Soil Physio-Chemical Analysis In Tea Growing Areas of Mokokchung District, Nagaland

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Abstract- *The present work is an attempt to report status of soil physio-chemical characteristics in two tea gardens of Mokokchung district in Nagaland, India. Twenty soil samples were collected from rhizospheric and non-rhizospheric regions at three months interval and soil parameters such as pH, moisture, temperatures, moisture, organic carbon and macronutrients NPK were recorded. Variations in studied soil properties were found throughout the sampling periods. Highest soil pH, temperature, moisture and organic carbon recorded were 6.30, 36.63°C, 48.49% and 1.92% from TR, T, UR and UR. Results on macronutrients analysis showed medium to high levels of available N, medium to high levels of available P and low to medium levels of available potassium. Statistical analysis gave strong and positive correlation between available N and soil parameters temperature and pH, between available P and O.C, and between available K and moisture, temperature, pH and O.C in soil of Tuli. In soil of Ungma, strong and positive correlation was observed between available N and O.C, between available P, available K and moisture, temperature, pH and O.C. Results from present study can be of great assistance in further development of reliable and accurate data on nutrient conditions and can be used in assessing soil fertility programme for tea growing areas in the state.*

Keywords- Macronutrients, Soil Parameters, Tea Gardens, Variation.

I. INTRODUCTION

Tea is the cheapest non-alcoholic beverage made from young leaves and buds of *Camellia sinensis* L.(O.)Kuntze. When it come to tea production, India ranks second among the largest producer of tea in the world however, major portion of its total production are being consumed within the country indicating its potential as a great economic crop of the country. North-East region of India is gifted with pleasant climatic conditions and rich biodiversity allowing region to be favorable for growing many agricultural crops. Tea growing is a recent practice in Nagaland despite its neighbouring state Assam being considered as one of the largest tea growing states in India since introduction of the crop in the country. In recent years tea plantation in Nagaland has been growing in small holdings and maximum tea plantation can be seen in Mokokchung district.

Before introducing any crop to an area it is prerequisite to have knowledge on status of nutrients and soil properties inorder to establish ideal growing conditions especially for economic crop like tea where growth and yield are the source of livelihood for millions. Soil is a dynamic medium serving as an interaction ground among physical, chemical and biological factors, the outcome of which aids in environment stability and crop productivity. Plant available elements are indicated by their concentration in the soil [1]. Plants uptake nutrients from soil and in turn maintain soil fertility through litter and other plant parts that fall in the soil [2] thus, positive inter-relationship exist between plants and soil. Climatic conditions and management practices are the two most important factors affecting nutrient transformation in any land use system [3]. In the present scenario of increasing population and pollution, proper management of soil properties and understanding relationship among themselves has become foremost requirement for any agricultural practice as all these factors ultimately determine fate of any crop. The present work attempted to evaluate soil macronutrients nitrogen (N), phosphorus (P) and potaasium (K) and other soil properties in two major tea-growing areas of Mokokchung district, Nagaland. This report is the first of its kind related to work concerning soil physio-chemical properties and nutrient status in these tea gardens of Mokokchung district, Nagaland.

II. MATERIALS AND METHODS

Study site

Tea gardens located at Tuli (geographical coordinates- N 26°39’19.3 E 094°39’22.7) and Ungma (geographical coordinates- N 26°17’30.6 E 094°28’29.2) under Mokokchung district of Nagaland, India were selected for the present study. Twenty soil samples were collected from rhizosphere and non-rhizosphere of both tea gardens after every three months from April 2016 to April 2017. Rhizospheric soils were collected by uprooting tea plants and shaking off soils adhering to tea roots in a sterile polythene bags and non-rhizospheric soils were collected few

centimeters away from tea plants by digging out soils from 10-15 cm depth. Collected samples were mixed into composite samples and transferred to laboratory under sterile conditions. For soil nutrients and physio-chemical analysis, samples were air dried and sieved to pass through <2mm screen. Rhizospheric soil of Tuli and Ungma were designated as TR and UR while non-rhizospheric soils were named as T and U.

