Annals of Plant and Soil Research 15(2): 87-92 (2013)

FERTILITY STATUS AND POTASSIUM FRACTIONS OF ACID SOILS OF MOKOKCHUNG, NAGALAND UNDER SOME IMPORTANT LAND USE SYSTEMS

Y.K. SHARMA

Department of Agricultural Chemistry and Soil Science, SASRD, Nagaland University, Medziphema, Nagaland, 797 106
Received: December, 2012, Revised accepted: September, 2013

ABSTRACT

Eighty surface (0-20cm) soil samples were collected from different locations of Mokokchung district of Nagaland under various land use systems and analyzed for some important physical and chemical properties, SOC, available N, P, S and different forms of potassium. Soils of this district were acidic in reaction (pH 4.19-5.26) and normal in total soluble salts concentration (0.14 to 0.24 dSm^{-1}). Slightly low pH was noticed in the soils of forest ecosystem. The CEC of the soils was quite low.(9.5 to 16.6 cmol (P^{+}) kg^{-1}) and soils under forest land use indicated higher CEC than other land use systems. On the basis of average values, the soils of the district were high in organic carbon, medium in available nitrogen and low in available phosphorus contents. Higher values of SOC and available N, P and S were recorded in the soils of forest ecosystem followed by soybean, vegetable and cereal ecosystem. Available S in the soils varied from 13.8 to 37.6 kg ha^{-1}. The total K, 1N NH_4OAc- K, water soluble- K, 1N HNO_3 -K and 0.01M $CaCl_2$ -K ranged between 1641 and 3455, 61.3 and 130.0, 4.8 and 9.5, 865 and 1497 and 16.4 and 36.3 mg kg^{-1}. Wide variations in K content were observed in four extractants and highest values were recorded in boiling 1N HNO_3 K. The available K, water soluble K, boiling 1N HNO_3-K and 0.01 M $CaCl_2$- K constituted 3.7, 0.3, 45.1 and 1.1% towards total K in these soils. Highly significant and positive relationship amongst different forms of K indicated an existence of dynamic equilibrium among various forms of K. All fractions of K were significantly and positively correlated with SOC.

Key words: Physical and chemical characteristics, soil fertility, potassium fractions, land use systems.

INTRODUCTION

Detailed knowledge about soil fertility status of an area is very much relevant for identifying problems and constraints in crop production management for attaining sustained productivity and facilitating agro-technology transfer programme. Nutrients status of soil play a vital role in the growth, development and yield of plant and the information on the nutritional status of an area can go a long way in planning judicious fertilizers and soil management practices to develop economically viable alternatives. Knowledge about nutrients status of the soil and their interrelationship with physical and chemical properties is helpful in understanding the inherent capacity of soil to supply essential plant nutrients for utilization to crops. Potassium, a component of various soil forming minerals, an activator of enzymes involved in protein and carbohydrate metabolism, helps in carbohydrate translocation, stomatal opening, membrane permeability and enhances the plants ability to resist diseases, is released to soluble and exchangeable form by soil forming minerals at different rates. Soil potassium exists in dynamic equilibrium in four forms viz., water soluble, exchangeable, non- exchangeable and lattice K, of which the first two are important for the growth of plants and microbes. The annual removal of N, P_2O_5, K_2O and S by different crops in North Eastern Hill Region of India is about 96300, 17360, 84200 and 6328 tonnes, respectively. The annual replenishment of N, P_2O_5 and K_2O through fertilizers and organic sources is only 26.4, 41.5 and 9.4%, respectively (Sharma and Shukla, 2001). 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. Therefore, determination of these soil properties along with nutrient status and different forms of potassium of important land use systems may have significant importance. Scanty information is available on physical and chemical properties and nutrient status of soils of Mokokchung district of Nagaland. Therefore, an attempt has been made to generate information regarding physical and chemical properties along with available NPS and different forms of potassium of soils under cereals, vegetable, soybean and forest ecosystem.

