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C O N T E N T S

EDITORIAL

The current volume of Tea Journal of Bangladesh contains a total of five articles, of which three are research papers, one related to feasibility study and one short communication.

The 1st article titled as "DISTRIBUTIONAL PATTERN AND SEASONAL ABUNDANCE OF MAJOR PESTS OF TEA IN BANGLADESH" deals with seasonal variation as well as regional variation of different pest incidences in tea in Bangladesh condition. It also focuses variation of pest attack due to different topography, agrotypes and pruning cycles. The findings of the study in particular is being applied determining pest control strategies for economic cultivation of present day of Bangladesh Tea.

The 2nd paper titled "CHANGE OF CHEMICAL COMPOSITIONS IN SEMI-FERMENTED TEA ON LAND ELEVATION" focuses on the effect of land elevation on the chemical constituents of made tea which can be compared to oolong tea. We don't produce such tea commercially; the finding is of academic interest though at present.

The 3rd article titled as "SOIL PROPERTIES OF LALMAI HILL, SHALBAN BIHAR AND NILACHAL HILL OF GREATER COMILLA DISTRICT AND ITS SUITABILITY FOR TEA PLANTATION" is actually a survey report of soil and climatic conditions of selected areas of greater Comilla district in Bangladesh. Domestic consumption of tea is rapidly increasing in Bangladesh. So, extension of tea plantation is an urgent need to meet future demand. The findings of the paper show that some regions of greater Comilla district are suitable for tea cultivation. It will help policy makers to take decision for extending tea plantation in new areas other than conventional tea areas.

The 4th article titled as "COMPARATIVE STUDY ON TEA SOILS OF SOUTH INDIA AND BANGLADESH" reconfirms that organic matter content of Bangladesh soil is much lower than that of South Indian soil. High organic matter in South Indian soil is one of the major reasons for higher productivity of tea there. The article reveals that burial of pruning litter is practiced in south India for increasing organic matter management. It could be easily adopted in Bangladesh for improving organic matter content of our tea soil.

The last article titled as "COMPARATIVE EFFECT OF CONTINUOUS BED FERMENTER AND STACKED TRAY FERMENTER ON THE QUALITY OF TEA" shows that there are not much differences on quality contributing components in both the methods undertaken for fermentation. So, as far as quality is concerned any of the fermenters can be used. Both the methods have some advantage over conventional floor or bed fermentation which needs large rooms within factory building. Fermentation process in Stacked Tray Fermenter (STF) and Continuous Bed Fermenter (CBF) revealed that the difference in liquor characteristics and infusion of tea was insignificant but in case of leaf appearance, the difference was highly significant. Higher percentage of bolder grade and heavier tea was obtained with STF.

(**Dr. Mainuddin Ahmed**)
Chief Editor

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DISTRIBUTIONAL PATTERN AND SEASONAL ABUNDANCE OF MAJOR PESTS OF TEA IN BANGLADESH

M. Ahmed[1] and M.S.A. Mamun[2]

Abstract

A study was carried out to investigate the distributional pattern as well as seasonal abundance of major pests of tea in Bangladesh. Data on the distributional pattern of tea pests were collected and assessed from the tea estate's monthly report of the different valley circles during 2005 - 2007. Seasonal abundance of major pests of tea was determined by obtaining month-wise data of pest infestations (%) from Bilashcherra Experimental Farm during the experimental periods. From the reports of the valley circles, it revealed that the incidences of red spider mites (31.29%), *Helopeltis* (17.45%) and termites (13.15%) were found to be predominant followed by jassids, flushworms and aphids. It was observed that the pest-complex in six valley circles namely-North Sylhet, Juri, Lungla, Monu-Doloi, Balisera and Luskerpore were mainly composed of red spider mites, *Helopeltis* and termites. Incidence of red spider mites was severe in Luskerpore (33.77%), Juri (32.28%) and Monu-Doloi circles (32.24%) respectively. *Helopeltis* was found more prevalent in Balisera (31.51%), Monu-Doloi (25.98) and Lungla (15.47%) circles during the study period. Termite infestation was more prevalent in Luskerpore valley (18.69%) followed by Balisera (15.15%) and Monu-Doloi (12.84%). The maximum average infestation of *Helopeltis,* red spider mite and termites was found in flat and furrow areas. Light Pruning (LP) time is the best time for removal of maximum foliar pests including *Helopeltis,* red spider mites, aphids, jassid, thrips and also soil pest like termites. The infestation of *Helopeltis* (17.73%), red spider mites (11.84%) and termites (18.83%) were more on TV1 followed by BT1 and seedling. Maximum infestation of insect pests except termite prevailed during April to August. In case of termite, the maximum infestation was found in the month of December.

Keywords: Distributional pattern, Seasonal abundance, Tea, Pests

Introduction

Tea, *Camellia sinensis* (L.) O. Kuntze is an intensively managed perennial monoculture crop cultivated on large- and small-scale plantations situated between latitudes 41ºN and 16ºS. It is an important cash crop in Bangladesh, which is considered as major agricultural commodity sustaining the economy of Bangladesh. The geographical location of tea growing area is restricted only between 21º3' and 26º15' North latitude and between 89º0' and 92º41' East longitude (Alam, 1999).

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Tea cultivation in Bangladesh developed concurrently with the northeast Indian tea during early part of 19th century. Bangladesh tea grows in the three fairly divergent ecological zones, namely Surma valley in greater Sylhet, Halda valley in Chittagong and Karatoa valley in Panchagarh district (Mamun, 2011). Tea ecosystem is a complex agro-ecosystem. It comprises tea, shade trees, green crops, forest etc. Obviously the intensive monoculture of a perennial crop like tea over an intensive cultivated area during last 160 years had formed a stable tea ecosystem for widely divergent endemic or introduced pests. Moreover, a characteristic feature viz. the performance of shade trees, ancillary crops, forests, an uniformity of cultural practices such as sequential pruning cycles, weekly plucking rounds, weeding, mulching etc. have a greater impact on the subsequent colonization, stabilization and distribution of pests (Ahmed, 1997). As a long-lived woody perennial and monoculture, tea provides a stable microclimate and a continuous supply of food for rapid buildup of phytophagous species that includes insects, mites and eelworms. Some tea pests are cosmopolitan and widely distributed over a wide range of ecological zones but many are found in the restricted areas of the tea world.

Tea plants are subjected to the attack of insects, mites and nematode pests. Since the dawn of tea culture, a wide array of pests have been associating with tea plantations. Each tea growing country has its own distinctive pests, diseases and weeds. In world tea, 1034 species of arthropods and 82 species of nematodes are associated with tea plants (Chen and Chen, 1989). Looking at the pest spectrum of the tea world, it is seen that cosmopolitan pests like tea mosquito bug, red spider mite and scarlet mite are distributed between 0° to 27° N latitude. Many other pests, such as, flushworm, jassid, aphid and tortrix are localized and distributed in tea areas between latitude 24°S-11°N (Sana, 1989). The national economy of many of the tea producing countries is largely dependent upon its production, and of several constraints that affect production. Insect and mite pests (arthropods) are the most damaging agents, causing on an average of 5% to 55% yield loss (Muraleedharan, 1992; Rattan, 1992; Sivapalan, 1999). This loss costs approximately U.S. $500 million to $1 billion (Agnihothrudu, 1999). In some cases yield loss can be 100% (Muraleedharan and Chen, 1997). In Bangladesh tea, 25 species of insects, 4 species of mites and 10 species of nematodes are recorded (Ahmed, 2005). The common insect pests of tea in Bangladesh are tea mosquito bug (*Helopeltis theivora*), red spider mite (*Oligonychus coffeae*), termite (*Microcerotermes* ssp.), thrips (*Scirtothrips dorsalis*), aphid (*Toxoptera aurantii*), jassid (*Empoasca flavescens*), flushworm (*Laspeyresia leucostoma*), looper caterpillar (*Biston suppressaria*) and nematode (*Meloidogyne* spp.) etc (Mamun and Ahmed, 2011). These pests are predominant in different tea estates of Bangladesh in different periods of time round the year. Only a few of them have become major pests while most of them are minor and localized and cause occasional damage. In tea, a major pest of today may be minor of tomorrow. Of the production, about 15% of its crop could be lost per year by various pests particularly insects, mites and nematodes if adequate control measures are not taken. Moreover crop losses to the extent of 50% or more may be inflicted by the advent of an epidemic or outbreak of specific pests in a particular season or tea estate.

Dispersion is spatial pattern of distribution of members of a population (Schowalter, 2006). Little information is available on status of pests, distributional pattern and seasonal abundance of these pests in Bangladesh. The study aims to determine pest status in different valley circles, different topographies, different operations of pruning cycle and different varieties/agrotypes of tea and the seasonal incidence of these pests. This knowledge can help predict where and when infestation will occur, how big they will become, and how long they will last. Ultimately this information trends to take decision making in integrated pest management in tea.

Materials and Methods

The study was carried out at Bilashcherra Experimental Farm (BEF) an experimental unit of Bangladesh Tea Research Institute (BTRI), Srimangal, Moulvibazar during 2005-2007 to investigate the distributional pattern as well as seasonal abundance of major pests of tea in Bangladesh. Data on the distributional pattern of tea pests were collected and assessed from the tea estate's monthly report of the different valley circles during the study period. Different pests become prominent in different season even in different times of single year. Monitoring on pest infestation was done based on season, topography (Tillah, Flat and Furrow), pruning operations (Light Pruning-LP; Deep Skiff-DSK; Medium Skiff-MSK; and Light Skiff-LSK) and variety or agrotypes (Seedling, BT1 and TV1). Seasonal abundance of major pests of tea was determined by obtaining month-wise data of insect infestation (%) during the experimental period. 100 bushes were randomly selected from the experimental plot. All the recommended package of practices for the crop was followed and the experimental plots were kept free from insecticidal contamination during the period. The per cent infestation was assessed at weekly interval both for *Helopeltis* & red spider mites and at monthly interval for termites. The relative population abundance of major three pests such as *Helopeltis*, red spider mites and termites was assessed by indirect sampling method i.e. percentage of infestation which was calculated by collecting shoots (in case of *Helopeltis*), counting infested leaves (in case of red spider mites) and observing the infested bush (in case of termite). The per cent infestation was calculated by the following formula:

$$\text{Number of infested shoots/bush} = \frac{\text{\% infestation} \times 100}{\text{No. of total shoots/bush}}$$

The meteorological data were also obtained from the Department of Meteorology at Srimangal, Moulvibazar. The influence was determined by using multiple regression analysis and simple regression analysis (Gomez and Gomez, 1984).

Results and Discussion

Distributional pattern and status of major pests in different valley circles

Many pests are cosmopolitan and distributed over a wide range of ecological zones. It is observed in the world tea *Helopeltis*, red spider mite and scarlet mite are distributed between 0° to 27° N latitude. Some pests such as flush worm, aphid and jassid are distributed in tea areas between latitude 24°S-11°N. High soil pH and clay loams are suitable for some pests like termites and nematodes. Aspect/topography influences the climate and moisture which sometimes strictly control *Helopeltis* survival in Sylhet Zone but restrict in Chittagong Zone. Even soil type and geographically isolated area (like Lalakhal T.E) does not face this acute *Helopeltis* problem. In very low temperature during cold weather period only termite is active while during high temperature and high humidity most of the foliar pests of upper and mid canopy such as *Helopeltis*, red spider mites, scarlet mites, pink mites, purple mites, aphids, jassids, thrips etc. are abundant. Sometimes shade species itself is the host plant and subsequently the pests migrate to the tea plant. It is now fairly established that optimum shade species minimizes red spider mite. On the contrary, optimum shade condition with hilly topography influences *Helopeltis* outbreak.

