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Effects of Microclimatic Parameters on Tea Leaf Production in Different Tea Estates in Bangladesh

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Abstract: Tea industry of Bangladesh is one of the most important foreign exchange earner and source of income. Sylhet, the northeastern divisional city of Bangladesh, is the major tea-producing region of the country. For this reason the study area was selected purposively in Sylhet district to assess the pattern and causes of fluctuation on tea leaf production in selected tea estates and the impact of micro-climatie change on the productivity of tea leaf. The yield of tea is greatly influenced by microclimatic parameter of a region especially rainfall, temperature. Scanty rainfall causes irreparable losses because irrigation is seldom used on tea plantations. On the other hand, heavy rains erode top soil and wash away fertilizers and other chemical. An analysis of the results of field experiments with weather data showed that increase highest tea leaf production per hectare lies on 4000mm to 4600mm rainfall. Heavy or scanty or delayed rainfall adversely affected the growth and yield of tea. It is observed that tea leaf production was slightly increased with increase in total annual rainfall. The temperature and humidity had no direct effect on tea leaf production. It may largely depend on soil quality and solar radiation. Loobacherra tea estate produced high amount (1838.70 kg) of tea leaf per unit area, on the other hand, Lackatoorah tea estate produced lowest amount (682.31 kg) of tea leaf. Further study is needed to identify the cause of variation of tea leaf production in different tea estate. Awareness should be rise on micro-climate change amongst the farmer, estates and worker groups for the maximum production of tea leaf.

Key words: Tea production · Microclimate · Rainfall · Temperature · Humidity

INTRODUCTION

Tea (*Camellia sinensis* L.) is a unique crop relative to any others typical crop due to its cultivation and harvesting system. It is a type of crop which shows wide adaptability and grows in a range of climates and soils in various parts of the world [1]. Tea is grown at altitudes of up to 2700 meters in Kenya and Rwanda [2]. Yields of tea decline with increasing altitude due to slower growth of the plants. It has been estimated that in Kenya there is a reduction in yield of 1 kg ha^{-1} of made tea for every 100m increase in altitude [3]. The slower growth of tea plants at higher altitudes leads to improved quality, as exemplified by Darjeeling tea. However, there are large differences between tea varieties in the manner in which they respond to changing environmental conditions, including differences in altitude [2].

Tea plant is perennial, evergreen shrub under Theaceae family and its tender leaves and bud are plucked for processing the black and green tea. It is the oldest non alcoholic caffeine containing beverage in the world [4]. The Chinese were the first to use tea as medicinal drink, later as beverage and have been doing so for the past 3000 years [5]. The art of tea cultivation in Bangladesh began over a century and a half ago in the 1840s near the Chittagong Club and first tea garden for commercial purpose was established at Malnicherra in Sylhet in 1854 [6]. Its commercial production began shortly thereafter in 1857 and this same year Bangladesh Tea Board was established in Dhaka and Bangladesh Tea Research Institute (BTRI) was founded in Srimangal [7]. The tea cultivation in Bangladesh has been expanding since then. At present there are 163 tea gardens in the country [8]. In Bangladesh, tea grows well at only 80300 ft. above from

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sea level mainly in the hilly regions northeast of Sylhet (Sylhet, Moulvibazar and Habibgonj districts) and southeast of Chittagong [9]. But few tea gardens also present in Brahmanbaria and Panchagar districts. From total annual production, 94% comes from Sylhet (63% Moulvibazar district) from and rest from others part of the country [8]. It is noted that Sterling companies produce about 50% of annual crop from about 42% of plantation area [10]. Bangladesh is the world's 10th-largest tea producer and fifteen number exporters and sixteen number consumers in the world [8]. Taking tea is an integral part of social life in Bangladesh. The consumption is increasing day by day mainly due to the rapid increase in population. The tea producing industry has been traditionally regarded as one of the major agro-based labor intensive industry and occupies an important role in the national economy of Bangladesh. The role of Bangladesh tea industry in global context is insignificant. It is only 1.68% of the global tea production and 0.58% of the world tea export [8]. It seems that its export is gradually declining. If this trend continues, Bangladesh will turn into a tea importing country by 2015 [9, 11].

