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SUITABILITY ASSESSMENT OF SOILS OF PANCHAGARH AND THAKURGAON FOR TEA (*CAMELLIA SINENSIS* L.) AND ORANGE (*CITRUS AURANTIUM* L.) CULTIVATION

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Abstract

Experiments were conducted in soils of the five Upazilas, namely Atwari, Tetulia, Boda, Ranisankail and Panchagarh Sadar of Panchagarh and Thakurgaon districts of Bangladesh to assess their potentialities for tea and orange cultivation. Geographic Information Systems (GIS) based soil suitability map was prepared depending on the hydrological, land and soil characteristics. It was observed that about 86, 76 and 50% soils in Atwari, Tetulia and Panchagarh Sadar Upazilas, respectively are suitable for tea and orange cultivation. But in Boda and Ranisankail Upazilas above 60% soils are suitable for cultivation of tea and orange. Besides, five representative soil pedons, namely Bhajanpur, Ranisankail, Pirgachha, Domar and Dimla were studied and compared with the standard suitability formats. The results revealed that soils of the Thakurgaon and Panchagarh districts under the Old Himalayan piedmont plain are suitable for tea and orange cultivation. There is a vast scope of utilizing the land and soil resources of the above sites for tea and orange farming.

Introduction

Sustainable agricultural development depends on the potential land use planning. Land and soil resources should be utilized according to their potentiality (Uddin 2000). Soil information is very vital component in this planning process, reflecting directly upon land use suitability (Coleman and Galbraith 2000). The utility of soil and land resource information for proper and pragmatic agricultural land use was proposed by Dumanski *et al*. (1987). The land evaluation system of FAO (1983) was based on land qualities as related to individual crops that was used to develop the crop requirements based on experiences in tropical areas (Sys *et al*. 1993). Soil characterization also helps in documenting soil properties at research sites, which is essential for the successful transfer of research results to other locations (Jenny 1980, Buol *et al*. 2003). The suitability analysis allows identifying the limiting factor of any crop production and enabling decision makers to develop crop management system for increasing the productivity of the land (Gahlod *et al*. 2017). The utility of land and soil resources information for proper agricultural land use was proposed by Naidu *et al*. (2006). Sahu *et al*. (2014) has developed soil suitability criteria for the major horticultural crops grown for identifying the potential areas for maximizing the production. Advanced digital technology like Geographic Information Systems (GIS) has contributed to speed up the overall planning processes as well. Application of GIS in land use planning was well documented by many authors (Maji *et al*. 2001, Gahlod *et al*. 2017).

At present, tea and orange are mainly cultivated in Sylhet and Chittagong Hill Tracts of Bangladesh. Moreover, the potential land for tea and orange in the north-western part of Bangladesh remained unexplored. The success story of growing tea and orange in Darjeeling and Shiliguri areas of India has made the argument that why it cannot be successful in the neighboring areas having more or less similar topographic nature with suitable soils. The poverty level thus can

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be minimized through cultivation of tea and orange in the vast areas of Panchagarh and Thakurgaon districts by selecting appropriate land and soil resources. An attempt was undertaken to explore the suitable land and soil resources for tea and orange cultivation in the Panchagarh and Thakurgaon districts of Bangladesh.

Materials and Methods

An intensive field study was carried out in the Upazilas of Tetulia, Atwari, Panchagarh Sadar, Boda and Ranisankail under the districts of Panchagarh and Thakurgaon (Fig. 1). During field study, semi detailed soil survey maps (Scale 1: 50,000) of Soil Resource Development Institute (SRDI) were used as a source map to identify the appropriate land and soil conditions for potential

