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Soil-site suitability for Indian mustard in Malwa plateau in Rajasthan

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Abstract

Ten typical pedons in Malwa plateau of Banswara district, Rajasthan were evaluated for their suitability to Indian mustard [*Brassica juncea* (L.) Czern & Coss.] cultivation using limitation method regarding number and intensity of limitations. The study suggests that Indian mustard is moderately suitable in soils of Pedon P5, P8 and P9 but marginally suitable in soils of Pedon P4, P7. Whereas soils of Pedon P1, P2, P3 and P10 are not suitable for Indian mustard cultivation. Soil depth, drainage, erosion, texture and organic carbon are the major limitations for crop growth in the most of soils of Malwa plateau. Results showed that the suitability classes can be improved if the correctable limitations (soil fertility characteristics) are altered through soil amelioration measures.

Key words: *Soil-site suitability, Brassica juncea, limitations, potential*

Introduction

Soil is recognized as one of the most valuable natural resources on whose proper use depend the life supporting systems and social and economic development. Indiscriminate use of land resources, in general, leads to their degradation and in-turn decline in productivity. They need to be used according to their capacity to satisfy the needs 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 cotton (Sehgal, 1991; Kharche and Gaikawad, 1993; Mandal *et. al.*, 2002), wheat (Sharma and Sharma, 1991; Baskar *et. al.*, 1996; Sharma, 1999), sorghum (Pakhan *et. al.*, 2010) and rubber (Kharche *et. al.*, 1995). However, such information on soils of Banswara district of Rajasthan is very scanty hence, In view of this, the present study was undertaken to evaluate soil-site suitability for mustard crop.

Materials and Methods

The study area lies between 23°10' 26" to 23°31' 5" N latitudes and 74° 20' 34" to 74° 39' 20" E longitudes encompassing Malwa plateau area in southern part of Rajasthan with attitude ranging from 140 to 425 m above mean sea level (amsl). The average annual rainfall is 972 mm and the climate of the area is semi- arid characterized by extremes of temperature and low wind velocity. The mean annual temperature varies from 10.3°C to 42°C. The temperature regime of the area is hyperthermic. The area comprises hills, undulating pediments, undulating plain, alluvial plain with basalt as an igneous parent rock. The soil moisture regime is "Ustic".

Ten typical pedons representing major landforms of the area viz., hill top, side slope, foot slope, undulating pediment, moderately sloping pediment, gently sloping pediment and very gently sloping alluvial plain were studied for their morphological characteristics following the procedure outlined in Survey Manual (Anonymous, 1995). Horizon-wise soil samples collected from the typifying pedons were analysed for their physical, physico-chemical and chemical properties following standard procedures and soils were classified according to Key to Soil Taxonomy (Anonymous, 1998). These

