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Influence of Landform on the Spatial Variability of Soil Fertility in Central State Farm, Jetsar, Sri Ganganagar District of Rajasthan

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Abstract: Understanding the spatial variability in soil parameters is important for efficient management of soil resources. The present study evaluated the influence of landform on the spatial variability of physical, chemical and fertility attributes of soils of Central State Farm, Jetsar, Sri Ganganagar district, Rajasthan. The highest available macro and micro-nutrients content were observed in soils of aeo-fluvial plain followed by stabilized sand dune and active sand dune. The soil samples across the landforms were low in organic carbon content barring 3 per cent soil samples of aeo-fluvial plain. The mean available N was 153, 139 and 112 kg ha^{-1} in aeo-fluvial plain, stabilized sand dune and active sand dune, respectively. The available P in stabilized sand dune and aeo-fluvial plain was found high, whereas it was medium in active sand dune. About 41, 22 and 17 per cent soil samples were high in avaiable K in aeo-fluvial plain, stabilized and active sand dunes, respectively.

Keywords : *Soil fertility, sand dunes, spatial variability*

Introduction

Soils are considered as an integral part of the landscape and thus their characteristics are largely governed by the landforms on which they have developed (Yadav *et al*. 1998; Sahoo *et al.* 2003). Soil properties play key roles in determining soil processes, which control the transformation of nutrients and their availability to plants and microorganisms and thus affect soil quality and productivity. Soils across Ghaggar flood plain in Rajasthan are low in organic matter and its distribution is irregular which indicates litho-logical discontinuity (Shyampura *et al.* 1992; Giri *et al.*1993). Sharma and Dev (1985) studied the physiography-soil relationship in North-east Punjab and observed that the soils are variable in texture, those on unstable surfaces being coarse textured while the others on relatively stable geomorphic surfaces are comparatively finer in texture. However, Choudhari (1989) reported that the calcium carbonate content varied in form, content and distribution in the soils of alluvial plain of western Rajasthan.

In general, the soils of the desert have been developed by aeolian and alluvium parent materials wherein sand dunes are common feature of desert ecosystem. Different types of soil dunes are found in desert ecosystem which influences the physical-chemical properties of soil. However, limited information is available in desert ecosystem and hence this research study was carried out to understand the spatial variability in soil fertility across the landform in Central State Farm, Jetsar, Sri Ganganagar district, Rajasthan.

Materials and Methods

General characteristics of study area

The Central State Farm, Jetsar (29° 20′ 53″ N to 29° 24′ 47″ N, 73° 30′ 00″ E to 73° 37′ 38″ E) in Sri Ganganagar district, Rajasthan, India (Fig. 1) cover an

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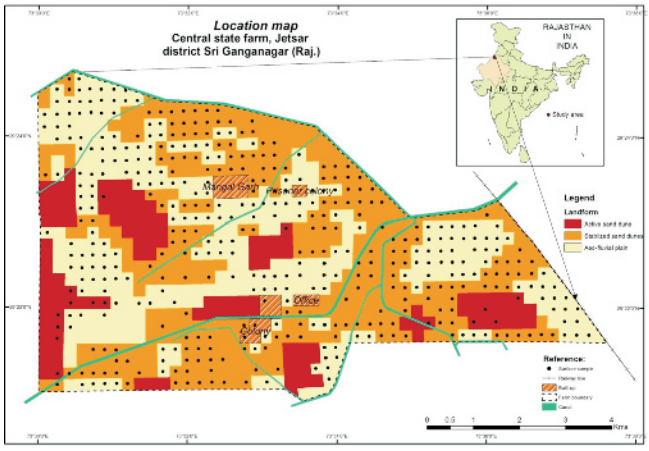

Fig. 1. Geographical location of the Central State Farm, Jetsar Sri Ganganagar district Rajasthan, India

area of 5394 ha. It is part of western plain (semi-arid transitional plains) which represents the hot arid sandy plains and the Ghaggar flood plains agro-eco sub-region. The average rainfall of the area is 286 mm. The area is characterised by strong south westerly winds during summer, which causes frequent sandstorm and sand movement. The area experiences cold winter.

