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Nutrient Status of Different Landuse Systems and Water Quality Traits for Irrigation Purpose in Mid Hills of Western Himalayas

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ABSTRACT

The study was conducted during 2009-2010 in Sirmaur district of Himachal Pradesh. Seven landuse systems viz. S1: Agriculture, S2: Horticulture, S3: Agrihorticulture, S4: Agrisilviculture, S5: Agrisilvihorticulture, S6: Pasture and S7: Silvipasture were identified and soil chemical analysis determined. Water quality traits for irrigation purpose were analyzed. The pH of soil was in the acidic to neutral range whereas EC was in suitable range for the growth of all types of crops. Organic carbon of soil was in medium to high range. The available N and K were in range of medium to high and medium to high, respectively. Groundwater was generally neutral to alkaline in nature. Water quality traits for irrigation purpose viz., pH, EC, Cl^-, Na^+, Ca^{++}, Mg^{++}, CO_3^{--}, and HCO_3^- were well within the desirable limits.

Key words:
Agroforestry; landuse system; soil nutrient; water quality

INTRODUCTION

The Himalayan region is characterized by small and fragmented land holdings, rain-fed subsistence agriculture, low input-low output production system, sparse population, undulating terrain, poor means of transport and communication, poor productivity of crop and livestock, fragile eco-system, low risk bearing capacity of farmers yet rich in plant and animal diversity (Chander and Mukherjee 1995; Singh 2006). Land is the major non-renewable resource and faces the biggest threat of degradation. Faulty land use system in the steep Himalayan slope has resulted into severe soil erosion (Nair 1985). Soils vary according to aspect, slope, and climatic conditions. They are very vulnerable to sheet and gully erosion. It is estimated that of the cultivated area of 7.6 lakh ha, nearly 43 per cent are prone to very high intensity of erosion (GoHP 2009). In Asia, adverse effects on soil health and soil quality arise from nutrient imbalance in soil, excessive fertilization, soil pollution and soil loss processes (Zhang et al. 1996; Hedlund et al. 2003).

There are almost unlimited numbers of agroforestry systems in use all over the world. Singh et al. (1990) has recognized three subtypes of systems in the hill region: forest-based systems; agriculture-based systems; and horticulture-based systems. The land use systems are in the process of transformation due to the rapid changes in the socioeconomic status of farmers, industrialization and climate change as well as government policies. Leakey (2001) contended that agroforestry is now increasingly being seen as an alternative paradigm for rural development.

Water is finite in quantity, tangible in nature, and unequally distributed throughout the

world. Only 2.5% of 1386 million cubic kilolitres of water available on earth is freshwater and only one-third of this smaller quantity is available for human use (Postel, 1996). Total water drawn globally for human use has almost tripled in the last 50 years and is projected to increase even further by 2025 (Clarke and King 2004). Keeping above in view, the basic objective of this study is (i) to determine pH, EC, OC and available N, P, K in different landuse system. (ii) pH, EC, Cl^-, Na^+, Ca^{++}, Mg^{++}, CO_3^{--}, and HCO_3^- of water for irrigation purpose.

MATERIALS AND METHODS

The investigation was conducted during 2009-2010 in Sirmaur district of Himachal Pradesh. The district lies in the Shivalik hills between 30° 22' 30" and 31° 01' 20" North Longitude and between 77° 01' 12" and 77° 49' 40" East Longitude spread over an area of 2825 km^2. The elevation of hills varies from 900 m to 3650 m. A greater portion of Sirmaur is drained by Giri River. The mean annual temperature of the district ranges between 3.5° C to 38° C and the average annual rainfall is 104 cm, a major part of which is received during monsoons.

In Rajgarh subdivision of Sirmaur district two development blocks viz., Rajgarh and Pachhad were selected. Three village panchayats were chosen in each development block In each village seven landuse systems viz. S1: Agriculture (A), S2: Horticulture (H), S3: Agrihorticulture (AH), S4: Agrisilviculture (AS), S5: Agrisilvihorticulture (ASH), S6: Pasture (P) and S7: Silvipasture (SP) were identified.

Soil samples from soil layer 0 – 15 cm and 15 – 30 cm were collected separately replicated three times from different agro forestry systems of six village panchayt and analysed soil chemical properties. The pH and EC (Jackson, 1973), per cent OC (Walkley and Black, 1934), available N (Subbiah and Asija 1956) and available K (Merwin and Peach, 1951) were estimated from soil samples.

Water samples were collected for all the six village panchayats. Water quality traits for irrigation purpose viz., pH, EC (dSm^{-1}), Cl^- (mg/L), Na^+ (mg/L), Ca^{++} (mg/L), Mg^{++} (mg/L), CO_3^{--} (mg/L), and HCO_3^- (mg/L) were analyzed using APHA (2005).

