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SOIL-SITE SUITABILITY AND EVALUATION FOR SOYBEAN CROP ON SOME VERTISOLS OF MARATHWADA REGION OF MAHARASHTRA STATE

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ABSTRACT

A study was conducted in arid and semi-arid zones of Marathwada region of Maharashtra during 2011-12. Six soil profiles on different topographic condition were chosen at Nanded, Latur, Osmanabad and Beed districts of Marathwada region. These profiles were examined for soil site properties such as climate, depth, texture, structure and drainage. Physico-chemical properties such as pH, EC, Organic carbon, CEC, $CaCO_3$ content, available micro nutrient contents, bulk density, hydraulic conductivity, sand, silt and clay were also studied,. Morphological analysis showed that surface structure was weak, and sub surface structure was sub angular to angular blocky. Soil color showed dark grayish brown to very dark gray in color. Drainage was moderately well in all soils except P4, P5 and P6, which were showed imperfect drained. Soils were clayey in texture the clay per cent ranged from 50.1 % to 62.1 %, sand ranged from 9.7 % to 21.6 % and silt varied from 25.1% to 32.9 %. The bulk density range from 1.27 to 1.56 Mg m^{-3}. Hydraulic conductivity ranged from 0.1. to 5.3 cm hr^{-1}. The pH ranges showed that soils were moderately to strongly alkaline in reaction. Organic carbon ranged from 1.95 to 10.04 g kg^{-1}, calcium carbonate ranged from 2.8 to 19.0 % and CEC ranged from 38.2 to 78.2 cmol $p^{(+)}$ kg^{-1}. Based on field morphology and laboratory characterizations, the soil of the study area classified to Vertisols of great group Haplusterts. The all soil profiles were classified as Typic Haplusterts at great group level except pedon P6 is Vertic Haplusterts. Soil profile when correlated with yield it was concluded that pedon P5 Typic Haplusterts belonging to order Vertisols were best soils for soybean growing that order.

Keywords: soil classification, Marathwada region, soil site characteristics, soybean, Vetrisols

INTRODUCTION

Variation in soil properties from place to place arise from differences in parent material, climate, topography, biosphere and the age of ground surface. Even if the parent material does not vary, the variation in physiography in a given area significantly affects the soil properties and, in turn, nutrient availability. The information regarding effect of physiography on nutrient availability is limited except that reported by (Meena*, et. al.,* 2010). Therefore, an investigation was carried out to study the landform-nutrients availability relationship in soybean growing Vertisols of arid and semiarid part of Marathwada region of Maharashtra.

In Maharashtra, most of the soils have developed over basaltic parent material and are heavier in texture. These soils are classified as Vertisols and associated soils (very deep to very shallow) as per USDA soil classification system (Anonymous,.1951). A survey in Maharashtra showed that black soil having depth of ~ 60 cm, constituting 45 percent of an area in 1910 was reduced to 18 percent after 50 years. The remaining 27 per cent almost got turn to shallow soils category (Abrol, 1991). It was also reported by Bhaskar *et al.,* (1987) that shallow, medium deep and deep soils cover 36.2, 38.1 and 25.7 per cent area, respectively in the state. Thus, shallow soil covers larger area as compared to deep soils.

The important crops grown in the study area, Marathwada were soybean, pigeon pea and cotton. Deep soils with high clay content pore management problem due to water logging and require greater draft in cultivation. The clay content in soil generally increased with depth indicating movement of clay from surface to sub surface layers. Very high profile water storage capacity was observed in Vertic Haplusterts and high profile water storage capacity was observed in Typic Haplusterts.

There is need of location specific research attention on delineation of available N, P and K status of soils and their deficiencies and toxicities, affecting the crop growth. Such study is felt necessary now more than ever before. Hence, estimation of soil fertility status of Vertisols of Marathwada region was undertaken. For effective planning and better utilization of soil resources, information relating to soil-site suitability for cultivation of soybean is necessary.

