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Soil fertility characterization of Mandh watershed in mid hills sub-humid zone of Himachal Pradesh

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Abstract

Surface soil samples (0-15 cm) from six cultivated soil series viz., Patti, Majhenu, Tikkar, Sun, Daramman and Kotlu of Mandh watershed were analyzed for available N, P, K and micronutrient cations. At subgroup level, these soils belong to Typic Udorthents, *Typic Dystrudepts, Typic Paleudalfs* and *Typic Hapludalfs*. The soil texture, pH, organic carbon, CEC and base saturation of these soils varied from loamy skeletal to fine silty, 5.2 to 6.4, 0.52 to 1.48%, 7.6 to 12.2 cmol (p+) kg^{-1} and 48 to 62%, respectively. Available N, P and K status was low to high, low to medium and low to high, respectively. DTPA extractable Fe, Mn and Cu were sufficient in all soil series, available zinc, however, was found to be deficient to extent of 20 to 75 per cent in Kotlu and Sun series. The data on vertical distribution of nutrients revealed that surface soils registered higher available N and P contents compared to subsurface soils whereas, reverse trend was obtained with available K. To balance available contents, doses of N and P should be lowered by 25% of the recommended dose and for K it should be increased by 25 per cent. There was an irregular trend of distribution of micronutrient cations with depth. Zn deficiency was noticed in three soil series viz, Kotlu, Daramman and Sun to the extent of 20, 50, and 75 per cent, respectively. Therefore, to correct Zn deficiency in the study area, application of Zn@25kg/ha is suggested. Thus, it is inferred that the fertilizer recommendations should be based on soil test values, fertilizer schedule should be based on whole crop sequence instead of single crop, balanced fertilization and micronutrient deficiencies should be corrected as and when required.

Key words: Soil fertility status, soil series, macronutrients, micronutrients.

Introduction

Though primary purpose of soil testing is to provide a base for site-specific fertilizer application, soil fertility characterization on watershed basis is useful for guiding farmers and assisting land use planners to devise nutrient and fertilizer policies to sustain agro-ecosystems. Generally, soil fertility characterization is done using administrative boundaries e.g. of a village, block, district, etc. Since nutrient supplying capacity of a soil depends largely on pedogenic factors, it is worthwhile to characterize soil fertility on soil series basis (Sekhon *et al.* 1985). Such type of information is of limited availability especially for difficult terrains of Himachal Pradesh. The present investigation therefore was carried out in Mandh watershed representing mid hills sub-humid agro-ecosystems of Himachal Pradesh. Mandh is an important stream draining from Dhauladhar range of Kangra district to the Beas river.

Materials and Methods

Mandh watershed, of about 110 km^2 area, lies between 31°52'17" to 32°06'37"N latitude and 76°30'33" to 76°35'17"E longitude. Agricultural land in Mandh watershed is 42.9 per cent of total watershed area. Six soil series viz. Patti, Majhenu, Tikkar, Daramman, Sun and Kotlu represent the cultivated soils on different landforms of Mandh watershed (Table 1). The landforms namely fluvio-glacial terraces, fluvial terraces and hill slopes occupy 53.3, 26.7 and 21.0 per cent of the total watershed area, respectively. Main crop sequences in irrigated (52.5) and rain-fed situations (47.5 %) of the watershed are paddy-wheat and maize-wheat, respectively.

Each soil series differs in its soil properties and have different soil properties and available nutrients. Therefore, separate soil samples for each soil series in a field were collected. Horizon-wise soil samples drawn from typifying pedons and representative (five) soil samples (0-15 cm) collected from each soil series were analyzed for pH, organic carbon, soil texture, CEC, base saturation and available N,P,K and micronutrient cations using standard procedures (Black, 1965; Lindsay and Norvell, 1978). Soil nutrient indices (SNI) were worked out to depict the

