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SOILS OF RAJASTHAN DESERT AND THEIR CHARACTERISTICS

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The soils of Rajasthan desert area are generally sandy, reddish brown to yellowish brown and grey in colour, often calcareous with thick concretionary lime accumulation zone at varying depths. These are broadly classified into the following soil groups : (i) desert soils, (ii) sand dune and sand deposits, (iii) Red desertic soils, (iv) Sierozems, (v) Red and yellow soils of the foothills, (vi) Saline and sodic soils in depressions, and (vii) Lithosols and regosols. Typical profile of each group has been described, analytical data presented and geographical distribution indicated.

The soils in general are poor in fertility status, being low in nitrogen, low to medium in phosphorus and medium to high in potash. Organic matter content is very low and water retention capacity is also low.

The major limitations restricting agriculture, pasture and forestry in the region are the arid climate with low and erratic rainfall, high summer temperatures and high evaporation, very severe wind erosion, loose sandy nature of soils, low water-holding capacity, occasional salinity and scarcity of water.

Soil survey has shown that in areas with the low, erratic rainfall and severe wind erosion, most of the lands fall under Classes VI and VII of land-use capability classes, i.e. those where good pasture can be had only under careful management. Where rainfall is somewhat higher lands fall under Classes III and IV capability classes, i.e. those which could be cropped under intensive soil and water conservation practice.

Introduction

Rajasthan desert, which extends through an area of about 2,00,000 sq. km, forms the eastern part of the Great Indian Desert or Thar Desert. It comprises of the districts of Barmer, Jaisalmer, Bikaner, Ganganagar, Jodhpur, Nagaur, Churu, Jhunjhunu, Sikar and Jalor, and also parts of Pali, Ajmer and Jaipur districts. The entire desert area is flat to gently sloping plain broken by sand dunes of different shapes and sizes and low barren hills. 'Playas' or shallow depressions are occasionally present.

The soils belong to the desert soil group, being generally sandy in texture, reddish brown to brown and grey in colour, often calcareous at the surface or in the subsoil, with a thick concretionary lime accumulation zone at varying depth.

Soil Genesis

Aeolian sands and the quaternary alluvium are the dominant parent materials for the formation of the soils. Weathered products of granite, rhyolite as also sedimentary

sandstones are often the parent materials. Physical and mehanical disintegration of the parent materials rather than their chemical weathering, has however, mostly given rise to more of coarse fraction than clay in the soil. Under arid climate the low rainfall, ranging from 100 to 350 mm, does not permit much illuviation, and accumulation of soluble salts and calcium carbonate is thus common in these soils. Vegetation is scanty and this supplies little organic matter to the soil. The particles are thus loose and susceptible to severe wind erosion.

Soils in the Region

The soils of the Rajasthan desert may be broadly classified into the following soil groups :

(i) Desert soils
(ii) Sand dunes and sand deposits
(iii) Red desertic soils
(iv) Sierozem
(v) Red and yellow soils of foothills
(vi) Saline and sodic soils in depressions (solonchak and solonetz)
(vii) Lithosols and regosols

Desert Soils

These are the dominant soils of the area covering practically the whole of Bikaner, Jaisalmer and Barmer districts and parts of Ganganagar, Nagaur, Churu and Jodhpur districts. The soils are developed under arid conditions with rainfall less than 250 mm from stabilized aeolian sands both on the dune and the sandy plains. In the area of occurrence of these soils there is considerable sand movements and at most places the soil is covered with fresh sand deposits of varying thickness. These soils generally have a light yellowish brown sandy structureless surface and a yellowish brown sandy to loamy sand, structureless to very weakly blocky friable subsoil. Free calcium carbonate is distributed throughout the profile and there is invariably a thick lime concretion zone at varying depths. Clay content varies from 2 to 6% in the surface soil and 4 to 8% in the subsoil. The *p*H value ranges from 8.0 to 8.5 and free calcium carbonate 1 to 1.5%. Organic carbon content is very low, ranging from 0.08 to 0.20% in the surface layer. Moisture retention capacity is very low and the soils are highly pervious. The surface, however, has a tendency to form a crust resulting in reduced infiltration.

