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Azra Amin
Division of Environmental sciences SKUAST-K, J&K, India

Shoukat Ara
Division of Environmental sciences SKUAST-K, J&K, India

FA Lone
Division of Environmental sciences SKUAST-K, J&K, India

Tahir Ali
Division of soil science SKUAST-K, J&K, India

SA Mir
Division of Agri-statistics SKUAST-K, J&K, India

ZA Baba
Division of Basic sciences, FOA wadura SKUAST-K, J&K, India

Shahnaz Mufti
Division of Vegetable science SKUAST-K, J&K, India

Corresponding Author:
Azra Amin
Division of Environmental sciences SKUAST-K, J&K, India

Comparative study on soil quality and nutrient availability of apple orchards under organic and conventional nutrient management systems

Azra Amin, Shoukat Ara, FA Lone, Tahir Ali, SA Mir, ZA Baba and Shahnaz Mufti

Abstract
The investigation was conducted in 2018 at Urr Charsoo village located in pulwama district of Kashmir valley to study impact of nutrient management systems on soil.16 apple orchards with uniform topography were selected from 4 locations for sampling and 192 soil samples were collected from organically and conventionally managed apple orchards. Samples were analyzed for physico-chemical properties and nutrient characteristics. The results revealed highest values of physico-chemical characteristics (Electrical conductivity and Bulk density), nutrients *viz.* Available Nitrogen, Available Phosphorus, Available Potassium, Available Calcium and heavy metals (Cadmium and Lead) were found in soil samples collected from conventionally managed orchards. However, maximum values of various physico-chemical characteristics (pH, Organic Carbon) and micro-nutrients (Copper, Iron) were recorded in organically managed orchards. The present study indicated that, the physico-chemical characteristics of soil were improved under organic nutrient management system. Besides organic nutrient sources reduced the heavy metal pollution which may be used in minimizing the pollution load in soil.

Keywords: physico-chemical, micro-nutrients, organically, conventionally, heavy metals, pollution

Introduction
Horticulture occupies very important position in the predominantly agricultural economy of Himalaya. Jammu and Kashmir occupies first position in apple production in India producing 1882319 metric tonnes of apple from an area of 163432 hectare (Anonymous, 2018) [3]. As a dominant crop of the valley, "Apple" proudly represents the fruit industry of Kashmir valley (Bhat, 2014) [5]. Maximum yield and quality of crop can be achieved by nutrient management of the orchard. Soil being a source of nutrition for plants; it also acts as a buffer to protect groundwater and plants against pollution (Marzaioli *et al.*, 2010) [18]. Conventional farming largely depends on intensive use of synthetic fertilizers. Continuous use of chemical fertilization can usually cause soil degradation (Reganold *et al*., 2001) [21], reduced biodiversity (Lupwayi *et al*., 2001) [17], increased the incidences of disease and pest attacks, leads to accumulation of heavy metals in plants and consequently decrease environmental sustainability (Horrigan *et al*., 2002) [14]; reducing nutritional value and edibility of fruits (Peck *et al*. 2006) [20].
During the last decade the growing consumer's concern towards healthier and safer food along with environmental protection, emphasized the role of agronomic practices as one of the main determinants of food quality and environment protection (Bourn and Prescott, 2002) [7]. Under these circumstances, use of organic manures has assumed great importance for sustainable production. Now-a-days, it is very important method for providing the plants with their nutritional requirements without having an undesirable impact on the environment (Abou *et al.,* 2007) [1]. The sustainable agriculture involves optimizing agricultural resources and at the same time maintaining the quality of environment. The organic manures not only supply macro- and micronutrients, but also improve the soil physical, chemical and biological health under apple cultivation (Goh and Ridgen, 2008) [11].