Tea plants are highly susceptible to drought and will not thrive well when moisture is limiting. The seasonal monsoons, of course, also greatly affect the quality of tea [12]. Although there are a growing number of countries that produce teas in a multiplicity of blends, there are essentially three main types of Camellia tea, which are Green, 'Oolong' and Black. The difference lies in the 'fermentation', which actually refers to oxidative and enzymatic changes within the tea leaves, during processing. Green tea is essentially unfermented, Oolong tea is partially fermented and Black tea is fully fermented. Black tea, which represents the majority of international trade, yields an amber coloured, full-flavour liquid without bitterness [12]. In addition to these conventional teas, many countries of Asia have a number of herbal teas, made from brewing plant leaves, or other plant parts including flowers. For example, *Gymnema sylvestre,* a member of the botanical family Asclepiadaceae, found mainly in India, has been used as a healthy and nutritive herbal tea which claims to have a number of medicinal properties. Numerous other herbal teas are gaining more popularity recently [12, 13].

Tea is the most important agriculture crop which plays a great role to earn foreign money. The growth of plants is controlled by the availability of photosynthesized carbohydrates. Since both rainfall and sunshine are needed for photosynthesis an empirical expression is proposed which relates vegetative growth to the product of rainfall and bright sunshine hours over a specified period. Tea is a crop in which the yield is entirely vegetative and harvested throughout the year. Being a rain fed plantation crop in Sylhet, tea depends greatly on weather for optimal growth. Therefore, changes in weather conditions would undoubtedly affect tea production [14].

Climatic factors, which include rainfall, temperature, humidity, intensity and duration of light etc., determine the success of crop production of a region. Of these, perhaps rainfall and temperature play the most important role in the development and growth of plants and ultimately yield per unit area.Tea production in Bangladesh will be decreased about 25% in early future due to drought-like situation [9]. However, inadequate rainfall in the Sylhet region, the country's major tea producing area, has hampered fertilization in most of the tea gardens. Consequently, unusual fluctuation in temperature is the main reasons for the fall in production. This season has experienced at least 50% less rainfall over the corresponding period of the last season, added the manager. To achieve the target of tea leaf production, each tea garden needs 200-300 mm of rainfall. If the drought-like situation will remain production could fall 15-25%. For this rationale the study was conducted to assess the present pattern of tea production and how microclimate (rainfall, temperature and humidity) impact on the productivity of tea leaf.

MATERIALS AND METHODS

Study Area: Sylhet district (small unit of division) is one of the major tea producing areas in Bangladesh which lies in the delta of the Surma river. Geographically Sylhet district is situated between 23°59′ and 25°13′ North latitude and 90°54′ and 92°29′50′′ East longitude whereas the Burjan, Lackatoorah, Malnichera and Loobacherra tea estates are in the north-eastern part of this district was selected for study area (Fig: 1). Beside scenic tea plantations, Sylhet district is most significant area for lush green tropical forest, natural waterfall, green hillock etc. This beautiful scenery always attract national and international tourist to visit Sylhet district.

Methods of Data Collection and Analysis: North-eastern region of Sylhet district is the major tea leaves producing zones along with other agricultural crops due to its climatic condition and geographic position. Therefore, this area was selected purposively to conduct this study. An exploratory survey on Burjan, Lackatoorah,

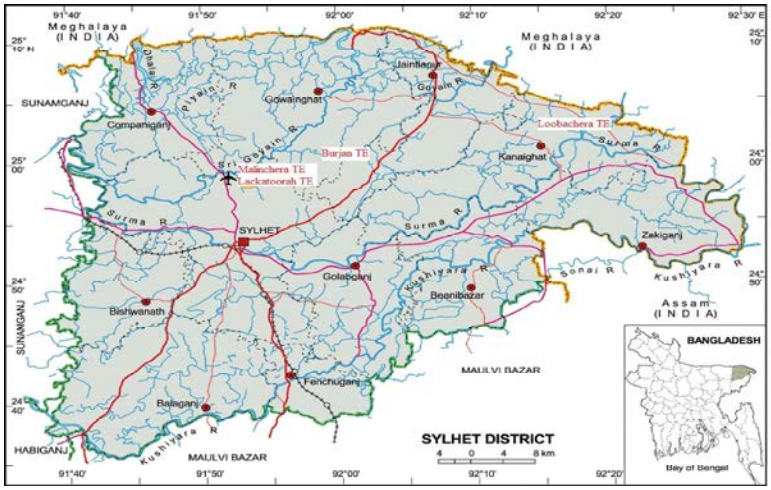

Fig. 1: Location of the selected tea estate of Sylhet district (source: Map of Bangladesh, [15]).