MATERIALS AND METHODS

The study area was chosen arid and semi arid 6.1- Drought Prone zone at Osmanabad, Latur and Beed districts, Nanded is moderately high rainfall zone of Marathwada region. The geology at the area is basalts of the Deccan trap. Six sites on different macro topographic conditions were selected and nomenclature the soils of the study area as, P1 to P5 are Typic Haplusterts and P6 is Vertic Haplusterts. The profiles were exposed and examined on each selected site. The morphological characteristics such as structure, texture, consistence, pores, roots, nodules, effervescence, coarse fragment and other feature like deep cracks were observed as seasonal dry and wet periods produced short-term cycles of soil surface crack area density (crack density). Horizon wise soil samples were collected as per the guidelines given by Anonymous (1951). In addition, the site characteristics such as location, slope, and climate were also studied. Soil samples were collected for each soybean growing soil profile (horizon-wise). The properties air dried, processed and passed through 2 mm sieve for laboratory analysis. Soil properties like particle size distribution were determined as per the international pipette method. Bulk density was determined by dry clod waxing technique, Hydraulic conductivity was determined by constant head method. The pH and EC were measured in 1:2.5 soil-water suspension, cation exchange capacity (CEC) was determined by 1 NaO Ac at pH 8.2 exchangeable Ca^{2+} was determined by KCI-triethanolamine method followed by EDTA titration and organic carbon was determined by Walkley and Black method. Calcium carbonate equivalent was determined by acid neutralization method of Black *et al.,* (1965). Available nitrogen by permanganate method (Subbian and Asija, 1956), available phosphorus by Olsen *et. al.,* (1954) and available potassium by ammonium acetate extractant Jakson, (1973). Available zinc, copper, iron and manganese were extracted by 0.005 M DTPA solution (Lindsay and Norvell, 1978) and analyzed with the help of Atomic Absorption Spectrophotometer.

RESULTS AND DISCUSSION

The characteristics of the six soil sites are presented in excavated the representative soil profile. The details about location of soil profile, name of soil series, latitude and longitude, mean annual rainfall (MAR), mean annual temperature (MAT) (^{0}C), topography, drainage and slope are given in Table 1. The soils of pedon P1, P2, P5 and P6 plateau in topography to be slightly undulating, that of pedon P3 and P4 were subdued plateau. The slop and drainage were recorded to be 0-3 % except pedon P3, moderate well and imperfect of all pedon. The variation in morphological characteristic of six profiles indicated that the soil vary in depth and color considerably depending upon the topographic situation. The morphological characteristics showed considerable variation in the nature and degree of horizon development reported by Raina (2008). The morphology of the Vertisols indicated that the soils were deep to very deep (100 cm to more than 120 cm). The cracks were 2 to 10 cm wide at the surface and extended up to a depth of 50 cm. The pressure faces were observed in all the profiles. Slicken sides were well developed and were tilted to an angle 45-60 degree from all horizontal.

The peds broke into small sub angular blocky to angular blocky peds. The soils were very dark grey to dark yellowish brown (10YR 3/1 to 10YR 5/1).The surface horizons of all the pedons generally had sub angular blocky structure and slightly hard to hard (dry) and friable to moderately friable (moist) condition and very sticky and very plastic in wet condition of consistency (Table 2). In pedons 1, 2, 3, 4 and 5 the effervescence (with 10% HCl) was slight, where as in pedons 6, it was strong to violent, which attributed process of diffuse powdery from of $CaCO_3$. Calcium carbonate was observed throughout the depth of all soils. The Soil texture is an inherent property of soil that determines the makeup of primary particles and it controls mainly air, water and nutrient availability to the plant. It could be judged considering sand 16.57 (%), 28.74 (%) and clay 54.7 (%). The data indicated that all the soils were clayey in texture. Per cent clay ranged from 50.1% (pedon 1) to 62.1 % (pedon 6), whereas the sand per cent ranged from 9.7 (pedon 6) to 21.6 (pedon 1) and silt per cent ranged from 25.1 (pedon 2) to 32.9 (pedon 5). It is also observed that the clay distribution below the profile for all soils was almost uniform suggesting of their

Table 1: Soil site characteristics of soybean growing Vertisols of Marathwada region

Location	Latitude	Longitude	MAR (mm)	MAT (^{0}C)	Topography	Drainage	Slope %
Beed P1	18^{0}95”48	75^{0}75”80	699.4	25.15	Plateau	moderately Well	1-3
Govindpur P2	18^{0}63”96	76^{0}78”70	736.2	25.8	Subdued Plateau	moderately Well	2-3
Wadgaon P3	18^{0}28”68	76^{0}09”97	708.4	25.8	Subdued Plateau of inter hill	Imperfect	1-3
Latur P4	18^{0}41”96	76^{0}61”85	743.5	26.7	Plateau	moderately Well	1-3
Babulgaon P5	19^{0}24”93	75^{0}61”37	743.5	26.7	Plateau	Imperfect	1-3
Hadgaon P6	19^{0}16”34	77^{0}45”89	905.6	28.3	Plateau	Imperfect	0-3

***** *MAR*
***** *MAT*

development from their same kind of parent material under same climatic condition. Macro topography must have been played key role in the profile development (Pal *et al.,* 2000).

