Annals of Plant and Soil Research 17 (1): 50-54 (2015)

STATUS OF AVAILABLE NUTRIENTS AND POTASSIUM FRACTION IN SOILS OF DIMAPUR, NAGALAND IN RELATION TO LAND USE SYSTEMS

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Received: September, 2014; Revised accepted: November 2014

ABSTRACT

Seventy two surface (0-20cm) soil samples were collected from different locations of Dimapur district of Nagaland under cereal, orchard and forest land use systems and analyzed for status of available nutrients and forms of potassium. Soils of the district were strong to moderate acidic (4.40 to 5.80) in reaction. Sand, silt and clay content of the soils ranged from 30.8 to 55.0, 24.1 to 40.2 and 18.2 to 36.3 % with mean values of 40.0, 32.0 and 27.7 %, respectively. The CEC of the soils was quite low and irrespective of land use systems, varied from 9.5 to 17.2 cmol (p^+) kg^{-1}. The soils under forest land use were recorded to be high in CEC than other land use systems. Soils of the district were high in organic carbon, medium in available nitrogen and low in available phosphorus contents. Available sulphur in the soils varied from 14.8 to 35.0 kg ha^{-1}. DTPA extractable Zn varied from 0.20 to 3.50 mg kg^{-1} with a mean value of 1.52 mg kg^{-1}. Higher amounts of organic carbon, available N, P, S and Zn were recorded in the soils under forest land use followed by orchard and cereal land use. Total K, 1N NH_4OAc K, water soluble K, exchangeable K, 1N HNO_3 K and non-exchangeable K of the soils ranged between 1720 and 3450, 67.7 and 120.0, 5.5 and 9.2, 62.1 and 110.8, 797 and 1477 and 721.1 and 1357 mg kg^{-1}, respectively. Available, water soluble, exchangeable, 1N HNO_3 K and non-exchangeable K constituted 3.7, 0.3, 3.4, 42.9 and 39.3 % of the total K. Soils under cereal land use system were deficient to the extent of 4.2, 66.7, 12.5, 62,5 and 41.7% in available N, P, K, S and Zn, respectively. In orchard land use system, extent of deficiency was 50.0, 20.8 and 29.2% for P, S and Zn, respectively soils were medium to high in N and medium in K under this land use system. In forest land use system, 29.2 and 8.3% soils were deficient in P and S, respectively. Highly significant and positive relationship amongst different forms of K indicated existence of dynamics equilibrium among various forms of K. Various fractions of potassium had positive and significant correlation with organic carbon and clay content of the soils.

Keywords: Available nutrients, potassium forms, land use systems, Dimapur

INTRODUCTION

Knowledge about physical, chemical properties and soil fertility status of an area is very much relevant for identifying problems and constraints in crop production for enhancing crop productivity in sustained manner. Nutrients status of soil play a vital role in the growth, development and yield of plants and information of available nutrient status of an area can go a long way in planning in judicious use of nutrient sources and soil management practices. Knowledge about nutrients status of the soil is helpful in understanding the inherent capacity of soil to supply essential plant nutrients for utilization to crops. Potassium is released in soluble and exchangeable form during weathering of potassium bearing minerals at widely differing rates. Soil potassium exists in dynamic equilibrium between its forms. The availability of K to plants is not only controlled by solution K, rather it is manifested by exchangeable and non- exchangeable K. Potassium dynamics refer to renewal of K at any point of time as controlled by the climatic variables, soil and hydrological conditions, cultural practices, crops and cropping pattern of the area in question (Baruah et al., 2002). Major portion of soil K exists as constituent of mineral structure and in fixed or non-exchangeable forms with minor portion as water soluble and exchangeable K (Pasricha, 2002). Besides the soil characteristics, land use pattern also plays a vital role in governing the nutrient dynamics and fertility of soils (Venkatesh et al., 2003). Soils under particular land use system may affect physico- chemical properties which may modify fertility status and nutrient availability to plants. Scanty information is available on physicochemical properties, nutrient status and different forms of potassium of soils of Dimapur district of Nagaland. Therefore, survey investigation was carried out to study the fertility status and forms of potassium in relation to land use systems and soil properties.

