Nutritional status of orchard soils in selected apple growing areas of Shimla district of Himachal Pradesh

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ABSTRACT

Investigations were carried out to assess the nutritional status of orchard soils in selected pockets of apple growing belts of district Shimla, Himachal Pradesh encompassing 5 Tehsils. Total 164 soil samples were collected and analysed for soil macronutrient parameters. Correlation study was carried out to assess the degree of correlation among various soil chemical properties and soil fertility index was worked out to assess fertility level of orchard soils. The soil pH ranged from strongly acidic (4.74) to neutral (7.22); soil salinity was found to be in safer limits (<0.974 dS/m); organic carbon varied from very low (0.15%) to very high (2.80%). Soil available N content varied from low (150 kg/ha) to high (815 kg/ha), P content varied from very low (4.7 kg/ha) to very high (1,086.4 kg/ha) and K content ranged from very low (32 kg/ha) to very high (5,174 kg/ha). In total, 33.5, 3.0 and 4.9 per cent samples were reported deficient in available N, P and K status respectively. The soil nutrient index for N, P and K came out to be 1.68, 2.82 and 2.63 respectively which suggested medium nitrogen and high phosphorus and potassium availability. The correlation study showed soil pH to have significant effect on P and K availability; EC had positive correlation with SOC and available nutrient contents while organic carbon content was significantly correlated to available NPK content.

Keywords: Nutrient status; soil fertility index; orchard soils; correlation

INTRODUCTION

Apple has been the major cash crop for the farmers of hilly states like Himachal Pradesh, Uttarakhand and Jammu and Kashmir for many decades. Now farmers are shifting from traditional plantation system to high density orchards which is an intensive cropping management system. The farmers are more often adding fertilizers and other chemical inputs without proper nutritional, pest or disease diagnosis. This injudicious addition of chemical inputs in soil leads to soil health problems, destroy soil physical properties and chemical constitution which affects soil fertility and ultimately productivity in a long run. Soil test-based fertility management is an effective tool for increasing productivity of agricultural soils that have high degree of spatial variability resulting from the combined effects of physical, chemical or biological processes. Long term sustainability of hill agriculture system must rely, as much as possible, on balanced use of fertilizers and effective management of resource inputs (Annepu et al 2017). The present study was carried out in order to work out the nutritional status of apple orchards in Shimla district of Himachal Pradesh and establish a correlation aspect among chemical and nutritional parameters of orchard soils.

MATERIAL and METHODS

The present study was conducted in orchard soils of farmers from 5 Tehsils of district Shimla covering 164 orchards. One representative soil sample was made by collecting soil from 10 points within a field of approximately 2–3 bighas and mixed properly. Quartering was done to obtain 0.5 to 1 kg soil sample for lab testing with proper tags and labels. Samples were air-dried, sieved with standard 2 mm sieve and stored in moisture proof containers for further analysis.

The soil pH and EC were analysed in soil and water suspension in the ratio of 1:2 with the help of microprocessor-based digital pH and EC meter calibrated with 3-point buffer and calibration standards. The soil organic carbon was estimated by wet digestion method (Walkley and Black 1934) and available nitrogen content by alkaline potassium permanganate method as suggested by Subbiah and Asija (1956). Available phosphorus was estimated by Olsen's method by using 0.5 M $NaHCO_3$ as soil extractant (Olsen et al 1954) and determined calorimetrically by stannous chloride reduced ammonium molybdate method in visible spectrophotometer. Estimation of available potassium was done on microprocessor-based flame photometer by using neutral normal ammonium acetate as an extractant (Merwin and Peech 1951). The nutrient index value of orchard soils was worked out using formula as suggested by Parker et al (1951) as given below:

$$\text{Nutrient index} = \frac{(Nl \times 1) + (Nm \times 2) + (Nh \times 3)}{Nt}$$

where Nl= Number of samples falling in low category of nutrient status, Nm= Number of samples falling in medium category of nutrient status, Nh= Number of samples falling in high category of nutrient status, Nt= Total number of samples analysed

Separate indices were calculated for different nutrients like N, P and K. The soils were rated as per nutrient index values as low (<1.67), medium (1.67–2.33) and high (>2.33).