Malnichera and Loobacherra tea gardens were done to collect information on the fluctuation pattern of tea leaf production and changing impacts of microclimatic parameters (rainfall, temperature and humidity) on tea leaf yield. The climatic data of Sylhet district was collected from the Bangladesh Meteorological Department (BMD) and tea production, rainfall data were collected from the selected tea estates and plantation and other time series data was explored from the web site of Bangladesh tea board, the different statistical year book of Bangladesh, BBS. The published data of Lackatoorah, Burjan, Loobacherra and Malinichara tea estates were collected from their administrative office and from the Banglapedia. This study was carried out over a period of six month ranging from January 2012 to June 2012. The data was analyzed graphically by using MS Excel.

RESULTS AND DISCUSSION

Pattern of Tea Leaf Production in Selected Tea Estates: Production and quality of tea leaf in the selected four tea estates was different. The maximum average (for one year) tea leaf production was found in Loobacherra tea estate (1835.7013 kg/ha) and lowest was found in Lakkatoora (682.30811 kg/ha). Production of others two estates Burjan and malnichara was 877.8412 kg/ha and 1367.3418 kg/ha respectively (Fig: 2). This variation may be due to the soil property and management potentiality of these tea estates. In favor of the maintenance of good quality tea it is required to collect one bud and two leaves [16] but in the field observation it is noticed that, in Loobacherra tea estate collected more than two leaves and a bud. Thus the quantity may increase but the quality of tea may hamper.

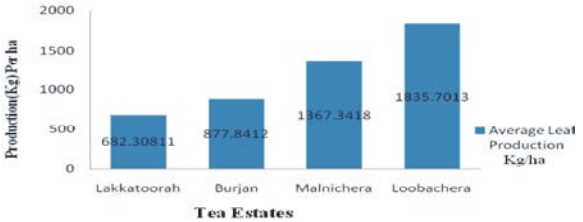

Fig. 2: Tea leaf production per hectare in selected four tea estates

Effects of Microclimatic Parameter on Tea Leaf Production: Microclimate has large impact on tea leaf production. The seasonal monsoon also greatly affects the tea leaf production [12]. In the selected tea estates there was significant relationship with microclimates and tea leaf production.

Effect of Rainfall on Tea Leaf Production: Rainfall was positively related with tea leaf production in Lackatoorah and Burjan tea estate. In the previous 10 years, the minimum rainfall was recorded 3132.24 mm whereas the maximum rainfall was recorded 5523.76 mm for Lackatoorah tea estate (Fig: 3. a). However, in the last 10 years the minimum rainfall was recorded as 3070.22 mm for Burjan tea estate while the maximum rainfall was recorded as 5050.95 mm (Fig: 3. b). The tea leaf production and rainfall in Loobacherra tea estate was moderately correlated and had positive influence on each other. In the past 10 years, the minimum rainfall in Loobacherra tea estate was 3314.54 mm where the maximum rainfall was 5398.77mm. In this tea estate the per unit area production was highest among the four tea estate. The soil property and other extraneous factor played positive role for tea

