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STATUS OF MACRONUTRIENTS (N, P AND K) IN SOME SELECTED TEA GROWING SOILS OF SIVASAGAR DISTRICT OF ASSAM, INDIA

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ABSTRACT:

Soil macronutrients (N,P, and K) are essential to tea plants. The excessive application of commercial N, P, and K fertilizers on soil to high yield of tea can be increase the potentially hazardous element into the field, which has been cited as a source of contamination of surface and ground water. In this study, thirty composite soil samples were randomly collected from the top soil (0-20 cm) in some selected tea growing soils from the ten tea estates in Sivasagar district. The samples were analyzed for physio-chemical properties and total concentration of N, P and K. Soil textures were classified as sandy clay loam, sandy loam and sandy clay. The P^H ranged from 4.28 to 5.36. The total organic matter content ranged from 2.18 to 3.12 % with mean value of 2.71 %. The nitrogen ranged from 0.124 to 0.242 mg/kg with a mean value of 0.179 mg/kg, phosphorus ranged from 43.56 to 154.38 mg/kg with a mean value of 103.06 mg/kg and potassium ranged from 2.32 to 3.08 meq/kg with a mean value of 2.66 meq/kg. Soil samples were found sufficient amount of total organic matter, nitrogen, phosphorous and potassium. Significance positive correlations were found to exist between P^H, organic matter content and clay with total N, P and K status of soil under study.

KEY WORD: *Soil Macronutrients, Total Organic Matter Content, Fertilizers, Physio-Chemical Properties, Texture.*

INTRODUCTION:

Tea is an aromatic beverage commonly prepared by pouring hot or boiling water over cured leaves of the tea plant, *Camellia sinensis*. After water, tea is the most widely consumed beverage in the world (Alan and Iris, 2004, Kotoky et al., 2013). It has a cooling, slightly bitter, and astringent flavour that many people enjoy (Penelope, 2000). Tea originated in China as a medicinal drink (Mary and Robert, 2011). Drinking tea became popular in Britain during the 17th century. The British introduced it to India, in order to compete with the Chinese monopoly on the product (Collen, 2004).

Tea has long been promoted for having a variety of positive health benefits. Recent studies suggest that green tea may help reduce the risk of cardiovascular disease and some forms of cancer, promote oral health, reduce blood pressure, help with weight control, improve antibacterial and antivirasic activity, provide protection from solar ultraviolet light (Heinrich et al., 2011) and increase bone mineral density. Green tea is also said to have "anti-fibrotic properties, and neuroprotective power (Cabrera et al., 2006). Tea contains catechins, a type of antioxidant which has known anti-inflammatory and neuroprotective properties (Korte et al., 2010). Consumption of green tea is associated with a lower risk of diseases that cause functional disability, such as “stroke, cognitive impairment, and osteoporosis” in the elderly (Tomata et al., 2012). Tea contains L-theanine, an amino acid (Nobre et al., 2008). Camellia sinensis is an evergreen plant that grows mainly in tropical and subtropical climates. Research by the U.S. Department of Agriculture has suggested that the levels of antioxidants in green and black teas do not differ greatly, as green tea has an oxygen radical absorbance capacity (ORAC) of 1253 and black tea an ORAC of 1128 (measured in μmol TE/100 g) (Webcitation.org, 2009). Tea also contains small amounts of theobromine and theophylline, which are stimulants and xanthines similar to caffeine (Graham, 1992). Tea contains a large number of possibly bioactive chemicals, including flavonoids, amino acids, vitamins, caffeine and several polysaccharides, and a variety of health effects have been proposed and investigated (Mandal,2007). It has been suggested that green and black tea may protect against cancer (Toda et al., 1989) though the catechins found in green tea are thought to be more effective in preventing certain obesity-related cancers such as liver and colorectal cancer (Mukoyama et al., 1991), while both green and black teas may protect against cardiovascular disease (Toda et al., 1989).

Although green tea has several beneficial effects on health, the effects of green tea and its constituents may be beneficial up to a certain dose yet higher doses may cause some unknown adverse effects. Negative effects of tea drinking are centered on the consumption of sugar used to sweeten the tea. Those who consume very large quantities of brick tea may experience fluorosis (Yama et al., 1997). Numerous recent epidemiological studies have been conducted to investigate the effects of green tea consumption on the incidence of human cancers. These studies suggest significant protective effects of green tea against oral, pharyngeal, oesophageal, prostate, digestive, urinary tract, pancreatic, bladder, skin, lung, colon, breast, and liver cancers, and lower risk for cancer metastasis and recurrence (Toda et al., 1989). Another study found that higher intake of green tea might cause oxidative DNA damage of hamster pancreas and liver (Takabayashi et al., 2004). Sometimes tea may contain fluoride and aluminium . Certain types of tea made from old leaves and stems have the highest levels (I-sis.org.uk., 2011; Fung et al., 1999) Some studies revealed the capacity of tea plants to accumulate high levels of aluminum. This aspect is important for patients with renal failure because aluminum can be accumulated by the body, resulting in neurological diseases (Costa et al., 2002).

