Int. J. Agricult. Stat. Sci. Vol. 10, Supplement 1, pp. 227-235, 2014 ***ISSN : 0973-1903***
ORIGINAL ARTICLE

CHARACTERIZATION, CLASSIFICATION AND EVALUATION OF SOILS OF NORTH EASTERN FRINGE OF THAR DESERT OF INDIA

Mahesh Kumar* and B. K. Sharma
Division of Natural Resources and Environment, Central Arid Zone Research Institute, Jodhpur - 342 003, India.
E-mail: maheshcazri@gmail.com

Abstract : Soils of Jhunjhunu district were characterized, classified and mapped on 1:50,000 scales. The soils were very deep with an overburden of loose sand of 10-15 cm thickness and intermittent hummocks, somewhat excessively drained, light yellowish brown to brown in colour, fine sand to sandy loam, single grained fine to medium weak sub-angular blocky structure, alkalinein reaction and low in organic carbon and cation exchange capacity. The soils were generally low to medium in available phosphorus and medium to high in available potassium. The soils were found sufficient in DTPA extractable micronutrient cations except Zn and Fe at some places. The soils were mapped as association of Chomu, Bassi and Dune complex series. Chirai series was the other soils of aeolian plains. Soils of alluvial plains (14.6% of the district) were sandy loam to silt loam with medium moderate sub-angular blocky structure and mapped as association of Guda, Saledipura and Naurangpura series. An excessive drainage and higher sand content restricted pedological manifestations in soils of aeolian plains, while the distance from the source of alluvia and load of overburden sand governed pedality in soils of alluvial plains. Chomu, Bassi and Dune complex were classified as Typic Torripsamments, while Naurangpura series as Typic Torrifluunts at subgroups of Entisol. Chirai and Bassi series were classified as Typic Haplocambids, while Guda and Saledipura were classified as Fluventic Haplocambids subgroups of Aridisol. Land suitability evaluations of these soils are described for arid agriculture and other alternate land uses for sustainable management.

Key words : Arid soil, Characterization, Classification, Soil suitability evaluation.

1. Introduction

Soil is the most precious natural resource. Information on soil characteristics and quality are the important requirement for sustainable management of land resources. The declining land area for agriculture, depletion in soil fertility and increasing soil degradation, wrong land use policies and imbalanced use of inputs draw more attention in recent years towards sustainable management of natural resources. The systematic study on morphology and taxonomy of soils provide information on nature and types of soils, their extent and distribution, constraints, potentials, capabilities and their suitability for various uses. For sustainability of the present agricultural system and for management of our soil resources, knowledge of the soils and their fertility status of is important for making area specific recommendations [Kumar *et al*. (2011), Kumar *et al*. (2012) and Jatav *et al*. (2011). This is still more important for hot arid areas of Thar desert of Rajasthan, which experiences low, erratic and spotty rainfall, high temperature with large variations (-3.5 to 49.0^{o}C), annals of drought, high wind speed and low biological productivity. The soils varied widely with respect to morphology, lime and silica content. These together construct fragile ecosystem. Agriculture intensification and massive infrastructure development in the recent years without considering the variability of entire production system enhances the risk of soil erosion and fertility depletion [Singh *et al*. (2007)]. Developing and adopting an ideal land use plan based on the soil quality and constraints is of immense use for achieving the goal of sustainability. Keeping in view the above point, the present investigation aims to characterize and classify the soils of the district and to evaluate suitability of these for agriculture and alternate land uses.

2. Materials and Methods

Geographic setting

The district Jhunjhunu with an area of 5928 km^2 is situated in north eastern fringe of Thar Desert of India

Author for correspondence** ***Received *June 14, 2014* ***Revised*** *October 21, 2014* ***Accepted*** *October 31, 2014*

lying between $27^0 38' 15"$ to $28^0 31' 14"$ N latitude and $75^0 01' 32"$ to $75^0 05' 51"$ E longitude, on an altitude of 300 to 450 meter above mean sea level. The mean annual rainfall of the district is 444.5 mm with a decreasing trend of 484 mm to 331 mm. On an average most of rainfall is received during onset of summer monsoon in 26 to 32 rainy days. The coefficient variability of annual rainfall is 40%. The potential annual evapotranspiration is 1578 mm exceeds always to the precipitation characterizing short growing period. The mean maximum and minimum temperatures are 45^oC and 23^oC, respectively. Occasionally during winters the minimum temperature dips below 0^0C at some places. Pearl millet, cluster bean, moth bean, moong bean and sesamum are the important crops. Wheat and mustard are grown with ground water irrigation, while grams are cultivated with the support of conserve moisture and winter rains (*Mawat*). Jhunjhunu district is bounded with Mahendragarh and Hisar districts of adjoining Haryana State in the north east and on west, south, south east and north west by Sikar and Churu districts of Rajasthan. Aeolian plains are the major landforms, while a trap of alluvial plain was marked along the Kantali river, flows in the district. There is marked shift in land use from the last one and half decades (1988-89 to 2005-06). The area under pasturelands and rainfed *kharif* crop lands has declined by 3.3 and 49.7%, respectively. The net irrigated area under *rabi* cropping (irrigated and on conserved moisture) has been increased tremendously by 93.7% during the period [Anonymous (2007)].