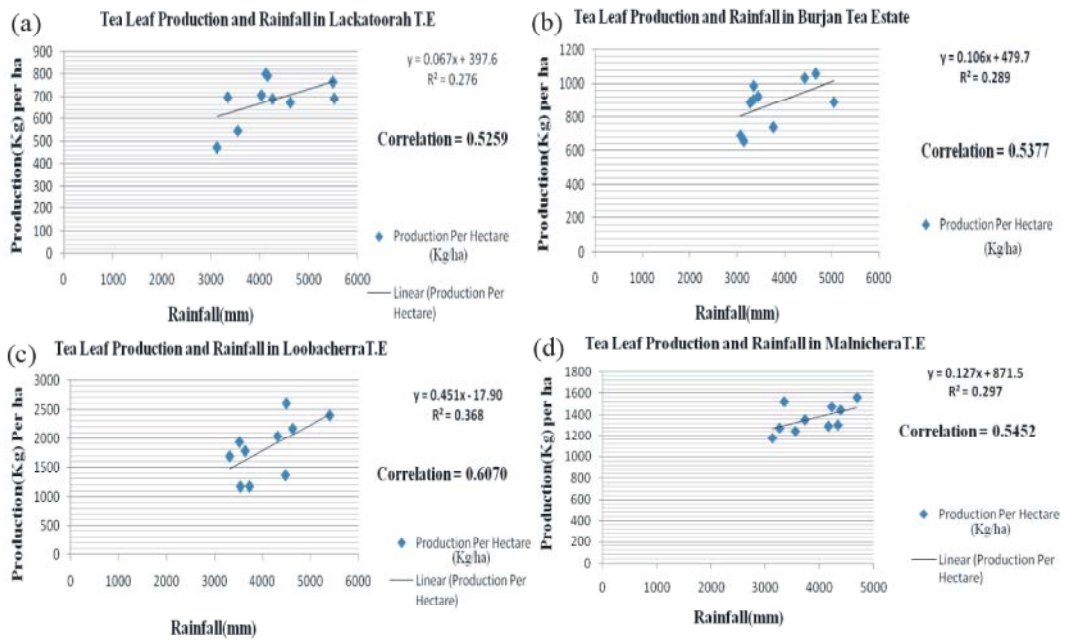

Fig. 3: Relationship between tea leaf production and rainfall in different tea estates

leaf production. On the other hand for good quality tea one bud and two leaves are generally collected, but in the field observation it found that more than two leaves including buds were collected from this tea estate. Malnichera is the oldest tea estate in Bangladesh where there was less fluctuation of tea production per unit area. In Malnichera tea estate the rainfall was positively related with tea leaf production. In last 10 years the minimum rainfall was recorded as 3132.87mm whereas the maximum rainfall was recorded as 4692.88 mm (Fig: 3. d). Tea leaf production was slightly increasing with increasing rainfall. The production was fluctuating in the same range of rainfall. It might be potential of the management and other extraneous factors like intensity of sunlight, distribution of yearly rainfall etc. The maximum tea leaf production per hectare of the Lackatoorah tea estate was 791.82 kg which lies in the rainfall 4163.21 mm (Fig: 3. a) and for the Burjan tea estate it was 1059.91 kg with maintaining rainfall 4666.13 mm (Fig: 3. b). The maximum tea leaf production of other two tea estates namely Loobacherra and Malnichera was 2605.61kg/ha and 1563.32 kg/ha with maintaining rinfall 4495.22mm and 4692.88 mm respectively (Fig: 3. c and d).

The effect of rainfall is manifested more by its influences on moisture status of the soil and in inducing vegetative growth. Therefore distribution of rainfall is as important as the total annual rainfall. The water requirement of tea varies according to the prevailing environmental conditions. It is assumed that tea on an average may transplant 900 mm per annum [17] concluded that the optimal annual rainfall requirement is 2500 to 3000 mm with a minimum 1200 mm for tea crop [18]. Mahlman's final category ("probable projections," which have a greater than two thirds chance of occurring) included the forecast that there would be decreases in soil moisture because of increased temperatures, although this could be offset by simultaneously increased precipitation. In the selected four tea estates the mean annual rainfall was positively related with per unit area tea leaf production. The maximum production was between rainfalls range 4000 to 4600mm. In Sri Lanka certain areas receive as much as 5100 mm of rain yet tea does well [19]. As regards the lower range it is thought that rainfall of less than 1300 mm per annum has a detrimental effect upon tea growth [20].

Effect of Temperature on Tea Leaf Production: Temperature is most important microclimatic parameter for the production of tea leaf. Temperature did not show any significant relationship with tea leaf production of the selected four tea estates (Lackatoorah, Burjan, Loobacherra and Malnichera) (Fig: 4. a, b, c, d).