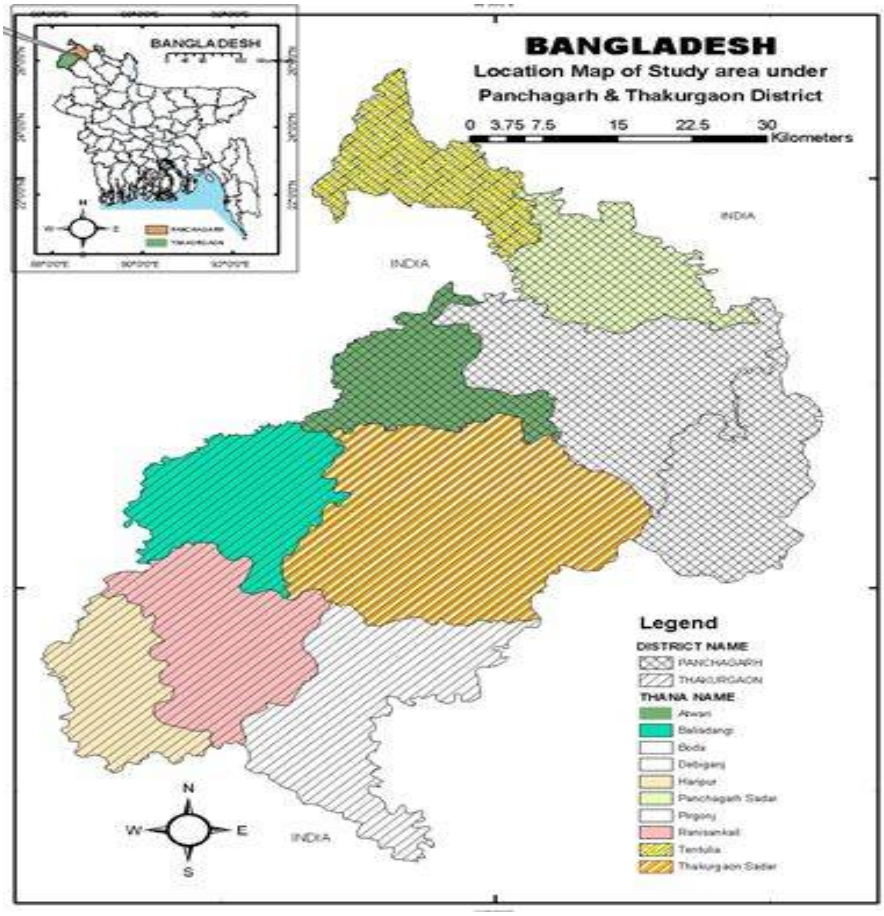

Fig. 1. Location map of the study sites.

land use for tea and orange. For each land utilization type, nine land quality parameters were considered: land type, relief, drainage, soil depth, waster recession conditions, texture, consistence, water supplying capacity and soil reaction etc. A digital database on tea and orange suitability assessment of the above areas was prepared using GIS tools (ArcGIS ver 9.1 developed by ESRI, USA). Respective polygon attribute tables of the digitized cover were calculated to

estimate the suitable areas in the study sites. On the other hand, five representative soil pedons were also selected to complete the present study. The selected 5 soil series were: Bhajanpur, Ranisankail, Pirgachha, Domar and Dimla. Field characteristics of the soil series were studied based on the morphological properties of each soil horizon following the guidelines of FAO (2006). The parametric approaches were used to evaluate land and soil resources for its suitability as per Naidu *et al.* 2006. This approach is based on the comparison of the qualities of different land units with the requirements of actual and potential land use.

