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Characteristics of natural and planted sandalwood-supporting soils in Seoni district, Madhya Pradesh

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ABSTRACT

Two sandalwood-supporting pedons, one planted (P1) and other natural growing, were characterized in Seoni district of Madhya Pradesh. The solum depth of both the pedon was 30 cm underlain by weathered basalt beyond 50 cm. Pedon was dark reddish brown while P2 was characterized by dark reddish brown to dusky red. P2 had sandy clay texture (A1 horizon) and other horizons of both the pedons was associated with clay texture. These soils had more than 35 cmol(p+)kg^{-1} CEC and dominance of smectite (>20%) followed by vermiculite. There was more than 20 per cent feldspar in Bw horizon of P1 while underlying horizon of P2 had 25 per cent quartz. The nearly neutral soils had more than 1.0 per cent organic carbon barring A2 horizon of P2. These calcareous soils were dominated by exchangeable Ca^{++} followed by Mg^{++}, Na^{+}, K^{+} on exchange complex and grouped as Typic Haplustepts and Typic Ustorthents at subgroup level.

Key words: Sandalwood-supporting soils, Soil horizon, Soil taxonomy, Mineralogy

INTRODUCTION

Sandalwood (*Sontalum album*) is a prized gift of the plant kingdom woven into the culture and heritage of India. It is medium-sized hemi parasitic tree is grown in variety of soils and climatic conditions in Karnataka, Tamilnadu, Andhra Pradesh, Kerala, Gujarat, Madhya Pradesh, Uttar Pradesh, Manipur and in some other states, however, it prefers a well-drained, moderately fertile land but can grow under varying conditions of soil pH and even on soils having poor nutrient status (Rangasamy *et al*., 1986).

Sandalwood was introduced in the year 1880 in Seoni district and has spread over 300 ha due to seed dispersal by birds and natural generation. Recently B. S. Group started commercial planting of sandalwood in some pockets of Seoni district. However, Harsh *et al*. (2000) while working on decline of sandal tree in Seoni district, repeated forest fires alongwith uncontrolled grazing eventually led to the disappearance of ground flora, natural regeneration and leaf litter followed by drying of roots, shoot and branch tips (die back) and secondary invasion by termites, decay fungi and heart rot fungi. Virtually no information is available on characteristics of soils supporting natural *vis-a-vis* planted sandalwood in Seoni district barring one on micronutrient status (Choudhari *et al*., 2018) and hence present investigation was carried out.

MATERIALS AND METHODS

Site characteristics

Two pedons, one planted (P1) and other naturally growing (P2) sandalwood were selected in Salaia village, Lakhanadan tehsil of Seoni district, Madhya Pradesh. Pedon 1 (22°51′30″ N; 79°40′14″ E) occur at foot slope (8-15% slope) of basaltic plateau supporting plantation of 25 years old sandalwood in association of moderately dense fully stocked forest comprising of Salai, Dhawai, Bamboo, Teak, Ber, Saj, Khair and Tendu. Pedon 2 (P2) supporting naturally grown sandalwood occur on escarp slope (15-30%-slope, 20 m below to basaltic plateau) at 564 m above MSL (22°39′48″ N; 79°40′14″ E) associated with thin forest comprising of Teak, Karonda and Charoli. Both the sites have 3 to 15 per cent stones on surface. Pedon 1 was moderately eroded but P2 was severely eroded having mean annual rainfall of 1325 mm and mean maximum and minimum temperatures of 31.3°C and 18.9°C, respectively associated with ustic moisture and hyperthermic temperature regimes of soil respectively. The pedons at respective

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sites were exposed and studied for their morphological properties. Horizon-wise soil samples were collected and processed for laboratory analysis.