RESULTS and DISCUSSION

Soil pH, EC and SOC: The pH of the orchard soils ranged from 4.74 to 7.22 with overall mean of 5.85. The minimum average pH of 5.74 was recorded in soils of Jubbal orchards while the maximum of 6.33 was recorded from soils of Kotkhai orchards. Some of the Rohru and Chirgaon orchards were reported to have pH less than 5.00 falling in strongly acidic range while few orchards from Jubbal and Kotkhai were observed to have pH in the range of 5.14 to 5.50 being classified as soils with highly acidic character (Table 1). These two types of soils on the basis of pH need reclamation in terms of pH improvement by adding lime to their orchard soils in order to enhance nutrient availability. Total 25.6 per cent of the studied soils fell under pH category of less than 5.50 (highly acidic), 37.8 per cent under moderately acidic range (5.50–6.00), 23.8 per cent under slightly acidic range (6.00–6.50) and only 12.8 per cent samples under neutral pH range (6.50–7.30). No samples were found to have pH greater than 7.30 (Table 3). Majority soils of Shimla district orchards were recorded to have moderately acidic to highly acidic pH. Low temperature associated with higher rainfall resulting in leaching out of basic cations could have resulted in lower pH in hilly soils of these orchards (Logan and Floate 1985).

Electrical conductivity is the measure of soil salinity. In general, the soils having EC less than 2.00 are considered safe for apple cultivation. None of the soil samples from studied orchards were reported to have EC greater than 1.00 which is considered as non-saline category of EC as illustrated in Table 3. The EC of orchard soils varied from 0.030 to 0.974 dS/m with overall mean of 0.190 dS/m. The minimum average EC (0.160 dS/m) was observed in soils of Tikker orchards while the maximum average EC (0.270 dS/m) was recorded in soils of Jubbal orchards. Lower EC values may be ascribed to the leaching and wash out of salts due to heavy rains associated with undulating topography of these orchards (Annepu et al 2017).

Organic carbon content of the soils ranged from 0.15 to 2.80 per cent with overall average content of 1.02 per cent. The soils of Rohru recorded the lowest average OC content (0.89%) while the highest (1.46 %) was recorded in both Kotkhai and Tikker orchards (Table 1). Out of total 164 soil samples, 17.1 per cent samples fell in low category (<0.50%), 37.2 per cent samples in medium category (0.50–1.00%), 39.6 per cent in high (1.00–2.00%) category of EC, whereas, 6.1 per cent samples had OC greater than 2.00 (Table 3). The prevailing low temperature conditions of these orchards might have resulted in suppression of microbial and enzymatic activities leading to accumulation of organic residues from FYM addition in soils and least SOM decomposition and thus higher levels of SOC can be seen in surface layers of orchard soils (Bhattacharyya et al 2008, Annepu et al 2017).

Available NPK: The available nitrogen content in orchard soils varied from 150 to 815 kg/ha with average content of 319 kg/ha. Minimum average N content (299 kg/ha) was reported in soils of Rohru orchards while the maximum (372 kg/ha) was observed in soils of Tikker orchards (Table 1). Out of total soil samples

Table 1. Nutritional status of orchard soils in Shimla district, Himachal Pradesh

Tehsil	Number of samples	pH			EC (dS/m)			OC (%)			N (kg/ha)			P (kg/ha)			K (kg/ha)		
		Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
Rohru	87	5.85	4.74	7.02	0.170	0.034	0.905	0.89	0.15	2.70	299	150	470	163.1	6.7	756.0	784	32	3,164
Chirgaon	41	5.75	4.87	6.75	0.200	0.030	0.804	1.10	0.285	2.79	356	182	815	154.4	4.7	1,086.4	828	108	2,268
Jubbal	18	5.74	5.14	6.94	0.270	0.090	0.974	1.08	0.24	1.95	313	232	545	173.0	10.3	441.3	804	156	2,570
Kotkhai	12	6.33	5.40	7.22	0.180	0.078	0.681	1.46	0.27	2.37	317	201	646	142.5	18.8	285.6	1936	174	5,174
Tikker	6	5.79	5.59	6.20	0.160	0.057	0.209	1.46	0.915	2.80	372	345	420	301.1	201.6	445.8	841	293	1,263
Overall	164	5.85	4.74	7.22	0.190	0.030	0.974	1.02	0.15	2.80	319	150	815	165.5	4.7	1,086.4	884	32	5,174

	pH	EC	OC	N	P	K
SD	0.505	0.199	0.559	86.18	156.4	833.9
SE	0.039	0.016	0.044	6.73	12.2	65.11

analysed, 33.54 per cent samples were reported deficient in N availability, 64.63 per cent samples were in medium range and only 1.83 per cent samples were found to have high N content. The soil nutrient index for nitrogen was 1.68 which suggested that nitrogen in these soils was in medium range (Table 4). Since organic carbon content is an indicator of soil available nitrogen status, the soils should have sufficient N content as reported by Mondal et al (2015) and Singh and Rathore (2013). The present study also affirms positive correlation between available N and SOC (Table 2) but low N status specifies its rapid depletion from the surface soils which may be due to crop removal or losses in or out of the soil system (Annepu et al 2017).

