

Land Capability Assessment of Soils of Bhal-Nal Area of Gujarat Based on Soil Physical Limitations

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Abstract : Studies on some representative soils of Bhal-Nal area of Gujarat have revealed that the soils are marginally suitable for the crops that are grown there for several generations. Experiments conducted in the area, and elsewhere, have revealed that the performance of these soils can be improved through certain management practices like deep ploughing, raised bed method of cultivation, larger addition of organic matter, protective irrigation, etc. Certain new crops can be introduced, but their viability has to be experimentally proved through actual demonstration on farmer's field.

Key words : Soil suitability rating, soil physical conditions, protective irrigation, deep ploughing.

Numerous land capability systems are currently in use or being proposed for many countries. The complexity or otherwise of the systems depends on the number of factors considered. A system, however, should be as simple as possible without losing its compatibility for meaningful results. The criteria that are used to derive the system should be those that are observable in the field, rather than having to wait for laboratory results or other specialised processes (Mansfield, 1979).

The main difficulty that is encountered in deriving a capability system, based on physical soil differences, is the lack of response data of crop growth in relation to soil characteristics.

In the Bhal-Nal area of Gujarat, the choice of crop is limited due to its typical climatic conditions, and the yields are low, on account of peculiar soil conditions. In the present study pedons, representative of the area, were selected and their morphological characters were observed. The soil samples of these profiles were collected for laboratory analysis of physico-chemical properties.

Study Area

The entire Bhal-Nal area is developed over coastal alluvium that overlays a now extinct sea

(Krishnan, 1982). The climate of the area is typically semi-arid with an annual rainfall of 550-600 mm which occurs in 30-35 rainy days. The mean annual air temperature is 27.8°C. The mean summer temperature is 40.7°C and the mean winter temperature is 11.8°C. Vegetation is scarce and thorny, mixed, deciduous type with grasses and shrubs forming the under growth. The soils have low fertility. These are also highly sodic and saline and clayey in texture with high shrink-swell characteristics. Some are typical Vertisols, while others belong to the Inceptisol and Aridisols with vertic properties. The CEC of the soils is high. The soils are poorly drained and the water table is within 3 to 15 m. The underground water is very saline with EC ranging from 2000 to 5000 micro siemen cm^{-1} . The soils are generally cultivated for a single crop of wheat/ gram, except in case of pedon 1 which is under scrub vegetation.

The study was taken up mainly to prepare a working hypotheses on soil characterisation. It considers only crops like wheat and gram which are grown on stored moisture. Attempts to apply the proposed system to cotton and pigeonpea are also made.

Soil Characterisation

The physical soil characteristics that have been considered are those that remain fairly constant.

Table 1. Assessment code and criteria for the limitations

Limitation depth (cm)	Assessment code					
	0	1	2	3	4	5
	150	100-150	50-100	25-60	25	-
Drainage (depth to gleying)	No gleying upto 150 cm	20% gleying between 100-150 cm	20% gleying between 50-100 cm	Gleyed horizon between 50-100 cm	10% gley mottles at 50 cm	Gleyed horizon at 50 cm
Texture (Class)		Fine (Cl, Sc, C, Sic, Sicl)	Medium (L, SCl, Sil, Si)	Coarse (S, LS, Sl)	Very coarse (Cs, Lcs, Csl)	-

0 = Nil ; 1 = Minor ; 2 = Slight; 3 = Moderate ; 4 = Severe ; 5 = Very severe limitation.

Table 2. Physical characteristics of Bhal-Nal area

Depth (cm)	Textural Class	ECe (dSm ⁻¹)	pH	CaCO ₃ (%)	Hydraulic conductivity (cm day ⁻¹)	Bulk density (g/cc)
Durgi (Ustertic camborthid)						
0-15	Clay	24.6	8.8	3.3	0.45	1.74
15-30	Clay	22.2	8.5	3.3	0.45	1.78
30-60	Clay	12.6	8.4	3.5	0.30	1.83
60-90	Clay	7.8	8.1	3.7	0.22	1.91
90-120	Clay	7.8	8.1	1.3	0.23	1.86
Mithapur (Typic camborthid)						
0-20	Clay	19.7	8.5	10.3	1.33	1.71
20-45	Clay	24.9	8.5	11.8	0.99	1.72
45-60	Clay	29.3	8.7	15.1	0.94	1.74
60-100	Clay	24.5	8.7	13.1	0.76	1.84
100-120	Clay	22.1	8.9	9.9	0.80	1.83
Arnej (Typic chromustert)						
0-15	Clay	2.3	8.1	6.3	1.33	1.36
15-45	Clay	2.5	8.1	6.5	0.90	1.57
45-70	Clay	4.7	8.1	7.9	0.75	1.70
70-100	Clay	7.6	8.1	8.0	0.52	1.91
100-130	Clay	8.0	8.2	18.8	0.55	1.56
Wataman (Vertic camborthid)						
0-20	Clay loam	1.5	7.8	8.4	4.07	1.50
20-50	Clay loam	1.7	7.9	11.6	1.32	1.33
50-80	Clay	3.4	7.9	12.2	0.57	1.49
80-100	Clay	7.2	8.2	13.5	0.39	1.72
100-120	Clay loam	13.2	8.3	13.4	1.20	1.82
Dholka (Typic camborthid)						
0-20	Loam	2.7	7.5	2.1	18.14	1.29
20-50	Loam	3.2	7.6	2.3	16.39	1.41
50-80	Loam	3.5	7.9	2.4	15.06	1.43
80-110	Loam	5.6	8.1	8.3	12.51	1.63
110-120	Loam	6.8	8.4	6.8	12.65	1.57
Simej (Ustertic haplargid)						
0-20	Clay loam	1.9	7.6	1.5	6.18	1.48
20-45	Clay loam	2.1	7.5	2.0	4.77	1.44
45-85	Clay	2.3	8.0	7.2	3.58	1.52
85-110	Clay	2.6	7.9	10.5	2.33	1.56
110-120	Clay	2.1	7.9	10.8	2.30	1.71

Any alteration in these characteristics would require special management practices, which under present conditions are beyond the capacity of the farmers of the area.