The photosynthetic rate of tea is at maximum between 30°C and 35°C, falls rapidly between 37°C and 39°C and at 42°C there is virtually no net photosynthesis [21]. So elevated CO_2 (temperature increase) would result in increased photosynthesis and water use efficiency. This would lead to yield increases in most crops in most production conditions [20]. Tea being a perennial crop

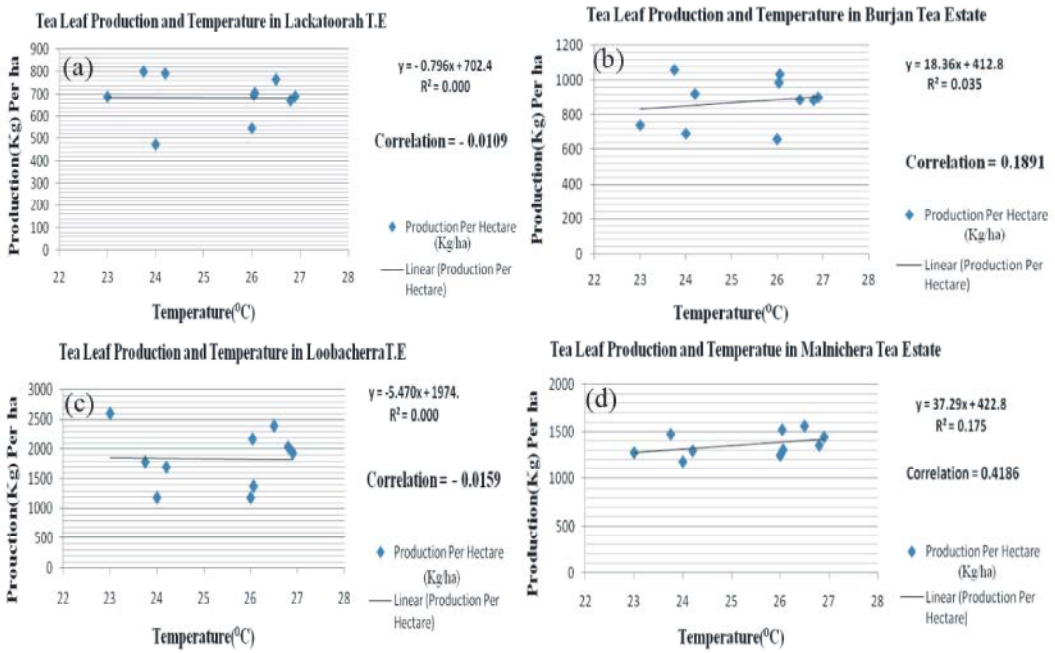

Fig. 4: Relationship between tea leaf production and temperature in different tea estates

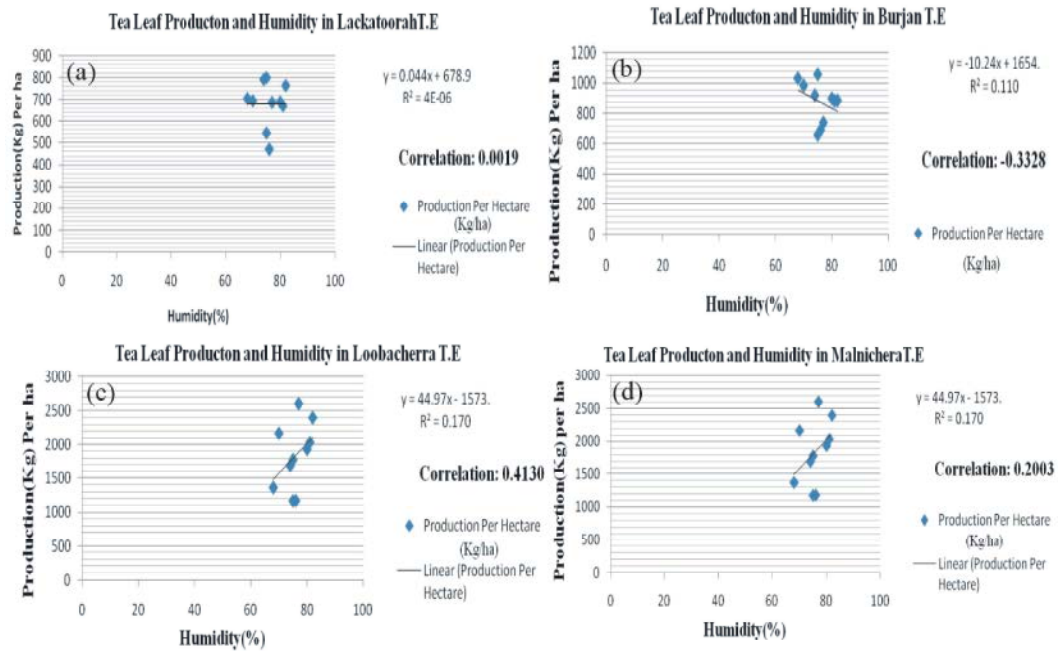

Fig. 5: Relationship between tea leaf production and humidity in different tea estates