The available phosphorus content in soils ranged from 4.7 to 1,086.4 kg/ha with average P content of 165.5 kg/ha. The minimum average P content (142.5 kg/ha) was recorded in soils of Kotkhai orchards while the maximum (301.1 kg/ha) in soils of Tikker orchards (Table 1). Out of total samples analysed, only 3.05 per cent samples were deficient in soil available P content, 12.19 per cent had medium P availability and rest of 84.76 per cent were high in soil P content. The soil nutrient index value for phosphorus came out to be 2.82 which denoted high P availability (Table 4). High P content in these soils may be ascribed to the high organic matter content present. At the same time farmers had been adding phosphatic fertilisers every year without proper soil test-based recommendations. The phosphatic fertilisers being less mobile in soil system keep on accumulating year after year of application and thus have high residual P content.

Potassium being a major primary nutrient plays significant role in plant nutrition. The available K content in orchard soils ranged from 32 to 5,174 kg/ha with mean of 884 kg/ha. The minimum average K content (784 kg/ha) was recorded in soils of Rohru orchards while the maximum (1,936 kg/ha) was recorded in soils of Kotkhai orchards (Table 1). Out of total samples tested, 4.88 per cent samples fell in K deficient range, 26.83 per cent under medium range and majority (68.29%) in high range. The SNI value for the potassium in these soils came out to be 2.63 that indicated the K availability to be in high range (Table 4). High available K content in these soils could be due to presence of clay minerals like illite and kaolinite in hilly soils that attributed to sufficient levels of potassium (Sharma et al 2001). Also farmers had been applying MoP indiscriminately as they were more

Table 2. Correlation matrix of chemical properties of orchard soils of Shimla district, Himachal Pradesh

Property	pH	EC	OC	N	P	K
pH	1.00					
EC	-0.218**	1.00				
OC	0.080NS	0.187*	1.00			
N	-0.048NS	0.218**	0.416**	1.00		
P	-0.308**	0.426**	0.215**	0.316**	1.00	
K	-0.163*	0.409**	0.447**	0.057NS	0.447**	1.00

*Significant at 5% LoS, **Significant at 1% LoS

Table 3. Soil chemical properties

Component	Level	Samples	
		Number	Percentage
pH	Highly acidic (<5.50)	42	25.6
	Moderately acidic (5.50-6.00)	62	37.8
	Slightly acidic (6.00-6.50)	39	23.8
	Neutral (6.50-7.30)	21	12.8
	Slightly alkaline (>7.30)	0	0.0
EC	Non-saline (<1.00)	164	100.0
	Slightly saline (1.00-2.00)	0	0.0
	Saline (>2.00)	0	0.0
SOC	Low (<0.50)	28	17.1
	Medium (0.50-1.00)	61	37.2
	High (1.00-2.00)	65	39.6
	Very high (>2.00)	10	6.1

Table 4. Soil nutrient index (SNI)

Nutrient	Level (kg/ha)	Samples		SNI	
		Number	Percentage	Value	Level
Nitrogen	Low (<280)	55	33.54	1.68	Medium
	Medium (280-560)	106	64.03		
	High (>560)	3	1.83		
Phosphorus	Low (<10.0)	5	3.05	2.82	High
	Medium (10.0.25.0)	20	12.19		
	High (>25.0)	139	84.76		
Potassium	Low (<137)	8	4.88	2.63	High
	Medium (137-337)	44	26.83		
	High (>337.0)	112	68.29		

concerned with fruit quality without having proper soil test-based fertiliser application.

Correlation studies: The study on correlation was performed at 1 and 5 per cent level of significance (Table 2). pH was found to be negatively correlated to EC (−0.218), available P (−0.308) at 1 per cent and K content (−0.163) at 5 per cent level. EC was positively correlated with soil organic carbon (0.187) at 5 per cent and available N (0.218), available P (0.426) and available K (0.409) at 1 per cent level. OC was positively correlated to available N (0.416), available P (0.215) and available K content (0.447) at 1 per cent level. Soil available N was positively correlated with available P content (0.316) at 1 per cent level and was non-significant in relation with available potassium. Soil P content was positively correlated with available K content (0.447) at 1 per cent level. The strong

correlation between SOC and available nutrients suggests that organic carbon in soil regulates the adequate supplies of these nutrients. Organic matter on decomposition releases these nutrients in a proportionate amount in the soil.

CONCLUSION

From the present study, it can be concluded that about 2/3rd of the orchard soils were moderate to strongly acidic which required liming for pH correction to an optimum range so that nutrient availability could be ensured. Currently, no soil salinity problem was reported. About one-fifth of the samples were still having low organic carbon. Majority of the samples (4/5th) fell under medium to high OC category. Nitrogen had medium availability while phosphorus and potassium had high availability as inferred from SNI values. Still, 33.5, 3.0 and 4.9 per cent orchard soil samples were found deficient in available N, P and K content respectively. Hence farmers are advised to make fertilizer application as per soil test-based recommendations. It will save fertilizer input cost and improve nutrient use efficiency and sustain soil health for long term.

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