Tea grows well on high land well drained soils having a good depth, acidic pH in the range 4.5 to 5.5 and more than 2% organic matter. Shallow and compacted sub-soils limit root growth. Tea plants growing on such soils are liable to suffer from draught during dry period and water logging during the rainy months. There should not be any hard pan or concretions in the subsoil within 2m depths. The depth of ground water table should not be less than 90 cm for good growth of tea. Catchment planning is required for improved soil and water management practices in a tea estate for which land survey designed to identify all major and minor topographical features needs to be carried out.Tea requires a moderately hot and humid climate. Climate influences yield, crop distribution and quality. Therefore, before cultivating tea in a new area, the suitability of the climate is the first point to be considered. Tea grows best on well-drained fertile acid soil on high lands. The average annual rainfall in North East India ranges from 2000-4000 mm. However, more than the total amount, the distribution of rainfall matters a lot for sustained high yield of tea throughout the season. In the North East India, the rainfall distribution is not even. The excess rainfall in the monsoon months of June-September causes drainage problems. The average monthly rainfall during November to March is less than the evapotranspiration loss and the resulting soil moisture deficit affects tea bushes. If this dry spell persists for a longer period, tea plants suffer heavily and crop goes down in spite of having sufficient rainfall in the monsoons. Thus, adequate rainfall during winter and early spring is crucial for high yield. Temperature affects tea yield by influencing rate of photosynthesis and controlling growth and dormancy. In general, the ambient temperature within 13°C and 28-32°C is conducive for growth of tea.

The soil macronutrients, nitrogen (N), phosphorus (P), and potassium (K) are essential for crop growth (Marschner, 1995 ; Hak-Jin et al., 2009). They provide nutrients necessary for plant growth, which are important to maintain ecosystems and high crop yields (Qu et al., 2014). The application of commercial N,P, and K fertilizers has contributed to a tremendous increase in yields of agricultural crops that feed the world's population (Hak-Jin et al., 2009). However, excessive use of these fertilizers has been cited as a source of contamination of surface and groundwater (Kaiser, 2001; Vadas et al., 2004). Improper fertilization has increasingly become a serious problem and the eutrophication problem caused by the loses of N and P from farmland to the water bodies (Sharpley, 1995; Almasri and Kaluarachchi, 2004; Chen et al., 2010). Ideally, application rates should be adjusted based on estimates of the requirements for optimum production at each location because there is high spatial variability of N, P, and K within individual fields (Page et al., 2005; Ruffo et al., 2005). Most of macronutrient contents exist in fixed forms in soils e.g., contained in organic matter and minerals, and thus cannot be directly utilized by plants or transported to water bodies. Part of fertilizers applied to the soil also can be fixed by soil and thus become unavailable to plants. The total concentration of a macronutrient in soil is only a potentially available content in long term, rather than its currently available content (Qu et al., 2014).Therefore, soil testing is a management tool that can help accurately determine the available nutrient status of soils and guide the efficient use of fertilizers (Hak-Jin et al., 2009). With the increasing awareness of fertilizer effects on environmental and soil quality, soil tests have been instrumental in determining where insufficient or excess nutrient level occur (Hergert et al., 1997). Soil fertility research has indentified levels of macronutrient concentrations in the soil that are sufficient for field crop production without further additions (Hak-Jin et al., 2009). Therefore, it is important to investigate the soil macronutrient status and may provide valuable information to tea soil. The objectives of this study were to analyze the relationship between some soil properties and macronutrients concentration of soil N, P, and K.

MATERIALS AND METHOD:

Study Area

Sivasagar district is historically one of the most important districts of Assam. It is located between $25^{0}45^{/}$ to $27^{0}15^{/}$ N latitudes and $94^{0}25^{/}$ to $95^{0}25^{/}$ E longitudes. The geographical area covered by Sivasagar district is 2668 sq km. Sivasagar district carries a pleasant weather throughout the year. The temperature ranges from 8^0C to 18^0C in winter and 15^0C to 35^0C during summer. The district is characterized by highly humid atmosphere and abundant rains. The average annual rainfall is about 230 cm.

Physico-chemical properties of soil

In the plains of Sivasagar, the soil is alluvial. The soil adjacent to the river banks is sandy and away from the bank is muddy. The main crops grown in this district are tea and rice.

Soil sampling and Laboratory analyses

This research was conducted in the tea cultivated soil in Sivasagar district in the year 2013. Thirty soil samples were collected from the ten tea estates in the month of December, because no fertilization or compost was applied in this month in the tea estates. Composite soil samples were taken from 0 to 20 cm depth and prepared for necessary analysis in the laboratory (Jackson, 1995; Gupta, 2007). The locations of sampling stations were determined by using Global Positioning System (GPS) shown in **Figure 1**.Texture in the present experiment was determined by the Hydrometer method (Bouyoucos, 1962). Soil p^H was measured using a p^H meter with a soil/water ratio of 1: 1.25 (Gupta, 2007). Soil organic matter was measured using the wet oxidation method with a mixture of potassium dichromate and sulphuric acid by the procedure (Walkey and Black, 1974, Gupta,2007). Total nitrogen was determined by the Kjeldahl method with H_2SO_4 + H_2O_2 digestion (Jackson, 1973, Gupta, 2007). Phosphorus in soil is generally determined as total phosphorus, which can be extracted from soil with 0.002 (N) H_2SO_4. After extraction, the phosphorus is estimated spectrophotometrically by Dickman and Bray (1940) method. This method is suitable for acid soils having pH around 5.5 or less. Potassium was measured by the flame photometer method (Elico Model CL 361).

Statistical analysis

The relationship between soil texture, organic matter content and water holding capacity were determined using correlation coefficient " r ". The correlation co-efficient, r, between two variables, x and y is given by:

$$r = \frac{1/n \sum xy - \bar{x}\ \bar{y}}{\sqrt{(1/n\sum x^2 - \bar{x}^2)\ (1/n\sum y^2 - \bar{y}^2)}}$$

$\bar{x} = 1/n \sum x$, $\bar{y} = 1/n\sum y$ and n=number of measurements.