has wide range of tolerance as it grows between sea level and altitudes of over 2000m and as much as 30°C or even more and south of equator but the monsoon areas of south east Asia are found to be the best suited [22]. Under north-east Indian conditions an optimum of 30 to 35°C is generally considered ideal [23]. In Lackatoorah, Burjan, Loobacherra and Malnichera tea estates there was no significant relation between tea leaf production and temperature. The existing temperature is suitable for tea leaf production in these tea estates. The highest production was lies in (23-25°C. Tea leaf production did not respond in relation to temperature. It is because the amount of rainfall in different tea estates in Sylhet was high.

Effect of Humidity on Tea Leaf Production: In the selected four tea estates humidity did not show any significant relationship with tea leaf production (Fig: 5. a, b, c, d). The rate of evaporation would increase in a warmer climate, which would lead to an increase in global precipitation of 2-2.5% per 1°C warming [24]. Higher latitudes in the northern hemisphere are expected to experience above-average increases in both temperature and precipitation [25].

Humidity is increase with increase in temperature and precipitation. In the selected four tea estates in Sylhet district there was suitable rainfall and temperature. Thus the humidity was also perfect for tea leaf production. Hence it had no direct effect on tea leaf production. In the selected four tea estates it was observed that the per unit tea production in independent about mean annual humidity. If humidity increases the rate of evapotranspiration is decreases and conversely the rate of evapotranspiration is increases with decrease of humidity in the air. The average humidity in Sylhet was lies in 75.8% of last 10 years.

CONCLUSIONS

The study provides evidence that ultimate per hectare tea leaf production was slightly increasing in different tea estates of Sylhet district due to increased rainfall. Heavy or scanty or delayed rainfall adversely affects the growth and yield of tea but it had been found that tea leaf production was slightly increasing with increase in annual rainfall where the production per unit area was highest at the 4000mm to 4600mm rainfall. Temperature and humidity had no direct effect on tea leaf production in Sylhet region. This study found that, mean annual rainfall and yield per hectare is positively correlated. There were significant uncertainties in the climatic parameters. The present study suggests that if microclimate changes due to low rainfall and significant increase in temperature will be resulted in a significant loss of yield of tea leaf production. Moreover, because of the rapid change in the land use pattern through increased urbanization and other anthropogenic activities, tea production is also hampered enormously. In the selected four tea estate it was observed that tea production per unit area in Loobacherra was much higher than other tea estates. Other than rainfall, it was also due to the different management potentiality and effect of other extraneous factors like soil properties, light intensity and erosion etc.

Following recommendation is essential for the tea estates to increase tea leaf production per unit area:

- Trained personnel should be employed to manage the garden properly
- Training programme should be induced to make the existing manpower qualified
- Soil should be tasted every year and prescribed precaution should be applied
- Capacity building in climate change issues and environmental conservation
- Good tea agricultural practices and diversification
- Regulation of the application of pesticides and control pest through Integrated Pest management strategies
- Regular inspection should be made during heavy rainfall to remove the water from the root zone should be made by digging drains to a depth of 1 m