Field and laboratory studies

Soil survey has been carried out on 1:50,000 scale following three tier approach *i.e.* image interpretation (IRS LISS III data); laboratory and field investigation for correcting landform boundary and characterizing soils [Soil Survey Staff (2003)]; map printing and cartography. During field detailed morphological studies [Soil Survey Division Staff (1995)] were carried out and horizon-wise soil samples were collected for detailed laboratory characterization. Besides these, several auger bores were also examined during the course of field traverse for correlating the soils and correcting soil boundary. The analysis of physical and chemical characteristics of soils was carried out following standard analytical procedures [Jackson (1973) and Black (1965)]. Particle-size analysis was carried out by International Pipette Method [Piper (1966)]. The pH (1:2 soil water suspension) was determined by pH meter [Jackson (1973)]. Electrical conductivity (EC) of soil extract was determined using conductivity bridge [Richards (1954)]. Organic carbon and calcium carbonate content in soils was estimated following methods given by Piper (1966). The CEC was determined by saturation of soils with 1*N* sodium acetate (pH 8.2). After removal of excess sodium acetate by washing with ethanol till the supernatant gave an EC of 0.040-0.055 dSm^{-1}. The absorbed sodium was then replaced by ammonium acetate (pH 7.0) solution and the sodium concentration from the lechate was determined by flame photometer. Available phosphorus by Olsen extraction method, estimated calorimetrically [Olsen *et al*. (1954)] and available potassium was estimated by flame photometer after extraction with neutral normal ammonium acetate solution (pH 7.0). Seven soil series were characterized and mapped (Table 1) in the course of investigation. Four soil series belonged (Chomu, Bassi, Chirai and Dune complex) to the aeolian plain covering over 75% area of Jhunjhunu and three (Naurangpura, Guda and Saledipura) were identified (Fig. 2) in alluvial plains (14.6% area of Jhunjhunu). The soils were classified according to International System of Taxonomy [Soil Survey Staff (2003)]. Soil suitability evaluation was carried out following FAO framework [FAO (1976)] and as per guidelines described by Sys *et al*. (1991). Land use requirement as given by Sys *et al.* (1991) was modified based on the personal experience and published results of local experiments.

3. Results and Discussion

Morphological characteristics

The soils of the district are developed on nearly level (0-1%) to gently slopping (1-3%) topography. These soils are deep to very deep and light yellowish brown (10 YR6/4) to brown (10 YR 5/3) in color. The value and chroma ranged from 5 to 6 and 3 to 4 in the surface soils of Chomu, Chirai, Guda, Chirai and Saledipura series, however, subsoil exhibited dominantly darker chroma and value in Hue of 10 YR. The soil color appears to be the function of chemical and mineralogical as well as textural make up of soil as conditioned by the topographical position and moisture regime [Walia and Rao (1997)]. Darker colour down the profile may be due to higher silt and clay content *vis-à-vis* higher moisture retention for longer duration

(Table 1). However, in Chirai series higher $CaCO_3$ content (Ck horizons) (Table 2) overshadowed the influence of higher silt and clays and induced grayer value and chroma, ranging from 6 to 7 and 1 to 2, respectively in 10 YR Hue [Kumar *et al*. (2009) and Singh *et al*. (1999)]. Hummocky phase of soils showed similar colour characteristics (10 YR 6/3 to 10 YR 6/4) at the surface because of common source of aeolian sand for Chomu, Chirai, Bassi and Dune complex series.

Soils of the district show wide textural variations (fine sand to silt loam) caused by parent materials, *in situ* weathering and translocation of clay. Fine sand and loamy sand textural classes were dominantly observed on the surface and in the subsurface, respectively in Chomu and Chirai, series. Fine sand characterized dune complexes, while sandy loam textural class was observed below the surface in Bassi series (Table 1). Soils of Naurangpura series have dominantly silt loam texture at the surface and sandy loam (sometimes loam) in the sub surface. Structurally soils were single grained on the surface and had very fine to fine, weak sub-angular blocky structure in the subsurface of Chomu, Chirai and Bassi series. Medium moderate sub-angular blocky structure was noticed below the surface in Saledipura and Guda series. Structure development ran parallel to the clay content and textural class. However, precipitation of lime in pores discounted the influence of clays and was accounted for massive soil structure below the solum in Chirai series. Mark of stratification and sign of sedimentation were the characteristic features of Naurangpura series.

Soil textural class and clay content also accounted for consistency in soils of Jhunjhunu. Dry, moist and wet consistency was examined as loose, loose and none sticky and none plastic, respectively in Dune complex, Chomu, Bassi and in surface soils of and Chirai series. Coherence of soil particles increased down the depth in Chirai Guda and Saledipura series and consistence was rated as soft, very friable, slightly sticky and none-plastic to slightly plastic (Table 1). However, lime and silica content slightly modified the moist and wet consistence in Chirai series, which were examined friable as moist; slightly sticky and slightly plastic as wet consistence.

