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Characterization and Classification of Soils for Nagpur Mandarin in Eastern Part of Nagpur District

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Abstract :

The present investigation entitled 'Assessment of soil site suitability for Nagpur mandarin in eastern part of Nagpur district' was carried out. The total six healthy 10-12 yrs old trees orchards of Nagpur mandarin from six villages were studied on the basis of visual observations and morphological characteristics. The leaf, fruit and depth wise soil samples were collected for laboratory analysis. The study area map was prepared with the help of remote sensing data and GIS.

The results showed that the soils of the study area were medium to very deep. The soil was brown (10YR 5/3) to grayish brown (10YR 5/2) in colour. The soil structure was sub angular blocky, hard consistency in dry condition and firm in moist condition. The bulk density and hydraulic conductivity of soil varied from 1.35 Mg m-3 to 1.56 Mg m-3 and 0.4 to 3.6 cm hr-1 respectively. Soil was neutral to moderately alkaline in reaction and non-saline. The organic carbon in soil was found to be very low to high. The calcium carbonate in soil increased with depth and was calcareous in nature. The available nitrogen was low, phosphorus was very low to high, potassium was low to high and sulphur was low to moderate. The exchangeable calcium and magnesium in soil varied from 30.6 to 39.8 cmol (p+) kg-1, 6.0 to 7.9 cmol (p+) kg-1 respectively. The DTPA extractable micronutrients in soil varied from low to moderately high for zinc, moderately high to high for iron, moderately high to very high for copper and moderately high to very high for manganese respectively. Based on the climatic condition and soil site suitability criteria for citrus all the pedons were found marginally suitable for Nagpur mandarin plantations with limitations of temperature, depth and presence of CaCO3 in high amount.

(Key words: Soil taxonomy, soil fertility, citrus suitability)

INTRODUCTION

Globally citrus is the leading fruit crop with a total production of 104.5 million tonnes (Mt), with the maximum production of 32.6 Mt in Asia followed by 25.8 Mt in South America. Country-wise, Brazil tops the list with a production of 19.9 Mt, followed by USA, 5.7 Mt by India, anchored at sixth spot. The highest global citrus production comes from soils represented by the order Alfisol, Ultisols, Entisols and Inceptisol (Srivastava and Singh, 2002). In India, citrus grown in an area of 5.63 lakh ha world total production of 56.8 lakh tonnes with productivity 10.1 tonnes. Out of which area under orange cv. mandarin is 2 lakhs ha with production of 16.6 lakh tones. In terms of area, Maharashtra topped a list (137000 ha. with production 11.17 tonnes) followed by Andhra Pradesh and Karnataka in national pool, accounting for 48% of orange production in country. Orange is cultivated in 84000 ha area in Vidarbha with production of 5 lakhs tones per year. Nagpur district alone has 20965 ha area under Nagpur mandarin. It is the most important fruit crops in the world. Soil suitability classification involves the execution and interpretation of basic surveys of climate, soils, vegetation and other aspects of land in terms of land use (FAO, 1976). Land suitability is the degree of appropriateness of land for a certain use. The suitability of a given piece of land is its natural ability to support a specific purpose and may be major kind of land use, such as rain fed agriculture, forestry. According to FAO (1976), two stages approaches is often used in resources inventories for broad planning purposes and in studies for assessment of biological productive potential. Also, there are four categories of decreasing generalization which are recognized namely, Orders, Classes, Subclasses and Units. These classes are numbered consequently by Arabic numbers, in sequence of decreasing degrees of suitability within the orders.

MATERIALS AND MEHODS

An Research Survey on "Assessment of soil site suitability for Nagpur Mandarin in Eastern part of Nagpur district" was undertaken during the year 2015-2016 to assess the soil site suitability for Nagpur mandarin in the month of October, 2015 at Eastern Nagpur zone of Umred and Bhiwapur tahsil with the help of Remote sensing and GIS mapping.