REFERENCES

1. Hamid, F.S., 2006. Yield and Quality of Tea under Varying Conditions of Soils and Nitrogen Availability. Pakistan Research Repository, Higher Education Commision Pakistan. http:// eprints.hec.gov.pk/ 2348/1/2203.htm, accessed 10 July 2012.
2. Owuor, P.O., F.N. Wachira and W.K. Ng'etich, 2010. Infl uence of region of production on relative clonal plan tea quality parameters in Kenya. Food Chemistry, 119: 1168-1174.
3. Othieno, C.O., W. Stephens and M.K.V. Carr, 1992. Yield variability at the Tea Research foundation of Kenya. Agricultural and Forest Meteorology, 61: 237-252.
4. Mondal, T.K., 2004. Plant Cell Tissue Org Cult, Netherlands, 76: 195-254.
5. Bekhit, M.Y., 2006. Levels of Essential and Non-Essential Metals in Leaves of the Tea Plant (Camellia sinensis L.) and Soils of Wushwush Farms, Ethiopia. http://etd.aau.edu.et/dspace/bitstream/123456789/307/1/Michael%20Yemane.pdf, accessed 10 July 2012.
6. Redowan, M. and A.H. Kanan, 2013. A Study on Maximization of Land Use with Associated Crops Other Than Tea and Management. Int. J. of Ecol. and Devt., 25(2): 57-70.
7. Nasir, T. and M. Shamsuddhoa, 2011. Tea production, Consumption and Exports: Bangladesh Perspective. International Journal of Education Research and Technology, 2(1): 68-73.

8. BTD (Bangladesh Tea Board), 2012. http://www. Teaboard.gov.bd/, accessed 25 June 2012.
9. BTRI (Bangladesh Tea Research Institute), 2012. Brief note on tea culture for the BTRI annual report, Shromongal, Bangladesh.
10. Islam, G.M.R., M. Iqbal, K.G. Quddus and M.Y. Ali, 2005. Present status and future needs of tea industry in Bangladesh. Proc. Pakistan Acad. Sci., 42(4): 305-314.
11. Mahmud, M., 2004. Tea in a New Brew. The Daily Star, p 1, Retrieved January 5, 2006, from http:// www.thedailystar. et/ 2004/01/05/ d4010501022.html, accessed 2 June, 2012.
12. Hicks, A., 2001. Review of Global Tea Production and the Impact on Industry of the Asian Economic Situation. AU J.T. 5(2), October. Also in: Asian Int. Tea Conf. '98, Singapore, 1-2 October 1998.
13. Chomchalow, N., 1996. Herbal Tea, an Editorial. NANMAP-17, February 1996, FAO/RAP, Bangkok, Thailand.
14. Carr, M.K.V. and W. Stephens, 1992. Climate weather and the yield of tea, in: *Tea: Cultivation to Consumption*, Willson K.C. and Clifford M.N. (eds), Chapmann and Hall, London, pp: 87-135.
15. Map of Bangladesh. 2012. Available at http://www.google.com.bd/imgres?imgurl=http://4. bp.blogspot.com/, accessed 10 June, 2012.
16. Hays, J., 2008. Tea cultivation and production. http://factsanddetails.com/world.php?itemid=1565/, accessed 16 May 2012.
17. Eden, T., 1976. The Chemistry of the tea leaf and of its manufacture, 3rd edition@ Longman Group Limited, London, pp: 153-65.
18. Waheed, A., F.S. Hamid, H. Ahmed, S. Aslam, N. Ahmed and A. Akbar, 2012. Different climatic data observation and its effect on tea crop. J. Mater. Environ. Sci., 4(2): 299-308.
19. Bhatt, V., 2012. A global study report on revitalizing Indian tea export in Russia. http:// www.gtu.ac.in/ ABP/ Final%20Reports% 20for% 20Upload/ 807% 20% 20 Russia.pdf, accessed 10 May 2012.
20. Idso, S.B., 1994. Plant response to atmospheric CO2 enrichment in the face of environmental constraints: a review of the past 10 years' research. Agric. For. Meteorol., 69: 153-203.
21. Sengupta, B., P.M. Ansar, R.S. Mahwa, H.K. Karform, S.K. Gupt and V.H. Jwala, 2007. Comprehensive Industry Documenton Tea Processing Industry. http:// www.cpcb.nic.in/ newitems/21.pdf, accessed 05 june 2012.
22. Hasan, K.A., S.H. Chaudhury and A. Halim, 1965. Effect of climate factors on the yield of tea. Tea J. Pak., 3(1): 19-26.
23. Hadfield, W., 1968. Leaf temperature, leaf dose and productivity of the tea bush. Nature, 219: 282-84.
24. Budikova, D., 2009. Role of Arctic sea ice in global atmospheric circulation: A review. Global and Planetary Change, 68: 149-163.
25. Mahlman, J.D., 1997. Uncertainties in projectionsof human-caused climate warming. Science, 278: 1416-17.