A survey was carried out to find out the incidence of pests in different valley circles in Bangladesh. A total of 87, 113 and 70 reports out of 163 tea estates were received in 2005, 2006 and 2007 respectively. There were no reports received from Chittagong and Panchagarh area. It was observed that the pest-complex in six circles namely- Luskerpur, Balisera, Monu-doloi, Juri, Lungla and North Sylhet were composed of red spider mites, *Helopeltis,* termites, flushworm, aphids and jassids. From the reports it revealed that the incidence of red spider mite and *Helopeltis* was more prevalent in all the valley circles. The year wise incidence of major insect pests of tea in six valley circles during 2005 to 2007 is presented in Fig. 1. Result revealed from the average of three years that *Helopeltis* was more prevalent in Balisera (31.51%) followed by Monu-Doloi (25.98%), Lungla (15.47%) and Juri (14.31%)valley circles (Table 1). The most of the valley circles reported severe infestation of Red spider mite which was more prevalent in Luskerpore (33.77%) and Juri (32.28%) followed by Monu-Doloi (32.24%) and Lungla (30.32%) valley circles and was alarming round the year for the tea industry. Because of rising high temperature, intermittent sunny day, intermittent rainfall, high humidity, uneven droplet size of rainfall where eggs of RSM are least affected. Termite infestation was more prevalent in Luskerpore valley (18.69%) followed by Balisera (15.15%) and Monu-Doloi (12.84%). The average incidence of red spider mite (31.29%), *Helopeltis* (17.45%) and termite (13.15%) were found to be predominant in all the valley circles during the experimental period (Table 1). The minor incidence of jassid, flush worm and aphid was observed that was negligible.

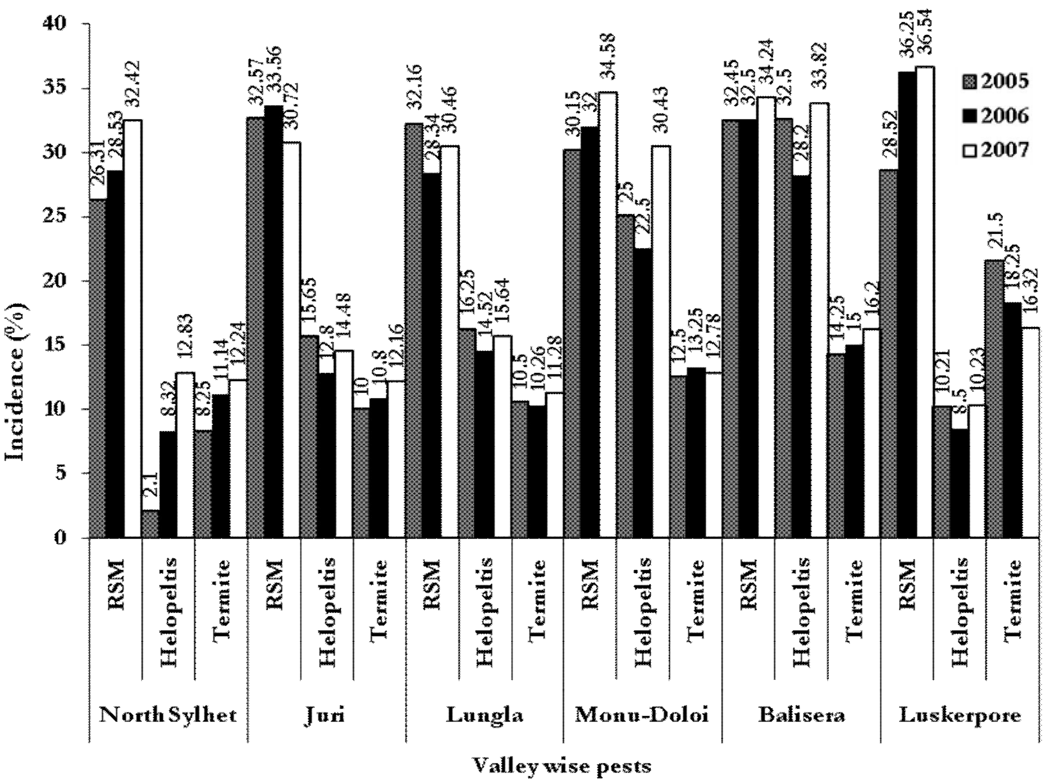

Fig. 1. Valley wise pest incidence during 2005 to 2007

Table 1. The incidence of major three pests in different valley circles

Major pests	% infestation of pests in six valley circles (3 years average)						
	North Sylhet	Juri	Lungla	Monu-Doloi	Balisera	Luskerpore	Mean
Helopeltis	7.75h	14.31e	15.47e	25.98c	31.51b	9.65g	17.45b
Red spider mite	29.09b	32.28a	30.32b	32.24a	30.06b	33.77a	31.29a
Termite	10.54g	10.99g	10.68g	12.84f	15.15e	18.69d	13.15c

Within column and row values followed by different letter (s) are significantly different by DMRT ($p \leq 0.05$)

Incidence of pests on different system of pruning cycle

Pruning is one of the important cultural operations in tea husbandry. Pruning is an essential agronomic practice implemented in winter for renovating vegetative growth to increase crop productivity in subsequent years. Pruning removes a large part of the pest populations present on the foliage and stems. Most foliar pests like tea mosquito bug, flushworm, aphid, jassid, red spider mite, scarlet mite and purple mite are removed during pruning operation. Medium prune (24-28 inch or 61-71 cm) is best suited for shot hole borer infested fields. Longer pruning cycles will trend to increase the intensity of borer damage, especially in mid and low elevation areas. Experiments have established an exponential relationship between the percentage of attack by shot hole borer and the age of the field since pruning (Muraleedharan *et al.*, 1992). Differences of pruning cycle provide differential suitable habitat and favourable micro-climate for many pests and sometimes reduce the pest attacks. It may either induce the formation of a pocket infestation of a specific pest in one bush, or increase the proliferation of various pests in the different parts of the bush.

Experiment on influence of pruning operations on pest incidence has been continuing and weekly/monthly observations and data were recorded regularly at Bilashcherra Experimental Farm during 2005 to 2007. Systematic sampling was done on the bush count method in sections received LP, DSK, LSK and MSK. The following pests were recorded- aphid, jassid, flush worm, *Helopeltis*, red spider mites and termites. Incidence of RSM & *Helopeltis* is more in skiff areas. The incidence of *Helopeltis* was found to be highest in LSK, MSK and DSK sections (15.82%, 15.14% and 13.56%) where as termite was found to be highest in MSK, LSK and DSK sections (21.47%, 17.38% and 14.76%) (Table 2). RSM incidence was the lowest in LP (1.68%) and the highest in LSK (14.24%) and MSK (12.54%) sections. The incidence of aphid, jassid and flushworms were higher in light prune sections in the early cropping time (Fig. 2). The incidence of these pests was less in skiff sections round the year. Result revealed that Light Pruning (LP) is the best time for removal of maximum foliar pests including *Helopeltis,* RSM and soil pests like termite. LP is the high time for proper control of termites in tea.

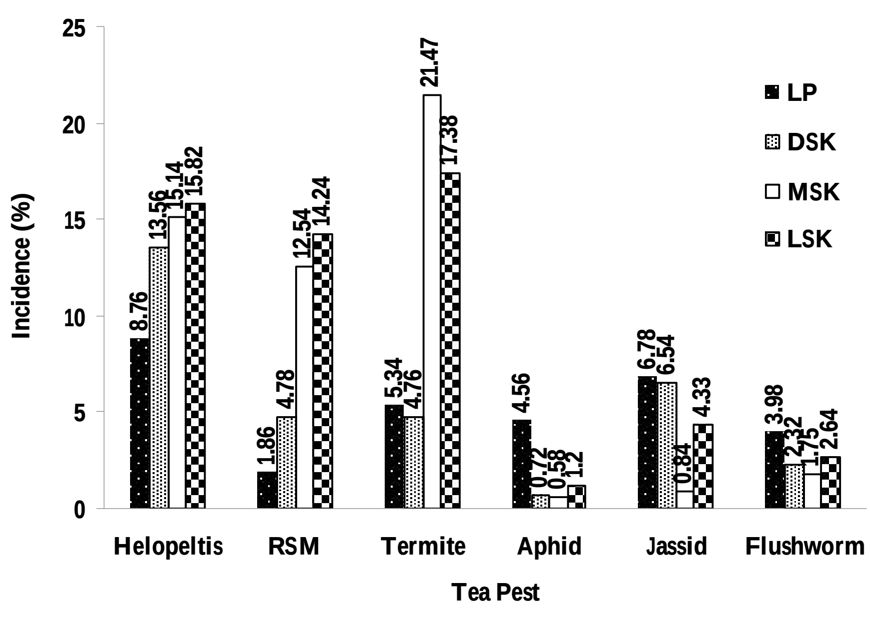

Fig. 2. Comparative incidence of pests of tea in different pruning operations

Table 2. The incidence of major three pests in different pruning operations

Major pests	% infestation in different pruning operations (3 years average)				
	LP	DSK	MSK	LSK	Mean
Helopeltis	8.76e	13.56c	15.14b	15.82b	13.32b
Red spider mite	1.86g	4.78f	12.54d	14.24c	8.36c
Termite	5.34f	14.76c	21.47a	17.38b	14.74a

Within column and row values followed by different letter (s) are significantly different by DMRT ($p \leq 0.05$)

Incidence of pests on different topographies

The incidence of the major three pests of tea like *Helopeltis,* red spider mite and termites were recorded from each of the three topographical regions i.e. Hillock, flats and furrows at BEF during the experimental period. Flat and furrow areas are vulnerable to pests. The maximum infestation of *Helopeltis* was found more in furrow (17.68%) areas followed by flat (14.26%) and hillock (8.67%). Red spider mite (18.86%) and termite (15.52%) were found more in flat areas. The incidence of all the insect pests was found to be lowest in hillock areas (Fig. 3).