The 6 Nagpur mandarin orchards were selected from Eastern part of Nagpur and depth wise soil sampling were done along with the leaves and fruit samples for their suitability to Nagpur mandarin. The soil pits maximum upto 1.5 meter long, 1 meter wide and 1.5 feet deep were dug at all the sites. Characteristics of the pedon and also depth wise soil characteristics were studied for morphological characters in the field as per the procedures laid out in the Soil Survey Manual (Soil Survey Staff, 1998). Revised horizon designations were used. Special observations regarding the depth of cracking were also recorded. The photographs of the soil profiles were taken. The profile samples from the various depth of the exposed profile were collected for physical and chemical analysis. About 1.5 kg representative soil sample from each horizons of various depth were collected in cloth bag for laboratory characterization. The bulk soil samples were allowed to air dry in shade and then weighed soil aggregates were passed through 5 mm, 2 mm, and 0.5 mm sieve and used for laboratory analysis. The bulk density of soil was determined by dry clod coating method (Black *et al.,* 1965). The hydraulic conductivity of soil was determined by Constant Head method given by Singh *et al.*, (1989).

Soil pH and electrical conductivity was determined in soil suspension (1: 2.5 soil: water) by a glass electrode pH meter and conductivity bridge (Jackson, 1967). Organic carbon was determined by the Walkley and Black rapid titration procedure by using 0.5 mm sample (Jackson, 1967). The calcium carbonate was estimated by rapid titration method from different size aggregate (Piper, 1966). Exchangeable calcium and magnesium were determined by using 1 N KCl triethanolamine buffer solution (pH 8.2) and titrating the leachate with standard EDTA solution using mureoxide and EBT as an indicator (Richard, 1954). The available N was determined by alkaline permanganate method as described by Subbiah and Asija (1956). The soil was extracted with Olsen's reagent 0.5 m $NaHCO_3$ of pH 8.5 and in the extract, available P was estimated colorimetrically (Olsen, *et al.,*1954). The available potassium was determined by flame photometer method using neutral ammonium acetate as extractant (Jackson, 1967). The sulphur was estimated by extracting soil with Morgan's solution and the resultant turbidity was measured colorimetrically using blue filter (Chesnin and Yien, 1950). The DTPA (Diethylene triamine penta-acetic acid) (0.005 M) extractable (1:2, Soil: DTPA) Fe, Mn, Zn and Cu were determined as per the procedure outlined by Lindsay and Norvell, (1978) using Atomic Absorption Spectrophotometer.

RESULTS AND DISCUSSION

Morphological properties of soil

The surface horizons of the soils have brown (pedon 3, 5, 6), yellowish brown (pedon1), grayish brown (pedon 2) and grey in colour (pedon 4). The soil of subsurface horizons of pedon 3 and 5 have pale brown to light grey and pedon 6 grayish brown and brown colour in pedon 1, 2. All pedons have clay texture, smectite mineralogy, organic carbon and drainage condition. However, the subsurface horizon of pedon 5 and 6 grey colour (rubbed) due to presence of powdery lime resulting in variegated colour. The variation in the soil colour was a function of chemical and mineralogical composition, topographic position, and textural makeup and moisture regimes of the soils. The results are in conformity with those earlier reported by Thangasamy *et al.*, (2005).

Physical characteristics of soil

Bulk density values ranged from 1.35 Mg m^{-3} to 1.56 Mg m^{-3} (table 2). The highest value of bulk density 1.56 Mg m^{-3} was observed in the 90-110 cm depth of pedon 5 and lowest value 1.35 Mg m^{-3} in 60-90 cm depth of pedon 3. The bulk density of soil increased with depth of soil. Similar results were recorded by Singh and Agrawal, (2005). The saturated hydraulic conductivity ranged from 0.4 to 3.6 cm hr^{-1} (table 2). The highest value observed in 0-30 cm depth of pedon 1 and lowest value observed in 120-150 cm depth of pedon 6. The trend indicated gradual decrease with soil depth. The higher values in surface horizon were due to their porous nature as a result of regular tillage operations. The reduction in hydraulic conductivity with increasing depth was also observed in black soils by Kadu *et al.*, (1993).