The sand, silt and clay contents of soils were determined as per International Pipette method after the removal of cementing agents (Jackson, 1979). The water dispersible clay was determined by taking 10g of soil and then shaking on an end to end shaker for 8 hrs. Suspension aliquots were drawn by following the International Pipette method. The moisture relation at 33 and 1500 kPa was determined by using pressure plate apparatus. The bulk density was determined by core sampler. The pH of soil was measured by pH meter and the electrical conductivity (EC) of soil: water (1:2) suspension was determined by ELICO conductivity bridge (Richards, 1954). Organic carbon in 100 mesh soil samples was determined by modified Walkley and Black rapid titration procedure (Jackson, 1973). The calcium carbonate ($CaCO_3$) content was estimated following the procedure outlined by Piper (1966). Exchangeable sodium and potassium were determined by flame photometer while Ca^{++} and Mg^{++} were analysed using Atomic Absorption Spectrophotometer (Jackson, 1973). The cation exchange capacity of the soils was determined as per the procedure outlined by Richards (1954) using 1*N* sodium acetate solution. The total clay of each horizon were analysed for mineralogy by x-ray diffractometer technique. For identification of minerals, total clay was subjected to XRD of the parallel oriented samples using a Philips X' Pert Pro diffractometer with Ni filtered Cu–Ka radiation at a scanning speed of 2020/min. Different thermal pre-treatments as required were given to distinguish and confirm the type of mineral present (Jackson, 1979).

RESULTS AND DISCUSSION

Morphological properties

The surface horizon of P1 had its colour in 5YR hue while sub-surface cambic horizon was associated with 2.5YR hue and their colour notation reflect as dark reddish brown. Both the horizons of P2 had Munsell colour notation in 2.5YR (dark reddish brown to dusky red) which indicated that both the pedons are highly leached and Fe^{3+} might have given redder colouration. Both the horizons of P1 and surface horizon of P2 had moderate medium sub-angular blocky structure but it was moderate fine sub-angular block in sub-surface horizon of P2. The coarse fragments constituted 5 to 10 per cent in P1 but it was 10-15% in P2. There were fine and medium sized roots in surface and sub-horizons respectively in P1but their quantities were common. The presence of weathered basalt in substratum beyond 50 cm does not restrict roots to penetrate. Jagdish Prasad and Patil (2002) reported similar finding in teak supporting soils of Dindori district of Madhya Pradesh. Fine and medium sized many roots were observed in A1 and A2 horizons respectively. It was slightly hard, friable, sticky and plastic consistencies were observed in both the pedons.

Physical properties

The sand content in both the horizons of P2 was 45 per cent but in P2 it increased to 34.7% in Bw horizon of P1 than surface horizon (26.9%) which clearly indicate the role of stope and site. Contrary to sand content, silt content decreased in P1 but increased in P2 with depth (Table 1). The clay content in P1 did not decrease considerably with depths but it was in P2 although both the pedons have their legacy with basalt which weathering lead to clay synthesis. P1 had clay texture in both the

Table 1. Physical properties of soils

Horizon	Depth (cm)	Particle size class (%) and diameter (mm)					Bulk density (Mg m^{-3})	Water retention (%)	
		Sand 2.0-0.05	Silt 0.05-0.002	Clay <0.002	Fine clay <0.0002	Water dispersible clay		33 kPa	1500 kPa
P1 : Clayey, smectitic, hyperthermic Typic Haplustepts									
A	0-11	26.9	24.3	48.8	34.2	8.8	1.41	25.40	18.95
Bw	11-30	34.7	18.8	46.5	31.6	7.5	1.45	27.77	21.62
P2 : Clayey, smectitic, hyperthermic Typic Ustorthents									
A1	0-14	45.1	11.0	43.9	34.0	8.2	1.63	23.06	16.53
A2	14-30	45.0	20.0	35.0	23.5	7.1	1.65	20.06	12.20

Table 2. Chemical properties of soils

Depth (cm)	pH (1:2)	EC (1:2) ($dS\ m^{-1}$)	OC (%)	$CaCO_3$ (%)	CEC	Exchangeable Ca^{++}	Mg^{++}	Na^{+}	K^{+}
						cmol kg^{-1}			
			P1 : Clayey, smectitic, hyperthermic Typic Haplustepts						
0-11	6.8	0.09	1.50	2.41	39.47	18.6	15.3	0.6	0.3
11-30	6.9	0.11	1.09	1.38	39.70	18.9	15.1	0.6	0.3
			P2 : Clayey, smectitic, hyperthermic Typic Ustorthents						
0-14	6.9	0.14	2.34	1.84	41.63	21.1	14.1	0.5	0.4
14-30	7.1	0.04	0.95	1.95	31.07	14.1	11.9	0.5	0.3

