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Soil site suitability evalution for cotton in Girnar toposequence of southern Saurashtra region of Gujarat

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ABSTRACT : The five representative pedons were studied for soil site suitability for cotton in the soils of different land slops of Girnar toposequence of southern Saurashtra region in Gujarat. The soils of hill slope (Lithic Ustorthents, P_1) and upper piedmont (Lithic Haplustepts, P_2) are marginally suitable (S_3) for cotton cultivation, lower piedmont (Typic Haplustert, P_3) are moderately suitable (S_2), whereas the soils of upper coastal plain (Typic Haplustepts, P_4) and coastal depression (Typic Ustifluvents, P_5) are currently not suitable (N_1) for cotton cultivation.

Key words : Cotton, girnar toposequence, limitations, soil site suitability

The soils of Saurashtra region are unique in origin having diverse in genesis, physiography, climate, vegetation, depth, colour, age etc. An understanding of soil characteristics are helpful in the magnitude of changes that may have taken place during the development and in planning the proper management practices to its efficient use in land use planning. Therefore, it is worthwhile to characterize the soils of Girnar toposequence for better management.

Yield of any crop is influenced by kind of soils occurring in the area, prevailing climate, topography and management levels. Thus, it is essential to interpret the soil site characteristics of any place for the major crops grown in the area and alternative land use planning on sustainable basis. Cotton (*Gossypium species*) is a main fiber crop grown in southern Saurashtra region of Gujarat state. The cotton production in this area is not stable. Growing the crop without proper consideration of soil and site characteristics has result in lower yield and deterioration of soil health. For effective planning and better utilization of soil resources, information relating to soil site suitability for cultivation of cotton is necessary.

The study area (Girnar toposequence) is located between $21^0$30' to $21^0$38' N latitudes and $69^0$20' to $70^0$28' E longitudes. The area fails under semi-arid (dry) climate with mean annual rainfall is 706 mm. The representative water balance of the study area is given in Fig. 1. The temperature regime of the study area is hyperthermic in hill slope, upper piedmont and lower piedmont areas, whereas isohyperthermic in upper coastal plain and coastal depression (tidal) area.

IRS 1A LISS II FCC imagery on 1:50,000 scale in conjunction with survey of India (SOI) topographical map referred about on 1:50,000 scales were used to identify various land forms units. Five representative pedons from different land slops *viz.*, P_1 (hill slope), P_2 (upper piedmont), P_3 (lower piedmont), P_4 (upper coastal plain) and P_5 (coastal depression) were selected during 2011-2012 (Fig. 2). Physical and chemical characteristics were estimated by using standard procedure (Table 1). The soils were evaluated in different suitability classes *viz.,* S_1- highly suitable, S_2- moderately suitable, S_3- marginally suitable, N_1- currently not suitable and N_2- not suitable.

The results of the present study as well as relevant discussions have been presented under the following sub heads:

Table 1. Climate and soil site suitability for cotton.

1	2	3	4	5	6
Climatic characteristics					
Total rainfall (mm)	700-1050	550-700	< 550	-	-
Rainfall growing season (mm)	600-950	450-600	< 450	-	-
Rainfall during critical period (soil development)	100-120	-	-	-	-
Length growing period (days)	> 135	120-135	< 120	-	-
Mean temprature growing season (^{0}C)	22.32	> 32	-	-	-
Mean maximum temprature growing Season (^{0}C)	-	-	> 36	-	-
Mean minimum temprature growing Season (^{0}C)	-	-	< 19	-	-
Mean Raining Humidity in growing season	60-90	-	< 50	-	-
Site characteristics					
Slope (%)	< 3	3-5	> 5	-	-
Erosion	e_1	e_2	e_3	-	-
Drainage	Well to moderate	Imperfect	Poor excessive	-	-
Water stagnation (days AWC (mm/m)	< 2	2-3	3-5	> 5	-
Stoniness (surface)	> 150	100-150	50-100	-	-
Soil characteristics texture	< 15	15-40	> 40	-	-
Texture	sic, sicl, c, cl	scl, sicl, l, sc	sl	s, ls	-
Coarse fragments (vol. %) within 50 cm Below 50 cm	< 155-35	15-3535-50	> 35> 50	—	—
Depth (cm)	> 75	50-75	25-50	< 25	-
$CaCO_3$ (%)	< 10	10-20	> 20	-	-
Gypsum (%)	-	-	-	-	-
Soil fertility					
CEC (cmol (p^+)/kg	> 20	< 20	-	-	-
BS (%)	> 50	35-50	<35	-	-
O.M. (%) (0-15 cm)	> 0.75	0.5-0.75	< 0.50	-	-
ECe (d/Sm)	< 2	2-4	> 4	-	-
ESP	< 10	10-15	> 15	-	-
PH (1:2.5)	8.0-8.5	8.5-9.5	> 9.0	-	-

