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Effect of Management Practices on Soil Nutrient Status of Apple Orchards in Kullu District of Himachal Pradesh

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Abstract

Apple (*Malus domestica* Borkh) is one of the important fruit crops in Himachal Pradesh. The study was conducted to evaluate the soil nutrient status of apple orchards at different altitudes (Bajaura: 1090m amsl, Seobagh: 1189 m amsl, Naggar: 1880 m amsl and Arsu: 2080m amsl) and with different fertilizer management practices (low input and high input) in Kullu district of Himachal Pradesh during the years 2015 and 2016. In each location, twelve orchards were selected and six to seven trees in each orchard were randomly marked for soil nutrient evaluation. The study revealed maximum average soil pH (6.77) and OC (2.92%) in low input orchards as compared to high input orchards. Soil pH (6.47), electrical conductivity (0.31) and organic carbon (2.49) were found maximum at highest location i.e. Arsu as compared to other locations. High input orchards recorded higher values of soil macronutrients N (330.4 kg ha^{-1}), P (36.64 kg ha^{-1}) and K (287.4 kg ha^{-1}) than low input orchards. Similarly, soil micronutrients Fe, Zn and Cu were also found higher in high input orchards.

Keywords: Apple, management practices, soil nutrient

1. Introduction

Apple is the major fruit crop of Himachal Pradesh commonly grown in the sub temperate to temperate hilly region of the state. Apple can be grown at altitudes of 1,500-2,700 m amsl in the Himalayan range which experience 1,000-1,500 hours of chilling. In Himachal Pradesh, the area under apple cultivation has been increased to 301 hectares with annual production of 2327 metric tonnes (NHB, 2018). The agrochemicals are widely used in apple orchards to obtain higher yields due to which soil health deteriorates. The intensive use of these chemicals also lowers the biological activity, organic matter content and soil fertility which can leads to low productivity. The intensive farming by using fertilizers and pesticides may deteriorate soil health, leading to poor productivity and adverse environmental effects (Wells et al., 2000). Physical, chemical, biological and biochemical properties are important in soil functioning. The biological and biochemical properties of soil tend to react quickly to changes in the external environment and are therefore generally used in assessing soil quality (Nannipieri et al., 1990). The application of chemicals changes the composition of the farm soils and degrades their health. Synthetic chemicals also deteriorate the environmental quality by polluting air and water resources and harm human health by entering into their food chain (Benbi and Brar, 2009). Farming management systems alter the soil microbial community structure through changes in carbon availability, pH, nutrient availability or other chemical parameters (Cookson et al., 2007). For many organically managed fruit crops, soil nutrient availability plays a critical role in the potential success of fruit production. However, the sustainability of conventional apple production systems have been brought into question by consumers increasing in demand for apples free of chemical residues, escalating production costs, water contamination from orchard practices, and soil degradation (Peck et al., 2006). The objective of this study was to evaluate the influence of high and low input orchard management practices on soil nutrient status of apple orchards in Kullu district of Himachal Pradesh.

2. Materials and Methods

The research work was carried out at four locations viz. Bajaura, Seobagh, Naggar and Arsu in Kullu district of Himachal Pradesh. The treatments comprised of four locations, two manures and fertilizer application practices i.e low inputs and high inputs. In low input orchards, FYM with very low quantities of inorganic fertilizers were used. Whereas in high input orchards, university recommended manures and inorganic fertilizer doses were applied. At each location, 12 orchards were sampled, six with low input and six with high input fertilizer applications. Apple trees aged between 15-20 y were selected for the study. Six to seven trees in each orchard were randomly sampled. Sampling was done in the month of October during both the years i.e. 2015 and 2016. Soil samples were collected from the selected apple trees at 0-20 cm depth by using tube auger. Soil samples were dried in shade and grounded using wooden pestle and mortal. The grounded soil samples were passed through a 2mm sieve and stored in polythene bags for subsequent analysis. Soil pH was determined in 1:2.5 soil and water suspension (Jackson, 1973) and measured by microprocessor based pH-meter (model 510 of EIA make). The electrical conductivity of the soil was estimated in 1:2.5 soil and water suspension (Jackson, 1973) by using microprocessor based conductivity meter (model-1601 EIA make) and expressed as dS m^{-1}. Soil organic carbon was determined by Walkley and Black (1934) rapid titration method. The available nitrogen in soil was determined by alkaline potassium permanganate method of Subbiha and Asija (1956). Estimation of available phosphorus was done by Olsen's method by using 0.5N $NaHCO_3$ as extractant (Olsen et al., 1954) and determined calorimetrically by stannous chloride reduced ammonium molybdate method in HCL system. The available potassium was analyzed by using neutral normal ammonium acetate solution as extractant (Merwin and Peach, 1951). The micronutrients viz., zinc, copper, manganese and iron were analyzed through DPTA method (Lindsay and Norvell, 1978) using ICP Spectrometer (ICAP 6300 duo).