A-C horizon sequence was observed in Dune complex, Chomu, Guda and Naurangpura series, while Ap-B-C horizon sequence found in Bassi and Saledipura series. Chirai series showed a horizon sequence of Ap-Bw-Ck. Boundary between the two adjacent horizons was either clear smooth or gradual smooth/ diffuse smooth, except abrupt and wavy boundary between Bw and Ck; A and Ck horizons of Chirai series.

Physical and chemical characteristics

Soils of Dune complex contained 85 to 94% sand, of which 83 to 91% was fine sand (Table 2). Clay and silt content varied from 3.2 to 5.5% and 1.5 to 2.8%, respectively. Organic carbon content (0.04 to 0.12%), available phosphorus (1.8 to 10.2 kg ha^{-1}) and potassium (75 to 165 kg ha^{-1}) were very low to low, low and low to medium, respectively [Muhr *et al*. (1963)]. Available micronutrients (Fe, Mn and Cu) were adequate except occasional deficiencies of zinc and iron at places.

Chomu and Chirai series contained relatively higher clay (5.0 to 11.0%) and silt (2.5 to 10.0%) than the Dune complex series. Water holding capacity (24 to 35%) increased with the increased silt and clay content in the profile. These soils were moderately alkaline (7.9-8.5), having 2.8 to 7.2 cmol (P^+) kg^{-1} cation exchange capacity; very low organic carbon (0.08-0.25%), low to medium available phosphorus (3.0 to 15.0 kg ha^{-1}) and medium to high potassium (90 to 287 kg ha^{-1}). These were well supplied with respect to available micronutrients. The organic carbon (0.10 to 0.22%), the available phosphorus (7.5 to 23.5 kg ha^{-1}) and potassium (101 to 357 kg ha^{-1}) in Bassi series were similar to that of Chomu and Chirai series (Table 2). The results are in close agreement with the findings of Kumar *et al*. (2009), Sharma *et al*. (2006), Dhir (1977) and Ahuja *et al*. (1992, 1996).

Guda and Saledipura series were moderately alkaline and non calcareous in the control section, while Naurangpura series in alluvial plains were calcareous. Water holding capacity in Guda and Saledipura ranged from 34 to 49%; cation exchange capacity varied from 10.8 and 22.6 cmol (P^+) kg^{-1}. Organic carbon (0.15-0.45%) was low; available phosphorus (10 to 32.0 kg ha^{-1}) was medium while potassium availability was rated as medium to high (157-416 kg ha^{-1}). Clay and silt content ranged from 6.8 to 22.0 and 5.8 to 33.8, respectively in soil profiles of Naurangpura series. The water holding capacity ranged from 28-49%, cation exchange capacity, 5.8 to 22.0 cmol (P^+) kg^{-1}, low organic carbon (0.12-0.42%), medium to high in available phosphorus (8.5-48.7 kg ha^{-1}) and available

