Soil Analysis for its Physico - Chemical Parameters from Lirise Village, Angangba Village and Longkhim Town, Tuensang District, Nagaland

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Abstract: ***Soil fertility, physical properties and chemical properties of soil plays an important role in enhancing crop productivity. Therefore the determination of available nutrient, physical and chemical properties of soil is crucial. This can be achieved through a chemical analysis termed as soil analysis. Soil samples were collected from three places i. e. Longkhim town, Lirise village and Angangba village under Tuensang district of Nagaland for fertility determination. Available nitrogen, organic carbon, phosphorus, potassium, sulphur, p^H, water holding capacity, moisture content, chloride content and electrical conductivity were analyzed by laboratory method to determine the fertility status of the soil samples. Study suggests that nitrogen and organic carbon content is high, phosphorus and sulphur are low, chloride content is from low to high range where as potassium content is low in the studied soil samples. p^H values shows that the studied soils are acidic in nature and electrical conductivity values shows that the salinity effect is negligible. Nutrient index value shows low to high fertility status of soil samples. To increase the fertility status of these soils, study recommends the enhancement of elemental concentration by use of organic and inorganic fertilizers.***

Keywords: Electrical conductivity (EC), Nagaland, Nutrient index (NI), Soil organic matter (SOM), Tuensang, Water holding capacity (WHC).

1. Introduction

The earth's surface is covered by a thin layer of materials called soils which are essential for plants growth. Evaluation of fertility status of the soils of an area or a region is an important aspect in the context of sustainable agriculture (Singh and Mishra, 2012). Evaluation of soil fertility can be done through soil testing and the data thus obtained aids in determining the type and quantity of fertilizer for better and higher crop productivity. Basic plant nutrients such as P^H, calcium carbonate, available lime, organic matter, sulphur, WHC, and EC are determined by chemical soil analysis. When the essential plant nutrients are below the required amount needed by the plants for optimum yield it is considered deficiency. Plant deficiencies arise when a plant does not have enough of essential nutrient for growth. Phosphorus (P), potassium (K), chloride (Cl^{-}), sulphur (S), nitrogen (N), and other nutrients are required by the plant. The symptoms of these conditions will result in the form of poor yielding. Nutrients are lost by soil erosion, removal of crop, leaching, denitrification and volatilization. Erosion of soil results in loss of phosphorous. In acidic and alkaline soil, phosphorus can change to unavailable form. Potassium and ammonium can be fixed by clay materials. Aim of present work is to determine the fertility status of soil and comparison of the fertility status of three areas on the basis of nutrient index of Tuensang district i. e. Longkhim town, Lirise village and Angangba village. Cropping pattern, sequence of cropping related to soil, limiting of soils and environmental conditions also shows the insights of the status of quality of soil samples (Jayanthi et al., 2015). The soil fertility status of the soil differs according to the type of land use system (Singh et al., 2017). The physical and chemical properties determines suitability of soil for planned use and management requirements to keep it most productive to a limited extent, the fertility of a soil determine its possible uses and to large extent it yields (Jaiswal, 2004). Imbalance use of fertilizers, improper irrigation and various cultural practice deplete the soil quality (Medhe et al., 2012). Soil management practice includes site specific nutrient managements, increased use of organic nutrient sources, sustainable land uses and cropping system and appropriate agronomics (Denis et al., 2017). For getting maximum yield and high quality of product, determination of fertility status of agricultural land is important factor. Present study will enhance our understanding and knowledge of the soil of the studied area and use of land for healthy and maximum yield of the crops.

The following limits were used for classification of the soil of India on the basis of the values of soil test (Ramamoorthy and Bajaj, 1969).

Nutrient	Limits		
	Low	Medium	High
Organic carbon	Below 0.5%	0.5 - 0.75%	Above 0.75%
Available Nitrogen (kg ha^{-1})	Below 280	280 - 560	Above 560
Available P, (kg ha^{-1})	Below 36	36 - 68	Above 68
Available K (kg ha^{-1})	Below 120	120 - 240	Above 240

2. Study Areas

The study area is Longkhim town, Lirise village and Angangba village under Tuensang district and located in the eastern part of Nagaland. It is located at latitude - 26.2, Longitude - 94.8. Physiographically, Tuensang is covered with hills, high ridges, deep groves and narrow valley.