MATERIALS AND METHODS

For present investigation, seventy two (three samples from each ecosystem of each village) soil samples (0-20cm), representing leading land use ecosystems viz., cereal ecosystem, orchard ecosystem, and forest ecosystem were collected from

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different locations of Dimapur district of Nagaland. Large area of the Dimapur district is in the plains with an average elevation of 260 m above sea level excepting the Medziphema sub-division and a few villages of Niuland sub-division, which are located in the foothills. Dimapur is situated at 25° 54' 45" N Latitude and 93° 44' 30" E Longitude. Climate of the district is hot and humid in the plains during summer (reaching a maximum of 36ºC, with humidity up to 93%) while the winter months are cool and pleasant. The average annual rainfall of the district is 1504.7 mm. Major crops of the district are paddy, maize, soybean, cucurbits, pineapple, banana, litchi and jackfruit. Collected soil samples were analysed for pH, mechanical composition, porosity, CEC, organic carbon, available N, P and K using standard methods (Jackson, 1973). Available phosphorus was extracted with NH_4F (Bray and Kurtz, 1945). Available sulphur was extracted with 0.15% $CaCl_2$ solution (Williams and Steinbergs, 1959) and subsequently estimated by turbidimetric method (Chesnin and Yien, 1951). Total K was extracted by digestion of the soil samples with perchloric and hydrofluoric acid. Water soluble K was extracted by shaking the soil with distilled water (1:5 soil -water suspension). The 1N boiling HNO_3 K was extracted adopting the method advocated by Wood and Deturk (1941). Different forms of potassium in extracts were determined flame photometrically. Zinc was extracted with DTPA (Lindsay and Norvell, 1978) and analyzed by atomic absorption spectrophotometer.

RESULTS AND DISCUSSION

Physicochemical properties

Irrespective of land use systems, the pH of soils varied from 4.40 to 5.80, indicating that the soils are acidic in reaction (Table 1). The soils under orchard land use system showed slightly high pH as compared to other land use system. Excess leaching of bases from the soil profile due to heavy rainfall might be caused acidity in these soils (Sharma and Singh, 2002). Similar findings have also been reported by Amenla *et al.*, (2010). Irrespective of land use systems, the sand, silt and clay contents of the soils varied from 30.8 to 55.0, 24.1 to 40.2 and 18.2 to 36.3 %, respectively. The CEC of the soils of cereal, orchard and forest land use patterns varied from 9.5 to 13.5, 9.8 to 15.0 and 12.3 to 17.2 cmol (p^+) kg^{-1} with an average of 11.1, 12.2 and 14.5 cmol (p^+) kg^{-1}, respectively. The soils under forest ecosystem indicated higher CEC value than other ecosystems which might be due to high amount of organic carbon in the soils under forest ecosystem. Irrespective of land use system, the porosity of the soils ranged from 44.7 to 59.4 % with an average of 53.9 %. Higher porosity was recorded in the soils of forest land use system, while low porosity was found in the soils under cereal land use. Possible reason of this trend of porosity might be variation in organic carbon content of the soils of different land use systems. Irrespective of land use systems, organic carbon content in soils of Dimapur district ranged from 6.5 to 20.4 g kg^{-1} with an average of 12.5 g kg^{-1}. Average organic carbon content of the soils under cereal, orchard and forest ecosystems was 8.5, 11.4 and 17.4 g kg^{-1}, respectively indicating higher amount in forest ecosystem. All the soil samples contained high amount of organic carbon except soils of Medziphema village under cereal land use. Wide variation in organic carbon accumulation under different land use systems has also been reported by Sharma *et al.*, (2013).

Fertility Status

Available N content of the soils under cereal, orchard and forest land use patterns ranged from 293.4 to 442.5, 364.8 to 494.0 and 467.0 to 562.1 kg ha^{-1} with an average of 362.0, 416.4 and 518.6 kg ha^{-1}, respectively. The corresponding ranges of available P in these soils were from 7.5 to 10.6, 8.0 to 13.5 and 10.1 to 15.7 kg ha^{-1} with average of 9.1, 11.1 and 12.4 kg ha^{-1}. Except soils of Piphema village under forest land use, soils of rest villages under all land use systems fell under medium category of nitrogen. Medium class of available N indicated that the mineralizable nitrogen fraction under prevailed climatic condition and acidic environment is rather low. Variation in available N and P status of the soils under different land use systems within village might be due to variation in organic carbon status of the soils. These results are in agreement with those of Somasundaram *et al.* (2009). Available sulphur content in the soils under cereal, orchard and forest ecosystems varied from 14.8 to 25.0, 18.0 to 27.0 and 24.2 to 35.0 kg ha^{-1} with an average of 17.9, 23.0 and 29.3 kg ha^{-1}, respectively. Soils under forest land use system had high amount of sulphur as compared to soils of other land use systems which might be due to high amount of organic carbon. Irrespective of land use systems, the DTPA extractable Zn content varied from 0.20 to 3.50 mg kg^{-1} with a mean value of 1.52 mg kg^{-1} which clearly indicates that soils were deficient to sufficient in Zn. On the basis of average Zn content, soils under cereal land use were marginal and soils under orchard and forest use were sufficient. However, soils of six villages under cereal and orchard use showed deficient amount of Zn.