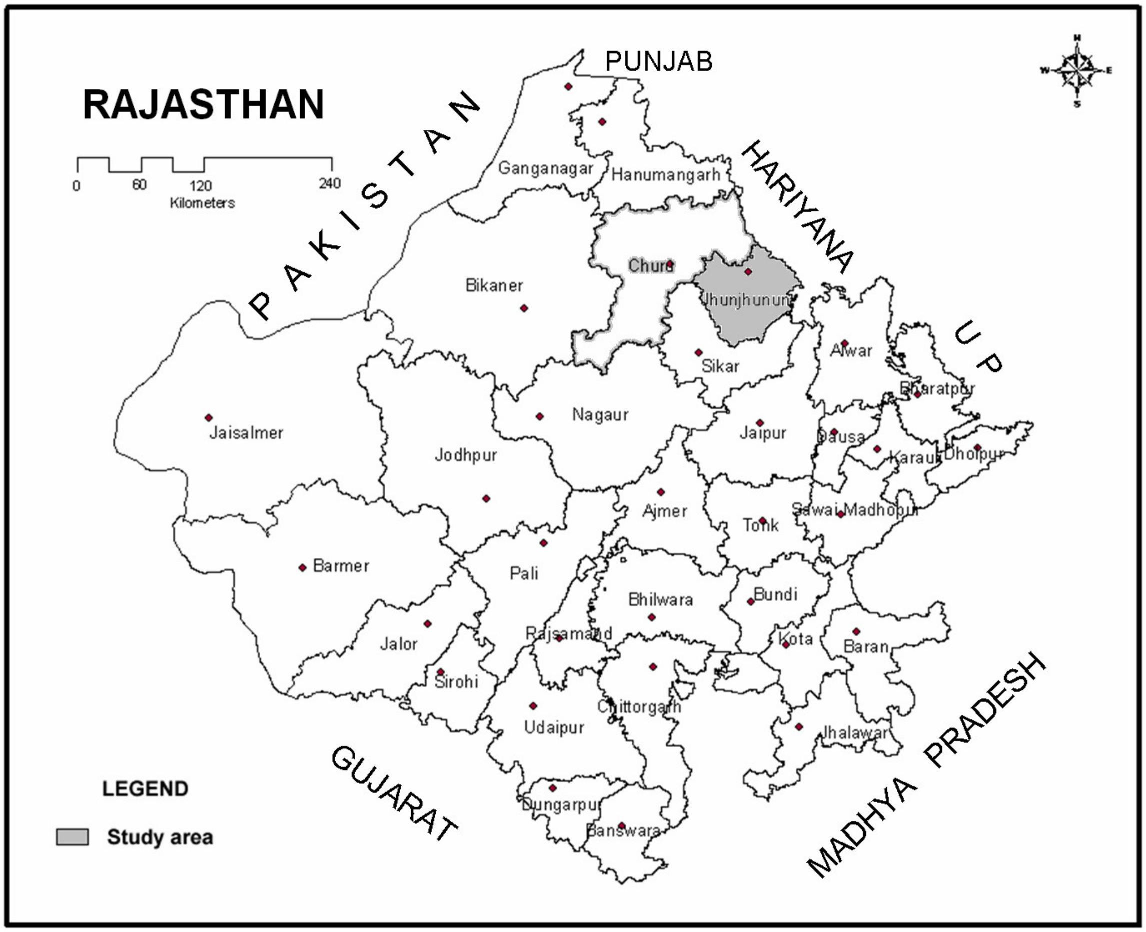

Fig. 1 : Location.

potassium (137-480 kg ha^{-1}). The DTPA extractable micronutrients were adequate in these alluvial soils compared to other soils of the region [Gupta *et al.* (2000), Dhir and Kolarkar (1977), Sharma *et al.* (1985)].

Pedogenesis

High sand content (> 90%) in Dune complex; comparable in Chomu and in first 0-30 cm soils of Chirai series (80 to 90%) coupled with excessive drainage restricted pedogenesis. However, comparatively higher fine sand *vis-a-vis* higher water holding capacity in subsoils of Chirai series than other soils of aeolian plain had led to the development of Bw horizon (Cambic horizons) in terms of structural improvement (fine to medium, weak sub angular blocky structure) and signature of lime movement. Lime content 6 to 12% in Ck horizons of Chirai precluded the pedogenic process to move forward because of plasma immobilization [Rimmer and Greenland (1976), Boul *et al.* (1980)] and massive soil structure was noted in the respective horizons. Carbonates had played a similar role in Ck horizon of Naurangpura series of alluvial plains. The pedality was marked weak in soils of Nauragpura series, which was located near the source of alluvia, receiving fresh sediments during rains. This may be the probable reason that restricted the pedogenesis in Naurangpura series. A sharp decline of silt and clay content below 50 cm of the soil profile further endorsed the findings. An irregular distribution of organic carbon (Table 2) was also confirming the factuality of the observation as well. Since, Guda and Saledipura series were situated away from the source of alluvium and had fairly high silt and clay content (13 to 27%) exhibited high degree of pedality in terms medium moderate sub-angular blocky structure and medium common porosity. Even though, irregular distribution of organic carbon (Table 2) indicated that pedogenesis was not strong enough to obliterate the mark of stratification.

Classification of soils

Based on morphology, soils of Jhunjhunu district were classified according to Key to Soil Taxonomy [Soil Survey Staff (2003)]. Absence of pedogenic activities

Table 1 : Morphological characteristic of soil series of Jhunjhunun district.

