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SOIL TEXTURE AND TOTAL ORGANIC MATTER CONTENT AND ITS INFLUENCES ON SOIL WATER HOLDING CAPACITY OF SOME SELECTED TEA GROWING SOILS IN SIVASAGAR DISTRICT OF ASSAM, INDIA

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ABSTRACT

A study was carried out to determine the soil texture and total organic matter content and its influences on soil water holding capacity of some selected tea growing soils in Sivasagar district of Assam. Thirty composite soil samples were randomly collected from the top soil (0-20 cm) from the ten tea estates. The samples were analysed for texture, total organic matter content and water holding capacity. The textures of the soil samples found to be sandy clay loam and sandy loam. The total organic matter varied from 2.16 to 3.38% with mean value of 2.71%. The water holding capacity ranged from 50.44 to 59.18% with a mean value of 54.41%. The results showed that the soil samples have medium water holding capacity and soil total organic matter was found to be higher. It was concluded that soil texture and soil organic matter content had influence on water holding capacity of the tea cultivated soil. It was suggested that high concentration of organic matter on soil should be incorporated to the soils with improving water holding capacity. A significance positive relationship was observed between water holding capacity with organic matter content and clay, while, a negative relationship was found with sand content.

Key words: Soil texture, Total organic matter content, Sandy clay loam, Sandy loam, Water holding capacity.

INTRODUCTION

Tea is an important crop of commerce and a major foreign exchange earner. Agro-climatic conditions and other eco-biological factors largely determine the growth and yield of tea. Being a rain fed crop, it depends largely on rains. There is no upper limit of rainfall. It has been recorded that tea plants can grow even if annual rainfall reaches up to 508 cm and the lower limit of rainfall for its growth is 127 cm. Tea plant is the part of human life and a

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cheap drink. It is the most preferred drink after water and has been increasing all over the world because tea is a healthy drink[1]. Tea is the agricultural product of leaves, leaves buds and internodes of Camellia sinensis plant, prepared and cured by various methods. After water, tea is the most widely consumed beverage in the world[2]. Tea is one of the most popular beverages after water in the world. It is use as folk medicine for headache, digestion, dieresis, immune defense, energizer and longevity of life is well known[3]. Tea is one of the commonly consumed beverages in the world for its desirable aroma, taste and putative positive physiological functions[4,5]. The growing interest in drinking tea all over the world would be connected with polyphenol antioxidative activity, fighting the harmful influence of environmentally generated free radicals[6]. Tea is an infusion made from dried leaves of *Camellia sinensis* L. It is the most important species of all *Camellia spp*. used for beverages[7]. The chemical composition of tea leaves consists of tanning substances, flavonols, alkaloids, proteins and amino acid, enzymes, aroma-forming substances, vitamins, minerals, and trace elements[8]. Among the minerals and essential trace elements, Ca, Na, K, Mg, and Mn are present in tea leaves at g/Kg level, while Cr, Fe, Co, Ni, Cu, Zn are present at mg/Kg level[9]. The total metal components in tea plants depend on many factors, primarily the age of tea leaves, the soil conditions, rainfall, altitude, genetic makeup of the plant[7]. The quality of tea leaf is highly important and the contents of the nutrients in tea soil and tea plant affect the leaf quality[10]. To produce economic and quality tea production, it needs best management practices particularly fertilization[11].

Tea growing soils of the world are of different origin. Tea grows on soils ranging from the lightest of sand to heavily silty loam or even silty clay loam types. However, medium or light textured soils of acidic character are found to be suitable for the best growth of tea irrespective of countries[12]. In North-East India, most of the soils under tea are alluvial in origin and tea crop is grown on fairly flat or gently sloping valley beds reaching up to the foothills[13]. Soil is the natural body of animal, mineral and organic constituents differentiated into horizons of variable depth, which differ from the material below in morphology, physical make up, chemical properties and composition and biological characteristics[14]. According to a soil scientist, soil as a solid earth material that has been altered by physical, chemical and organic processes such that it can support rooted plants. However, according to modern concept, soil is a three dimensional, dynamic, natural body occurring on the surface of the earth that is a medium for plant growth and whose characteristics have resulted from the integrated effect of climate and living matter acting upon parent material, as modified by relief over periods of time. Therefore, soil performs the natural medium for plant growth, provides mechanical support to plant and supplies essential nutrients and water to plants.

Soil texture is one of the most stable properties and a useful index of several other properties that determine the agricultural potential of soil. The framework of the soil consists principally of mineral and organic particles of various sizes. Soil textures refer to the sizes that make up the soil and proportion of particle sizes determines a soil texture[15]. The relative proportion of different soil particles i.e. sand, clay and silt is known as soil texture. It affects the properties of soil including its water supplying power, rate of water infiltration, aeration, soil fertility, ease of tillage and susceptibility to erosion. Sandy soils are porous, have high infiltration rates, and retain little water, but clays have low infiltration rates, retain much water and may be poorly drained. Aeration is good in sandy soils but poor in clays. Roots penetrate sand more easily than clays. The fine and medium textural soils, such as the loam, clay loam, sandy clay loam, silt clay loam and sandy silt loams are generally more desirable because of their superior retention of nutrients and water[16].