RESULTS AND DISCUSSION:

Soil p^H and soil texture

The p^H values of soil samples ranged from 4.28 to 5.36 with an average of 4.84 **(Table 1)**.The soil samples were acidic in nature and tea plant grow well such type of soil. There are three different kinds of soil were found in the tea estates viz., sandy clay loam, sandy loam and sandy clay. The results show that sand dominates over clay and silt, and the values could be arranged in the ranges of Sand: 60.08 to 77.42 %, Silt: 4.04 to 5.44 % and Clay: 17.24 to 35.88 %. Usually clay loam soil is considered as more preferable for agricultural crops (White, 1987), but it seems that good tea production can also take place in other types of soil. Soil texture is considered an important parameter. It influences the other properties like water holding capacity, bulk density and hydraulic conductivity that control the flow dynamics of water, nutrients and salts in soil.

Soil organic matter

Organic matter amounts of soil samples ranged from 2.18 to 3.12 %. (**Table 2**). The value of the mean organic carbon from one site to another for the surface soil is shown in **Figure 2**. If the organic carbon content is < 0.50 %, the soil is considered as low in carbon and if the same is > 0.75 %, the soil is considered very rich in carbon (Baruah and Barthakur, 1977). All the soil samples in the study area contains sufficient amount of organic carbon.

Total Nitrogen

The value of the total nitrogen from one site to another for the surface soil is shown in **Figure 3.** The nitrogen status varied from 0.124 to 0.242 mg/kg with an average value of 0.179 mg/kg. All the tea soil contains sufficient amount of nitrogen. Nitrogen was positively (**Figure 4**) correlated with P^H (r= 0.75). A significance positive correlation (r=0.85) was found between organic carbon and nitrogen (**Figure 5**). Since most of the soil nitrogen is found in organic form, therefore, this relationship was observed. Similar result was also reported by Singh and Mishra (2012). Nitrogen also positively (r=0.70) correlated with Clay (**Figure 6).**

Total phosphorus

The value of the total phosphorus for the surface soil is shown in **Figure 7.** The phosphorus content varied from 43.56 to 154.38 mg/kg with a mean value of 103.06 mg/kg .On the basis of the limits suggested by Muhr et al., (1965) most of the soil samples were medium in phosphorus content. A significant positive correlation (r=0.74) was observed between phosphorus and P^H (**Figure 8).** A significant positive correlation (r=0.77) was observed between organic carbon and phosphorus (**Figure 9).**This indicates that presence of organic matter increases the of phosphorus in soil. Total phosphorus and clay was found to be significantly and positively (r=0.86) correlated (**figure 10**). Similar result was also reported by Singh and Mishra (2012).

Total potassium

Total potassium status varied from 1.32 to 3.12 meq/kg with an average value of 2.66 meq/kg. The value of the potassium from one site to another for the surface soil is shown in **Figure 11.** On the ratings suggested by Muhr et al., (1965), all the tea soil contains sufficient amount of potassium. A Significant positive (r= 0.62) correlation was found between potassium with P^H (**Figure 12).** A significance positive correlation (r=0.70) was found between organic carbon and total potassium (**Figure13**). This might be due to creation of favorable soil environment with presence organic matter. Similar result was also reported by Chauhan (2001) and Singh and Mishra (2012). Significant positive (r=0.72) correlation was also found between potassium with and Clay (**Figure 14).**

CONCLUSION:

To increase the yield of productivity of tea it is necessary to need apply optimum quantity of fertilizers on the soil for tea growth. This work has established that levels of soil organic matter and soil macronutrients (N, P and K) are within the accepted limits. Assessment of soil organic matter and soil macronutrients (N,P and K) in the ten tea estate soil samples (as listed table 2) can be summarized as follows : Organic matter ($T_2 > T_5 > T_3 > T_8 > T_6 > T_4 > T_{10} > T_7 > T_9 > T_1$) , Nitrogen ($T_6 > T_2 > T_5 > T_3 > T_8 > T_{10} > T_4 > T_7 > T_1 > T_9$) , Phosphorus ($T_8 > T_6 > T_2 > T_3 > T_5 > T_{10} > T_7 > T_4 >$ T 9$> T_1$) and Potassium ($T_3 > T_2 > T_{10} > T_5 > T_6 > T_8 > T_7 >$ T4 $> T_1 > T_9$) . It was seen that tea soils with high organic matter and macronutrients have good yield and best quality of tea. A strong relationship exists between soil texture, soil organic matter and soil macronutrients. It was concluded that clay soil retain more water than the sandy soil and addition of soil organic matter could increase the soil macronutrients. Soil texture and organic matter are the key components that control the soil macronutrients.

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Table 1: Soil P^H and soil texture of the tea estate soil samples (Surface soil, 0-20 cm depth)

Sl.No	Tea Estate	No. of samples	PH	Sand (%)	Silt (%)	Clay (%)	Textural class
1	TI	3	4.28	77.42	5.34	17.24	SL
2	T2	3	5.36	60.08	4.04	35.88	SC
3	T3	3	5.24	60.98	4.86	34.16	SC
4	T4	3	4.33	72.36	5.12	22.52	SCL
5	T5	3	5.02	65.12	5.23	29.65	SCL
6	T6	3	5.32	64.18	4.26	31.56	SC
7	T7	3	4.88	68.64	4.52	26.84	SCL
8	T8	3	5.12	61.28	4.98	33.74	SC
9	T9	3	4.35	70.48	5.44	24.08	SCL
10	T10	3	4.46	66.42	4.86	28.72	SCL
	Minimum		4.28	60.08	4.04	17.24	
	Maximum		5.36	77.42	5.44	35.88	
	Mean		4.84	66.69	4.86	28.44	

Table 2: Soil organic matter, nitrogen, phosphorous and potassium of the tea estate soil samples (Surface soil, 0-20 cm depth)