3. Results and Discussion

3.1. Soil pH

Significant differences in soil pH were recorded at different locations and management practices (Table 1). Maximum soil pH (6.47) was recorded in Arsu apple orchards, which was significantly highest than all other locations and the lowest pH (6.24) was recorded in Naggar apple orchards. Between different orchard management practices, significantly higher pH (6.69) was recorded from low input orchards as compared to high input orchards (5.73). The interaction of locations and management practices revealed highest soil pH (6.92) in Arsu low input orchards and the minimum (5.72) in Seobagh high input orchards.

In low input orchards, farmers applied more FYM than chemical fertilizers, which resulted in higher pH. The organic matter in the soil increased the buffering capacity of soil. Despite their differences, the pH values of the soils under study were mostly within the acceptable range for apple production as suggested by Kanwar (1987). The organic fertilizer had a positive effect on soil as indicated by its corresponding higher pH levels. Continuous application of chemical fertilizers in apple orchards reduced the soil pH due to nitrification of the ammonium fertilizers or urea which results in increasing amounts of H^+ ions in the soil (Ruth and Goh, 1992).

3.2. Soil electrical conductivity (dS m^{-2})

The orchard management practices and altitude variation also influenced the soil electrical conductivity (Table 1). Among different locations, maximum soil EC (0.31 dS m^{-2}) was recorded in Arsu orchards located at highest altitude which was significantly higher than all other locations and the lowest (0.27 dS m^{-2}) in Bajaura apple orchards. Between management practices, significantly higher soil EC (0.33 dS m^{-2}) was recorded from high input orchards as compared to low input orchards (0.25 dS m^{-2}). In interaction of locations and management practices, highest soil EC (0.36 dS m^{-2}) was recorded in Arsu low input orchards and the lowest EC (0.23 dS m^{-2}) was recorded in Bajaura high input orchards. Electrical conductivity was found higher in high input orchards where inorganic fertilizer had been applied at higher rates. An increase in the EC in conventionally managed soils could be due to the higher input of salts in the forms of chemical fertilizers. However, in organically managed low input orchards, EC has been found to be low. These findings are in conformity with Srikanth et al., (2000) and Usha et al., (2004) who have reported a decrease in electrical conductivity of soil with the application of vermicompost and FYM.

3.3. Soil organic carbon (%)

Maximum soil organic carbon contents (2.49%) were recorded in Arsu apple orchards, which were significantly higher than all other locations (Table 1). The lowest organic carbon contents were recorded in Naggar (1.51%) apple orchards. Similarly, in orchards with varied management practices, significantly higher soil organic carbon (2.92%) contents were recorded from low input orchards as compared to high input orchards (0.94%). In interaction studies, maximum soil organic carbon (3.90%) was recorded in Arsu low input orchards and the minimum (0.75%) in Naggar high input orchards. Significantly higher organic carbon was recorded in low input orchards where mainly organic inputs were applied. These results are in confirmation with the findings of Ghuman and Sur (2006) who reported increase in organic carbon in manured plots.