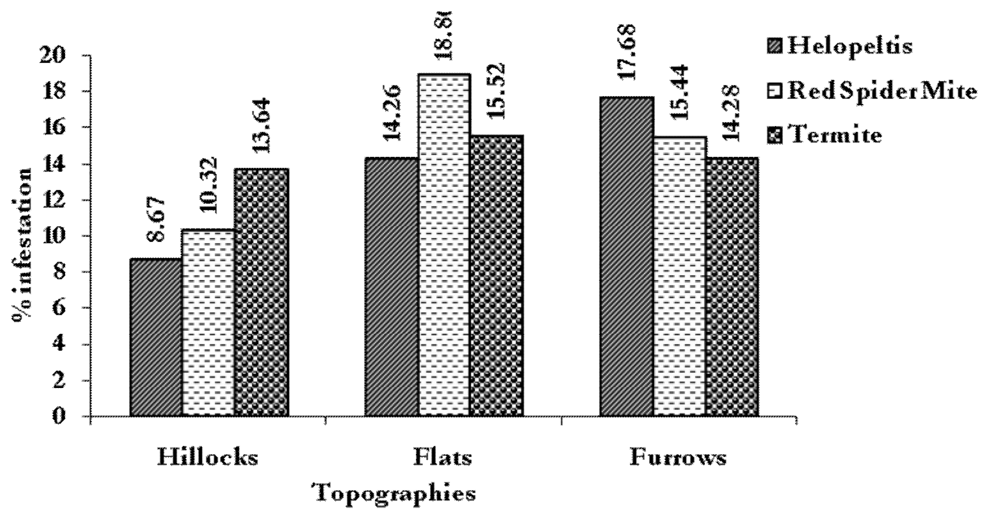

Fig. 3. The incidence of pest complex of three topographical region

Incidence of pests on different varieties / agro-types

Tea plant is propagated either by seeds or vegetative parts i.e. nodal leaf cutting. Tea seeds are the product of cross fertilization and thus the progenies of any tea agrotype are heterogeneous in respect of morphological features such as growth and vigour, yield and quality performance, susceptibility to pests and diseases, and adaptability to various edaphic and climatic elements. On the other hand, the progenies produced by vegetative propagation using nodal leaf cuttings are known as vegetative clones. Plant itself has its own resistance capability to tolerate or compensate the insect attack. Sometimes plants evolve diverse means to avoid or recover from pest attack. The mechanism of pest resistance in plants is generally physiological (i.e. plant toxins inhibit pest) or mechanical (i.e. plant morphology leaf structure, pubescence, distastefulness of sap, vigour or antibiosis, etc.) which may be controlled by single gene or multiple gene. Planting materials such as seedlings or vegetative clones are the integral part in tea cultivation and it may be resistant or susceptible of pest attack.

On this view, the study was continued to find out the incidence of major pests on plant varieties. Infestation intensity of seedling and clonal teas is quite different. Result showed that the infestation of *Helopeltis* was more in TV1 (17.73%) and BT1 (13.15%) compared to seedling (11.60%) and Red spider mites and termites were more predominant in TV1 (11.84% and 18.83% respectively) compared to seedling (Table 3). The seedling varieties are less affected by the pests. In the improvement programme like breeding and selection, seedlings with fairly broad and dark leaf should be choice for termite resistance in tea.

Table 3. Incidence of the major three pests on different tea varieties/agrotypes

Major Pests	% infestation in different tea agrotypes (3 years average)			
	TV1	BT1	Seedling	Mean
Helopeltis	17.73±0.10	13.15±0.10	11.60±0.09	14.84±0.09
Red spider mite	11.84±0.07	8.73±0.08	7.26±0.08	9.28±0.07
Termite	18.83±0.10	12.68±0.09	9.75±0.07	13.75±0.08

Studies on the seasonal abundance of major pests of tea

The seasonal abundance of major pests of tea such as *Helopeltis*, red spider mites and termites was monitored at Bilashcherra Experimental Farm during 2005 to 2007. The population of *Helopeltis*, red spider mites and termites was present throughout the year, nevertheless it was at the lowest (±10% infestation of pluckable shoots) in December to February except termites. The population of *Helopeltis* and red spider mite usually started to build up in the month of March/April reaching a peak (±40% in June/July). After which their abundance was diminished. In case of termite, population started to increase from the month of November to April. The lowest (0.78%) shoot infestation and the highest (54.6%) shoot infestation of *Helopeltis* were recorded in the month of January and July respectively (Fig. 4). Cloudy weather influences the population of *Helopeltis*.

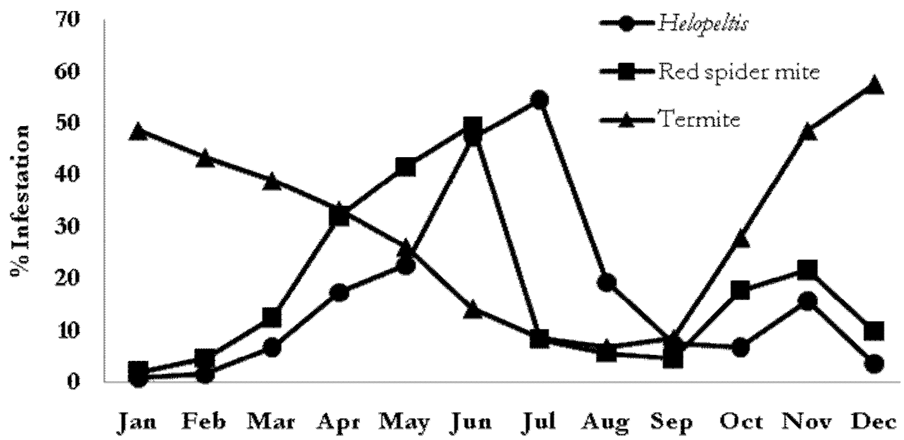

Fig. 4. Seasonal abundence of major pests of tea in Bangladesh during 2005-2007

The present findings are similar to that of Das (1991); Sarmah and Phukan (2004). Similarly, the infestation of red spider mite commenced from the first week of March and continued till the shoots and leaves present on the bushes. The lowest (1.9%) and the highest (49.5%) infestation of red spider mite were recorded in the month of January and June respectively. Drought also accelerates the infestation of red spider mite. During the rainy season, the infestation of red spider mite declined sharply. In case of termite, the infestation remained round the year but the highest infestation (57.6%) was found in the month of December and it will be continued up to monsoon period i.e. March/April. The infestation declined from April to September due to rainy season.

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CHANGE OF CHEMICAL COMPOSITIONS IN SEMI-FERMENTED TEA ON LAND ELEVATION

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Abstract

The study was undertaken to know the effect of chemical compositions in semi-fermented oolong tea on different land elevation. After collecting leaves and processing to semi-fermented tea, essential components were determined by solvent extraction method, UV spectrophotometer, using AACC and AOAC methods and oven dry methods. As soil condition in land elevation for tea cultivation varies, the average percent of caffeine, polyphenol and ash were gradually increased from flat to high land whereas moisture content, lipid and protein percent slightly decreased. Besides, there were slight increases of acidity in high land when pH is counted as low as high ones. On the other hand, the values of ascorbic acid in mg/100g were moderately decreased from flat to high land.

Keywords: Land elevation, Semi-fermented, Oolong tea, Composition

Introduction

Topography is a nonliving factor that refers to the "lay of the land." It includes the physical features of the earth such as the land elevation, slope, terrain (flat, rolling, hilly, etc.), mountain ranges and bodies of water. The steepness of a slope affects plant growth through differential incidence of solar radiation, wind velocity and soil type. Tea (*Camellia sinensis* L.) is grown on different land elevation which is the oldest and best beverage in the world next to water (Choudhury, 1989). There are three types of tea: green, oolong and black. Green and Oolong tea are the most widely consumed beverages in Asian countries and has been familiar in China and Japan from centuries (Zaveri, 2006). Oolong tea is semi-fermented during processing, whereas green tea is not fermented and black tea is fully fermented. Semi-fermented tea is especially good for digestion, hence it is advisable to have after a large meal. It is also useful for diabetic patients.

The chemical composition of semi-fermented oolong tea is counted between the ranges of non-fermented green tea to fully fermented black tea. This tea liquor contains quantitatively important polyphenols, minerals, alkaloids, carbohydrates, proteins and amino acids, vitamins and traces of lipids.

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The major constituents of green and oolong tea includes theaflavins, thearubigins, ascorbic acid, polyphenolase enzyme and flavanols. Tea grows at different land elevation and has difference in its constituents. Moisture content is estimated in the ranges of 3-4 percent in processed tea. Muhammed and Suliman (2009) reported the mean moisture content of all the tea samples was 6.8%, ranged from 5.6-7.5% with Mambila and Srilanka tea having the lowest contents of 5.6 and 6.5% respectively. The most commonly known sources of caffeine are coffee, and tea leaves (Barone *et al*., 1996; Frary *et al*., 2005). There are two major kinds of tea, black tea and green tea. It contains caffeine (1 to 5) % of its dry weight (Amra *et al*., 2006) depending on type, brand (Bennett and Bonnie, 2001) and brewing method (Hicks *et al*., 1996). The polyphenol contents are one of the major constituents of tea which is reported to account for up to 40 % of the dry weight (Clement, 2009). The lipids content in tea has a significant difference due to variety and climatic difference moreover the region also influence the results. Lipids present in the protoplasm up to 6-10% by weight may or may not have any significant role of quality in the manufacturing process (TRIC, 1948). Tea contains protein upto 15% (Eden, 1960), which helps building human body. Most of the researchers are interested in analyzing the constituents of different types of tea, its concentration, molecular structure and functional properties, etc., to provide better quality tea to the consumer. Green and Oolong tea leaves on dry weight basis contain 15-20% protein (Cabrera *et al*., 2006). The ash content of a sample is an indication of its mineral contents, it does not necessarily indicate high quality except when there is a favorable balance of the essential minerals (Ahmed *et al*., 1989). The ash content in processed tea is about 3-9 percent of inorganic matter (Stagg and Millin, 1975; Millin and Rustidge, 1967). Ascorbic acid contents are greater in the younger shoots than in the mature tea leaves but lesser in shaded in comparison with that of un-shaded shoots. Black and oolong tea have lesser amount of ascorbic acid than green tea (Takayanagi, 1977). pH is the most important factor for the production of pigmented compounds *viz.,* theaflavins and thearubigins. Optimum pH favourable for the production of pigmented compound is 5.0 to 6.0 (Nestle, 1966). Choudhury (2001) reported that green tea leaves having pH of 5.0-5.8, moisture content of 78-80 percent and 20-25 percents of dry matter content respectively.

The factors influencing the quality of tea includes soil type, land elevation *viz*., flat, major and high land, plucking and manufacturing methods. Normally tea with better quality is grown well in high land than major and flat ones. Land elevation plays the major role in assuring the quality of tea when compared to others. In view of the above discussion, the objective of the present study has been carried out to evaluate the changes in chemical compositions of semi-fermented oolong tea with respect to different land elevation.

Materials and Methods

Samples Collection and Preparation

The tea leaves *(Camellia sinensis)* were collected from different land elevation i.e. Flat, Major and High land of Lackatoorah Tea Estate, Sylhet, Bangladesh to analyze the physico-chemical compounds during the year 2012. The samples were used for producing semi-fermented Oolong tea. The manufacturing process of Oolong tea is given below:

Manufacturing Process of Oolong Tea (Semi-fermented Tea)

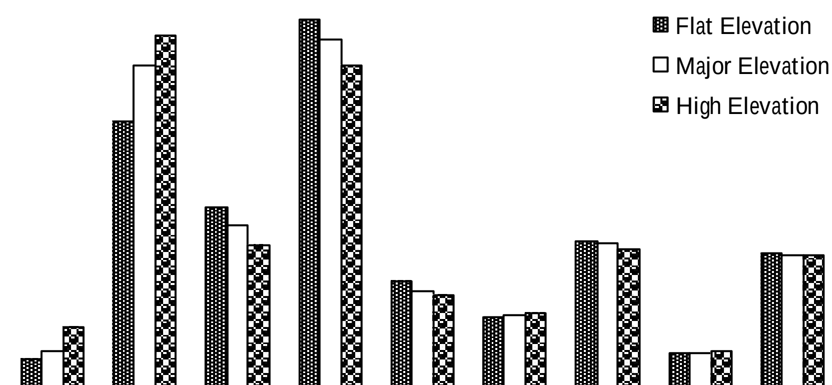
After plucking the samples were spread thinly on flat bamboo basket for withering under sunlight for 30-60 minutes. Duration of withering is completely dependent on the availability of sunlight. After that the sample leaves were transferred to a floor for further withering for 6-8 hours and agitated by hand at one hour interval. In these processes, the border of the sample leaves became red and a strong aroma evaporates with the decreasing of moisture content gradually. The withered leaves were dried to inactivate the enzymes for fermentation. After this tea leaves were crushed and re-dried under sunlight to receive oolong tea having below 7 percent moisture content and used for analyzing its constituents.