Physical properties of soybean growing Vertisols of Marathwada region

The uniformity in clay distribution is attributed to the movement of finer soil particles along with runoff water from higher topographic position to lower situation and pedoturbation in Vertisols (Sharma and Ray Choudhari, 1988). Bulk density of pedon ranged from 1.27 Mg m^{-3} (pedon 5) to 1.56 Mg m^{-3} (Pedon 6). The increase in dry bulk density is indicative of the compactness of the soil, which is highly correlated with fine clay content of the soil (Ahuja *et.al*., 1988). The hydraulic conductivity ranged from 0.1 cm hr^{-1} (P4 and P5) to 5.3 cm hr^{-1} (P3). Pedon P4 and P5 were found to be the poorly drained depth of soil which showed the low hydraulic conductivity which might be due to presence of Mg^{2+} in the subsurface origin. In general hydraulic conductivity decreased with depth (Table 3).

Chemical properties of soybean growing Vertisols of Marathwada region

The chemical properties of soil are presented in (Table 4). The pH data indicated that the soil were generally moderate to strongly alkaline in reaction with pH varying between 7.8 (P2) to 8.7 (P6). The increase in soil pH below the slope and at lower depth may be attributed to the accumulation of the alkaline earth salts (Kadu,. *et. al.,* 2003). It may be further stated that calcareousness of soil might be due to its formation form basalt rich in calcium (Ca^{2+}) and high or moderately alkaline earth, which leads to neutral to alkaline conditional as reported by Kaushal *et al.,* (1986). Slight variation in electric conductivity (1:2.5 soil: water suspension) was observed with increase in soil depth. This might be due to leaching of salts from surface to down below through the percolating water, followed by evapotranspiration resulting in the salt accumulation in the subsurface horizon. Similar to this observation Rajankar (1990) also reported that increase in depth i.e. the surface horizon is associated with variation in electric conductivity. The organic carbon data indicated that, organic carbon content decreased with depth in all studied soils. This content ranged from 1.95 g kg^{-1} (P6) to 10.04 g kg^{-1} (P5). This might be due to sieving effect and adsorption of fine organic particles and water soluble organic matter by soil particles. The calcium carbonate content varied from 2.8 % (P1) to 19.0 % (P4). The high calcium carbonate in soil affect the water holding capacity of soil which has great bearing on crop production under rainfed condition. Calcium carbonate affects the physical and chemical characteristics of soil and may prevent root penetration (Sys, 1985). The CEC ranged from 38.2 cmol (P^+) kg^{-1} (P6) to 78.2 cmol (P^+) kg^{-1} (P5). The cation exchange capacity of these black soils is attributed to its smectitic clay mineralogy (Pal and Deshpande, 1987). The high cation exchange capacity is attributed to the high amount of clay. Since soils under study had low to moderate organic carbon status, clay fraction appeared to influence largely the CEC value. This might be due to basaltic parent material (weathered rock and alluvium) which are basic in nature (Pal *et al.,* 2000).

Nutrient status of soybean growing Vertisols of Marathwada region

The available N, P and K ranged from 62.7 to 334.8, 1.00 to 27.00 and 229.6 to 618.2 kg ha^{-1}, respectively in different pedons and in general, these contents decreased with the soil depth (Table 5). The variation in available N content in soil could be attributed to the differences in their physiographic, differential cultivation and better management practices of this soil but also removed of N by the crop, losses through leaching, denitrification and fixation and valorization. Some nitrogen is immobilized by soil microbes. These results were in confirmatory with results reported by Malewar *et. al.,* (1998), and Malode and Patil (2014).

