Sandy Soils of India

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Abstract: *Sandy soils are largely observed in arid and semi-arid regions of north-western plains and along the coastline, and also to some extent in cold desert areas of the country. These regions experience low rainfall with high temperature in summer, and low temperature in winter. The frequent dust storms are common.*

These soils qualify for classification as Usti-and Torripsamments, and occur in association with Camborthids, Ustochrepts, Ustifluvents, etc. They are of aeolian and fluvial nature. The aeolian sands are generally overburdened on fluvial deposits. The major problems are due to coarse texture associated with low moisture and low nutrient holding capacity, poor structure and susceptibility to erosion. Suitable soil conservation and erosion control measures greatly enhance their prospects to successful cropping. Drip irrigation and application of bitumen emulsion may increase water use efficiency. Along sea-coast, wind breaks with suitable plantations, such as Casuarina are imperative to stabilise the areas.

Soil is an important natural resource as it provides the basic needs of human beings and animals. Its intimate knowledge is, therefore, a pre-requisite in any national development plan for sustained food production. The present attempt is aimed to study the sandy soils with respect to their nature, characteristics, extent, problems and potentials for developing ra tional land use plans.

GEOGRAPHICAL SETTING

Distribution: Sandy soils are those having sandy or loamy sand texture, and containing less than 50 per cent very fine sand. They may also be sandy-skeletal containing 35 per cent or more of rock fragments. They occur mostly in western Rajasthan, southern Haryana, south-west Punjab and north-western parts of Gujarat in arid to semi-arid regions and along the east and west coasts of India. Besides, they are also encountered in patches in the interior regions of the flood plains of the major rivers, and in cold desert areas of Leh and Ladakh (Fig. 1; Tables 1, 2).

Climate: Arid zone is strongly influenced by monsoonic regime as 78 to 96 per cent of the total rainfall (100 to 450 mm in Rajasthan; 300 to 500 mm in Gujarat; and 200 to 450 mm in Punjab & Haryana) is received during the monsoon months. The annual potential evapotranspiration varies from 1411 to 1700 mm resulting in an annual deficit of 1019 to 1171 mm (Krishnan 1978). Precipitation, temperature and water balance diagrams of selected stations of semi-arid to arid regions where sandy soils