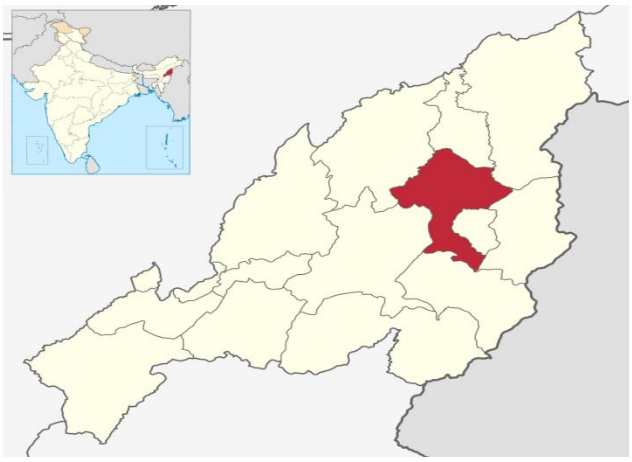

Figure 1: Map of Tuensang district

Area 1. Longkhim town

The soil sample is collected from Longkhim town. Samples were collected from three different part of the area to check the variation of different parameters present on the field of that particular area.

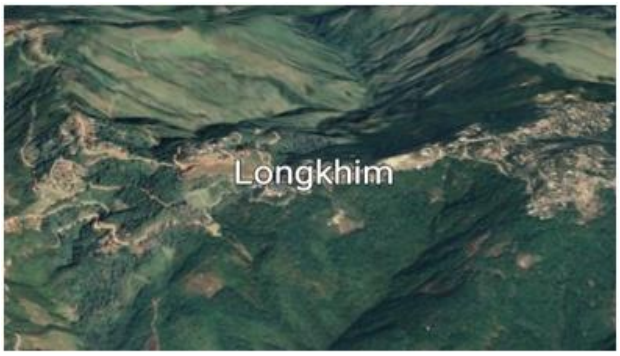

Figure 2: Location map of Longkhim town

Area 2. Lirise village

The samples were collected from Lirise village. Samples were collected from three different part of the area to check the variation of different parameters present on the field of that particular area.

Figure 3: Location map of Lirise village

Area 3. Angangba village

The soil samples were collected from Angangba village. Samples were collected from different part of the field to check the variation of different parameter present on the field of that area.

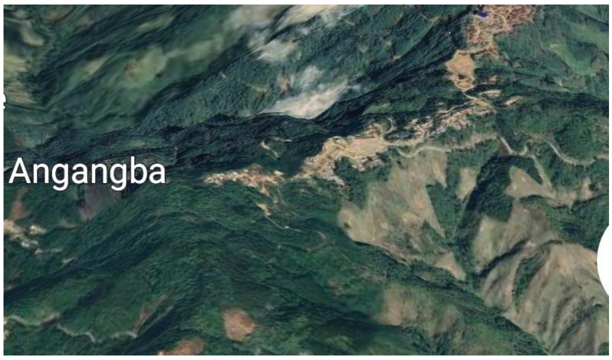

Figure 4: Location map of Angangba village

3. Materials and methods

The soils were collected from three region of Tuensang district of Nagaland namely; Longkhim, Lirise and Angangba. A total of nine samples, three from each region were collected. The collected samples were first air dried at 35^0C temperature. The air dried soil samples were then subjected to the removal of stones, pebbles, roots etc. After that, the soil clods were smashed and put through sieve. About 400 - 500 g of the processed soil samples was stored in a polythene bags for analysis.

Table 1: Showing the various parameters of soil sample analysis and methods.

Sl. No	Parameter	Method
1	pH	pH metry
2	Electrical conductivity	Conductometry
3	Moisture	Oven dry
4	WHC	Oven dry
5	O. C	Wet digestion
6	Available N	Micro - kjeldahl distillation unit
7	Available P	Spectrophotometry
8	Available K	Flame photometry
9	Available S	Spectrophotometry
10	Available Cl^-	Silver nitrate titration

The methods and techniques for acquiring soil samples differ depending on the sampling goal. The outcome of careful soil analysis can be just as excellent as the soil samples themselves. Soil sampling efficiency is determined by the care and competence with which soil samples are gathered. As a result, effort is taken to collect soil samples that are accurately representing the field.

