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CONVERSION OF POTATO FIELDS INTO SMALL TEA PLANTATIONS AT BHOTEPATTY, MAINAGURI: CONSEQUENCES OF THIS SHIFTING AGRICULTURE THROUGH SURVEY AND SOIL ANALYSIS

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SUMMARY

Over the past years, the tea industry in India has started to suffer from various drawbacks, i.e. issues regarding low productivity and rising input costs (namely the uneconomic age profile of tea bushes across the tea estates of North Bengal), leading to a decline in the industry and dramatic expansion of small tea growers. Accordingly, the vast expansion of small tea plantations in North Bengal prompted this study to examine the purpose and outcome of such an expansion concept. In the present study, Bhotepatty, Maynaguri (the Jalpaiguri district), was considered due to an immense conversion of agricultural land into numerous small tea plantations in the region. The study focuses on the agricultural shift from potato fields to small tea gardens. Initially, a cumulative approach encompassing the preliminary survey work and analysis of soil physicochemical characteristics was adopted to assess the adequacy of this agricultural shift. The survey conducted revealed the lack of proper land preparation, land rehabilitation before planting, sound soil nutrient management, and soil testing programs after shifting (responsible for the depletion of major nutrients such as potassium and phosphorus in the tea soil, which can be resolved with proper and timely manuring practices). Sulphur and the organic matter, organic carbon and available nitrogen of the top soil were detected in huge amounts compared to the optimum values suggested by the Tea Board of India.

Key words:
small tea growers, potato, tea, survey, soil analysis

Abbreviations:
STG - small tea grower; OC - organic carbon; EC - electrical conductivity; OM - organic matter; N - total nitrogen; P - available phosphorus; K - available potassium; S - available sulphur

INTRODUCTION

Over the past twenty years, a significant transformation in the tea industry of India has been observed with the emergence of small tea growers, establishment of bought-leaf factories, shifting from inorganic to organic methods of cultivation, foreign market competition, and struggles due to old bushes and depleted soil nutrients. Small tea growers (STGs) are becoming potential tea producers, accounting for more than 50% of the total tea production in the country. There are about 50,000 STGs in the entire North Bengal region (Sinha, 2020). According to various sources (small tea growers associations and forums), a total of 15,000 small tea growers are registered by the Tea Board of India (Sinha, 2020; https://www.teaboard.gov.in). The emergence of small tea plantations took place in the

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Terai region (previously renowned for its pineapple cultivation) during the late 1980's (Rama & Dasgupta, 1987). A number of Terai farmers converted their land into tea gardens due to the insufficient marketing of pineapples (Hannan, 2021). Small tea plantations were first established in the Chopra block of Uttar Dinajpur district, which is considered the birth place of small tea plantations in North Bengal (Hannan, 2021). Initially, STGs used to sell green leaves to set gardens, but later, bought-leaf factories came into existence to meet their needs. During the initial stage, tea growers faced transportation issues as small tea plantations emerged mainly in the commercially backward areas. The cultivation areas in Dooars, which had been predominated by major grain crops (such as paddy, wheat, maize, etc.), vegetables (such as potato, cabbage, cauliflower, brinjal, etc.), and jute, were converted into small tea plantations. According to the report by Hannan (2021), there were 20,352 small tea growers in four districts of northern West Bengal (spread across 25,708.06 hectares) in 2009. The largest number of growers is still concentrated in Uttar Dinajpur. The average farm size in North Bengal is 1.27 hectares (Hannan, 2021).

Tea bushes from the small tea gardens in Dooars are comparatively less in age than those of Terai. The quality of soil in the region is considered ideal, showing no signs of depletion. Initially, new tea estates were set up in the waste land of Dooars and forest clearings. Even this trend of setting up tea gardens in agricultural lands continued by small tea gardens without factory in plains of Jalpaiguri district and North Dinajpur district (Ahmed & Datta, 2015). The total production of tea leaves from STGs is increasing daily in comparison with that from big gardens or tea estates (https://www.teaboard.gov.in). According to the most recent reports on the estimated tea leaf production in India, published by the Tea Board of India, STGs have been identified as more potential tea growers than big tea gardens because STGs contributed about 57.26% and 58.13% of the total tea leaf production in Dooars in 2020 and 2021, respectively. Small tea growers (STGs) used to sell green tea leaves to set gardens for manufacturing before bought-leaf factories came into the scenario. The small tea sector mushroomed in North Bengal because tea was found to be relatively more economically viable than other crops, and it is expected to remain remunerative for the years to come. Paddy, vegetables and jute used to be the predominant crops in the Jalpaiguri area, whereas the pineapple and sesame used to predominate in the Darjeeling and Uttar Dinajpur areas, respectively.