Sl.No	Tea Estate	No. of samples	O C (%)	N (mg/kg)	P (mg/kg)	K (meq/kg)
1	TI	3	2.18	0.134	43.56	2.36
2	T2	3	3.12	0.226	128.82	2.92
3	T3	3	3.04	0.202	122.24	3.08
4	T4	3	2.56	0.148	72.54	2.44
5	T5	3	3.06	0.204	117.18	2.78
6	T6	3	2.86	0.242	136.22	2.76
7	T7	3	2.42	0.145	89.26	2.54
8	T8	3	2.98	0.188	154.38	2.65
9	T9	3	2.32	0.124	58.98	2.32
10	T10	3	2.54	0.178	107.42	2.78
	Minimum		2.18	0.124	43.56	2.32
	Maximum		3.12	0.242	154.38	3.08

Table 3: Correlation between soil characteristics and macronutrients

Soil properties	Maconutrients		
	N	P	K
PH	0.75	0.74	0.62
Organic carbon	0.75	0.77	0.70
Clay	0.67	0.86	0.72

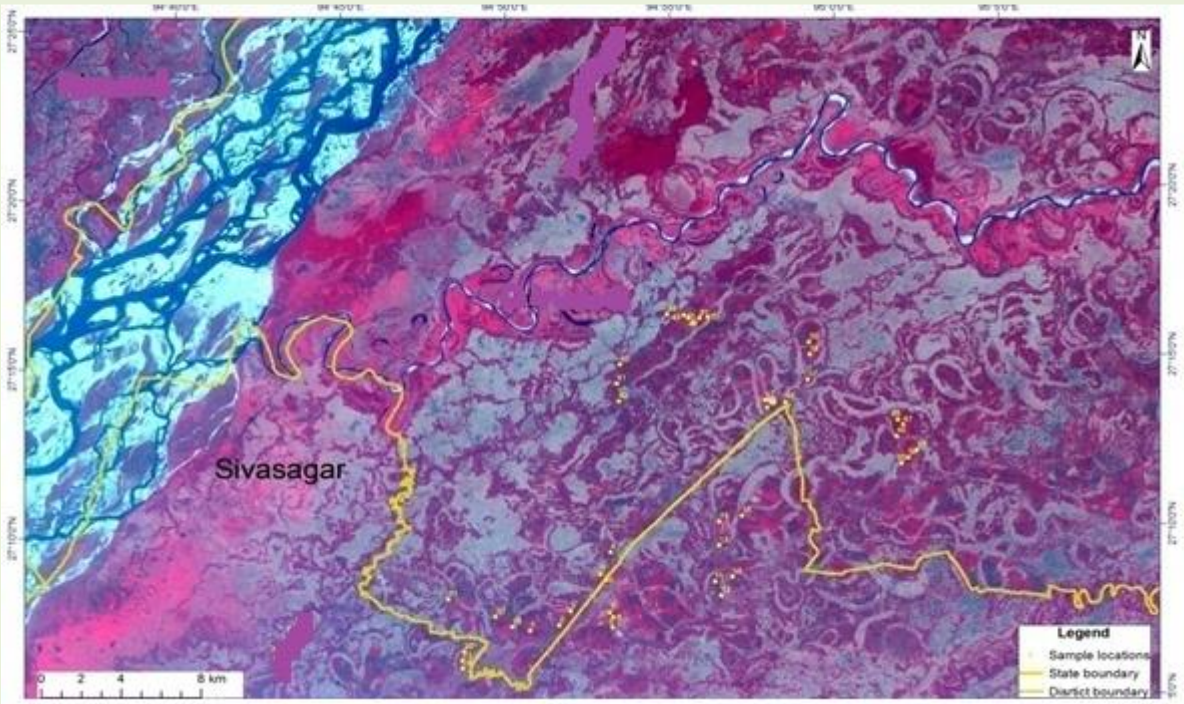

Figure 1: Locations of soil sampling stations

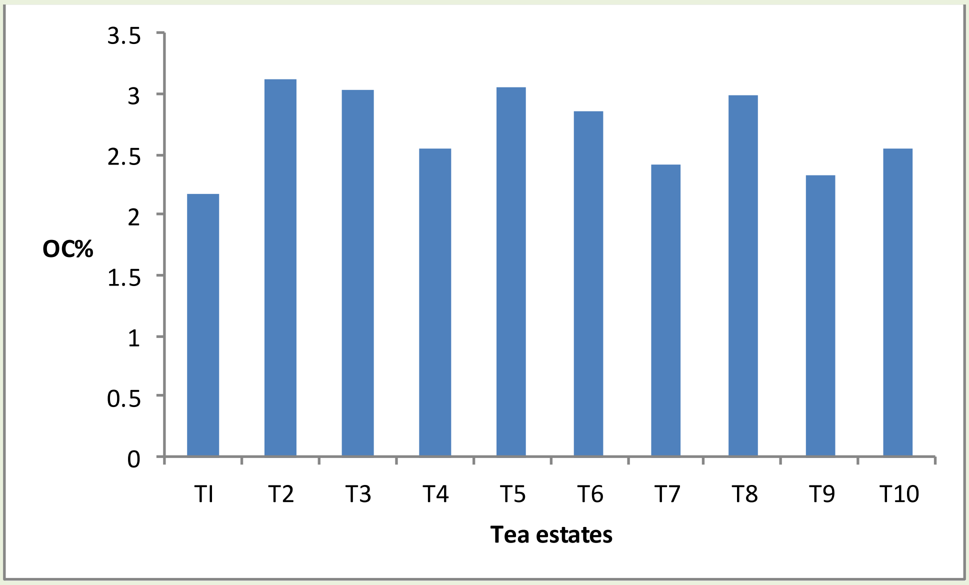

Figure 2: Total organic matter (%) of the soil samples

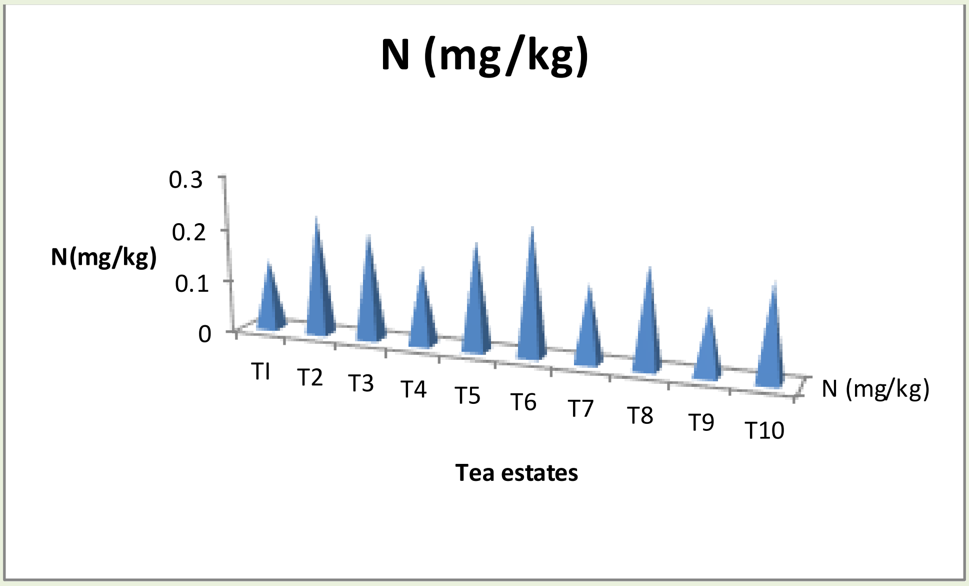