Horizon	Depth (cm)	Colour	Texture*	Structure**	Consistence#			Boundary##
					dry	moist	wet	
Chomu series : Typic Torripsamments								
AP	0-15	10YR5/4	fs	sg	l	l	s0/p0	
A1	15-45	10YR4/4	ls	sg	l	l	s0/p0	cs
C1	45-75	7.5YR5/4	ls	sg	l	l	s0/p0	ds
C2	75-95	7.5YR4/4	ls	sg	l	l	s0/p0	ds
C3	95-140	7.5YR4/4	ls	sg	l	l	s0/p0	ds
Chirai series: Typic Haplocambids								
AP	0-12	10YR6/3	fs	sg	l	l	s0/p0	
A2	12-40	10YR5/4	ls	sg	l	l	s0/p0	cs
Bw1	40-65	10YR6/3	ls	f 1 sbk	sh	vfr	ss/p0	gs
Bw2	65-90	10YR5/3	ls	m 1 sbk	h	vfr	ss/p0	gs
Ck1	90-130	10YR6/3	ls	massive	h	vfr	ss/p0	aw
Ck2	130-170	10YR6/3	gsl	massive	h	vfr	ss/p0	gs
Bassi series: Typic Haplocambids								
AP	0-20	10YR6/4	ls	sg	l	fr	s0/p0	
A1	15-45	10YR5/4	sl	f	1 sbk	l	fr	s0/p0 cs
B1	45-75	10YR4/4	sl	f 1 sbk	l	fr	s0/p0	ds
B2	75-120	10YR4/3	sl	f 1 sbk	l	fr	s0/p0	ds
C1	120-150	10YR4/3	l	f 1 sbk	l	fr	ss/p0	ds
Guda series: Fluventic Haplocambids								
AP	0-15	10YR6/4	l	f 1 sbk	l	l	s0/p0	
Bw1	15-40	10YR4/4	l	f 1 sbk	l	l	s0/p0	cs
Bw2	40-70	10YR4/3	cl	f 2 sbk	sh	fr	ss/p0	aw
Ck1	70-95	10YR4/3	sil	f 2 sbk	sh	fr	ss/ps	gs
Ck2	95-130	10YR4/3	sil	f 2 sbk	sh	fr	ss/ps	gs
Saledipura series: Fluventic Haplocambids								
AP	0-15	10YR6/4	l	f 1 sbk	l	vfr	s0/p0	
Bw1	15-45	10YR5/3	l	f 2 sbk	l	fr	ss/p0	cs
Bw2	45-75	10YR5/4	cl	f 2 sbk	sh	fr	ss/p0	gs
Ck1	75-120	10YR5/4	cl	m 2 sbk	sh	fr	ss/ps	gs
Ck2	120-150	10YR4/4	l	m 2 sbk	h	fr	ss/ps	gs
Naurangpuraa series: Typic Torrifluents								
AP	0-20	10YR5/3	sil	f 1 sbk	sh	fr	ss/p0	
C1	20-40	10YR3/3	sil	f 1 sbk	sh	fr	ss/ps	cs
C2	40-65	10YR3/3	l	f 1 sbk	sh	fr	s0/p0	cs
C3	65-105	10YR5/3	l	f 1 sbk	sh	fr	s0/p0	as
C4	105-150	10YR5/3	ls	f 1 sbk	sh	fr	s0/p0	as
Dune Complex series: Typic Torripsamments								
AP	0-20	10YR6/3	fs	sg	l	l	s0/p0	
C1	20-65	10YR6/4	fs	sg	l	l	s0/p0	ds
C2	65-105	10YR6/4	fs	sg	l	l	s0/p0	ds
C3	105-130	10YR6/4	fs	sg	l	l	s0/p0	ds
C4	130-180	10YR6/4	fs	sg	l	l	s0/p0	ds

*ls-loamy sand; fs-fine sand; sil-silt loam; l-loam; sl-sandy loam; gsl-gravelly sandy loam; scl-sandy clay loam; cl-clay loam ** sg-single grained; f-fine, m-medium, 1-weak, 2-moderate, sbk-subangular blocky; # l-loose, sh-slightly hard, fr-friable; s0-none slight; ss-slightly slight, p0-none plastic ## cs-clear smooth, ds-diffuse smooth, as –abrupt smooth, gs-gradual smooth, aw –abrupt wavy.

Table 2 : Physical and chemical characteristics of soils.