Table 1: Morphological characteristics

Horizon	Depth (cm)	Boundary	Colour (moist)	Texture	Gravel volume (%)	Structure	Consistence D	M	W	Roots
Pedon-1:Clayey- skeletal, mixed hyperthermic Lithic Ustorthents										
All	0-30	cs	10YR 2/2	gcl	50-60	$m_1$sbk	h	fr	sp	mc
Pedon-2:Clayey- skeletal, mixed hyperthermic Lithic Ustorthents										
All	0-22	ds	10YR2/1	gc	40-50	$m_2$sbk	h	fr	sp	mm
C1	22-45	cs	10YR 2/1	gc	70-80	massive	h	fr	sp	cc
Pedon-3:Clayey- skeletal, mixed hyperthermic VerticUstorthents										
AP	0-17	ds	10YR 2/1	gc	-	$m_2$sbk	h	fr	sp	mm
C12	17-45	ds	10YR 2/1	gc	-	massive	h	fr	sp	cc
Pedon-4:Clayey- skeletal, mixed hyperthermic Lithic Ustorthents										
All	0-25	cs	5YR 3/3	gcl	-	$f_2$sbk	h	fr	sp	ff
Pedon-5:Fine, smectite, hyperthermic Vertic Haplustepts										
AP	0-21	ds	10YR 3/1	c	10-15	$m_3$abk	h	fi	sp	ff
B21	21-40	cs	10YR 3/1	c	10-15	$m_3$abk	h	fi	sp	ff
B31	40-60	cs	10YR 3/4	c	30-40	massive	h	fi	sp	cc
Pedon-6:Clayey- skeletal, mixed hyperthermic Lithic Ustorthents										
Al	0-20	cs	5YR 2.5/2	gcl	40-50	$m_2$sbk	h	fr	sp	mc
Pedon-7:Clayey, smectite, hyperthermic Lithic Ustorthents										
AP	0-15	ds	10YR 2/1	c	-	$m_2$sbk	h	fr	sp	ff
B21	15-30	cs	10YR2/1	c	-	$m_2$sbk	h	fr	sp	ff
BC	30-50	cs	10YR3/3	gc	-	massive	h	fr	sp	ff
Pedon-8:Fine, smectite, hyperthermic Typic Haplusterts										
AP	0-23	ds	10YR 2/1	c	-	$m_2$sbk	h	fr	sp	mc
A12	23-45	cs	10YR 2/1	c	-	$m_2$sbk	h	fr	sp	mc
A13	45-68	ds	10YR 2/1	c	-	$m_2$sbk	h	fr	sp	mc
A14	68-100	cs	10YR 2/1	c	-	$m_2$sbk	h	fr	sp	mc
A15	100-130	ds	10YR 2/1	c	-	$m_2$sbk	h	fr	sp	mc
Pedon-9:Clayey- skeletal, mixed hyperthermic Lithic Ustorthents										
AP	0-30	cs	10YR 2/1	gc	40-50	$m_2$sbk	h	fr	sp	fc
Pedon-10:Clayey- skeletal, mixed hyperthermic Lithic Ustorthents										
AP	0-20	cs	5YR 3/3	gcl	30-40	$m_2$sbk	h	fr	sp	mm

Boundary: c- clear, d- diffuse s- smooth; Texture: c- clay, l- loam, g- gravelly; Structure: m- medium, f- fine, 2- moderate, sbk- subangular blocky; Consistence: h- hard, fr- friable, fi- firm, s- sticky, p- plastic; Roots: mc- medium common, ff- fine few, cc- coarse common, fc- fine common

pedons were evaluated for their suitability using limitation method regarding number and intensity of limitations (Sys *et al.* 1991).

The landscape and soil requirements for these crops were matched with generated data at different limitation level: no (0), slight (1), moderate (2), severe (3), very severe (4). The number and degrees of limitations suggested the suitability class of pedon for a particular crop (Sys *et al.* 1991). The

