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Impact of different land use systems on the Physico-chemical properties of soils in Kohima district Nagaland

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Abstract
This article presents a study on impact of different land use systems on the physico- chemical properties of soil in Kohima district, Nagaland. It was undertaken during 2020-2021 in the Department of Agricultural Chemistry and Soil Science, SASRD, Nagaland University. A total of sixty samples (60) surface soil samples (0-15 cm) were collected from twelve villages of the four blocks (4) of Kohima district from cereal, orchard, banana plantation, spice and vegetable land use practices and were analysed for different properties. On an average soil pH, EC and CEC ranged from 4.38 to 5.96, 0.06 to 0.32 dSm^{-1} and 8.4 cmol (p^+) kg^{-1} to 24.3 cmol (p^+) kg^{-1}. Bulk density, particle density and porosity ranged from 1.03 to 1.23 g cm^{-3}, 2.42 to 2.52 g cm^{-3} and 49.80 to 58.47%. On the basis of average value, soils of all the land use system were found to be medium to high in available N, low to medium in available P, K and S. High amount of organic carbon, available N, P, K and S were reported in orchard while lower amount of the same were reported in banana plantation.

Keywords: land, CEC, Physico-chemical, SASRD

Introduction
Kohima is predominantly an agrarian state and agriculture is the main occupation of the people and is the main economic activity of the district. Most of the villagers are cultivator and medium farmers. The most prevailing practice of agriculture is terrace paddy field and jhum cultivation. The indigenous cultivation system have been passed down from generation to generation but in time modern technologies and techniques have creeped into the system of cultivation. As there is prevalence of different agro-ecological situation, diverse farming systems, including shifting cultivation are predominant in Kohima district. The people of the state depend heavily on agriculture and allied sectors. Shifting cultivation has resulted in large scale land and environmental degradation in the region. Thus, land use and type of vegetation must be considered when relating soil nutrients with environmental conditions (Liu *et al*., 2010) [20]. Therefore, there is special need for the analysis of soil nutrients in relation to land use. Land use is defined as the arrangements, activities and inputs people undertake in a certain land cover type to produce, change or maintain it (Ufot *et al*., 2016) [35]. Successful agriculture requires the sustainable use of soil resource, because soil can easily lose its quality and quantity within a short period of time for different reasons such as intensive cultivation, leaching and soil erosion (Kiflu and Beyene, 2013) [15]. Agricultural practice, therefore, requires basic knowledge of sustainable use of the land. Land use and soil management practices influence the soil nutrients and related soil processes, such as erosion, oxidation, mineralization, and leaching, etc. (Celik, 2005; Liu *et al*., 2010) [7, 20]. Moreover, soils through land use change also produce considerable alterations and usually soil quality diminishes after the cultivation of previously untilled soils (Neris *et al*., 2012) [24]. Thus, land use and type of vegetation must be taken into account when relating soil nutrients with environmental conditions (Liu *et al*., 2010) [20]. Braimoh and Vlek (2004) [5] has shown the changes in land use, through altering the structure and functioning of ecosystems and influencing the 15 biogeochemical cycle, could drive changes in soil properties and land productivity, resulting in further changes in soil quality and landscape over time and space. Forest land is rapidly converted into agriculture or pastureland. Decomposition of native organic matter in soil is mainly governed by microbes and the rate of decomposition varies with the quality of substrate available to soil microbes which clearly depends on land use system, thus C mineralization also varies with different land use system.

Soils under particular land use system may affect physicochemical properties which may modify fertility status and nutrient availability to plants (Sharma *et al*., 2013) [31].

Materials and Method

1. Study site

Based on the proposed cropping land use system twelve (12) different villages under Kohima district of Nagaland are selected as the study site. The total geographical area of the Kohima district is around 1,463 sq.km. It is located at 25º40′28″N latitude and 94°06′39″ E longitude with elevation of 1,261 m. The mean annual rainfall ranges from 1500 mm to 3000 mm with an average of about 2000 mm approximately. For the proposed investigation five land use system are being chosen they are Orchard (Orange), Plantation (Banana), Cereal, Vegetable, Spice.