Material and Method
The present investigation was conducted in 2018 at apple orchards of Urr Charsoo village located in pulwama district. It lays between 32º 88′ N latitude and 74º 92′ E longitudes at an

altitude of 1630 meters above msl. The experimental site was well drained and had uniform topography. Climatically the experimental site is mid to high altitude temperate zone. The average annual temperature is 13.8º C, rainfall is 731 mm and more than 80 per cent of precipitation is received from western disturbances. Soil samples were collected from various depths at an interval of 20 cm up to a depth of 60 cm from apple orchards under Red Delicious apple. The laboratory investigations were carried out in the laboratories of Division of Environmental Sciences and Division of Soil Science, SKUAST-Kashmir. pH and electrical conductivity was determined by pH meter and electrical conductivity meter, respectively (Jackson, 1973) [15] using 1: 2.5 soil to water suspension. Bulk density was measured by core sampler technique (Black and Harty, 1971) [6]. The organic carbon was determined by the rapid titration method given by Walkley and Black (1934) [28]. Soil available nitrogen was determined by potassium permanganate method (Subbiah and Asija, 1956) [26]. Available phosphorus was determined by extracting phosphorus with Olsen's Extractant (0.5 N NaHCO3 at pH 8.5) and colour developed by stannous chloride was then measured at 660 nm with help of spectrophotometer using distilled water as blank. Available potassium was estimated by ammonium acetate method using 1N ammonium acetate at pH 7 (Jackson, 1973) [15] and determined with the help of flame photometer. Available calcium was estimated by EDTA titration method described by Chesnin and Yein (1956) [8].

The micronutrient estimation was done by using the method outlined by Lindsay and Norvell (1978) [16]. About 10 g of processed soil sample was shaken for 2 hours with mixture of 20 ml of diethyle tri-amine penta acetic acid (DTPA) extractant (0.005 M DTPA 0.01 M $CaCl_2$ and 0.1 N TEA buffered at 7.3 pH) on electrical shaker and the micronutrient contents were measured with the help of atomic absorption spectrophotometer. Heavy metals (lead and cadmium) from soil were extracted by the method of Jackson (1973) [15] using di-acid digestion mixture (HNO_3:$HClO_4$, 4:1) and analyzed by atomic absorption spectrophotometer.

Result and discussion

The data in table 1 revealed that organic and conventional orchard management of apple had significant effect on soil physico-chemical properties. It was found that the highest value of soil pH (7.03) and organic carbon (2.38 %) were observed in organically managed apple orchard whereas the highest value of EC (0.38 dSm^{-1}) and bulk density (1.24 g cm^{-3}) were recorded in conventional apple orchard. The higher values of pH under organic apple orchard might be due to the production of more organic acids during decomposition of organic materials which had a buffering effect on soil pH whereas the continuous application of chemical fertilizers in conventional apple orchard reduce the soil pH due to nitrification of nitrogenous fertilizers which resulted in increased content of H^+ ions in the soil. The increased electrical conductivity under conventional apple orchard could be due to the higher input of salts in the soil from chemical fertilizers which resulted in significantly higher EC as compared to organic apple orchard. These results are supported by the findings of Holb *et al*. (2009) [13]. The significantly higher content of organic carbon in organically managed apple orchard might be due the long term and continuous application of organic manures and its subsequent decomposition in the soil which might have resulted in maximum build up of organic carbon as compared to conventional orchard. These results are in close conformity with the findings of Sharma *et al*. (2013) [23]. The build-up of organic carbon over the year is a function of microbial activity and organic matter decomposition. Singh *et al*. (2012) [24] also observed that the increased organic carbon was due to enhanced root growth, accumulation of organic residues and direct incorporation of organic matter in soil. Furthermore, higher contribution of biomass to the soil in the form of litter and residue difference in the organic carbon content due to application of inorganic fertilizers might be result of differential rate of oxidation of organic matter by microbes (Holb *et al*., 2009) [13]. Besides, the higher amount of soil organic matter under organically managed apple orchard improved the soil physico-chemical properties which enhanced the soil quality significantly as compared to conventionally managed apple orchard. These results are supported by the findings of Adak *et al*. (2014). The lower value of bulk density in organic apple orchard as compared to conventionally managed orchard was due to the reason that enhanced soil organic carbon increases the soil aggregation and porosity of soil which subsequently decreased the soil bulk density. The improvement in soil porosity may also be due to enhancement in organic carbon content of soil and production of some adhesive agents like polysaccharides due to the action of microbes under originally abounded environment contributed to the better aggregation, which increase the porosity of the soil thus decreasing bulk density (Singh *et al*., 2012) [24].