Soil organic matter is any material produced originally by living organisms (plant or animal) that is returned to the soil and goes through the decomposition process. At any given time, it consists of a range of materials from the intact original tissues of plants and animals to the substantially decomposed mixture of materials known as humus. Organic matter within the soil serves several functions. It is important for two main reasons – (i) as a "revolving nutrient fund"; and (ii) as an agent to improve soil structure, maintain tilth and minimize erosion[17]. When plant residues are returned to the soil, various organic compounds undergo decomposition. Decomposition is a biological process that includes the physical breakdown and biochemical transformation of complex organic molecules of dead material into simpler organic and inorganic molecules[18]. Decomposition of organic matter is largely a biological process that occurs naturally. Its speed is determined by three major factors: soil organisms, the physical environment and the quality of the organic matter[19]. In the decomposition process, different products are released: carbon dioxide, energy, water, plant nutrients and resynthesized organic carbon compounds. Successive decomposition of dead material and modified organic matter results in the formation of a more complex organic matter called humus[18]. This process is called humification. Humus affects soil properties. Humus or humified organic matter is the remaining part of organic matter that has been used and transformed by many different soil organisms. It is a relatively stable component formed by humic substances, including humic acids, fulvic acids, hymatomelanic acids and humins[20]. It is probably the most widely distributed organic carbon-containing material in terrestrial and aquatic environments. Humus cannot be decomposed readily because of its intimate interactions with soil mineral phases and is chemically too complex to be used by most organisms. Soil organic matter, the organic fraction of the soil, is a complex mixture of plant and animal products in various stages of decomposition[21]. Organic carbon influences the soil compatibility[22]. Humas supplies nutrients to the soil and improves its ability to retain moisture[23]. Soil organic carbon and soil organic matter maintains a ratio of 1:1.724. The presence of organic matter is of great importance in the formation and stabilization of soil structure.

Water holding capacity is defined as the amount of water in a soil when its pore space is filled up with water and the drainage is restricted. Available water holding capacity can be defined as the amount of water the soil can hold for the use of plants root for certain period of time[24]. Under natural conditions, only poorly drained soils are at their maximum water holding capacity for long time. Clay soil held more water than sandy soil[16]. Organic matter has a high affinity for moisture. The addition of organic matter to the soil usually increases the water holding capacity of soil. This is because the addition of organic matter increases the number of micropores and macropores in the soil by gluing soil particles together or by creating favourable living conditions for soil organisms. Certain types of soil organic matter can hold up 20 times their weight in water[25]. It was showed that for each 1% increase in soil organic matter, the available water holding capacity in the soil increases by 3.7 percent[26]. Soil water is held by adhesive and cohesive forces within the soil and increase in pore space will lead to an increase in water holding capacity of the soil[17]. Therefore, soils high in organic matter retain more water than similar soils with low organic matter. In soils, water is supplied to plants through the roots, it is necessary for microbial mobility and action, and it allows nutrients mobility. This study aims to investigate the influence of texture and organic matter on soil water holding capacity of some selected tea growing soils in Sivasagar district of Assam.

EXPERIMENTAL

Materials and methods

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^{o}C to 18^{o}C in winter and 15^{o}C to 35^{o}C 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[27,28]. The locations of sampling stations were determined by using Global Positioning System (GPS) shown in Fig. 1. Texture in the present experiment was determined by the Hydrometer method[29]. Organic matter was determined by the reported procedure[30]. The water holding capacity was determined by earlier reported procedure[28].

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

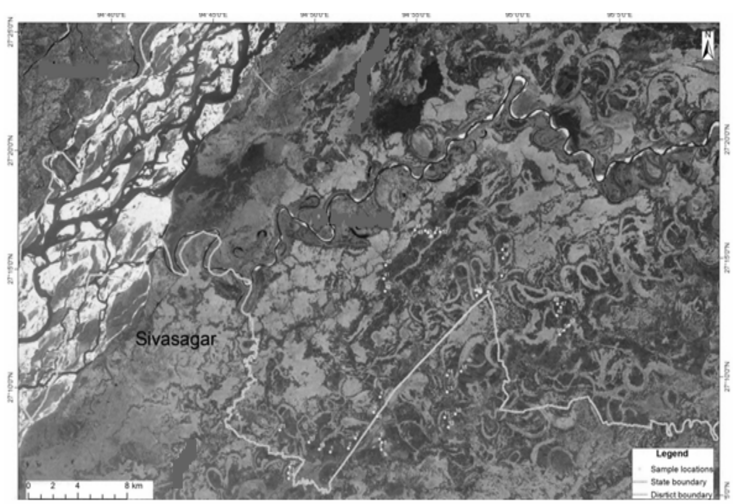

Fig. 1: Locations of soil sampling stations

RESULTS AND DISCUSSION

Soil texture

There are two different kinds of soil were found in the tea estates viz., sandy clay loam and sandy loam. The texture of the soil samples are given in Table 1. The results show that sand dominates over clay and silt, and the values could be arranged in the ranges of Clay: 16.12 to 26.18%, Silt: 2.40 to 5.72% and Sand: 71.42 to 78.16%. Usually clay loam soil is considered as more preferable for agricultural crops[16], 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.