2. Soil sample collection and analysis

Soil samples were collected from twelve (12) different villages from the soil surface (0-15 cm). Five (5) composite soils samples were collected from each land use system of each village. A total of 60 composite soil samples were collected and processed for subsequent analysis of soil physicochemical properties for the proposed investigation. The collected soil sample were air dried, passed through 2 mm sieve and stored in a polythene bag for further analysis. The soil pH was determined in (1:2.5) water suspension, using glass electrode pH meter as described by (Richard, 1954) [28]. EC of the soil was obtained in soil water (1:2) extract using conductivity meter (Richard, 1954) [28]. CEC of the soil was determined by leaching of soil with 1N ammonium acetate (NH4OAC) at pH 7.0 (Chapman, 1965) [8]. Organic carbon of the soil was determined by Walkley and Black's wet digestion method and expressed in percentage as described by Jackson (1973) [13]. Available N content in the soil was determined by using alkaline potassium permanganate method (Subbiah and Asija, 1956) [32]. Available P content in the soil was determined by using Bray's and Kurtz No-1 method (Bray and Kurtz, 1945) [6]. Available K content in the soil was extracted with neutral normal ammonium acetate (pH 7.0). Available S content in the soil was estimated by turbimetric method using extractant solution (0.15% CaCl2). Exchangeable Ca and Mg content in the soil was estimated by Versanate method (Gupta, 2007) [12]. The soil texture was determined by International Pipette method described by Piper (1966) [25]. Soil colour was determined by Munsell soil colour chart. Bulk density of the soil was obtained by dividing weight of soil with the volume of soil as reported by Chopra and Kanwar (1976) [11]. Particle density of the soil was obtained by Pycnometer method (Baruah and Barthakur, 1997) [3]. Porosity of the soil was determined by calculating from the bulk density and particle density. Total microbial biomass carbon (SMBC) was determined by following the chloroform fumigation extraction method. Soil respiration was estimated following the alkali absorption method (AA-method) described by Kirita (1971) [16]. The nutrient index was worked out by using the formula suggested by Biswas and Mukherjee (1989) [4].

Results and Discussion

a) Effect of land use practices on physical properties of soil

The bulk density of the soils under cereal, orchard, banana plantation, spice and vegetable land use systems varied from 1.03 to 1.22, 1.03 to 1.16, 1.07 to 1.23, 1.03 to 1.23 and 1.03 to 1.23 g cm^{-3} with a mean value of 1.12, 1.10, 1.16, 1.13 and 1.14 g cm^{-3}, respectively. The highest mean value 1.16 g cm^{-3} was observed in banana plantation land use and the lowest mean value 1.10 g cm^{-3} was observed in orchard land use. Low bulk densities could be due to high organic matter present in the soil. Similar results were also reported by Chaudhary *et al.* (2005) [9]. The particle density of the soils under cereal, orchard, banana plantation, spice and vegetable land use systems varied from 2.41 to 2.50, 2.44 to 2.53, 2.42 to 2.50, 2.44 to 2.48 and 2.44 to 2.53 g cm^{-3} with a mean value of 2.46, 2.47, 2.44, 2.47 and 2.47 g cm^{-3}, respectively. Orchard, spice and vegetable land use recorded the highest mean value 2.47 g cm^{-3} and banana plantation land use recorded the lowest mean value 2.44 g cm^{-3}. These results are in agreement with the findings of Amenla. (2007) [1]. The porosity of the soils under cereal, orchard, banana plantation, spice and vegetable land use systems varied from 51.61 to 57.79, 51.22 to 58.30, 49.59 to 56.80, 49.59 to 58.47 and 49.80 to 58.13% with a mean value of 54.41,55.02, 53.12, 54.36 and 53.76%, respectively. Highest mean value 55.02% was observed under orchard land use and the lowest mean value 53.12% was observed under banana plantation land use. Similar findings were also reported by Sharma *et al.* (2012) [30]. The sand, silt and clay in the soils of Kohima district under cereal, varied from 27.7 to 52.6, 21.13 to 384 and 23.37 to 49.67 with mean of 36.28, 30.94, and 32.33%, respectively. The sand, silt and clay under orchard varied from 21.73 to 53.31, 25.7 to 40.2, and 26.9 to 40.46%, respectively. The sand, silt and clay under banana plantation were 27.70 to 51.80, 21.39 to 38.4, 26 to 37.6% with mean 41.66, 27.67 and 30.58% respectively. The sand, silt and clay under spice ranged from 29.1 to 50.48, 22.6 to 37.64, 25.8 to 38.5% with mean 31.46, 39.24 and 29.26%, respectively. The sand, silt and clay under vegetable land use varied from 27.7 to 46, 27 to 40.2, 27.38 to 38.73% with mean 35.42, 32.93 and 31.63%, respectively. Similar finding reported by Raychauduri *et al*. (1963) [27].