Table 2 : Physico-chemical characteristics of the selected pedons

Depth (cm)	Sand	Silt	Clay	$CaCO_3$	CEC (cmol (p^+) kg^{-1})	BS (%)	Sum of cations (cmol (p^+) kg^{-1})	pH (1:2)	EC (dSm^{-1})	OC	ESP
	(----------%--------)										
P1 (Chota Dungra) Clayey - skeletal, mixed hyperthermic Lithic Ustorthents											
0-30	41.28	22.19	36.53	12.00	22.40	92.67	20.76	6.4	0.24	12.3	2.14
P2 (Chota Dungra) Clayey - skeletal, mixed hyperthermic Lithic Ustorthents											
0-22	35.93	23.09	40.98	13.00	27.90	96.20	26.84	6.4	0.37	11.5	2.25
22-45	34.95	21.76	43.29	15.20	28.20	97.44	27.48	6.5	0.25	9.2	1.80
Pedon - 3 (Chota Dungra) Clayey - skeletal, mixed hyperthermic VerticUstorthents											
0-17	30.21	22.55	47.24	13.30	33.60	96.13	32.30	6.5	0.39	10.2	2.17
17-45	29.12	26.86	44.02	16.50	32.30	94.55	30.54	6.6	0.37	9.1	2.10
Pedon - 4 (Napla) Clayey - skeletal, mixed hyperthermic Lithic Ustorthents											
0-25	37.27	27.62	35.12	15.00	20.50	93.90	19.25	6.7	0.28	5.5	1.07
Pedon -5 (Daldi) Fine, smectite, hyperthermic Vertic Haplustepts											
0-21	19.80	30.35	49.85	21.80	31.70	97.94	31.05	6.4	0.60	8.2	2.74
21-40	22.14	26.76	51.10	35.00	34.50	98.31	33.92	6.6	0.60	7.5	1.85
40-60	22.73	27.31	49.96	53.40	30.90	94.04	29.06	6.9	0.49	5.2	3.07
Pedon -6 (Khajuran) Clayey skeletal, mixed hyperthermic Lithic Ustorthents											
0-20	36.34	25.39	38.27	18.70	24.10	95.76	23.08	6.5	0.41	13.6	3.60
Pedon -7 (Khandu) Clayey, smectite, hyperthermic Lithic Ustorthents											
0-15	22.80	27.93	49.27	24.20	31.40	99.33	31.19	6.9	0.42	6.1	2.10
15-30	20.18	27.32	52.50	27.60	35.10	95.41	33.49	6.9	0.43	5.8	2.79
30-50	24.42	22.47	54.10	45.50	29.60	89.45	26.48	7.2	0.45	5.2	1.92
Pedon - 8 (Chimsarwan) Fine, smectite, hyperthermic Typic Haplusterts											
0-23	16.41	29.13	54.46	19.30	34.50	98.14	33.86	6.7	0.53	9.4	2.28
23-45	12.49	35.31	52.20	24.50	31.10	95.98	29.85	6.6	0.52	8.4	3.02
45-68	14.28	29.98	55.74	31.50	35.30	96.45	34.05	6.9	0.45	7.6	3.11
68-100	14.68	23.15	62.17	35.80	38.10	99.31	38.04	7.1	0.42	7.9	2.57
100-130	19.23	23.57	57.20	40.20	33.70	92.40	31.14	7.3	0.36	7.8	2.19
Pedon -9 (Dungripada) Clayey - skeletal, mixed hyperthermic Lithic Ustorthents											
0-30	23.89	21.77	54.34	29.50	33.90	95.57	32.40	7.1	0.46	9.9	2.18
Pedon -10 (Kotra) Clayey - skeletal, mixed hyperthermic Lithic Ustorthents											
0-20	32.72	27.06	39.82	22.40	24.10	91.95	22.16	6.9	0.37	8.5	2.48

potential land suitability (Table 4) sub-classes were determined after considering the improvement measures to correct these limitations (Sys *et al.,* 1991).

Results and Discussion

The relevant soil characteristics are given in table 1 and table 2 and the site and weighted means of soil characteristics are given in table 3. The soils are developed from basalt parent material. The kind and degree of limitations of the soils for the mustard crop are presented in table 4. The soils with no or only slight limitations were grouped under highly suitable class (S1); the soils with more than four slight limitations, and /or with more than three moderate limitations under moderately suitability class (S2); the soil with more than three moderate limitations, and/or one or more severe limitations(s) under marginally suitable class (S3); the soils with very severe limitations which can be corrected under N1 (currently not suitable); the soil with very severe limitations which can not be corrected were grouped under unsuitable class N2 (Sys *et al.,* 1991). This method also identifies the dominant limitations that restrict the crop growth in the sub-class symbol such as climatic (c), topographic (t), wetness (w), physical soil characteristics (s), soil fertility (f) and soil salinity/alkalinity (n). The suitability classes and sub-classes were decided by the most limiting soil characteristics (Table 4).

Pedon P1 and P2 are not suitable for mustard cultivation. The major limitations are wetness (drainage), physical soil characteristics (texture, coarse fragments and soil depth) and soil fertility characteristics (pH and organic carbon). The major limiting factors are shallow depth and excessive slope which make them unfit for mustard cultivation. These soils should be developed as forest or as grasslands.