4. Results

a) Soil pH

pH is scale used for measurement of the acidic and alkaline nature of a soil solution. Nutrient's solubility and availability in the soil is determined by pH values. The availability of nutrients for plant uptake is affected by the pH of the soil. Overall nutrient availability, crop tolerance, and soil microbial activity are best at pH 7. p^H affects all physical, biological and chemical properties of soil (Brady and Weil, 2002). p^H of different soil samples are shown in table 2 and graphically represented in fig 5.

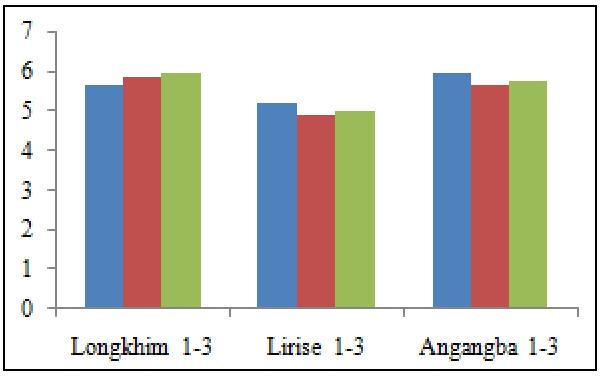

Figure 5: Graphical representation of pH values

b) Electrical conductivity

Electrical conductivity describes current flow in the soil and depends on total dissolved solids (TDS) in the soil. It is a good indicator of soil texture and water capacity, as well as nutrient availability and loss. The data obtained for EC of different soils are shown in table 2 and graphically represented in fig 6.

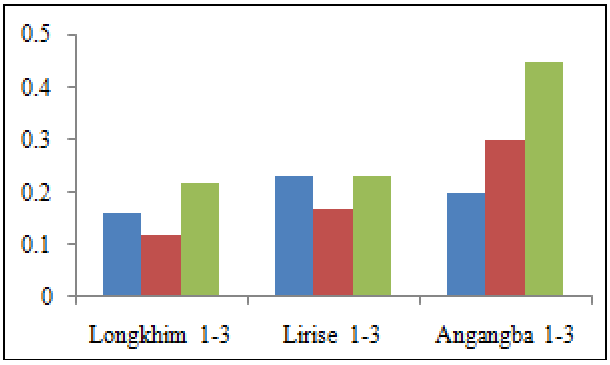

Figure 6: Graphical representation of E. C (dS/m) values of soil samples

c) Organic Carbon

Physical, chemical, and biological properties of soil depend on presence of organic carbon. organic carbon is a component of soil organic matter that can be measured and has significant role in agricultural functions. Soil organic carbon (SOC) is measure of soil fertility and its productivity. Maintaining and improving SOC is must to ensure soil quality, crop yield, and agricultural ecosystem sustainability.

SOC help plants flourish by releasing nutrients, improving soil structure, biological and physical health, and acts as a buffer against hazardous elements. Increase of SOC has two advantages: climate change and enhancement of soil health. It was measured by wet digestion method (Walkely and Black, 1934) and the data obtained through analysis is shown in table 2 graphically represented in fig.7.

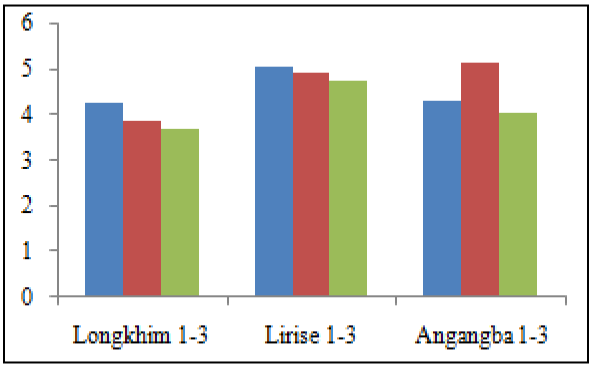

Figure 7: Graphical representation of Organic matter (in %) of soil samples

d) Available Nitrogen

Nitrogen is macronutrients which is required for plant metabolism and growth and act as a primary nutrient for plants. The natural nitrogen supply to plants takes place in two steps: first ammonification and second nitrification. Nitrogen is a major component of chlorophyll and plays an important role for soil fertility management. For estimation of nitrogen, micro - Kjeldahl distillation method (Subbiah and Asija, 1956) was used and the data obtained through analysis is shown in table 2 and graphically represented in fig 8.