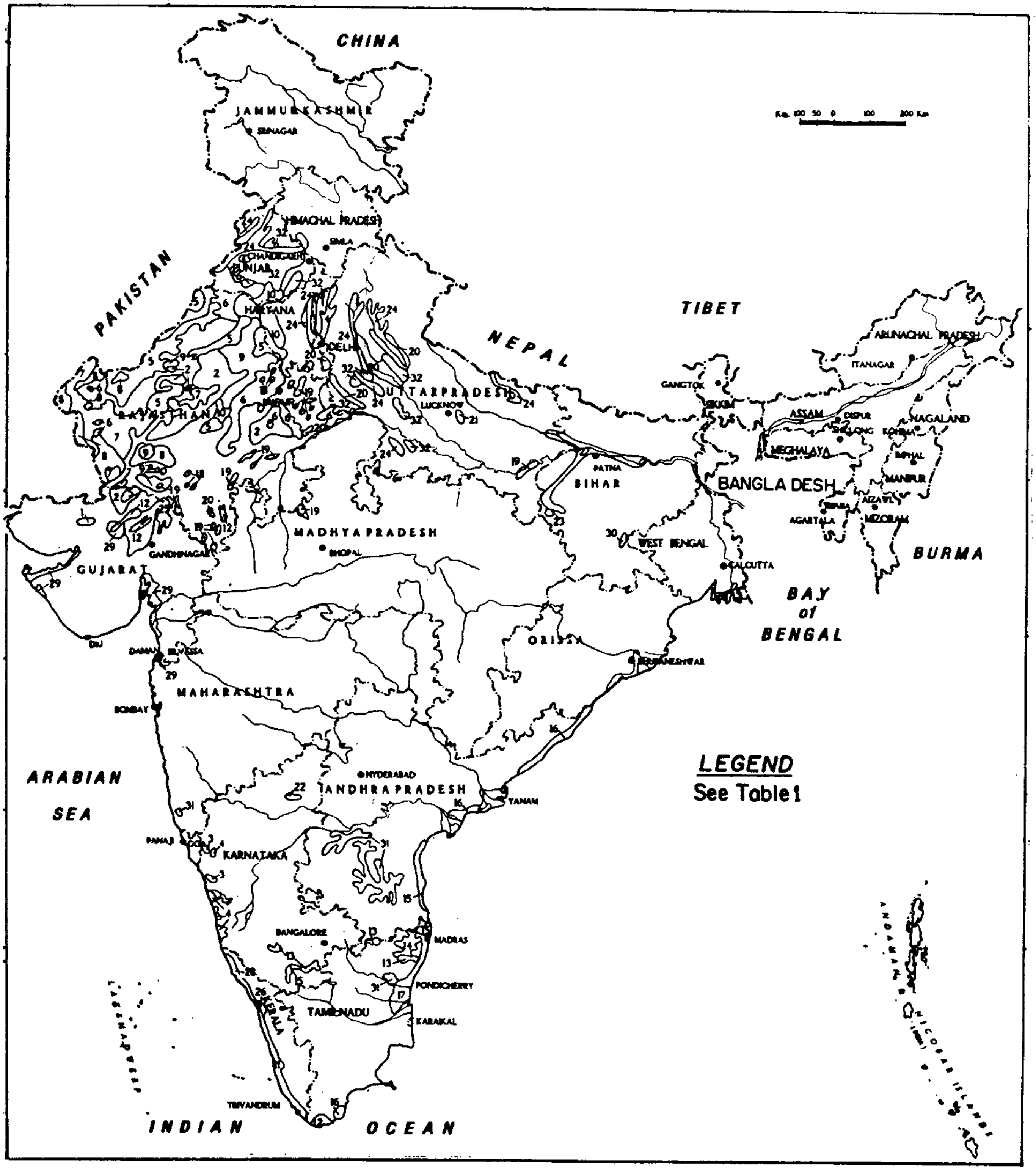

Figure 1. Distribution of sandy and associated soils in India

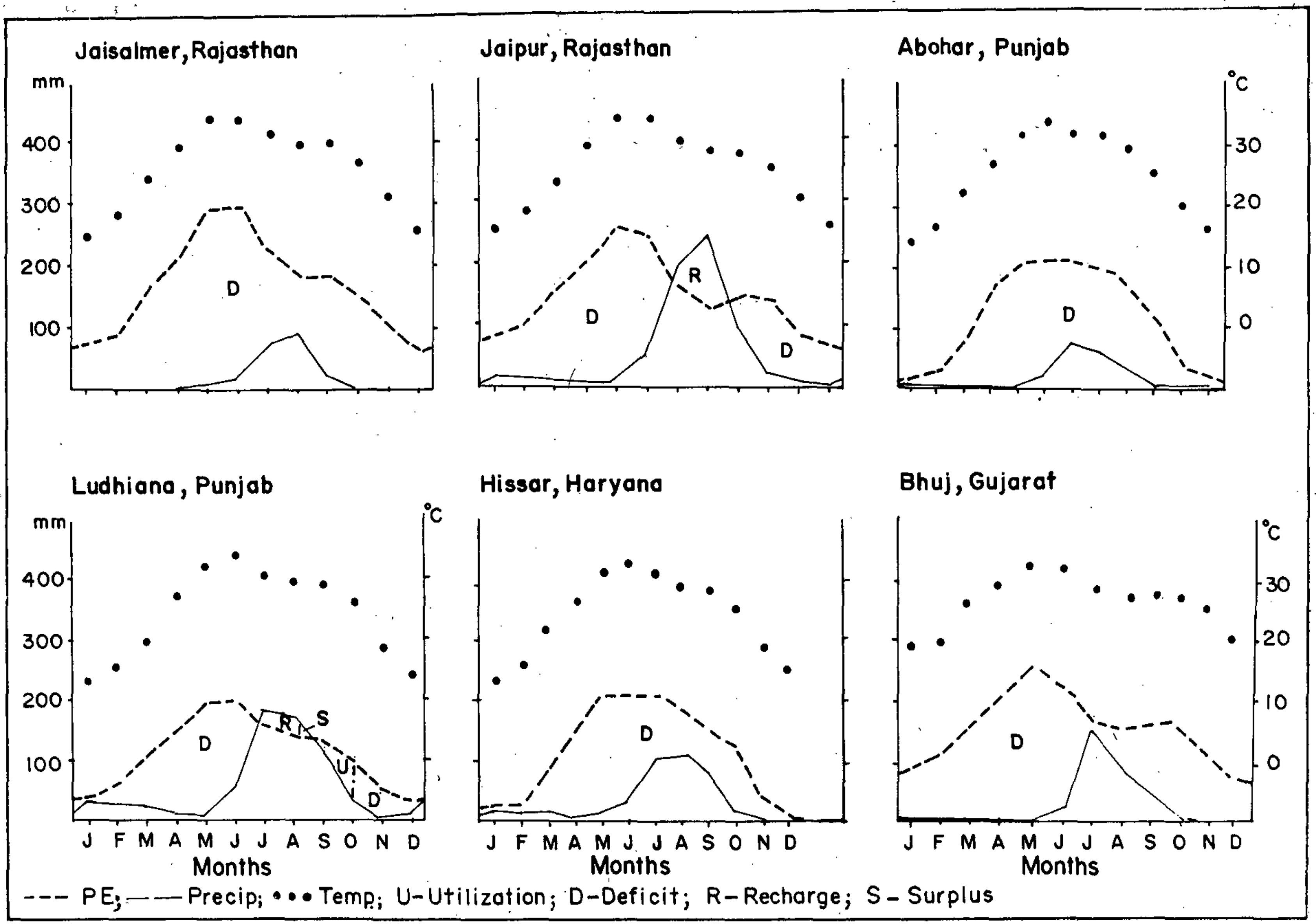

Figure 2. Precipitation, temperature and water balance diagrams

TABLE 1. Estimated distribution of sandy and associated soils of India (area in '000 ha)

Sr. No.	Soil association (Great Groups)	Rajasthan	Uttar Pradesh	Punjab	Gujarat	Andhra Pradesh	Tamil Nadu	Haryana	Bihar	Karnataka	Kerala	Madhya Pradesh	Maharashtra	Total
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1.	Salorthids-Ustipsamments	-	-	-	69	-	-	-	-	-	-	-	-	69
2.	Camborthids-Torripsamments	2831	-	-	371	-	-	-	-	-	-	-	-	302
3.	Tropaquents-Udifluvents-Udipsamments	-	-	-	-	-	-	-	-	57	-	-	-	57
4.	Psammaquents-Fluvaquents Haplaquents	-	220	-	-	-	-	83	-	128	-	-	-	431
5.	Torripsamments	3749	-	-	114	-	-	114	-	-	-	-	-	3977
6.	Torripsamments-	2226	-	76	-	-	-	-	-	-	-	-	-	2302
7.	Torripsamments-Calciorthids	3448	-	-	-	-	-	-	-	-	-	-	-	3448
8.	Torripsamments-psamments-Calciorthids Quartzi-	1987	-	-	-	-	-	-	-	-	-	-	-	1987