MATERIALS AND METHODS

For present investigation, eighty (four samples from each ecosystem of each village) composite soil samples (0 – 20 cm), representing leading land use ecosystems viz., cereals ecosystem, vegetable ecosystem, soybean ecosystem and forest ecosystem and covering wide area of district were collected with the help of auger from different locations of the villages of Mokokchung district of Nagaland. The study area (Mokokchung district) is one of the major district of Nagaland located between $93^0$53' and $94^0$53' E longitude and 25^0 56' and 26^0 56' N latitude situated at an altitude of 1326 m above msl having a total area of 1615 km^2 with mean annual rainfall of 1250 mm. Physiographically, the district made up of high hills, medium hills, low and very low hills, valleys and river terraces (Zende, 1987). Major crops of the district are paddy, maize, soybean and cucurbits, grown under rain fed condition. Maximum area of the district is covered by forest. Processed soil samples were analysed for pH, EC, CEC using standard methods of proposed by Chapmam, (1965). Soil organic carbon, available nitrogen and available potassium were analyzed using standard methods (Jackson, 1973). For estimation of available P, soil samples were extracted with NH_4F (Bray and Kurtz, 1945) and phosphorus content in soil extract was determined as described by Jackson (1973). Available sulphur of soil samples was determined by extracting the soil with 0.15% $CaCl_2$ (Williams and Steinbergs 1959) and sulphur in the extract was estimated by turbidimetric method (Chesnin and Yien 1951). Total K was determined by digestion of the soil samples with perchloric and hydrofluoric acid (Jackson, 1967). Water soluble K was determined by shaking the soil with distilled water (1:5 soil and water suspension). The 1N boiling HNO_3-K and 0.01M $CaCl_2$-K were estimated adopting the methods advocated by Wood and Deturk, (1941) and Woodruf and Mclntosh, (1960), respectively. Different forms of potassium were determined flame photometrically. Simple correlation coefficients were worked out to relating various forms of potassium with soil properties (Panse and Sukhatme 1961).

RESULTS AND DISCUSSION

Physico- Chemical properties

Irrespective of land use systems, the average pH and EC values of soils of the district varied from 4.19 to 5.26 and 0.14 to 0.24 dSm^{-1}, respectively indicating that the soils are acidic in reaction without remarkable accumulation of soluble salts (Table 1). Average pH and EC values of the soils under cereal, vegetable, soybean and forest ecosystem were recorded 4.51, 4.56, 4.80 and 4.43 and 0.18, 0.17, 0.18 and 0.20 dSm^{-1}, respectively. The soils under forest ecosystem showed slightly less pH and higher EC as compared to other ecosystems. Excess leaching of bases from the soil profile due to heavy rainfall might be caused acidity in these soils (Sharma and Singh, 2002). Less accumulation of soluble salts in soil profile might be due to leaching of soluble salts, releases during weathering of soil forming minerals with sufficient water received by high rainfall of the district. Similar findings have also been reported by Amenla *et al.* (2010). Mean CEC of the soils of cereals, vegetable, soybean and forest land use patterns varied from 9.9 to 15.5, 9.5 to 14.0, 9.8 to 12.4 and 10.2 to 16.6 cmol (p^+) kg^{-1} with an average of 11.6, 12.6, 11.3 and 14.0 cmol (p^+) kg^{-1}, respectively. The data further revealed that the soils under forest ecosystem indicated higher CEC value than other ecosystems might be due to high organic carbon content of the soils under forest ecosystem. Low CEC values of the soils of Nagaland have also been reported by Patton *et al.* (2007). Soils under different land use had wide variation in the soil organic carbon (SOC) status. Irrespective of land use systems, the mean SOC content in soil samples of different villages ranged from 9.0 to 21.4 g kg^{-1}. Average SOC under cereals, vegetable, soybean and forest ecosystems were 10.7, 12.5, 16.0 and 19.9 g kg^{-1}, respectively. The data further revealed that lands under forest ecosystem tended to promote SOC accumulation while continues cultivation of cereals, vegetable and soybean in the same fields accelerated SOC depletion. Irrespective of land use systems, all the samples contained high amount of SOC. Wide variation in SOC accumulation under different land use systems has also been reported by Singh *et al.* (2006).