The available Nitrogen was optimum in Ap horizons of P4, P2 and P5. Available P was optimum in surface horizon of P4 and low to deficient in other pedons. The available K was above optimum in P5, P4 and P6 and it was optimum in P1, P2 and P3.

Distribution of DTPA extractable micronutrients of soybean growing Vertisols of Marathwada region
Zinc

The DTPA-Zn varied from 0.46 to 1.39 mg kg^{-1} irrespective of depths and pedons. As per the critical limit of 0.6 mg kg^{-1} (Katyal 1985). In general soils of Marathwada are deficient in Zinc content. The Zn deficiency was not observed in P2, P3 and P4, whereas, sub surface of pedon P1, P2 and P5 are appeared to be deficient in Zn. The Zinc deficiency was noticed after 60 cm and 90 cm in pedon P4 and P1 and then other pedons respectively. Lower content of Zn in black soils is due to its fixation by clay (Manohar, 1974) or available Zn in these soils might be due to fact that under alkaline conditions, the zinc cations are changed largely to their oxides or hydroxides and there by lower the availability of zinc (Singh and Sekhon, 1991; and Tondan 1995). Soil pH, sand and silt also had negative correlation but organic carbon and clay had positive influence on DTPA-Zn in table no. 5 (Sharma *et al*., 1996; Patil, 2013 and Malode and Patil, 2014).

Copper

DTPA - extractable Cu content in the soils ranged from 0.59 to 4.23 mg kg^{-1} with a mean value of 2.66 mg kg^{-1} considering 0.2 mg kg^{-1} as critical limit for Cu for normal

Table 2. Morphological properties of soybean growing Vertisols of Marathwada region

Soil series	Depth (cm)	Horizon	Matric colour		Structure			SS/PF pressure faces	Soil Consistency	Slope %
			Dry	Moist	Size	Grade	Type			
Latur P1	Ap	0-25	10 YR 3/2	10 YR 3/2	m	2	Sbk	--	vh, vfi, vs, vp	1-3
	Bw1	25-60	10 YR 3/2	10 YR 3/2	m	2	Sbk	---	vh, vfi, vs, vp	
	Bw2	60-90	10 YR 3/1	10 YR 3/1	m	2	Sbk	PF	vh, vfi, vs, vp	
	Bssk	90-120	10 YR 3/1	10 YR 3/1	m	2	Sbk	SS	vfi, vs, vp	
Beed P2	Ap	0-15	10 YR 3/2	10 YR 3/3	m	2	sbk	-	vh, vfi, vs, vp	1-3
	A	15-27	10 YR 3/2	10 YR 3/3	m	2	sbk	-	vh, vfi, vs, vp	-
	Bw	27-60	10 YR 3/2	10 YR 3/1	m	2	sbk	PF	vh, vfi, vs, vp	
	Bssk	60-100	10 YR 3/1	10 YR 3/1	m	2	sbk/ abk	SS	vh, vfi, vs, vp	
Govindpur P3	Ap	0-15	10 YR 3/1	10 YR 3/2	m	2	sbk	-	sh, vfi, vs, vp	2-3
	A	15-30	10 YR 3/1	10 YR 3/1	m	2	Sbk	-	fi, vs, vp	
	Bw	30-60	10 YR 3/1	10 YR 3/1	m	2	sbk	PF	vfi, vs, vp	
	Bssk	60-105	10 YR 3/1	10 YR 3/1	m	2	sbk/ abk	SS	vfi, vs, vp	
Wadgaon P4	Ap	0-15	10 YR 3/3	10 YR 3/3	m	2	Sbk	--	sh, fi, vs, vp	1-3
	A	15-33	10 YR 3/2	10 YR 3/3	m	2	Sbk	--	fi, vs, vp	
	Bss1	33-65	10 YR 3/2	10 YR 3/3	m	2	Sbk	PF	vfi, vs, vp	
	Bssk	65-100	10 YR 3/2	10 YR 3/2	m	2	Sbk	SS	vfi, vs, vp	
Babulgaon P5	Ap	0-20	10 YR 3/1	10 YR 3/1	m	2	Sbk	--	vh, vfi, vs, vp	1-3
	Bw1	20-45	10 YR 3/1	10 YR 3/1	m	2	Sbk	--	vh, vfi, vs, vp	
	Bw2	25-90	10 YR 3/1	10 YR 3/2	m	2	Sbk	PF	vh, vfi, vs, vp	
	Bssk	90-110	10 YR 3/2	10 YR 3/2	m	2	Sbk	SS	vh, vfi, vs, vp	
Hadgaon P6	Ap	0-15	10 YR 5/1	10 YR 4/1	m	2	sbk	-	vfi, vs, vp	0-3
	A	15-40	10 YR 4/2	10 YR 4/1	m	2	sbk	-	vfi, vs, vp	
	Bw	40-65	10 YR 4/2	10 YR 4/1	m	2	sbk	PF	fi, vs, vp	
	Bssk	65-105	10 YR 4/2	10 YR 4/2	m	2	sbk/ abk	SS	fi, vs, vp	