Maynaguri, "the Gateway of the Dooars", was selected as the study area for this research. The economy of Maynaguri is dependent on agriculture and tea plantation. The area receives an annual rainfall of 3,440 mm, which is ideal for tea cultivation in plains. Maynaguri is flood-prone because the rivers in the area regularly change their course inflicting major damage to the vegetation and cultivated land (https://www.thehindubusinessline.com/blink/know/small-farmers-perk-up-the-dooars-tea-economy/article9722911.ece), which has been perceived as a serious threat to STGs. The vast expansion of small tea plantations in North Bengal prompted this study to examine the purpose and outcome of such expansion concept. Accordingly, the present study focuses on this agricultural shifting in the village of Bhotepatty in Maynaguri, India. A cumulative approach encompassing the preliminary survey work and analysis of soil physicochemical characteristics was adopted to assess the adequacy of the agricultural shift considered. The research will highlight the consequences of shifting from potato cultivation to small tea plantations through a survey and soil analysis conducted in Maynaguri, West Bengal, India.

MATERIAL AND METHODS

Study area

The village of Bhotepatty, Maynaguri, (26°28'40" N, 88°51'82" E; Fig. 1) is located in the Jalpaiguri district of West Bengal. The altitude of the village is 84 m, with an annual mean temperature of 24 °C (generally ranging from 10 °C in January to 40 °C in July) and a humidity of around 84%. The area is mostly flat with slight elevation. Maynaguri is about 10 km away from Jalpaiguri and 50 km away from Siliguri, two of the major commercial cities in the region.

Survey

A preliminary survey on the small tea growers in Bhotepatty, Maynaguri, was carried out as an introductory part of the present study (Fig. 1). A total of ten farmers converting a major portion of their agricultural land into tea plantations were enrolled in the study. The respondents provided data on their land type, shareholding, cultivation, seasonal cultivation costs, production and economy losses/profits, use of fertilizers and pesticides, etc.

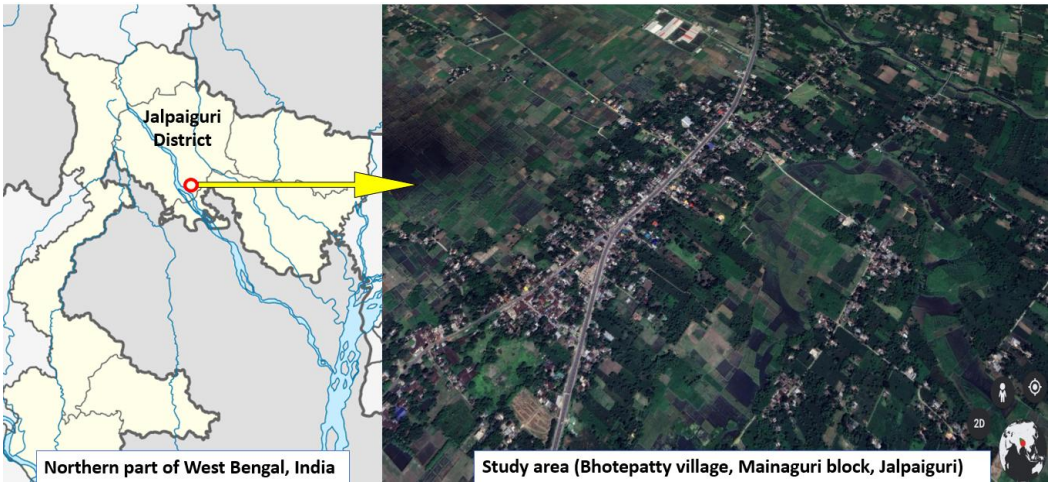


Figure 1. Location (left) and satellite view (right) of the research study area – Bhotepatty, Maynaguri (26°28'40" N, 88°51'82" E). Map source: Wikipedia (https://en.wikipedia.org/wiki/Mainaguri) and Google earth (https://earth.google.com/).