Fertility Status

Mean available N and P contents of the soils under cereals, vegetable, soybean and forest land use patterns ranged from 288.3 to 342.5, 321.1 to 396.3, 394.0 to 451.9 and 372.1 to 509.4 kg ha^{-1} and 6.5 to 8.8, 7.5 to 10.6, 7.5 to 11.4 and 8.1 to 12.3 kg ha^{-1} with an average of 316.1, 354.1, 417.0 and 452.7 kg ha^{-1} and 8.0, 8.7, 9.2 and 10.1 kg ha^{-1}, respectively (Table 1). On the basis of mean available N, soils of all the villages under different land use systems fell under medium category of nitrogen. Medium class of available N indicates that the mineralizable N fraction under such type of climatic condition and acidic environment is rather low. Forest ecosystem showed higher amount of available N and P as compared to other ecosystems might be due to higher status of

Table 1: The pH, EC, CEC, organic carbon and available N, P and S status of soils under various land use ecosystem

Land use ecosystem & location	pH	EC (dSm^{-1})	CEC Cmol (P^+) kg^{-1}	Organic carbon (g kg^{-1})	Available nutrients ($kgha^{-1}$)		
					N	P	S
Cereals Ecosystem							
Chami	4.62	0.23	11.7	10.0	326.2	8.5	15.0
Kupza	4.21	0.18	15.5	12.0	288.3	6.5	13.8
Mangmetong	4.34	0.21	9.9	11.4	293.4	7.8	20.8
Mopungchuket	4.52	0.14	10.3	10.9	342.5	8.8	25.0
Settsu	4.88	0.16	10.8	9.0	330.3	8.5	18.0
	(4.51)	(0.18)	(11.6)	(10.7)	(316.1)	(8.0)	(18.5)
Vegetable Ecosystem							
Chami	4.95	0.16	9.5	9.8	321.1	7.5	13.8
Kupza	4.70	0.24	13.4	14.0	396.3	10.6	15.5
Mangmetong	4.31	0.14	13.7	12.2	329.1	6.8	22.4
Mopungchuket	4.35	0.18	12.3	11.3	342.1	9.6	24.0
Settsu	4.50	0.15	14.0	15.1	382.1	8.9	18.0
	(4.56)	(0.17)	(12.6)	(12.5)	(354.1)	(8.7)	(18.7)
Soybean Ecosystem							
Chami	4.37	0.23	12.4	14.6	394.0	8.0	21.7
Kupza	4.66	0.17	11.1	19.6	404.8	7.5	24.3
Mangmetong	4.60	0.14	12.0	14.7	404.0	10.3	18.4
Mopungchuket	5.26	0.20	11.2	12.0	430.1	8.8	26.0
Settsu	5.12	0.17	9.8	19.1	451.9	11.4	20.8
	(4.80)	(0.18)	(11.3)	(16.0)	(417.0)	(9.2)	(22.2)
Forest Ecosystem							
Chami	4.32	0.24	10.2	20.8	372.1	9.6	24.0
Kupza	4.19	0.16	16.6	17.9	421.0	12.3	30.5
Mangmetong	4.44	0.20	13.2	21.4	486.8	9.7	33.0
Mopungchuket	4.98	0.22	14.8	20.7	509.4	8.1	37.6
Settsu	4.21	0.18	15.1	18.6	474.0	10.8	25.9
	(4.43)	(0.20)	(14.0)	(19.9)	(452.7)	(10.1)	(30.2)

Figure in parenthesis indicates mean value

SOC under forest ecosystem. These results are in agreement with those of Somasundaram *et al.* (2009) and Mandal *et al.* (2013). The mean sulphur content in the soils under cereals, vegetable, soybean and forest ecosystems varied from 13.8 – 25.0, 13.8 – 24.0, 18.4 – 26.0 and 24.0 – 37.6 kg ha^{-1} with an average of 18.5, 18.7, 22.2 and 30.2 kg ha^{-1}, respectively. Likewise SOC, available N and P, soils under forest land use system showed higher amount of sulphur in comparison to soils of other land use system. Lower amount of these nutrients under cereals, vegetable and soybean ecosystem might be ascribed to regular mining and poor recycling of nutrients, which tended to deplete nutrient status of the soils. Variation in available NPS contents under different land use systems might be due to variation of organic carbon status of the soils.