Chemical properties of soil

The pH of studied soils (1:2.5 soil:water suspension) ranged between 7.00 to 8.27 which indicates the soil of study area was neutral to moderately alkaline in soil reaction (table 3). The maximum pH was observed in 30-60 cm of pedon 5 (8.27) and minimum pH was observed in 120-150 cm depth of pedon 6 (7.00). The slight soil alkaline reaction may be due to the moderate to high calcareous nature of the soil. Similar results were observed by Kuchanwar *et al.*, (2005) in typical acid growing soils of Akola district. The electrical conductivity of soil ranged from 0.151 to 0.392 dS m^{-1} (table 3) which was well within the acceptable limit of EC, designated for normal soils (Richards, 1954) indicating that these soils are non saline. The highest value of EC was observed in 90-120 (0.392 dSm^{-1}) cm depth of pedon 6 and lowest value of EC was observed in 90-120 cm depth (0.151 dS m^{-1}) of pedon 3. The organic carbon content of the soil varied from 1.60 to 8.91 g kg^{-1} i.e very low to high in availablility and which found to decreases with depth (table 3). The highest content of organic carbon was observed in 0-30 cm depth of pedon 5 (8.91 g kg^{-1}) whereas the lowest values was recorded in 90-120 cm depth of pedon 2 (1.60 g kg^{-1}). Similar observations were reported by Ghawade *et al.*,

(2009) that, the soil organic carbon decreases with depth of soil. The surface layers had relatively higher organic carbon than underlying horizons. Similar findings were given by Likhar and Prasad, (2011[a]). The calcium carbonate in soil varied from 2.11 to 14.21 per cent which is slightly calcareous to calcareous in nature. The maximum calcium carbonate found in pedon 6 (12.47 to 14.21%) whereas minimum in pedon 4 (2.11%). The $CaCO_3$ increases with depth of soil and it was recorded in all pedons. Similar results were reported by Kadu *et al.*, (2010).

The available N in the soil varied from 168.70 to 232.02 kg ha^{-1}. In surface samples it varied from 220.7 to 232.0 kg ha^{-1}. The available nitrogen showed a decreasing trend with depth in all the soil profiles. All the soil profiles had low to medium available N. The higher available nitrogen was observed in pedon 2 and 4. The available phosphorus in the soil varied from 5.01 to 34.35 kg ha^{-1} but in surface layers it ranged from 22.70 to 34.35 kg ha^{-1} and was found to be very low to high. The higher available phosphorus was observed in pedon 3 and 1. The available potassium in soils varied from 150.3 to 612.0 kg ha^{-1}. In surface layer, the available potassium varied from 216.8 to 616.00 kg ha^{-1} and found it decreased with depth in all the soil profile except in pedon 1 and 2. This soil was rated as low to very high for available potassium and all pedons were in optimum level for available potassium. The available sulphur was low to moderate (8.2 to 17.8 mg kg^{-1}). No trend observed with depth for availability of sulphur. The exchangeable calcium in soil varied from 30.6 to 39.8 cmol (p+) kg^{-1}. The calcium was increased with increase in depth. The exchangeable magnesium in soil varied from 6.0 to 7.9 cmol (p+) kg^{-1}. The maximum magnesium content was observed in 30-60 cm depth of pedon 5 and minimum in 60-90 cm depth of pedon 1. The magnesium value was found to be decreasing with the increase in depth.

The DTPA extractable-Zn in soils varied from 0.30 to 1.66 mg kg^{-1}, which was low to moderately high in category and its higher values was observed in pedon 5. The DTPA-Cu varied from 0.69 to 3.49 mg kg^{-1} (moderately high to high in category). Cu content was higher in surface samples and that decreased with depth. DTPA-Fe content ranged from 9.6 to 24.5 mg kg^{-1} which was moderately high to very high and found decreased with depth. The DTPA-Mn varied from 4.80 to 16.4 mg kg^{-1}, which was moderately high to very high in category in surface soils (Singh, 2008).

Suitability assessment to citrus species

As per Anonymous, 1994 the ideal soils for citrus are deep (above 150 cm), well drained and well structured silty clay to clayey with lots of organic matter. The physicochemical characteristics of soil influenced the yield and quality parameters of citrus, which are pH, EC, texture, structure, bulk density, content of organic matter and water retention capacity. Citrus grows and fruits well in pH range of 6.5–7.5, however lower limit is 4 and upper limit is 8.5. The electrical conductivity of soil should be below 1 dS m^{-1} and calcium carbonate content below 10 per cent.