Soil analysis

Soil temperatures were measured during the sampling time with a thermometer. For soil pH, 5g of soil were mixed with distilled water at a ratio 1:2.5 ml and kept in rotary shaker for 15 minutes. Solutions were allowed to settle for 5 minutes and pH was measured using digital systronic pH meter 361. For soil moisture, 20g of soil were oven dried and weight loss was recorded. Soil moisture percentage were calculated with the formula-

$$\text{Moisture content (\%)} = \frac{\text{fresh weight} - \text{dry weight}}{\text{dry weight}} \times 100$$

Soil organic carbon was determined following the wet digestion of [4] and percentage organic carbon content in soil were calculated with the formula-

$$\text{\% O.C} = \frac{10\ (S-B) \times 0.003}{S} \times \frac{100}{\text{weight of soil sample}}$$

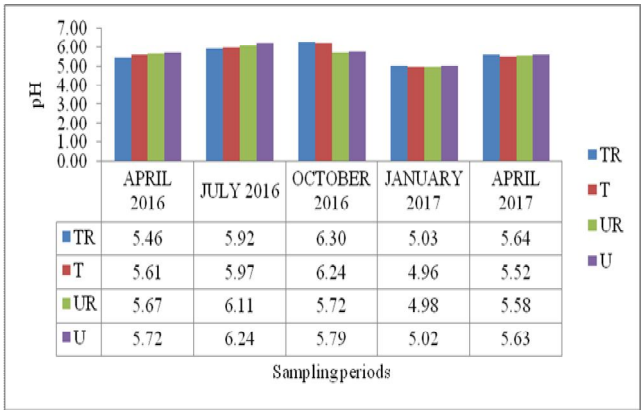
Available Nitrogen (N) was determined using KEL PLUS Nitrogen analyser. Reagent preparations and experimental setup were done following manufactures manual. Available phosphorus (P) was determined spectrophotometrically at 660nm following Brays and Kurtz method [5] using ELICO double beams SL210. Available potassium (K) was extracted using ammonium acetate solution [6] and readings were done employing flame photometer according to manufacturer's manual. All these analysis were performed in triplicates.

Data analysis:

Microsoft excel 2007 and Spss 16.0 was used for calculations and data analysis. Datas were subjected to Pearson's correlation to find correlation among soil factors.

III. RESULT AND DISCUSSION

Soil pH- Soil pH can affect soil properties be it biology, chemistry or physical [7]. Soils from both study areas were moderately acidic throughout the season. Soil acidity was highest during the cold winter month of January which may be due to debris from pruning of tea bushes [8] during this month. pH values were found to be ranging from 5.03 to 6.30 in TR, 4.96 to 6.24 in T, 4.98 to 6.11 in UR and 5.02 to 6.24 in U (Figure 1). Acidity was more in rhizospheric soils throughout the sampling period except in the month of January in soil samples from Tuli where it was more acidic in T than in TR. Lower pH in rhizospheric soils may be due to uptake of large amount of cations than anions by tea roots as indicated by others through their studies in rhizosphere of different ecosystems [9,10]. Similar observations where tea rhizospheric soils having lower pH than non-rhizospheric soils were also recorded by Pandey and Palni [11] through their work in five tea bushes differing in plantation age. Statistical analysis showed significant positive correlation of soil pH with other soil parameters in both study areas except with O.C in tea garden of Tuli where no significant correlation was established (Table 1 and 2).

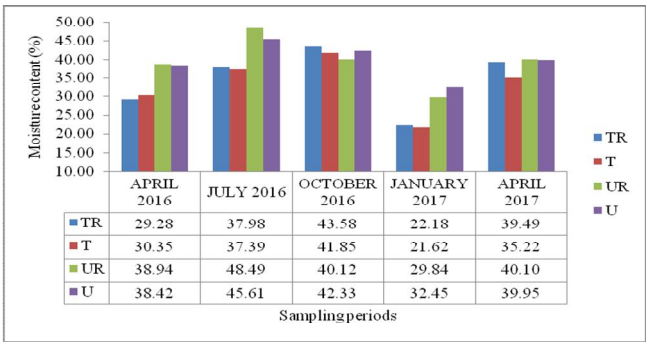


	APRIL 2016	JULY 2016	OCTOBER 2016	JANUARY 2017	APRIL 2017
TR	5.46	5.92	6.30	5.03	5.64
T	5.61	5.97	6.24	4.96	5.52
UR	5.67	6.11	5.72	4.98	5.58
U	5.72	6.24	5.79	5.02	5.63

Figure. 1. Differences in soil pH of tea gardens under different sampling periods.

values are mean of triplicates.

Soil moisture content (%) - Moisture content ranges from 22.18% to 43.58% in TR, 21.62% to 41.85% in T, 29.84% to 48.49% in UR and 32.45% to 45.61% in U (Figure 2). Soil moisture has profound effect in soil microbial activity [12] which in turn enhances soil organic carbon content. Highest moisture content in T and TR was observed in October while it was observed in July incase of U and UR. Heavy rainfall during these months may be the factor responsible for these high moistures. Significantly strong positive relation was observed between soil moisture content and temperatures in tea garden of Tuli and Ungma with correlation coefficient (r) .811** and .920** at $p<0.01$. Similarly at $p<0.01$, strong and positive correlations were also recorded between soil moisture content and pH in both study areas (Table 1 and 2).