3.4. Soil macronutrients (kg ha^{-1})

The data on effect of management practices and orchard altitude on available nitrogen (N) contents are presented in Table 2. Maximum available N (313.70 kg ha^{-1}) was recorded in Seobagh which was significantly highest than all other locations. The minimum available N was recorded in Bajaura (297.20 kg ha^{-1}) apple orchards. Between management practices, significantly higher soil available nitrogen (330.40 kg ha^{-1}) was recorded in high input orchards as compared to low input orchards (278.00 kg ha^{-1}). The interaction of locations and management practices revealed maximum soil available N (348.03 kg ha^{-1}) in Seobagh high input orchard and the minimum available N (273.73 kg ha^{-1}) in Naggar low input

Table 1: Effect of management practices on soil chemical properties in apple orchards at different altitudinal gradients in Kullu district of HP

Locations	pH			EC			OC		
	Low input orchards	High input orchards	Mean	Low input orchards	High input orchards	Mean	Low input orchards	High input orchards	Mean
Bajaura (1090 m amsl)	6.66	5.83	6.25	0.23	0.31	0.27	2.80	0.88	1.84
Seobagh (1189 m amsl)	6.84	5.71	6.28	0.24	0.31	0.28	2.72	1.06	1.89
Naggar (1880 m amsl)	6.63	5.84	6.23	0.25	0.35	0.30	2.27	0.75	1.51
Arsu (2080 m amsl)	6.92	6.08	6.50	0.26	0.36	0.31	3.90	1.07	2.49
Mean	6.76	5.86		0.25	0.33		2.92	0.94	
CD (p=0.05)									
Locations (A)	0.062			0.013			0.065		
Management practices (B)	0.044			0.009			0.046		
A×B	0.087			0.019			0.092		

orchard. Highest available P contents (31.43 kg ha^{-1}) were recorded in Arsu apple orchards, followed by Seobagh, Bajaura and Naggar (Table 2). The lowest contents were recorded in Naggar (26.53 kg ha^{-1}) apple orchards. In orchard management studies, significantly higher soil available phosphorus (36.64 kg ha^{-1}) was recorded from high input orchards as compared to low input orchards (20.79 kg ha^{-1}). The interactive effect of locations or altitude gradient and management practices resulted in maximum soil available phosphorus (41.13 kg ha^{-1}) in Seobagh high input orchards and minimum (19.53 kg ha^{-1}) in Seobagh low input orchards.

The available soil potassium (K) was recorded maximum (260.3 kg ha^{-1}) in Naggar apple orchards, which was also at par with Arsu apple orchards (257.9 kg ha^{-1}). The lowest potassium was recorded in Bajaura (251.4 kg ha^{-1}) apple orchards. Between management practices, significantly higher soil available potassium (287.4 kg ha^{-1}) was recorded in high input orchards as compared to low input orchards (224.4 kg ha^{-1}). In interaction of locations and management practices, highest soil available potassium (293.7 kg ha^{-1}) was recorded in Naggar high input orchard and the lowest (222.7 kg ha^{-1}) in Seobagh low input orchards.

Table 2: Effect of management practices on soil macronutrients in apple orchards at different altitudinal gradients in Kullu district of HP

Locations	pH			EC			OC		
	Low input orchards	High input orchards	Mean	Low input orchards	High input orchards	Mean	Low input orchards	High input orchards	Mean
Bajaura (1090 m amsl)	279.4	315.1	297.2	20.81	32.36	26.59	223.7	279.1	251.4
Seobagh (1189 m amsl)	279.3	348.0	313.7	19.52	41.12	30.32	222.9	285.4	254.1
Naggar (1880 m amsl)	273.7	327.2	300.5	20.04	33.02	26.53	226.8	293.7	260.3
Arsu (2080 m amsl)	279.6	331.2	305.4	22.80	40.06	31.43	224.3	291.5	257.9
Mean	278.0	330.4		20.79	36.64		224.4	287.4	
CD (p=0.05)									
Locations (A)	3.314			0.149			0.796		
Management practices (B)	2.343			0.105			0.563		
A×B	4.686			0.210			1.125		