Fractions of Potassium

Irrespective of land use systems, the total potassium content of soils studied varied from 1641 to 3455 mg kg^{-1} (Table 2). Mean total potassium content under cereal, vegetable, soybean and forest ecosystem ranged from 1875 to 2714, 1727 to 2517, 1641 to 2702 and 2070 to 3455 mg kg^{-1} with an average of 2318, 2136, 2227 and 2830 mg kg^{-1}, respectively with an overall average of 2378 mg kg^{-1}. The available K, water soluble K, exchangeable K, 1N HNO_3 K, 0.01 M $CaCl_2$ K and non-exchangeable K constituted 3.7, 0.3, 3.5, 45.1, 1.1 and 41.4% of the total K. Total K had positive significant correlation with EC, SOC and available N and S and other forms of potassium (Table 3). The mean available potassium content of the soils varied from 61.3 to 130.0 mg kg^{-1}. Average available K content under cereal, vegetable, soybean and forest ecosystem was recorded 86.4, 80.0, 83.2 and 105.8 mg kg^{-1}, respectively. The water soluble and exchangeable K contributed about 7.1 and 92.8% towards available K. Higher values of

Table 2: Different forms of potassium of the soils under various land use ecosystem

Land use ecosystem & location	Total K (mg kg $^{-1}$)	1N NH_4OAc (mg kg $^{-1}$)	WS K (mg kg $^{-1}$)	Ex- K (mg kg $^{-1}$)	1N HNO_3 K (mg kg^{-1})	0.01M $CaCl_2$ K (mg kg $^{-1}$)	NE K (mg kg $^{-1}$)
Cereals Ecosystem							
Chami	2620	97.4	7.1	90.3	1203	30.0	1105.6
Kupza	2206	82.4	5.9	76.5	973	25.0	890.6
Mangmetong	2178	81.6	5.8	75.8	960	24.5	878.4
Mopungchuket	1875	69.7	4.6	65.1	882	19.0	812.3
Settsu	2714	100.9	7.4	93.5	1216	29.5	1115.1
	(2318)	(86.4)	(6.1)	(80.3)	(1046)	(25.6)	(960.3)
Vegetable Ecosystem							
Chami	2517	93.6	6.8	86.8	1124	28.2	1030.4
Kupza	1727	65.9	5.2	60.7	797	16.4	731.1
Mangmetong	2431	90.4	6.5	83.9	1127	29.0	1036.6
Mopungchuket	1936	72.2	5.0	67.2	910	21.8	837.8
Settsu	2070	77.7	5.5	72.2	959	23.2	881.3
	(2136)	(80.0)	(5.7)	(74.1)	(983)	(23.6)	(903.3)
Soybean Ecosystem							
Chami	2210	85.4	6.1	79.3	1012	25.1	926.6
Kupza	2280	85.4	5.9	79.5	972	25.4	886.6
Mangmetong	2702	99.5	7.3	92.2	1107	28.7	1007.5
Mopungchuket	2300	85.9	5.9	80.0	1019	25.6	933.1
Settsu	1641	61.3	4.8	56.5	865	18.5	803.7
	(2227)	(83.2)	(6.0)	(77.4)	(995)	(24.6)	(911.3)
Forest Ecosystem							
Chami	3455	130.0	9.5	120.5	1497	36.3	1367.0
Kupza	2070	76.8	5.2	71.6	881	20.4	804.2
Mangmetong	3010	112.2	8.2	104.0	1359	32.7	1246.8
Mopungchuket	2642	100.0	7.0	93.0	1264	26.8	1164.0
Settsu	2982	111.3	8.1	103.2	1348	32.7	1236.7
	(2830)	(105.8)	(7.5)	(98.2)	(1269)	(29.7)	(1163.7)

