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Research Article

Fertility status of soil under forest and cultivated land use system of Nagaland: A comparative study

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Summary

Forty-eight soil samples were collected from 0-15 cm from each forest and cultivated areas of 12 different places of Nagaland. Nutrients availability status of N, P and K found to be ranges under low to medium. Forest soils contained higher values of available N, organic carbon, whereas available P and K were found to be more in cultivated soils. Value of available S was also found to be higher in forest soils and in both the states and value of available B was found to be very low. Soil respiration in both land use showed ideal to high soil respiration rate, average soil respiration rates exhibited higher in cultivated land than the forest in both the states. Soil pH was found negatively correlated with organic carbon, available N, K, exchange acidity and lime requirement. With soil organic carbon, positive correlation was found with available N, K, exchange acidity and lime requirement, but negative correlation with total acidity. The results concluded that types of soil and land uses practices were responsible for the varying soil inherent properties. The organic carbon content of the forest soils of Nagaland varied from 1.59 to 2.76% and average value recorded was 2.21%. The average value of pH in forest and cultivated was found 4.9, whereas, average value of EC was found in forest and cultivated soil 53.5 and 52.6 us/m, respectively.

Key words : Nutrients status, Acidic components, Physico-chemical properties

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Introduction

Soil resources are which forms the basis of entire life support systems. They serve as a reservoir of nutrients and water for crops, provide mechanical anchorage and favourable tilth. Soils are integral and vital parts of agriculture. Food and nutritional security of the country and environmental safety relies on the witty management and sustainable technology.

The role of soils in agricultural development has appreciated since time immemorial, today's world population of 5.5 billion will be double by the year 2050 over 95% of this growth will take place in developing countries including India. Consequently the demand for food will also grow over this period. But the amount of available cultivable land worldwide will fall to 0.17 ha per capita in 2050. If this demand is to be addressed, agricultural productivity will have to increase significantly in those areas of the world that are lagging in this respect.

In India, acid soils cover a very large fraction of the country's land mass, out of the total geographical area of 328 m ha, approximately 100 m ha of land suffer from soil acidity (Mishra, 2004). Most of the North Eastern states of India soils are acidic reaction, Arunachal Pradesh, Assam, Manipur, Mizoram, Meghalaya, Nagaland, Tripura and Sikkim has almost entire area (more than 95%) having acidic reaction (Sharma and Singh, 2002). Soils are acidic in reaction due to leaching of base from the exchange complex under the prevailing high rainfall and hilly topography, highly acidic soils of the states pose a great challenge due to incidence of crop root damages due to high concentration of iron (Fe^{+2}) and aluminium (Al^{+3}) which also inhibit absorption of Ca^{+2} and Mg^{+2} and thereby soil biological health is adversely affected due to dominance of fungi in the acid soil. The problem of soil acidity appears to be more severe than that of soil alkalinity and has, therefore, been recognised as an important agricultural problem which adversely affects the crop production, either directly or indirectly.

The exploitation of marginal soils, improper cultivation and management practices and intensive agriculture without appropriate soil may arise the constraint for the production are either unfavourable physico-chemical properties of soil or some inherent land feature and environmental conditions limiting optimum growth of crops. In NE states top soil is degrading enormously due to shifting cultivation as such the productivity of these lands goes down to a considerable extent. The quality of the soils is declining annually and will continue to if means are not found to increase nutrient inputs. Appropriate formulation of land use plans based on the quality and type of soils could be achieve by proper knowledge and understanding of physico-chemical characteristics of soils. Evaluation and characterisation of soil fertility status of a region is an important aspect in content of sustainable agriculture production. So it is necessary to develop strategies prevent the degradation and deterioration of soil quality and assist in optimising land use that will ensure both economic prosperity and ecological security.

In appraising the productivity of the soils, one needs to have a fair knowledge of their physical, chemical and biological properties to prevent irreparable damage done to the land and water resources. Prediction of crop input requirements and relative responsiveness to the input applications requires knowledge of soil properties and their relationship to applications of crop production technology. So soil testing is important and foremost step to set for studying the changing pattern in soil fertility and to monitor the changes in soil nutrient status. So the study on the physico-chemical properties of the soils becomes essential to equip the farmers with tools for maintaining the soil health and increasing the productivity. Therefore to acquire a comprehensive knowledge and to general information on the above aspect a research investigation was undertaken to study the physico-chemical properties of soil.