Determination of Essential Components in Oolong Tea (Semi-fermented Tea)

Moisture content for each tea sample was determined using an oven set at 102^0C and dried to constant weight (AOAC, 1984). The caffeine was determined by separating from the sample by refluxed and filtered. The filtered is then extracted with chloroform as solvent which removed by evaporation and weigh the caffeine (AACC, 2000). The total polyphenol content (TPC) was determined by spectrophotometer (T-60UV-Spectrophotometer) using Gallic acid as standard, according to the method described by the International Organization for Standardization (ISO, 2005). Lipid content in the samples was determined using soxhlet extraction method (AOAC, 2000). Protein content was analyzed using Kjeldhal digestion method followed by distillation and titration (AOAC, 2000).Total ash was determined using Muffle furnace set at 550^oC for 3hrs (AACC, 2000). pH of the tea infusion was determined by using portable pH meter according to the method of AOAC (1990). The amount of ascorbic acid was measured by preparing iodine solution and then titrated with extracted samples. Total acidity of made tea sample was determined by titrating samples against 0.1N sodium hydroxide solution to persistent pink color following protocols of AOAC (1990).

Results and Discussion

The result in the figure 1 shows the change of chemical components in semi-fermented oolong tea with the land elevation**.** The caffeine content in oolong tea gradually increased from flat to high land with 1.25%, 1.61% and 2.59%, respectively. The caffeine content reported in the ranges of 1% to 5% percent in black tea and green tea (Amra *et al*., 2006). The total polyphenol content of tea grown in flat, major and high land found 11.23%, 13.57% and 14.85%, respectively. From flat to high land polyphenol content increased from 11.23% to 14.85%. Polyphenol content in oolong tea varies in the ranges with green and black tea and the results are similar with the finding of Anesini *et al*. (2008) who described that TPC in green tea varied from 14.32±0.45 to 21.02±1.54%. Lipids content of semi-fermented tea from flat to high land were found 7.59%, 6.84%, and 6.01%, respectively, that indicates higher lipid content in the flat land and lower in the high land. The results are in coincidence with the findings of Hara *et al*. (1995), who found the lipid content of 7-10% in various teas. The total protein contents were 15.45% in flat, 14.65% in major and 13.55% in high land as shown in figure. The proteins content was 15% in various teas and decreased in long withers (Eden, 1960). Moisture content is an important factor in semi-fermented or all processed tea and obtained moisture content was 4.53%, 4.12% and 3.96%, respectively.



	Caffein%	Polyphenol%	Lipid%	Protein%	Moisture %	Ash%	Ascorbic Acid%	Himidity %	pH
Flat Elevation	1.25	11.23	7.59	15.45	4.53	3.02	6.2	1.49	5.71
Major Elevation	1.61	13.57	6.84	14.63	4.12	3.07	6.07	1.53	5.61
High Elevation	2.59	14.85	6.01	13.55	3.96	3.17	5.85	1.61	5.58

Fig. 1. Chemical components present in semi-fermented oolong tea on flat, major and high land elevation

From flat to high land, moisture content decreased moderately as shown in the figure and it is same as the results of Harler (1964) who reported that the moisture content of processed tea should be 3 to 7% approximately. In oolong tea, the ash content were slightly increased from flat to high land and found 3.02%, 3.07%, and 3.17% respectively, which is identical to the reported value of Stagg and Millin (1975). The ash content of these samples is an indication of its mineral content; it does not necessarily indicate high quality except when there is a favourable balance of the essential minerals (Ahmed *et al*., 1989). The ascorbic acid content in semi fermented tea were found 6.20 mg, 6.07 mg, and 5.85 mg respectively, per 100 ml distilled water from flat to high land as shown in figure. This result reveals that the ascorbic acid content gradually decreased due to land elevation. The information of the acidity content in oolong tea was found 1.49%, 1.53% and 1.61%, respectively. The value of acidity content was gradually increased from flat to high land. Besides the pH content of tea leaves in flat land was higher (5.71) than high land (5.58).

Conclusion

Tea is grown in mild, warm and well watered hilly region in Bangladesh where other agricultural products are cultivated in all places due to water. But the land for tea planting is not fully mountain; it is produced on land of different elevation i.e. flat, medium, and high land. The study was conducted on different land elevation to analyze the nutritional qualities of semi-fermented oolong tea. The result revealed that the studied essential components in the oolong tea were an acceptable level. The caffeine and polyphenol contents which are very crucial components in tea were higher in high land than flat and major ones. The other parameters were changed with an acceptable ranged between the values of green and black tea contents due to variation of land elevation.

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SOIL PROPERTIES OF LALMAI HILL, SHALBAN BIHAR AND NILACHAL HILL OF GREATER COMILLA DISTRICT AND ITS SUITABILITY FOR TEA PLANTATION

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Abstract

Tea is grown in Bangladesh under marginal climatic and soil conditions. Its production is greatly influenced by many physical and natural factors, such as, altitude, topography, climate, etc. A feasibility study was carried out at Lalmai hill, Shalban Bihar and Nilachal hill of greater Comilla district to increase new plantation area. Physico-chemical properties of the soils such as texture, pH, organic matter and other nutrient content were found satisfactory. Climatic conditions such as rainfall, temperature, relative humidity and physiographic conditions are also satisfactory for growing tea.

Keywords: Soil properties, Lalmai hill, Shalban Bihar, Nilachal hill, Climate, Tea plantation

Introduction

The tea industry of Bangladesh dates back to 1857. Now tea is an agro based labour intensive industry of Bangladesh. It plays an important role in the national economy through trade balancing and employment generation. It produces 1.5% of world production and 0.7% of world exports (ITC, 2008). At present there are 163 tea estates in Bangladesh. The tea estate covers 1,14,014.39 ha of the grant area of which 49.82% i.e. 56,801.99 ha is under tea plantation. The very old tea occupied 8999.83 ha (7.89%). The rest 48,212.57 ha (42.29%) is occupied by factories, banglows, labour lines, paddy land and non-tea crops (PDU, 2010). It can be said that if we do not go for further development of tea industry, it may so happen that tea would be required to be imported to meet the local consumption of the growing population of the country and this will remain little or no scope for export after 2015 as opened by the exporters (BTB, 2002). On an average, Bangladesh produces 63 million kilograms tea annually. It may be mentioned here that the growth of tea production is 1% per year where as consumption of tea is increasing @ 3.5% per year although our per capita consumption as compared to other country is less (Khan and Alam, 2002). On the other hand, owing to urbanization and change in the socio-economic condition of the people, per capita consumption of tea will increase from the present consuption of 0.350 kg per year head of much higher quality (BTB, 2013).

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In the year 2010 total production of tea in Bangladesh was 59.27 million kilograms. Export of Bangladesh tea is gradually decreasing due to increase of local consumption. In the year 2007, Bangladesh exported 10.56 million kilograms of tea but in the year 2008, 2009 and 2010 it decreased to 8.39, 3.15 and 0.91 million kilograms respectively (ITC, 2011).

So, in order to increase the tea production, new avenues for tea cultivation need to be assessed which will decrease poverty through new employment opportunity and improve socio-economic condition of the country.

Materials and Methods

The ecological soil survey of the Lalmai hill, Shalban Bihar and Nilachal hill of greater Comilla district had been conducted in the year 2009 to assess the feasibility for growing tea. Climatological data were collected from the Meteorological observation center, Comilla. Soil profile study and measurement of water table were done. Soil samples were collected from different topographical zone to determine the physico-chemical properties of the selected areas. During profile study soil colour was measured by Munshell soil colour chart. Soil samples were collected from three different depths (0-23 cm, 23-46 cm and 46-92 cm) of different location. Soil texture, pH, amount of organic carbon, total nitrogen, available phosphorus, potassium, calcium, magnesium, C/N Ratio, available zinc and sulphur of the soil samples were determined. Soil texture was determined by hydrometer method, pH was determined by using pH meter (Soil: distilled water = 1:2.5). Soil organic carbon (in %) was determined following Walkley and Black wet oxidation method. For determination of total nitrogen, Micro kjeldahl steam distillation method was adopted (Imamul Huq and Alam, 2005). Available phosphorus was done colorimetrically. For determination of available potassium, calcium, magnesium and zinc soils were extracted with 77% ammonium acetate solution and then potassium was determined by flame photometer and calcium, magnesium and zinc were determined by AAS (atomic absorption spectrophotometer). Available sulphur was determined by turbidimetric method by using tween-80 solution.

Results and Discussion

Tea is grown on a variety of land with various topographical, textural and structural characteristics. Tea being a perennial crop needs to be cultivated under suitable climatic and edafic conditions. But the Bangladesh, tea is grown under marginal land and climatic conditions such as low elevation, poor relief (topography), the presence of impervious subsoil layer (hardpan), low nutrient status etc. Under such conditions a careful consideration is to be made through a well-planed soil survey and profile study for selecting a new site for plantation.

To examine the suitability and prospect of growing tea in above mentioned regions, the following essential factors were taken into consideration.

Physical properties of soil

The main physical characteristics of the soils of Lalmai, Shalban Bihar and Nilachal hill as identified soil profile as well as from the soils collected by auger boring show that the soils are mostly blackish brown to reddish brown in colour, texturally sandy clay loam to clay loam with relatively medium content of organic matter. The soils of Lalmai, Shalban Bihar and Nilachal hill are well aerated. No hardpan or impervious layer was observed during boring. In short the characteristics of top soils and subsoil are described below:

Top soil

Top soil is blackish brown to reddish brown in colour and sandy clay loam in texture. Structure of the soil is loose and friable (moist), consistency being non sticky to non-plastic. The soils are well aerated. Subsoil is yellowish brown to reddish brown and texturally clay loam to clay, loose and friable. Consistency is non-sticky to non-plastic.

Substratum

It is brownish grey, silt loam to clay loam, very friable (moist) and non-sticky to non-plastic. Most of the soils of Lalmai, Shalban Bihar and Nilachal hills are characterized by reddish brown to yellowish brown with medium content of organic matter. It is to be mentioned that 90% soils of Lalmai, Shalbanbihar and Nilachal hill falls under sandy clay loam to clay loam (SRDI, 1999). Although tea grows best in sandy loam soil, sandy clay loam is also suitable for growing tea (Ahsan, 1996).