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

available K was recorded under forest ecosystem which might be due to high SOC content. It had highly positive correlation with water soluble K, exchangeable K, 1N HNO_3-K, 0.01 M $CaCl_2$-K and non-exchangeable-K.These values are fairly comparable to the results reported by Amenla et. al. (2010) for acidic soils of Nagaland. Water soluble K ranged from 4.6 – 7.4, 5.0 -6.8, 4.8 – 7.3 and 5.2 – 9.5 mg kg^{-1} with an average of 6.1, 5.7, 6.0 and 7.5 mg kg^{-1} under cereal, vegetable, soybean and forest ecosystems, respectively. Likewise total and available K, water soluble K was found to be more in the soils of forest ecosystem and least under vegetable ecosystem. Water soluble K had significant and positive correlation with other forms of potassium studied. Irrespective of land use systems, the soils had exchangeable K ranging between 60.7 and 120.5 mg kg^{-1} and averaging 82.5 mg kg^{-1}. The HNO_3 soluble K in the soils under cereal, vegetable, soybean and forest ecosystem varied from 882 to 1216, 797 to 1127, 865 to 1107 and 881 to 1497 mg kg^{-1} with average of 1046, 983, 995 and 1269 mg kg^{-1}, respectively. The HNO_3 soluble K constituted, on an average 45.1% of the total K. Positive and significant relationship indicated that the HNO_3 soluble K has some bearing on the level of forms of K. Irrespective of land use systems, the 0.01M $CaCl_2$ K and non-exchangeable K content of the soils of the district ranged from 16.4 to 36.3 mg kg^{-1} and 731.1 to 1367.0 mg kg^{-1} with an average of 25.9 and 984.7 mg kg^{-1}, respectively. The 0.01M $CaCl_2$ and non-exchangeable K constituted, on an average 1.1 and 41.4% towards total K, respectively. Both, the 0.01M $CaCl_2$ K and non- exchangeable K have positive and significant relationship with other forms of K studied. These results are in agreement with those of Gupta *et al.* (1983) and Mandal *et al.* (2011).

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

Soil properties	Total	Available	Water soluble	Exchan.	1N HNO_3	0.01M $CaCl_2$	Non. Exch.
pH	0.18	0.19	0.15	0.18	0.120	0.18	0.11
EC	0.24*	0.27*	0.31**	0.27*	0.28*	0.18	0.28*
CEC	0.04	0.05	0.02	0.05	0.04	-0.01	0.04
SOC	0.35**	0.36**	0.37**	0.36**	0.38**	0.24*	0.38**
Available N	0.22*	0.23*	0.23*	0.23*	0.28*	0.10	0.28*
Available P	-0.04	-0.05	-0.01	-0.05	-0.04	-0.18	-0.04
Available S	0.28**	0.29**	0.21	0.30**	0.33**	0.17	0.34**
Total K	-	0.99**	0.98**	0.99**	0.97**	0.96**	0.96**
Available K	-	-	0.88**	0.99**	0.77**	0.86**	0.66**
Water soluble K	-	-	-	0.98**	0.86**	0.75**	0.86**
Exchangeable K	-	-	-	-	0.57**	0.76**	0.76**
1N HNO_3 K	-	-	-	-	-	0.94**	0.92**
0.01M $CaCl_2$	-	-	-	-	-	-	0.74**

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

The results of the present study lead to a conclusion that the soils of study area differed in nutrient status. Soils are rich in organic matter, medium in available N and K, adequate in available sulphur but deficient in available phosphorus content. Available nutrients content were relatively low in soils under cereal, vegetable and soybean ecosystems than soils of forest ecosystem. SOC showed significantly positive correlation with all forms of potassium. Highly significant and positive relationship was observed amongst different forms of K. Forest have capacity to maintain sufficient range of available nutrients through addition of huge amount of organic matter, whereas soils under cereal crops cultivated fields showed more mining of nutrients. In general, the soil had a major problem of acidity and poor fertility.