Table 3. Physical properties of soybean growing Vertisols of Marathwada region

Pedon	Horizons	Depth (cm)	SHC (cm hr^{-1})	Bulk density (Mg m^{-3})	Particle size distribution (%)			Textural class
					Sand	Silt	clay	
Latur P1	Ap	0-25	1.0	1.30	21.6	28.4	50.1	c
	Bw1	25-60	1.4	1.31	18.03	30.27	51.7	c
	Bw2	60-90	1.1	1.40	16.1	30.8	53.1	c
	Bssk	90-120	0.9	1.42	15.8	28.3	55.8	cl
Beed P2	Ap	0-15	2.3	1.48	16.8	30.1	53.1	c
	A	15-27	2.8	1.51	14.6	29.8	55.6	c
	Bw	27-60	1.1	1.53	20.6	27.6	51.8	cl
	Bssk	60-100	0.2	1.53	16.1	25.1	58.9	cl
Govindpur P3	Ap	0-15	4.7	1.36	17.2	31.6	51.2	c
	A	15-30	5.3	1.41	16.1	31.1	52.7	cl
	Bw	30-60	1.9	1.39	15.8	29.1	55.1	cl
	Bssk	60-105	0.9	1.29	14.2	27	58.8	cl
Wadgaon P4	Ap	0-15	2.5	1.29	19.8	28.1	52.2	c
	A	15-33	2.7	1.32	17.9	28.4	53.7	c
	Bss1	33-65	0.9	1.36	16.2	28.2	55.6	c
	Bssk	65-100	0.4	1.27	14.9	27.8	57.3	cl
Babulgaon P5	Ap	0-20	1.0	1.39	21.2	26.7	52.1	c
	Bw1	20-45	2.1	1.48	20.3	26.5	53.2	cl
	Bw2	25-90	0.4	1.42	19.4	26.2	54.4	cl
	Bssk	90-110	0.1	1.41	10.1	32.9	56.8	cl
Hadgaon P6	Ap	0-15	0.5	1.52	15.8	27.1	57.1	c
	A	15-40	1.0	1.54	12.8	28.7	59.2	c
	Bw	40-65	0.4	1.56	16.7	31.8	51.2	c
	Bssk	65-105	1.9	1.55	9.7	28.3	62.1	c

plant growth (Katyal and Randhawa 1983). The highest content of available Cu in P3 and P4 might be due to presence of Cu minerals like chalcocite, cuprite etc. in the parent material (Patil and Sonar, 1994), reported that the available Cu content in swell-shrink soils of Maharashtra was between 1.3 to 6.1 mg kg^{-1} in table no. 5. The similar results were also reported by (Malewar and Randhawa 1978).

Iron

DTPA extractable Fe content in these soils varied between 3.00 to 7.21 mg kg^{-1} in different horizons in table no.5 considering the critical limit of 4.5 mg kg^{-1} for Fe (Lindsay and Norwell 1978). The Fe was deficient in sub-surface layer of P2 and P6 and the highest Fe content in soil was observed in pedon P5, P4 and P3 due to low amount of organic carbon and calcareous nature of these soils. (Sharma *et. al*., 2006 and Yelvikar *et. al*., 1996).

Manganese

DTPA extractable Mn content was found to vary between 2.36 to 21.89 mg kg^{-1} in different horizons which are above the critical limit for normal plant growth (3 mg kg^{-1}) suggested by (Thkkar *et. al.*, 1989). Available Mn content was significantly and positively correlated with organic carbon and clay P2 and P6 In general, Calcium carbonate decreased the availabilities of micronutrients owing to their insoluble hydroxides at higher pH (Sahoo *et.al.,* 1995). Contrary to it, organic carbon had positive influence on DTPA- micronutrients due to complexation table no. 5 (Hodgson 1963, Katyal and Sharma 1991).