Soil characteristics: The data pertaining to soil characteristics of different landforms of pedon P_1 to P_5 are presented in Table 2.

The clay content ranged from 21.83 to 68.74 per cent (mean value of 39.40%) indicates dominant of clay having loam to clayey texture. The pH ranged from 7.13 to 8.15 (mean value of 7.70) indicating slightly alkaline in reaction which might be due to well drained association with comparative high rainfall. The pH of soils were increasing sequence of Hill Slope < Upper Piedmont < Lower Piedmont < Upper Coastal Plain < Coastal Depression (Tidal) (Table 2). A thorough examination of the data revealed that an increase in soil pH gradually along the topography from hill slope to coastal depression (tidal) could be the result of continuous flow of bases from higher topography to lower topography. This finding is in conformity with that of Singh *et al.* (1991); Rathore (1993); Sharma (1995); Sharma *et al.*, (1996) and Savalia (2005). The higher values of pH in upper coastal plain and coastal depression (tidal) might be due high accumulation of soluble salts (Savalia, 2005). The soils were low in organic carbon varied from 0.46 to 1.01 per cent (mean value of 0.50 %) which might be due to the prevalence of tropical condition, where the degradation of organic matter occurs at faster rate with low vegetation cover (Savalia, 2005 and Leelavathi *et al.*, 2009). The $CaCO_3$ ranged from 2.30 to 78.78 per cent (with mean value of 27.67 %) indicating the soils

were highly calcareous in nature.

The $CaCO_3$ content was found in the increasing order of Hill Slope < Lower Piedmont < Upper Coastal Plain < Coastal Depression (Tidal) < Upper Piedmont. The $CaCO_3$ increased along with down the slope and it registered its maximum value in Upper Piedmont (78.78%) (Table 2) because the upper piedmont area, especially Sodavadar village near Junagadh is a rich source of lime stone. The CEC ranged from 21.12 to 50.95 (cmol (P^+)/kg. The CEC was recorded in the increasing order of Hill Slope < Upper Piedmont < Lower Piedmont < Upper Coastal Plain < Coastal Depression (Tidal) indicating that CEC increased with decreasing topography. The content of BSP and ESP were found in increasing sequence of Hill Slope < Upper Piedmont < Lower Piedmont < Upper Coastal Plain < Coastal Depression (Tidal) indicating BSP and ESP increases with decreasing in elevation. The results are in concurrence with those obtained by Savalia (2005).

The comparatively lower value of ESP at

Table 2. Soil characteristics of Girnar toposequence in Southern Saurashtra (weighted mean).

Pedon	Particle size (%)			pH	EC	Org.	$CaCO_3$	CEC	BSP	ESP
	Sand	Silt	Clay	(1:2.5)	(dSm^{-1})	C (%)	(%)	[cmol (P^+)/kg]		
P_1: Lithic Ustorthents, MSL: 150m	41.68	36.48	21.83	7.13	0.29	1.01	2.30	21.12	90.57	0.54
P_2: Lithic Haplustepts, MSL : 87 m	16.61	45.10	38.28	7.60	0.28	0.75	78.78	24.20	91.79	2.80
P_3: Typic Haplustert, MSL : 70 m	12.63	16.65	68.74	7.73	1.05	0.71	14.28	29.35	92.84	4.94
P_4: Typic Haplustepts, MSL : 15 m	25.72	38.02	36.43	7.92	3.20	0.50	21.15	48.84	95.46	15.87
P_5: Typic Ustifluvents, MSL : 5 m	18.94	50.23	31.71	8.15	4.69	0.46	21.84	50.95	96.26	17.18
Overall mean	23.12	37.30	39.40	7.70	1.91	0.50	27.67	34.89	93.38	8.27