As per criteria given by NBSS & LUP, 1994 all the pedons were marginally suitable for citrus cultivation. As per climatic characteristics the study area is moderately suitable under total rainfall condition, highly suitable in length of growing period i.e. 240-265 days and marginally suitable under mean temperature in growing season for citrus. As per soil site characteristics the slope of the study area is ideal for citrus cultivation i.e. 1 to 3%, while drainage of study area is moderately well and shows moderate limitation. As per the soil texture all pedon are suitable for plantation of citrus. According to soil depth all pedons are moderately to marginally suitable for citrus plantation. All the soils pedons are found to be marginally suitable citrus cultivation inspite of severe limitation of calcium carbonate in pedon 2, 3, 4, 6 which directly or indirectly affects the availability of nitrogen, phosphorus, potassium, magnesium, iron, manganese and zinc under certain management condition can be suitable for cultivation of citrus.

As per above discussion all the pedon are suitable under certain management condition like land configuration for plantation of citrus with management of nutrients required by the crop, high content of total calcium carbonate in pedons can be made suitable for plantation of citrus nursery under certain management condition by addition of higher application of organic manure and proper care for some nutrient which are not available due to calcareous nature of soil.

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Table 1: Morphological characteristics of soil

Depth	Munsell colour	Texture	Structure	Consistence			Effervescence (10% dilute HCl)
	Dry			Dry	Moist	Wet	
1	2	3	4	5	6	7	8
Pedon 1: Clayey, Fine, Calcareous, Typic Haplustert							
0-30	10YR 5/4	Clay	Sbk	sh	fl	s	Slight
30-60	10YR 5/3	Clay	Sbk	sh	F	ss	Strong
60-90	10YR 5/3	Clay	Sbk	sh	vfl	ss	Strong
90-120	10YR 5/2	Clay	Sbk	sh	F	ss	Strong
pedon 2: clayey, fine, smectitic (calcareous), vertic haplustep							
0-30	10YR 5/2	Clay	Sbk	sh	F	s	Strong
30-60	10YR 5/2	Clay	Sbk	sh	F	s	Strong
60-90	10YR 5/3	Clay	Sbk	sh	F	ns	Strong
90-120	10YR 5/4	Clay	Sbk	sh	F	ns	Strong
pedon 3: clayey, fine, smectite (calcareous), vertic haplustert							
0-30	10YR 5/3	Clay	sbk	sh	F	p	Strong
30-60	10YR 7/2	Clay	sbk	sh	F	p	Strong
60-90	10YR 6/3	Clay	sbk	sh	F	vp	Violent
90-120	10YR 5/3	Clay	sbk	sh	F	vp	Violent
pedon 4: clayey, fine, Smectite (calcareous) typic haplustept							
0-30	10YR 5/1	Clay	sbk	sh	F	s	Slight
30-60	10YR 5/2	Clay	sbk	sh	F	ss	Slight
60-80	10YR 5/4	Clay	sbk	sh	F	ns	Strong
Pedon 5: Clayey, Fine, Smectite (Calcareous), Typic Haplustept							
0-30	10YR 5/3	Clay	sbk	sh	fl	ss	Slight
30-60	10YR 4/2	Clay	sbk	sh	F	ss	Strong
60-90	10YR 4/2	Clay	sbk	sh	efl	ns	Strong
90-110	10YR 5/1	Clay	sbk	sh	efl	ns	Violent
Pedon 6: Clayey, Fine, Calcareous, Vertic Haplustert							
0-30	10YR 5/3	Clay	sbk	sh	F	ss	Strong
30-60	10YR 5/2	Clay	sbk	sh	F	ss	Strong
60-90	10YR 5/2	Clay	sbk	sh	F	ss	Strong
90-120	10YR 5/1	Clay loam	sbk	sh	fl	ss	Violent
120-150	10YR 5/1	Clay loam	sbk	sh	F	ns	Violent

Note: Symbols used are according to Soil Survey Manual notations (Soil Survey Division staff, 1998). Details are given in appendix I

Table 2: Physical properties of soil

Depth (cm)	Bulk density (Mg m^{-3})	Hydraulic Conductivity (cm hr^{-1})
Pedon 1: Clayey, Fine, Smectitic (calcareous), Typic Haplustert		
0-30	1.45	3.6
30-60	1.48	3.2
60-90	1.50	2.4
90-120	1.52	1.2
Pedon 2: Clayey, Fine, Smectitic (calcareous), Vertic Haplustert		
0-30	1.43	2.3
30-60	1.44	1.9
60-90	1.48	1.2
90-120	1.47	0.6
Pedon 3: Clayey, Fine, Smectite (calcareous), Vertic Haplustert		
0-30	1.39	1.9
30-60	1.36	1.7
60-90	1.35	1.2