b) Effect of land use practices on chemical properties of soil

All the soils of Kohima district under cereal, orchard, banana plantation, spice and vegetable land use systems are acidic in nature. The pH of the soils of different villages under cereal, orchard, banana plantation, spice and vegetable land use varied from 4.63 to 5.53, 4.67 to 5.68, 4.68 to 5.88, 4.68 to 5.96 and 4.38 to 5.28, respectively with a mean value of 4.89, 5.17, 5.05, 5.14 and 4.98 respectively. The highest mean value 5.17 was observed in orchard land use system while the lowest mean value 4.89 was observed in cereal land use system. Rice straw/stubble is known to decrease soil pH which may be the result of lower pH in cereal (rice) land use. Higher pH in orchard land use system is in agreement with the findings of Loria *et al*. (2016) [22] and Langnyei Angh (2017). Electrical conductivity (EC) of the soils of Kohima district under cereal, orchard, banana plantation, spice and vegetable land use varied from 0.11 to 0.32, 0.06 to 0.23, 0.03 to 0.31, 0.06 to 0.24 and 0.04 to 0.32 dSm^{-1} with a mean value of 0.18, 0.14, 0.19, 0.15 and 0.19 dSm^{-1}. Thus, it indicates that all the soil samples from all the five land use systems fell under the normal category of electrical conductivity. Similar findings were reported by Amenla *et al*. (2010) [2]. The CEC of the soils under cereal, orchard, banana plantation, spice and vegetable land use varied from 9 to 20, 9 to 24, 9 to 20, 8 to 20 and 9 to 23 [cmol (P+) kg^{-1}], respectively with a mean of 15, 16, 14, 12 and 15 [cmol (P+) kg^{-1}]. Among all the land use systems, the soils of orchard land use system showed the highest mean, while the lowest mean was found in spice land use system which might be due to higher amount of organic carbon. (Rudramorthy *et al*., 2007) [29]. The soil organic carbon content of the soils under cereal, orchard, banana plantation, spice and vegetable land use system varied from 0.80 to 2.28, 1.93 to 2.72, 0.78 to 2.24, 0.75 to 2.24 and 0.97 to 2.54%, respectively with a mean value of 1.61, 2.08, 1.52, 1.56 and 1.74%. The highest mean value 2.08% was observed in orchard land use while the lowest mean value 1.52% was observed in banana plantation land use. Similar results were reported by Jing *et al*. (2012) [12] and Chen *et al*. (2011) [10]. This may be due to accumulation of tree leaves and above biomass addition in orchard. The nutrient index (NI) for organic carbon was 3.0 for all the five land use systems which indicated that the soils of the district had high fertility status. The available nitrogen of the soils of Kohima district under cereal, orchard, banana plantation, spice and vegetable land use system varied from 282.7 to 439.0, 337.4 to 602.1, 276.3 to 464.1, 318.7 to 439.0 and 326.1 to 489.2 kg ha-1, respectively with a mean value of 364.3, 432.8, 326.3, 358.2 and 402.2 kg ha-1. Nutrient index (NI) for available nitrogen was 2.00, 2.08, 2.00, 2.00 and 2.00 for the soils under cereal, orchard, banana plantation, spice and vegetable land use systems which indicated that the soils of the district are medium in available nitrogen. Orchard soils had a higher amount of available nitrogen than other soils. Similar finding given by Tripathi *et al*. (2007) [34]. The available phosphorus content of the soils under cereal, orchard, banana plantation, spice and vegetable land use systems varied from were 11.7 to 24.1, 9.8 to 24.8, 9.6 to 23.9 and 11.1 to 24.4 kg ha^{-1} with a mean value of 17.7, 16.8, 18.2, 18.1 and 18.6 kg ha^{-1}, respectively. The nutrient index (NI) for available phosphorus was 2.00, 1.92, 1.02, 2.00 and 2.00 for the soils under cereal, orchard, banana plantation, spice and vegetable land use systems, respectively. This indicated that the soils of the district are medium in available phosphorus. Kumar *et al*. (2006) [17] also reported medium to high content of available phosphorus. The available potassium of the soils under cereal, orchard, banana plantation, spice and vegetable land use systems varied from 112 to 268.8, 121.5 to 282.2, 117.3 to 256.5, 132.68 to 278.9 and110.2 to 256.5 kg ha^{-1} with a mean value of 198.1, 212.9, 190.2, 212.1 and 192.0 kg ha^{-1}, respectively. The nutrient index (NI) for available potassium was 2.00, 2.08, 2.00, 2.00 and 2.00 for the soils under cereal, orchard, banana plantation, spice and vegetable land use systems, respectively. This indicated that the soils of the district are medium in available potassium. The available sulphur of the soils under cereal, orchard, banana plantation, spice and vegetable land use systems varied from 11.2 to 30.8, 19.5 to 37.8, 11 to 38.2, 10.7 to 33.5 and 21.6 kg ha^{-1} with a mean value of 20.5, 27.5, 19.8, 20.1 and 21.6 kg ha^{-1}, respectively. The nutrient index (NI) for available sulphur was 1.58, 1.75, 1.67, 1.67 and 1.58 for the soils under cereal, orchard, banana plantation, spice and vegetable land use systems, respectively. This indicated that the soils of the district are medium in available sulphur. The exchangeable calcium of the soils under cereal, orchard, banana plantation, spice and vegetable land use systems varied from 1.19 to 1.86, 1.19 to 1.95, 1.19 to 1.83, 1.28 to 1.88 and 1.2 to 1.95 [cmol (P+) kg^{-1}], with a mean value of 1.45, 1.72, 1.51, 1.58 and 1.61 [cmol (P+) kg^{-1}], respectively. Similar range of values was reported by Loktimen Lonchari (2018) [21] and Namei (2015) [23]. The exchangeable magnesium of the soils under cereal, orchard, banana plantation, spice and vegetable land use systems varied from 0.30 to 0.92, 0.43 to 0.96, 0.41 to 0.87, 0.38 to 0.88 and 0.39 to 0.91 [cmol (P+) kg-1] with a mean value of 0.49, 0.68, 0.61, 0.68 and 0.54 [cmol (P+) kg-1], respectively. Similar range were also reported by Loktimen Longchari (2018) [21].