Depth (cm)	Sand	Silt	Clay	WHC	$CaCO_3$	Org.C	pH	EC	CEC[1]	P	K
	(%)						(1:2)			(kg ha^{-1})	
Chomu series: Typic Torripsamments											
0-15	89.2	5.2	5.6	26.0	0.0	0.18	8.0	0.01	4.9	15.6	236
15-45	87.6	5.6	6.8	28.0	0.0	0.12	8.1	0.01	5.5	7.2	158
45-75	84.1	7.1	8.8	30.0	0.0	0.12	8.1	0.05	5.1	7.2	158
75-90	83.6	6.2	10.2	32.0	0.0	0.10	8.1	0.02	6.0	5.8	135
90-130	83.0	6.8	10.2	32.5	0.0	0.08	8.0	0.02	7.1	3.7	119
Chirai series: Typic Haplocalcids											
0-12	89.6	4.5	5.9	23.6	1.50	0.15	8.4	0.14	3.2	12.6	170
12-40	86.4	6.0	7.6	26.3	5.95	0.12	8.5	0.10	4.8	10.7	139
40-65	84.0	6.6	9.4	28.0	8.20	0.15	8.5	0.11	5.5	7.2	131
65-90	82.9	6.8	10.3	29.7	9.45	0.12	8.5	0.08	5.5	5.7	116
90-130	84.5	6.2	9.3	30.5	11.20	0.15	8.4	0.05	5.8	3.2	98
130-170	80.2	10.0	9.8	31.6	12.85	0.18	8.4	0.05	6.4	3.2	90
Bassi series: Typic Haplocalcids											
0-20	86.5	6.4	7.1	27.8	0.0	0.25	7.9	0.01	6.2	21.7	225
15-45	77.3	8.4	14.3	32.5	0.0	0.16	7.9	0.01	8.4	15.6	161
45-75	74.3	9.2	16.5	36.0	0.0	0.13	8.1	0.05	8.7	14.2	124
75-120	73.2	10.0	16.8	37.5	0.0	0.10	8.0	0.02	8.7	9.5	101
120-150	70.4	12.1	17.5	37.5	0.0	0.10	8.0	0.02	9.6	7.8	101
Guda series: Fluventic Haplocambids											
0-15	72.7	12.1	15.2	34.4	1.9	0.39	8.1	0.20	10.8	25.2	236
15-40	67.4	13.7	18.9	36.5	3.8	0.22	8.2	0.26	12.2	18.7	191
40-70	52.5	21.2	26.3	46.4	4.1	0.22	8.3	0.40	16.7	12.6	168
70-95	48.0	24.5	27.5	47.8	6.6	0.18	8.3	0.62	19.4	11.4	124
95-130	46.7	27.1	26.2	49.5	7.2	0.12	8.3	0.65	22.6	7.2	124
Saledipura series: Fluventic Haplocambids											
0-15	67.7	20.6	11.7	34.2	0.50	0.30	8.2	0.02	13.6	23.7	420
15-45	62.0	18.5	19.5	38.0	0.50	0.24	8.3	0.01	14.2	21.0	308
45-75	54.0	22.4	23.6	42.7	0.80	0.13	8.1	0.05	16.8	14.3	275
75-120	50.0	23.4	26.6	47.5	2.80	0.13	8.0	0.05	18.7	11.7	275
120-150	58.0	20.8	21.2	45.7	2.50	0.09	8.0	0.05	16.8	9.8	190
Naurangpuraa series: Typic Torrifluvents											
0-20	54.0	27.3	18.7	49.8	9.0	0.35	8.5	0.65	20.2	32.0	451
20-40	48.7	33.7	17.6	48.4	7.0	0.25	8.4	0.61	21.5	26.4	281
40-65	72.7	12.2	15.1	32.0	1.1	0.18	8.6	0.54	9.4	13.4	258
65-105	64.7	17.0	18.3	38.8	0.40	0.25	8.4	0.46	11.7	10.7	203
105-150	85.4	5.8	8.8	28.0	0.30	0.12	8.2	0.61	5.5	8.5	137
Dune Complex series: Typic Torripsamments											
0-30	93.5	2.3	4.2	23.4	0.0	0.10	8.3	0.00	2.0	8.2	157
30-70	93.0	1.8	5.2	24.2	0.0	0.08	8.2	0.05	2.5	7.2	135
70-100	92.7	2.6	4.7	25.9	0.10	0.08	8.2	0.05	2.5	5.0	95
100-130	93.4	2.0	4.6	25.9	0.20	0.10	8.4	0.10	3.6	3.0	82
130-180	92.0	2.6	5.4	26.2	0.20	0.08	8.3	0.10	3.6	1.7	74

[1] cmol(P+)kg^{-1}.

were the major criteria to classify Dune complexes, Chomu and Naurangpura series as Entiosls, while pedogenic structure and aridic soil moisture regime were the characteristics identified to group the soils of Chirai, Bassi, Guda and Saledipura series into Aridisol. Sand content more than 80% throughout the soil profile was the differentia characteristics to key out soils of Chomu, and Dune complex as Psamments from other Entisols (Table 2), while irregular distribution of organic carbon and mark of stratification were the key characteristics for classifying Naurangpura series as Fluvents within Entisols. Presence of cambic horizons were the basis for classifying Chirai, Bassi, Guda and Saledipura series as Cambids suborder of Aridisols. Considering aridic

Table 3 : Land suitability evaluation for various land uses in the district.

Soil series	Crop cultivation		Horticulture	Agroforestry	Forestry	Silvipasture	Pasture
	Rainfed	Irrigated					
Dune complex	N	N	N	S3	S1	S1	S1
Chomu	S1	S2	S1	S1	S3	S3	S3
Chomu hummocky	S3	S3	S3	S3	S1	S1	S1
Chirai	S2	S2	S1	S1	S3	S3	S3
Bassi	S1	S1	S1	S2	S2	S2	S3
Guda	S1	S1	S1	S1	S3	S3	S3
Saledipura	S1	S1	S1	S1	S3	S3	S3
Naurangpuraa	S1	S1	S1	S1	S3	S3	S3

S1: Highly suitable, S2 : Moderately suitable, S3 : Marginally suitable, N : Not suitable.

soil moisture regime as the differentia characteristics at great group level, Psamments (Dune and Chomu series) and Fluvents (Naurangpura series) suborders of Entisols were classified as Torripsamments and Torrifluvents, respectively. Cambids (Chirai, Bassi, Guda and Saledipura series) were further classified as Haplocambids at Great group level. The identified Great groups as Torripsamments, Haplocambids and Torrifluvents identified represented the central concept of great group, consequently further classified as Typic Torripsamments, Typic Haplocambids and Typic Torrifluvents at sub-group levels, respectively. Haplocambids in Guda and Saledipura series were classified as Fluventic Haplocambids at sub group accounting irregular distribution of organic carbon as a sign of fluvial action in the alluvial plains. Based on particle size class, mineralogy and soil temperature regime at family level, soils of Gudda and Saledipura series were classified as the member of coarse loamy mixed hyperthermic family of Fluventic Haplocambids; whereas the soils of Chirai and Bassi series grouped as the member of coarse loamy, mixed hyperthermic family of Typic Haplocambids. The soils of Naurangpura series associated with alluvial plains were classified as the member of Coarse loamy, mixed hyperthermic family of Typic Torrifluvents.