Mansfield (1979) proposed four main soil physical characteristics that are likely to influence crop growth, viz., depth, drainage, texture and coarse material.

Each soil characteristic is assigned a code letter. Thus, depth is given the letter 'D', drainage carries the letter 'W', while texture is denoted by the letter 'T'. Within each characteristic, every important class variation is assigned a code number. But for texture, the degree of limitation increases in severity as the numerical value increases.

The assignment of assessment code is presented in Table 1. The limitation and the criteria used to arrive at the assessment are also shown.

Assignment of the Degree of Limitation to Code Numbers

Being qualitative in nature, the limitation is assigned the degree as nil, minor, moderate and

severe. The no limitation denoted by 'O', the minor degree of limitation denoted by the lower case letters, i.e., 'd', 'w' and 't' for depth, drainage and texture, respectively. The moderate limitation is denoted by upper case letters, i.e., 'D', 'W' and 'T' for depth, drainage and texture, respectively, while the severe limitation carries a bar below the upper case letters, i.e., 'D', 'W' and 'T', respectively.

The physical properties of the soils of the region are shown in Table 2. All the soils are more than 50 cm deep, and hence, as far as depth is concerned, the soils have enough thickness for crops like wheat and gram, but soils of pedon 1 and 4 offer a moderate limitation. Similarly, as far as the texture of the soils is concerned, except pedon 4, all the soils have clayey texture and hence offer no limitation for the crops grown. Soils of pedon 4, due to their loamy texture, offer moderate limitation for all the crops, as these have a lower moisture holding capacity and thus, will marginally affect the yields, especially in pigeonpea.

The soils are imperfectly drained or are impeded. Thus, the soils offer severe to very severe drainage limitation to all the crops.

Table 3. Suitability criteria and rating of soils for different crops

Crop	Overall rating of individual pedons					
	Pedon-1	Pedon-2	Pedon-3	Pedon-4	Pedon-5	Pedon-6
Cotton	$\frac{*D \bar{W}+ t}{5}$	$\frac{d \bar{W} t}{3}$	$\frac{D \bar{W}+ t}{4}$	$\frac{D \bar{W} t}{4}$	$\frac{d \bar{W} t}{4}$	$\frac{d \bar{W} t}{3}$
Pigeonpea	$\frac{D+ t}{5}$	$\frac{d \bar{W} t}{3}$	$\frac{D \bar{W}+ t}{4}$	$\frac{D \bar{W} t}{4}$	$\frac{d \bar{W} T}{4}$	$\frac{d \bar{W} t}{3}$
Wheat	$\frac{d t \bar{W}+}{4}$	$\frac{d t \bar{W}}{3}$	$\frac{D t \bar{W}+}{4}$	$\frac{d t \bar{W}}{3}$	$\frac{d T \bar{W}}{4}$	$\frac{d t \bar{W}}{3}$
Gram	$\frac{d t \bar{W}+}{4}$	$\frac{d t \bar{W}}{3}$	$\frac{D t \bar{W}+}{4}$	$\frac{d t \bar{W}}{3}$	$\frac{d T \bar{W}}{4}$	$\frac{d t \bar{W}}{3}$

3 = Moderate, 4 = Severe, and 5 = Very severe limitation.

* The + sign after the capital letters W & D with a bar underneath indicates very severe limitation. The numerical value is the overall limitation class.

Suitability Rating

Table 3 shows the suitability criteria and the overall ratings of the soils of the region for various crops grown.

Cotton

The results in Table 3 show that the soils of the region offer severe to very severe limitation for cotton. For successful growth of this crop, the raised bed method has been found to be beneficial, as compared to the flat bed cultivation (Anonymous, 1981).

Pigeonpea

Pedon 2 and 6 have moderate restrictions on the growth of pigeonpea, but the other profiles offer severe to very severe limitations (Table 3). The main physical constraints are depth and drainage in pedons 1, 3 and 4. In others, drainage is the limiting factor, except in pedon 5, where in addition to drainage, soil texture is also a limiting factor.

Thus, improving the surface drainability of these soils by deep ploughing and heavy additions of organic matter, will be beneficial.

Wheat

Wheat is grown as a winter crop on stored mois-

ture. The farmers of the area bund their fields during monsoon and allow the water to stagnate. Before the sowing season, and after the cessation of rains, the excess water is allowed to drain out and after the field attains a condition suitable for sowing, wheat is sown. The quality of wheat is of high order, but its yield is very low. In all the soils, drainage is the single limiting characteristic. In pedon 5, soil texture is also a limiting factor.

Gram

Gram is grown on these soils on stored moisture, but only in years when the rainfall is not enough for wheat, or in rotation after previous year's wheat crop. It is seen from Table 3, that in all the soils, drainage is the limitation, along with depth, in pedon 3 and texture in pedon 5.

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