Table 4. Chemical properties of soybean growing Vertisols of Marathwada region

Pedon	Horizo	Depth (cm)	pH	EC (dSm^{-1})	OC (g kg^{-1})	$CaCO_3$ (%)	CEC (cmolp+ kg^{-1})
Latur P1	Ap	0-25	8.1	0.291	6.82	2.8	55.8
	Bw1	25-60	8.0	0.287	6.24	3.8	52.1
	Bw2	60-90	8.3	0.337	4.29	3.0	62.5
	Bssk	90-120	8.3	0.345	3.51	5.0	40.5
Beed P2	Ap	0-15	8.0	0.270	6.24	4.1	59.2
	A	15-27	7.8	0.286	5.85	3.5	62.1
	Bw	27-60	8.1	0.231	5.62	8.6	62
	Bssk	60-100	7.9	0.261	3.31	11.2	59.1
Govindpur P3	Ap	0-15	8.1	0.254	9.94	4.8	45.4
	A	15-30	8.5	0.288	6.24	7.6	47.1
	Bw	30-60	8.3	0.346	5.24	9.0	51.6
	Bssk	60-105	8.4	0.560	2.92	11.0	41.3
Wadgaon P4	Ap	0-15	8.0	0.233	9.75	9.5	48.9
	A	15-33	7.9	0.269	7.21	11.0	51.5
	Bss1	33-65	7.9	0.204	5.46	15.8	56.3
	Bssk	65-100	8.1	0.290	4.09	19.0	40.3
Babulgaon P5	Ap	0-20	8.2	0.470	10.04	4.8	77.5
	Bw1	20-45	8.1	0.238	8.77	4.0	76.1
	Bw2	25-90	8.0	0.203	6.82	6.5	78.2
	Bssk	90-110	8.3	0.221	3.90	11.5	68.2
Hadgaon P6	Ap	0-15	8.4	0.635	6.24	7.5	45.5
	A	15-40	8.7	0.444	5.07	14.1	47.3
	Bw	40-65	8.4	0.591	3.51	7.8	66.2
	Bssk	65-105	8.5	0.600	1.95	18.9	38.2

Soil classification and soil site suitability of soybean crop

The clayey soil texture, poor drainage and poor rainfall distribution placed the soil under arid to semi-arid zones of Marathwada region. The soil site characteristics of soil units were matched with criteria (Table 6).

The suitability of different soil mapping units for various crops is presented in (Table 6). The optimum requirements of a crop are always region specific. Climate and soil-site parameters play a significant role in maximizing the crop yield. Based on the degree of limitation the soils were classified using USDA system of soil classification (Soil Surveys staff 2003). Soil suitability evaluation was carried out following FAO frame work (FAO 1983) and as per guide lines described by Sys *et.al,* (1991).

The soils of Typic Haplusterts (P1, P2, P3 and P4) were marginally suitable (S3) as there soils having marginal limitations of soil organic carbon and texture and pedon (P5) are moderately suitable (S2) for soybean. Whereas, Vertical Haplusterts (P6) were moderately suitable (S2) with marginally limitations and Pedon (P5) was highly suitable (S2) with very sever limitation of hydraulic conductivity for soybean crop. This suggested that Typic Haplusterts soils were suitable for both shallow and deep rooted crop soybean and other *viz*., pigeon pea) for suitable sustaining the productivity of soils in the study area.

CONCLUSION

It can be concluded from the available data that the soil of these arid and semi-arid region of Marathwada region are degraded due to hot dry weather. These soils characterized by high clay, calcareous, alkalinity, moderate well drainage

Table 5. Available macro nutrient status of soybean growing Vertisols of Marathwada region