The available N, P and K values in the high input orchards were found to be higher than those in the low input orchards due to the application of direct sources of fertilizers. In present study, higher available P was recorded in high input orchards which may be due to the direct application of phosphotic fertilizers, however, the contents were between optimum ranges. The content of available phosphorous varied from 2.69 to 28.22 kg ha^{-1} in soils of Kangra, Kullu, Mandi and Sirmour areas of Himachal Pradesh (Verma et al., 1985). Walker and Mason (1960) studied soil nutrient status of Delicious, Golden Delicious, Rome Beauty and Stayman in North Carolina and reported presence of P, K, Ca and Mg at a medium to high levels in all the orchards. Application of FYM and green manuring with phosphatic fertilizers results in increase in the available phosphorous status of the soil (Maurya and Ghosh, 1972). Available P_2O_5 contents increase with the increase in clay content of soil profiles (Jha et al., 1988). Basso et al. (1990) analyzed the apple orchard soils in Southern Brazil and recorded the minimum and maximum range for P and K as 1.0-66.0 and 65-582 ppm. Prakash et al., (2002) reported that availability of all major nutrient elements, except P and micronutrients was higher in the treatments with organic sources compared to chemical fertilizers. They also observed higher Fe, Cu and Zn availability in the soil profile when supplemented with organic manures. Sharma (2002) has reported that vermicompost released nutrients slowly and steadily into the soil that enhanced the capability of plants to absorb these nutrients. The soil enriched with vermicompost provided additional substances that are not found in the chemical fertilizers under organic cultivation of apple.

3.5. Soil micronutrients (kg ha^{-1})

The data pertaining to effect of altitude gradient and management practices on available micronutrients in apple orchards have presented in Table 3. Significantly highest available Fe contents (51.91 mg kg^{-1}) were recorded in Bajaura apple orchards and lowest in Arsu (38.92 mg kg^{-1}) apple orchards. Between management practices, significantly higher soil mean available iron (58.02 mg kg^{-1}) contents were recorded in high input orchards as compared to low input orchards (33.25 mg kg^{-1}). When comparing management practices at different altitudes, maximum soil available Fe contents (66.08 mg kg^{-1}) were recorded in Bajaura high input orchard and minimum (28.75 mg kg^{-1}) in Arsu low input orchard.

Significantly maximum available Zn (3.77 mg kg^{-1}) was recorded in Bajaura apple orchards, followed by Seobagh (3.65 mg kg^{-1}), Naggar (3.59 mg kg^{-1}) and Arsu (3.50 mg kg^{-1}). The high input orchards recorded higher soil available zinc (3.78 mg kg^{-1}) contents as compared to low input orchards (3.48 mg kg^{-1}). Maximum available Cu contents (5.60 mg kg^{-1}) were also recorded in Bajaura apple orchards, which were significantly higher than all other locations. The lowest Cu contents were recorded in Arsu (2.69 mg kg^{-1}) apple orchards. Similarly, between management practices, significantly higher soil available copper (4.39 mg kg^{-1}) contents were recorded in high input orchards as compared to low input orchards (3.94 mg kg^{-1}). The interaction of locations and management practices revealed higher soil available Cu (5.87 mg kg^{-1}) in Bajaura high input orchards and the minimum (2.56 mg kg^{-1}) in Arsu low input orchards.

Similarly, available manganese (Mn) was also found maximum (33.19 mg kg^{-1}) in Bajaura apple orchards, followed by Seobagh, Naggar and Arsu. The minimum contents were recorded in Arsu (22.30 mg kg^{-1}) apple orchards. The comparison of management practices revealed significantly higher soil available manganese (28.94 mg kg^{-1}) in low input orchards as compared to high input orchards (26.22 mg kg^{-1}). In interaction studies, we recorded maximum soil Mn (34.52 mg kg^{-1}) in Bajaura low input orchard and minimum (20.54 mg kg^{-1}) in Arsu high input orchard.

