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Soil-site suitability evaluation for mustard in calcareous soils of Girnar toposequence in Southern Saurashtra region of Gujarat

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Abstract

The five representative pedons were evaluated for their suitability to Indian mustard [*Brassica juncea* (L.) Czern & Coss.] in the soils of different land slope of Girnar toposequence of Southern Saurashtra region of Gujarat. The soils of pedon P_3 belong to Typic Haplustert are highly suitable for Indian mustard cultivation, whereas the soils of pedon P_1 belong to Lithic Ustorthents, pedon P_2 belong to Lithic Haplustepts, pedon P_4 belong to Typic Haplustepts and pedon P_5 belong to Typic Ustifluvents are currently not suitable for Indian mustard cultivation. Topography, shallow soil depth, high $CaCO_3$, drainage, salinity and sodicity are the major limitations in most soils of Girnar toposequence of Southern Saurashtra. Results showed that the suitability classes can be improved if the correctable limitations (soil fertility characteristics) are altered through soil amelioration measures.

Key words: *Brassica juncea, girnar toposequence, limitations, soil-site suitability.*

Introduction

The soils of Saurashtra region are unique in origin having diverse genesis, physiography, climate, vegetation, depth, colour and age. An understanding of soil characteristics is helpful in the pedogenic that may have taken place during the developmental process and in planning the appropriate management practices for its efficient land utilization planning.

Yield of any crop is influenced by kind of soils type occurring in the area, prevailing climate, topography and management levels. Crop cultivation without proper consideration of soil and site characteristics results in lower yield and deterioration of soil health. They need to be use according to their capacity to satisfy the need of its inhabitants. This can be achieved through proper investigations of land resources and their scientific evaluation. Land suitability evaluation is the process of estimating the potential of land for land use planning (Sys *et al.,* 1991). Several workers have worked out the suitability of soils for various crops such as wheat (Sharma, 1999), cotton (Mandal *et al.,* 2002) and sorghum (Pakhan *et al.,* 2010). However, such information on soils of Saurashtra region of Gujarat is lacking. The present study was undertaken to evaluate soil-site suitability for mustard crop.

Materials and Methods

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 encompassing the Girnar toposequence area in Southern Saurashtra of Gujarat with altitude ranging from 5 to 150 m above mean sea level (MSL). IRS IA LISS II FCC satellite toposheets on 1:50,000 scale on conjunction with Survey of India topographical (SOI) map were used to select various landforms of Girnar toposequence of Southern Saurashtra region. The mean annual rainfall is 706 mm and the climate of the area is semi-arid characterized by extremes of temperature and low wind velocity. 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, whereas isohyperthermic in upper coastal plain and coastal depression (tidal) area (SWMR & NBSS & LUP, 2000).

Five typical pedons from different land slope *viz.* P_1 (hill slope), P_2 (upper piedmont), P_3 (lower piedmont), P_4 (upper coastal plain) and P_5 (coastal depression) were studied during 2011-12 (Fig. 2). Horizon-wise soil samples collected from the typifying pedons were analysed for their physical and chemical characteristics following standard procedure and soils were classified according to Key to Soil Taxonomy (Anonymous, 2003). The soil-site suitability for Indian mustard was carried out using limitation method according to Sys *et al*., (1991) and NBSS & LUP (1994) and matched with generated data (Table 1) at different limitation level: S_1- highly suitable, S_2- moderately suitable, S_3- marginally suitable, N_1- currently not suitable and N_2- not suitable (Sys *et al*., 1991).