Figure 3: Total nitrogen (mg/kg) of the soil samples

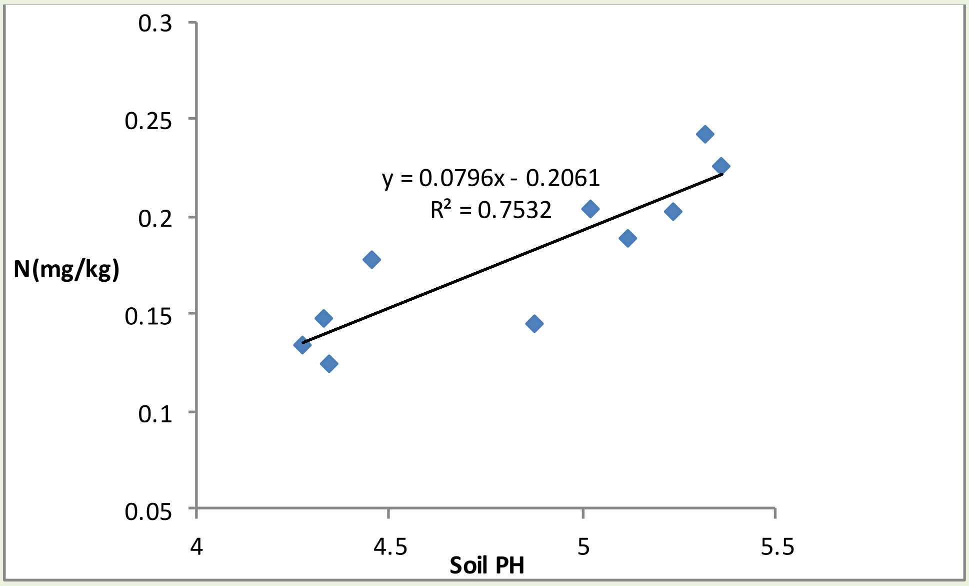

Figure 4: Correlation between Soil P^H and total nitrogen (%) of soil samples

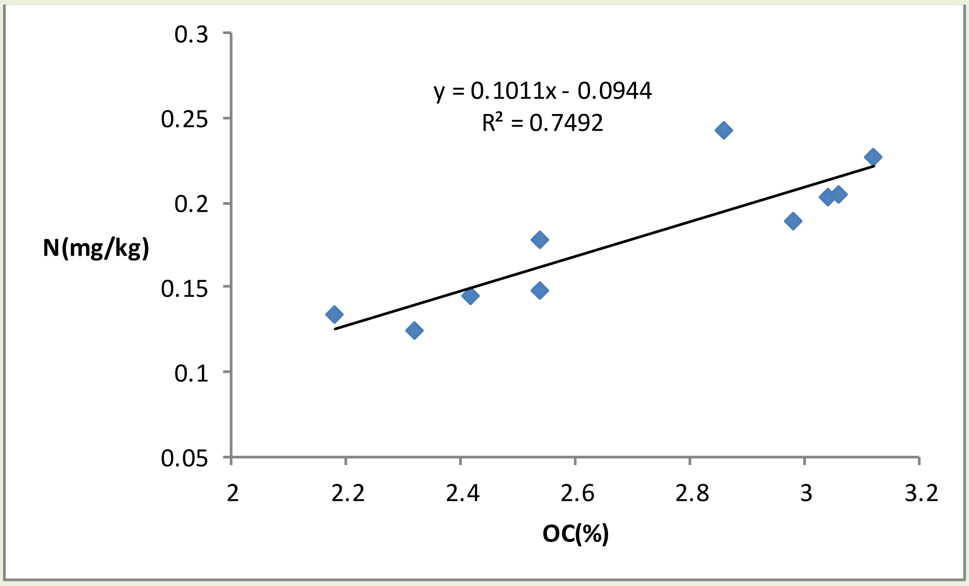

Figure 5: Correlation between OC (%) and total N (%) of soil samples

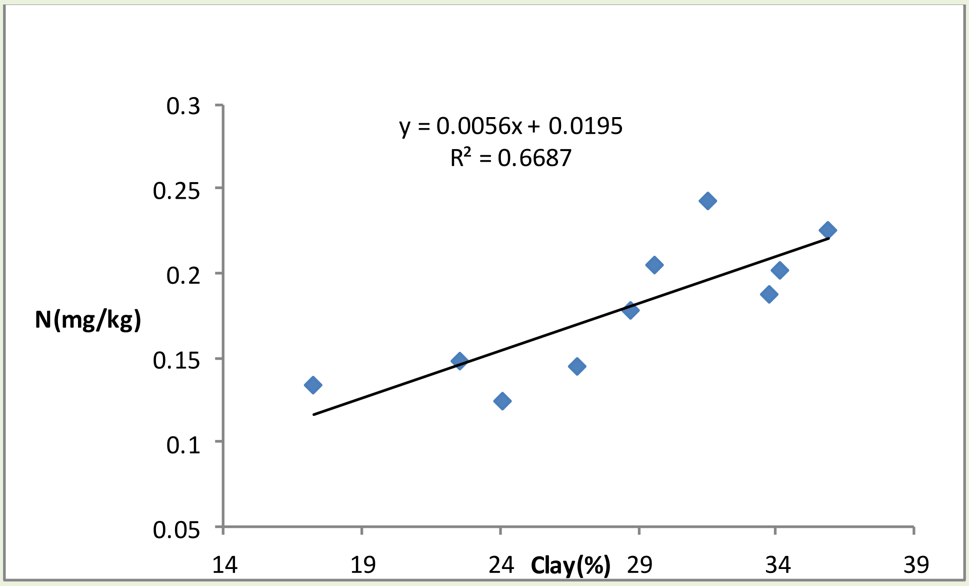

Figure 6: Correlation between Clay (%) and total nitrogen (%) of soil samples

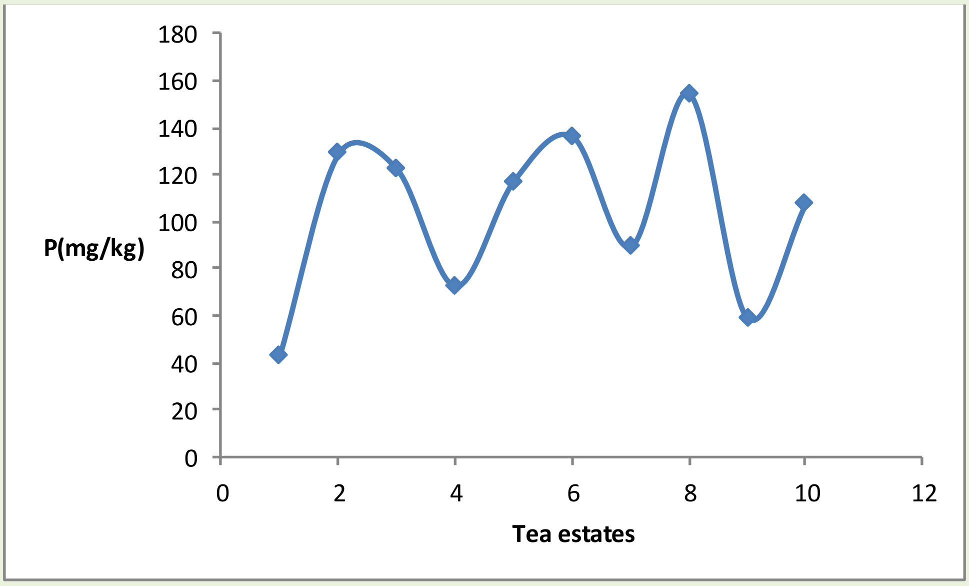