9.	Torripsamments-Paleorthids -Calciorthids	2036	-	-	-	-	-	16	-	-	-	-	-	2052
10.	Torripsamments-fluvents-Camborthids Torri-	187	-	238	-	-	-	651	-	-	-	-	-	1076
11.	Tropopsamments-Troporthents	-	-	-	-	-	-	-	-	-	331	-	-	331
12.	Ustipsamments	62	-	-	153	-	54	-	-	-	-	-	-	269
13.	Ustipsamments-Ustorthents - Ustropepts	-	-	-	-	-	134	-	-	156	-	-	-	290
14.	Ustipsamments-Haplustalfs	-	-	-	-	-	238	-	-	-	-	-	-	238
15.	Ustipsamments-Ustifluvents	-	-	-	-	137	128	-	-	71	-	-	-	336
16.	Ustipsamments-Quartzipsamments	-	-	-	-	519	39	-	-	-	-	-	-	558
17.	Ustipsamments-Ustropepts	-	-	-	-	-	630	-	-	-	-	-	-	630
18.	Ustipsamments-Ustorthents - Rock outcrops	231	-	-	-	-	-	-	-	-	-	-	-	231
19.	Ustipsamments-Ustorthents	587	107	-	-	-	-	-	-	-	-	78	-	772
20.	Ustipsamments-Ustifluvents - Ustochrepts	81	703	-	-	-	-	67	-	-	-	-	-	851
21.	Ustipsamments-Psammaquents - Ustorthents	-	33	-	-	-	-	-	-	-	-	-	-	33
22.	Ustifluvents-Ustipsamments - Psammaquents	-	-	-	-	-	-	-	-	53	-	-	-	53
23.	Ustifluvents-Ustipsamments - Chromusterts	-	-	-	-	-	-	-	29	-	-	-	-	29