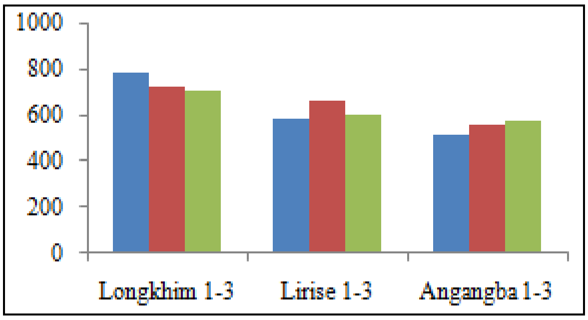

Figure 8: Graphical representation of Nitrogen content (in kg/ha) in the soil samples

Table 2: Showing the value of p^H, EC, % of OC, %of OM and Nitrogen content

Samples	pH	E. C (dS/m)	Percentage % of OC	Percentage % of OM	Remarks	Nitrogen (kg/ha)	Remarks
Longkhim (1)	5.7	0.16	1.91	4.27	High	790.02	High
Longkhim (2)	5.9	0.12	1.73	3.88	High	727.32	High
Longkhim (3)	6.0	0.22	1.66	3.71	High	714.78	High
Lirise (1)	5.2	0.23	2.26	5.07	High	589.38	High
Lirise (2)	4.9	0.17	2.20	4.93	High	664.62	High
Lirise (3)	5.0	0.23	2.13	4.77	High	601.92	High
Angangba (1)	6.0	0.20	1.93	4.31	High	514.14	High
Angangba (2)	5.7	0.30	2.31	5.17	High	564.30	High
Angangba (3)	5.8	0.45	1.82	4.07	High	576.84	High

e) Available phosphorous

Phosphorus is essential for every living cell and one of the most important micronutrients for plant growth. Phosphorus acts as energy storage and limits the amount of nutrients that remain in plant nucleus. The function of phosphorus is to store and transport energy formed by photosynthesis process for growth and reproduction in plants. P deficiency affects production through delaying maturity, slowing development, and limiting the plant's ability to use energy. Spectrophotometer (Bray and Kurtz, 1945) was used for estimation of phosphorus and the data obtained through analysis is shown in table 3 and graphically represented in fig 9.

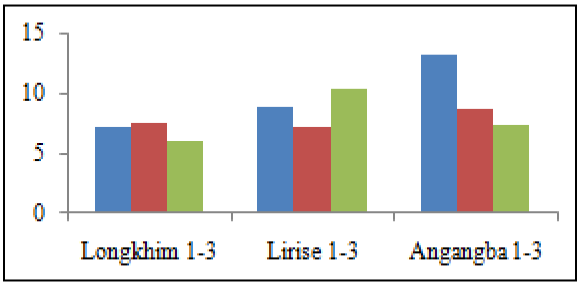

Figure 9: Graphical representation of phosphorus content (in kg/ha) in the soil samples

f) Available Potassium

Most soils have high levels of total potassium (K), but low levels of plant accessible potassium. Potassium is regarded as the second most critical element for plant growth. It functions as a catalyst for a variety of enzymatic reactions in plants that are required for growth. Potassium was estimated by flame photometer (Toth and Prience, 1949) and the data obtained through analysis is shown in table 3 and graphically represented in fig 10.

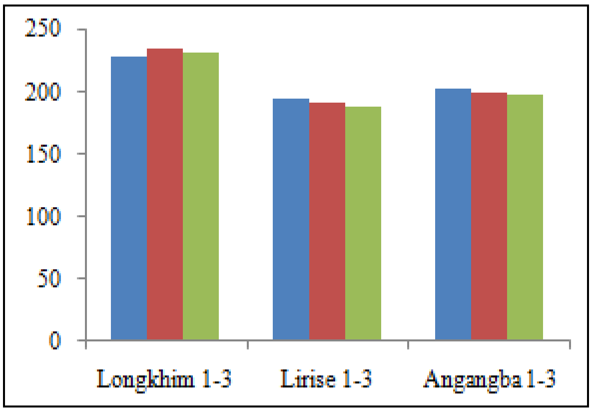

Figure 10: Graphical representation of available Potassium (in kg/ha) in the soil samples.

g) Available Sulphur

Sulphur is a protein component that is required for plant growth, and its deficiency causes discoloration and irregular growth of plant tissues. Sulphur has been proved to be a yield and quality increasing nutrient. Sulphur application has been shown to increase crop yields, soil health and quality by improving nitrogen usage efficiency in plants and protein production in seed oil. Spectrophotometer was used to estimate the sulphur content in soil samples and the data obtained through analysis is shown in table 3 and graphically represented in fig.11.