Table 1: Physicochemical properties and available nutrient status of soils under various land use system

Land use ecosystem & location of sampling	pH	Mechanical composition (%)			CEC cmol (p^+) kg^{-1}	Porosity (%)	Organic carbon ($g\ kg^{-1}$)	Available nutrients ($kg\ ha^{-1}$)			DTPA Zn ($mg\ kg^{-1}$)
		Sand	Silt	Clay				N	P	S	
Cereal Ecosystem											
Maova	4.92	34.2	40.2	25.5	10.7	44.7	7.6	320.2	9.5	16.0	0.30
Rajuphema	4.61	36.8	29.4	33.7	13.5	54.6	10.0	388.3	7.5	14.8	0.75
Piphema	4.88	30.8	37.9	31.1	9.7	52.0	8.4	293.4	9.8	20.0	1.22
Pherema	5.50	35.7	37.8	26.4	11.0	54.5	10.0	442.5	8.0	25.0	2.00
Socunema	4.98	43.0	31.3	25.6	11.8	52.0	9.2	338.3	10.5	19.0	2.00
Medziphema	5.56	33.8	33.8	32.3	10.6	45.4	6.5	386.1	8.0	17.5	0.20
Sirhima	4.90	45.7	31.2	23.0	9.5	50.1	7.8	331.1	9.5	14.8	1.10
Jharnapani	5.70	50.9	27.7	21.3	12.4	44.7	9.0	396.3	10.6	16.5	0.50
	(5.13)	(38.8)	(33.6)	(27.3)	(11.1)	(49.7)	(8.5)	(362.0)	(9.1)	(17.9)	(1.00)
Orchard Ecosystem											
Maova	5.38	45.3	34.4	20.2	13.0	55.0	11.2	420.1	11.8	24.4	3.00
Rajuphema	5.05	34.1	37.7	28.1	11.3	50.4	10.0	402.1	10.8	24.0	1.20
Piphema	4.59	38.2	32.2	29.5	15.0	55.0	12.3	392.1	10.9	23.0	2.05
Pherema	4.96	36.0	34.8	29.2	12.0	53.0	10.5	394.1	10.7	18.0	2.15
Socunema	4.97	41.2	29.9	28.8	12.8	55.0	12.6	494.0	8.0	21.0	0.50
Medziphema	5.66	35.8	35.4	28.6	9.8	57.2	11.6	364.8	13.5	24.3	0.50
Sirhima	5.66	34.6	29.7	35.6	12.8	52.0	11.7	414.0	10.3	22.4	1.10
Jharnapani	5.36	55.0	23.1	21.2	11.2	58.6	12.0	450.1	12.8	27.0	0.20
	(5.20)	(40.1)	(32.1)	(27.6)	(12.2)	(54.5)	(11.4)	(416.4)	(11.1)	(23.0)	(1.33)
Forest Ecosystem											
Maova	5.18	55.0	24.1	20.8	14.8	57.0	15.4	551.9	11.4	24.8	3.04
Rajuphema	5.80	47.2	34.5	18.2	12.3	55.9	16.8	467.0	14.2	24.2	2.20
Piphema	5.32	38.3	34.3	27.3	13.2	59.4	20.0	562.1	15.6	28.0	0.92
Pherema	4.99	35.8	38.2	26.0	16.6	55.0	17.0	511.0	10.3	30.0	2.80
Socunema	5.44	42.0	29.2	28.7	17.2	59.0	20.4	496.8	15.7	35.0	1.53
Medziphema	4.90	35.3	28.2	36.3	14.8	57.6	12.7	529.4	11.1	30.6	1.15
Sirhima	5.00	34.6	30.0	35.4	13.1	59.0	19.6	478.0	10.8	29.9	3.50
Jharnapani	4.40	41.8	24.2	33.8	14.0	58.2	17.9	552.7	10.1	32.2	2.85
	(5.13)	(41.2)	(30.3)	(28.3)	(14.5)	(57.6)	(17.4)	(518.6)	(12.4)	(29.3)	(2.24)
Overall average	(5.15)	(40.0)	(32.0)	(27.7)	(12.6)	(53.9)	(12.5)	(432.3)	(10.8)	(23.4)	(1.52)