The data obtained were subjected to statistical analysis by the Randomized Block Design of the experiment as per the procedure suggested by Gomez and Gomez (1984). Wherever, the experimental effects exhibited significance at 5 per cent level of probability, the critical difference (CD) was calculated.

RESULTS AND DISCUSSION

Soil pH and EC

The pH of soil appraised at 0-15cm and 15-30cm soil layers in all six village panchayats under different landuse systems were acidic in reaction, except in S1 at 0-15 cm soil layer in Karganoo where pH was 7.02. In general in 0-15cm soil layer pH ranged from 6.05 of Sarahan in S7 to 7.02 of Karganoo in S1 whereas in 15-30 cm soil layer it ranged from 5.85 of Habban in S2 to 6.90 of Karganoo in S1, i.e. acidic to neutral. The acidic nature of the soils could be due to the organic acids liberated from the decomposition of the higher organic matter. The results are in line with Bishnoi et al. (1983) who reported that soil reaction vary between 5.0 to 6.8 under different locations in Himachal Pradesh and showed irregular pattern of pH depth wise. Negi (2009) reported that soil pH vary between 6.02-6.66 in peach orchards of Sirmaur. Electrical conductivity (dS m^{-1}) of the soils irrespective of soil layers in all the six panchayats showed low level of soluble salts concentration. The difference in electrical conductivity among different landuse systems at 0-15cm soil layer in Habban and at 15-30 cm soil layer in Habban and Narag was non-significant. The EC in 0-15 cm soil layer varied from 0.17 dS m^{-1} (Karganoo) in S7 to 0.43 dS m^{-1} (Kothiajajar) in S5 and in 15-30 cm soil layer 0.14 dS m^{-1} (Karganoo) in S4 to 0.36 dS m^{-1} (Kothiajajar) in S5. Awasthi *et al.* (1992) also observed EC values ranging from 0.18 to 0.39 dS m^{-1} in peach orchard soils of district Sirmaur. Similar trend was obtained by Negi (2009); Kumar (1994); Badyal (1980) in different orchards of Sirmaur. EC of different location varied because of variation of salt concentration (Table 1).

Soil Organic Carbon

Organic carbon decreased with the increase in soil depth (Table 2). Higher amount of soil organic carbon on the surface layer may be due to

continuous accumulation of leaf litter on the surface, which keeps on decomposing and thus enriches the surface layer continuously (Joao Carlos et al. 2001; Nair and Chamuah 1988; Minhas et al. 1997). In surface (0-15 cm) layer soil organic carbon ranged from 0.83 % (Katli) in S6 to 1.20 % (Habban) in S7, whereas in subsurface (15-30 cm) layer it ranged from 0.63 % (Katli) in S6 to 0.99 % (Habban) in S7, which indicated medium to high O.C. status of soils. The findings are in line with Kumar (1994) who reported 0.76-1.37 per cent OC in Sirmaur district and Negi (2009) who reported 0.39-1.17 per cent soil organic carbon in Peach orchards of Sirmaur district. In different landuse systems of six village panchayats OC followed decreasing order: SP > AH > H > ASH > AS > A > P in surface and subsurface soil layers. This may have happened because of enhanced accumulation of leaf litter in the tree and fruit based land use systems. The abundant leaf litter or pruned biomass returns to soil, combined with decay of roots contribute to the improvement of organic matter under complex land use systems (Beer et al. 1990; Lehmann et al., 1998; Rao et al. 1998; Kumar et al. 2001; Koul and Panwar 2012). Low amounts of per cent soil organic carbon under the agriculture and pasture land use system can be ascribed to intensive cropping (Lal et al. 1998).

Available N and K

Data given in Table 3 showed that surface soil layer contained higher amount of available nitrogen, phosphorus and potassium compared to subsurface soil layer. The findings were significant for different land use systems. Available nitrogen content in 0-15 cm soil layer varied from 326.14 kg ha^{-1} (Katli) in S6 to 583.30 kg ha^{-1} (Karganoo) in S2, while in 15-30 cm soil layer it ranged from 301.07 kg ha^{-1} (Katli) in S6 to 554.03 kg ha^{-1} (Karganoo) in S2. In all the six panchayats available nitrogen content followed order: H > A > AH > AS > ASH > SP > P except of Narag and Sarahan, having order: A > AS > AH > ASH > H > SP > P and A > AS > H > SP > P, respectively. Available potassium in surface (0-15 cm) layer varied from 151.20 kg ha^{-1} (Katli) in S6 to 500.27 kg ha^{-1} (Karganoo) in S3. In subsurface (15-30 cm) layer it varied from 139.63 kg ha^{-1} (Katli) in S6 440.53 kg ha^{-1} (Karganoo) in S3. Available potassium content was maximum either in H or AH system followed by A and least in P system.