The examination of data in table 2 indicated that organic and conventionally managed apple orchard had significant effect on the available nutrient status of soil. It was observed that highest amount of available nitrogen (426.54 kg ha^{-1}), phosphorus (26.82 kg ha^{-1}), potassium (333.05 kg ha^{-1}) and calcium (2282.85 kg ha^{-1}) were recorded under conventional apple orchard. The higher amount of soil available nitrogen, phosphorus, potassium and calcium under conventionally managed orchard than organic apple orchard might due to the application of direct sources of mineral fertilizers in soil whereas the lowest of nitrogen, phosphorus, potassium and calcium under organically managed apple orchard could be attributed to the fact that organic materials decompose slowly which resulted in slow release of major nutrients. These results are supported by the findings of Holb *et al*. (2009) [13], Singh *et al*. (2011) [25] and Salem *et al*. (2014) [22].

The data in table 3 showed maximum amounts of copper (2.26 ppm) and iron (26.13 ppm) was recorded under organically managed apple orchard. The highest content of soil iron and copper recorded under organically managed apple orchard as compared to conventional apple orchard could be attributed to the reason that organically managed soil with higher level of organic matter observe maximum content of some secondary nutrients and micro-nutrients in soil which is due to the ability of organic matter to increase the solubility of secondary and micro-nutrients (Herencia *et al*., 2008) [12]. Moreover, microbial decomposition of organic compounds creates reduced conditions and increases the availability of iron accounting for its higher concentration in organically managed apple orchard as compared to conventional apple orchard. These results are supported by the findings of Gasparatos *et al*. (2011) [9]. The lower content of iron and copper under conventionally managed orchard might be due the fact that chemical application of these nutrient was not followed in the conventional apple orchard which resulted in their lower content. The results are in close conformity with the findings of Glover *et al*. (2009) [10] and Verma and Chauhan (2014) [27].

Analysis of data showed that heavy metals content *viz.* cadmium and lead varied significantly between organic and conventional apple orchard (Table 3). The data showed that highest content of cadmium (0.388 ppm) and lead (0.872 ppm) was recorded under conventionally managed orchard as compared to organic apple orchard which recorded cadmium and lead content of 0.097 and 0.357 ppm, respectively. The high heavy metal content under conventional apple orchard compared to organically managed apple orchard could be due the fact that synthetic fertilizers are contaminated with heavy metals and their application to the soil subsequently increase the content of heavy metals under conventional orchard. These results are supported by the findings Glover *et al.* (2009) [10]. Aoyama *et al.* (2015) [4] also reported high content of heavy metals in soils under conventionally nutrient management as compared to soils with organic nutrient management. This could be attributed to the reason that synthetic fertilizers contain heavy metals as impurities

Table 1: Impact of selected nutrient management system on Physico- chemical parameters of soil of apple orchards

	pH			Electrical Conductivity (dS m^{-1})			Bulk Density (g cm^{-3})			Organic Carbon (%)		
Location	**Organic**	**Conventional**	**Mean**	**Organic**	**Conventional**	**Mean**	**Organic**	**Conventional**	**Mean**	**Organic**	**Conventional**	**Mean**
Location 1	7.067	6.730	6.898	0.225	0.356	0.290	0.829	1.242	1.035	2.407	1.687	2.047
Location 2	6.898	6.454	6.677	0.270	0.371	0.321	0.847	1.231	1.040	2.276	1.637	1.956
Location 3	7.099	6.292	6.696	0.315	0.378	0.346	0.834	1.249	1.041	2.506	1.712	2.109
Location 4	7.084	6.617	6.850	0.333	0.444	0.388	0.826	1.248	1.037	2.345	1.727	2.036
Mean	7.036	6.523		0.285	0.387		0.834	1.242		2.383	1.690	
CD ($P \leq 0.05$)												
Location (L)	0.187			0.023			NS			NS		
Orchard type (O)	0.132			0.016			0.018			0.208		
L × O	NS			0.033			NS			NS		