Soil sampling

In this survey, a total of forty soil samples were collected, including topsoil and subsoil samples from both selected tea and potato fields in Bhotepatty. The sampling was done at several locations from each field in a zigzag pattern to ensure homogeneity. A soil depth of up to 15 cm was considered topsoil, whereas a soil depth between 15 cm and 30 cm was regarded as subsoil. About 100 g of soil sample were collected at each site and brought to a laboratory in airtight bags for testing. The soil collection and subsequent analysis were conducted for a consecutive period of three years (2020-22), and the results obtained were expressed as mean ± SD. The samples collected were coded as T1 – T10 (for 10 tea field soil samples) and P1 – P10 (for 10 potato field soil samples), Tab. 1.

Table 1. Codes used for the tea and potato field soil samples in this study

Name of tea plantation owner	Codes for tea field soil samples	Codes for potato field soil samples
Mr. Partha Ghosh	T1	P1
Mr. Sanjay Sarkar	T2	P2
Mr. Subal Sarkar	T3	P3
Mr. Bablu Roy	T4	P4
Mr. Ramani Mohan Roy	T5	P5
Mr. Shyamal Basak	T6	P6
Mr. Ashok Ghosh	T7	P7
Mr. Satish Roy	T8	P8
Mr. Subash Saha	T9	P9
Mr. Swapan Mandal	T10	P10

Analysis of soil sample nutrients relevant to the physicochemical parameters considered

The samples collected were air dried and sieved through a 2-mm filter. For organic carbon (OC) determination, the samples were further ground and sieved through a 0.5-mm filter. The pH, electrical conductivity (EC), moisture content, organic carbon (OC), total nitrogen (N), available phosphorus (P), available potassium (K), and available sulphur (S) of the tea and potato soil samples were determined. The soil sample pH and EC were measured in water extracts (20 g soil in 100 ml double distilled water), using a pre-calibrated pH meter and EC meter, respectively (Sarkar et al., 2022; Ghosh et al., 2022). The moisture content of the soil samples was determined following the protocol of Ghosh et al. (2022). The soil sample OM (%) and OC (%) were assessed following the titration method developed by Walkley & Black (Walkley & Black, 1934). The total soil sample N (percentage) was measured by the Kjeldahl method (Kirk, 1950). The available soil phosphorus was extracted and measured using the colorimetric method with molybdenum (Bray & Kurtz, 1945). The estimation of available soil potassium was done with a flame photometer (Jackson & Smith, 1956). The available soil sulphur was established following the protocol of Williams & Steinbergs (1962). The soil sample values of available P, K and S were calculated according to the respective standard curves, and the results obtained were expressed as parts per million (ppm) (Mukherjee et al., 2020).

RESULTS AND DISCUSSION

Survey

A body of information was gathered through the survey conducted and described herein using the questionnaires attached as supplementary material. According to the survey, the predominant crops in Maynaguri are potato, tea, paddy, and maize. Nowadays, the Maynaguri farmers are experiencing economic difficulties due to an inflation which hinders the profit-making from cultivating these crops. Therefore, they are gradually shifting to growing other crops, mainly tea, aiming at long-term benefits. To grow such crops, they started borrowing money from moneylenders, which indirectly led them to financial entrapment. In the case of potato, it was found that small farmers were not offered the possibility of keeping potatoes in cold storage as these were occupied by buyers and large landholders. Consequently, they have been shifting to tea cultivation for profit purposes. A number of potato farmers have already shifted to tea plantations. Moreover, the paddy fields in the area are also being replaced by tea gardens for profit making. Although the government has denied recognizing these small gardens, the farmers continued with the shift unabashedly. As a result, the rice production has dropped in the study area, whereas the tea production has increased manifold. On average, each farmer receives around fifteen rupees for every kilogram of tea produced, thus generating higher profits than in the production of any other crop. This steady reduction in agricultural land has directly affected the production of rice and other agricultural crops. In a bid to check the strategic shift to tea cultivation in the areas considered, the agriculture department stopped issuing the no-objection certificates (NOCs) to farmers who devote an area of 10.12 ha or less to tea cultivation. Although this decision came into effect in 2001, a number of farmers have continued to cultivate tea. According to some respondents and other villagers, tea production is generating higher profits. The crop can withstand inclement weather and it is not consumed by elephants, which are considered a major threat to agriculture in this region. Accordingly, more and more farmers are switching to tea cultivation, thus changing the agricultural pattern from traditional to commercial. The conversion of agricultural lands into tea plantations has been observed in China not long ago. Recently, Yao et al. (2018) reported the conversion from paddy to tea plantations in the subtropical China due to an increasing demand of commercial markets for tea products. Their study showed that the conversion of paddy fields to tea plantations significantly alters green-house gas (CH_4 and N_2O) and NO emissions. The current trend of converting rice paddy fields into tea plantations in China has been underlined as critical by the scientists (Yao et al., 2018).