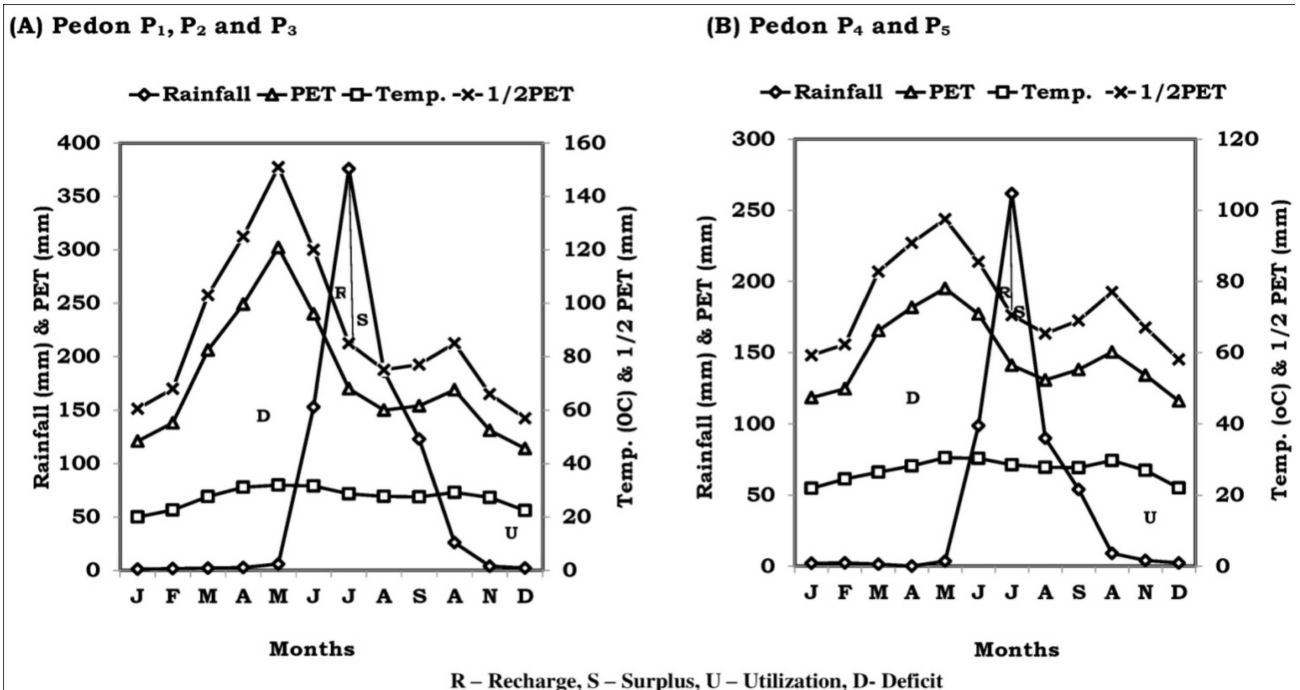

Fig. 1: Representative water balance diagrams of the study area.

Table 3. Soil characteristics of studied pedons using assessing suitability.