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
24.	Ustifluvents-Ustipsamments - Fluvaquents	-	827	569	-	-	-	45	-	-	-	-	-	1441
25.	Ustifluvents-Ustipsamments -Haplustalfs	27	-	-	906	-	-	-	-	-	-	-	-	933
26.	Tropofluvents-Tropopsamments -Troporthents	-	-	-	-	-	-	-	-	-	37	-	-	37
27.	Udifluvents-Udipsamments -Haplaquepts	-	38	-	-	-	-	-	787	-	-	-	-	825
28.	Troporthents-Tropo-psamments-Fluvaquents	-	-	-	-	-	-	-	-	-	93-	-	-	93
29.	Halaquepts-Ustipsamments	-	-	-	722	-	-	-	-	-	-	-	-	722
30.	Haplaquepts-Psammaquents	-	-	-	-	-	-	-	27	-	-	-	-	27
31.	Ustropepts-Ustipsamments -Ustifluvents	-	-	-	-	965	71	-	-	-	-	-	15	1051
32.	Ustochrepts-Ustipsamments	111	1300	1712	-	-	-	-	-	-	-	-	-	3123
	Total	17563	3228	2595	2335	1621	1294	976	843	465	461	78	15	31474

predominate are given in fig. 2. The coefficient of rainfall variation from year to year is as high as 40 to 56 per cent (Mann & Dhir 1982). The moisture regime varies from aridic to ustic.

The temperature in extreme arid region rises to 52°C during summer, and it drops below the freezing point in winter. Soil temperature at 30 cm depth is about 34°C. In winter, it is 20 to 30°C (Krishnan & Rao 1979). There is high diurnal variation with an amplitude of 25 to 30°C at the surface and about 20°C at 5 cm depth throughout the year except during the monsoon months. The maximum soil temperature (>50°C) was recorded at 5 cm depth during summer (Dhir & Jain 1982). In coastal region, the seasonal temperature variation is narrow. The soil temperature regime is generally hyperthermic in plains and is cryic in cold desert region of Leh and Ladakh.

Physical setting: The region shows erosional remnants of rocks ranging from Pre Cambrian, through Palaeozoic to Tertiary; but their extent is limited. A major coverage is of Quaternary alluvium and sands. Old aggraded alluvial plains under arid climate indicate massive fluvial activities during Pleistocene period. Over a large area, the surface of these plains is covered with wind sorted sands (Ghose 1964).

The soils in aeolian plain are formed in hummocks, dunes and interdunal areas and in aeo-fluvial plain on aggraded alluvial plains, pediment surfaces, flood plains and playa basins. In the coastal regions, they are associated with the sand beaches, bars and coastal sand dunes. In the interior, they

TABLE 2. Estimated approximate area under each great group of sandy and associated soils of India

Soils (Great group) 1	Area ('000ha) 2	(%) 3
SANDY SOILS		
Torripsamments	11,265.3	35.79
Ustipsamments	5,109.6	16.24
Quartzipsamments	819.3	2.60
Udipsamments	258.9	0.82
Psammaquents	246.8	0.78
Tropopsamments	237.6	0.76
Total	17,937.5	56.99
ASSOCIATED SOILS		
Aridisols:		
Calciorthids	2,187.0	6.95
Camborthids	2,136.4	6.79
Paleorthids	615.6	1.95
Salorthids	41.4	0.13
Total	4,980.4	15.82
Entisols:		
Ustifluvents	1,827.9	5.81
Torrifluvents	1,243.6	3.95
Ustorthents	471.7	1.50
Fluvaquents	436.1	1.39
Udifluvents	429.6	1.36
Troporthents	186.3	0.59
Haplaquents	86.2	0.27
Tropaquents	28.5	0.09
Tropofluvents	18.5	0.06
Total	4,728.4	15.02
Inceptisols:		
Ustochrepts	2,044.0	6.49
Ustropepts	835.5	2.65
Halaquepts	433.2	1.38
Haplaquepts	181.2	0.58
Total	3,493.9	11.10
Alfisols:		
Haplustalfs	281.8	0.90
Vertisols:		
Chromusterts	5.8	0.02
Rock outcrops:	46.2	0.15
Grand Total	31,474.0	100.0

* Calculation basis: 6:4 (in 2 associated soils) and 5:3:2 (in 3 associated soils)

are associated with sand bars and flood plains of the major rivers.

CHARACTERISTICS

Depending on climatic variation, parent material and drainage conditions, the soils differ in their morphology and physico-chemical characteristics. The salient properties of some typical soils, (Thar, Chomu and Dune of Rajasthan; Fatehpur and Bhanra of Punjab; Behal and Khoh of Haryana; and Balasar of Gujarat) are given in table 3.