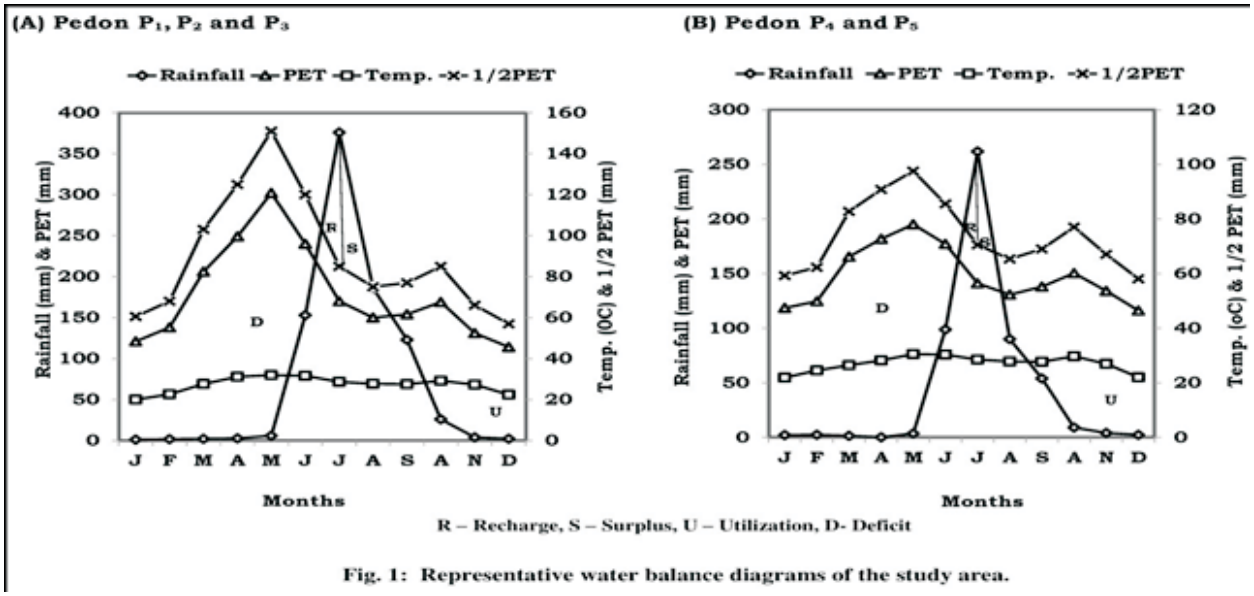

Fig. 1: Representative water balance diagrams of the study area.