Sand Dunes

These are accumulation of fresh sand blown by the wind. These have been grouped separately from desert soils as they are only deposited sand and little profile development has taken place. In stabilized sand dunes, however, there is slight evidence of some illuviation, since the lime content in the soil increases with depth and calcium carbonate concretions in increasing numbers are seen at 3 to 4 metres depth.

Red Desertic Soils

These soils occur in parts of Nagaur, Jodhpur, Pali and Jalor districts. Like the desert soils these have also developed on aeolian sands but under relatively higher rainfall of 250 to 400 mm. Some of these soils have also developed on quaternary alluvium and weathered rhyolite. Although some workers (Raychaudhuri 1963, 1964; Mehta *et al.*, 1969) have included these soils under desert soil group, it is more appropriate to class them under a separate soil group in view of their distinctive properties. The soil colour is reddish brown and there is a greater degree of leaching of calcium carbonate resulting in its accumulation as a well-developed zone at 60 to 150 cm depth. There is also greater degree of weathering and secondary mineral formation as compared to desert soils described above.

Red desertic soils have a reddish brown sandy to loamy sand structureless surface soil and a dark brown to dark reddish brown loamy sand to sandy loam, weak subangular blocky subsoil. This is followed by lime concretion or gravelly strata from weathering of the underlying rocks which has been cemented by free lime leached down from the solum. The soil *p*H is from 7.6 to 8.3 and organic carbon ranges from 0.15 to 0.30%. Clay content is slightly higher than in desert soils and water retention capacity is 2.4 to 8% in surface and 5 to 9% in subsoil.

Sierozem Soils

These soils cover relatively large areas in the districts of Pali, Jalor and Nagaur. They have developed on old alluvium or weathered products of rhyolite or sandstone in the semi-arid zone having a rainfall between 400 to 500mm. These soils have earlier been described under different names by various workers such as grey brown alluvial soils (Mehta *et al.*, 1969), pedocal sierozem (Raychaudhuri, 1964). These are sandy loam to sandy clay loam and clay loam soils with a clearly developed profile down to 1 to 1.5 meter. They have fairly strong blocky structure. Lime concretion is high throughout the profile and there is a distinct lime accumulation zone. The soil *p*H ranges from 7.6 to 8.5. Organic carbon is still low varying from 0.2 to 0.4%. Moisture retention capacity is 6 to 12% in the surface and 10 to 18% in subsoil.

Red and Yellow Soils

These soils are found in slopes along the foothills of the Aravalli ranges. They are reddish to yellowish red in colour and sandy loam to loamy sand in texture. Rainfall ranges from 500 to 600 mm.

Saline and Sodic Soils

These are found in depressional areas or 'playas' where water table is near to the surface and impeded drainage condition attribute to the development of salinity. Such soils are also formed on flood plains of long vanished rivers. These have a light greyish brown colour, fine sandy loam to silty clay loam texture. The soils are either saline or sodic or saline sodic depending upon the degree of saturation and exchangeable sodium percentage. Large areas of such soils are completely bare of vegetation.

Lithosols and Regosols

These soils are found on hill-slopes and on piedmont plains around hills. These are shallow and gravelly with light texture and often mixed with varying amounts of aeolian sand. They are excessively drained and thinly vegetated with very hardy perennials and some annuals.

Description of typical soil profile under each of these groups is given in the Appendix. All these soils have illite as the predominant clay mineral.

Fertility Status of the Soils

Work done at the Central Arid Zone Research Institute and also by the Rajasthan Department of Agriculture (Seth & Mehta, 1963), show that all these desert soils test low in nitrogen, low to medium in phosphorus and medium to high in potash. Organic matter content is very low and work at Central Arid Zone Research Institute shows that even after several years of continuous grass cultivation, increase in organic matter in the soil is inappreciable. In all cases distinct response to application of nitrogen in the soil is shown.

Because of the sandy texture of the soil, moisture retention capacity is low (field capacity 9-11%, wilting point 3.2% for red desertic soils). Residual moisture left in the soil after harvest of kharif crop is too low for growing a second crop. Only a single kharif crop, either bajra or pearl millet (*Pennisetum typhoides*) or a legume like (*Cyamopsis tetragonolaba*) or green gram (*Phaseolus aureus*), is thus taken in this region. Wheat or barley is taken in winter only where irrigation water is available.