Table 1. Brief description of cultivated soil series of Mandh watershed

Series	Taxonomic name	Major landform the series represent	Location of typifying pedon
Patti	Fine-silty, deep, mixed, thermic, *Typic Paleudalfs*	Gently undulating (1-3%) fluvio-glacial terraces	32°04′ 29″N to 76°32′39″E
Majhenu	Fine-loamy, deep, mixed, thermic, *Typic Hapludalfs*	Undulating (3-5%) fluvio-glacial terraces	32°03′27″N to 76°33′05″E
Tikkar	Coarse loamy, medium, mixed, thermic, *Typic Dystrudepts*	Gently rolling (5-10%) fluvio-glacial terraces	32°01′30″N to 76°32′44″E
Kotlu	Fine loamy, deep, mixed, thermic, *Typic Dystrudepts*	Gently undulating (1-3%) river terraces, gently undulating to undulating valley fills and undulating hill tops	31°55′25″N to 76°31′43″E
Sun	Loamy skeletal, medium, mixed, thermic, *Typic Udorthents*	Extremely steep (> 50%) hill slopes	31°59′32″N to 76°34′16″E
Daramman	Loamy skeletal, medium, mixed thermic, *Typic Dystrudepts*	Steep (15-25%) hill slopes	31°59′25″N to 76°33′07″E

available nutrient status on soil series/watershed basis (Parker *et al.* 1951).

Results and Discussion

Physical and chemical properties of soils of Mandh watershed

The clay, silt and sand contents in cultivated soils of Mandh watershed varied from 14.6 to 36.0, 31.4 to 48.4, and 18.6 to 53.4 per cent, respectively (Table 2). The soil texture varied from loamy skeletal to fine silty. Except Sun series, the subsurface horizons of all soils registered higher clay content as compared to surface horizons which may be attributed to illuviation process prevailing in the area (Verma *et al*. 1976). A reverse trend of vertical distribution was obtained for silt and sand contents. Though their contents vary and exhibit an irregular trend with depth, but the magnitude of variation was not much from pedogenesis point of view.

Generally, higher organic carbon content and lower pH values were recorded in surface as

Table 2. Brief description of soil parameters of Mandh watershed

Parameters	Range (Surface soils)	Range (Sub-surface soils)
Organic carbon (%)	0.52 to 1.48	0.16 to 0.74
pH (1:2.5:: soil:water)	5.2 to 6.4 (strongly acid to slightly acid)	5.3 to 6.4 (strongly acid to slightly acid)
Cation exchange capacity (cmol (p^+) kg^{-1})	7.6 to 12.2	7.5 to 15.8
Per cent base saturation	48 to 62	50 to 60

compared to those in subsurface horizons (Table 3). On the contrary, subsurface horizons exhibit higher values of CEC and base saturation. Higher organic carbon content and lower soil pH values in surface horizons may be explained in the light of continuous process of leaf fall/decay, soil forming factors (vegetation and parent material low in bases, heavy rainfall, low temperature and topography) and nutrient applications. Mandal (1984) also reported that the acidic reaction of *Hapludolls, Udifluvents, Udorthents, Dystrochrepts, Haplumbrepts* and *Hapludalfs* in Himalayas to high rainfall and parent material poor in bases. The increase in clay content with soil depth was too small to qualify for the argillic horizons in Tikkar, Daramman and Kotlu series. However, they may develop into *Alfisols* in near future.

Available nutrient status in Mandh watershed

Available N, P, K, Fe, Mn, Zn and Cu contents in surface or sub-surface soils of Mandh watershed ranged from 188 to 840 kg/ha, 3.4 to 24.6 kg/ha, 110

Table 3. Physical and chemical attributes of different soil series in Mandh watershed

Soil series	Horizon(s)	Mechanical separates (%)			pH (1:2.5)	OC (%)	CEC [cmol(p+) kg^{-1}]	Base saturation (%)
		Sand	Silt	Clay				
Patti	Surface	28.4	48.4	23.2	5.2	1.48	12.2	48
	Sub-surface	18.6 – 25.0	44.6 - 48.4	29.0 - 36.0	5.3 -5.8	0.28 - 0.74	12.9-15.8	50-56
		(20.8)*	(45.8)	(33.3)	(5.65)	(0.51)	(14.1)	(52)
Majehnu	Surface	44.5	39.3	16.2	5.3 -5.5	0.68-0.84	8.3-8.6	51
	Sub-surface	37.6 - 43.0	33.2 - 40.0	17.0 - 29.2	5.7 - 6.0	0.26-0.38	10.4-13.2	51-58
		(40.1)	(35.9)	(24.0)	(5.7)	(0.39)	(11.0)	(54.7)
Tikkar	Surface	53.4	32.0	14.6	5.8	0.78	7.6	55
	Sub-surface	49.6-52.5	31.5 - 33.9	16 -17	5.7-6.0	0.28-0.44	7.5-7.7	53-59
		(51.0)	(32.7)	(16.5)	(5.8)	(0.36)	(7.6)	(56)
Kotlu	Surface	47.8	33.4	18.8	6.1	0.96	8.8	58
	Sub-surface	46.4 - 48.8	31.4 -32.8	19.6 -21.1	6.0-6.4	0.16-0.56	8.0-9.3	57-60
		(47.5)	(32.1)	(20.4)	(6.3)	(0.35)	(8.6)	(58.2)
Sun	Surface	27.4	43.4	29.2	6.4	0.52	11.8	62
	Sub-surface	26.1 -26.8	44.8 -46.3	27.6 -28.4	6.3-6.4	0.16-0.36	10.0-10.4	60
		(26.45)	(45.5)	(28.0)	(6.3)	(0.26)	(10.2)	(60)
Daramman	Surface	33.0	43.2	23.8	5.9	0.26-0.38	10.3	57
	Sub-surface	31.3 -32.4	41.8 -42.3	25.8-26.4	6.0-6.2	0.28-0.74	10.0-11.1	58-59
		(31.0)	(42.0)	(26.1)	(6.1)	(0.32)	(10.5)	(58.5)