Morphology: Soils of Rajasthan, Haryana and Punjab are very deep, pale brown, brown, brownish yellow or yellowish brown, single grained, sand to loamy fine sand and

TABLE 3. Morphological and physico-chemical properties of sandy soils

Hori-zon	Depth (cm)	Colour (Munsell)	Text-ure	Struc-ture	Sand (%)	Silt (%)	Clay (%)	pH	EC (dSm^{-1})	$CaCO_3$ (%)	Org.C (%)	CEC $cmol+kg^{-1}$
1	2	3	4	5	6	7	8	9	10	11	12	13
Thar series (Typic Torripsamment) - Western Rajasthan (Murthy *et al.* 1982)												
C1	0-38	10YR6/3	lfs	sg	84.5	9.8	5.7	8.0	-	6.0	0.10	2.3
C2	38-92	10YR 6/3	lfs	sg	83.2	10.0	6.8	8.2	-	6.6	0.12	2.2
C3	92-108	10YR 6/3	lfs	sg	86.1	7.4	6.5	8.2	-	8.0	0.10	2.4
C4	108-138	10YR 6/3	lfs	sg	86.7	6.3	7.0	8.2	-	8.2	0.01	2.6
C5	138-160	10YR 6/3	fs	sg	91.7	3.3	5.0	8.3	-	7.3	0.01	2.5
Chomu series (Typic Ustipsamment*) - Jaipur, Rajasthan (Murthy *et al.* 1982)												
Ap	0-11	10YR 5/6	fs	sg	89.4	5.9	4.7	8.3	0.30	Tr	0.18	5.5
A12	11-26	10YR 6/4	lfs	lfgr	86.9	5.7	7.4	8.1	0.23	Tr	0.07	5.5
B21	26-55	7.5YR 4/4	lfs	lfsbk & gr	87.1	5.7	7.2	7.8	0.25	-	0.06	7.1
B22	55-87	7.5YR 4/4	lfs	lfsbk & gr	86.8	5.3	7.9	7.7	0.25	-	0.04	5.8
B3	87-119	7.5YR 6/4	lfs	sg	87.0	5.2	7.8	7.7	0.18	-	0.04	6.0
C1	119-155	7.5YR 5/6	lfs	sg	86.4	6.0	7.6	7.8	0.31	-	0.03	5.8
C2	155-170	7.5YR 5/6	lfs	sg	86.8	6.0	7.2	7.9	0.38	-	0.03	5.9
Dune series (Typic Torripsamment) - Jodhpur, Rajasthan (Established Soil Series, 1986 - CAZRI)												
C1	0-50	10YR 6/3	s	sg	97.0	1.0	2.0	8.4	0.13	-	0.08	2.2
C2	50-100	10YR 5/4	s	sg	96.8	1.2	2.0	8.4	0.14	0.4	0.08	2.4
C3	100-150	10YR 5/4	s	sg	95.7	2.1	2.2	8.4	0.17	0.4	0.08	3.0
C4	150-200	10YR 6/4	s	sg	95.8	2.0	2.2	8.2	0.26	3.3	0.08	2.8
C5	200-250	10YR 6/4	s	sg	96.0	2.2	1.8	8.4	0.17	4.4	0.08	2.8