Soil sampling and analysis

By using cadastral maps (1:4000 scale) followed by ground truth, the area was divided into three landforms *viz.* active sand-dunes, stabilized sand-dune and aeo-fluvial plain. Soil samples (0–15 cm) were collected from active sand dune (n = 29), stabilized sand dune (n = 264) and aeo-fluvial plain (n = 143) and processed. The soil samples were analyzed for particle-size (Piper1968), dry soil colour (Soil Survey Staff 1966), soil pH (1:2 soil water ratio) and electrical conductivity (Jackson 1973), Calcium carbonate content (Richards 1954) and soil organic carbon content (Walkley and Black 1934). The available N was determined using alkaline potassium permanganate as per the procedure given by Subbiah and Asija (1956). Available P was extracted with 0.5 M $NaHCO_3$ (pH 8.5) as outlined by Olsen *et al.* (1954) and the P content in the extract was determined using ascorbic acid as reducing agent by spectrophotometer. Available K was extracted with neutral 1 *N* ammonium acetate (Hanway and Heidel 1952) and estimated by flame photometer. The available Zn, Fe, Cu and Mn in soil samples were extracted with DTPA as per method described by Lindsay and Norvell (1978) and their concentration was determined using atomic absorption spectrophotometer. The nutrient index (NI) and classification of available nutrients as low (<1.67), medium (1.67-2.33) and high (>2.33) as suggested by Ramamoorthy and Bajaj (1969) were assessed using the following equation:

Nutrient index = [(1 × no. of samples in low categories) + (2 × no. of samples in medium categories) + (3 × no. of samples in high categories)] / total number of samples

Results and Discussion

Spatial variability in soil properties

The active sand-dunes (recently developed dunes) of varying heights, occurring on gently sloping land are irregular spread over the whole area. Stabilized sand dunes (older developed dunes) occur on nearly level to gently sloping land. Soils developed on nearly level landform are of aeo-fluvial plain. Soils developed on active and stabilized sand-dunes were deep light yellowish brown in colour, loamy sand to sandy texture (calcareous), very low in organic carbon and slightly to strongly alkaline (pH 7.45-9.17). Soils of aeo-fluvial landform were deep, well drained, brown to dark yellowish brown in colour, sandy loam to sandy clay loam (calcareous), very low in organic carbon, slightly to strongly alkaline (pH 7.68-9.02) and slightly eroded. The soils across the landforms had 59 to 95 per cent sand, 5 to 21 per cent clay and 0.5 to 20 per cent silt. The EC of soils varied from 0.10 to 0.83 dS m^{-1}. The organic carbon ranged from 0.06 to 0.88 per cent in soils of different landform (Table 1, Fig. 2). Relatively low organic carbon content in sand dune soils than the soils of aeo-fluvial may be attributed to the poor vegetation, high rate of organic matter decomposition and removal of the surface soil. Meena *et al.* (2006) also reported similar findings. The maximum mean $CaCO_3$ was recorded in aeo-fluvial plain (4.25%) followed by soil of stabilized sand dune (3.64%) and active sand dune (3.54%) soil.

Spatial variability of macronutrients

The soil samples of three landforms were classified in low nitrogen class (Fig. 2). The highest available P and K content were found in aeo-fluvial plain followed by stabilized and active sand dune (Table 2). On the basis of the limits suggested by Muhr *et al.* (1965), 23 and 77 per cent soil samples of aeo-fluvial

Table 1. Physical and chemical properties of soils occurring on different landforms

Soil characteristics	Active sand dune (n=29)			Stabilized sand dune (n=264)			Aeo-fluvial Plain (n=143)		
	Range	Mean	Std Dev	Range	Mean	Std Dev	Range	Mean	Std Dev
Slope (%)	3-8	-	-	1-3	-	-	0-1	-	-
Soil colour	Light yellowish brown	-	-	Dark yellowish brown to yellowish brown	-	-	Brown to dark yellowish brown	-	-
pH	8.12-9.17	-	-	7.45-8.52	-	-	7.68-9.02	-	-
EC (dS m^{-1})	0.10-0.34	0.18	0.07	0.11-0.22	0.26	0.16	0.10-0.83	0.31	0.13
OC (%)	0.06-0.12	0.10	0.02	0.13-0.29	0.22	0.05	0.31-0.88	0.38	0.08
$CaCO_3$ (%)	2.15-5.92	3.54	0.85	1.44-8.25	3.64	1.23	1.88-8.99	4.25	1.35
Sand (%)	90-95	92.5	-	85-90	87.5	-	59-81	70	-
Silt (%)	0.5-01	0.5	-	3-4	3.5	-	8-20	14	-
Clay (%)	5-9	7	-	7.5-10.5	9	-	11-21	16	-
Texture	Loamy sand to sand	-	-	Loamy sand	-	-	Sandy loam	-	-

plain were classified as medium and high available P content, respectively (Fig. 2). About 17, 22 and 41 per cent soil samples of active sand dune, stabilized sand dune and aeo-fluvial plain were classified into high category for available K respectively. It was observed that fertility of soils determined the land use and crops to be grown. Wheat, barley, mustard, chickpea, pearl millet, green gram, cluster bean are cultivated in aeo-fluvial plain. Wheat, cluster bean, barley, green gram, mustard, grasses and at places barren are the dominant land use in stabilized sand dunes while active sand dunes are under barren and open scrub land.