Resource and Research Methods

A total sixty (60) soil samples were collected from different location of Nagaland under different land use systems (Forest and Cultivated). Cultivated land use for cultivation for many years. Forest land was naturally occurred. Soils in forest and cultivated land are classified as Typic Hapluequent , Pachic Umbrichrepts and Typic alfiaquent. Samples were processed and analyzed for physico-chemical properties by standard procedure (Jackson, 1973). The CEC was calculated with the sum of exchangeable Ca, Mg, Na, K. Particle size analysis was done by international pipette method. The available micronutrients cations were extracted with DTPA (Lindsay and Norvell, 1978). The micronutrients were estimated in the extracts with atomic absorption spectrometer (AAS). The soil and plant samples were prepared for analysis and analysed by standard procedure like available N (Subbaih and Asija, 1956) P (Bray and Kurtz,1954) K (Jackson, 1973) pH (Richards, 1954) , OC (Jackson, 1973), and available S (Baruah, and Barthakur, (1997).

Research Findings and Discussion

The experimental findings of the present study have been discussed in three sub-groups *i.e.* Physico-chemical properties, nutrients status and acidic properties.

Physico-chemical properties of the Nagaland soils :

The pH value ranged from 4.1 to 5.8 in forest area. Average value was 4.9. In cultivated area pH value varied from 4.5 to 5.5 and average value of pH was 4.9 (Table 1). Soils were almost highly acidic in reaction due to downward migration of cationic bases and formation of some organic acids simpler in composition than humic acid during decomposition resulting lowering of soil pH (Mukherjee, 1976). The soil of entire region of is acidic in reaction caused by heavy rainfall and leaching of bases to lower horizon. On an average soil pH ranged from 4.1 to 5.9 in cultivated and forest soils. Almost 84% soils of Nagaland are considered strongly acidic (Panda, 1998).

The value of EC of the forest soils varied from 32.5 to 80 us/m and average value of EC found to be 53.5 us/m. In cultivated soils value of EC varied from 32 to 80 us/m and average value of EC of cultivated soils recorded was 52.6 us/m.

The organic carbon content of the forest soils of Nagaland varied from 1.59 to 2.76% and average value recorded was 2.22%. Khonoma area contained highest organic carbon content *i.e.* 2.76% and lowest in Chumukedima area *i.e.* 1.59%. The organic carbon content of the cultivated soils of Nagaland varied from 1.32 to 2.03% and average value of OC content recorded was 1.63%. Piphema area had highest OC content *i.e.* 2.03% and lowest in Medziphema area *i.e.* 1.32%. The forest soils were found to contain higher organic carbon% than the cultivated soils. Similar findings were reported by Banerjee and Chakraborthy (1977) .Organic carbon decreased when virgin soils were brought under cultivation which may be attributed to a slow microbial degradation of accumulated organic matter. The cultivation decreases the organic matter in soil (Retzer and Russel, 1941).

The bulk density for the forest soils of Nagaland was recorded to vary from 0.81 to 1.04 gm/cc. Average value of Bulk density was 0.91 g/cc for the forest soils. The bulk density for the cultivated soils of Nagaland varied from 0.78 to 1.11 g/cc and average value is 0.92 g/cc. Retzer and Russel (1941) reported that the cultivation decreased the large size pores pedzolic soil. The continuous cropping, particularly of soil originally high in organic matter often resulted in a reduction of total pore spaces. Ray *et al.* (2006) reported that bulk density, particle density and porosity etc varied due to variation in land use system.

The particle density was recorded for the forest area which varied from 1.59 to 2.76 g/cc. The average values of particle density is 2.22 g/cc. In cultivated soils of Nagaland, the particle density varied from 1.32 to 2.03 g/cc and average value of particle density was found to be 1.63 g/cc. Bulk density is of greater importance than particle density in understanding the physical behaviour of soils. It is observed that particle density of the forest soils was higher than the cultivated soils. Soils containing high amounts of organic matter will have particle density reserves around 2.4 g/cc. Patiram *et al.* (2001) compared two soils under cropped and un-cropped and was found that the particle density is increased at un-cropped area. The total porosity for the forest soils varied from 37.7% to 71%. The average value for total porosity for the cultivated soil ranged from 33.40% to 70% and average value was recorded to be 47.9%.