Pedon P3 is marginally suitable for mustard cultivation. These soils showed limitations of wetness (drainage), physical soil characteristics

Table 3 Site and soil characteristics of pedons

Pedon	Landform	Wetness (w) Drainage	Soil depth (cm)	$CaCO_3$ (g kg^{-1})	CEC (cmol (p^+) kg^{-1})	BS (%)	pH (1:2)	OC (g kg^{-1})	EC (dSm^{-1})	ESP
P1	Hill top	Some what excessive	30	12.0	22.40	96.67	6.40	12.3	0.24	2.14
P2	Side slope	Some what excessive	45	14.12	28.05	96.82	6.45	10.3	0.31	2.02
P3	Foot slope	Some what excessive	45	15.29	32.79	95.34	6.56	09.5	0.38	2.13
P4	Undulating pediment	Some what excessive	52	15.0	20.50	93.90	6.70	05.5	0.28	1.07
P5	Moderately sloping pediment	Well drainage	60	36.51	32.32	96.76	6.63	07.0	0.56	2.57
P6	Gently sloping pediment	Some what excessive	20	18.70	24.10	95.76	6.50	13.6	0.41	3.60
P7	Gently sloping pediment	Well drainage	50	33.74	31.79	94.73	7.02	05.6	0.43	2.23
P8	Gently sloping pediment	Well drainage	130	31.22	34.76	96.45	6.95	08.1	0.45	2.60
P9	Very gently sloping alluvial plain	Well drainage	30	29.50	33.90	95.57	7.10	09.9	0.46	2.18
P10	Very gently sloping alluvial plain	Some what excessive	20	22.40	24.10	91.95	6.90	08.5	0.37	2.48

Table 4: Limitation levels of the land characteristics and land suitability classes for Mustard

Pedon	Wetness (w) Drainage	Physical soil characteristics (s)			Soil fertility characteristics (f)					Salinity/ Alkalinity (n)			Actual sutaibility subclass	Potential land suitability subclass
		Texture	Coarse fragments (vol.%)	Soil depth (cm)	$CaCO_3$ (g kg^{-1})	CEC (cmol (p^+) kg^{-1})	BS (%)	pH (1:2)	OC (g kg^{-1})	EC (dSm^{-1})	ESP			
P1	3	2	4	3	0	1	0	1	1	0	0		N 2 s,f,w	-
P2	3	2	4	3	0	0	0	1	1	0	0		N 2 s,f,w	-
P3	3	2	0	3	0	0	0	0	1	0	0		S 3 s,f,w	S 3
P4	3	2	0	2	0	1	0	0	2	0	0		S 3 s,f,w	
P5	0	2	2	2	0	0	0	0	2	0	0		S 3 s,f	S 2 s
P6	3	2	3	4	0	0	0	0	1	0	0		N 2 s,f,w	-
P7	0	2	0	3	0	0	0	0	2	0	0		S 3 s,f	S 3 s
P8	0	2	0	0	0	0	0	0	1	0	0		S 2 s,f	S 1 s
P9	0	2	3	3	0	0	0	0	1	0	0		S 3 s,f	S 3 s
P10	3	2	3	4	0	0	0	0	1	0	0		N 2 s,f,w	-

Limitations: 0-no slight; 1- slight; 2- moderate; 3- severe; 4- very severe

Suitability subclass: f- soil fertility limitations; s- physical soil limitations; w- wetness limitations; n- salinity (and/or alkalinity) limitations

(texture and soil depth) and soil fertility characteristics (organic carbon). The major limitations are drainage, texture, soil depth and organic carbon.

Pedon P4 is also marginally suitable for mustard cultivation due to poor drainage, texture, soil depth, CEC and organic carbon. Pedon P5 is marginally suitable for mustard crop. The major limitations include texture, coarse fragment, soil depth and organic carbon. The organic carbon is a major limiting factor and so, the organic carbon status in soils can be improved by the application of farmyard manure, green manuring and inclusion of legumes in rotation.

Pedon P6 and P10 are not suitable for growing mustard due to shallow depth, wetness, texure, coarse fragments and organic carbon. The major limiting factor is shallow depth which make unfit for mustard cultivation. Pedon P7 and P9 are marginally suitable for growing mustard crop. The major limitations are texture, soil depth and organic carbon.

Pedon P8 is moderately suitable for mustard cultivation. The limitations include texture and organic carbon.

Pedon 1,2,6 and 10 are not suitable foe growing mustard crop. The soils of P8 is moderately suitable but P3, P4, P5 P7 and P9 are marginally suitable for mustard cultivation. These findings are corroborated with the finding of Bera *et al* (2005) who indicated that erosion and low inherent fertility in soils of Chhotanagpur plateau in Eastern India causes moderately suitable for mustard crop.

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