90-120	1.49	0.7
Pedon 4: Clayey, Fine, Smectitic (calcareous), Typic Haplustept		
0-30	1.48	3.2
30-60	1.47	2.6
60-80	1.48	1.8
Pedon 5: Clayey, Fine, Smectite (calcareous), Typic Haplustept		
0-30	1.46	2.4
30-60	1.50	1.3
60-90	1.52	1.1
90-110	1.56	0.6
Pedon 6: Clayey, Fine, smectitic (calcareous), Vertic Haplustert		
0-30	1.45	3.1
30-60	1.47	2.2
60-90	1.47	1.8
90-120	1.48	1.8
120-150	1.54	0.4

Table 3: Chemical Properties of soil

Depth (cm)	pH	EC (dS m^{-1})	$CaCO_3$ (%)	OC (g kg^{-1})
Pedon 1: Clayey, Fine, Smectitic (Calcareous), Typic Haplustert				
0-30	7.45	0.278	2.85	4.60
30-60	7.50	0.362	3.70	4.20
60-90	7.53	0.371	5.35	3.10
90-120	7.42	0.345	5.46	3.04
Pedon 2: Clayey, Fine, Smectitic (Calcareous), Vertic Haplustept				
0-30	7.62	0.271	2.88	5.50
30-60	7.63	0.262	4.52	2.50
60-90	7.62	0.314	7.64	2.50
90-120	7.60	0.328	8.84	1.60
Pedon 3: Clayey, Fine, Smectite (Calcareous), Vertic Haplustert				
0-30	7.74	0.172	8.12	7.20
30-60	8.07	0.193	9.23	5.70
60-90	7.99	0.159	12.56	4.41
90-120	7.90	0.151	12.83	4.12
Pedon 4: Clayey, Fine, Smectitic (Calcareous), Typic Haplustept				
0-30	7.60	0.281	2.11	5.10
30-60	7.82	0.246	2.22	4.50
60-80	7.21	0.261	4.87	4.30
Pedon 5: Clayey, Fine, Smectite (Calcareous), Typic Haplustert				
0-30	7.80	0.355	2.57	8.91
30-60	8.27	0.314	6.43	7.80
60-90	7.89	0.251	8.17	7.60
90-110	8.14	0.334	11.69	7.51
Pedon 6: Clayey, Fine, Smectitic (Calcareous), Vertic Haplustert				
0-30	7.19	0.328	4.51	7.30
30-60	7.07	0.335	6.58	7.60
60-90	7.76	0.284	7.52	6.60
90-120	7.74	0.392	12.47	6.00
120-150	7.00	0.367	14.21	5.23

Table 4: Fertility status of soil

Pedon	Depth (cm)	N kg ha^{-1}	P_2O_5 kg ha^{-1}	K_2O kg ha^{-1}	S mg kg^{-1}	Ca	Mg
						cmol (p+) kg^{-1}	
Pedon 1: Clayey, Fine, Smectitic (Calcareous), Typic Haplustert							
1	0-30	223.21	27.18	325.6	11.7	30.6	7.8
	30-60	211.52	15.18	291.2	11.8	32.5	6.2
	60-90	180.77	12.57	224.0	10.2	32.6	6.0