Soil respiration for the forest soils varied from 54.3 to 131.2 kg CO_2 ha/hr. Average value of soil respiration for the forest soils was 74.8 kg/ha. For the cultivated area of Nagaland soils, soil respiration ranged from 72.7 to 179.8 kg CO_2 ha/hr and average is 110.8 kg/ha.

Nutrients status :

The available N, P, K, S, Ca+ Mg and B values were recorded from forest and cultivated soils of Nagaland are presented in Table 2.

Available N recorded from forest soils of Nagaland ranged from 251 to 426.4 kg ha^{-1}, which indicated low to medium to high limits and the average value of available N was 318.9 kg ha^{1}. Cultivated soils of Nagaland were found to vary from 230.2 to 413.9 kg ha^{-1} and the average value of available N was 286 kg ha^{-1}. Jharnapani area recorded to be highest in available N *i.e.* 413.9 kg ha^{-1} and lowest in Khonoma area *i.e.* 230.3 kg ha^{-1}. This is in line with the findings of Ellert and Gregorich (1996) who reported the forest soils contain more nitrogen than cultivated soils. Average available N content was observed higher in Nagaland soils. Available P of forest area varied from 20 to 52.2 kg ha^{-1} and average value of available P was 30.8 kg ha^{-1}. Available P recorded highest in Chumukedima area *i.e.* 52.2 kg ha^{-1} and lowest in Piphema area *i.e.* 20 kg ha^{-1}. Available P in the cultivated area ranged from 21.5 to 59.7 kg ha^{-1} and average value of available P in cultivated area was 31.5 kg ha^{-1}. Highest available P was found in Chumukedima area *i.e.* 59.7 kg ha^{-1} and lowest in Medziphema area *i.e.* 21.5. Available P in Nagaland varied from low to medium, the available P content of the entire soil of North Eastern region are deficient in Phosphorus (Prasad *et al.*, 1981). It is reported that over 60% of the soils in Nagaland were deficient in available P (Sharma *et al.*, 2001), these soils might be due to higher formation of phosphorus by Fe^{2+}, Mn^{2+} and Al^{3+}, also reported by Medhi *et al.* (2002).

The value of available K of forest area ranged from 134.4 to 221.5 kg ha^{-1} and average value of available K was found to be 165.1 kg ha^{-1}. Khonoma area recorded highest in available K *i.e.* 221.5 kg ha^{-1} and lowest in Chumukedima area *i.e.* 134.4

Table 1: Values of EC, pH, bulk density, particle density, porosity and respiration of soils of Nagaland under different land use practices

Places	pH		EC (ds/m)		BD (g/cc)		PD (g/cc)		Porosity %		Respiration		OC %	
	C	F	C	F	C	F	C	F	C	F	C	F	C	F
Khonoma	5.2	5.2	32	32.5	0.79	0.85	1.64	2.76	53	55	96	91.5	1.64	2.76
Mezoma	4.7	4.4	55	56	0.87	0.90	1.66	2.64	58	60	136.7	19.6	1.66	2.64
Piphema	4.7	4.1	76	80	0.78	0.81	2.03	2.11	70	71	92.5	92	2.03	2.11
Medziphema	4.5	4.4	33	42.5	0.99	0.85	1.32	2.59	35	63	179.8	131.2	1.32	2.59
Jharnapani	4.9	5.7	40	60	0.96	0.97	1.58	1.61	33.40	37.75	87.2	57.7	1.58	1.61
Chumukedima	5.5	5.8	80	50	1.11	1.04	1.56	1.59	38.20	44.00	72.7	54.3	1.56	1.59
Mean	4.92	4.93	52.6	53.5	0.92	0.91	1.63	2.22	47.93	55.13	110.82	74.83	1.63	2.22

Note: C=cultivated soil, F=forest soil

Table 2 : Values of Available N, P, K, S B,CA and Mg (kg/ha) of soils of Nagaland under different land use practices