The available N and K were in range of medium to high, high and medium to high, respectively. Higher concentration of N and K in horticulture and agriculture landuse system was may be due to excessive use of inorganic fertilizers. High available N and K status in Karganoo, Kothiajajar and Habban indicated high use of NPK fertilizers in these panchayats as compare to Katli, Narag and Sarahan panchayats. Raina and Kumar (2000) also found medium to high available K content in forest nursery soils of district Sirmaur. Attar (2006) reported available nitrogen in different locations of Himachal Pradesh ranged from 213 to 460.49 kg ha^{-1}.

Water Parameters

Water quality traits for irrigation purpose viz., pH, EC, Cl^-, Na^+, Ca^{++}, Mg^{++}, CO_3^{--}, and HCO_3^- for six village panchayats were presented in Table 4. pH of water is an indicator of its quality and geochemical equilibrium for solubility calculation (Hem,1985). The pH value in the study area lies in the range 7.65 in Sarahan to 8.02 in Karganoo indicating neutral to alkaline nature of ground water. Normal range of pH in the irrigation water is 6.5 to 8.4 (Ayers and Westcot 1985). All the values of pH of water from study area were within the limits prescribed by BIS (1991) i.e. 6.5-8.5. Singh et al. (2008) recorded 7.4 pH in surface water of Renuka Lake in Sirmaur district. Electrical conductivity of water is considered to be an indication of the total dissolved salt content (Hem, 1985). EC is a good measure of salinity hazard to crops. The electrical conductivity of irrigation water varied from 0.41 dS m^{-1} in Narag to 0.96 dS m^{-1} in Karganoo. All the values of EC of water samples from six panchayats were within the limits prescribed by BIS (1991).

Chloride content of irrigation water ranged between 13.64 mg L^{-1} in Kothiajajar to 22.76 mg L^{-1} in Sarahan. All the values shows that chloride content in all six panchayats were within the permissible limit of 250 mg L^{-1} (BIS, 1991). High chloride concentrations indicated organic pollution (Batheja et al. 2007). The sodium concentration of

Table 1: Soil pH and electrical conductivity (dS m^{-1}) of six village panchayats studied at 0-15 and 15-30 cm soil layers of different landuse systems

Landuse System	Soil pH											
	Karganoo		Kothiajajar		Habban		Katli		Narag		Sarahan	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
S1 (A)	7.02	6.90	6.94	6.82	6.68	6.54	6.82	6.70	6.38	6.49	6.27	6.24
S2 (H)	6.94	6.81	6.72	6.79	6.10	5.85	6.85	6.68	6.93	6.63	6.16	6.10
S3 (AH)	6.65	6.60	6.92	6.83	6.89	6.77	0.00	0.00	6.39	6.63	0.00	0.00
S4 (AS)	6.48	6.44	6.86	6.74	6.91	6.68	6.60	6.49	6.64	6.63	6.61	6.10
S5 (ASH)	6.58	6.82	6.94	6.86	6.96	6.80	0.00	0.00	6.71	6.73	0.00	0.00
S6 (P)	6.76	6.70	6.87	6.83	6.35	6.49	6.13	6.08	6.92	6.58	6.44	6.19
S7 (SP)	6.88	6.76	6.72	6.42	6.52	6.42	6.80	6.67	6.67	6.65	6.05	5.91
SE	0.11	0.13	0.09	0.14	0.23	0.22	0.14	0.16	0.12	0.23	0.14	0.18
$CD_{0.05}$	0.23	0.28	NS	NS	0.49	0.48	0.30	0.35	0.26	NS	0.31	0.40
	Soil Electrical conductivity (dS m^{-1})											
S1 (A)	0.25	0.23	0.25	0.21	0.24	0.21	0.25	0.23	0.26	0.27	0.26	0.21
S2 (H)	0.23	0.19	0.38	0.31	0.28	0.25	0.30	0.29	0.26	0.27	0.28	0.23
S3 (AH)	0.26	0.22	0.42	0.31	0.23	0.21	0.00	0.00	0.23	0.27	0.00	0.00
S4 (AS)	0.18	0.14	0.36	0.33	0.26	0.22	0.30	0.27	0.26	0.17	0.24	0.21
S5 (ASH)	0.19	0.21	0.43	0.36	0.23	0.21	0.00	0.00	0.23	0.25	0.00	0.00
S6 (P)	0.18	0.17	0.18	0.16	0.25	0.22	0.22	0.19	0.35	0.32	0.22	0.17
S7 (SP)	0.17	0.15	0.21	0.18	0.23	0.20	0.21	0.17	0.22	0.21	0.21	0.18
SE	0.016	0.019	0.028	0.017	0.026	0.033	0.018	0.019	0.019	0.058	0.020	0.018
$CD_{0.05}$	0.034	0.042	0.060	0.038	NS	NS	0.040	0.042	0.043	NS	0.043	0.040

