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# A study on the physicochemical properties of soils of Jhum and terrace fields under rice cultivation in Kiphire district of Nagaland

**Kihika G[1*], Yabi Gadi[1], Sentimenla[2], AK Singh[1], SK Sharma[1]**
[1] Department of Agricultural Chemistry and Soil Science, School of Agricultural Sciences and Rural Development, Nagaland University, Medziphema, Nagaland, India
[2] Subject Matter Specialist, Soil Science, KVK Nagaland University, Lumami, Nagaland, India

**Abstract**
For the proposed study, soil samples were collected from 15 villages under jhum and terrace rice field under Sitimi block of Kiphire district. The soil pH of different villages under Kiphire district ranged from 5.03- 6.08 indicating moderate to slightly acidic condition. The values of OC were found to be very high too high in both Jhum and Terrace where it ranged from 0.96-5.86%. CEC of the soils varied from 28.99-2.80 c mol ($p^+$) $kg^{-1}$. Bulk density and Particle density of the soils varied from 0.80-1.37g $cm^{-3}$ and 2.23-2.66 g $cm^{-3}$ respectively. The soil available N, P and K ranged from 150.53-602.11 kg $ha^{-1}$, 4.10-28.21 kg $ha^{-1}$ and 121.50-218.27 kg $ha^{-1}$ respectively.

**Keywords:** jhum, terrace, pH, OC, bulk density, particle density, porosity, organic carbon, cation exchange capacity

## Introduction

Soil – a nature's marvel – is one among the vital natural resources on whose health the survival of all mortals depends. The term soil is derived from the Latin word 'solum', which means 'ground or floor'. **"**Healthy soils are the foundation for food, fuel, fiber and even medicine (FAO, 2015). Soil performs many agricultural and non- agricultural functions. It serves as a medium for plant growth, store house of water and nutrients which are required for plant growth. It is an important habitat for a wide range of beneficial and harmful micro-organisms. Besides agriculture, it serves as a base for different types of engineering structures. However as a result of man's activities there is adverse effect on various physical and chemical properties of the soil. These activities include intensive cultivation, deforestation, excessive use of fertilizer and pesticides, over grazing, urbanization, pollution from domestic and industrial waste etc. In Nagaland, jhum cultivation is one of the important factors that contribute to the soil degradation. Jhum cultivation when practiced with a cycle of 15 to 20 years does not possess any threat as sufficient time for regeneration of forest and soil fertility is provided. However due to population pressure the area under jhum has been increased but the cycle has been reduced to less than 10years which has adverse impact on both the agricultural yield as well as soil properties. As a result, modern agriculture is facing a challenge of producing sufficient food for the ever increasing population in a diminishing area of land under cultivation without depleting the resources for future generation *i.e.* sustainable agriculture. Thus in order to overcome this challenge, modern agriculture should have a very in-depth knowledge about the physical and chemical properties of soil such as the fertility status, soil reaction, organic matter content etc. so that the management practices can be advocated based on the requirement of the specific crop. Thus keeping in mind the above points, research study based on the physico-chemical properties of soils under jhum and terrace rice fields in kiphire district of Nagaland were conducted.

## Materials and Methods

The district is located between the latitude 25°54'N to 25°9'N and longitude 94°47'E to 94°78'E having total geographical area of 1255 sq. kms, elevation of 896.42 meters above mean sea level and temperature ranges from 27 – 37°Celsius during winter and summer respectively Monsoon period extends from June to September and sometimes up to October with average rainfall of 1500 to 1800mm. Sitimi block under Kiphire district was selected for study by random sampling. A total of fifteen villages were selected by random sampling. Soil samples were collected from the paddy fields of jhum and terrace to study the significant difference with respect to soil physicochemical properties. Collected soil samples were air-dried. Stones, pebbles, plant roots etc were removed and the soil were grounded and passed through a 2 mm sieve. About 500gm of processed soil were stored in a polyethene bag after labeling it properly.