According to the survey report, the areas used by farmers for tea plantation in India were found to be mostly flatland or plains, varying from 2.5 bigha (around 1 acre) to 10 bigha (3.3 acres), with an impressive rate of production ranging 1,100–2,300 kg per plantation. None of the farmers was in bank debt. Water pipelines were usually used for irrigation. The Finish-38 and Finish-58 herbicides were mostly used for weed-control alongside cultural practices such as cheeling and mulching. To control pests, Rodhak (a herbal multipurpose pest controller), Monocil (a broad-spectrum insecticide affecting sucking, chewing and boring pests with acaricidal properties), Biodose and Fipronil (for thrips and mites) were used. Both inorganic fertilizers (such as urea, diammonium phosphate, muriate of potash, and single super phosphate) and organic fertilizers (such as Biozyme) were used for soil fertilization. Hand plucking was considered the preferred method of tea leaf harvesting to assure the quality of tea harvested. However, the respondents shared their concerns about the poor soil nutrient management after shifting to tea cultivation and lack of soil testing program required to maintain soil standards recommended by the Tea Board of India.

Analysis of soil sample nutrients according to the physicochemical parameters considered

Moisture

Soil moisture is the measure of water content present in a certain area of the ground. The optimal range of soil moisture content for crops depends on the specific plant species, ranging mostly between 20% and 60% (https://eos.com/blog/soil-moisture/). In the study area, the moisture content was found to vary from 9.56±4.71% to 24.82±3.65% in case of the tea garden soils and from 16.54±6.23% to 28.22±8.47% in case of the potato field soils. The moisture content determined was not adequate in the tea garden soils compared to the potato field soils (Tab. 2), indicating poor irrigation management by the farmers.

Soil pH and EC

The pH of the soil is a parameter used for measuring the acidity and basicity of the soil. The soil pH is a key characteristic that can be used for both quantitative and qualitative analysis of soil characteristics. In a tea plantation soil, pH should range between 4.5 and 5.5, as recommended by the Tea Board of India (http://www.tocklai.org/activities/tea-cultivation/). In case of a potato field soil, the optimum pH ranges from 5.5 to 7.5 (Smith, 1940). The pH values of the tea and potato field soils in the study area are given in Table 2. In the tea

garden soils, the pH values were found to be in the range from 3.1±0.1 to 4.7±0.3 for the topsoil, and from 3.9±0.1 to 5.4±0.3 for the subsoil, which was quite acidic and below the ideal pH range recommended by the Tea Board of India. This should be controlled by limestone application (Bordoloi, 2021). In the potato fields, 9 out of 10 topsoil samples showed an ideal pH value of 5 or more. A total of 50% of all the subsoil samples exhibited a pH value of 5 or more, which was little more acidic compared to the ideal pH value of potato plantation soil.

The results obtained suggest that the pH of the potato plantation soil was marginally low, which is an issue that needs to be resolved. However, this declining pH can be useful for tea plantation in the same field. It is reported that the presence of organic matter (the source of carbon and nitrogen) and nutrients (such as potassium, phosphate, sulphur, etc.) in the soil decreases its pH by upregulating the activities of respective microorganisms, thus increasing the organic acid content in the soil (Nyawade et al., 2019). Interestingly, the soil nutrient results obtained confirm the decreasing pH condition of the soils analyzed (Tab. 2 and Fig. 2).

Soil electrical conductivity (EC) measures the ability of soil water to carry electrical current. In agriculture, EC has been used principally as a measure of soil salinity. If EC of a soil is too low then crop will not be able to receive enough micronutrients, resulting in the discoloration of leaves (yellow or brown). Electrical conductivity, which used to quantify the charge particles present in the sample, was found to change with plant species. The electrical conductivity values of the tea and potato soil samples collected in the Bhotepatty regions are given in Table 2. The electrical conductivity of the tea garden soils ranged from 81±9 to 5877±149 µS/cm in the topsoil, and from 45±9 to 182±23 µS/cm in the subsoil.