c) Effect of land use practices on biological properties of soil

The soil microbial biomass carbon of the soils under cereal, orchard, banana plantation, spice and vegetable land use systems varied from 142.1 to 253.9, 262.07 to 361.64, 107.76 to 261.57, 153.9 to 283.99 and 164.3 to 293.97 µg/g with a mean value of 179.23, 286.11, 144.70, 200.38 and 232.15 µg/g, respectively. Orchard land use system recorded highest mean value while banana plantation land use system recorded lowest mean value. This may be due to higher organic matter in orchard land use system which allows higher microbial activity. This is in accordance with the reasoning given by Powlson *et al*. (1987) [26]. The soil respiration of the soils under cereal, orchard, banana plantation, spice and vegetable land use systems varied from 33.12 to 59.29, 37.44 to 68.64, 24.24 to 48.24, 29.04 to 50.14 and 34.56 to 63.12 µg CO2/g soil/hour with a mean value of 45.64, 51.86, 32.34, 39.88 and 48.54 µg CO2/g soil/hour, respectively. The highest mean value was observed under orchard land use while the lowest mean value was observed under banana plantation land use. It may be due to higher organic carbon because it can supply substrates to microbial substrates. Similar findings were reported by Liming Lai *et al*. (2012) [18].

Table 1: Impact of different land use systems on bulk density

Sl. No	Name of the block	Name of the village	Bulk density (g cm^{-3})				
			Cereal	Orchard	Plantation	Spice	Vegetable
1.	Kohima	Chiedema	1.21	1.12	1.21	1.12	1.13
		Sechu	1.20	1.12	1.08	1.11	1.23
		Kiruphema	1.08	1.11	1.07	1.13	1.23
2.	Jakhama	Jakhama	1.03	1.03	1.21	1.20	1.11
		Viswema	1.22	1.11	1.10	1.03	1.23
		Kigwema	1.11	1.11	1.09	1.19	1.14
3.	Chiephobozou	Phezha	1.03	1.03	1.23	1.20	1.11
		Nachama	1.20	1.11	1.13	1.10	1.07
		Chechama	1.11	1.13	1.11	1.23	1.12
4.	Tseminyu	Tseminyu	1.12	1.16	1.23	1.08	1.20
		Kashanyu	1.14	1.12	1.15	1.09	1.03
		Terogvunyu	1.09	1.20	1.08	1.03	1.12
		Range	1.03-1.22	1.03-1.16	1.07-1.23	1.03-1.23	1.03-1.23
		Mean	1.12	1.10	1.16	1.13	1.14

