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Soil Physico-Chemical and Microbial Status of Old Apple Orchards in Shimla and Sirmaur Districts, Himachal Pradesh

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Abstract: The apple orchards planted during the late sixties in Himachal Pradesh, India have shown symptoms of declining productivity as these plants have completed their economic life span. A survey was conducted to determine and compare the population density of bacterial, fungal, actinomycetes species and nutrient status in the rhizosphere of declining apple trees from different locations of Shimla and Sirmaur districts of Himachal Pradesh during 2015 and 2016. Based on the uniformity with respect to age and growth, ten declining apple orchards were selected in ten blocks (Rohru, Gumma, Jubbal, Kotkhai, Pulbahal, Kharapather, Malat, Kupvi, Habban and Bogdhar) in Shimla and Sirmaur districts. Rhizosphere soil samples were collected from declining apple orchards (*cv.* Royal Delicious) and analyzed for the physicochemical properties, biological activity and their macro and micro-nutrient (Zn, Cu, Fe, and Mn) status. Soil reaction (pH) was found to be slightly acidic to near neutral and electrical conductivity were in safe limits (0.8 dS m^{-1}). Almost all the samples registered high organic carbon content. However, soils were low to medium in available N, medium to high in Zn and Cu and high in P, K, Fe and Mn status.

Keywords: *Apple declining orchards, Himachal Pradesh, microbial count, soil physico-chemical property*

Introduction

Horticulture plays an important role in the economic prosperity of the people of the North-West Himalayan region, because of the favourable climate and topographic conditions. Among the temperate fruits, apple is the major fruit crop, commercially grown in the North-Western Himalayan region comprising the states of Jammu and Kashmir, Himachal Pradesh, Uttrakhand and to some extent in North-Eastern states like Arunachal Pradesh, Sikkim, Meghalaya, Mizoram, Nagaland and Manipur. India ranks 5th in apple production in the world and occupies an area of 3,05,000 ha with an annual production of 22,65,000 MT and productivity of 7.43 MT (NHB 2018). The decline in apple productivity has been attributed to fungi, bacteria, nematodes, toxic agents, insect-pests, nutritional disturbances and chemical residues (Benizri *et al.* 2005). The reasons for the low productivity of declining apple orchards could be many but one of the most important reasons is the age of orchards (Singh 2013). Awasthi *et al.* (1996) reported the deficiencies of N, P, Zn, Mn and B in apple orchards of the Kullu and Shimla districts. Bhandari and Sharma (1981) surveyed the apple orchards of Shimla district and found half of the plant samples deficient in P, whereas the deficiency of Ca, S,

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K, N, and Mg was 38, 26, 25, 6 and 1 per cent samples, respectively. Rana *et al.* (1984) surveyed some apple orchards in Himachal Pradesh and observed that apple orchards were low in N, P, K, Ca, Cu, and Zn supply. Sharma (1988) found that the soils under apple orchards of Sirmaur district were low to medium in available N, S, B; whereas the leaf analysis data exhibited low to sufficient contents of K, Zn, Cu and B. Sharma (1994) conducted a nutritional survey of some apple growing belts of Chamba and reported that the soils in the area were low to medium in available N and B, medium to high in P, Zn and Cu, adequate in K, Ca, Mg and S while they were high in available Fe and Mn. This study aimed to the survey of old declining apple orchards for available nutrient status in Shimla and Sirmaur district, Himachal Pradesh.

Materials and Methods

Study areas

A survey of declined apple orchards was conducted to evaluate the status of available macro and micronutrients and microbial population in ten apple orchards of Shimla and Sirmour districts of Himachal Pradesh, India in October 2016. Five soil samples were taken from five different plant rhizosphere and mixed, to make a composite sample. Similarly, three composite samples were collected from different sub-sites of each of ten different replant site locations. The rhizospheric soil samples along with pieces of roots were collected around 10 cm apart and from a depth of 1½ - 2 feet. A total of thirty composite soil samples were collected from ten replant sites and were brought to the laboratory in polythene bags and stored at 4º C for further isolation and analysis.

Methodology

One gram of soil from each sample was taken and transferred to 9 ml sterilized water blank under aseptic condition and then agitated intermittently for 5-10 minutes on a shaker, which provided 10^{-1} dilution and further serial dilutions were made accordingly. Suspension of 0.1 ml from dilution blank was spread over pre-poured solid media *viz.,* Nutrient Agar, Potato Detox Agar and Kenknights Agar Mediums (Jensen 1987) with the help of glass spreader under aseptic conditions for enumeration of bacteria, fungi and actinomycete, respectively. Plates were incubated in an inverted position at 28±2°C for 48 hours. After the incubation period, the microbial count was expressed as colony-forming unit per gram of soil (CFU g^{-1} soil). The soil microbial count was performed by standard plate count technique (Wollum 1982) by employing different media for different groups of microorganisms. The soil pH and electrical conductivity were measured (Jackson 1973). Organic carbon was determined by the chromic acid titration method of Walkley and Black (1934). The macronutrient status *i.e.*, available nitrogen (Subiah and Asija 1956), phosphorus (Olsen's *et al.* 1954) and potash (Mervin and Peech 1951) were determined. The analysis of soil micronutrients was carried out as per the method suggested by Lindsay and Norvell (1978). The recorded data were subjected to statistical analysis by adopting a one-way analysis and also the simple correlation coefficient was computed to establish the correlation between physicochemical properties, available nutrients and microbial counts.