1	2	3	4	5	6	7	8	9	10	11	12	13
Fatehpur series (Typic Ustipsamment*) - Ludhiana, Punjab (Murthy *et al.* 1982)												
Ap	0-15	10YR 5/4	lfs	sg	83.1	11.4	5.5	7.8	0.80	-	0.12	3.6
A12	15-25	10YR 4/4	ls	sg	77.5	14.1	8.4	7.8	0.70	-	0.11	4.2
B21	25-47	7.5YR 4/4	ls	sg	78.6	12.5	8.9	7.8	0.60	-	0.05	4.0
B22	47-63	7.5YR 4/4	ls	sg	78.7	12.1	9.2	7.7	0.90	-	0.07	5.1
B23	63-75	7.5YR 4/4	ls	1fsbk	78.7	12.0	9.3	7.8	1.00	-	0.03	6.0
B24	75-100	7.5YR 4/4	sl	1fsbk	76.7	15.8	7.5	7.7	0.80	-	0.03	3.9
B25	100-117	7.5YR 4/4	sl	1fsbk	74.4	17.8	7.8	7.6	0.80	Tr	0.03	3.7
B26	117-123	7.5YR 4/4	ls	1fsbk	76.4	16.2	7.4	7.6	0.70	Tr	0.03	3.8
C1	123-143	7.5YR 4/4	ls	sg	79.4	13.8	6.8	7.6	0.80	Tr	0.03	3.1
C2	143-165	7.5YR 4/4	ls	sg	82.6	10.9	6.5	7.7	0.90	Tr	0.03	2.8
Bhanra series (Typic Ustipsamment) - Patiala, Punjab (NBSS & LUP 1981)												
A	0-20	10YR 5/6	s	sg	88.7	3.5	7.8	7.6	0.20	-	0.11	1.1
C1	20-66	10YR 5/6	s	sg	90.7	2.6	6.7	7.5	0.20	-	0.08	1.3
C2	66-150	10YR 5/6	s	sg	89.3	4.0	6.7	7.6	0.20	-	0.08	1.1
Behal series (Typic Torripsamment) - Hissar, Haryana (Ahuja & Singh 1983)												
Ap	0-45	10YR 5/4	s	sg	91.4	3.0	5.6	7.9	0.10	-	0.04	4.6
C1	45-80	10YR 4/6	s	sg	90.4	3.6	6.0	7.8	0.13	-	0.03	5.0
C2	80-145	10YR 5/3	s	sg	91.2	2.6	6.2	7.9	0.09	1.5	0.03	4.8
C3	145-200	10YR 5/3	s	sg	91.8	1.6	6.6	7.9	0.09	1.4	0.03	4.1
Khoh series (Typic Ustipsament) - Gurgaon, Haryana (NBSS & LUP 1982)												
Ap	0-24	10YR 5/6	ls	1fsbk(gr)	84.2	9.0	6.8	8.3	0.02	-	0.06	3.8
C1	24-65	10YR 5/6	ls	lfsbk(gr)	79.6	10.9	9.5	8.3	0.02	-	0.04	3.3
C2	65-104	10YR 5/6	ls	1msbk	79.9	11.1	9.0	8.0	0.01	-	0.05	4.9
C3	104-155	10YR 5/6	sl	1msbk	78.5	10.7	10.8	8.5	0.05	0.9	0.04	6.0
Balasar series (Typic Torripsamment) - Kutch (Bhuj), Gujarat (NBSS & LUP 1977)												
A11	0-10	10YR 5/4	ls	1fsbk	85.5	4.6	9.9	8.9	<0.20	16.6	0.21	-
A12	10-32	10YR 5/4	ls	1fsbk	85.5	4.7	9.8	9.3	<0.20	25.7	0.01	-
C1ca	32-59	10YR 5/4	s	sg	91.1	3.8	5.1	9.3	<0.20	23.0	0.01	-
IIC2ca	59-99	10YR 5/4	s	sg	93.4	3.0	3.6	9.3	0.45	28.8	0.05	-
IIC3ca	99-137	10YR 6/6	s	sg	94.0	2.9	3.1	9.4	0.85	28.8	0.02	-

* Classification tentative
Colour : Dry colour of Thar series and moist colour of other series
Texture : s-sand, fs-fine sand, ls-loamy sand, lfs-loamy fine sand, sl-sandy loam
Structure: sg-single grain, gr-granular, sbk-subangular blocky, f-fine, m-moderate, 1-weak

show almost no profile development. Chomu series of Rajasthan and Fatehpur series of Punjab occurring on aeo-fluvial plain are very deep, light yellowish brown to dark brown, single grained on surface and substratum, weak fine subangular blocky in subsurface, and fine sand to loamy fine sand, and occasionally sandy loam in subtratum. The Balasar soils occurring on sloping beach ridge slough and marine salt waste of Gujarat coast, are very deep, light yellowish brown to very pale brown, single grained to weak fine subangular blocky, sand to loamy sand and show lithological discontinuity in the subsoil.

Physical and chemical properties: Soils in Thar desert of Rajasthan, are moderate to strongly calcareous (5 to 15% $CaCO_3$) (Lodha *at al*. 1982). The Chomu and Dune soils of Rajasthan; Behal and Khoh soils of Haryana, Fatehpur and Bhanra soils of Punjab are almost noncalcareous. The soils of coastal area (Balasar series) are highly calcareous (16 to 30% $CaCO_3$).

They have, in general, low organic matter (0.1-0.2%) and slight to moderately alkaline pH (7.6 to 8.4). However, in some cases strongly to very strongly alkaline pH (8.9 to 9.3), is observed. The ECe is generally low (<1ds m^{-1}). The CEC is very low, usually less than 6 C mol$(P^+)kg^{-1}$.