Table 2: Impact of different land use systems on particle density

Sl. No	Name of the block	Name of the village	Particle density (g cm^{-3})				
			Cereal	Orchard	Plantation	Spice	Vegetable
1.	Kohima	Chiedema	2.50	2.48	2.47	2.48	2.45
		Sechu	2.48	2.46	2.48	2.47	2.46
		Kiruphema	2.48	2.47	2.44	2.46	2.50
2.	Jakhama	Jakhama	2.48	2.47	2.42	2.46	2.50
		Viswema	2.46	2.52	2.45	2.48	2.48
		Kigwema	2.41	2.44	2.46	2.48	2.46
3.	Chiephobozou	Phezha	2.44	2.43	2.44	2.50	2.47
		Nachama	2.48	2.44	2.26	2.44	2.43
		Chechama	2.42	2.53	2.50	2.46	2.44
4.	Tseminyu	Tseminyu	2.46	2.48	2.44	2.46	2.53
		Kashanyu	2.46	2.50	2.42	2.46	2.45
		Terogvunyu	2.46	2.46	2.44	2.45	2.50
		Range	2.41-2.50	2.44-2.53	2.42-2.50	2.44-2.48	2.44-2.53
		Mean	2.46	2.47	2.44	2.47	2.47

Table 3: Impact of different land use systems on pH of soil

Sl. No	Name of the block	Name of the village	pH				
			Cereal	Orchard	Plantation	Spice	Vegetable
1.	Kohima	Chiedema	4.72	5.01	4.74	4.86	4.82
		Sechu	5.21	5.16	5.31	4.97	5.23
		Kiruphema	4.64	4.83	5.95	5.96	5.24
2.	Jakhama	Jakhama	5.23	5.68	5.88	5.08	4.38
		Viswema	5.53	4.88	4.69	5.43	5.21
		Kigwema	4.64	5.60	4.74	5.24	5.22
3.	Chiephobozou	Phezha	4.63	5.07	4.90	4.94	5.01
		Nachama	4.82	5.55	5.02	4.68	5.28
		Chechama	4.55	4.99	4.68	5.54	4.69
4.	Tseminyu	Tseminyu	4.76	5.54	4.76	5.00	5.01
		Kashanyu	5.14	4.67	5.03	5.14	4.82
		Terogvunyu	4.86	5.02	4.86	4.86	4.89
		Range	4.63-5.53	4.67-5.68	4.68-5.88	4.68-5.96	4.38-5.28
		Mean	4.89	5.17	5.05	5.14	4.98

Table 4: Impact of different land use systems on available nitrogen

Sl. No	Name of the block	Name of the village	Available nitrogen kg ha^{-1}				
			Cereal	Orchard	Plantation	Spice	Vegetable
1.	Kohima	Chiedema	352.0	472.1	338.7	376.3	426.5
		Sechu	413.9	426.5	353.2	413.9	464.1
		Kiruphema	439.0	514.3	338.7	426.5	337.4
2.	Jakhama	Jakhama	401.4	337.4	351.2	326.1	489.2
		Viswema	338.2	388.9	326.1	391.7	441.3
		Kigwema	388.9	287.3	464.1	351.2	396.4
3.	Chiephobozou	Phezha	401.4	383.7	288.5	376.3	338.7
		Nachama	325.3	430.6	289.0	338.5	397.2
		Chechama	326.1	429.5	313.7	318.7	353.2
4.	Tseminyu	Tseminyu	326.1	592.7	276.3	336.4	464.1
		Kashanyu	282.7	527.8	287.6	338.7	439.0
		Terogvunyu	376.32	402.4	288.5	439.0	326.1
		Range	282.7-439.0	337.4-592.7	276.3-464.1	318.7-439.0	326.1-489.2
		Mean	364.3	432.8	326.3	358.2	402.2