Table 2. Values of moisture content, pH and EC of the soils collected from the tea (T1 – T10) and potato (P1 – P10) plantations

Sample code	Moisture		pH		EC	
	Top soil	Sub soil	Top soil	Sub soil	Top soil	Sub soil
T1	24.82±3.65	21.25±4.09	3.8±0.1	4.1±0.1	155±21	151±35
T2	21.2±9.3	16.45±5.12	4.3±0.1	4.1±0.3	169±45	116±75
T3	19.77±5.2	15.95±2.58	4.5±0.2	4.9±0.1	205±18	179±31
T4	21.69±7.45	20.44±9.61	4.2±0.5	4.5±0.2	81±9	45±9
T5	21.19±9.74	21.69±4.43	4.7±0.3	5.4±0.3	85±16	109±5
T6	13.63±7.9	22.77±7.69	4.5±0.1	4.9±0.7	177±32	85±41
T7	13.1±6.23	14.35±2.73	3.1±0.1	3.6±0.2	5877±149	182±23
T8	20.5±5.6	18.76±5.31	3.7±0.2	4.5±0.3	253±24	81±11
T9	12.86±6.21	22.86±3.59	4.4±0.2	5.1±0.1	5780±100	73±31
T10	9.56±4.71	21.55±4.71	3.7±0.1	3.9±0.1	187±120	126±73
P1	21.35±8.32	23.01±2.01	5.2±1.3	4.2±0.6	415±68	263±54
P2	23.44±5.57	27.57±5.2	5.3±0.5	4±0.5	560±29	371±91
P3	24.96±9.31	27.21±8.41	5.3±0.2	5.2±0.4	5280±331	146±12
P4	23.41±6.12	26.88±6.34	5.2±0.5	5.2±0.5	970±91	191±19
P5	28.22±8.47	26.57±3.05	6.7±0.3	4.8±0.6	546±121	460±48
P6	22.08±2.44	27.72±7.21	5±0.3	5.1±0.3	508±52	263±50
P7	21.2±7.52	26.45±7.06	3.5±0.4	3.3±0.6	5557±743	430±94
P8	27.11±8.5	27.27±4.5	5±0.2	4.5±0.1	4100±1134	279±95
P9	16.54±6.23	25±7.34	5.2±1.1	5.1±0.4	490±120	126±34
P10	16.79±9.11	27.07±5.6	5±0.5	5.1±0.6	5542±213	158±47
Mean (T)	17.83±6.59	19.6±4.98	4.09±0.19	4.5±0.24	1296.9±53.4	114.7±33.4
Mean (P)	22.51±7.16	26.47±5.67	5.14±0.53	4.65±0.46	2396.8±290.2	268.7±54.4

Organic carbon and organic matter

Organic carbon in the soil mainly constitutes the non-mineral matter present in the soil, including products derived from plant and animal tissues. Organic carbon and organic matter are very useful for maintaining soil fertility and health (Chan, 2008). About two percent of the organic carbon content is desirable in tea garden soil according to the Tea Board of India. Soil having organic carbon in an amount of below 1% is considered unhealthy, requiring proper maintenance (Mukherjee et al., 2020; Sarkar et al., 2022). Organic carbon levels above 3% are generally good for potato cultivation (Chander et al., 1997). The organic carbon and organic matter values of the tea and potato soil samples analyzed are shown in Table 3. The organic carbon values of tea garden topsoil samples were found to be as high as 3.97±0.24%, whereas the mean OC contents of the subsoil in the potato fields and tea gardens were 1.48 % and 0.9%, respectively. The lack of proper land preparation (ploughing and mulching) and rehabilitation before planting are responsible for this issue, which can be resolved by sound and timely manuring. The results obtained suggest that the tea garden topsoil samples are rich in organic carbon compared to those of potato fields.

Available nitrogen

Nitrogen is a vital macronutrient and an abundant element of plant cell. Nitrogen forms amino acids, the building block of proteins (Ghosh et al., 2022). The nitrogen content values of the tea and potato soil samples analyzed are shown in Table 3. The nitrogen content estimated in the tea gardens of the study area ranged 0.09±0.02–0.34±0.01 % in the topsoil, and 0.08±0.03–0.14±0.07 % in the subsoil. In this region, the nitrogen content should range 0.1–2.0%, as recommended by the Tea Board of India (https://www.teaboard.gov.in). On balance, the topsoil samples analyzed met the recommended level.