Results and Discussion

Many research workers (Nel and Bennie 1984, Mongia and Bandyopadhyay 1994, De Silva 2007) reported that a well aerated soil and a sufficiently deep profile to allow tap roots to penetrate to the desired depths (1 - 2 m) are required for growing tea and orange plants. Light to medium textured soils, free from stagnant water and non-sticky, pervious layers are preferred. Areas with a high water table should be avoided. The ground water table should preferably be below 1.5 meters. The Panchagarh and Thakurgaon districts belonging to the Himalayan piedmont plain are mostly suitable for tea and orange cultivation where the appropriate properties prevail (Table 1). Considering the above land qualities Ranisankail, Pirgachha, Bhajanpur, Domar and Dimla soil series were found to be most suitable for the cultivation of tea and orange. Ranisankail soil is moderately well drained, and dark brown sandy loam soil. The soil is strongly acidic and occurs on highland condition. Pirgachha soil is moderately well drained and brown loam soil. These are strongly acidic and occur on highland condition. Bhajanpur soil is moderately well drained, and very dark brown to black sandy loam. The soil is slightly acidic and occurs on highland condition. Domar and Dimla soil is moderately well drained, and pale brown or brown sandy loam. The soil is slightly acidic and occurs on highland condition. Using ArcGIS polygon attribute tables, it was found that out of 1,30,268 hectares in Panchagarh district, Bhajanpur soil series occupy about 3,624 ha, Pirgachha soil series occupy about 16,412 ha, Ranisankail soil series occupy about 4,631 ha, Domar and Dimla soil series occupy about 2,811 ha. On the other hand, ArcGIS polygon attribute tables showed that out of 1,81,025 hectares in Thakurgaon district, Ranisankail soil series occupy about 12,195 ha, Pirgachha soil series occupy about 17,552 ha, Domar and Dimla soil series occupy about 1,318 ha. Among the two districts, Tetulia and Atwari Upazilas occupy the vast areas for the cultivation of tea and orange (Table 2). It is important to note that these two Upazilas are very adjacent to Indian border or territory where India is cultivating tea and other citrus crops. Mongia and Bandyopadhyay (1994) noted that plantation crops like tea grows well under certain conditions of climatic and soil requirements. He also stated that tea and other citrus fruit grows well in the pH range of 4.0 to 5.5, well drained conditions with good aeration, under loamy texture and deep rooting depth. Rahman *et al.* (1999) also noted that land and soil characteristics along with climatic condition satisfy the criteria for the growth of orange in the Panchagarh and Thakurgaon districts.

Naidu *et al.* (2006) reported that the optimum mean daily temperature for the growth of tea or orange is 23 to 30ºC. The growth markedly reduced above 38ºC and below 13ºC. Active root growth occurs when soil temperatures are higher than 12ºC. Strong wind is harmful to citrus plants, because flowers and young fruits fall off easily. High humidity increases the incidence of pests and diseases. An analysis of the agro-climatological data of Panchagarh and Thakurgaon regions indicates that the mean daily temperature and mean annual rainfall of this region satisfies the optimum requirements of horticultural crops (Hossain *et al.* 1999). Further analysis of temperature data reveals that the frequency of occurrence of temperature below 10ºC is only 25 - 35 days. At this temperature, the offshoot sprouting will remain dormant. Again, the frequency of

Table 1. Field characteristics of the soil pedons under the districts of Panchagarh and Thakurgaon.

Field characteristics	Soil pedons				
	Bhajanpur	Ranisankail	Pirgachha	Domar	Dimla
Color	Very dark greyish brown to light olive or pale olive	Dark yellowish brown to light olive brown	Olive brown to olive grey	Olive brown to light olive grey	Brownish grey to olive grey
Soil profile depths (cm)	0 - 120	0 - 60	0 - 69	0 - 70	0 - 71
Soil pH	Ranges from 5.5 - 6.5	Ranges from 4.8 - 5.2	Ranges from 4.6 - 5.6	Ranges from 5.1 - 6.0	Ranges from 5.7 - 6.0
Drainage	Moderately well drained	Moderately well drained	Moderately well drained	Moderately well drained	Moderately well drained
Parent material	Himalayan piedmont plain	Himalayan piedmont plain	Himalayan piedmont plain	Himalayan piedmont plain	Himalayan piedmont plain
Relief or topography	Very gently undulating piedmont ridge	Very gently undulating piedmont ridge	Nearly level piedmont ridge	Nearly level piedmont ridge	Nearly level piedmont ridge
Texture	Sandy loam to sand	Fine sandy loam to loamy sand	Loam to loamy sand	Fine sandy loam to fine sand	Sandy loam to coarse sandy loam
Structure	Sub-angular blocky to single grained	Sub-angular blocky to single grained	Sub-angular blocky to single grained	Sub-angular blocky to single grained	Sub-angular blocky to single grained
Consistence	Friable under moist condition; slightly sticky to non-plastic under wet condition	Friable under moist condition; slightly sticky to non-plastic under wet condition	Friable under moist condition; slightly sticky to non-plastic under wet condition	Very friable under moist condition; non sticky and non-plastic under wet condition.	Very friable under moist condition; non sticky and non-plastic under wet condition.
Nature of pores	Many, very fine to fine tubular pores	Many, very fine to fine tubular pores	Common very fine to fine tubular pores	Many, very fine to fine tubular pores	Many, fine to fine tubular pores
Boundary	Abrupt to wavy	Clear to abrupt smooth	Clear to abrupt smooth	Clear to abrupt smooth	Clear to abrupt smooth
USDA nomenclature	Humic Endoaquepts	Typic Dystrudepts	Aeric Endoaquepts	Typic Dystrudepts	Typic Udorthents