Figure in parenthesis indicates mean value

Extent of deficient, marginal and sufficient soil samples was 41.7, 29.2 and nil, 33.3, 20.8 and 12.5 and 25.0, 50.0 and 87.5% under cereal, orchard and forest land use system, respectively. Higher amount of Zn in soils of forest land use system might be due to high organic carbon content of the soils which provides more surface area for ion exchange and cation adsorption and contributed to higher values of Zn in soils. Since DTPA is an organic chelating agent, extracts Zn from different pools and higher amount of organic carbon and severe soil acidity enhanced Zn concentration in soil solution. Similar findings were also noted by Talukdar *et al.*, (2009). Low amount of NPS and Zn under cereal and orchard ecosystem might be ascribed to regular mining and poor recycling of nutrients, which tended to deplete nutrient status of the soils.

Potassium Fractions

Total potassium content under cereal, orchard and forest ecosystems ranged from 1720 to 2710, 1930 to 2700 and 2670 to 3450 mg kg $^{-1}$ with an average of 2253.6, 2226.4 and 3019.0 mg kg $^{-1}$, respectively (Table 2). Available K, water soluble K, exchangeable K, 1N HNO_3 K and non-exchangeable K constituted 3.7, 0.3, 3.4, 42.9 and 39.3 % of the total K. Total K had positive significant correlation with organic carbon, clay content and other potassium forms and negative significant correlation (r= -0.34) with soil pH (Table 3). Irrespective of land use systems the available potassium content of the soils varied from 67.7 to 120.8 mg kg^{-1} with a mean value of 91.9 mg kg^{-1}. Available K content in the soils under cereal, orchard and forest ecosystem was 85.6, 88.6 and 101.5 mg kg^{-1}, respectively. 12.5% samples in cereal land use and 4.2% samples in forest land use were low and high in available K, respectively. While rest samples in each land use system were medium in available K. Extent of soil samples to medium class of K was 87.5, 100 and 95.8% in cereal, orchard and forest land use system, respectively. The water soluble K and exchangeable K contributed about 7.3 and 92.6 % towards available K. High amount of

Table 2: Forms of potassium of the soils under various land use system

Land use ecosystem & location of sampling	Total K (mg kg $^{-1}$)	Av K (1N NH_4OAc) (mg kg^{-1})	WS K (mg kg $^{-1}$)	Ex K (Av K - WS K) (mg kg^{-1})	1N HNO_3 K (mg kg $^{-1}$)	NE K (1N HNO_3 K - Av K) (mg kg^{-1})
Cereal Ecosystem						
Maova	2600	94.4	6.1	88.3	1203	1108.6
Rajuphema	2216	84.4	5.6	78.8	973	888.6
Piphema	2170	81.0	5.6	75.4	960	879.0
Pherema	1895	67.7	5.6	62.1	882	814.3
Socunema	2710	102.9	7.4	95.5	1216	1113.1
Medziphema	2218	88.4	6.1	82.3	1046	957.6
Sirhima	2500	90.6	6.0	84.6	1124	1033.4
Jharnapani	1720	75.9	5.5	70.4	797	721.1
	(2253.6)	(85.6)	(5.9)	(79.6)	(1025.1)	(939.4)
Orchard Ecosystem						
Maova	2411	91.4	6.5	84.9	1127	1035.6
Rajuphema	1930	92.2	5.6	86.6	910	817.8
Piphema	2080	77.7	5.9	71.8	959	881.3
Pherema	2130	80.0	6.7	73.3	983	903.0
Socunema	2010	85.4	7.1	78.3	1012	926.6
Medziphema	2220	85.4	5.7	79.7	972	886.6
Sirhima	2700	109.5	7.3	102.2	1107	997.5
Jharnapani	2330	87.9	6.9	81.0	1019	931.1
	(2226.4)	(88.6)	(6.4)	(82.2)	(1011.1)	(922.4)
Forest Ecosystem						
Maova	3251	91.3	6.8	84.5	865	773.7
Rajuphema	2807	87.2	7.0	80.2	995	907.8
Piphema	3450	120.0	9.2	110.8	1477	1357.0
Pherema	2670	86.8	6.2	80.6	901	814.2
Socunema	3010	112.2	8.2	104.0	1359	1246.8
Medziphema	3042	106.0	7.7	98.3	1264	1158.0
Sirhima	2992	101.3	8.8	92.5	1348	1246.7
Jharnapani	2930	107.0	8.5	98.5	1269	1162.0
	(3019.0)	(101.5)	(7.8)	(93.6)	(1184.7)	(1083.2)
Overall average	(2499.7)	(91.9)	(6.7)	(85.1)	(1073.6)	(981.7)