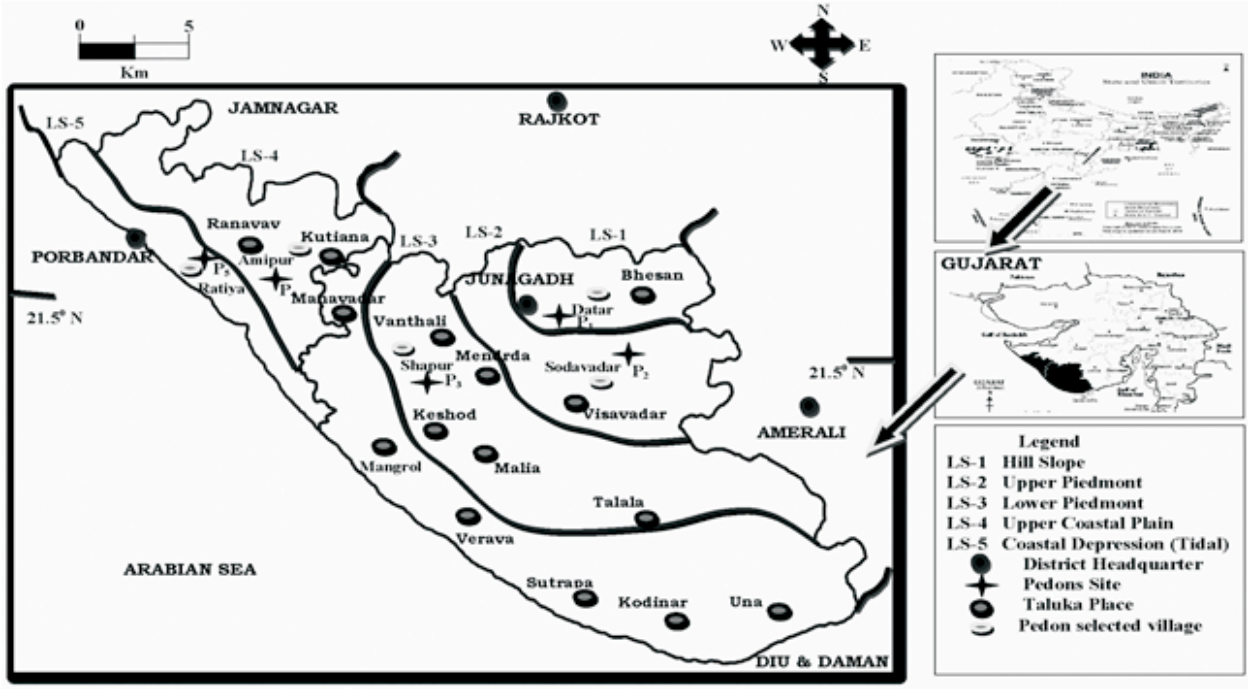

Fig. 2: Site of Pedons of the Girnar Toposequence in Southern Saurashtra

Table 1: Climate and soil-site suitability criteria for mustard

Land characteristics	Rating class				
	S_1	S_2	S_3	N_1	N_2
Climatic (c)					
Precipitation (mm)	250-350	150-250	100-150	< 100	-
Mean temp.(^{0}C)	20-28	18-20	16-18	< 16	-
Wetness (w)					
Topography [Slope (%)]	< 3	3-8	3-8	> 8	-
Drainage	Moderately well drained	Imp./some what excessive	Very low	-	-
Physical characteristics (s)					
Texture / structure	cl, l	sl	ls	s	-
Coarse fragments (%)	< 15	15-35	> 35	-	-
Soil depth (cm)	> 75	75-50	50-25	< 25	-
$CaCO_3$ (%)	< 20	20-30	30-40	> 40	-
Gypsum (%)	< 3	3-5	5-10	> 10	-
Soil fertility characteristics (f)					
CEC [cmol (P^+) kg^{-1}]	> 16	8-16	< 8	-	-
Base Saturation (%)	> 50	50-35	< 35	-	-
Organic carbon (%)	> 0.4	0.2-0.4	0.1-0.2	-	-
Salinity alkalinity (n)					
ECe (dSm^{-1})	< 8	8-12	12-16	> 16	-
ESP (%)	< 15	15-25	25-35	> 35	-

Results and Discussion

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 in the range of 21.83 to 68.74 % (mean value of 39.40 per cent) indicates dominance 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 proper drained association with comparative high rainfall (Deshmukh and Bapat, 1993). 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 gradual increase in soil pH along the topography from hill slope to coastal depression (tidal) could be the result of continuous flow of bases from higher topographical region to lower topographical region. These finding are in conformity with those of Sharma *et al*. (1996) and Savalia (2005). The higher values of pH in upper coastal plain and coastal dipression (tidal) might be due to high accumulation of soluble salts (Singh, 1999 and Savalia, 2005). The soils were tested low in organic carbon ranging from 0.46 to 1.01 % (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 (Leelavathi *et al*., 2009). The $CaCO_3$ content ranged from 2.30 to 78.78 % (with mean value of 27.67 %) indicating the highly calcareous nature of soils.

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 per cent) (Table-2). The CEC ranged from 21.12 to 50.95 cmol (P^+) kg^{-1}. The CEC was recorded in the increasing order of hill slope <

