Soil Health Indicators of Rhizospheric Soils of Apple (*Malus domestica* Borkh.) Variety Delicious in Himalayan Kashmir

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Rhizospheric soils are rich sources of nutrients, enzymes, proteins, beneficial microbes responsible for sustainable growth of the plants. They supply principal elements to the plant and also promote microbial activity in the soil and improve its structure, aeration, and water holding capacity, which in turn improve the soil capabilities to respond to inputs. This discourse deals with the evaluation of thirty composite soil samples collected from different apple orchards of Baramulla district of Kashmir valley and analyzed for soil characteristics (organic carbon content, total available N, P, K, S; EC, pH, total viable bacterial, fungal and actinomycetes count) which in turn were used as chemical and microbial indicators of rhizospheric soil health of apple orchards in Himalayan Kashmir. It was observed that the soil characteristics were significantly correlated.

Keywords: Composite soil sample, rhizosphere, organic carbon, available N, P, K, S.

Soil is a renewable natural resource and there is a hidden microbial world of incredibly diverse nature below its surface. The underground environment of a plant is as important for the plant health as the above ground part which contains harmonious friendly microorganisms to normalize the soil health and put pathogenic organisms to stress conditions, thus extend the life span of a soil (Dar, 2010). Interactions among the rhizobacteria, present in rhizospheric soils and the roots of plants have been studied intensively (Kurkcuoglu *et al*., 2007; Ambrosini *et al*., 2012; Souza *et al*., 2013). Rhizobacteria colonize plant roots where they multiply and occupy all the ecological niches found on the roots at all the stages of plant growth (Antoun and Prevost, 2006). Some of the rhizobacteria play a key role in the natural nutrient cycles. Some species of rhizobacteria are capable of N_2 fixation, some mobilizing phosphorus, potassium, and sulphur in accessible forms in the soils. There is a considerable population of P and K solubilizing bacteria in soil, particularly in rhizosphere (Sperberg, 1958). Silicate bacteria were found to dissolve potassium, silicon and aluminum from insoluble minerals (Aleksandrov *et al.*, 1967). The phosphorus and potassium are made available to plants when the minerals are slowly weathered or solubilized (Bertsch and Thomas, 1985). Bacteria, fungi and actinomycetes in the rhizospheric soils of apple trees may be taken as microbial indicators of their health status. Successful identification of

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an elite microbial strain capable of forming PGPS (Plant Growth Promoting Substances), solubilizing phosphorus, potassium, zinc and other essential minerals quickly in large quantity can conserve our existing resources and avoid environmental pollution hazards caused by heavy application of chemical fertilizers. The chemical indicators of soil health include its reaction (pH), salinity (EC) and the nutrient ion concentration. All the parameters have a significant bearing on physical and biological health of soil and hence on the plant growth.

Keeping in view the adverse effects of agro-chemicals on the soil health of apple orchards and their effect on growth and yield of apple crop, an attempt through the present study was made to assess the biological wealth status of the soils under apple in Kashmir valley.

Materials and Methods

The present investigation was carried out at the Regional Research Station and Faculty of Agriculture, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Wadura Campus. Thirty rhizosphere soil samples of apple trees (var. delicious) were collected from thirty representative orchards of ten selected villages of Baramulla district of Jammu & Kashmir. The collected samples brought in sterilized zip-locked polythene bags to the laboratory were analyzed after due processing. Organic carbon was determined by Walkley and Black's wet oxidation method (Jackson, 1967), available nitrogen by Kjeldhal method (Subbaiah and Asija,1956), available phosphorus by Olsen's method (Muhr *et al.*, 1965), available potassium by flame photometer method (Stanford and English, 1949) and available sulphur by Chesnin and Yein method (1951). The electrical conductivity was determined by EC Bridge (Jackson, 1967) and the pH of the soil was measured by using a digital pH meter (Jackson, 1967). Bacterial, fungal and actinomycetes populations were also calculated by plate count method using colony counter.

RESULTS AND DISCUSSION

Perusal of the data presented in Table 1 & Table 2 revealed that organic carbon (OC) in the rhizospheric soil samples of apple trees ranged between 1.54% and 1.93% with the mean value of

Table 1. Mean Characteristics of soil samples collected from district Baramulla

S. No.	Location	Organic carbon (%)	Available nitrogen (kg ha^{-1})	Available phosphorus (kgha^{-1})	Available potassium (kg ha^{-1})	Available sulphur (kg ha^{-1})	Electrical conductivity (dSm^{-1})	pH	Total viable bacteria (x 10^6/g)	Total viable fungi (x 10^4/g)	Total viable Actinomycetes (x 10^5/g)
1.	Pattan	1.83	443.27	19.15	188.81	25.98	0.23	6.3	82.26	57.38	29.80
2.	Delina	1.78	439.23	19.21	184.32	24.85	0.26	6.4	81.92	59.39	32.11
3.	Sangrama	1.80	455.12	18.44	186.34	27.31	0.31	6.4	81.87	57.76	29.91
4.	Patukha	1.83	443.53	18.80	188.73	26.19	0.39	6.3	82.20	57.34	29.87
5.	Dangerpora	1.82	448.85	18.00	188.45	26.88	0.34	6.3	82.00	59.50	32.15
6.	Bomai	1.83	440.50	19.06	188.62	25.03	0.35	6.3	77.16	57.23	29.90
7.	Janbazpora	1.83	449.75	19.10	188.77	26.97	0.39	6.3	83.81	60.27	32.4
8.	Hadipora	1.93	466.36	20.25	197.18	28.17	0.15	6.3	86.38	60.72	32.98
9.	Wadoora	1.86	444.59	19.18	190.58	26.48	0.21	6.3	84.42	60.23	32.46
10.	Watergam	1.54	425.65	17.45	175.66	23.11	0.21	6.6	77.62	54.71	29.58