*Mean of sub-surface values

to 358 kg/ha, 14 to 110 ppm, 4.2 to 42 ppm, 0.3 to 2.1 ppm and 0.2 to 1.2 ppm, respectively (Table 4). As for the nutrient status in Mandh watershed is concerned, it was noted to be low to high, low to medium and medium to high for available N, P and K, respectively. Except Patti series, all the soil series were found to be low in available P (Table 4 & 5). Taking 4.5 ppm Fe, 1 ppm Mn, 0.6 ppm Zn and 0.2 ppm Cu as soil critical limits (Sharma *et al.* 2007) all the soil series were rated as sufficient in Fe, Mn and Cu. Zn deficiency however was noticed in three soil series viz, Kotlu, Daramman and Sun to the extent of 20, 50 and 75 per cent, respectively. The variation in nutrient contents and

Table 4. Content and status of available primary nutrients in different soil series

Soil Series	Soil samples (No.)	Primary nutrient contents (kg ha^{-1})			Soil Nutrient Index (SNI)		
		N	P	K	N	P	K
Patti	10	460-840	9.4-24.6	220-314	2.80 (H)	1.90 (M)	2.30 (M)
Majhenu	5	364-610	6.8-17.5	210-358	2.40 (H)	1.60 (L)	2.60 (H)
Tikkar	5	364-610	6.8-17.5	210-358	2.40 (H)	1.60 (L)	2.60 (H)
Kotlu	7	310-560	6.8-19.6	156-310	2.00 (M)	1.40 (L)	2.30 (M)
Sun	6	188-270	3.4-6.2	110-240	1.00 (L)	1.00 (L)	1.83 (M)
Daramman	4	260-360	5.2-18.6	110-310	1.75 (M)	1.50 (L)	2.50 (H)
Mandh watershed	37	188-840	3.4-21.2	110-358	2.05 (M)	1.49 (L)	2.24 (M)

Parentheses indicate nutrient status
L = Low, M = Medium, H = High

Table 5. Content and status of DTPA extractable micronutrient cations in different soil series

Series	Land use	Micronutrient cations (ppm)				% samples deficient in			
		Fe	Mn	Zn	Cu	Fe	Mn	Zn	Cu
Patti	Tea	60-110	11-31	0.9-2.1	0.9-1.2	-	-	-	-
	Paddy-wheat	64-90	17-42	0.9-1.6	0.3-0.7	-	-	-	-
Majhenu	Tea	21-28	11-15	0.6-0.7	0.3-0.5	-	-	-	-
	Paddy-wheat	28-64	13-19	0.9-1.8	0.6-1.0	-	-	-	-
Tikkar	Tea	17-35	14-18	0.6-0.7	0.4-0.4	-	-	-	-
	Paddy-wheat	28-44	7-11	0.8-1.1	0.6-0.9	-	-	-	-
Kotlu	Paddy-wheat	15-45	4.2-24.2	0.4-1.8	0.2-1.2	-	-	20	-
Sun	Maize-wheat	15-29	6.4-11.4	0.4-0.6	0.3-0.5	-	-	75	-
	Paddy-wheat	14-18	7.3-10.4	0.4-1.8	0.2-0.5	-	-	50	-
Daramman	Maize-wheat	22-31	10.4-24.0	0.5-0.8	0.4-0.9	-	-	50	-
	Paddy-wheat	21-24	6.2-9.6	0.3-0.4	0.2-0.4	-	-	50	-
	Mandh watershed	14-110	4.2-42	0.3-2.1	0.2-1.2	-	-	19	-