Figure 7: Total phosphorus (mg/kg) of the soil samples

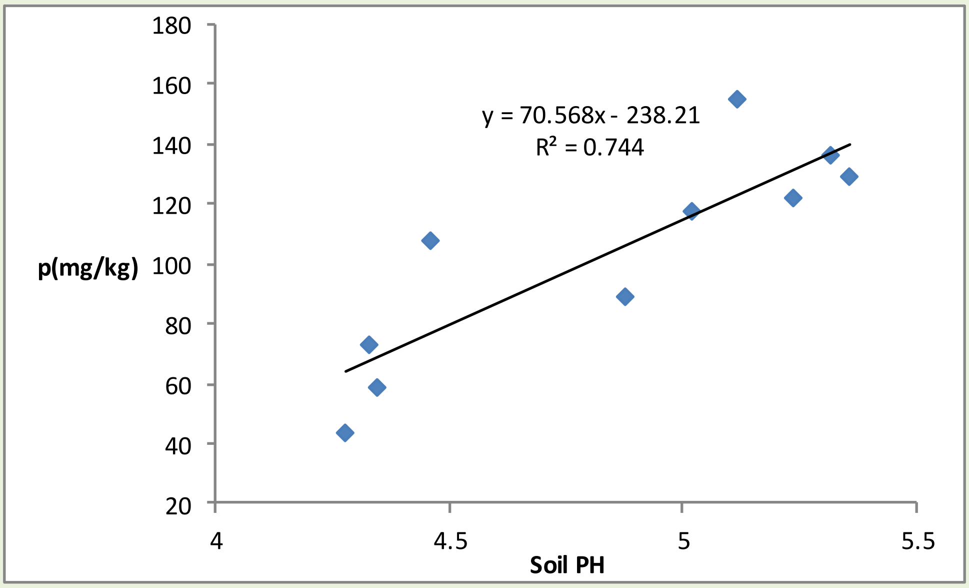

Figure 8: Correlation between Soil P^H and total P (%) of soil samples

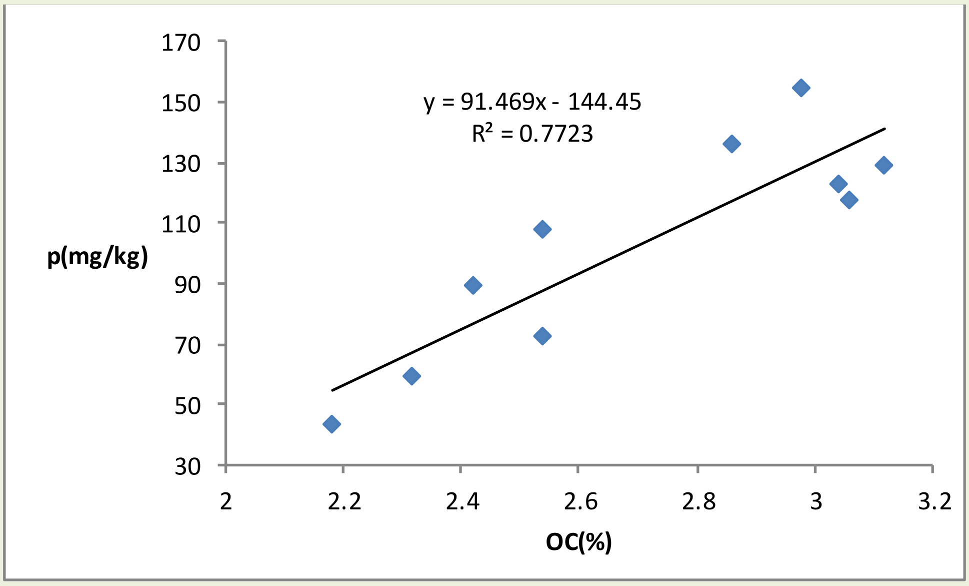

Figure 9: Correlation between OC (%) and total P (%) of soil samples

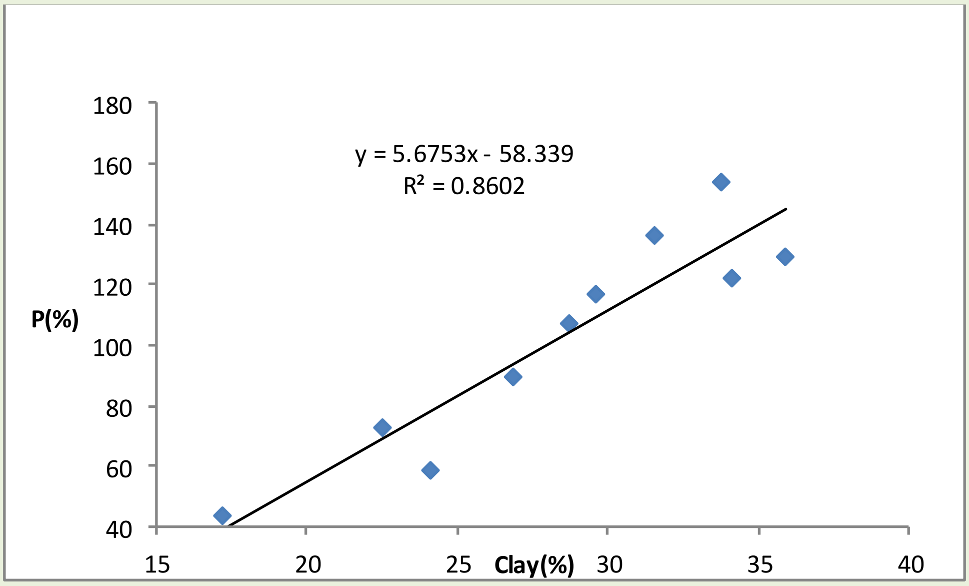

Figure 10: Correlation between Clay (%)and total P (%) of soil samples

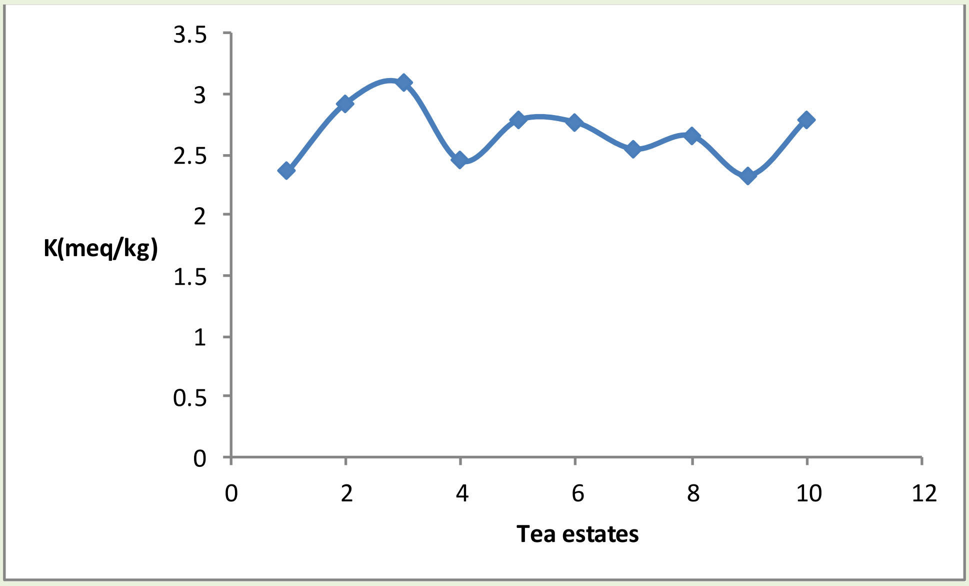