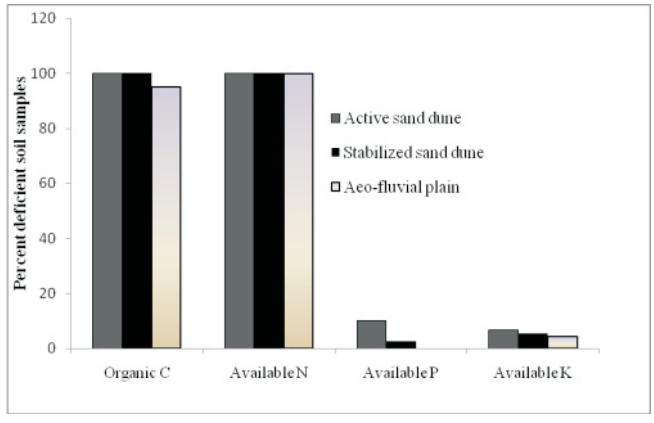

Fig. 2. Status of organic carbon and available nutrients in different landforms

Table 2. Available nutrient status of different landforms

Available nutrient	Active sand dune			Stabilized sand dune			Aeo-fluvial plain		
	Range	Mean	Std Dev	Range	Mean	Std Dev	Range	Mean	Std Dev
N (kg ha^{-1})	72.4-150.5	111.85	24.1	96.2-186.5	138.51	22.7	98.0-225.5	152.97	23.8
P (kg ha^{-1})	8.85-29.51	18.33	6.32	8.26-57.26	29.82	11.3	10.63-59.65	34.11	11.3
K (kg ha^{-1})	103-384	214.92	69.0	44.8-429.5	226.43	70.5	80.08-496.2	268.33	87.0
Zn (mg kg^{-1})	0.14-0.70	0.33	0.13	0.05-5.80	0.86	0.73	0.19-4.13	1.09	0.67
Cu(mg kg^{-1})	0.07-0.61	0.31	0.11	0.12-1.47	0.46	0.20	0.16-1.94	0.69	0.35
Mn(mg kg^{-1})	1.55-8.32	4.67	1.61	1.54-19.88	6.40	3.10	1.22-27.08	8.44	4.73
Fe(mg kg^{-1})	1.52-13.12	4.93	2.69	0.26-43.22	7.19	5.83	1.19-31.44	6.64	4.36

Spatial variability of available micronutrients

The highest available Zn, Cu, Mn and Fe content were observed in aeo-fluvial plain followed by stabilized and active sand dunes (Table 2). As per critical limit (0.6 mg kg^{-1}) of Zn as suggested by Bansal and Takkar (1986), the deficiency of available Zn were observed in all the soil samples of active sand dune, 44%, soil samples of stabilized sand dune and 19% soil samles of aeo-fluvial plain (Fig. 3). Majority of soil samples were sufficient in DTPA-Cu and Mn against critical limits (0.2 mg Cu kg^{-1} and 3 mg Mn kg^{-1}) but 55, 34 and 34 per cent soil samples were deficient in DTPA-Fe against critical limits (> 4.5 mg Fe kg^{-1}) in active sand dune, stabilized sand dune and aeo-fluvial plain, respectively.

Spatial variability of soil nutrient index

Soil nutrient index indicated low status of available N in soils of three landforms (Table 3). Available P in stabilized sand dune and aeo-fluvial plain was found to high while it was medium in active sand dune area. Nutrient index of available K was medium in active sand dune and stabilized sand dune but high in aeo-fluvial plain with the index values of 2.10, 2.17 and 2.36, respectively.