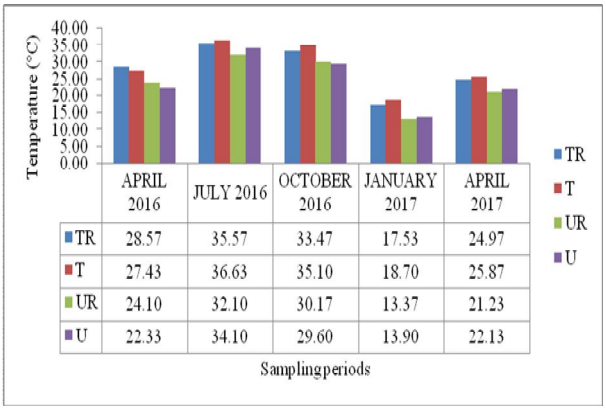


	APRIL 2016	JULY 2016	OCTOBER 2016	JANUARY 2017	APRIL 2017
TR	29.28	37.98	43.58	22.18	39.49
T	30.35	37.39	41.85	21.62	35.22
UR	38.94	48.49	40.12	29.84	40.10
U	38.42	45.61	42.33	32.45	39.95

Figure.2. Differences in soil moisture content (%) under different sampling periods.

values are mean of triplicates.

Soil temperatures- Soil temperatures were recorded to be ranging from 17.53°C to 35.37°C, 18.70°C to 36.63°C, 13.37°C to 32.10°C and 13.90°C to 34.10°C in TR, T, UR and U (Figure 3). Variations were observed in soil temperatures in all study sites throughout the sampling periods. This may have been due to sampling time and differences in geographical location between the two tea gardens. Between the two study areas highest soil temperature was recorded from tea garden of Tuli. Among soil properties, temperature is considered as the most important factor when it comes to mineralization process of organic matter [13] and soil organic carbon mineralization rate were reported to increase significantly with temperature [14]. However in the present work, no significant relation was established (Table 1and 2) between soil organic carbon content and temperature in both the study areas.

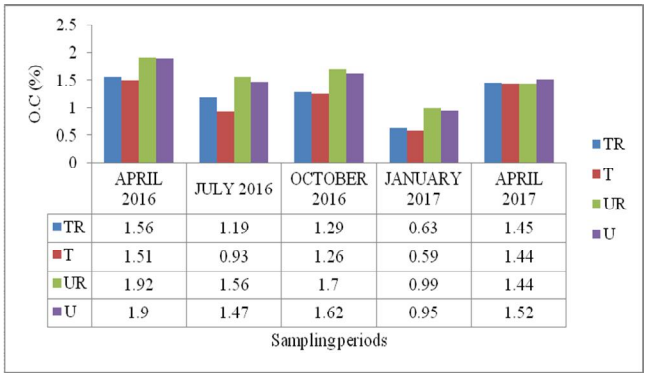


	APRIL 2016	JULY 2016	OCTOBER 2016	JANUARY 2017	APRIL 2017
TR	28.57	35.57	33.47	17.53	24.97
T	27.43	36.63	35.10	18.70	25.87
UR	24.10	32.10	30.17	13.37	21.23
U	22.33	34.10	29.60	13.90	22.13

Figure.3. Differences in soil temperatures (°C) under different sampling periods.

values are mean of triplicates.

Organic carbon (%)- Soil is the largest reservoirs of carbon and acting as it sink or source. Global soil organic carbon is estimated to be 1,500- 1,550 Pg [15,16]. Results on carbon content showed highest content in April 2016 in both tea gardens (Figure 4) which could be due to maximum inputs of carbon in the form of tea litterfall during winter months that are in turn decomposed by microbial activity during spring rain. Variations in soil organic carbon content were observed among the sampling periods between the two study areas. This can be due to seasonal changes that affect other soil physio-chemical parameters and microbial activity. Correlation between soil organic carbon and other soil properties indicate significantly positive relation with soil pH (r=.653*) at $p<0.05$. Amount and quality of soil organic carbon sustains soil quality and productivity [17] thereby, serving as energy source for biological process.