As a result of the loose sand in the soil surface, sparse vegetation and high wind velocity, the soil suffers from severe wind erosion. There is constant sorting of the aeolian sand which piles up either to form dunes and hummocks or deposits over plain lands. Suitable management practices are thus called for checking such wind erosion.

Extensive areas in the arid zone have saline and sodic soils where crops and grasses have restricted growth. Reclamation of such lands could sometimes be possible by leaching with water in the usual way, either alone or with addition of amendments. In most cases, however, either sufficient sweet water for leaching out the salt is not available or the drainage is impeded due to the depression in land. Reclamation method thus becomes difficult and such lands could thus be utilized only by growing salt-resistant plants and grasses.

Calcium carbonate hard pan at varying depths is very common in these desert soils, and this often affects the root development of plants. While in some cases only lime forms coatings on pebbles, in most other cases concretions of various sizes are found ultimately forming a thick indurated calcium carbonate layer. Calcium carbonate accumulation has resulted from weathering of calcareous rock material, rather than from leaching down of lime through soil profile (Roy *et al.*, 1969).

Land-use Capability Classification

In these desert areas the major limitations which restrict the agriculture, pasture and forestry are the arid climatic conditions, with low and erratic rainfall, high summer

temperature and high evapo-transpiration, very severe wind erosion, sandy nature of the soil with low water-holding capacity, occasional salinity and scarcity of water. Based on these, the lands could be classified into land-use capability classes. Distribution of such classes of lands in some of the typical Panchayat Samiti blocks of western Rajasthan are given below :

Panchayat Samiti block	Average annual rainfall (mm)	Land-use capabitity classes (% of total area)							
		I	II	III	IV	V	VI	VII	VIII
Chohtan	220	—	—	12.9	19.9	1.0	59.8		6.4
Saila	320	—	2.3	32.8	29.2	5.8	28.4	0.7	0.8
Siwana	344	0.2	2.1	46.6	25.2	4.3	5.5	4.8	11.3
Jalor	363	—	2.7	68.8	5.3	2.7	10.9	4.0	5.6
Luni	366	—	—	75.6	11.6	0.5	11.8	—	0.5
Ahor	400	—	12.4	50.2	6.1	3.8	6.8	15.3	5.4

It will be seen that where rainfall is low, extensive areas are under land-use capability Classes VI and VII where pasture and grasses are recommended. Those lands are not suitable for normal cropping but excellent pasture could be developed using such perennial grasses as *Lasiurus sindicus*, *Cenchrus ciliaris* and *Cenchrus setigerus*. Where rainfall is somewhat higher, more areas are under classes III and IV, which could be put under crops provided careful soil conservation measures for preventing wind erosion are adopted.

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APPENDIX

(i) *Desert Soils*

0–20 cm [Pale brown (10 YR 6/3), sandy, loose, structureless, slight effervescence with HCl

20–60 cm [Pale brown (10 YR 6/3), loamy sand, loose, very weakly blocky, strong effervescence with HCl

60–90 cm [Same as above but with more effervescence with HCl

90–120 cm [Light brownish grey (10 YR 6/2), sandy, loose, structureless

Depth (cm)	Coarse sand	Mechanical composition (%) Fine sand	Silt	Clay	$CaCO_3$ (%)	*p*H	Organic C (%)
0–20	21.3	70.7	2.6	5.4	1.50	8.4	0.17
20–60	15.0	70.3	6.3	8.4	7.30	8.6	
60–90	14.2	71.1	8.4	6.3	9.13	8.5	
90–120	18.8	70.2	7.3	3.7	7.45	8.5	

(ii) *Sand Dunes*

Depth (cm)	Coarse sand	Mechanical composition (%) Fine sand	Silt	Clay	$CaCO_3$	*p*H	Organic C
0–30	22.4	70.5	1.4	4.7	0.7	8.5	0.10
30–60	11.4	81.1	1.1	5.0	0.6	8.5	
60–90	14.7	78.1	1.0	4.8	0·6	8.5	
90–120	12.5	82.7	0.4	3.9	0.5	8.5	
120–150	14.0	81.0	1.5	2.5	0.6	8.5	
150–180	14.2	78.8	2.0	3.3	0.8	8.5	
180–210	13.8	80.3	1.2	2.9	0.8	8.5	

(iii) *Red Desertic Soils* (Pal series)

0–15 cm [Brown (10 YR 5/3) loamy sand, single grained, dry and loose, non calcareous, abundant roots, rapid permeability, diffused boundary.