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

Pedon	Particle size (%)			pH (1:2.5)	ECe (dSm^{-1})	Org. C (%)	$CaCO_3$ (%)	CEC [cmol (P^+) kg^{-1}]	BS (%)	ESP
	Sand	Silt	Clay							
P_1	41.68	36.48	21.83	7.13	0.29	1.01	2.30	21.12	90.57	0.54
P_2	16.61	45.10	38.28	7.60	0.28	0.75	78.78	24.20	91.79	2.80
P_3	12.63	16.65	68.74	7.73	1.05	0.71	14.28	29.35	92.84	4.94
P_4	25.72	38.02	36.43	7.92	3.20	0.50	21.15	48.84	95.46	15.87
P_5	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

upper piedmont < lower piedmont < upper coastal plain < coastal depression (tidal) indicating that CEC increased with decreasing topography. The base saturation and ESP were increased from hill slope to coastal depression (tidal). The results are in concurrence with those obtained by Savalia (2005). The comparatively lower value of ESP at higher elevation might be due to washing off the salts by rain (Paramshivam, 1992). 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. These facts corroborated by the finding of Barua (1989); 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 soils at higher elevation were low in pH, EC, CEC, base saturation and ESP then lower elevation.

Soil-site suitability for Indian mustard

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 Indian mustard are given in Table 4 and 5.

Pedon P_1 (Hill slope): The soils associated with pedon P_1 belongs to Lithic Ustorthents are not suitable (N_1) for mustard cultivation due to higher topography which make them unfit for mustard cultivation. Soil conservation measures like graded narrow base terrace bunds or trenches and contour bunding should be adopted to make it suitable for mustard cultivation.

Pedon P_2 (Upper piedmont): The soils of pedon P_2 belongs to Lithic Haplustepts are currently not suitable (N_1) for mustard cultivation. These soils showed limitations of shallow soil depth as well as high $CaCO_3$. On adoption of corrective measures such as increasing soil depth, conservation tillage, forage based crop rotation and rehabilitate top soil should be used to make them suitable for mustard cultivation.

Pedon P_3 (Lower piedmont): The soils associated with pedon P_3 belong to Typic Haplustert, are highly suitable (S_1) for growing mustard without any limitation.

Pedon P_4 (Upper coastal plain): The soils of pedon P_4 belong to Typic Haplustepts are currently not suitable (N_1) for mustard cultivation. The major limitations are poor drainage and high salinity. On adoption of corrective measures like provision of surface drainage through lateral ditches to drain excessive salts and adoption of salt tolerant varieties can be helpful to make it suitable for mustard cultivation.

Pedon P_5 (Coastal depression): The soils of pedon P_5 belong to Typic Ustifluvents are currently not suitable (N_1) for mustard cultivation due to poor drainage, high salinity as well as sodicity. On adoption of corrective measures like provision of surface drainage through lateral ditches to drain excessive salts, application of green manuring and adoption of salt tolerant varieties should be used to make them suitable for mustard cultivation. Based on the present study it can be concluded that the soils of study area were slightly alkaline in reaction and highly calcareous in nature. The soils of pedon P_3 belonging Typic Haplustert are highly suitable for Indian mustard cultivation, whereas the

Table 3: Soil characteristics of studied pedons using assessing suitability

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

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

Table 4: Soil-site suitability evaluation for the Indian mustard in the soils of Girnar toposequence

Pedon	Climate (C)		Wetness (w)		Physical characteristics (S)		Soil fertility (f)			Salinity/ Alkalinity (n)	
	Rainfall	Temp. (°C)	Topography	Drainage	Texture	Soil depth	CEC	BS (%)	OC	Salinity (ECe)	Sodicity (ESP)
P_1	S_1	S_1	N_1	S_1	S_1	S_3	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_1	S_1	S_1	S_1	S_1
P_3	S_1	S_1	S_1	S_1	S_1	S_1	S_1	S_1	S_1	S_1	S_1
P_4	S_1	S_1	S_1	S_3	S_1	S_1	S_1	S_1	S_1	S_2	S_2
P_5	S_1	S_1	S_1	S_3	S_1	S_1	S_1	S_1	S_1	S_2	S_2

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

Source: Sys *et al.*, 1991 and NBSS & LUP, 1994

Table: 5 Limitation levels of the land characteristics and land suitability class for Indian mustard