Table 2: Effect of landuse on Soil pH, organic carbon (%) of six village panchayats studied at 0-15 and 15-30 cm soil layers

Landuse System	**Soil Organic Carbon (%)**											
	Karganoo		**Kothiajajar**		**Habban**		**Katli**		**Narag**		**Sarahan**	
	0-15 cm	**15-30 cm**	**0-15 cm**	**15-30 cm**	**0-15 cm**	**15-30 cm**	**0-15 cm**	**15-30 cm**	**0-15 cm**	**15-30 cm**	**0-15 cm**	**15-30 cm**
S1 (A)	0.92	0.72	0.93	0.75	0.95	0.78	0.89	0.67	0.92	0.72	0.93	0.75
S2 (H)	1.10	0.89	1.11	0.91	1.15	0.94	1.08	0.89	1.05	0.90	1.07	0.93
S3 (AH)	1.12	0.92	1.14	0.93	1.17	0.96	-	-	1.07	0.96	-	-
S4 (AS)	1.06	0.85	1.08	0.87	1.10	0.90	0.93	0.72	0.97	0.75	1.05	0.95
S5 (ASH)	1.07	0.87	1.08	0.90	1.12	0.92	-	-	0.96	0.73	-	-
S6 (P)	0.89	0.68	0.90	0.71	0.95	0.76	0.83	0.63	0.85	0.66	0.89	0.69
S7 (SP)	1.14	0.95	1.17	0.95	1.20	0.99	1.10	0.92	1.11	0.94	1.13	0.96
SE	**0.04**	**0.07**	**0.05**	**0.03**	**0.05**	**0.06**	**0.03**	**0.08**	**0.14**	**0.04**	**0.10**	**0.07**
$CD_{0.05}$	**0.09**	**0.16**	**0.11**	**0.07**	**0.11**	**0.14**	**0.06**	**0.17**	**NS**	**0.10**	**0.22**	**0.16**

groundwater varied from 7.08 mg L^{-1} in Habban to 25.30 mg L^{-1} in Karganoo. All the values were well below the permissible limit of 200 mg L^{-1} (BIS, 1991). Calcium concentration of irrigation water lies in the range of 48.95 mg L^{-1} in Habban to 64.3 mg L^{-1} in Karganoo. The calcium hardness observed in all the 6 village panchayats were within the desirable limit i.e. 75 mg L^{-1} (BIS 1991). Singh et al. (2008) observed 51 mg L^{-1}calcium concentration in surface water of Renuka Lake in district Sirmaur. Magnesium concentration of irrigation water in the study area ranged from 9.53 mg L^{-1} in Sarahan to

Table 3: Effect of land use on available N and K (kg ha^{-1}) content of soils of six village panchayats studied at 0-15 and 15-30 cm soil layers