Study of soil profile

Soil profile is a vertical cross-section of soil that may provide information on physical features such as texture, structure, colour, presence of hardpan etc. This study is essential before allocating land for tea. The root system of trees may also provide a valuable index of permeability of the soils of the new sites. Tea requires deep, well-drained and permeable soils for its satisfactory growth. The topo sequence of the selected areas is given below:

Table 1 shows the topo sequence of the sampling areas in Lalmai hill. Colour of the soils of different horizons of the sampling spots was reddish brown and greyish brown. Sandy clay loam to clay loam texture were found in different horizons.

Table 1. Topo sequence of selected areas in Lalmai hill

District	Location	Sampling site	Depth (cm)	Colour	Topography	Texture
Comilla	Lalmai hill	1	0-23	R.B	Tillah Top	SCL
			23-46	R.B	Tillah Top	SCL
			46-92	R.B	Tillah Top	CL
		2	0-23	R.B	Tillah Slope	SCL
			23-46	R.B	Tillah Slope	SCL
			46-92	R.B	Tillah Slope	SCL
		3	0-23	G.B	Flat	SCL
			23-46	G.B	Flat	SCL
			46-92	G.B	Flat	SCL
		4	0-23	R.B	Tillah Top	SCL
			23-46	R.B	Tillah Top	SCL
			46-92	R.B	Tillah Top	CL
		5	0-23	R.B	Tillah Slope	SCL
			23-46	R.B	Tillah Slope	SCL
			46-92	R.B	Tillah Slope	SCL

Note: R.B=Reddish Brown, G.B=Greyish Brown, SCL=Sandy Clay Loam, CL=Clay Loam

Table 2 shows the topo sequence of the sampling areas in Shalban Bihar. Colour of the soils of different horizons of the sampling spots was reddish brown and greyish brown. Sandy clay loam to clay loam texture was found in different horizons.

Table 2. Topo sequence of selected area in Shalban Bihar

District	Location	Sampling site	Depth (cm)	Colour	Topography	Texture
Comilla	Shalban Bihar	1	0-23	R.B	Tillah Top	SCL
			23-46	R.B	Tillah Top	SCL
			46-92	R.B	Tillah Top	CL
		2	0-23	R.B	Tillah Slope	SCL
			23-46	R.B	Tillah Slope	SCL
			46-92	R.B	Tillah Slope	SCL
		3	0-23	R.B	Tillah Top	SCL
			23-46	R.B	Tillah Top	SCL
			46-92	R.B	Tillah Top	CL
		4	0-23	R.B	Tillah Slope	SCL
			23-46	R.B	Tillah Slope	SCL
			46-92	R.B	Tillah Slope	CL
		5	0-23	R.B	Tillah Slope	SCL
			23-46	R.B	Tillah Slope	SCL
			46-92	R.B	Tillah Slope	CL
		6	0-23	G.B	Flat	SCL
			23-46	G.B	Flat	SCL
			46-92	G.B	Flat	SCL

Table 3 shows the topo sequence of the sampling areas in Nilachal hill. Colour of the soils of different horizons of the sampling spots was reddish brown. Sandy clay loam to clay loam texture was found in different horizons.

Table 3. Topo sequence of selected area in Nilachal Hill

District	Location	Sampling site	Depth (cm)	Colour	Topography	Texture
Comilla	Nilachal Hill	1	0-23	R.B	Tillah Top	SCL
			23-46	R.B	Tillah Top	SCL
			46-92	R.B	Tillah Top	CL
		2	0-23	R.B	Tillah Slope	SCL
			23-46	R.B	Tillah Slope	SCL
			46-92	R.B	Tillah Slope	CL

The colour of tea soils is sometimes considered to be the indicator of suitability of tea cultivation. Tea soils of Sri Lanka, Java, South India, N-E India (Assam) and Bangladesh are red in colour. However, tea soils of many parts of North-East India and Bangladesh are grey in colour and perhaps derived from the grasslands (Sana, 1989). So, from the topo sequence study of the soils of Lalmai, Shalban Bihar and Nilachal hill it is clear that the colour of the soils of the survey area is more or less similar to the colour of the soils of tea growing areas. The reddish brown colour of the soils of survey area also indicates a high state of oxidation of iron compounds and well drained condition.

Tea soils are highly weathered, extremely acidic and low in fertility status. Furthermore these soils do not receive deposits of fertile silt by flooding; rather they suffer from erosion. Sana (1989) reported that the most suitable tea soil is thought to be light, friable and well drained having soil pH from 4.5 to 5.8. The critical values have been fixed at 0.1% for nitrogen and 1% for organic matter. The minimum level of nutrient status of tea soil should be 10µg/g for P, 80µg/g for K, 25µg/g for Mg, 90µg/g for Ca, 2µg/g for Zn and 20µg/g for S (Alam, 1999).

Table 4 shows the chemical properties of Lalmai hill soil. pH of the soils ranges from 4.5 to 5.0. Organic carbon of the surface soils ranges from 0.98% to 1.52% but the subsurface soils contained below 1% organic carbon. Mean of organic carbon content in three depths varies from 0.67% to 0.95%. Total nitrogen content varies from 0.099% to 0.147% in the surface soils while subsurface soils contained less than 0.1% total nitrogen. Organic matter content of the surface soil ranges from 1.68% to 2.61% but subsurface soils contained lesser amount of organic matter than the surface soils. Phosphorus content of Lalmai hill soils is upto the mark. Potassium content also below the critical limit (<80 ppm) but calcium and magnesium content are in satisfactory level. Content of zinc in the surface soil is below 3.0 ppm but within the critical limit. Available sulphur content is also in the satisfactory level.

Table 4. Chemical properties of the soil of Lalmai Hill

Sampling Site	Depth (cm)	pH	OC (%)	Total N (%)	OM (%)	Av.P (ppm)	Exchangeable Cation (ppm)			C/N Ratio	Zn (ppm)	S (ppm)
							K	Ca	Mg			
1	0-23	5.0	0.99	0.101	1.70	34.37	54.55	273.2	30.4	9.8	3.2	22.0
	23-46	4.7	0.55	0.051	0.94	2.23	54.55	114.0	18.0	10.7	1.6	15.0
	46-92	4.6	0.48	0.041	0.82	1.48	40.91	76.6	10.4	11.7	1.0	12.0
2	0-23	4.6	1.06	0.108	1.82	1.71	45.45	380.0	48.2	9.8	2.9	24.0
	23-46	4.6	0.62	0.066	1.06	1.02	36.36	312.0	52.2	9.3	2.0	12.0
	46-92	4.7	0.47	0.041	0.80	0.90	31.82	275.2	50.8	11.4	1.5	8.8
3	0-23	4.5	1.52	0.147	2.61	23.82	27.27	413.8	35.2	10.3	3.1	20.0
	23-46	4.7	0.70	0.072	1.20	4.30	27.27	585.2	46.4	9.7	2.5	13.0
	46-92	5.0	0.62	0.063	1.06	3.27	18.18	662.4	52.2	9.8	1.1	10.0
4	0-23	4.7	0.98	0.099	1.68	5.98	18.18	50.8	8.2	9.7	3.0	25.0
	23-46	4.8	0.60	0.066	1.03	3.09	22.73	57.2	7.6	9.0	2.2	16.0
	46-92	4.5	0.45	0.047	0.77	2.06	31.82	87.0	9.8	9.5	1.5	10.0
5	0-23	4.7	1.36	0.127	2.33	4.13	36.36	326.6	45.2	10.7	2.9	23.0
	23-46	4.8	0.40	0.043	0.68	2.75	40.91	294.2	49.8	9.3	2.2	20.0
	46-92	4.9	0.38	0.036	0.65	3.67	27.27	217.4	44.4	10.5	1.6	16.0

Table 5 shows the chemical properties of Shalban Bihar soil. pH of the soils ranges from 4.5 to 5.0 which is within the critical limit. Organic carbon (in %) of the surface soils ranges from 0.98% to 1.40% but the subsurface soils contained below 1% organic carbon. Total nitrogen content varies from 0.101% to 0.137% in the surface soils while subsurface soils contained less than 0.1% total nitrogen. Organic matter content of the surface soil ranges from 1.68% to 2.40% but subsurface soils contained lesser amount of organic matter than the surface soils. Phosphorus content of Shalban Bihar soils are upto the mark. Potassium content also below the critical limit (<80 ppm) but calcium and magnesium content is in satisfactory level. Content of zinc in the surface soil is around 2.5 ppm and within the critical limit. Available sulphur content is also in the satisfactory level.

Table 5. Chemical properties of the soil of Shalban Bihar

Sampling Site	Depth (cm)	pH	OC (%)	Total N (%)	OM (%)	Av.P (ppm)	Exchangeable Cation (ppm)			C/N Ratio	Zn (ppm)	S (ppm)
							K	Ca	Mg			
1	0-23	4.5	1.40	0.137	2.40	2.69	72.73	198.0	26.8	10.2	2.6	25.0
	23-46	4.7	0.62	0.067	1.06	1.08	50.00	177.8	24.2	9.2	2.0	18.0
	46-92	4.8	0.54	0.056	0.92	0.62	45.45	416.0	49.0	9.6	1.0	14.0
2	0-23	4.5	1.06	0.109	1.82	4.88	22.73	243.6	16.0	9.7	2.5	22.0
	23-46	4.7	0.57	0.052	0.98	1.71	18.18	272.4	21.0	10.9	1.9	17.0
	46-92	5.0	0.46	0.048	0.79	2.00	13.64	383.8	30.6	9.5	1.3	12.0
3	0-23	4.5	1.06	0.108	1.82	30.25	77.27	453.8	29.6	9.7	2.4	25.0
	23-46	4.7	0.36	0.042	0.61	1.94	59.09	331.2	31.4	8.5	1.6	16.0
	46-92	4.8	0.44	0.046	0.75	1.42	45.45	417.0	38.2	9.5	1.2	10.0
4	0-23	4.5	1.21	0.118	2.08	4.77	36.36	281.2	26.8	10.2	2.5	9.0
	23-46	4.7	0.41	0.043	0.70	2.63	22.73	272.4	27.0	9.5	1.8	19.0
	46-92	4.9	0.30	0.033	0.51	1.83	18.18	333.8	32.8	9.0	1.4	12.0
5	0-23	4.9	1.02	0.104	1.75	106.0	9.09	290.8	12.4	9.8	2.7	8.9
	23-46	4.7	0.54	0.056	0.92	37.85	13.64	163.0	9.6	9.6	2.0	22.0
	46-92	4.5	0.30	0.035	0.51	6.72	13.64	80.6	8.4	8.5	1.5	15.0
6	0-23	4.6	0.98	0.101	1.68	4.65	27.27	20.4	8.0	9.7	2.3	12.0
	23-46	4.5	0.45	0.047	0.77	2.63	18.18	21.0	8.2	9.5	1.5	26.0
	46-92	4.4	0.33	0.036	0.56	1.83	18.18	23.8	9.2	9.1	1.1	20.0

Table 6 shows the chemical properties of Nilachal Hill's soil. pH of the soils ranges from 4.6 to 4.9 which is within the critical limit. Organic carbon (in %) of the surface soils ranges from 1.16% to 1.65% but the subsurface soils contained below 1% organic carbon. Total nitrogen content varies from 0.119% to 0.152% in the surface soils while subsurface soils contained less than 0.1% total nitrogen. Organic matter content of the surface soil ranges from 1.99% to 2.83% but subsurface soils contained lesser amount of organic matter than the surface soils. Phosphorus content of Shalban Bihar soils are not upto the mark. Potassium content also below the critical limit (<80 ppm) but calcium and magnesium content is in satisfactory level. Content of zinc in the surface soil is around 3.0 ppm and within the critical limit. Available sulphur content is below the critical limit.