A number of leguminous shade trees such as *Albizia chinensis, Albizia odoratissima, Dalbergia sissoo, Erythina indica* etc. are probably the reason behind the high organic carbon, organic matter and nitrogen contents in the topsoil of tea fields as these shade trees fix nitrogen with the help of *Rhizobium* bacteria. Another viable reason could be fallen leaves and pods from shade trees which enhance the organic carbon and organic matter contents in the soil. However, the organic carbon and nitrogen contents in the subsoil of tea plantations were considerably low compared to those of the topsoil. The exposure to organic matter might play a major role here. Subsoil is less exposed to organic matter, which is generally decomposed by soil microbes and deposited in the topsoil.

Available phosphorus

Phosphorus is also an essential plant macronutrient and its deficiency is one of the limiting factors for growth and development of plants (Divjot et al., 2021). The use of phosphorus fertilizer is recommended for increasing the phosphate availability in the soil. Plants use less than 20% of phosphorus and a remainder of 80–90% is fixed in the soil. The available phosphorus concentrations, in the form of phosphate, determined in the tea and potato soil samples analyzed are given in Table 3. The recommended range for tea soil in this region (by the Tea Board of India) is 10-20 ppm (https://www.teaboard.gov.in). The phosphorus values determined ranged from 4±1 ppm to 35±7 ppm in the tea garden topsoil, and from 3±1 ppm to 53±6 ppm in the tea garden subsoil. The phosphate content of the potato field soil in this region ranged 63±5–153±23 ppm in the topsoil and 33±6–147±12 ppm in the subsoil. The results of this study showed that the mean phosphorus content in the potato fields considered was higher than that of the tea garden soils (Tab. 3). The poor soil nutrient management and lack of soil testing program can be held responsible for the depletion of such nutrients in the tea garden soil.

Available potassium

Potassium is the most abundant inorganic cation important for ensuring the optimal plant growth. It is involved with enzyme activation within the plant, which affects protein, starch and ATP production. The production of ATP can regulate the rate of photosynthesis (Ghosh et al., 2022). After nitrogen, potassium is the second major nutrient required for tea cultivation (Mukherjee et al., 2018). The available potassium levels (in the form of potash) in the tea garden and potato field soils in Bhotepatty are given in Table 3. The soil potassium concentration in this region ranged 17±7–57±12 ppm in the tea garden topsoil, and 12±2–26±1 ppm in the teagarden subsoil. In case of the potato fields, it ranged 24±4–130±17 ppm in the topsoil, and 13±5–52±4 ppm in the subsoil. In this region, the potassium concentration range of 60–80 ppm is recommended for tea gardens by the Tea Board of India (https://www.teaboard.gov.in). Potassium deficiency occurs in tea plantations mainly due to excessive leaching caused by increased precipitation and higher plant requirements.

Available sulphur

Sulphur is a very important element for plant growth because cysteine and methionine are the sulphur containing amino acids important for the body of plants. Sulphur deficiency results in the decolouration and abnormal growth of plant tissues (Brosnan & Brosnan, 2006; Ghosh et al., 2022), thus representing a common concern in farming. Its incidence is more common in light and shallow soils with low organic matter contents, with the highest deficiency recorded in calcareous and waterlogged soils (Brown, 1982). The sulphur contents of the garden soils analyzed ranged 8±5–25±1 ppm in the topsoil, and 12±1–19±5 ppm in the subsoil. The sulphur contents in the potato fields ranged 20±5–81±21 ppm in the topsoil, and 9±1–28±8 ppm in the subsoil (Tab. 3).

A heat map of the soil analysis results obtained (Fig. 2) displays the overall results in a comparative manner, suggesting that the tea plantation soil had not been prepared ideally. Organic matter, organic carbon, available nitrogen (of the topsoil), and sulphur were detected in huge amounts in the tea garden soils according to the optimum values suggested by the Tea Board of India. The potassium and phosphorus values were found to be little lower in the tea soils due to the lack of proper soil management (soil testing and fertilizer application), which needs to be resolved. The rest of the crop field may be converted into tea plantations provided proper soil management is implemented. Deep ploughing will resolve the pH issue through the proper mixing of top- and subsoil. Moreover, the adequate drainage and soil management are also required to resolve the issues stated above.