Landuse system	Village Panchayat (Available N (Kg ha^{-1})											
	Karganoo		Kothiajajar		Habban		Katli		Narag		Sarahan	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
S1 (A)	577.02	535.21	556.12	520.57	543.58	514.30	470.40	445.31	487.12	459.95	476.67	451.77
S2 (H)	583.30	554.03	579.11	545.66	570.74	533.12	485.04	455.77	401.31	364.18	401.41	374.23
S3 (AH)	574.48	530.13	545.66	526.85	541.48	524.76	-	-	453.68	422.31	-	-
S4 (AS)	560.74	513.48	518.48	487.13	533.12	515.64	449.49	422.31	462.04	411.86	453.68	424.40
S5 (ASH)	480.94	451.58	505.94	476.67	470.23	450.25	-	-	449.49	413.95	-	-
S6 (P)	345.76	320.57	342.87	317.78	344.96	332.42	326.14	301.07	350.13	332.41	328.29	310.85
S7 (SP)	370.05	354.13	367.88	332.35	363.78	344.96	359.60	342.87	368.45	342.87	363.98	345.72
SE	**13.51**	**13.83**	**9.98**	**7.64**	**9.24**	**10.38**	**7.18**	**8.68**	**14.18**	**8.97**	**9.29**	**9.97**
$CD_{0.05}$	**29.43**	**30.13**	**1.75**	**6.64**	**0.13**	**2.61**	**5.65**	**8.92**	**0.89**	**9.54**	**0.24**	**1.72**
Available K (Kg ha)												
S1 (A)	489.07	421.87	412.91	362.88	302.40	246.40	218.40	178.83	317.33	264.69	253.87	172.85
S2 (H)	492.80	414.40	421.12	366.24	321.40	247.89	310.00	250.13	322.19	283.73	220.64	178.45
S3 (AH)	500.27	440.53	418.88	362.88	321.07	271.41	-	-	285.60	224.37	-	-
S4 (AS)	436.80	350.93	351.31	326.29	229.60	192.64	207.20	173.60	246.40	213.17	245.65	173.97
S5 (ASH)	451.73	373.33	394.61	350.56	294.93	238.93	-	-	257.60	183.68	-	-
S6 (P)	194.13	173.60	163.89	150.83	162.40	150.45	151.20	139.63	194.13	172.85	168.37	155.68
S7 (SP)	259.47	217.65	177.33	155.68	164.64	151.95	166.13	144.48	212.80	188.16	207.20	178.08
SE	26.17	21.06	20.49	18.60	19.69	19.61	8.73	11.36	23.69	14.45	15.19	10.17
$CD_{0.05}$	57.01	45.06	4.64	0.52	2.90	2.72	9.02	4.74	1.61	1.49	3.10	2.16

Table 4: Status of irrigation water quality parameters viz. pH, EC, Cl, Na, Ca, Mg, CO_3 and HCO_3 in six village panchayats

Study site	pH	EC (dSm^{-1})	Cl ($mg\ L^{-1}$)	Na ($mg\ L^{-1}$)	Ca ($mg\ L^{-1}$)	Mg ($mg\ L^{-1}$)	CO_3 ($mg\ L^{-1}$)	HCO_3 ($mg\ L^{-1}$)
Karganoo	8.02	0.96	21.52	25.30	64.3	19.20	36.00	77.78
Kothiajajar	7.97	0.48	13.64	15.28	55.3	15.71	54.00	82.35
Habban	7.96	0.50	21.80	7.08	48.95	13.30	30.50	71.68
Katli	7.89	0.90	16.14	22.08	61.6	14.13	36.50	83.88
Narag	7.93	0.41	17.12	10.50	54.8	10.73	31.00	61.00
Sarahan	7.65	0.55	22.76	19.22	57.1	9.53	54.00	86.93
SE	0.09	0.07	1.24	0.89	1.20	0.70	3.64	6.30
$CD_{0.05}$	0.19	0.15	2.65	1.91	2.55	1.48	7.76	13.43

groundwater varied from 7.08 mg L^{-1} in Habban to 25.30 mg L^{-1} in Karganoo. All the values were well below the permissible limit of 200 mg L^{-1} (BIS, 1991). Calcium concentration of irrigation water lies in the range of 48.95 mg L^{-1} in Habban to 64.3 mg L^{-1} in Karganoo. The calcium hardness observed in all the 6 village panchayats were within the desirable limit i.e. 75 mg L^{-1} (BIS 1991). Singh et al. (2008) observed 51 mg L^{-1}calcium concentration in surface water of Renuka Lake in district Sirmaur. Magnesium concentration of irrigation water in the study area ranged from 9.53 mg L^{-1} in Sarahan to 19.20 mg L^{-1} in Karganoo. All the values of magnesium concentration of irrigation water in all the 6 village panchayats were within the limit of 30 mg L^{-1} prescribed by BIS (1991).

Carbonate and Bicarbonate concentration of irrigation water varied from 31.00 mg L^{-1} in Narag to 54.00 mg L^{-1} in Kothiajajar and Sarahan and 61.00 mg L^{-1} in Narag to 86.93 in Sarahan mg L^{-1}, respectively. Alkalinity increases as the amount of dissolved carbonates and bicarbonates increase (Flood, 1996; Radha Krishnan et al. 2007). All the values were well below the permissible limit of 200 mg L^{-1} (BIS 1991).

CONCLUSIONS

The pH of soil was in the acidic to neutral range. On the other hand, EC test proved the suitability of the soils for all kinds of agricultural crops. Organic carbon indicated medium to high OC status of soils. The available N and K were in range of medium to high, high and medium to high, respectively. Groundwater in the Sirmaur district was generally neutral to alkaline in nature. Water quality traits for irrigation purpose viz., pH, EC, Cl^{-}, Na^{+}, Ca^{++}, Mg^{++}, CO_3^{--}, and HCO_3^{-} were well within the desirable limits.

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