Pedon	Horizon	Depth cm	Available macro nutrient (kg ha^{-1})			Available micronutrient (mg kg^{-1})			
			N	P	K	Fe	Mn	Zn	Cu
Latur P1	Ap	0-25	213.2	21.20	465.8	5.52	15.66	0.91	2.83
	Bw1	25-60	194.3	6.50	438.9	5.10	12.13	0.68	3.10
	Bw2	60-90	140.1	2.80	382.7	4.37	8.17	0.49	2.01
	Bssk	90-120	90.7	1.80	337.5	3.18	6.42	0.46	0.59
Beed P2	Ap	0-15	259.9	18.20	318.2	6.13	21.89	1.23	2.61
	A	15-27	125.4	2.80	404.7	4.20	14.39	0.92	3.11
	Bw	27-60	94.9	1.20	350.3	3.17	12.94	0.92	2.16
	Bssk	60-100	74.4	1.00	272.6	3.00	8.39	0.49	1.67
Govindpur P3	Ap	0-15	128.5	16.30	403.8	5.91	12.81	0.93	4.13
	A	15-30	134.8	8.90	427.1	4.76	13.80	1.11	4.12
	Bw	30-60	97.2	3.10	348.2	3.93	2.36	0.81	4.23
	Bssk	60-105	87.8	2.00	382.5	3.51	3.09	0.61	2.22
Wadgaon P4	Ap	0-15	206.9	27.10	583.8	6.20	15.42	1.39	3.90
	A	15-33	334.8	11.20	472.1	5.53	12.83	0.91	4.10
	Bss1	33-65	128.5	1.60	461.2	4.18	6.40	0.61	2.56
	Bssk	65-100	63.9	1.40	382.3	3.81	7.51	0.51	1.75
Babulgaon P5	Ap	0-20	225.8	16.10	618.2	7.21	13.18	0.47	3.32
	Bw1	20-45	100.4	3.20	512.7	5.16	15.54	0.90	4.11
	Bw2	25-90	81.5	2.10	348.7	4.71	10.59	0.81	2.42
	Bssk	90-110	69.6	1.60	317.2	3.58	5.63	0.68	1.56
Hadgaon P6	Ap	0-15	103.5	10.60	519.9	5.17	14.18	0.90	2.13
	A	15-40	222.7	4.60	303.9	3.90	12.37	0.81	1.98
	Bw	40-65	65.9	2.20	229.6	4.13	8.87	0.82	1.72
	Bssk	65-105	62.7	1.20	294.1	3.29	4.98	0.51	1.67

Table 6. Soil site suitability classes and yield of soybean growing Vertisols of Marathwada region

Pedon	Sys *et. al.*, (1991) and NBSS & LUP (1994) Soybean	Soil site suitability class with limitation (FAO.1983)		
		Yield q/ha^{-1}	% Yield optimum yield (25 q ha^{-1})	Suitability Class
Pedon-1	S2 (o)	17.21	68.84	S2
Pedon-2	S2 (h, o)	13.2	52.8	S2
Pedon-3	S3 (o)	18.6	74.4	S2
Pedon-4	S2 (k, o)	--	--	S2
Pedon-5	S2 (h)	23.5	94.0	S1
Pedon-6	S3 (o)	14.8	59.2	S2

* Based on maximum observed yield as optimum: 25 q ha^{-1} (mean of 10 farmer)
*--- mans not cultivated regularly.
* Latter in parentheses show limitation as, dt-soil depth, s- slop, o-organic carbon, k-$CaCO_3$, h-hydrolic conductivity and p- pH
* Suitability class – S1- Highly suitable, S2- Moderately suitable, S3- Marginally suitable, N1- Currently not suitable & N2- Un suitable.
*The yield was notated in mean of 5 years (-- Not regular sowing).

and less vegetative cover and require proper conservation measures for normal cultivation. These black cotton soils may be used for cultivation of field crops and some drought tolerant horticultural crops. Further, careful soil management techniques on pedon P4, with conservation practices coupled with selection of suitable crop can help in better sustained out-put from the soils.

REFERENCES

Abrol, J.P. (1991). Challenge of Nineties – The Role of Soil Scientist. *J. Indian Soc. Sci*., 39 (1): 6-13.

Anonymous, (1951). Soil survey manual. USDA handbook no. 18. Govt. Printing Office, Washington.

Anonymous, 1992. Key to soil taxonomy. 5th edition SMSS Technical monograph no. 19. Black burn, Virginia, Pocahontas Press, Inc. pp.566.

Bhaskar, K.S., Lal, S., Challa, O. and Madavi S.H. (1987). Effect of soil depth on cotton yield. *J. Maharashtra Agric. Univ*. 12(1):139.