Figure 11: Total potassium (meq/kg) of the soil samples

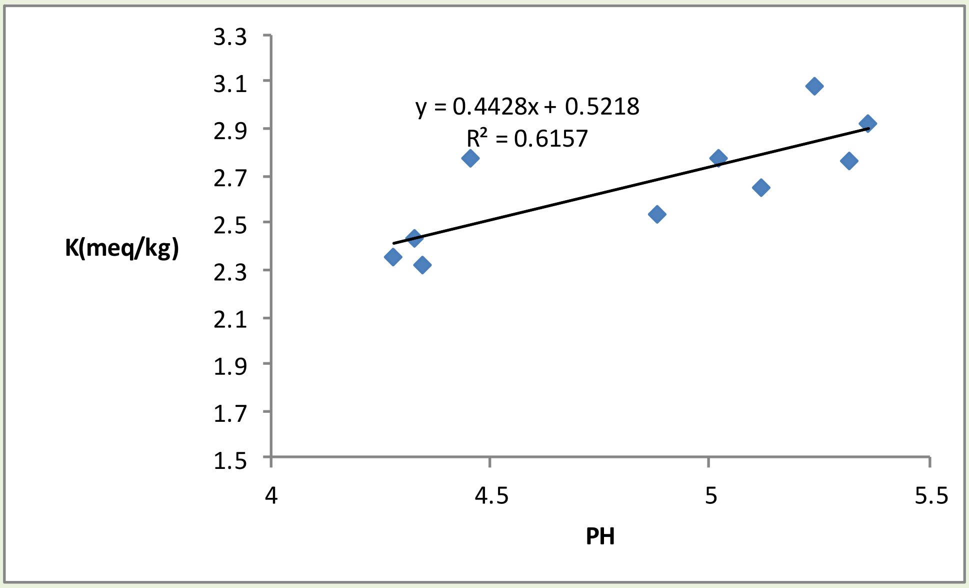

Figure 12: Correlation between Soil P^H and total K (meq/kg) of soil samples

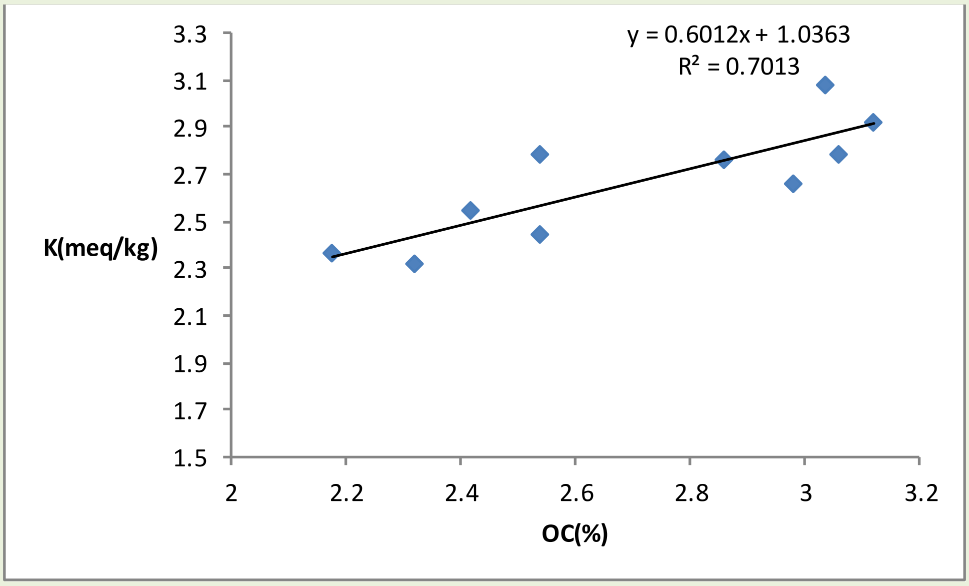

Figure 13: Correlation between OC (%) and total total K (meq/kg) of soil samples

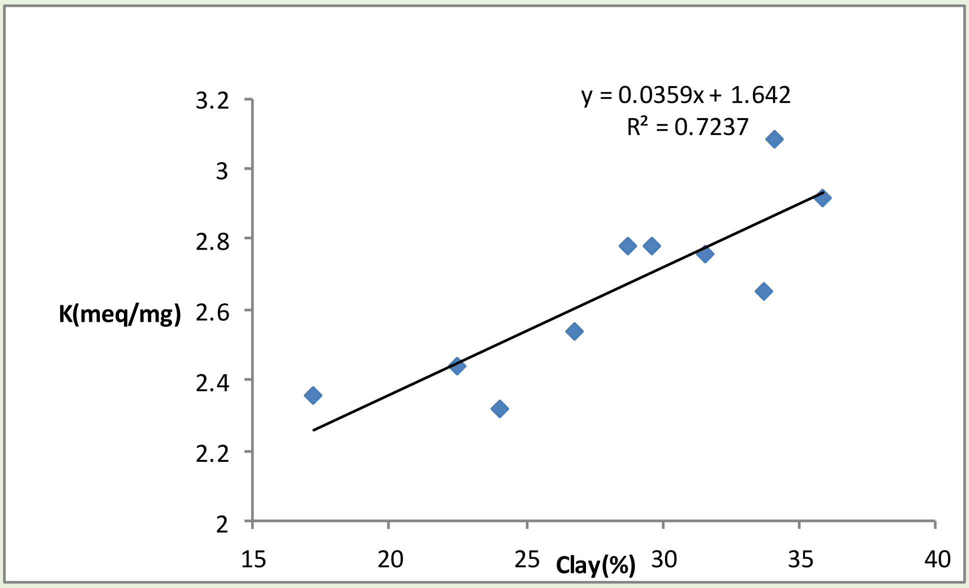

Figure 14: Correlation between Clay (%) and total potassium (meq/kg) of soil samples