The pH of all the soil samples were determined in the soil water (1:2.5) suspension, using Glass Electrode pH Meter (Jackson, 1973) [9]. Bulk Density was determined by dividing the weight of soil with the volume of soil as described by Chopra and Kanwar (1976). Particle Density was determined by the Pycnometer method as described by Baruah and Barthakur (1997) [2]. Porosity of the soil was obtained by using the relation between Bulk Density and Particle Density as -Total Porosity (%) = (1- Bulk Density/ Particle Density) 100. Organic Carbon was estimated by rapid titration method of Walkely and Black as described by Jackson (1973) [9]. Cation Exchange Capacity of the soil was determined using $NH_4OAC$ method at pH 7.0 by Bower *et al.* (1952) [4]. The available Nitrogen content of the soil was estimated by Alkaline Potassium Permanganate Method by Subbiah and Asija (1956) [17]. Available phosphorus was

determined by Bray's I Method (Bray and Kurtz, 1945) as described by Baruah and Barthakur (1997) [2]. Available Potassium was extracted from the soil with neutral ammonium acetate (Jackson, 1973) [9] and estimated Flame Photometrically and the results obtained were statistically analysed using MS Excel.

## Results and Discussion

Chemical properties of soils.

The details of the values of different chemical properties of soils under jhum and terrace rice fields are given in Table 1. The soil pH of different villages under Kiphire district ranged from 5.03-5.40 in jhum indicating moderately acidic condition, while that from the terrace ranged from 5.29- 6.08 indicating moderate to slightly acidic conditions. pH of the soils was found to be lower in jhum as compared to terrace; the higher acidity in jhum may be due to the higher amount of organic matter present in the soil which releases organic acids resulting in leaching of bases in the soils of higher altitude due to heavy rainfall (Chase *et al*.,2014) [5]. Singh *et al.* (2011) [16] also reported lower values of pH in jhum over lowland paddy as the soil pH varied due to variation in the land use systems.

Organic Carbon content of the soil under jhum and terrace cultivation ranged from 5.86- 3.70 % and 3.42- 0.96 % respectively. Similar values of OC 2.23 to 6.25% were reported in Longleng district of Nagaland by Phom (2014). The values of OC was found to be very high too high in both jhum and terrace, however the mean values of OC were found to be higher in jhum (4.83) as compared to terrace (1.79). This may be due to the higher organic matter content in the *jhum* fields. The higher organic carbon status in the soil might be due to the lower temperature in the higher altitudes which retards the rate of decomposition of organic matter (Bhattacharyya *et al*.,2000) and lower OC in terrace due to intensive cultivation annually. Zhang *et al*., (2015) [18] also reported similar observation on soil organic carbon content in a sloping terrace landscape. The CEC of the soil samples ranged from 2.80-13.04 cmol ($p^+$) $kg^{-1}$ in jhum and 15.94-28.99 cmol ($p^+$) $kg^{-1}$ in terrace. Higher value of CEC was observed in terrace as compared to jhum. This is due to the higher amount of clay content in the soils under terrace rice cultivation. Sharma *et al*. (2013) [15] also reported similar findings in rice land use system and Patton *et al.* (2007) [11] under different land use pattern in Nagaland.

## Physical Properties of Soils

The details of various physical properties of soils under jhum and terrace are given in the table 2. Bulk density of the soil samples ranged from 0.80-1.25 g $cm^{-3}$ in the jhum fields and 1.13-1.37 g $cm^{-3}$ in terrace. Phom (2014) reported similar values of bulk densities (*i.e.*1.1-1.3 g $cm^{-3}$) from Longleng district of Nagaland. The lower bulk density in jhum is attributed to the higher amount of organic matter in the fields due to the long fallow period practiced in jhum cultivation. Saplalrinliana *et al.* (2016) [14] reported similar findings while studying the jhum fields in Nagaland and Mizoram. Particle density of the soil samples varied from 2.23-2.51 g $cm^{-3}$ for jhum and 2.35-2.66 g $cm^{-3}$ for terrace. Patton (2015) [12] reported similar Particle density values in the soils under different land use system in Wokha district of Nagaland. The mean of particle density was found to be lower in the jhum fields (2.38 g $cm^{-3}$) as compared to the terrace (2.53 g $cm^{-3}$). Possible explanation for this result is that the jhum soil contains more organic matter which has low density, whereas in terrace the percentage of clay having greater density is higher. Amenla (2007) reported similar observations in the soils of Mokokchung district of Nagaland. The porosity (%) of the soil samples collected for the jhum fields varied from 48.94- 65.96 % and the porosity in the terrace fields ranged from 41.70-56.70 %. In general the mean of porosity of jhum was found to be higher with 55.26% pore space and 51.05% pore space in terrace. The greater pore space in jhum soils is attributed to the organic matter content in the jhum fields, which on decomposition releases polysaccharides which binds the soil together into stable aggregate which in turn increases the total pore space in soils.