Pedon	Landforms	Sub group	Soil-site suitability class for mustard
P_1	Hill slope (Datar, Junagadh)	Lithic Ustorthents	N_1ws
P_2	Upper piedmont (Sodavadar, Junagadh)	Lithic Haplustepts	N_1s
P_3	Lower piedmont (Shapur, Junagadh)	Typic Haplustert	S_1
P_4	Coastal upper plain (Amipur, Porbander)	Typic Haplustepts	N_1wn
P_5	Coastal depression (Ratiya, Porbandar)	Typic Ustifluvents	N_1wn

S_1 = Highly suitable, S_2 = Moderately suitable, S_3 = Marginally suitable, N_1 = Currently not suitable, w = Wetness, s = Physical characteristics, N = Salinity/Alkalinity hazard

soils of pedon P_1 (Lithic Ustorthents), pedon P_2 (Lithic Haplustepts), pedon P_4 (Typic Haplustepts) and pedon P_5 (Typic Ustifluvents) are currently not suitable for Indian mustard cultivation. Corrective measures can be used to improve the limitation factors for mustard cultivation.

References

Anonymous. 2003. Keys to Soil Taxonomy. USDA Natural Resources Conservation Service, Washington, 340 pp.

Barua J. 1989. Genesis of salt affected soils of Punjab. PhD Thesis, PAU, Ludhiana.

Deshmukh SN and Bapat MV. 1993. Characterization and classification of soils in relation to different parent rocks and land forms. *J Indian Soc Soil Sci* **41**: 326-330.

Leelavathi GP, Naidu MVS, Ramavatharam N and Karunasagar G. 2009. Studies on genesis, classification and evaluation of soils for sustainable land use planning in yerpedu mandal of chittoor district. Andhra Pradesh. *J Indian soc soil Sci* **57**: 109-120.

Mandal DK, Kandare NC, Mandal C and Challa O. 2002. Assessment of quantitative land evaluation methods and suitability mapping for cotton growing soils of Nagpur district. *J Indian Soc Soil Sci* **50**: 74-80.

NBSS and LUP 1994. *Proc.* National meet on soil-site suitability criteria for different crops. Feb. 7-8, 1994 held at NBSS and LUP (ICAR), New Delhi.

Pakhan AD, Chatterji S, Sen TK, Venugopalan MV, Patil S and Challa O. 2010. Use of different techniques in evaluation of suitability of shrink swell soils of Nagpur district, Maharashtra for rainfed Sorghum. *J Indian Soc Soil Sci* **58:** 117-124.

Paramsivam PC. 1992. Characterization and classification of the soils of a toposequence at Coimbatore. PhD Thesis, Tamilnadu Agricultural University, Coimbatore, India.

Patel HP. 2010. Characterization, classification and evaluation of soil and water resources of the soils of different land of Meghal irrigation command area of Southern Saurashtra. MSc Thesis, JAU, Junagadh.

Savalia SG. 2005. Characterization, classification and evaluation of soil and water resources across the toposequences of Southern Saurashtra. PhD Thesis, JAU, Junagadh.

Sharma RC. 1999. Soil suitability of reclaimed salt affected soils for wheat. *Agropedol* **9**: 59-62.

Sharma SS, Totawat KL and Shyampura RI. 1996. Characterization and classification of soils in toposequence over basaltic terrain. *J Indian Soc Soil Sci* **44**: 470-475.

Singh SK. 1999. Studies on variability in soil properties as related to genesis in Vertisols of Rajasthan. PhD Thesis, RAU, Bikaner.

SWMR and NBSS & LUP 2000. Natural resources of Gujarat. Soil and water management research unit, GAU, Navsari and NBSS & LUP, Regional Centre, Udaipur, SWMP Pub. 11.

Sys IC, Vanrasant B and Debavye J. 1991. Land evaluation, Part 2. Method of land evaluation. Agriculture Pub **7**, Belgium.

Tiwary JR, Jha PP and Mishra BB. 1989. Characteristics and classification of red, black and yellow soils of Rajmahal Trap of Bihar. *J Indian Soc Soil Sci* **37**: 518-523.