Table 3. Concentrations of organic carbon (OC), organic matter (OM), available nitrogen (N), available phosphorus (P), available potash (K) and available sulphur (S) in the soils collected from the tea (T1 – T10) and potato (P1 – P10) plantations

Sample code	OC		OM		N		P		K		S	
	Top soil	Sub soil	Top soil	Sub soil	Top soil	Sub soil	Top soil	Sub soil	Top soil	Sub soil	Top soil	Sub soil
T1	2.8±0.64	1.4±0.74	4.82±0.36	2.41±0.45	0.24±0.03	0.12±0.02	35±7	34±2	18±6	20±4	25±1	14±1
T2	1.98±0.68	1.59±0.63	3.41±0.83	2.73±0.71	0.17±0.02	0.12±0.03	20±3	53±6	41±11	22±3	10±2	12±1
T3	1.4±0.34	1.05±0.05	2.41±0.42	1.81±0.51	0.12±0.03	0.13±0.03	22±6	7±1	55±29	25±1	8±5	19±5
T4	1.91±0.57	1.37±0.67	3.28±0.43	2.36±0.24	0.09±0.02	0.12±0.08	4±1	3±1	30±5	26±1	19±7	15±1
T5	1.69±0.09	0.5±0.02	2.91±0.09	0.86±0.08	0.11±0.02	0.14±0.07	10±2	4±1	57±12	22±5	15±2	19±2
T6	3.97±0.24	1.43±0.24	6.83±0.81	2.46±0.2	0.34±0.01	0.12±0.03	25±5	26±9	23±2	23±3	20±5	14±5
T7	1.75±0.57	0.95±0.07	3.01±0.63	1.63±0.49	0.15±0.05	0.08±0.03	5±1	30±4	30±3	13±8	10±7	15±7
T8	1.37±0.46	0.62±0.06	2.36±0.44	1.07±0.4	0.12±0.03	0.15±0.07	21±4	28±1	17±7	14±4	17±2	12±2
T9	1.32±0.23	0.16±0.01	2.28±0.54	0.27±0.01	0.11±0.07	0.09±0.06	10±6	3±1	22±3	12±2	17±1	14±3
T10	2.03±0.55	0.91±0.1	3.48±0.65	1.57±0.07	0.17±0.03	0.08±0.05	27±3	12±1	23±4	18±1	13±4	15±7
P1	0.78±0.04	1.11±0.72	1.34±0.9	1.9±0.25	0.06±0.01	0.09±0.03	153±23	144±3	24±4	15±8	22±2	19±4
P2	1.56±0.35	2.93±0.78	2.68±0.63	5.05±0.12	0.13±0.04	0.18±0.05	115±4	115±9	26±7	13±5	54±8	28±8
P3	1.4±0.05	1.22±0.6	2.4±0.87	2.1±0.51	0.12±0.01	0.11±0.03	150±21	117±5	54±9	20±8	29±7	13±2
P4	1.11±0.37	1.67±0.33	1.9±0.45	2.87±0.72	0.09±0.02	0.14±0.01	100±4	117±23	35±7	14±5	43±3	22±3
P5	0.95±0.13	1.56±0.64	1.63±0.76	2.69±0.6	0.08±0.02	0.13±0.01	130±12	120±6	38±8	24±3	47±5	24±4
P6	2.13±0.86	1.52±0.4	3.66±0.54	2.61±0.09	0.2±0.01	0.17±0.02	111±4	147±12	36±3	14±9	51±9	19±5
P7	1.4±0.96	1.27±0.65	2.4±0.49	2.18±0.3	0.12±0.01	0.11±0.01	95±4	21±9	130±17	52±4	35±7	20±3
P8	1.25±0.35	0.95±0.5	2.15±0.7	1.63±0.35	0.11±0.04	0.08±0.02	132±23	126±8	30±4	20±3	20±5	22±3
P9	2.03±0.78	1.24±0.67	3.49±0.45	2.13±0.43	0.17±0.01	0.02±0.01	63±5	33±6	36±4	14±1	35±13	17±1
P10	1.71±0.21	1.4±0.12	2.94±0.1	2.4±0.73	0.15±0.05	0.12±0.01	144±8	41±8	29±5	17±7	81±21	9±1
Mean (T)	2.02±0.44	0.1±0.26	3.48±0.52	1.72±0.32	0.16±0.03	0.115±0.05	17.9±3.8	20±2.7	31.6±8.2	19.5±3.2	15.4±3.6	14.9±3.4
Mean (P)	1.43±0.41	1.49±0.54	2.46±0.59	2.56±0.41	0.12±0.02	0.12±0.02	119.3±10.8	98.1±8.9	43.8±6.8	20.3±5.3	41.7±8	19.3±3.4