Distribution of soils

Dune complex series covered 683.9 km^2, comprising 11.5% of the total geographical area of Jhunjhunu district. Chomu, Bassi, association of Chomu and Bassi series and Chirai in aeolian plains were mapped on 2702.8, 734.2, 105.1 and 243.1 km^2 area, occupying 45.5, 12.4, 1.7 and 4.1% area of the district, respectively. Area under Guda, Guda Basi association, Saledipura and Nauragpura was 110.9, 473.03, 160.2, 125.4 km^2, covering 1.9, 7.9, 2.7 and 2.1% of Jhunjhunu. Soil series of aeolian plain together was mapped on 75.2% area of Jhunjhunu, while soil series of alluvial plain was mapped on 14.6% area of the district.

Soil suitability evaluation

Chomu and Chirai series occurring on interdunal plains were moderately suitable (S2) for growing pearl millet, cluster bean, moong bean and moth bean with safety measures to protect the land from erosion, while normal phase of these soils were suitable (S1) for rainfed cultivation of pearl millet, cluster bean, moong and moth bean during kharif season. Hummocky phase of these soils were marginally/ not suitable (S3/N3) for cropping because of excessive risk of erosion. The Dune complex and highly hummocky part of Chomu series were not suitable (N) for any type of cropping and tillage operation. Bassi, Guda, Saledipura and Naurangpura series in association or alone were highly suitable (S1) for rainfed cultivation. Under irrigated agriculture, Bassi, Guda and Saledipura series were highly suitable (S1) for growing of wheat, mustard, barley and gram. However, soils of Naurangpura may be used with precaution under irrigated condition because of high lime content in the subsurface. Soils of Chomu and Chirai series were moderately suitable (S2) for wheat, barley, gram and mustard with improved method of irrigation such as sprinklers. Hummocky part of these soils were marginally suitable for agriculture under pressurize irrigation because of undulated relief (Table 3).

Soils of Chomu, Chirai and Bassi series are highly suitable (S1) for agroforestry. *Prosopis cineraria*, *Tecomella undulata*, *Acacia senegal*, *Acacia albida* and *albizia* tree species in combination with pearl millet, moong, moth bean and cluster bean may be successfully grown. Hummocky parts of these soils may be kept for growing grasses. Besides these, lands can also be used for horticultural plantation. Chomu and Chirai series were highly suitable (S1) for growing *Ber, Karonda* and *Kair* and hummocky part of these soils were moderately suitable for these crops. Dune complex on account of undulating relief and droughtiness were neither suitable for horticulture plantation [Vashishtha and Prasad (1997)] nor for agroforestry. Dune complex and highly hummocky part of Chomu were highly suitable for silvipasture and pasture.

Land capability classification

Land capability classification is an interpretative grouping of different soil units and plays an important role in land use planning to show relative suitability of soils for cultivation of crops, pasture, silvipasture, forestry in addition to focusing problems which need preventive measures [Sarkar *et al*. (2002)]. The grouping of soils into land capability classes and sub classes is done mainly based on the climate, erosion (slope length and percent), soil (nutrient supplying, capacity for biological system) and wetness (drainage). Based on these soils of Jhunjhunu district have been classified under land capability class III c s, III c s ea, IV c s ea, VI c s ea and VII & VIII. The soils associated with Dune complex are highly susceptible to wind erosion are best suited for silvi pastoral system and put under class VI c s ea. Whereas, light textured soils of Chomu series with its hummocky relief are placed in class IV c s ea while, normal phase of Chomu and Chirai soil series belong to class III c s ea. Naurangpura, Saledipura and Guda soil series with negligible to slight wind erosion hazards and poor workability put under land capability class III c s. Waste lands with hilly pediments and hills may be put under class VII and VIII depending upon the severity of hazards. They were best suited for wild life recreation, rehabilitation and afforestation.

References

Anonymous (2007). *Annual Progress Report*. Central Arid Zone Research Institute, Jodhpur, Rajasthan.

Ahuja, R. L., M. L. Manchanda, B. S. Sangwan, V. P. Goyal and R. P. Agarwal (1992). Utilization of remotely sensed data for soil resources mapping and its interpretation for land use planning of Bhiwani district (Haryana*). Journal of the Indian Society of Remote Sensing*, **2 & 3**, 105-120.

Ahuja, R. L., Partipal Singh, Jagan Nath and Dinesh (1996). Land evaluation of sand dunal topo sequences of Haryana. *Agropedology*, **6**, 37-42.

Black, C. A. (1965). *Methods of soil analysis*. Part I and II American Society of Agronomy, Inc., Publishers, Madison, Wisconsin, USA.

Buol, S. W., F. D. Hole and R. J. McCracken (1980). *Soil genesis and classification*, Second Edition, The Lowa University Press America Iowa. pp 55-65.