Places	N		P		K		S		Ca+Mg		B	
	C	F	C	F	C	F	C	F	C	F	C	F
Khonoma	230.2	251.1	30.2	29.1	209.8	221.5	34.1	35.6	0.7	0.8	0.41	0.44
Mezoma	240.8	260.6	25.4	22.8	125.2	150	36.9	37	2.1	2.2	0.56	0.57
Piphema	240.8	251	22.5	20.0	148.6	150.2	59.5	59.9	1.7	1.8	0.42	0.44
Medziphema	244.5	348.5	21.5	25.0	151.6	187.1	27.2	35.6	0.8	1.0	0.54	0.58
Jharnapani	413.9	426.4	29.8	35.8	171.3	147.8	72	82.5	0.9	1.1	0.48	0.49
Chumukedima	351.2	376.3	59.7	52.2	120.9	134.4	13.7	17.5	0.8	1	0.51	0.58
Mean	286.9	318.98	31.51	30.81	154.56	165.16	40.56	44.68	1.16	1.32	0.48	0.52

Note: C=cultivated soil, F=forest soil

kg ha^{-1}. In cultivated area available K varied from 120.9 to 209.8 kg ha^{-1}. Average value for the cultivated soils of available K was 154.5 kg ha^{-1}. Khonoma area recorded to be highest in available K *i.e.* 209.8 kg ha^{-1} and lowest in Chumukedima area *i.e.* 120.9 kg ha^{-1}. Motsara (2002) reported low status of available K in Naglanad soils; On an average the available K content in Nagaland soil was found to low to medium.

The available Ca and Mg in the forest area of Nagaland soils varied from 0.8 to 2.1 meq/100 g. Average values of available Ca and Mg was found to be 1.3 meq/100 gm. And for the cultivated area of Nagaland soils values varied from 0.7 to 2.1 meq/100 g. Average available Ca and Mg recorded was 1.16 meq/100 g. Similar results were reported by Mishra and Saithantuaanga (2000).

Available S for the forest area of Nagaland soils ranged from 17.5 to 82.5 kg/ha and average value recorded was 44.6 kg/ha. Jharnapani area found to be highest in available S *i.e.* 82.5 kg/ha and lowest in Chumukedima area *i.e.* 17.5 kg/ha and for the cultivated soils available S varied from 13.7 to 59.5 kg/ha. Average value for the cultivated soils was recorded 40.5 kg/ha. Piphema area found highest in available S *i.e.* 59.5 kg/ha and lowest in Chumukedima area *i.e.* 13.7 kg/ha. Similar result was found by Singh *et al.* (2006).

Available B in the forest soils of Nagaland value ranged from 0.44 to 0.58 kg/ha. Average value of available B recorded was 0.52 kg/ha. Highest available B was found in Chumukedima area *i.e.* 0.58 kg/ha and lowest in Piphema area *i.e.* 0.44 kg/ha. In cultivated area of Nagaland soils available values varied from 0.41 to 0.56 kg/ha and average recorded was 0.48 kg/ha. Mezoma area recorded highest in available B *i.e.* 0.56 kg/ha and lowest in Khonoma area *i.e.* 0.41 kg/ha.

Acidic properties :

Data on average value of exchange acidity, exchangeable H^+ and total acidity of forest and cultivated soil of Nagaland are given in Table 3.

The exchange acidity of the forest soils of Nagaland vary from 0.82 to 2.81 meq/100 g and average value of exchange acidity recorded was 1.61 meq/100 g. In cultivated area value of exchange acidity varied from 1.10 to 2.33 meq/100 g and average value of exchange acidity was 1.63 meq/100 g.

The exchangeable H^+ of the forest soil of Nagaland varied from 5.2 to 8.1 meq/100 g. Average exchangeable H^+ recorded is 6.1 meq/100 g. For the cultivated soils of Nagaland the average value of exchangeable H^+ was 1.13 meq/100 g.

The total acidity for the forest soils of Nagaland values

Table 3 : Values of exchangeable hydrogen, exchangeable aluminium, exchange acidity, and total acidity and lime requirement of soils of Nagaland under different land use practices

Places	Exch. H		Exch. Al		Exch. acidty		Total acidty		LR	
	C	F	C	F	C	F	C	F	C	F
Khonoma	3.3	5.2	1	1.8	1.10	1.12	3.11	4	8.6	8.6
Mezoma	0.8	8.1	1.33	1.4	1.50	1.81	2.23	2.28	10.6	11.2
Piphema	1.81	6.4	1.33	1.4	1.43	1.90	2.57	2.58	10.7	13.2
Medziphema	0.50	5.3	1.77	2.40	1.90	2.81	5.48	4.46	12.8	13.6
Jharnapani	0.71	7.3	1.76	1.77	2.33	1.20	4.44	4.48	10.1	6.5
Chumukedima	0.74	7.5	1.74	1.76	1.50	0.82	4.64	4.66	7.2	5.7
Mean	1.13	6.13	1.48	1.75	1.63	1.61	3.47	3.74	10.0	9.8