Table 2. Tea and orange suitable areas under the districts of Panchagarh and Thakurgaon.

Study sites	Total areas (ha)	Total cultivable areas (ha)	Highly suitable areas		Moderately suitable areas	
			Hectare	%	Hectare	%
Panchagarh Sadar Upazila	33,844	26,580	11,937	45	14,651	55
Tetulia Upazila	18,919	16,820	12,858	76	3,970	24
Atwari Upazila	21,002	20,190	17,346	86	2,844	14
Boda Upazila	28,923	26,588	15,864	60	10,724	40
Ranisankail Upazila	28,769	27,429	18,165	67	9,264	33

Table 3. Comparison of soil suitability criteria for tea cultivation in the study sites.

Soil-site characteristics		Units	Rating*		Potential values in the study sites
			Highly suitable (S1)	Moderately suitable (S2)	
Climatic regime	Mean temperature	^{0}C	18-25	26-28	23 to 30
	Total rainfall	mm	1800-2000	1600-1800	1800-2100
Moisture availability	Length of growing period	Days	> 240	240-180	210-230
Oxygen availability to roots	Soil drainage	Class	Well drained	Moderately to imperfectly drained	Moderately well drained
Rooting conditions	Effective soil depths	cm	>150	100 - 150	75 - 150
Nutrient availability	Soil pH	1 : 2.5 (soil : water)	4.5 - 5.0	5.1 - 6.0	4.8 - 5.4
	Texture	Class	scl, l, cl, sl, sil	c, sicl, sic	Sandy loam to loam

Source: Naidu *et al.* (2006)*

Table 4. Comparison of soil suitability criteria for orange cultivation in the study sites.

Soil-site characteristics		Units	*Rating		Potential values in the study sites
			Highly suitable (S1)	Moderately suitable (S2)	
Climatic regimes	Mean temperature	^{0}C	28 - 30	31-35 24-27	23 to 30
	Total rainfall	mm	1200 - 1800	1000-1200	1800 - 2100
Moisture availability	Length of growing period	Days	240 - 265	180-240	210 - 230
Oxygen availability to roots	Soil drainage	Class	Well drained	Moderately to imperfectly drained	Moderately well drained
	Depth of water table	cm	> 250	250 - 300 250 - 150	200 - 300
Rooting conditions	Effective soil depth	cm	> 150	100 - 150	75 to 150
	Presence of hard pan in sub soil	cm	> 200	200 - 150	No pan in the sub soil
	Presence of gravel in sub soil	%	Non gravelly	15 - 35	No gravel in the sub soil
Nutrient availability	Soil pH	1 : 2.5 (soil : water)	6.5 - 7.5	5.5 - 6.4 7.6 - 8.0	4.8 - 5.4
	Texture	Class	scl, l, sicl, cl, s	sc, sicl, sic	Sandy loam to loam

Source: Naidu *et al.* (2006)*

occurrence of temperature > 40^0C is only 0.5 - 10 days. An analysis of long term rainfall data and stored soil moisture to one meter depth indicates that there is a period of moisture shortage or dry period of maximum 50 - 60 days in this region (Manalo 1975). On the other hand, there is a humid or wet period when the total rainfall is continuously greater than the potential evapotranspiration of crops. During this period, excess water from the soil profile needs to be drained out timely. A Comparative study of climatic, hydrological, land and soil characteristics indicates that the study sites are most favorable for the farming of tea and orange (Tables 3-4), respectively. The above study revealed that soil and climatic characteristics of Panchagarh and Thakurgaon districts of Bangladesh are most suitable for growing tea and orange.

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