	90-120	168.70	12.36	251.21	9.6	33.5	6.1
Pedon 2: Clayey, Fine, Smectitic (Calcareous), Vertic Haplustept							
2	0-30	232.02	24.11	257.6	13.2	36.9	7.0
	30-60	200.25	23.02	224.0	12.7	38.1	7.2
	60-90	172.83	13.75	212.8	11.9	38.2	7.1
	90-120	170.31	11.92	235.2	11.3	39.8	6.9
Pedon 3: Clayey, Fine, Smectite (Calcareous), Vertic Haplustert							
3	0-30	224.79	34.35	364.2	13.8	32.3	7.3
	30-60	213.24	28.75	280.0	11.4	33.0	7.5
	60-90	200.70	20.51	168.0	11.5	34.5	6.4
	90-120	199.20	20.1	167.1	10.4	34.1	7.0
Pedon 4: Clayey, Fine, Smectitic (Calcareous), Typic Haplustept							
4	0-30	230.41	23.23	235.4	14.6	34.2	7.3
	30-60	218.23	17.33	212.0	12.9	35.6	6.6
	60-80	203.89	9.06	200.8	9.2	36.2	6.3
Pedon 5: Clayey, Fine, Smectite (Calcareous), Typic Haplustert							
5	0-30	220.70	24.82	612.0	12.8	34.4	7.8
	30-60	218.16	21.64	588.2	11.5	35.2	7.9
	60-90	225.21	19.42	476.2	12.6	35.1	7.4
	90-110	200.70	15.38	420.5	9.5	38.8	7.1
Pedon 6: Clayey, Fine, Smectitic (Calcareous), Vertic Haplustert							
6	0-30	225.72	22.70	216.8	12.4	37.1	7.2
	30-60	218.23	17.71	168.4	11.8	38.6	7.1
	60-90	184.50	17.27	160.0	10.6	38.4	7.0
	90-120	188.03	7.08	152.3	9.4	38.4	6.4
	120-150	170.23	5.01	150.3	8.2	38.9	6.9

Table 5: Micronutrient status of soil

Depth	Cu	Fe	Zn	Mn
(cm)	**mg kg^{-1}**			
Pedon 1: Clayey, Fine, Smectitic (Calcareous), Typic Haplustert				
0-30	1.88	21.2	0.59	16.3
30-60	1.73	19.4	0.37	15.4
60-90	1.54	17.3	0.38	12.2
90-120	1.45	17.2	0.36	11.2
Pedon 2: Clayey, Fine, Smectitic (Calcareous), Vertic Haplustept				
0-30	2.10	22.4	0.78	16.4
30-60	0.73	20.1	0.65	12.6
60-90	1.90	16.4	0.42	11.7
90-120	2.30	13.3	0.30	11.2
Pedon 3: Clayey, Fine, Smectite (Calcareous), Vertic Haplustert				
0-30	2.67	18.0	0.43	8.78
30-60	1.73	20.4	0.35	5.44
60-90	1.66	19.0	0.38	4.80
90-120	1.25	18.2	0.36	5.02
Pedon 4: Clayey, Fine, Smectitic (Calcareous), Typic Haplustept				
0-30	2.15	19.5	1.02	15.6
30-60	1.52	18.2	0.91	13.2
60-80	1.51	16.4	0.70	10.3
Pedon 5: Clayey, Fine, Smectite (Calcareous), Typic Haplustert				
0-30	3.49	24.5	1.66	15.2
30-60	2.33	22.6	0.91	12.4
60-90	2.12	15.2	0.89	10.5
90-110	2.29	12.5	0.78	10.2
Pedon 6: Clayey, Fine, Smectitic (Calcareous), Vertic Haplustert				
0-30	1.23	15.4	0.38	9.67
30-60	0.84	15.2	0.33	8.21
60-90	0.69	12.5	0.32	7.54
90-120	0.93	10.2	0.33	7.50
120-150	0.98	9.6	0.31	6.50

Table 6: Degree and limitation of soil suitability for citrus species

Char. / Pedon	Total rainfall (mm)	Length of growing period (days)	Mean temp. in growing season (°C)	Slope (%)	Drainage	Texture (%)	Soil depth (cm)	$CaCO_3$ (%)	pH (H_2O)	EC (dS/m^{-1})	Suitability class
Pedon 1	S_2	S_1	S_3	S_1	S_1	S_1	S_2	S_2	S_1	S_2	S_3 Marginally suitable
Pedon 2	S_2	S_1	S_3	S_1	S_1	S_1	S_2	S_3	S_2	S_2	S_3 Marginally suitable
Pedon 3	S_2	S_1	S_3	S_1	S_1	S_1	S_2	S_3	S_2	S_2	S_3 Marginally suitable
Pedon 4	S_2	S_1	S_3	S_1	S_1	S_1	S_3	S_2	S_2	S_2	S_3 Marginally suitable
Pedon 5	S_2	S_1	S_3	S_1	S_1	S_1	S_2	S_3	S_2	S_2	S_3 Marginally suitable
Pedon 6	S_2	S_1	S_3	S_1	S_1	S_1	S_2	S_3	S_2	S_2	S_3 Marginally suitable

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