Results and Discussion

Soil microbial properties

The bacterial count in the apple rhizosphere varied largely with locations. Among various sites, Habban had the highest bacterial count (130.49×10^5 CFU g^{-1} soil) which was statistically at par with Pulbahal. Gumma had the lowest count (73.15×10^5 CFUg^{-1} soil) which was statistically at par with Kharapather and Malat sites. The data on isolation of fungal pathogens (Table 1) revealed that the population capable of growth was counted highest (15.33×10^4 CFU g^{-1} soil) at Pulbahal. The minimum fungal population (12.33×10^4 CFU g^{-1} soil) was observed in Bogdhar soils, which was at par with Kharapather and Kupvi locations. The data (Table 1) indicated that the highest actinomycetes count was recorded (18.00×10^2 CFU g^{-1} soil) in a rhizospheric soil sample collected from Rohru. Lowest actinomycetes population was observed (14.33×10^2 CFU g^{-1} soil) in Kharapather. A significant difference was observed in

the population density of actinomycetes among rhizospheric soils of different locations.

Furthermore, the rhizosphere is known to be a zone of increased microbial activity and consequently enzyme activity. Because of the intensive and extensive interactions in the rhizosphere, microbial activity and population size have the positive effects of inoculated microorganisms. This might be due to higher concentration of easily degradable substrates in root exudates leading to more proliferation of microorganisms in the rhizosphere (Bais *et al.* 2006) and thus plant creates its specific microflora that may have neutral, deleterious or beneficial effects on the plants. These findings are in line with the work of Rumberger *et al.* (2007). Godara (1993) also reported lower microbial population in declining apple orchards.

Table 1. Longitude and latitude, Amsl and microbial from declining apple orchards

Decaling apple orchard sites	Longitude and Latitude	Amsl (m)	Total microbial count		
			Bacterial (CFU × 10^5 g^{-1} soil)	Fungal (CFU × 10^4 g^{-1} soil)	Actinomycetes (CFU × 10^2 g^{-1} soil)
Kotkhai	31.1172° N,	1,881	114.15		
	77.5409° E			13.33	17.00
Habban	30.9156° N,	2040	130.49		
	77.3253° E			14.33	16.67
Pulbahal	30.9267° N,	1646	121.05		
	77.4512° E			15.33	17.00
Rohru	31.2046° N,	1,554	110.72		
	77.7524° E			13.33	18.00
Jubbal	31.1117° N,	1,901	97.95		
	77.6665° E			13.33	16.33
Bog Dhar	30.7531° N,	1760	118.39		
	77.3834° E			12.33	15.67
Kupvi	30.8335° N,	2510	119.49		
	77.5770° E			13.00	16.67
Gumma	31.1198° N,	1676	73.15		
	77.4888° E			13.67	15.67
Kharapather	31.1187° N,	2700	77.35		
	77.6265° E			13.00	14.33
Malat	30.8225° N,	1720	82.72		
	77.6468° E			13.67	15.33
C.D	31.1172° N,	1,881	10.10		
	77.5409° E			0.95	0.76

Soil physicochemical properties

The average pH value of apple orchard soils of Shimla and Sirmaur (Table 2) were found to be 6.99. The maximum pH value was registered in Kotkhai (pH 7.42) and minimum at Rohru (pH 6.28) among different declining apple orchard sites. The average values of EC

for rhizosphere soils were recorded as 0.72 dS m^{-1}. The highest and lowest values for EC were noted in Pulbahal and Kotkhai sites. Declining apple orchard soils of Shimla and Sirmaur exhibited average organic carbon (OC) content of 15.8 g kg^{-1}. The soils were categorized high in OC status. The mean maximum water holding capacity of the soil was 45.74 per cent. The highest and lowest values of maximum water holding capacity were

Table 2. Soil physico-chemical properties of declining apple orchards

Replant Sites	pH	EC (dSm^{-1})	Organic carbon (g Kg^{-1})	Maximum water holding capacity (%)	Bulk density (Mg m^{-3})
Kotkhai	7.42	0.66	16.0	44.12	1.34
Habban	6.8	0.67	15.1	44.60	1.40
Pulbahal	6.77	0.79	16.8	46.10	1.37
Rohru	6.28	0.74	17.6	43.39	1.31
Jubbal	7.39	0.65	16.3	46.50	1.33
Bogdhar	6.47	0.74	13.5	43.80	1.39
Kupvi	7.38	0.77	19.6	48.76	1.36
Gumma	6.87	0.78	16.5	46.32	1.3
Kharapather	7.21	0.71	15.4	45.61	1.38
Malat	7.31	0.68	11.4	48.15	1.37
Average	6.99	0.72	15.8	45.74	1.36
SE (±d)	0.41	0.05	0.22	1.80	0.03
CV	5.88	7.26	14.10	3.94	2.49
Range	6.28-7.42	0.65-0.79	11.4-19.6	43.39-48.76	1.30-1.40

recorded in Kupvi and Kotkhai locations. The average values of bulk density (BD) for rhizosphere soils were recorded as 1.36 Mg m^{-3}. The highest and lowest values for BD were recorded in the soil of Habban and Gumma.