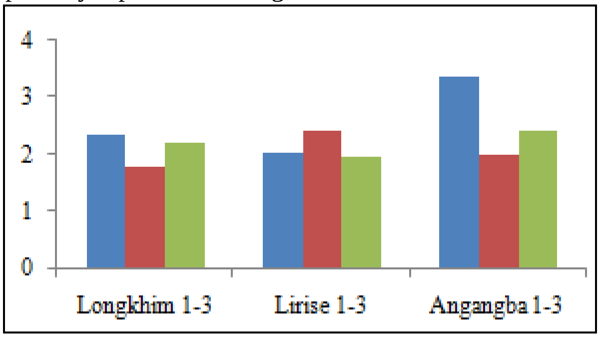

Figure 11: Graphical representation of Sulphur (in ppm) in the soil samples.

h) Available Chloride (Cl -)

Sea spray, rain water, dust, and air pollution are the principal sources of chlorine (Cl) in soils. Human activities such as irrigation and fertilization also contribute to Cl deposition. Cl is mostly found as the chloride anion (Cl^{-}) in soil solutions. The Cl^{-} anion does not readily form complexes and adsorbs to soil components with minimal affinity. As a result, water flows play a big role in Cl^{-} mobility in the soil. It was measured by titration method and the data obtained through analysis is shown in table 3 and graphically represented in fig.12.

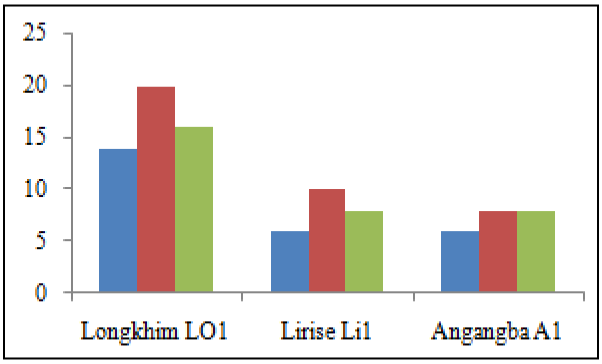

Figure 12: Graphical representation of chloride content (in ppm) in soil samples.

Table 3: Showing the amount of phosphorus, potassium, sulphur and chloride content.

Samples	Phosphorus kg/ha	Remarks	Potassium kg/ha	Remarks	Sulphur ppm	Remarks	Chloride ppm	Remarks
Longkhim (1)	7.336	Low	228.48	Medium	2.337	Low	14	Medium
Longkhim (2)	7.728	Low	235.20	Medium	1.787	Low	20	High
Longkhim (3)	6.160	Low	231.84	Medium	2.212	Low	16	Medium
Lirise (1)	8.960	Low	194.88	Medium	2.037	Low	6.0	Low
Lirise (2)	7.280	Low	191.52	Medium	2.412	Low	10	Medium
Lirise (3)	10.416	Low	189.28	Medium	1.962	Low	8.0	Low
Angangba (1)	13.328	Low	202.72	Medium	3.362	Low	6.0	Low
Angangba (2)	8.736	Low	200.48	Medium	2.000	Low	8.0	Low
Angangba (3)	7.504	Low	198.24	Medium	2.425	Low	8. o	Low

i) Soil Moisture

Water held in the soil is termed as soil moisture and it is influenced by temperature and soil properties. Moisture and nutrients available in soils control the crop health and its production. Plants' regular function and development minimized as moisture availability decreases, resulting in lowering agricultural production. Soils have different size of holes in which gaseous and liquid phases of air and water coexist. How much water, soils can hold and allows the movement of water depends on the size of its particles and pores. Oven dry method was used to calculate the value of % of moisture and the data obtained is shown in table 4.