Mineralogy: The heavy mineral assemblage comprises (in descending order) of hornblende, epidote, garnet with common opaque and occasional ubiquitous mineral and alterites (Table 4). Although the pattern of mineral distribution is comparable in fluviatile and aeolian materials, yet the amount of hornblende is significantly more in aeolian soils than in underlying alluvium. The ratio of nonweatherable to weatherable minerals is significantly low (0.1-0.2) in Torripsamments as compared to Ustipsamments ($\pm$ 1.6).

In the light fraction (Table 5), the amount of feldspars is dominant followed by quartz and muscovite. The aeolian soils are rich in feldspars (calcic) as compared to alluvium-derived soils (P2). The low quartz : feldspar ratio suggests that the aeolian material is comparatively less weathered than the underlying alluvial material.

The Psamments of ustic zone developed on sand bars, show the heavy mineral assemblage with dominance of epidotes, followed by hornblende, ubiquitous and opaque minerals. The distribution of light minerals shows the predominance of feldspars, quartz and muscovite. There is no significant difference in mineral composi tion between aeolian sand cover and underlying alluvial material. It suggests that the shifting sanddunes and the material under neath are the outcome of the same source.

The Ustipsamments of Indo-Gangetic plain are more weathered than Torripsamments, which is evident from the weatherable/nonweatherable and quartz/feldspar minerals.

The clay mineral make up of Psamments is dominated by illite followed by vermiculite with fair amounts of quartz and feldspars (Sehgal 1970). Torripsamments do not

TABLE 4. Heavy mineral composition in sand fraction of sandy soil

Horizon & Depth (cm)	Sand (50 - 420 µ in soil (<2mm) (%)	Heavy mineral in sand (50-420 µ) (%)	Opaque	Transparent minerals in matual percentage															
				Ubiquitons		Rutile	Titanite (sphene)	Para meramorphic		Garner	Epidote group		Pyroxene group	Amphi-bile group		Alterite	Non weatherable: weatheranle min. ratio	Biotite	Chlorite
				Tormaline	zircon			Staurolite	Kyanite		Ziosite	Epidote	Augite	Hornblende	Tremolite				
P-1 Torripsamment (Thapto-Camborthidic) from Haryana (Sehgal 1970), Vill. Khera Kheri, 30 km from Hissar - Fathehbad rd.																			
A12 (30 - 70)	90.8	4.06	7	3	2	1	-	1	-	12	12	10	-	56	-	4	0.11	-	-
B26 (110 - 150)	53.8	2.33	5	5	2	1	-	-	2	17	18	11	-	38	2	5	0.21	-	-
P-2 Ustipsamment (Typic) from Punjab (Sehgal 1970), Vill. Bhagpur, P.O. Kuhara (Ludhiana)																			
A1 (0-20)	94.3	2.71	26	11	13	2	7	-	2	11	15	10	-	20	-	9	1.57	4	-
IIA1(110+)	70.0	2.01	25	10	14	2	4	-	4	16	20	7	-	15	-	11	1.69	4	-

TABLE 5. Light mineral composition in sand fraction of sandy soils

Transparent light minerals composition in matual percentage							
Horixon	Quartz	Musco-vite	Feldspars Potossic	Feldspars Calcic	Quartz/ feld spars	Alterite	Rock frag-ments
P-1 Trorripsammentm (Thapto-Camborthidic) from Haryana (Sehgal 1991)							
A12	36	12	17	31	0.75	4	2
B26	37	12	12	34	0.80	5	2
P-2 Ustipsamment (Typic) from Punjab (Sehgal 1979)							
A1	37	12	18	24	0.88	9	3
IIA1	41	13	16	21	1.10	10	2

show any kind of mineral transformations but the Ustipsamments show the presence of chloritized montmorillonite or vermiculite, suggesting the role of climate in the transformation of these minerals.

TAXONOMY

Various investigators (Sehgal *et al.* 1965, 1986; Mathur *et al.* 1972; Sehgal 1974; Dhir 1977; Ahuja *et al.* 1978; Sehgal & Dhir 1982) attempted to classify the soils of arid region as per Soil Taxonomy (Soil Survey Staff 1975). Accordingly, the soils are classified to various great groups as Torripsamments, Ustipsamments, Quartzipsa--mments, Udipsamments, Psammaquents and Tropopsamments.