The nitrogen content in the surface soils (Table 3) ranged from 213.30 to 330.13 kg ha^{-1} with an average of 243.08 kg ha^{-1}. Maximum nitrogen was recorded in the soil of Kupvi (332.13 kg ha^{-1}) and minimum in Rohru (213.30 kg ha^{-1}). Available N was deficient in 80 per cent orchards. The phosphorus content in the rhizosphere soils ranged from 48.85 to 79.04 kg ha^{-1} with an average of 62.46 kg ha^{-1}. The highest phosphorus was observed in the soil of Kotkhai (99.04 kg ha^{-1}) and lowest is soil of Rohru (48.85 kg ha^{-1}) sites. The potassium content in the soils was ranged from 370 to 1798 kg ha^{-1} with an average of 1005.46 kg ha^{-1}. The maximum potassium content was recorded in the soil of Jubbal (1798 kg ha^{-1}) and lowest in Gumma (370 Kg ha^{-1}).

The calcium content (Table 3) in the surface soil ranged from 1240 to 1450 ppm with an average of 1367 ppm. The maximum calcium (1450 ppm) was found in Jubbal orchard soil and minimum of 1240 ppm in the soil of Habban. The magnesium content in the rhizosphere soil ranged from 650 to 760 ppm with an average of 702 ppm. The highest magnesium was recorded in Kharapather (760 ppm) and lowest magnesium (650 ppm) in Kothkai. The iron content in the surface soil ranged from 54.88 to 87.68 ppm with an average of 75.76 ppm. The highest iron was recorded in soil of Kharapather (87.68 ppm) and lowest is soil of Jubbal (54.88 ppm). The zinc content in the rhizospheric soils ranged from 2.86 to 3.30 ppm with an average of 3.06 ppm. The highest zinc was observed in soil of Kharapather (3.30 ppm) and lowest in soil of Rohru (2.91 ppm). The manganese content in surface soils were ranging from 20.47 to 24.34 ppm with an average of 22.43 ppm. The maximum manganese was observed in

soil of Kharapather (24.34 ppm) and minimum in soil of Rohru (20.47 ppm). The copper content in surface soils ranged from 4.95 to 8.79 ppm with an average of 6.09 ppm. The highest copper content was observed in soil of Pulbahal (8.79 ppm) and lowest in soil of Bogdhar (4.95 ppm).

Table 3. Soil fertility status of declining apple orchards

Replant Sites	Macro-nutrients (Kg ha^{-1})			----------Secondary and micro-nutrients (ppm)----------					
	Nitrogen	Phosphorus	Potash	Calcium	Magnesium	Iron	Zinc	Manganese	Copper
Kotkhai	220	79	667	1270	650	78.8	3.1	23.0	6.4
Habban	235	69	687	1240	670	69.7	3.0	21.1	5.6
Pulbahal	220	53	1644	1410	670	83.9	3.2	22.5	8.8
Rohru	213	49	778	1340	730	71.4	2.9	20.5	5.6
Jubbal	245	66	1798	1450	720	54.9	2.9	22.1	5.0
Bogdhar	282	69	654	1420	670	79.3	3.1	23.8	6.1
Kupvi	332	50	1523	1340	680	83.0	3.3	21.6	6.3
Gumma	257	55	370	1450	750	71.5	3.1	22.5	5.6
Kharapather	213	69	778	1390	760	87.7	3.3	24.3	6.6
Malat	214	68	468	1360	720	77.5	3.0	22.8	5.0
Average	243	63	1005	1367	702	75.8	3.1	22.4	6.1
SE(±d)	39	10	649	71.5	38.5	9.4	0.1	1.2	1.1
CV	16	16	65	5.2	5.5	12.4	4.6	5.2	18.1
Range	213-332	49-79	370-1644	1240-1450	650-760	54.88-87.68	2.86-3.30	20.47- 24.34	4.95-8.79

Conclusion

The rhizospheric soils from various declining apple orchards of Shimla and Sirmaur districts exhibited nitrogen deficiency. Almost all the samples registered high organic carbon content. However, soils were low to medium in available N, medium to high in Zn and Cu and high in P, K, Fe, and Mn status. Hence, crop management practices should include the application of these nutrients for higher crop production.

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