status may be due to the spatial variation in pedogenic factors as well as nutrient management practices of the area. Majority of the farmers apply urea and FYM to crops that too at rates much lower than the recommended ones and no micronutrient fertilizer application is done. During study, an irregular trend of distribution of micronutrient cations with depth was noticed. Among Cu, Fe, Mn and Zn micronutrients, Zn deficiency was noticed in three soil series viz, Kotlu, Daramman and Sun to the extent of 20, 50, and 75 per cent, respectively. Therefore, to correct Zn deficiency in the study area application of Zn @ 25kg/ha is suggested.

Vertical distribution of available nutrients

Available N, P, Zn and Cu were higher in surface horizons as compared to subsurface ones (Table 6) In

Table 6. Vertical distribution of available primary nutrients and micronutrient cations in different soil series

Soil series	Horizon	Depth (cm)	Primary nutrients (kg ha^{-1})			Micronutrient cations (ppm)			
			N	P	K	Fe	Mn	Zn	Cu
Patti	Ap	0-14	780	24.6	298	64	21	1.8	0.9
	Bt_1	14-40	540	11.8	260	56	17	1.3	0.8
	Bt_2	40-84	220	5.6	308	88	30	1.2	0.8
	Bt_3	84-116	180	2.4	340	84	34	0.8	0.7
	Bt_4	116-160	150	1.8	329	70	32	1.0	0.6
Majhenu	Ap	0-15	496	16.8	264	56	14	1.1	0.8
	AB	15-36	240	9.4	252	52	10	0.9	0.6
	Bt_1	36-66	128	6.8	278	68	19	0.7	0.4
	Bt_2	66-110	110	4.4	310	61	19	0.8	0.4
	Bt_3	110-152	90	3.4	298	71	16	0.7	0.4
Tikkar	Ap	0-19	410	8.6	228	35	6.4	0.6	0.4
	Bw_1	19-42	168	5.1	210	30	5.4	0.4	0.3
	Bw_2	42-76	124	2.4	248	38	7.2	0.5	0.3
Kotlu	Ap	0-15	496	17.4	230	32	18	0.6	0.4
	BA	15-32	274	9.6	224	36	12	0.5	0.3
	Bw_1	32-48	210	4.4	260	32	27	0.3	0.3
	Bw_2	48-64	110	2.4	248	131	24	0.2	0.2
	Bw_3	64-110	110	2.4	248	38	21	0.3	0.2
	Bw_4	110- 154	90	1.2	224	26	19	0.1	0.2
Sun	Ap	0-18	270	7.2	244	24	19	0.5	0.6
	CA1	18-45	110	4.4	220	18	15	0.3	0.3
	CA2	45-71	60	1.6	234	21	19	0.3	0.4
Daramman	Ap	0-17	320	9.2	260	29	17	0.8	1.0
	Bw_1	17-40	136	5.4	290	24	17	0.6	0.7
	Bw_2	40-62	110	2.6	276	26	21	0.5	0.7

general, an irregular trend of vertical distribution was noted with available K, Fe and Mn which may be ascribed to prevailing plant nutrient recycling processes and nutrient additions through manures and fertilizers. The favourable environment for eluviation and illuviation of clay, cations, etc. may be responsible for more amounts of available K, Fe and Mn in most of the subsurface horizons. Kanwar (1979) did survey in Swan valley, Paonta valley, Nurpur valley, Palam valley, Balh valley, Jahu area, Janjheli area and Kullu valley area and reported more amounts of available K, Fe and Mn in most of the subsurface horizons in different valleys. Similar results were reported by Sharma and Anil Kumar (2003) during the study of Maul khad catchment in wet temperate zone of Himachal Pradesh.

From the results obtained in the present investigation, it may be inferred that there is a need to apply manures and fertilizers on soil test basis to enhance soil productivity in Mandh watershed. Fertilizer schedule should be based on whole crop sequence instead of single crop. Even for general fertilizer recommendation, fertilizer dose of a particular nutrient must be increased/decreased by 25 per cent in soil series rating low and high in that nutrient, respectively. In areas where zinc deficiency is prominent, there is a need to apply zinc sulphate @ 25 kg/ha to soil before sowing of crops.

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