Note: C=cultivated soil, F=forest soil

Table 4 : Correlation co-efficient of different soil properties with pH of Nagaland

Factors	pH		OC	
	Cultivated	Forest	Cultivated	Forest
Available nitrogen	-0.39	-0.67	0.15	0.72
Available phosphorus	0.88*	0.88*	-0.30	0.69
Available potassium	-0.79	-0.13	0.20	0.72
Organic carbon	0.82*	-0.62	-0.14	0.62
Lime requirement	-0.97**	-0.97**	0.77*	0.51
Exchange acidity	-0.35	-0.80*	-0.52	-0.40
Total acidity	-0.79*	-0.12	-0.57	-0.22
Exchangeable Al	-0.76*	-0.74	0.36	-0.44
Electric conductivity	-0.32	-0.35	0.60	0.31
Available sulphur	-0.52	-0.008	0.57	0.59
Available boron	-0.27	-0.06		

* and ** indicate significance of values at P=0.05 and 0.01, respectively

varied from 2.28 to 4.66 meq/100 g and average value of total acidity was 3.74 meq/100 g. In the cultivated soils values varied from 2.23 to 5.48 meq/100 g. Average value of total acidity was 3.47 meq/100 g. In Nagaland soils both the land use soil recorded to be 3.74 meq/100 g. Kumar *et al.* (1995) reported that land use pattern affected the various forms of acidities considerably. The exchangeable Al for the forest soils of Nagaland varied from 1.4 to 2.4 meq/100 g. Average value of exchangeable Al was 1.7 meq/100 g. The cultivated soils of Nagaland varied from 1 to 1.77 meq/100 g. Exchangeable Al reported higher in forest soils than the cultivated soils. In acid soils of NEH Region, the amount of exchangeable aluminium ranged from nil to as high as 7.1 meq/100 g (Lahiri and Chakravarti, 1989).

Lime requirement at pH 6.4 for forest soils ranged from 5.7 to 13.6 t/ha. Lime requirement was found to be highest in Medziphema area *i.e.* 13.6 t/ha and lowest in Chumukedima areas *i.e.* 5.7 t/ha and average lime requirement recorded was 9.8 t/ha, and for the cultivated soils lime requirement varied from 7.2 to 12.8 t/ha. Medziphema area had highest in lime requirement *i.e.* 12.8 t/ha and Chumukedima area lime requirement was lowest *i.e.* 7.2 t/ha and average lime requirement was 10.0 t/ha. The high value of lime requirement could be due to high level of total acidity. Such types of results were also observed by Patton *et al.* (2005) in soils of Nagaland.

Correlation study :

Details of correlation values of the soil properties with soil pH and organic carbon of cultivated and forest of Nagaland soils are presented in Table 4.

Positive correlation was found between organic carbon and available N in cultivated soils, which could be attributed to the fact that most of the soil nitrogen is in organic forms. This finding is supported by the reports of Chibba and Sekhon (1985). Forest soils also showed similar correlation. Soil pH and soil organic carbon content were observed to be negatively correlated. Similar results were also observed by Saha *et al*. (1999). Soil reaction was noted to be negatively correlated with available N and K at forest soils. This might be due to increased rate of de-nitrification at low pH values.

A negative correlation was found between soil pH and lime requirement in both land uses. Saha *et al*. (1999) also found similar results. This may be attributed to the fact that pH measures only the intensity factor soil acidity but the organic carbon and available P were found to positively correlated in forest soil.

A positive correlation was observed between organic carbon and available K in both the land uses. This might be due to creation of favourable soil environment with presence of high organic carbon (Meena *et al.*¸ 2006). Organic carbon is positively correlated with available sulphur and available boron.

Organic carbon and total acidity were found to be negatively correlated. Under both forest and cultivated soils, organic carbon also showed positive correlation with exchange acidity and lime requirement. Patton *et al.* (2007) also reported similar findings.

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