Table 2: Impact of selected nutrient management system on nutrients of soil of apple orchards

	Nitrogen (kg ha^{-1})			Phosphorus (kg ha^{-1})			Potassium (kg ha^{-1})			Calcium (kg ha^{-1})		
Location	**Organic**	**Conventional**	**Mean**	**Organic**	**Conventional**	**Mean**	**Organic**	**Conventional**	**Mean**	**Organic**	**Conventional**	**Mean**
Location 1	377.79	428.04	402.91	19.37	26.16	22.77	214.00	349.45	281.72	2018.50	2236.95	2127.72
Location 2	379.16	418.37	398.77	19.54	24.25	21.89	211.87	317.20	264.54	2227.25	2239.45	2233.35
Location 3	368.12	431.87	400.00	19.58	27.16	23.37	203.25	330.33	266.79	2238.08	2310.95	2274.52
Location 4	370.62	427.87	399.25	19.54	29.70	24.62	203.75	335.20	269.47	2237.37	2344.08	2290.73
Mean	373.92	426.54		19.51	26.82		208.21	333.05		2108.3	2282.85	
CD ($P \leq 0.05$)												
Location (L)	NS			1.452			NS			122.84		
Orchard type (O)	10.591			1.027			10.833			NS		
L × O	NS			2.054			NS			173.73		

Table 3: Impact of selected nutrient management system on micronutrients and heavy metals (ppm) of soil of apple orchards

	Copper (ppm)			Iron(ppm)			Cadmium(ppm)			Lead (ppm)		
Location	**Organic**	**Conventional**	**Mean**	**Organic**	**Conventional**	**Mean**	**Organic**	**Conventional**	**Mean**	**Organic**	**Conventional**	**Mean**
Location 1	3.015	2.039	2.527	23.00	14.29	18.64	0.105	0.465	0.285	0.351	0.858	0.604
Location 2	3.534	2.290	2.912	25.04	13.95	19.50	0.101	0.407	0.254	0.371	0.886	0.628
Location 3	3.299	2.292	2.796	28.08	17.54	22.81	0.092	0.357	0.226	0.345	0.863	0.604
Location 4	3.207	2.442	2.824	28.41	15.25	21.83	0.087	0.324	0.206	0.362	0.880	0.621
Mean	3.263	2.266		26.13	15.26		0.097	0.388		0.357	0.872	
CD ($P \leq 0.05$)												
Location (L)	NS			1.591			0.039			NS		
Orchard type (O)	0.283			1.125			0.028			0.059		
L × O	NS			NS			0.056			NS		

Conclusion

The nutrient management systems have their impacts on the nutrient availability and soil quality of apple orchards. Synthetic chemical fertilizers enhance the fertility status of soil for short period of time and have negative effects on the complex system of the biogeochemical systems. The long term use of chemical fertilizers causes the environmental degradation, besides having low nutrient use efficiency. The use of organic manures alone in long run not only improves the physico-chemical properties of soil but also reduce the environmental impact of different chemical fertilizers. Organically managed orchards are also rich in micro-nutrients as compared to conventional managed orchards whereas the maximum value of bulk density, electrical conductivity, macro nutrients and heavy metals were observed in inorganic apple orchard. Therefore, it can be concluded that the use of organic manures and biofertilizers are useful in enhancing soil health with respect to physico-chemical properties and micro-nutrient status of soil.

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