Table 4: Showing % moisture content in studied soil samples

Sample location	Oven weight dry of soil	Loss in weight	%moisture $= \frac{loss\ in\ wt. \times 100}{oven\ dry\ wt. of\ soil}$
Longkhim	86.02	14.1	16.39%
Lirise	87.03	14.97	17.2%
Angangba	80.96	16.01	19.7%

j) Water holding capacity (WHC)

The quantity of water that a specific soil can hold for crop use is known as water holding capacity of soil. The purpose of soil water holding capacity test is to keep the field at the near capacity. The objective is to educate farmers to recognize variations in soil water holing capacity and to manage them so that they don't have to irrigate frequently or suffer from drought. Soil texture and organic matter determines the soil water retention capacity. In terms of soil texture, smaller particle size have a bigger surface area than sand, which makes the soil to store more water, and results in increase of water retention capacity. Soil organic matter is another component that increases soil water retention capacity. WHC influences soil organism, plant growth and serves as a solvent and carries of nutrients for plant growth. It regulates soil temperature and helps in chemical and biological activities of soil. Oven dry method was used to calculate the value of water holding capacity for five continuous days and the data obtained is shown in table 5.

Table 5: Showing Water holding capacity of the soil samples

Sample location	Percentage (%) of moisture content in soil samples				
	Day 1	Day 2	Day 3	Day 4	Day 5
Longkhim	14.7	12.3	11.9	9.6	9.1
Lirise village	13.6	12.1	10.7	8.7	8.3
Angangba village	13.9	12.4	11.3	9.2	8.9

5. Discussion

Deficiency of Nutrients

Plant deficiencies arise when a plant does not have enough of an essential nutrient for growth. Phosphorus (P), potassium (K), chloride (Cl^-), sulphur (S), nitrogen (N), and other nutrients are required by the plant.

Nutrient Index of Soils in different Samples

The concept of nutrient index (Parker et al., 1951) has been used for area wise fertilizer recommendation and comparison of soil fertility level of different sites. Soils were divided into three categories based on the results of soil tests for various nutrients viz low (NL), medium (NM) and high (NH).

$$\text{Nutrient index (NI)} = \frac{NL\times1+NM\times2+NH\times3}{\text{NT}} \quad \text{......... (1)}$$

Where, NT= total number of samples analyzed

Table 6: Nutrient index value of soil samples of Longkhim, Lirise and Angangba village

	Nutrients	NI values	NI	NI Fertility status
Longkhim	N	N	3	High
	P	P	1	Low
	K	K	2	Medium
Lirise village	N	N	3	High
	P	P	1	Low
	K	K	2	Medium
Angangba village	N	N	3	High
	P	P	1	Low
	K	K	2	Medium

1) pH has no direct effect on plants, but influence the availability of many nutrients. All the soil samples collected under Tuensang District were acidic in the nature. The acidic character is due to decomposition of organic matter which releases organic acid which leads to leaching of bases under high rain fall and hilly topography. The pH value of the soil samples from three different villages ranged from 5.7 – 6, 4.9 – 5.2 and 5.7 - 6 for Longkhim, Lirise and Angangba respectively. The p^H of the different sites follows the order based on their acidity levels Lirise > Longkhim = Angangba. Similar results were also shown by Mishra and Saithantuaanga (2000), Sarker at al., (2002), Bhasker et al., (2004), Patton et al., (2005), Singh et al., (2006), Das (2007). Amenla et al., (2010), Sharma et al., (2012), Sharma Y. K (2013), and Singh P. K. et al., (2017).
2) The particular conductivity of the soil - water suspension at a given ratio is known as its conductivity. Electrical conductivity of the soil of Tuensang District ranges from 0.12 – 0.22, 0.17 – 0.23, and 0.2 – 0.45 for Longkhim, Lirise and Angangba respectively. The EC for all the three samples falls under the range of 0 – 2 which shows that the total salt content is below 0.15 hence the salinity effect for all the three different samples can be neglected, except for some sensitive crops only. The electrical conductivity for different region under Tuensang district follows the order Angangba > Lirise > Longkhim. Similar findings were also reported by Mishra et al., (2007), Sharma et al., (2012), Sharma Y. K (2013), Nath (2014), Bier et al., (2018), and Sentimenla (2020).
3) Soil organic matter management is important for soil productivity and pH maintenance. It is regarded as the most important property for soil fertility indicator. High content is due to decomposition of litters. The study shows the soil organic carbon content of soils ranges from 1.66% - 1.91%, 2.13% - 2.26%, and 1.82% - 2.31% for Longkhim, Lirise and Angangba respectively. Thus, it can be concluded that the soil from Lirise has more organic content followed by Angangba and Longkhim. Similar result were obtained by Sarker at al.,

Paper ID: SR22828170819 DOI: 10.21275/SR22828170819

(2002), Patton et al., (2005), Singh et al., (2006), Amenla et al., (2010), and Sharma et al., (2012).