Black, C.A., Evans, D.D., Ensminger, L.E., White, J.L. and Clark, F.E. (Eds) 1965. Methods of soil analysis Part-I, Am. Soc. Agron. Inc. Publisher Madison, Wisconsin, USA.

Dudal, R. 1986. Land resources for Agricultural Development In Land Evaluation (D.D. Davidson, Ed.) Van Nostrand Reinhold Co. New York, pp.6-12.

Hillel, D. 1980. Fundamentals of soil physics. Academic Press, Inc. New York.pp.ll.

Jackson, M.L. 1973. Soil Chemical Analysis, Prentic Hall of India Pvt. Ltd., New Delhi.

Landey, R.J., Hirekerur, L.R. and Krishnamoorthy, P. (1982). Morphology, genesis and classification of black soil. In Review of Soil Research in India Part II. *12th Intl Congr.Soil Sci*. New Delhi. pp. 484-497.

Kadu, P.R., Vaidya, P.H., Balpande, S.S., Satyavathi P.L.A. and Pal, D.K. (2003). Use of hydraulic conductivity to evaluate the suitability of Vertisals for deep-rooted crops in semiarid part of central India. *Soil Use and Management* 19 : 208-216.

Kaushal, G.S., Tembhare, B.R. and Sinha, S.B. 1986. Morphology and taxonomy of black soil under Bargi irrigation project in Madhya Pradesh. *J. Indian Soc. Soil Sci.* 34(2): 329-339.

Kishne, A.S., Morgan, C.L.S., Ge, Y. and Miller, W.L. 2010. Antecedent soil moisture affecting cracking of a Vertisol in field conditions Geoderma. 157:109-117.

Meena, H. B., Giri, J. D. and Mishra, H. K. 2010. Nutrienty availability in soils as affected by physiography in chittorgarh district, Rajesthan, *Agropedology* 20 (1): 85-87.

Nimkar, A.M., Deshpande, S.B. and Babrekar, P.G. 1992. Evaluation of salinity problem in swell-shrink soils of a part of Purna valley, Maharashtra. *Agropedology*, 2: 59-65.

Pal, D.K., Deshpande, S.B., Velayutham, M., Srivastava, P. and Durge, S.L. 2000. Climatic change and polygenesis in Vertisols of Purna Valley (Maharashtra) and their management. *Res. Bull.* NBSSPub.No.83.

Pal D.K. and Deshpande S.B. (1987). Characteristics and genesis of minerals in some benchmark Vertisols of India. *Pedologie*, 37: 259–275.

Prasad A., Totey, N.G., Singh, A.K., Kulkarni, R., Khatri, P.K., Bhowmik, A.K., Chouhan, J.S. and Dahia, V.K. 1989. Profile development in relation to topography. *J. Indian Soc. Soil Sci.* 26: 320-322.

Raina, A.K. 2008. Forest Soil and Land Reclamation Div. Morphology, mineralogy and classification of soils developed on different parent material in Mussoorie Forest Division, Uttrakhand, India. *Indian J. Forestry,* 31(4): 533-540.

Rajankar, P.B. 1990. Soil moisture availability under different landform in Saongi watershed, Nagpur for land use planning. *M.Sc. (Agri.) Thesis (Unpub.) submitted to Dr. P.D.K.V,Akola.*

Sharma, J.R. and Raychaudhari, C. 1988. Soil landforms relationship in a basaltic terrain. *J. Indian Soc. Soil Sci.* 36(4) : 755-760.

Sharma, S.S., Totawat K.L. and Shyampura, R.L. 1996. Characterization and classification of soils in a toposequence over basaltic terrain. *J. Indian Soc. Soil Sci.* 44(3) : 470-475.

Sys. C. 1985. Land Evaluation (part 1,11,111) state Univ. Gent. Institute Training Center for post Graduate Soil Scientist, Ghent Belgium.

Van Wambeke, A. and Rossiter, D. 1987. Automated land evaluation system as a focus for soil research. *IBSRAM. Newsletter 6.*

Wesley, L.M., Ki, A.S., shn, C. and Morgan, C.L.S. 2010. Vertisol Morphology, Classification and Seasonal Cracking Patternsin the Texas Gulf Coast Prairie. *Soil Surv. Horiz.* 15:10-16.