1.80% and standard deviation of 0.10. Available nitrogen was 425.65 to 466.36 kg ha^{-1} with mean value of 445.68 kg ha^{-1} having standard deviation 10.67. Similarly available phosphorus ranged from 17.45 to 20.25 kg ha-$^{-1}$ with the mean of 18.86 kg ha^{-1} having the standard deviation of 0.76. The available potassium ranged from 175.66 to 197.18 kg ha-$^{-1}$ with mean value of 187.74 kg ha^{-1} with standard deviation of 5.38. The results are in conformation with the results found by Subash, and Tahir 2011. The upper limit for available sulphur was recorded as 28.17 kg ha^{-1} and the lower limit was 23.11 kg ha^{-1}. The mean available sulphur content in the soil samples collected from Baramulla district was recorded as 26.09 kg ha^{-1} having standard deviation of 1.45. The electric conductivity (EC) of the soil samples were from 0.15 to 0.39 dS m^{-1} with mean value of 0.28 dS m^{-1} and standard deviation 0.08. The pH recorded of the collected samples was slightly acidic narrowly ranged from 6.3 to 6.6. The viable bacterial population per gram ranged between 77.16 x 10^6 and 86.38 x 10^6 with the mean value of 81.96 x 10^6. The viable fungal population per gram of soil sample ranged between 60.72 x10^4 and 60.72x10^4 with the mean value of 58.45x10^4. The viable actinomycetes ranged between 32.98 x10^5 and 29.58 x10^5 with the mean value of 31.11 x10^5.The results are in conformation with the results shown by Wani *et al.* 2015.

With the increase in the pH the availability of organic carbon, available phosphorus, potassium and sulphur decreased significantly. At 95% to 99% confidence interval, Organic Carbon, available nitrogen, available phosphorus, available potassium and available sulphur showed positive significant correlation with each other except between available phosphorus and available sulphur (Table 3). These results are in conformity with the results of Sofi *et al.* 2012. The viable bacterial and fungal population in the rhizosphere of apple showed statistical positive significance with each other and with organic carbon, available nitrogen, phosphorus, potassium and sulphur.

Soil is a dynamic ecosystem that harbours many micro-organisms which are closely related to the plants. Microorganisms play their role in two ways one as pathogens causing diseases and the other as beneficial ones such as biological control agents and nutrient mobilizers and solubilizers. Numerous microorganisms, particularly those associated with roots, have the ability to increase plant growth and productivity (Chung *et al.*, 2005). However, certain groups of microorganisms can directly or indirectly transform rocks and minerals in quantities large enough to influence the geological distributions. These transformations include enzymatic oxidation-reduction reactions, formation of chelates and complexes with protein, amino-acids, organic acids *etc.* (Henderson and Duff, 1963).

Table 2. One-Sample Statistics of Baramulla District

	T	Mean	Standard Deviation	Standard Error Mean	95% Confidence Interval of the Difference	
					Lower	Upper
Organic Carbon	56.379	1.8050	0.10124	0.03202	1.7326	1.8774
Available Nitrogen	102.451	445.6850	10.67002	3.37416	338.0521	353.3179
Available Phosphorus	78.132	18.8640	0.76349	0.24144	18.3178	19.4102
Available Potassium	110.201	187.7460	5.38750	1.70368	183.8920	191.6000
Available Sulphur	56.905	26.0970	1.45023	0.45860	25.0596	27.1344
EC	10.731	0.2840	0.08369	0.02647	0.2241	0.3439
pH	206.626	6.3500	0.09718	0.03073	6.2805	6.4195
Viable Bacteria (x 10^6)	92.252	81.9640	2.80960	0.88847	79.9541	83.9739
Viable Fungi (x 10^4)	98.107	58.4530	1.88411	0.59581	57.1052	59.8008
Viable Actinomycetes (x 10^5)	70.437	31.1160	1.39696	0.44176	30.1167	32.1153

Table 3. Correlations of soil characteristics of Baramulla district

	Organic Carbon	Available Nitrogen	Available Phosphorus	Available Potassium	Available Sulphur	EC	pH	Bacteria	Fungi	Actinomycetes
Organic Carbon	1									
Available Nitrogen	0.808**	1								
Available Phosphorus	0.808**	0.642*	1							
Available Potassium	0.966**	0.851**	0.824**	1						
Available Sulphur	0.835**	0.958**	0.557	0.850**	1					
EC	0.075	-0.079	-0.272	-0.069	0.054	1				
pH	-0.932**	-0.612	-0.647*	-0.872**	-0.709*	-0.301	1			
Viable Bacteria	0.695*	0.765**	0.652*	0.732*	0.812**	-0.266	-0.536	1		
Viable Fungi	0.774**	0.715*	0.669*	0.752*	0.744*	-0.062	-0.667*	0.826**	1	
Viable Actinomycetes	0.509	0.527	0.512	0.540	0.523	-0.226	-0.394	0.732*	0.922**	1

**Correlation is significant at the 0.01 level, *Correlation is significant at the 0.05 level.

CONCLUSION

The following conclusion could be drawn from the present investigation. The distribution of microorganisms like bacteria and fungi in the rhizospheric soils of apple play a variety of roles in the growth and yield quality of apple by release of organic carbon; nitrogen ûxation; solubilization of phosphorus, potassium, sulphur; plant growth promotion; and alleviation of stress which are statistically significantly correlated with essential macronutrients available in the rhizosphere. So conserving the microbial activity in the soil is very important for release of essential nutrients in the rhizosphere for plant uptake and sustainable growth of the trees which are important indicators of soil health status.

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