Soil fertility

The soil fertility status of jhum and terrace fields are shown in table 3. The Available N in the soil ranged from 301.06- 602.11 kg $ha^{-1}$ in jhum and 489.25- 150.53 kg $ha^{-1}$ in terrace field. The high available N in the jhum is mainly due to the high organic matter content in the soils. Low value of available N in terrace field was also reported by Sharma *et al.* (2013) [15]. Available P ranged from 8.21-28.21 kg $ha^{-1}$ in jhum and 4.10-10.26 21 kg $ha^{-1}$ in terrace field. The available P in the soil varied from high to low in jhum and medium to low in terrace. The mean of available P was higher in jhum (11.98 kg $ha^{-1}$) as compared to that of terrace (7.21 ka $ha^{-1}$). The higher value of available P in jhum fields can be attributed to the incorporation of P from the slashed biomass in the form of ash as indicated by Giardina *et al*. (2000) [8]. Saplalrinliana *et al.* (2016) [14] also reported increased in available P in burnt jhum field. Available K in the soil ranged from 161.28-218.27 kg $ha^{-1}$ in jhum and 121.5-153.77 kg $ha^{-1}$ in terrace field. The mean value of available K was higher in jhum (196.07 kg $ha^{-1}$) as compared to terrace (140.45 kg $ha^{-1}$). Slightly higher value of available K in jhum may be due to burning of slashed vegetation (Singh *et al.*, 2011) [16]. Neff *et al*., 2005 [10] also observed increased in the soil available K due to burning. Neff *et al*. (2005) [10] have however reported about a mild shift in the K content after burning Neff *et al*. (2005) [10] have however reported about a mild shift in the K content after burning Neff *et al*. (2005) [10] have however reported about a mild shift in the K content after burning

**Table 1:** Chemical properties of the soils under jhum and terrace rice fields.

| Sl.no | Name of the village | Ph | | OC (%) | | CEC [cmol (p+) kg-1] | |
|---|---|---|---|---|---|---|---|
| | | jhum | terrace | jhum | terrace | jhum | terrace |
| 1 | Shothumi | 5.14 | 5.41 | 5.10 | 2.28 | 10.87 | 26.09 |
| 2 | Phisami | 5.03 | 5.32 | 5.86 | 2.50 | 10.14 | 21.74 |
| 3 | Lukhami | 5.21 | 5.90 | 4.20 | 1.31 | 10.87 | 24.64 |
| 4 | Yezutu | 5.35 | 5.60 | 3.70 | 2.10 | 11.59 | 26.81 |
| 5 | Sitimi | 5.17 | 5.80 | 5.04 | 1.71 | 5.80 | 20.29 |
| 6 | Nitoi | 5.33 | 6.02 | 4.10 | 1.03 | 8.70 | 19.57 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 7 | Thazuvi | 5.32 | 5.75 | 4.14 | 1.95 | 10.14 | 21.74 |
| 8 | Langzar | 5.20 | 5.52 | 4.20 | 1.52 | 5.80 | 17.39 |
| 9 | Natsami | 5.12 | 6.08 | 5.82 | 0.96 | 8.70 | 18.84 |
| 10 | New Monger | 5.40 | 5.62 | 3.46 | 1.50 | 13.04 | 28.99 |
| 11 | Old Monger | 5.06 | 5.29 | 5.86 | 3.42 | 2.80 | 15.94 |
| 12 | Thangthure | 5.12 | 5.54 | 5.82 | 1.50 | 4.35 | 16.38 |
| 13 | Yangphire | 5.10 | 5.90 | 5.82 | 1.08 | 5.80 | 17.39 |
| 14 | Honito | 5.14 | 5.70 | 5.10 | 1.21 | 8.70 | 23.19 |
| 15 | Tsungar | 5.18 | 5.50 | 4.26 | 2.82 | 10.14 | 21.74 |
| Mean | | 5.19 | 5.66 | 4.83 | 1.79 | 8.50 | 21.38 |