Table 1: Soil texture of tea cultivated soil samples (Surface soil, 0-20 cm depth; each value is the mean of the values obtained for three sampling sites of each of the tea estates)

S. No	Clay (%)	Silt (%)	Sand (%)	Textural class
T_1	20.05	5.02	74.93	Sandy clay loam
T_2	21.94	4.02	74.04	Sandy clay loam
T_3	26.18	2.40	71.42	Sandy clay loam
T_4	19.02	5.18	75.80	Sandy loam
T_5	24.74	2.95	72.31	Sandy clay loam
T_6	16.78	5.58	77.64	Sandy loam
T_7	17.42	5.38	77.20	Sandy loam
T_8	16.12	5.72	78.16	Sandy loam
T_9	22.62	3.74	73.64	Sandy clay loam
T_{10}	21.16	4.52	74.32	Sandy clay loam
Min	16.12	2.40	71.42	
Max	26.18	5.72	78.16	
Mean	20.60	4.45	74.95	

Laboratory work (2013)

Soil organic matter

The data showed (Table 2) that large amount of organic carbon was found in the tea estate soil. 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[31]. In the present study, the values of organic matter are in the ranges of 2.16 to 3.38 %. All the soil samples in the study area contains sufficient amount of organic carbon.

Soil water holding capacity

The results of soil water holding capacity (Table 2) were found to be 50.44 to 59.18% in the tea estate soil. It is also true that the soil texture will have certain influence on the water holding capacity. As the percentage of clay increases in the soil, the water holding capacity increases as clay can bind the water molecules more effectively. Thus, soils possessing higher amount of clay will have enhanced water holding capacity. Soil with little water holding capacity soon dried out and reduces the plan growth. In fact, a good positive correlation was observed between clay content and WHC of tea estate soil. The results showed that as the organic matter increases the water holding capacity of soil also increases. This clearly indicated that soil organic matter content influences the ability of soils to retain moisture. Similar result was suggested that addition of soil organic matter increases the amount of soil water holding capacity[32].

Table 2: Total organic matter (%) and water holding capacity (%) of tea cultivated soil samples (Surface soil, 0-20 cm depth; each value is the mean of the values obtained for three sampling sites of each of the tea estates)

S. No.	Total organic matter (%)	Water holding capacity (%)
T_1	2.58	53.72
T_2	2.93	55.92
T_3	3.38	59.18
T_4	2.46	52.68
T_5	3.23	58.06
T_6	2.21	50.58
T_7	2.32	51.59

Cont…

S. No.	Total organic matter (%)	Water holding capacity (%)
T_8	2.16	50.44
T_9	3.07	57.12
T_{10}	2.75	54.86
Min	2.16	50.44
Max	3.38	59.18
Mean	2.71	54.41
Laboratory work (2013)		

Relationship between soil texture and water holding capacity of soil samples

According to the following workers a good correlation is predicted if the linear regression co-efficient "r" is greater than seven[28,33]. The simple correlation coefficient (r) between soil texture and water holding capacity of soil samples are given in Table 3. It was observed that the water holding capacity is dependent on texture of the soil. As the clay content of the soil sample increases the water holding capacity increases and as the sand content increases the water holding capacity decreases. The WHC increases with increasing the level of clay[34,35]. The WHC decreases with increasing level of sand[35,36]. It was observed strong positive correlation between clay content and water holding capacity (r = 0.80) and negative correlation between sand content and water holding capacity (r = - 0.78).

Relationship between soil organic matter and water holding capacity of soil samples

It was obtained strong positive correlation (Table 3) between total organic matter content and water holding capacity of the soil samples (r = 0.82), which indicates that as the organic matter increases the water holding capacity of soil increases. The water holding capacity bears a positive relationship with the soil organic matter[16,23,34,35,37].

Table 3: Simple correlation coefficient (r) between soil texture and soil total organic matter with soil water holding capacity

Related soil parameters	Correlation coefficient (r)	Level of significance
Clay content (%) - WHC (%)	0.80	Strong positive
Sand content (%) - WHC (%)	-0.78	Significance negative
Total organic matter (%) - WHC (%)	0.82	Strong positive

CONCLUSION

This work has established that levels of soil organic matter and water holding capacity are within the accepted limits. Assessment of soil organic matter content and water holding capacity in the ten tea estate soil samples (Table 2) can be summarized as follows : $T_3 > T_5 > T_9 > T_2 > T_{10} > T_1 > T_4 > T_7 > T_6 > T_8$. It was seen that tea soils with high water holding capacity have good yield and best quality of tea. A strong relationship exists between soil texture, soil organic matter and soil water holding capacity. It was concluded that clay soil retain more water than the sandy soil and addition of soil organic matter could increase the soil water holding capacity. Soil texture and organic matter are the key components that control the soil water holding capacity.

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