Dhir, R. P. (1977). Western Rajasthan Soils : Their characteristics and properties. In: *Desertification and its control.* ICAR, New Delhi, India. pp. 102-115.

Dhir, R. P. and A. S. Kolarkar (1977). Observations on genesis and evolution of arid zone soils. *Journal of the Indian Society of Soil Science*, **25**, 260-264.

FAO (1976). *A frame work for land evaluation*. Soils Bulletin 32. FAO, Rome.

Gupta, J. P., D. C. Joshi and G. B. Singh (2000). Management of arid agro-ecosystem. In: *Natural Resource Management for Agricultural production in India*. (J.S.P. Yadav and G.B. Singh, Eds.), New Delhi, India. pp. 557-668.

Jackson, M. L. (1973). *Soil chemical analysis*. Prentice Hall of India. Pvt. Ltd., New Delhi.

Jatav, M. K., Manoj Kumar, S. P. Trehan, V. K. Dua and S. S. Lal (2011). Influence of microorganism's inoculation for nutrient economy in potato-radish crop sequence in north Western Himalayas. *International Journal of Agricultural and Statistical Sciences*, **7**, 309-316.

Kumar, Manoj, M. K. Jatav, V. K. Dua and Sushil Kumar (2012). Fertility status of potato growing pockets and nutrient recommendations based on yield targeted equations for potato crop in Bihar. *International Journal of Agricultural and Statistical Sciences*, **8**, 111-117.

Kumar, Manoj, M. K. Jatav, V. K. Dua, Shashi Rawat and S. S. Lal (2011). Precise nutrient recommendations using targeted yield equation based on spatially mapped available nutrients. *International Journal of Agricultural and Statistical Sciences*, **7**, 605-612.

Kumar, Mahesh, S. K. Singh and B. K. Sharma (2009). Characterization, classification and evaluation of soils of Churu district. *Journal of The Indian Society of Soil Science*, **57**, 253-261.

Muhr, G. R., N. P. Datta, N. Shankar Subraney, F. Dever, V. K. Lecy and R. Donahue (1963). *Soil Testing in India*. USAID Mission to India.

Olsen, S. R., C. V. Cole, F. S. Watanabe and L. A. Dean (1954). Estimation of available phosphorus in soils by extraction with sodium bicarbonate. *US department of Agriculture*, *Circular*, pp. 939.

Piper, C. S. (1966). *Soil and Plant Analysis.* Hans Publishers, Mumbai.

Richards, L. A. (Ed.) (1954). Diagnosis and improvements of saline and alkali soils. *Agricultural Handbook No*. 60, USDA, Washington, D. C. pp. 160.

Rimmer, D. L. and D. J. Greenland (1976). Effect of calcium carbonate on swelling behavior of soil clays. *Journal of Soil*

Science, **27**, 129-139.

Singh, S. K., F. M. Qureshi, R. L. Shyampura and F. Karan (1999). Genesis of some soils of derived from limestone. *Journal of the Indian Society of Soil Science*, **47**, 130-135.

Singh, S. K., Mahesh Kumar, B. K. Sharma and J. C. Tarfadar (2007). Depletion of organic carbon, phosphorus and potassium stock under pearl millet based cropping sequence in arid environment of India. *Arid Land Research and Management*, **21**, 119-131.

Sarkar, Dipak, U. M. Baruah, A. K. Gangopadhyay, A. K. Sahoo and M. Velayutham (2002). Characteristics and classification of soils of Loktak catchment area of Manipur for sustainable land use planning. *Journal of the Indian Society of Soil Science*, **50**, 196-204.

Sharma, B. K., R. P. Dhir and D. C. Joshi (1985). Available micronutrient status of some soils arid zone. *Journal of Indian Society of Soil Science*, **33**, 50-55.

Sharma, B. K., Nepal Singh and Mahesh Kumar (2006). Sandy soils of Jaisalmer district : Their morphogenesis and evaluation for sustainable land use. *Annals of Arid Zone*, **45**, 139-149.

Soil Survey Division Staff (1995). *Soil Survey Manual*, Scientific Publishers, Jodhpur.

Soil Survey Staff (2003). *Key to Soil Taxonomy*, 9th edition, USDA National Resource Conservation Services.

Sys, I. C., B. Vanaranst and J. Debaveye (1991). Land evaluation part II, Methods in Land Evaluation. Agriculture publication general administration for development co-operation, place, de, camp mars, 5 btc.57-1050, Brussels, Belgium.

Vashishtha, B. B. and R. N. Prasad (1997). Horti-silvi-pasture systems for arid zone. In: *Silvi-pastoral System in Arid and Semiarid Ecosystems* (M.S. Yadav, Manjit Singh, S.K. Sharma, J.C. Tiwari and Udai Burman, Eds.), pp. 277-284. CAZRI, Jodhpur.

Walia, C. S. and Y. S. Rao (1997). Characteristics and classification of some soils of Trans-Yamuna plains. *Journal of the Indian Society of Soil Science*, **45**, 156-162.