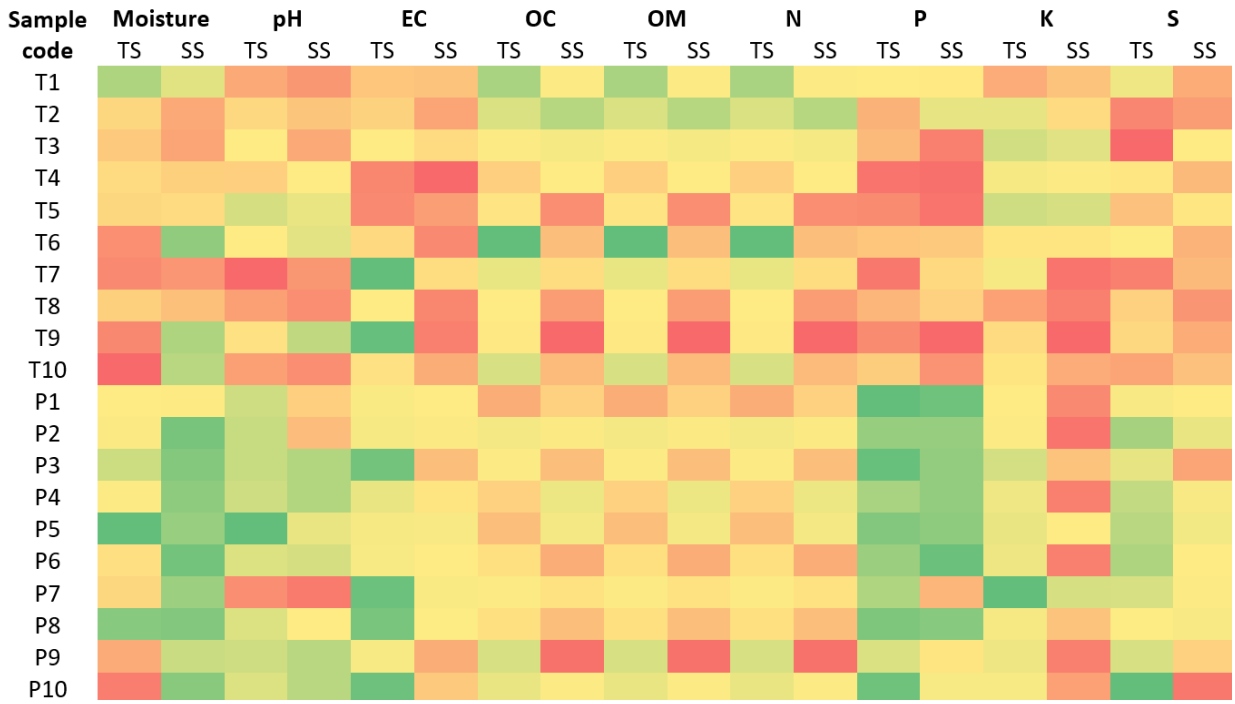


Figure 2. Heat map of the soil analysis results [Heat map colour gradient: Green – Yellow – Red = High – Moderate – Low] (T1-T10: Tea plantation soil; P1-P10: potato plantation soil; TS: Topsoil; SS: Subsoil)

CONCLUSION

The agricultural shift from potato to tea in Bhotepatty, Maynaguri, India has emerged with a number of advantages and disadvantages. The associated changes in soil parameters such as moisture, pH, EC, organic carbon, organic matter, nitrogen potassium, phosphate, and sulphur were discussed in a comparative way herein. The survey conducted revealed that the number of small tea growers in the region is rising, despite the fact that they constitute an unorganized sector and are deprived of various benefits granted to tea estates. The marketing of their products is one of the major challenges, especially for small tea growers who process their own tea leaves (unlike those who are fully dependent on bought-leaf factories). The soil testing performed revealed the acidic top- and subsoil (pH below 5.5) in the tea plantations, whereas the soil samples collected from the potato fields considered were little more acidic according to the ideal pH value for potato plantations. This can be helpful for the further expansion of tea plantation, as planned. However, the potato soil samples showed impressive phosphorus concentrations and can also be considered ideal for further shifting. Such initiatives taken by the small farmers in the region may cultivate the spirit of entrepreneurship and strengthen the backbone of the economy of Bhotepatty. The agricultural areas of Dooars serve as the granaries of the northern districts of West Bengal. Accordingly, this research suggests that, in view of long-term benefits, a balance between food crop cultivation and tea plantation needs to be maintained by sustainable agricultural practices that take into consideration both the fertility of land and socio-economic development of the farmers.

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