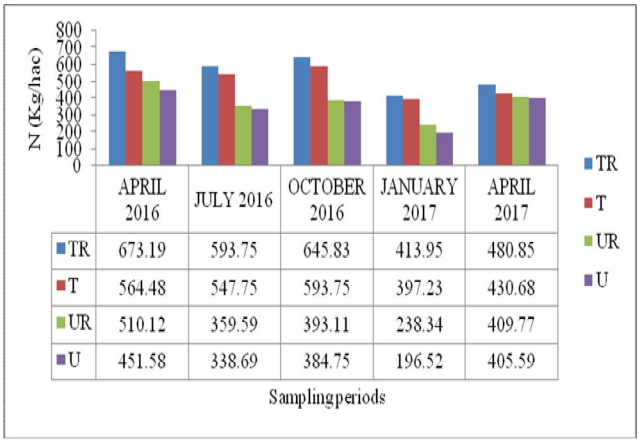
	APRIL 2016	JULY 2016	OCTOBER 2016	JANUARY 2017	APRIL 2017
TR	1.56	1.19	1.29	0.63	1.45
T	1.51	0.93	1.26	0.59	1.44
UR	1.92	1.56	1.7	0.99	1.44
U	1.9	1.47	1.62	0.95	1.52

Figure.4. Differences in soil carbon content (%) under different sampling periods.

values are mean of triplicates.

Soil Macronutrients- Nitrogen is the most limiting plant nutrient in soil and is taken up by plants in the form of ammonium or nitrate. Available N was found to be highest with an amount of 673.19 kg/hac while the lowest amount was 196.56 kg/hac (Figure 5). Taking reference from published work [18], levels of available N in tea gardens comes under medium to high category and under low to medium category depending upon sampling periods. Soil parameters such as soil pH, temperature and organic carbon were found to be significantly and positively correlated with available N in this study (Table 3 and 4) indicating their role in soil available N. Considered as major nutrient for plants only next to nitrogen, phosphorus plays a key role in plant development. 12.31 kg/hac to 34.90 kg/hac in TR, 9.86 kg/hac to 12.31 kg/hac in T, 16.71 kg/hac to 46.45 kg/hac in UR and 15.59 to 45.57 kg/hac in U (Figure 6). This indicates that available phosphorus in studied tea gardens belong to medium to high, low to medium, medium to high and medium to high category [18]. Correlation of available phosphorus with pH and soil organic carbon gave significant and positive result with r=.978** and .752* at $p<0.01$and $p<0.05$ in tea garden of Ungma while incase of Tuli despite significantly correlated with soil organic carbon (r=.842**) at $p<0.01$ no significant

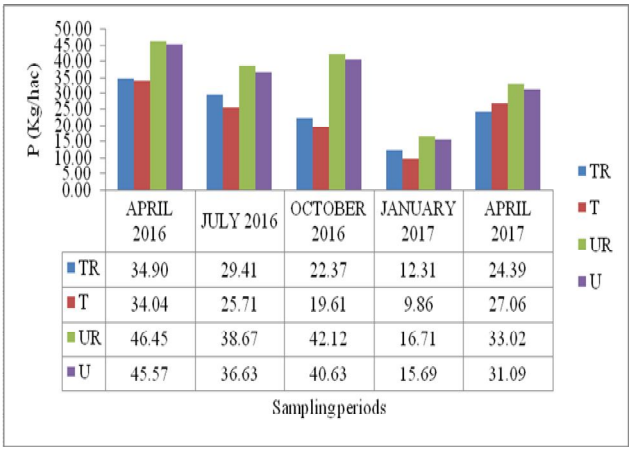
correlation was established with soil pH. Significantly strong and positive correlation of soil available phosphorus with pH and soil organic carbon can also be seen in the work previous workers [19]. Other soil parameters also seem to have influence soil phosphorus level as parameters such as soil moisture and temperature were positively correlated in one tea garden. Available potassium was found to be ranging from 71.49 kg/hac to 227.66 kg/hac in TR, 55.87 kg/hac to 224.19 kg/hac in T, 94 kg/hac to 265.8 kg/hac in UR and 92.3 kg/hac to 253.7 kg/hac in U (Figure 7) representing its level in low to medium category in both tea gardens when referred with standard data [18]. Potassium is an essential plant nutrient that plays a vital role in balancing of mineral, hydration of plants and is also an activator of many enzymatic processes [20]. Important soil properties such as soil pH in enhancing amount of available potassium was observed in studies of previous workers [21]. Correlation analysis in the present study showed strong and positive correlation between available potassium and soil pH, moisture, O.C, and temperature in both study areas (Table 3 and 4). Through this finding equal importance of other soil factors as well in enhancing K level in tea gardens was clearly indicated.



	APRIL 2016	JULY 2016	OCTOBER 2016	JANUARY 2017	APRIL 2017
TR	673.19	593.75	645.83	413.95	480.85
T	564.48	547.75	593.75	397.23	430.68
UR	510.12	359.59	393.11	238.34	409.77
U	451.58	338.69	384.75	196.52	405.59

Figure. 5. Differences in available nitrogen (%) under different sampling periods.