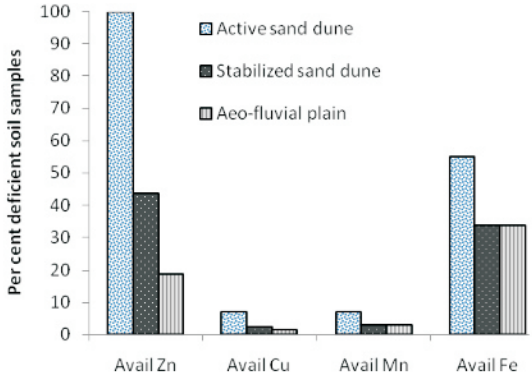

Fig. 3. Status of micronutrients in different landforms

Nutrient variability across landform as influenced by selected soil chemical properties

Correlation between available nutrients and soil chemical properties are presented in table 4. Nitrogen had significant and positive correlation with organic carbon in stabilized sand dune (r = 0.60**) and aeo-fluvial plain (r = 0.43**) but it was non-significant in active sand dune. N was negatively correlated with pH in active sand dune, whereas, it was significant in stabilized sand dune and aeo-fluvial plain (r = -0.29**). Available P had significant negative correlation with pH. Similar results were also reported by Meena *et al.* (2006). Available P was positively correlated (r =0.47**) with organic carbon in stabilized sand dune but the correlation was non-significant in active sand dune and aeo-fluvial plain. A positive correlation of available K was observed with EC and $CaCO_3$. Available K showed non-significant but positively correlation with organic carbon in stabilized sand dune and aeo-fluvial plain, whereas, non-significant and negatively correlation in active sand dune. Similar results were also reported by Soni *et al.* (2004).

The availability of Zn increased significantly with increase in organic carbon in stabilized sand dune (r = 0.44***) and aeo-fluvial plain (r = 0.41**). Available Zn was positively and non-significantly correlated with pH in active sand dune and stabilized sand dune, whereas, negatively and non-significantly correlated in aeo-fluvial plain. Available Cu was significantly and positively correlated with organic carbon in stabilized sand dune (r = 0.208**) and aeo-fluvial plain (r = 0.21*), whereas, non-significant and negatively correlated in active sand dune. Available Mn was showed non-significant and negatively correlated with organic carbon in active sand dune and aeo-fluvial plain, whereas, significant positive correlation with organic carbon and positively correlated in soils of

Table 3. Nutrient index of available nutrients of different landforms

Available nutrients	Active sand dune	Stabilized sand dune	Aeo-fluvial Plain
N	1.00	1.00	1.00
P	2.10	2.60	2.76
K	2.10	2.17	2.36

Table 4. Correlation between soil properties and available nutrients of different landforms

Parameters	pH	EC	OC	$CaCO_3$
Active sand dune				
N	-0.288	0.448*	0.012	0.195
P	-0.368*	0.210	0.142	-0.043
K	-0.174	0.240	-0.139	0.065
Zn	0.079	-0.361	0.288	-0.040
Cu	-0.142	0.144	-0.088	0.269
Mn	-0.322	0.367	-0.139	0.125
Fe	-0.374*	-0.036	-0.201	0.193
Stabilized sand dune				
N	-0.132*	0.255**	0.595**	0.001
P	-0.143*	0.446*	0.471**	0.027
K	-0.239**	0.144*	0.109	0.068
Zn	0.068	0.152*	0.435**	0.046
Cu	0.053	0.080	0.208**	0.235**
Mn	-0.187**	-0.024	0.424*	-0.132*
Fe	0.063	0.042	0.109	0.056
Aeo-fluvial plain				
N	-0.287**	0.168*	0.434**	0.030
P	-0.221**	0.149	0.122	-0.057
K	-0.149	0.193*	0.145	0.031
Zn	-0.137	0.139	0.407**	-0.025
Cu	-0.046	0.129	0.211*	0.105
Mn	-0.149	0.033	-0.020	-0.152
Fe	-0.005	0.191*	0.106	-0.025

**. Correlation is significant at the 0.05 level (2-tailed).*
***. Correlation is significant at the 0.01 level (2-tailed).*

stabilized sand dune (r = 0.42*). Available Fe content was positively correlated with EC and organic carbon in stabilized sand dune and aeo-fluvial plain, whereas, it was negatively correlated in active sand dune.

Conclusions

Soils of Central State Farm, Jetsar was deficient in organic carbon and available nitrogen. The highest available N, P, K, organic carbon and available micronutrient content were found in aeo-fluvial plain followed by stabilized and active sand dunes. The nutrient index indicates that soils of different landform were low in available N whereas, high available P in aeo-fluvial plain and stabilized sand dune and high available K in aeo-fluvial plain and accordingly these soils will be managed by suitable agro-managements.

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