From the above discussions it is clear that physico-chemical properties of the soils of Lalmai hill, Shalban Bihar and Nilachal hill are suitable for tea plantation. Soil pH, organic matter content and all other nutrient elements are in satisfactory level for tea plantation.

Table 6. Chemical properties of the soil of Nilachal Hill

Sampling Site	Depth (cm)	pH	OC (%)	Total N (%)	OM (%)	Av. P (ppm)	Exchangeable Cation (ppm)			C/N Ratio	Zn (ppm)	S (ppm)
							K	Ca	Mg			
1	0-23	4.6	1.65	0.152	2.83	2.69	50.00	178.2	24.4	10.0	3.1	15.0
	23-46	4.8	0.67	0.068	1.15	1.37	40.91	107.2	28.2	9.8	2.2	11.0
	46-92	4.7	0.40	0.046	0.68	1.08	45.45	103.2	31.4	8.6	1.5	9.9
2	0-23	4.6	1.16	0.119	1.99	1.48	54.55	331.4	47.0	9.7	3.3	13.0
	23-46	4.8	0.90	0.094	1.54	0.90	31.82	374.4	49.6	9.5	2.1	12.0
	46-92	4.9	0.52	0.056	0.89	0.85	45.45	390.0	48.0	9.2	1.6	8.8

Climatic condition

In general, Bangladesh tea has been growing in a marginal climatic condition. Lalmai hill, Shalban Bihar and Nilachal hill of greater Comilla district fall in moderate climatic condition in respect of rainfall, temperature and relative humidity.

Table 7. Rainfall distribution in Comilla district

Season	Year wise Rainfall distribution (mm)							
	2002	2003	2004	2005	2006	2007	2008	2009
Winter (Dec-Feb)	22	115	04	09	76	86	226	1725
Pre-monsoon (March-May)	534	542	498	564	985	887	373	283
Monsoon (June-Sept)	1200	1170	2181	1290	1311	1170	526	1045
Post Monsoon (Oct-Nov)	120	111	243	284	35	79	174	30
Total	1876	1938	2926	2147	2331	2222	1299	3083

Source: Meteorological observation center, Comilla (2009)

The distribution of rainfall plays a vital role on the growth of tea plant. It is found that 1270mm annual rainfall is marginal for tea cultivation (Sana, 1989). The average annual rainfall in Comilla sadar ranges from 1876-3083 mm which indicate optimum rainfall pattern for tea cultivation.

Maximum temperature ranges from 25.6 to 31.4°C and minimum temperature varies from 12.3 to 19.7°C in the year 2002 to 2009. Relative humidity ranges from 65-81%. Temperature is one of the most important factors for the growth and development of crops. Photosynthesis and respiration of plants are influenced by temperature and light intensity. Tea, being a perennial plant is grown under a wide range of temperature regimes in the tea world. It is cultivated best in temperatures ranging from 12.7°C to 28°C (Sana, 1989). So, temperature of the greater Comilla district is suitable for tea cultivation. The mean relative humidity ranges from 56 to 86% in Sylhet, and from 68 to 86% in Chittagong tea zone (Sana, 1989). By considering

Rainfall pattern, temperature and relative humidity, it can be concluded that the climatic condition of Lalmai hill, Shalban Bihar and Nilachal hill of greater Comilla district is suitable for tea plantation.

Table 8. Year-wise Temperature (°C) and Relative Humidity (%) in Comilla district

Year	Temperature (°C)		R.H. (%)
	Maximum	Minimum	
2002	25.6	12.3	74
2003	27.9	15.1	71
2004	31.3	19.7	67
2005	29.4	18.8	78
2006	26.7	13.7	65
2007	28.8	16.5	81
2008	30.7	17.8	77
2009	31.4	15.5	65

Source: Meteorological observation center, Comilla (2009)

Conclusion

Tea is grown on variety of soils with various topographical, textural and structural characteristics. The topographical position of the Lalmai hill, Shalban Bihar and Nilachal hill is medium to high tillah which will be suitable for growing tea. Presence of indicator plants and natural vegetation reflect that the areas are satisfactory for the tea plantation. Proper delineation of soil profile and observation of drainage condition indicate its suitability for the growth of tea plant. Physical properties of the soil i.e texture, structure and consistency in the field is up to the mark. The chemical properties of the soil samples as analyzed in the laboratory showed that chemical constituents of the soils are suitable for the growth of tea plants. Considering the climatic conditions like temperature, rainfall etc and also the physico-chemical properties of soil are more or less identical to the best tea growing zone of Sylhet and Chittagong and are congenial for the satisfactory growing of tea in Lalmai hill, Shalban Bihar and Nilachal hill of greater Comilla district.

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COMPARATIVE STUDY ON TEA SOILS OF SOUTH INDIA AND BANGLADESH

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Abstract

A comparative study on tea soils of south India and Bangladesh was done to know about the fertility status of the tea soils of south India and Bangladesh which is directly related to the productivity of tea. It contains predominantly kaolinite type of clay which lacks fixation sites. Tea soils of south India contain large amounts of free sesquioxides and phosphorus fixation is very strong. Tea soils of Bangladesh are generally medium textured with low organic matter and nitrogen contents. South Indian tea soils are heavy in character. It contains 1-8% organic matter while tea soils of Bangladesh contain 1.0-1.2%. The textural class of the south Indian tea soils varies from sandy clay loam to clay while the tea soils in Bangladesh are predominantly loamy to sandy loam. Exchangeable aluminium content of the tea soils of Bangladesh is over 85%. pH of the tea soils of south India is around 5.0, while in Bangladesh most of the tea soils of Balisera, Lungla and Monu-Doloi circles are below 4.5. The organic matter and pH status is better in the tea soils of Panchagarh (Northern part) in Bangladesh.

Keywords: Tea soil, Organic matter, Physico-chemical properties, Fertility

Introduction

The tea ecosystem, situated close to the forest ecosystem has a predominant role in the maintenance of terrestrial ecology by providing extensive land cover and preventing soil erosion (Muraleedharan, 2005). In Bangladesh, tea is being grown in different types of soil under marginal climatic condition. The soils of the tea growing area are highly weathered and extremely acidic. These do not receive deposits of alluvium by flooding rather suffer erosion. Low soil pH has a direct influence on the availability of soil nutrients.

As a perennial crop, tea is grown on the same land for years together. Its nutritional requirement is met by the inherent supplying capacity of soil as well as by the applied inorganic and organic fertilizers. Tea culture in south India has undergone several changes over the years. From the era of sustenance farming when organic manures were the sole source of nutrients.

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The industry has witnessed a multifold growth in production through adoption of intensive cultivation practices. The large scale use of chemical fertilizers in tea nutrition management is considered as an important factor in increasing the productivity in tea. Nonetheless, inadequate attention to maintenance of soil fertility seems to have resulted in deterioration in soil health and decline in soil productivity in many gardens. Therefore, judicious use of inorganic fertilizers in conjunction with maintaining optimum soil pH and required level of organic matter appears to be the promising sustainable system in tea nutrition management (Hudson, 2005).

The yield per hectare in Bangladesh is quite low compared to other leading tea growing countries of the world. Reasons for low yield for our tea are manifold. Among theses, inadequate and imbalance supply of nutrition, improper placement and untimely use of fertilizers are the main constraints in our country. Besides, overall content of nutrient in tea soil is low due to leaching, surface runoff and impeded drainage during monsoon. Every year plant nutrients are removed from the soil through plucking leaves, pruning litters, weeds, leaching, runoff etc. De Jong (1953) reported that 45.35 kg dry tea is produced with the loss of 2.95 kg N, 0.68 kg P_2O_5 and 1.59 kg K_2O. Inherent nutrient in soil cannot meet the losses and the requirement of the plant for its optimum yield. Application of fertilizer is, therefore, essential for proper maintenance of bush health in tea and to obtain high yield. Quality of tea depends on many factors. Nutritional status of the soil is one of the factors. Genetic character, elevation, plucking standard, manufacturing process and plant nutrient status are the factors which determine the quality of tea.

South India got remarkable progress in tea productivity over the past four and a half decades. It has more than trebled the yield from 685 kg/ha in 1946 to 2451 kg/ha in 1991 (Verma, 1993). In the year 2004, total production of tea in south India was 230.781 m.kg and productivity was 2003 kg/ha (Muraleedharan *et al*., 2007). Maintenance of organic matter may be played an important role for the increase of productivity. The organic matter content of the tea soils of South India varies from 1 to 8% (Muraleedharan *et al*., 2007). On the other hand, in tea soils of Bangladesh, an overall content of organic matter varies from 1.0 to 1.2 percent (Alam, 1999) and yield per hectare in Bangladesh is quite low compared to South India. In Bangladesh per hectare yield is 1236 kg, (ITC, 2007). So, increase of organic matter content of the tea soils of Bangladesh is required for getting higher productivity. In order to maintain the organic matter content, it is very essential to know about the physico-chemical properties of the tea soils. The study was undertaken with a view to present comparative status of physico-chemical properties of tea soils of Bangladesh as well as South India which will help maintenance of organic matter in our tea soil and thereby increase tea production.

Materials and Methods

Physico-chemical properties of the south Indian tea soils were collected as secondary data from the published books, journals and articles of the UPASI Tea Research Foundation when the author was in a Post Graduate Diploma course at Kothari Agriculture Management Centre, Tamil Nadu, India. On the other hand, the data of Bangladesh tea soils were collected from the published books, journals and articles of the Bangladesh Tea Research Institute (BTRI). Besides, some recent unpublished analytical data on nutrient status of some tea soils of Bangladesh were compiled in this study. These chemical analyses were done in the soil science laboratory of BTRI. Soil samples were collected from different tea growing circles of Bangladesh such as Balisera, Juri, Lungla, Luskerpore, Monu-Doloi, North Sylhet and Panchagarh. Soil samples were collected from a depth of 0-23 cm. Texture, pH, organic carbon (%), total nitrogen (%), available phosphorus (ppm), potassium (ppm), calcium (ppm) and magnesium (ppm) of the samples were analysed. Soil texture was determined by hydrometer method and pH was determined by using pH meter (Soil: distilled water = 1:2.5). Walkley and Black wet oxidation method was used to determine soil organic carbon (%). For determination of total nitrogen (in %) Micro Kjeldahl steam distillation method was applied (Imamul and Alam, 2005). Colorimetric estimation of available phosphorus was done by ascorbic acid method. Available potassium, calcium and magnesium were extracted with 77% ammonium acetate solution. Available potassium was determined by flame photometer while calcium and magnesium were determined by AAS (atomic absorption spectrophotometer).

Results and Discussion

Physico-chemical properties of some tea soils of South India

Table1 represents the different soil properties of six tea growing zones of South India. Among the regions, the soils of Nilgiris and Wynaad contain much higher percentage of clay but the soils of the other regions are distinctly open in texture. Acidity of those regions ranges from pH 5.0 to 5.8. Highest organic matter (6.0%) was found in High Range while more than 5% organic matter was reported in Anamallais and Nilgiris. Minimum organic matter was reported in Wynaad. Amount of nitrogen and total phosphoric acid were reported in the same trend in same regions. Comparatively coarse sand was found in South Travancore followed by High Range.