Table 3: Effect of management practices on soil micronutrients in apple orchards at different altitudinal gradients in Kullu district of HP

Locations	Fe			Zn			Cu			Mn		
	Low input	High input	Mean	Low input	High input	Mean	Low input	High input	Mean	Low input	High input	Mean
Bajaura (1090 m amsl)	37.74	66.08	51.91	3.61	3.93	3.77	5.32	5.87	5.60	34.52	31.85	33.19
Seobagh (1189 m amsl)	34.84	61.24	48.04	3.5	3.8	3.65	4.58	4.97	4.78	30.11	27.96	29.03
Naggar (1880 m amsl)	31.66	55.67	43.66	3.44	3.73	3.59	3.32	3.87	3.59	27.08	24.53	25.80
Arsu (2080 m amsl)	28.75	49.09	38.92	3.35	3.65	3.50	2.56	2.83	2.69	24.05	20.54	22.30
Mean	33.25	58.02		3.48	3.78		3.94	4.39		28.94	26.22	
CD (p=0.05)												
Locations (A)		0.409			0.021			0.019			0.100	
Management practices (B)		0.289			0.015			0.013			0.071	
A×B		0.578			NS			0.027			0.141	

The soils of the low input orchards exhibited lower concentrations of Fe, Cu, Zn and Mn as compared to high input orchards. This may be attributed to high application rates of agrochemicals, such as pesticides (copper containing fungicides) and synthetic fertilizers (containing micronutrients), in high input orchards. The increased soil contents of these metals may be due to soil application or through foliar applications of these agrochemicals due to foliar run off. In low input orchards, the farmers mainly depend upon organic fertilizers and pesticides and lower doses of chemical fertilizers and pesticides are applied. Many studies have shown that organically managed soil with adequate levels of organic inputs have maximum soil micronutrients such as Mn owing to the ability of the organic matter to increase the solubility of metals (Herencia et al., 2008a; 2008b). In present studies, higher Mn was recorded in low input orchards where apple trees received more of FYM than inorganic fertilizers.

Microbial decomposition of organic compounds creates reducing conditions and increases the solubility of some micronutrients especially that of Mn (Herencia et al., 2008a) accounting for its higher concentration in the organic orchards compared to the conventional ones. Improvements in all of these soil quality indicators have been found to optimize crop growth (Karlen and Stott, 1994). Thus, one of the most significant benefits of manure as an organic nutrient source is its potential to maintain or raise soil organic matter levels.

Grewal et al. (1969) in an extensive study of Himachal Pradesh soils revealed that Kullu district soils had 10-30 ppm Mn, 0.38-0.60 ppm Zn and 0.68-0.80 ppm Cu, thus all these elements showed a marginal range. The apple orchard soil of Kullu district were found to be deficient in zinc content and 100 g $tree^{-1}$ zinc sulphate was recommended as soil application (Tomar et al., 1970). Dev and Kapoor (1973) studied the zinc contents of soil in the Golden Delicious orchards of Kullu district and reported that zinc varied from 0.15 to 1.20 ppm in the deficient orchards and from 0.38 to 2.05 ppm in the non-deficient orchards, whereas in Red Delicious orchards the ranges were 0.05 to 1.35 ppm and 0.50 to 2.10 ppm, respectively.

The variations in available macro and micro nutrients among different locations may be due to variations in doses or rates of fertilizers and pesticides used by farmers and average temperature variations among different locations. At lower altitudes, there is more degradation of chemicals (fertilizers and pesticides) applied to the soil due to higher temperature as compared to orchards at higher altitudes which resulted lower contents of the available nutrients at these altitudes. The soils of high input orchards contained higher contents of most of available nutrients than low input orchards which might be due to higher fertilizer rates used in these orchards. In present studies, higher Mn was recorded in low input orchards as compare to high input orchards, which may be due to the ability of organic matter generally used in low input orchard to increase solubility of metals as reported by Herencia et al. (2008a; 2008b).

4. Conclusion

Maximum average soil pH (6.77) and OC (2.92%) were recorded from low input orchards as compared to high input orchards. Soil pH (6.47), electrical conductivity (0.31) and organic carbon (2.49) were found maximum at highest location i.e. Arsu as compared to other locations. High input orchards recorded higher values of soil macronutrients than low input orchards.

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