**Table 2:** Physical properties of the soil under jhum and terrace rice fields.

| Sl.no | Name of the village | Bulk density(g cm-3) | | Particle density (g cm-3) | | Porosity (%) | |
|---|---|---|---|---|---|---|---|
| | | jhum | terrace | jhum | terrace | jhum | terrace |
| 1 | Shothumi | 1.20 | 1.27 | 2.35 | 2.54 | 48.94 | 50.00 |
| 2 | Phisami | 0.95 | 1.13 | 2.35 | 2.61 | 59.57 | 56.70 |
| 3 | Lukhami | 1.03 | 1.21 | 2.35 | 2.42 | 56.17 | 50.00 |
| 4 | Yezutu | 1.10 | 1.37 | 2.40 | 2.35 | 54.17 | 41.70 |
| 5 | Sitimi | 1.16 | 1.22 | 2.33 | 2.51 | 50.21 | 51.39 |
| 6 | Nitoi | 1.12 | 1.26 | 2.40 | 2.40 | 53.33 | 47.50 |
| 7 | Thazuvi | 0.85 | 1.24 | 2.23 | 2.55 | 61.88 | 51.37 |
| 8 | Langzar | 0.92 | 1.18 | 2.38 | 2.39 | 61.34 | 50.63 |
| 9 | Natsami | 0.96 | 1.20 | 2.35 | 2.62 | 59.15 | 54.20 |
| 10 | New Monger | 0.80 | 1.15 | 2.35 | 2.61 | 65.96 | 55.94 |
| 11 | Old Monger | 0.80 | 1.15 | 2.40 | 2.56 | 50.83 | 51.56 |
| 12 | Thangthure | 1.18 | 1.24 | 2.51 | 2.61 | 50.20 | 49.81 |
| 13 | Yangphire | 1.25 | 1.31 | 2.50 | 2.66 | 55.60 | 55.64 |
| 14 | Honito | 1.11 | 1.18 | 2.48 | 2.60 | 52.42 | 51.54 |
| 15 | Tsungar | 1.21 | 1.28 | 2.38 | 2.45 | 49.16 | 47.76 |
| Mean | | 1.07 | 1.23 | 2.38 | 2.53 | 55.26 | 51.05 |

**Table 3:** Soil fertility under jhum and terrace rice fields.

| Sl.no | Name of the village | Available Nitrogen ((kg ha-1) | | Available Phosphorus (kg ha-1) | | Available Potassium (kg ha-1) | |
|---|---|---|---|---|---|---|---|
| | | jhum | terrace | jhum | terrace | jhum | terrace |
| 1 | Shothumi | 439.22 | 326.04 | 10.26 | 5.08 | 199.02 | 153.76 |
| 2 | Phisami | 602.11 | 263.42 | 8.21 | 5.05 | 218.27 | 153.54 |
| 3 | Lukhami | 351.23 | 188.16 | 11.54 | 8.46 | 193.76 | 133.52 |
| 4 | Yezutu | 301.06 | 238.34 | 19.47 | 6.51 | 173.00 | 143.81 |
| 5 | Sitimi | 439.04 | 225.79 | 10.26 | 8.46 | 196.77 | 143.01 |
| 6 | Nitoi | 325.79 | 150.53 | 14.62 | 9.49 | 189.02 | 132.26 |
| 7 | Thazuvi | 326.04 | 225.79 | 11.79 | 8.21 | 189.78 | 143.01 |
| 8 | Langzar | 363.78 | 213.25 | 11.03 | 6.41 | 196.77 | 136.77 |
| 9 | Natsami | 514.30 | 100.35 | 9.23 | 10.26 | 204.29 | 121.50 |
| 10 | New Monger | 288.16 | 188.16 | 28.21 | 6.67 | 161.28 | 136.32 |
| 11 | Old Monger | 639.74 | 489.25 | 8.46 | 4.10 | 207.52 | 153.77 |
| 12 | Thangthure | 539.39 | 188.16 | 8.72 | 6.41 | 207.52 | 135.70 |
| 13 | Yangphire | 526.85 | 150.53 | 8.46 | 9.23 | 207.52 | 132.56 |
| 14 | Honito | 489.25 | 188.16 | 9.23 | 7.69 | 199.78 | 133.52 |
| 15 | Tsungar | 413.95 | 351.23 | 10.26 | 6.16 | 196.77 | 153.76 |
| Mean | | 437.33 | 232.48 | 11.98 | 7.21 | 196.07 | 140.45 |

## Conclusion

From the study of physicochemical properties of soils under jhum and terrace rice cultivation, it is evident that the soils are acidic in reaction with low BD and sufficient amount of pore space. The Organic Carbon of the soils were high and major plant nutrient elements such as N was medium to high in jhum and low to medium in terrace, P was low to medium in jhum and low in terrace, K was medium in both jhum and terrace. In general the fertility status of jhum was significantly higher as compared to terrace. From the research data it is also evident that the soils of Kiphire district have problem of acidity which needs to be reclaimed by addition of recommended dose of $CaCO_3$ to obtain maximum benefit from the soil. Also for optimum crop production recommended dose of fertilizers may be applied in terrace fields where the NPK status is low.

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