Natesan (1986) quantified, by DTA (Differential Thermal Analysis), gibbsite content of 3 to 19% in clay fraction of tea soils in south India. The volume expansion of soils is low (1.75-13.26%). The soils contain about 92 to 98% of mineral matter and the remaining is the organic matter. The organic matter of the soil of South India varies from 1 to 8% (Muraleedharan *et. al*., 2007). The Cation Exchange Capacity (CEC) varies with the pH of the soil (Natesan, 1989). The soils of High Ranges, Anamallais, Central Travancore and South Travancore are open in texture, coarse and fine sand fractions together comprising 62% to 67% of the soil. Such open soils readily permit rapid percolation of water and so drainage takes place easily and rapidly. The aeration in these soils is free. They are easy to cultivate and do not form hard pan. Deep cultivation is not necessary as in the case of other types of tea soils (Anonymous, 1961). The soils of Wynaad and the Nilgiris are of clay loam type with the clay fraction preponderating. The presence of higher amounts of organic matter in the soil of the Nilgiris offsets to some extent the disadvantages of clay. These soils are heavy in character. They puddle easily with water, the particles adhere more closely and hence water does not drain through well. In dry weather, they form hard clods. They require good drainage since percolation of water is slow. Trenching and filling the trenches with organic matter will be useful in improving drainage and lightening the soil. There will be a tendency to form hard pan also. Deep rooted shade trees may be grown in such soils. A good deep forking will be found useful after pruning. Generally, cultivation operations have to be done when moisture content of the soil is appropriate and permits such operations, because these soils have a tendency for puddling at higher moisture levels. Chemically, it may be said that the soils of South Travancore and Wynaad are poorer than the soils of the other district. All soils are generally distinctly acidic.

Table 1. Tea soils of south India (Expressed as percent on oven dry basis)

Constituent	High Range	Anamallais	Nilgiris	Central Travancore	South Travancore	Wynaad
Gravel & Stone	30	35	20	30	15	15
Coarse Sand	38	35	25	28	43	26
Fine Sand	27	32	23	36	19	18
Silt	20	15	18	13	09	20
Clay	15	18	34	23	25	35
Loss of ignition	17.0	15.2	14.8	15.0	11.7	12.0
Organic Matter	6.0	5.4	5.5	4.4	3.6	3.4
Nitrogen	0.350	0.280	0.240	0.220	0.150	0.170
Total Phosphoric acid	0.130	0.140	0.110	0.130	0.090	0.064
Av. Phosphoric acid	0.010	0.009	0.004	0.008	0.005	0.003
Total potash	0.580	0.430	0.290	0.370	0.300	0.280
Av. Potash	0.040	0.030	0.023	0.024	0.025	0.022
pH	5.7	5.1	5.0	5.6	5.5	5.5

Source: (Anonymous, 1961)

Physico-chemical properties of the soils contribute towards productivity to a greater extent. Though, the tea plants grown under south Indian conditions possess deep root system, the feeder roots were observed only in the surface soil (0 to 25 cm) and negligible extent in the bottom soil (25 to 50 cm).

Table 2. Physico-chemical characteristics of tea soils of south India (adapted from Ann. Rep. UPASI Tea Res. Foundn., 2008)

Parameters	Soil Depth (cm)			
	0-25	25-50	50-75	75-100
pH	4.66	4.60	4.58	4.67
EC (dsm^{-1})	0.05	0.05	0.03	0.03
Bulk density (g/cm^3)	0.88	0.98	0.94	1.09
OM (g/kg)	18.4	15.8	12.9	6.7
Ca (mg/kg)	73	65	57	57
CEC (cmol/kg)	5.5	4.3	3.9	3.6
P (mg/kg)	22.06	12.01	6.25	9.21
K (mg/kg)	200	125	75	50
Mg (mg/kg)	40.0	27.0	17.7	15.7

Table 2 revealed that soil pH of tea grown area ranged between 4.60 and 4.88. Electrical conductivity (EC) of cultivated tea soils ranged between 0.03 and 0.05 dsm^{-1}. Continuous application of fertilizers could have imparted changes in pH and EC of tea soils. The decrease in pH could be due to the application of acid forming nitrogenous fertilizers where the ions dissociated in soil moisture could have contributed towards increase in EC. Organic matter (OM) content decreased with increasing depth of soil profile. In addition, cation exchange capacity, an interrelated parameter to organic matter exhibit similar trend like organic matter. Available P, K, Ca and Mg content was higher in the soil depth 0-25 cm.

Physico-chemical properties of some tea soils of Bangladesh

Mineralogical studies of Bangladesh tea soil have shown that it consists of kaolinite, quartz, hematite, goethite and gibbsite types minerals. These have low cation exchange capacity as well as low nutrient releasing capacity and show strong phosphate fixing capacity. Besides, tea soils of Bangladesh contain over 85% aluminium in the exchangeable sites (Ahsan, 1984) and its high concentration is known to interfere in the uptake of essential nutrients, such as Ca, P, Mg and Fe and produce some deficiency symptoms and aluminium toxicity. With such high aluminium content phosphate in the form of fertilizer will readily be fixed unless lime is used (Ahsan, 1994). In tea soils of Bangladesh, an overall content of nitrogen and organic matter varies from 0.07 to 0.09 percent and 1.0 to 1.2 percent respectively. The critical values in Bangladesh condition have been fixed at 0.1% for nitrogen and 1% for organic matter (Alam, 1999). The amount of available phosphorus, magnesium and base-saturation is low. The minimum level (critical limit) of nutrient status of tea soil should be 10µg/g for P, 80 µg/g for K, 25 µg/g for Mg and 90 µg/g for Ca. The C-N ratio needs to be 10 (Alam, 1999). It is observed that there is a low content of nitrogen and organic matter in tea soils of North Sylhet and Chittagong which might be due to leaching and surface run-off during monsoon. On the contrary, the low flat area of Luskerpore circle, part of Balisera and Monu-Doloi circles are subjected to impeded drainage and consequently reduce the proper utilization of nitrogen there. Texturally, the tea soils in Bangladesh are predominantly loamy. Soils of Balisera, Monu-Doloi and Luskerpore circles are loamy to sandy loam from surface downwards, while loamy sand to loam in North Sylhet circle, but soils in Chittagong zone are mostly loamy (Table 3). The most suitable tea soil is thought to be light, friable and well drained having soil pH from 4.5 to 5.8 (Sana, 1989).

Table 3. Physical and chemical composition of tea soils in Bangladesh

Area	Texture in depth (cm)		pH	Available (%)	
	0-23	46-92		Phosphorus	Potash
North Sylhet	LS-L	LS-L	4.7-5.5	0.0012-0.0058	0.0040-0.0135
Juri	L-CL	CL-L	4.3-5.8	0.0017-0.0054	0.0072-0.0263
Lungla	L-CL	CL-SL	4.0-5.6	0.0016-0.0050	0.0041-0.0291
Monu-Doloi	L-SL	CL-L	4.2-5.7	0.0020-0.0049	0.0030-0.0159
Balisera	L-SL	L-CL	4.0-5.7	0.0016-0.0047	0.0034-0.0402
Luskerpore	L-SL	CL-SL	4.3-5.7	0.0015-0.0043	0.0018-0.0159
Chittagong Zone	CL-SL	CL-SL	4.3-5.2	0.005-0.0020	0.0100-0.0310

L=Loam, LS=Loamy Sand, SL=Sandy Loam, CL=Clayey Loam, (Source: Sana, 1989)

Present nutrient status of some tea soils of Bangladesh

Recently some tea soils from Balisera circle, Juri circle, Lungla circle, Luskerpore circle, Monu-Doloi circle, North-Sylhet circle and Panchagarh (Northern part of Bangladesh) area were collected and analysed. Table 4 shows the nutrient status of some tea soils of different tea estates of the valley circles. In Balisera circle, the texture of the collected soil samples varies from sandy loam to sandy clay loam. Highest soil pH (4.8) was found in the soils of Rashidpur T.E and lowest soil pH (4.3) was recorded in the soils of Bidyabhell T.E & Sathgao tea estates. Organic matter content of the soils of Udnacherra T.E and Sathgao T.E was lower than the critical level (1%). In case of Bidyabhell T.E, the content of organic matter (2.15%), total nitrogen (0.14%), available P (150.27 ppm) and K (110.26 ppm) were found highest. However, soils of Amtali T.E contain highest (197.125 ppm) amount of Ca, Mg content was highest in Rashidpur (34.2 ppm) & lowest in the soils of Udnacherra T.E (14.23 ppm).

Table 4. Nutrient status of some tea soils of different valley circles

Name of the T.E	Depth (cm)	Texture	pH	%OC	%OM	Total N (%)	Av. P (ppm)	Av. K (ppm)	Av. Ca (ppm)	Av. Mg (ppm)
Balisera circle										
Hamidia	0-23	SL	4.7	1.07	1.84	0.12	5.42	24.20	228.2	33.87
Udnacherra	0-23	SCL	4.4	0.88	1.51	0.092	19.12	57.26	102.03	14.23
Bidyabhell	0-23	SL	4.3	1.25	2.15	0.14	150.27	110.26	167.54	22.2
Sathgao	0-23	SL	4.3	0.66	1.14	0.068	14.21	47.81	97.2	15.6
Rashidpur	0-23	SCL	4.8	1.13	1.94	0.12	123.32	93.05	157.5	34.2
Amtali	0-23	SCL	4.4	1.10	1.89	0.12	3.94	44.88	197.125	33.15
Juri circle										
Clevedon	0-23	SCL	5.0	1.58	2.72	0.17	72.33	65.13	1841.2	63.2
Silloah	0-23	SL	4.6	0.80	1.38	0.082	4.71	15.62	69.8	7.2
Lungla circle										
Etah	0-23	SL	4.3	0.63	1.08	0.065	2.73	26.01	93.4	15.2
Lungla	0-23	L	4.5	1.19	1.90	0.13	0.31	14.30	66	5.0
Chandbagh	0-23	SL	4.4	0.83	1.34	0.089	13.74	35.58	101.4	19.2
Luskerpore circle										
Amo	0-23	SL	4.4	0.63	1.08	0.055	10.95	35.68	138.87	37.07
Chandpore	0-23	SCL	4.6	0.93	1.60	0.101	6.20	21.36	83.38	9.78
Luskerpore	0-23	SL	4.5	0.92	1.58	0.105	2.02	26.10	88.33	21
Monu-Doloi circle										
Srigobindapur	0-23	SL	4.2	0.90	1.55	0.095	65.46	53.50	145.86	44.36
Madabpore	0-23	SL	4.5	0.61	1.05	0.063	3.92	13.39	52.4	6.4
Shumsernugger	0-23	SCL	4.1	0.72	1.24	0.074	3.40	122	116	14
North-Sylhet circle										
Khan	0-23	SL	4.6	0.90	1.55	0.092	5.38	54.52	133.6	19.2
Habibnagar	0-23	SL	4.6	0.69	1.19	0.072	18.98	53.87	108.31	14.73
Panchagarh region										
Jobber Chairman Tea Holding	0-23	CL	4.7	1.54	2.65	0.14	153.76	344.98	76.6	11.4
Moinaguri	0-23	S	4.8	1.35	2.32	0.12	127.50	47.80	65	10
Moli T.E	0-23	SCL	4.7	1.56	2.68	0.16	49.60	50.71	46.4	9.2
A. Halim	0-23	CL	4.8	1.41	2.42	0.15	45.19	90.77	91.2	15.6

Soil samples from two tea estates of Juri valley circle were collected and analysed. Among these, soils of Clevedon T.E were sandy clay loam in nature while soils of Silloah T.E were sandy loam. Soil pH and organic matter of both the tea estates were above the critical level. Available P content was higher than the critical level in case of Clevedon T.E but in Silloah T.E it was below the critical limit. In case of both tea estate K content is below the critical value. But the soils of Clevedon T.E were very rich in calcium and magnesium while calcium and magnesium status of soils of Silloah T.E were below the critical level.