Pedon	Climate (C)		Wetness (w)		Texture	Physical characteristics (S)		Soil fertility characteristics (f)				Salinity / Alkalinity (n)	
	Rainfall (mm)	Temp. (^{0}C)	Topography (slope %)	(drainage)		Soil depth (cm)	AWC (mm/m)	$CaCO_3$ (%)	Organic carbon (%)	Base saturation (%)	CEC (cmol (P^+) kg^-	ECe (dSm^{-1})	ESP
P_1: Hill slope, MSL: 150m	883	27.3	15-30	Well	l	25	148	2	1.01	90	21	0.21	0.54
P_2: Upper piedmont, MSL: 87m	883	27.3	1-3	Mod. well	sic	45	154	79	0.75	92	24	0.35	2.80
P_3: Lower piedmont, MSL: 70m	883	27.3	1-3	Mod. well	c	100	307	13	0.71	93	29	0.97	4.94
P_4: Coastal upper plain, MSL: 15m	529	26.9	0-1	Poor	c	150	211	21	0.50	95	49	3.11	15.88
P_5: Coastal depression, MSL: 5m	529	26.9	0-1	Poor	sicl	135	222	22	0.46	96	51	4.53	17.18

l- Loam, c – Clay, sic – Silty clay, sicl- Silty clay loam.

Table 4. Soil site suitability evaluation for the cotton in the soils of Girnar toposequence

Pedon No.	Climate (C)		Wetness (w)		Physical characteristics (S)			Soil fertility (f)			Salinity/ Alkalinity (n)	
	Rainfall	Temp. (^{0}C)	Topography	Drainage	Texture	Soil depth	CaCO (%)	CEC	BSP	OC	Salinity (ECe)	Sodicity (ESP)
1	2	3	4	5	6	7	8	9	10	11	12	13
P_1	S_1	S_1	S_3	S_1	S_2	S_3	S_1	S_1	S_1	S_1	S_1	S_1
P_2	S_1	S_1	S_1	S_1	S_1	S_3	S_3	S_1	S_1	S_1	S_1	S_1
P_3	S_1	S_1	S_1	S_1	S_1	S_1	S_2	S_1	S_1	S_1	S_1	S_1
P_4	S_3	S_1	S_1	S_3	S_1	S_1	S_3	S_1	S_1	S_1	S_2	S_3
P_5	S_3	S_1	S_1	S_3	S_2	S_1	S_3	S_1	S_1	S_1	S_3	S_3

S_1 = Highly suitable, S_2 = Moderately suitable, S_3 = Marginally suitable and N_1 = Currently not suitable.

Table 5. Limitation levels of the land characteristics and land suitability class for cotton

Pedon No.	Sub group	Soil-site suitability class for cotton
LS_1 : P_1: Hill Slope, Datar, Tal. Junagadh, Dist. Junagadh, MSL : 150 m		
P_1	Lithic Ustorthents	S_3ws
LS_2 : P_2: Upper Piedmont, Sodavadar, Tal. Junagadh, Dist. Junagadh, MSL : 87 m		
P_2	Lithic Haplustepts	S_3s
LS_3 : P_3: Lower Piedmont, Shapur, Tal. Vanthli, Dist. Junagadh, MSL : 70 m		
P_3	Typic Haplustert	S_2s
LS_4 : P_4: Coastal Upper Plain, Amipur, Tal. Kutiana, Dist. Porbander, MSL : 15 m		
P_4	Typic Haplustepts	N_1cwsn
LS_5: P_5: Coastal Depression (Tidal), Ratiya, Tal. Porbandar, Dist. Porbandar, MSL : 5 m		
P_5	Typic Ustifluvents	N_1cwsn

C= Climatic condition, w = Wetness, s = Physical characteristics, n = Salinity/Alkalinity hazard.

higher elevation might be due to washing down the salts by rain. The higher value of ESP at lower elevated areas might be due to its mobility and position of profile in transect, poor drainage, shallow underground water and high Na salts. A fact corroborated by the finding of Savalia, (2005) and Patel (2010).

In general, the soils of Girnar toposequence were slightly alkaline in reaction, highly calcareous in nature and low in organic carbon. The soil at higher elevation had low in pH, EC, CEC, BSP and ESP then lower elevation.

Soil site suitability for cotton: The soil characteristics of studied pedons used in assessing suitability are presented in Table 3, while a perusal of data on degree of limitations and suitability of soils for cotton in Table 4 and 5.

Hill slope: The soils associated with pedon P_1 belong to Lithic Ustorthents are marginally suitable (S_3) for cotton cultivation because of major limitations like topography, texture and shallow soil depth. Soil conservation measures like graded narrow base terrace bunds or trench and contour bunding should be adopted (Savalia *et al.*, 2009 and Patel, 2010).