Av = available, WS = water soluble, Ex = exchangeable, NE = non-exchangeable
Figure in parenthesis indicates mean value

available K in the soils under forest ecosystem might be due to high organic carbon content. It had highly positive correlation with water soluble K, exchangeable K, 1N HNO_3 K and non-exchangeable K. Water soluble K ranged from 5.5 to 7.4, 5.6 to 7.3 and 6.2 to 9.2 mg kg^{-1} with an average of 5.9, 6.4 and 7.8 mg kg^{-1} in the soils under cereal, orchard and forest land use, respectively. Water soluble K was found to be more in the soils of forest land use system. Water soluble K had significant and positive correlation with other forms of potassium (Table-3). Irrespective of land use systems, exchangeable K ranged between 62.1 and 110.8 mg kg^{-1} with a mean of 85.1 mg kg^{-1}. The HNO_3 soluble K in the soils under cereal, orchard and forest land use systems varied from 797 to 1216, 910 to 1127 and 901 to 1477 mg kg^{-1} with an average of 1025.1, 1011.1 and 1184.7 mg kg^{-1}, respectively. The HNO_3 soluble K constituted, on an average 42.9% of the total K. Significant positive correlation was reported among the various forms of K indicated the existence of equilibrium among the potassium forms. Further, significant positive correlation between HNO_3 K and CEC (r=0.24) indicated that some K might be absorbed in the inner side of the lattice, which could not be exchanged by exchangeable NH_4^+ but could be extracted with HNO_3, was a part of exchange complex which is slowly exchangeable (Prasad, 2010). The non- exchangeable K content of the soils of the district ranged from 721.1 to 1357.0 mg kg^{-1} with an average of 981.7 mg kg^{-1}. The non- exchangeable K constituted 39.3 % towards total K. The non-exchangeable K have positive and significant relationship with other forms of K. These results are fairly comparable to the results reported by Sharma (2013) for acidic soils of Nagaland.

Table 3: Correlation coefficient between different forms of potassium and soil properties

Soil properties	Total K	Available K	Water soluble K	Exchangeable K	1N HNO_3 K	Non Exchangeable K
pH	-0.34^{**}	-0.15	-0.25^{*}	-0.23^{*}	-0.32^{**}	-0.23^{*}
CEC	-0.06	0.16	0.15	0.15	0.24^{*}	0.18
Porosity	0.06	0.10	0.11	0.08	0.08	0.07
SOC	0.35^{**}	0.36^{**}	0.38^{**}	0.36^{**}	0.35^{**}	0.22^{*}
Clay	0.33^{**}	0.30^{**}	0.21^{*}	0.31^{**}	0.33^{**}	0.35^{**}
Total K	-	0.89^{**}	0.88^{**}	0.79^{**}	0.87^{**}	0.86^{**}
Available K	-	-	0.86^{**}	0.89^{**}	0.75^{**}	0.67^{**}
Water soluble K	-	-	-	0.92^{**}	0.89^{**}	0.82^{**}
Exchangeable K	-	-	-	-	0.54^{**}	0.73^{**}
1N HNO_3 K	-	-	-	-	-	0.82^{**}

* *Significance at 5%,* ** *Significance at 1%*

The above results lead to a conclusion that the soils are rich in organic matter, medium in available N, adequate in available sulphur and DTPA Zn but deficient in available phosphorus. Available nutrients are relatively low in soils under cereals and orchard ecosystems than soils of forest ecosystems. Higher amounts of different forms of K were noticed in the soils of forest land use system. Organic carbon and clay content of soils showed significant and positive correlation with all forms of potassium. Highly significant and positive relationship was observed amongst different forms of K.

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