of summit crests, shoulder slopes, escarpments and foot slopes are also marginally suitable for pigeon pea-cotton-fallow cropping systems. `

Acknowledgement
Authors are highly grateful to the Director, National Bureau of Soil Survey and Land Use Planning (ICAR) for providing facilities during soil survey and laboratory analysis to carry out the research work.

References
1. Coughlan KJ, McGarry D, Smith GD. The physical and mechanical characterization of *Vertisols*. In first Regional Seminar on management of Vertisols under semi-arid conditions IBSRAM Proceedings. 1986; 6:89-106.
2. Das K, Singh SK, Shyampura RL. Forms of potassium in

relation to landform and soil properties of basaltic terrain. Journal of the Indian Society of Soil Science. 1993; 41(3):557-559.
3. Eswaran H. Role of soil information in meeting the challenges of sustainable land management. Journal of the Indian Society of Soil Science. 1992; 40(1):6-24.
4. FAO. A framework for land evaluation. FAO Soils Bull. 32, FAO, Rome, Italy, 1976, 72p.
5. Gaikwad ST, Rao YS, Verma HKG. Characteristics of catenary soils developed on basalt parent rocks in Nagpur District of Maharashtra state. Journal of the Indian Society of Soil Science. 1974; 22(2):181-190.
6. Jackson ML. Soil chemical analysis. Prentice Hall of India, New Delhi, 1977; pp.111 -203. Kadrekar, SB. Vertical distribution of soil potassium. Indian Journal of Agricultural Chemistry,1977; 10(11/2):71-80.
7. Pal DK, Deshpande SB. Characteristics and genesis of minerals in some benchmark Vertisols of India. Pedology. 1987; 37(3):259-275.
8. Richards LA. Diagnosis and improvement of saline and alkaline soils. Agrilcultural Handbook No. 60, USDA, Washington, DC, 1954, 160p.
9. Sehgal JL. Pedology: Concept and Applications, Kalyani Publishers, Ludhiana, India, 1999.
10. Sehgal JL, Challa O, Gajja BL, Yadav SC. Suitability of swell-shrink soils of India for crop growth. *In*: Van Cleemput *et al.*, ed. Soil for Development, ITC-Ghent, 1989; Publ. Series No. 1989; 1:1129-1153.
11. Sharma SS, Totawat KL, Shyampura RL. Characterisation and classification of soils in a topo-sequence over basaltic terrain. Journal of the Indian Society of Soil Science. 1996; 44:470-475.
12. Soil Survey Staff. Soil Survey Manual, USDA, Washignton, 1993.
13. Soil Survey Staff. Keys to Soil Taxonomy 8th ed., USDA, Washignton, 1998.
14. Srivastava R, Prashad Jagdish, Tamgadge DB. Soil physiographic relationship in Ujjan District of Madhya Pradesh for land use planning. National Geographical Journal of India. 1991; 87(3):246-252.
15. Sys C, Van Ranst E, Debaveye J. Land evaluation Part I, II. Re-edited volumes of publication No.7 of the General Administration of Cooperation Development, Brussels, Belgium, 1991, 274p.
16. Tamgadge DB, Kalbande AR, Bhattacharjee JC. Charactersitics of the soils in relation to geomorphic setting in Bastar District, Madhya Pradesh. Journal of Maharashtra Agricultural University. 1984; 9(2):135-138.
17. Virmani SM, Saharawat KL, Burford JR. Physical and Chemical properties of *Vertisols* and their management. Chapter in Vertisols and Rice soils in Tropics. Trans of 12th International Congress Soil Science, New Delhi, India, 1982, 274p.