Table 5: Impact of different land use systems on available phosphorus

Sl. No	Name of the block	Name of the village	Available phosphorus kg ha^{-1}				
			Cereal	Orchard	Plantation	Spice	Vegetable
1.	Kohima	Chiedema	11.1	19.0	19.0	11.2	17.8
		Sechu	17.9	22.1	20.4	13.6	21.3
		Kiruphema	19.2	23.6	23.9	23.9	16.2
2.	Jakhama	Jakhama	24.8	14.3	22.8	14.2	22.4
		Viswema	12.2	14.0	18.7	16.7	24.1
		Kigwema	23.5	20.8	20.8	19.3	19.0
3.	Chiephobozou	Phezha	15.4	18.9	14.9	12.2	11.8
		Nachama	21.3	24.4	23.1	22.1	11.0

		Chechama	13.8	17.2	9.6	21.0	11.7
4.	Tseminyu	Tseminyu	18.4	22.0	13.6	15.6	16.6
		Kashanyu	14.7	11.1	15.2	18.8	19.7
		Terogvunyu	9.8	15.4	16.8	14.8	20.3
		Range	9.8-24.8	11.1-24.4	9.6-23.9	11.2-23.9	11.7-24.1
		Mean	16.8	18.6	18.2	18.1	17.7

Table 6: Impact of different land use systems on available potassium

Sl. No	Name of the block	Name of the village	Available potassium kg/ha^{-1}				
			Cereal	**Orchard**	**Plantation**	**Spice**	**Vegetable**
1.	Kohima	Chiedema	250.8	250.8	215.0	192.6	147.8
		Sechu	165.3	240.6	224.0	201.6	256.5
		Kiruphema	268.8	282.2	237.0	278.9	225.2
2.	Jakhama	Jakhama	249.2	241.9	190.6	132.7	241.6
		Viswema	219.6	190.6	256.5	173.7	110.2
		Kigwema	234.8	121.5	240.8	192.6	174.7
3.	Chiephobozou	Phezha	178.7	147.8	201.6	212.7	170.2
		Nachama	112.0	255.8	124.8	224.0	161.3
		Chechama	158.8	264.3	162.4	254.6	220.6
4.	Tseminyu	Tseminyu	202.6	228.4	117.3	213.2	237.0
		Kashanyu	199.1	173.7	173.7	174.7	224.0
		Terogvunyu	136.9	156.8	138.8	264.3	134.4
		Range	112-268.8	121.5-282.2	117.3-256.5	132.68-278.9	110.2-256.5
		Mean	198.1	212.9	190.2	212.1	192.0

Table 7: Impact of different land use systems on soil microbal biomass carbon (SMBC)

Sl. No	Name of the block	Name of the village	SMBC of sols (µg/g)				
			Cereal	**Orchard**	**Plantation**	**Spice**	**Vegetable**
1.	Kohima	Chiedema	153.90	292.07	158.97	156.31	287.24
		Sechu	219.05	263.30	156.31	158.97	293.97
		Kiruphema	277.63	297.07	130.83	203.68	283.99
2.	Jakhama	Jakhama	253.90	293.97	132.03	132.03	264.30
		Viswema	161.64	262.07	175.65	271.71	127.65
		Kigwema	148.92	287.24	261.57	164.30	213.75
3.	Chiephobozou	Phezha	156.31	264.30	142.10	277.53	164.30
		Nachama	142.10	277.63	113.75	254.54	261.57
		Chechama	135.83	283.99	127.65	153.90	156.31
4.	Tseminyu	Tseminyu	156.31	361.64	107.76	191.24	191.24
		Kashanyu	153.90	287.97	107.76	156.31	277.13
		Terogvunyu	191.24	262.07	121.97	283.99	264.30
		Range	142.1-253.9	262.07-361.64	107.76-261.57	153.9-283.99	164.3-293.97
		Mean	179.23	286.11	144.70	200.38	232.15

Conclusion

From the study it can be concluded that the soils were moderate to strongly acidic in reaction with high in organic carbon, medium in available N, P, K and S. The soil pH, CEC, organic carbon, available N, K, S, exchangeable calcium and magnesium, porosity, soil microbial biomass carbon (SMBC), soil respiration were highest in orchard land use system. Lower nutrient content was observed in ginger (spice) and banana (plantation) land use system. Management of the mentioned land use with companion plants or mulching is recommended. Fruit based land use systems are a good alternate land use system and are even practised for the rehabilitation of degraded soils.

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