4) Nitrogen is required for plant growth, food processing, and chlorophyll production. However excess of nitrogen results in weakened stems and delayed flowering or fruiting. Nitrogen was present in high amount in all the collected samples. The values ranged from 714.78 - 790.02, 589.38 - 664.62 and 514.14 - 576.84 for Longkhim, Lirise and Angangba respectively Nutrient index for available nitrogen is found to be 3 for all the samples indicating that soil samples are high in available nitrogen. Similar results were also reported by Sarker at al., (2002) and Singh et al., (2006).
5) Presence of sufficient P level encourages root development, winter hardiness and hastens maturity. In this study the available phosphorus was found to be present in small amount in all the soil samples. Phosphorus deficiency can be corrected by using manure and phosphate fertilizers. The values ranged from 6.16 – 7.728, 7.28 – 10.416 and 7.504 – 13.328 for Longkhim, Lirise and Angangba respectively. The nutrient index for available phosphorous was calculated 1 in all the location, denoting the low status of available phosphorus. Similar result were also obtained by Sarker at al., (2002), Singh et al., (2006), Das (2007). Amenla et al., (2010), Sharma et al., (2012), Bier et al., (2018) and Sentimenla (2020).
6) Potassium is the sole nutrient that is not found in organic plant molecules, although it is essential for the regulation of plant functions including osmosis and enzyme activity. In this study the available potassium ranges from 228.48 – 235.2, 189.28 – 194.88, and 198.24 – 202.72 for Longkhim, Lirise and Angangba respectively. The nutrient index was calculated 2 for all the soil samples, showing medium fertility of the soil. Potassium deficiency can be corrected by using potassium nitrate, potassium chloride and potassium sulphate. Similar results were also obtained by Sarker et al., (2002), Singh et al., (2006), Amenla et al., (2010), Sharma et al., (2012).
7) Sulphur is required for the production of nodules by nitrogen - fixing bacteria on legume roots. In this study the available sulphur content ranges from 1.787 – 2.337, 1.962 – 2.412, 2 – 3.362 for Longkhim, Lirise and Angangba respectively. The level of sulphur can be checked by the addition of animal manures, gypsum and the use of organic residue. The sulphur content in soil is highest in Angangba followed by Lirise and Longkhim. Similar result were also obtained Singh S. P, (2002), Sharma et al., (2012), Singh P. K. et al., (2017), Sentimenla (2020).
8) Choloride functions primarily for osmo - regulation in plants as well as opening and closing of the stomata. In this study, the available chloride ranges from low to medium. The value ranges from 14 – 20, 6 – 10, 6 – 8 for Longkhim, Lirise and Angangba respectively.
9) Soil moisture is an important factor in determining how much water and heat is exchanged between the atmosphere and land surface via evaporation and plant transpiration. Soil moisture is important in determination of weather patterns. The natural moisture content of different samples was found to be 16.39%, 17.2%, 19.7% for Longkhim, Lirise and Angangba respectively. It is observed that Angangba has the highest % of moisture content in soil followed by Lirise and Longkhim.
10) Water holding capacity of the soil from different location was found to be 9.1%, 8.3%, 8.9% for Longhim, Lirise and Angangba respectively. Thus, this study shows that the WHC of soils from Longkhim is the highest which is followed by Angangba and Lirise.

6. Conclusions

From the above observations it can concluded that all the soil samples of studied areas are acidic and non - saline in nature as far as the soluble salts are concerned. The above result also shows that the nutrient status for the soil of Longkhim, Lirise and Angangba contain high content of organic compound, high content of available nitrogen, medium content of available potassium, low content of available phosphorus and sulphur. The available chloride content is medium to high in Longkhim while Lirise and Angangba soil chloride content is low to medium range.

Acknowledgements

For analyzing soil samples laboratory of Directorate of Soil & Water conservation, Nagaland, Kohima was used and Authors thank the concerned authority and laboratory staff of Department of Chemistry, Kohima Science College, Jotsoma for their help**.** . The authors like to thank Principal, Kohima Science College for providing financial assistance to carry out this work.

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