REFERENCES

Amenla, T., Sharma, Y.K and Sharma, S.K. (2010) Characterization of Soils of Nagaland- With Special Reference to Mokokchung District. *Environment and Ecology*. ***28**: 198-201*

Bray, R.A. and Kurtz, L.T. (1945) Determination of total, organic and available forms of phosphorus in soils. *Soil Sci.* ***59**: 39-45.*

Chapmam, H.D. 1965. Cation exchange capacity In: Methods of Soil Analysis, Part II (C.A. Black, Ed) 891-901, *American Society of Agron.* Madison, Wisconsin, USA.

Chesnin, L. and Yien, C.H. (1951) Turbidimetric determination of available sulphate. *Soil Science Society of America Proceeding.* ***15**: 149-151.*

Gupta, R.K., Datta, M. and Sharma, S. (1983) difference forms and Q/I parameters of potassium in acid soils of Nagaland. *Journal of the Indian Society of Soil Science* ***31**: 305-307.*

Jackson, M.L. (1967 & 1973) *Soil Chemical Analysis*, Prentice Hall of India Pvt. Ltd. New Delhi.

Mandal, D., Dey. S.K. and Baruah, T.C. (2011) Forms of potassium and their distribution in rubber growing soils of Tripura. *Annals of Plant Soil Research* 13: 75-79.

Mandal, D., Dey. S.K. and Baruah, T.C. (2013) Status of major nutrients in rubber soils of north-east India in relation to soil acidity. *Annals of Plant Soil Research* 15: 23-26.

Panse, V.G. and Sukhatme, P.V. (1961) Statistical Methods for Agricultural Workers, ICAR, New Delhi.

Patton, S., Sharma, S.K. and Singh, P.K. (2007) Characterization of the acidity of soils under different land use patterns in Nagaland. *Journal of the Indian Society of Soil Science* ***55**: 134-138.*

Sharma, U.C. and Shukla, L.M. (2001) Nutrient mining in different agro- climate zones of the North Eastern Hill Region. *Fertilizer News* ***46**(4): 115-119.*

Sharma, U.C. and Singh, R.P. (2002) Acid soils of India- their distribution, management and future strategies for higher productivity. *Fertilizer News* ***47**(3): 45-52.*

Singh, R.D., Sanjay Kumar and Harit Pande (2006) Micronutrient status of soils under different vegetation in Uttranchal Hills. *Journal of the Indian Society of Soil Science* ***54****: 115-116.*

Somasundaram, J., Singh, R.K., Parandiyal, A.K. and Prasad, S.N. (2009) Micronutrient status of soils under land use systems in Chambal ravines. *Journal of the Indian Society of Soil Science* ***57****: 307-312*

Venkatesh, M.S., Majumdar, B., Kumar, K. and Patiram (2003) Status of micronutrient cations under various land use systems of Meghalaya. *Journal of the Indian Society of Soil Science* ***51****: 60-64*

Williams, C.H. and Steinbergs, A. (1959) Soil sulphate fractions and chemical indices of available sulphur in some Australian soils. *Australian Journal of Agriculture Research* ***10****: 340- 352*

Wood, L. K. and Deturk, E.E. (1941) The adsorption of potassium in soil in non- replaceable forms. *Soil Science of America Proceeding.* ***5****: 152-161.*

Woodruf, C.M. and Mclntosh, J.L. (1960) Testing of soil for potassium. *Proceedings of the 7th International Congress of Soil Sci.*, Madison, Wisconsin, pp. 80-85.

Zende, N. A. (1987) Soils of Nagaland in relation to their physiography, their characteristics and classification. *Journal of the Indian Society of Soil Science* ***35****: 706-711.*