Upper piedmont: The soils of pedon P_2 belong to Lithic Haplustepts are marginally suitable (S_3) for cotton because of major limitations like shallow soil depth and high $CaCO_3$.

Lower piedmont: The soils associated with pedon P_3 belong to Typic Haplustert have been evaluated to be moderately suitable (S_2) for cotton on account of only one major limitation like high $CaCO_3$.

Upper coastal plain: The soils of pedon P_4 belong to Typic Haplustepts have been evaluated to be currently not suitable (N_1) for cotton. This may be due to the limitations like low rainfall, poor drainage, high $CaCO_3$, salinity and sodicity. On adoption of corrective measures of mulching, rain water leeching, adoption of salt tolerant crops and use of organic manures, the suitability class of cotton could be corrected.

Coastal depression (tidal): The soils of pedon P_5 belong to Typic Ustifluvents have been evaluated to be currently not suitable (N_1) for cotton. This may be due to major limitations like low rainfall, poor drainage, texture, high $CaCO_3$, salinity and sodicity. On adoption of corrective measures like provision of surface drainage through lateral ditches (Savalia and Gundalia, 2009), adoption of salt tolerant varieties and use

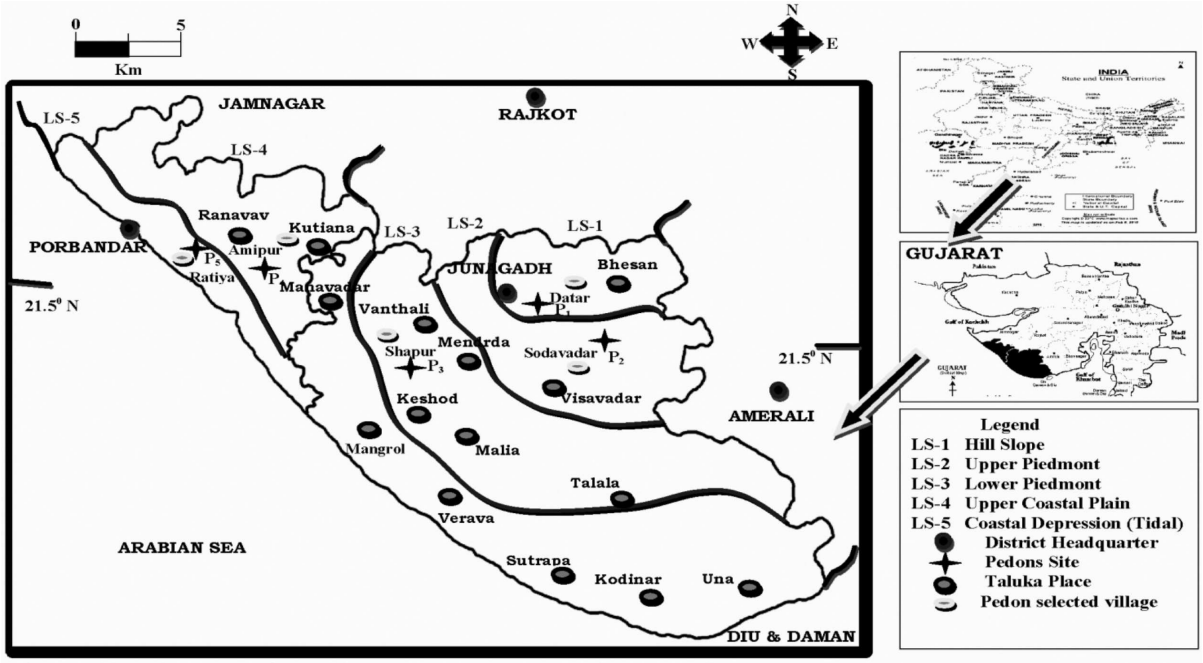

Fig. 2: Site of Pedons of the Girnar Toposequence in Southern Saurashtra

of organic manures along with gypsum could be corrected in these soils.

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