Table 3. Semi-quantitative estimate (relative per cent) of minerals in total clay fractions (<0.002 mm)

Horizon	Depth (cm)	Sm	Ch	Vm	M	Kl	Q	F
			P1 : Clayey, smectitic, hyperthermic Typic Haplustepts					
A	0-11	47	Nil	18	5	7	6	17
Bw	11-30	22	Nil	15	8	15	17	23
			P2 : Clayey, smectitic, hyperthermic Typic Ustorthents					
A1	0-14	35	Nil	30	5	13	7	9
A2	14-30	23	Nil	12	5	20	25	15

Sm - Smectite; Ch - Chlorite; Vm - Vermiculite; M - Mica, Kl - Kaolinite, Q - Quartz, F - Feldspars

horizons but it was sandy clay in surface horizon and clay loam in underlying A2 horizon of P2. The fine clay in surface horizons was 34.2 per cent (P1) and 34.2 per cent (P2) while it was 31.6 per cent in Bw horizon of P1 and 23.5 in sub-surface horizon of P2. The bulk density in P1 was approximately 1.4 Mgm^{-3} but it was more than 1.6 Mgm^{-3} in P2 owing to higher sand content. Water retentions ranged from 20.66 to 27.77 per cent at 33 kPa and 12.20 to 21.62 per cent at 1500 kPa in both the pedons and seems dependent on clay content (Nikam *et al*., 2006), organic carbon and structural stability as evidenced by cambic horizon in P1.

Chemical properties

The pH of both the horizons of P1 was nearly neutral (pH 6.8 and 6.9) and values of pH in P2 were 6.9 and 7.1 owing to leaching of salts on erosional sites. The electrical conductivity was below 0.2 d Sm^{-1} in the different horizons of P1 and P2. The organic carbon content in these horizons was more than 1 per cent barring sub-surface horizon of P2. The differences in organic carbon content under both type of sandalwood might be attributed to the slope, age of plant and undergrowth (P2 site). Patil and Jagdish Prasad (2004) also reported similar finding in sal-supporting soils of Dindori district of Madhya Pradesh. While working on carbon sequestration potential of natural sandalwood forest in southern-western Ghat, Kalaiselvi *et al*. (2023) reported higher carbon sequestration in naturally occurring sandalwood than other land uses. These soils had more than 1.0 per cent $CaCO_3$ being highest (2.41%) in A horizon of P1 but it decreased in sub-surface horizon. The pedons had exchangeable calcium, magnesium, sodium and potassium varying from 14.1 to 21.1; 11.9 to 15.3; 0.5 to 0.6 and 0.3 to 0.4 cmol (p^+) kg^{-1} respectively (Table 2). These soils had CEC more than 35 cmol (p^+) $kg^{-1}$and CEC/clay ratio more than 0.80 indicate dominance of smectitic mineralogy.

The mineral assemblage of P1 indicate more than 20 per cent smectite, more than 12 percent vermiculite, more than 7 per cent kaolinite in total clay fractions. In general, quartz content increased in sub-surface layer and reaches to 25 per cent in A2 horizon of P2. Feldspar was present (6.0 per cent) in Bw2 horizon of P1 but other horizons of P1 and P2 had traces of feldspars (Table 3) owing to differential weathering, erosive surface and deposition.

The pedon 1 is placed in order Inceptisols owing to ochric epipedon, cambic sub-surface diagnostic horizon. The moisture regimeis ustic so the suborder is Ustepts. At Great group level, it grouped as Haplustepts and at subgroup as Typic Haplustepts. Pedon 2 possess ochric epipedon and no sign of any sub-surface diagnostic horizon and hence placed in the order of Entisols, Orthents at suborder, Usterthents at Great group level and Typic Usterthents at subgroup level. As these soils had more than 35 per cent clay and that of smectitic type but less than 50 cm depth,these soils are classified as Clayey, smectitic, hyperthermic Typic Haplustepts (P1) and clayey, smectitic, hyperthermic Typic usterthents (P2), respectively.

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