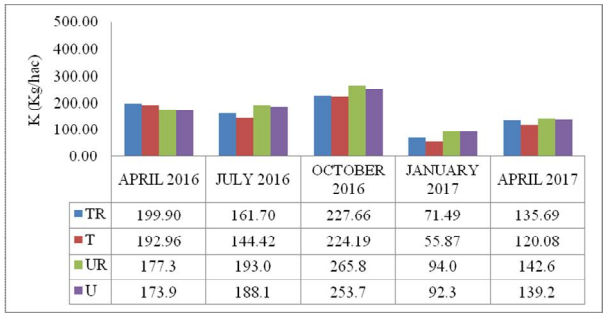
values are mean of triplicates.



	APRIL 2016	JULY 2016	OCTOBER 2016	JANUARY 2017	APRIL 2017
TR	34.90	29.41	22.37	12.31	24.39
T	34.04	25.71	19.61	9.86	27.06
UR	46.45	38.67	42.12	16.71	33.02
U	45.57	36.63	40.63	15.69	31.09

Figure. 6. Differences in available phosphorus (%) under different sampling periods.

values are mean of triplicates.



	APRIL 2016	JULY 2016	OCTOBER 2016	JANUARY 2017	APRIL 2017
TR	199.90	161.70	227.66	71.49	135.69
T	192.96	144.42	224.19	55.87	120.08
UR	177.3	193.0	265.8	94.0	142.6
U	173.9	188.1	253.7	92.3	139.2

Figure.7. Differences in available potassium (%) under different sampling periods.

values are mean of triplicates.

Table.1. Correlation coefficient among soil parameters in tea garden of Tuli.

		1	2	3	4
1	Moisture content (%) in tea garden of Tuli				
2	Soil temperature (°C) in tea garden of Tuli	.811**			
3	Soil organic carbon (%) in tea garden of Tuli	0.547	0.412		
4	pH in tea garden of Tuli	.938**	.916**	0.457	

**, * Correlation is significant at $p<0.01$ and $p<0.05$.

Table.2. Correlation coefficient among soil parameters in tea garden of Ungma.

		1	2	3	4
1	Moisture content (%) in tea garden of Ungma				
2	Soil temperature (°C) in tea garden of Ungma	.920**			
3	Soil organic carbon (%) in tea garden of Ungma	0.552	0.593		
4	pH in tea garden of Ungma	.959**	.947**	.653*	

**, * Correlation is significant at $p<0.01$ and $p<0.05$.

Table.3. Correlation coefficient between soil nutrients and other soil parameters in tea garden of Tuli.

	Moisture content (%) in tea garden of Tuli	Soil temperature (°C) in tea garden of Tuli	Soilorganic carbon (%) in tea garden of Tuli	pH in tea garden of Tuli
Amount of available N (kg/hac) in tea garden of Tuli	0.548	.757*	0.585	.703*
Amount of available P (kg/hac) in tea garden of Tuli	0.359	0.513	.842**	0.365
Amount of available K (kg/hac) in tea garden of Tuli	.707*	.759*	.716*	.823**

**, * Correlation is significantat $p<0.01$ and $p<0.05$.

Table.4. Correlation coefficient between soil nutrients and other soil parameters in tea garden of Ungma.

	Moisture content (%) in tea garden of Ungma	Soil temperature (°C) in tea garden of Ungma	Soil organic carbon (%) in tea garden of Ungma	pH in tea garden of Ungma
Amount of available N (kg/hac) in tea garden of Ungma	0.464	0.444	.944**	0.542
Amount of available P (kg/hac) in tea garden of Ungma	.661*	.722*	.978**	.752*
Amount of available K (kg/hac) in tea garden of Ungma	.643*	.833**	.683*	.679*

**, * Correlation is significantat $p<0.01$ and $p<0.05$.

IV. CONCLUSION

The present study can be concluded that soil physio-chemical properties in tea gardens of Mokokchung district, Nagaland showed great variation throughout the sampling periods. With differences in geographical locations, climatic conditions vary and soil microbial populations may also differ so this may be the reason for variations observed among soil factors between the two tea gardens. Overall status on macronutrients indicates medium to high levels of available N and P and low to medium levels of available K. Significantly positive correlation between soil macronutrients and other parameters indicate equal importance of soil parameters as well along with macronutrients for proper plant growth. The present work gives an insight into soil properties in tea growing areas of Mokokchung district, Nagaland which will be beneficial for tea growers in preparing effective management practice.

V. ACKNOWLEDGMENT

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