Etah and Chandbagh tea estates in Lungla circle were sandy loam in nature and pH was less than critical limit but soils of Lungla were loam in nature and pH was within the critical value. Organic matter content of the tea estates were above the critical limit but only the soils of Lungla contain more than 0.1% nitrogen. Soils of Chandbagh T.E contain P which was above the critical limit but soils of Etah T.E and Lungla T.E contain lower P than the critical level. The analyzed soil samples of those three tea estates contain lesser K & Mg than the critical limit. But soils of Etah T.E & Chandbagh T.E contain greater Ca & soils of Lungla T.E contain lesser Ca than the critical level.

Soil texture of the Luskerpore circle ranges from sandy loam to sandy clay loam. pH, total N and available K content of the soils of Amo tea estate were below the critical limit. Organic matter, pH and total N content of Chandpore and Luskerpore soils were within the critical range but available P, K, Ca and Mg were below the critical limit.

Texture of some soils of selected tea gardens of the Monu-Doloi circle ranges from sandy loam to sandy clay loam. Soil pH, total N and available K of Srigobindapur were below the critical limits but organic matter, available P, Ca and Mg were above the critical limits. Organic matter and pH of soils of Madabpore tea estate were within the critical limit but total N, available P, K, Ca and Mg content were below the critical limit. pH, total N and Mg content were below the critical limit in the soils of Shumshernugger T.E.

In North-Sylhet circle pH, organic matter and available Ca content of the soils of khan tea estate were above the critical limit but total N, available P, K & Mg were below the critical limits (Table 4). In the case of Habibnagar tea estate, soil pH, organic matter, available P & Ca were above the critical limits but total N, available K and Mg were below the critical limits.

The nutrient status of some selected tea soils of Panchagarh region of Bangladesh also determined where recently tea cultivation has started. Texture of soil samples were clay loam, sand, sandy clay loam in nature. pH & the content of organic matter, total N, available P were above the critical limits in all the soil samples. Available K content were higher in the soils of Jobber chairman tea holding and A.Halim tea estate but in the soils of Moinaguri and Moli tea estates K content were less than the critical limit. Available Ca content was higher than the critical limit in the soils of A. Halim T.E. All soils contain less Mg.

From the above discussion it is clear that there are some important variations between the soil properties of south India and Bangladesh. These variations occurred due to the geological & geographical difference between these countries. Tea soils in south India are classified as latosols while in Bangladesh it is red yellow podzolic and reddish brown lateritic. Latosols are sesquioxide-rich, highly weathered soils while red-yellow podzolic and reddish brown lateritic soils with a clay B horizon and <35% base saturation. Tea soils of south India varies from sandy clay loam to clayey texture in nature while tea soils of Bangladesh are predominantly loamy. Organic matter content of South India varies from 1 to 8% while in Bangladesh it ranges from 1.0-2.0%. These variations of organic matter may be due to the elevation. Highest altitude of the tea grown area of Bangladesh is 35 meter while in south India it varies from 450 meter to 2500 meter. In low elevated area temperature is higher and the mineralization rate is more, that's why organic matter degraded rapidly while in high elevation like south India, the temperature is quite lower than Bangladesh. As a result, depletion rate of organic matter is slow. That's the main reason of the high content of organic matter in tea soils of south India. Another important reason of the higher organic matter content in south Indian soils is burial of pruning litters.

From the comparative study on the physico-chemical properties of tea soils of south India and Bangladesh it can be concluded that the organic matter content of the south Indian tea soils are much more better than the Bangladesh tea soil and it is due to the elevation and also some extent for organic matter management process. Organic matter is very important part of the soil which influence the physical as well as the chemical properties of the tea soil. In tea field pruning litters is the main source of organic matter which should be maintained properly. As like south India incorporation of pruned litters will be a great measure to maintain the organic matter status in the tea soils of Bangladesh. In order to increase the productivity of the land and quality of tea, attention is to be grown to avail the full potential of the land and to maintain soil productivity by innovating a fertilizer policy. At the same time, it is also necessary to amend the soil reaction by liming for the best utilization of plant nutrients. Old tea soils also need to be replenished under rehabilitation programs especially by growing green manuring crops. Regular monitoring of nutrient status and the integrated fertilizer management of tea soils is essential for increasing soil productivity and improving tea quality for meeting domestic consumption and earning foreign exchange.

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Short Communication

COMPARATIVE EFFECT OF CONTINUOUS BED FERMENTER AND STACKED TRAY FERMENTER ON THE QUALITY OF TEA

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Abstract

Fermentation, an important step in black tea manufacture had since long been carried out on floor which requires large area. Subsequently in fermentation process, Stacked Tray Fermenter (STF) and Continuous Bed Fermenter (CBF) where introduced. Comparative study of tea manufactured by using STF and CBF revealed that the differences in liquor characteristics and infusion of tea were insignificant but in case of leaf appearance the difference was highly significant. Higher percentage of bolder grades and heavier tea was obtained with STF.

Keywords: Fermentation, Fermenter, CBF, STF, Bolder Grade

Introduction

Fermentation represents a series of complex chemical reactions which begin at the moment the leaf is broken in the roller (Sivapalan *et al.*, 1986). The most important reaction being oxidation of polyphenols. The air is derived from the surrounding atmosphere and the exothermic reactions that occur tend to heat up the leaf. Steps must be taken to control the rise of temperature; otherwise the quality of the product may suffer due to unwanted chemical reactions (Willson and Clifford, 1992).

Fermentation process is still being carried out by laying the cut out leaf on the floor in thin layers (Roberts, 1941). Although large area is required, the advantage of the floor is that it acts as natural sink and helps in dissipating the heat of reaction. In order to reduce the space requirement, trays are stacked one over the other with air gaps in between and wheels in bottom tray to facilitate movement (Werkhoven, 1988). The thickness of leaf spread is about half that of floor.

Subsequently, development in the fermentation process which centered around space saving devices led to the Sirocco type continuous fermenter with perforated moving bed was an improvement though it had shortcomings regarding uniform air supply and hygiene. The original concept of floor fermenting was later developed into a moving bed type continuous belt fermenter (CBF).

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A deep bed of cut leaf spread on a non-perforated rubber belt which moves in 4 or 5 circuits. Periodic replenishment of air occurs at the end of each circuit where high speed aerators are used. The purpose of this study was to compare the liquor characteristics, infusion, leaf appearance, grade percentage and bulk density of tea manufactured by using STF and CBF in the fermentation stage.

Materials and Methods

STF and CBF were used to manufacture CTC tea at the Bangladesh Tea Research Institute Experimental Factory over a span of five seasons (1993 - 1997) on thirteen different days. Two separate batches of tea were manufactured with each method on the same day to avoid differences in leaf and other conditions. The leaf quality during the course of the experiment varied from 48% to 65% soft leaf. The percentage of moisture in withered leaf varied from 66% to 70%. The period of manufacture for each batch varied from 40 to 115 minutes. Fermentation period varied from 60 to 65 minutes, but it was the same for the two methods on a particular day. The teas were sorted and their grade percentages determined. The bulk density of each grade was determined by the cylinder method i. e. measuring volume of 100gm tea. Samples of BOP and OF grades were securely packed in aluminium foil and stored in a desicator. Organoleptic assessment of the samples were done at the Institute and by two professional Tasters at Chittagong on two different occasion. Each sample was coded and presented to a Taster three times on each occasion. The scoring was done on a scale of 1-9. The average of the total combined scores for colour, briskness and strength was treated as score for liquor characteristics. The Tasters' combined scores for infusion and leaf appearance were done.

Results and Discussion

Tasters' combined mean scores on liquor characteristics of infusion tea and leaf appearance are presented in tables 1, 2 & 3 respectively. In respect of the leaf appearance the method STF was significantly superior of CBF. The other attributes showed no significant difference in respect of grades and methods of fermentation.

Table 1. Tasters means combined score on liquor characteristics for CTC tea with CBF & STF and grades

Method of Fermentation	Grade		Method Mean*
	BOP	OF	
CBF	38.33	40.25	39.29
STF	38.69	39.26	38.98
Grade Mean*	38.51	39.26	

** Method and grade mean difference are in highly significant*

Table 2. Tasters mean combined score on infusion for CTC tea with CBF & STF and grades

Method of Fermentation	Grade		Method Mean*
	BOP	OF	
CBF	14.14	14.58	14.36
STF	14.68	14.31	14.50
Grade Mean*	14.41	14.45	

** Method and grade mean difference are in highly significant*

Table 3. Tasters mean combined score on leaf appearance for CTC tea with CBF & STF and grades

Method of Fermentation	Grade		Method Mean*
	BOP	OF	
CBF	16.06	15.35	15.70
STF	16.60	16.44	16.52
Grade Mean*	16.33	15.90	

**Method mean difference is significant at 1% level*

The percentage of broken was a little higher with the STF. The Fannings and Dust percentages were higher with CBF. Percentage of oversized tea was higher with STF (Table 4).

Table 4. Average grade percentages of CTC tea using CBF & STF

Grade		Grade percentage			
		CBF		STF	
Oversize		8.04		13.60	
Broken Grades	FP	4.87	54.40	6.64	55.73
	FBOP	27.84		30.43	
	BOP	21.69		18.66	
Fannings Grades	OF	17.95	27.49	14.85	22.05
	FOF	9.54		7.20	
Dust Grades	PD	4.50	8.13	3.77	6.58
	RD	2.31		1.75	
	CD	1.32		1.06	
Waste		1.94		2.04	

** Grade mean difference is lightly insignificant*

The density of all grades of tea was higher when the STF was used irrespective of leaf quality and withering conditions (Table 5).

Table 5. The Density of different grades

Grade	Bulk Density* (cc)	
	CBF	STF
FP	291	283
FBOP	276	268
BOP	266	256
OF	254	243
FOF	246	233
PD	237	220
RD	223	211
CD	204	196

** Bulk Density = Volume (cc) per 100g tea (Lower figure indicates heavier tea)*

The reason for higher percentage of bolder tea and higher density from STF method may be due to the high speed aerators and falling of the leaf from one belt to the other at the end of each belt run of the CBF which break the bolder pieces and also open the grains making the tea lighter.

Conclusion

Both the method of fermentation gave tea of similar liquor characteristics and infusion. But the leaf appearance with the STF method was superior to that of CBF. There was no difference between the grades for all the attributes. Higher percentage of oversized and broken grades and heavier tea were obtained with STF.

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