15–38 cm [Dark brown (10 YR 3/3) sandy loam, very weak granular structure, dry and noncalcareous, abundant roots, rapid permeability, diffused boundary.

38–94 cm [Dark brown (10 YR 3/3) sandy loam, very weak subangular blocky structure, dry and loose, moist and friable, slightly more compact than above, noncalcareous, fewer roots present, rapid permeability, diffused boundary.

94–112 cm [Dark brown (10 YR 3/3), sandy loam, very weak subangular blocky structure, dry and loose, moist and friable slight effervescence with HCl, fewer roots, fairly rapid permeability.

112–127 cm [Dark brown (10 YR 3/7) loamy sand, very weak subangular blocky structure, dry and slightly hard, moist and friable, plenty of lime concretions present giving violent effervescence with HCl, more compact than above, clear boundary.

127 cm + [Concretionery layer of rhyolite and sandstone fragments coated with lime, mixed with some soil.

Depth (cm)	Coarse sand	Mechanical composition (%)			$CaCO_3$	*p*H	Organic C
		Fine sand	Silt	Clay			
0–15	18.1	68.0	6.5	7.4	0	7.7	0.25
15–38	30.1	50.5	7.8	11.6	0	7.6	
38–94	31.5	45.2	8.6	14.7	0	7.7	
94–112	41.9	36.8	6.5	14.8	0.1	7.8	
112–127	38.4	42.7	11.0	7.9	0.2	7.9	

(iv) *Sierozems*

0–22 cm — Brown (10 YR 5/3 D, 10 YR 4/3 M) sand, weak granular structure, dry and loose, violent effervescence with HCl, profuse root present.

22–47 cm — Light brownish grey (10 YR 6/2 D) to dark greyish brown (10 YR 4/2 M) loamy sand, angular blocky structure, dry and hard, violent effervescence with HCl, many roots present.

47–65 cm — Pale brown (10 YR 6/3 D) to greyish brown (10 YR 5/2 M) sandy loam, strong angular blocky structure, dry and very hard, violent effervescence with HCl, some roots present.

65–72 cm — Pale brown (10 YR 6/3 D) to greyish brown (10 YR 5/2 M) sandy loam to loam, dry and very hard, nodules of calcium carbonate present giving violent effervescence with HCl, a few roots.

72 cm + — Thick layer of weathered rocks with some soil.

Depth (cm)	Coarse sand	Mechanical composition (%)			$CaCO_3$	*p*H	Organic C
		Fine sand	Silt	Clay			
0–22	1.1	86.2	4.5	8.2	3.3	7.7	0.23
22–47	1.1	85.9	4.2	8.7	5.7	7.7	0.10
47–65	18.0	63.6	7.7	10.0	5.9	7.8	0.21
65–72	23.6	53.5	10.7	12.7	9.1	7.8	0.19

(v) *Red and Yellow Soils*

0–18 cm — Yellowish brown (10 YR 5/4) sandy loam, weak subangular blocky, dry and slightly hard, noncalcareous, plenty of root present.

18–30 cm — Yellowish brown (10 YR 5/4) clay loam, angular blocky, dry and hard, noncalcareous, some roots present.

30–47 cm — Yellowish brown (10 YR 5/4) clay loam mixed with some weathered rock, angular blocky structure, dry and hard, non calcareous.

47 cm + — Light brownish grey (10 YR 6/3) weathered rock, noncalcareous.

(vi) *Saline Soils*

0–7 cm — Dark grey (10 YR 4/1) sandy clay loam, blocky structure, dry and hard, sticky when wet, mild effervescence with HCl, moderate permeability.

7–28 cm — Grey brown (10 YR 5/2) clay loam, blocky structure, hard when dry, sticky when wet, mild effervescence with HCl, moderately slow permeability.

28–50 cm — Pale brown (10 YR 6/3) clay, blocky structure, dry and hard, sticky when wet, mild effervescence with HCl, show permeability.

50–100 cm + — Dark brown (10 YR 4/3) clay, blocky structure, dry and hard, sticky when wet, effervescence as above with HCl, slow permeability.