PROBLEMS AND POTENTIALS

Sandy soils are potentially fertile as observed from their mineralogical make up. However, they pose severe physical constraints associated with their inherent and site characteristics, such as climate, texture and single grained structure, wind erosion, droughtiness, low available moisture and nutrients, high percolation resulting in loss of added nutrients to deeper depths, and low organic matter. In arid areas, generally, the ground water is deep and also brackish.

They are in general, low in N, P and K. Some Typic Torripsamments of Haryana are also reported deficient in Cu and Zn (Ahuja & Singh 1983), while those of Rajasthan are well supplied with most of the micronutrients, except Zn in a few cases (Joshi *et al.* 1981, 1982). Boron toxicity has been reported in the Entisols of arid areas of Rajasthan (Lodha & Baser 1971).

The shifting of sand is intensified during the cyclonic period and causes severe damage to the standing crops in coastal dune areas. Extensive coastal sandy areas are lying unutilized due to high water table and salinity (NCA 1976).

The soils have rich potential because of the dominance of ferro-magnesian and feldspar in their sand fraction, but the productivity, in general, is low to medium. Adpoting erosion control and other ameliorative measures, such as stabilization of sand dunes, pasture development, strip cropping and moisture conservation practices (surface mulching), incorporation of organic manures and amendments, control of surface crusting and water harvesting (Singh 1982) enhances the productivity. Under irrigated conditions, controlling seepage and percolation loss of water becomes important. Water use efficiency can be increased by regulating irrigation frequency and amount of water applied in accordance with water holding capacity of soil.

To overcome the problems of high infiltration, low fertility, sand drifting and deep percolation of water, a suitable soil water technology needs to be developed for sustaining agriculture production. Such technology would emphasize on : greater reliance on crops with deep root system like cluster bean, raya and safflower; soil compaction to reduce infiltration rate, increase water retention capacity and use of slow releasing fertilizer to minimize leaching losses of applied nutrients (Dhir 1987). Land levelling, sprinkle irrigation, mulching and chemical amendments will also check the erosion and stabilize the dunes.

The high water loss in these soils due to deep percolation and high evaporation can be prevented by incorporating highly hydrophillic polymers (hydrogels). Addition of hydrogel (particles of $\pm$20-100 μ) tends to clog the wide capillary of sand particles, and enhances the formation of a meniscus, allowing to hold the water over a length of 40 to 50 cm. Besides, they also adsorb water and release it as and when needed by roots. Polyacrylate salts of K^+ and NH_{4+} adsorb moisture about 300 times of their weight and release 2/3 to 3/4 of it.

The high evaporation at soil surface can be decreased as much as 60 per cent by broadcasting a nonphytotoxic hydrophobic emulsion (called black milk). Broadcasting is mostly done by spraying along the seeding lines and/or drip irrigation tubes over a width of 10 cm or around a planted tree in a circle with a radius of 50 cm. About 20-40 g hydrophobic emulsion (expressed as bitumen) will be sufficient (De Boodt *et al.* 1989).

The sandy soils respond well to management and are also easy to manage. The moisture utilisation in these soils by wheat crop is mainly from upper 60 cm depth, while in case of gram and mustard from the upper 90 cm. In case of bajra, 90 per cent of the available moisture is used from the upper 60 cm of the soil, of which 60 per cent is from the top 30 cm (FAO/UNDP 1971).

Shankaranarayana and Hirekerur (1978) in their studies on crop yield and soil moisture characteristics advocated that the low yield of 10 q ha^{-1} of bajra in sandy soils may be due to lack of moisture in the effective rooting depth. This shows the necessity to carry out studies on different crops for formulating better management parameters for increased water use efficiency.

Murthy *et al.* (1978) interpreted the different mapping units of Thaska soils (Typic Ustipsamments) for available moisture status for *kharif* and *rabi* crops and observed that the surplus water available during monsoon (*kharif*) season can be retained by finetextured soils, whereas sandy soils soon become droughty, suggesting that only short duration crops like moong and moth can be grown in Ustipsamments. *Rabi* season crops are not possible without irrigation.

Experiments in Tamil Nadu (NCA 1976) show that plantation of casuarina on the sandy fore shores backed by coconut, cashewnut and eucalyptus further inland minimized considerably the problems of shifting sand.

It may be concluded that the sandy soils, although, are potentially fertile and easy to manage, they pose constraint of high water loss due to deep percolation and excessive evaporation. For understanding response to management inputs and for effective transfer of technology, it is imperative to diagnose their nature and delineate their extent and group them logically in the system of Soil Taxonomy.

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