Effect of Tobacco Cultivation on Soil Fertility and Farmer's Profitability in the Socio-Economic Perspective of Bangladesh

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Abstract

Tobacco cultivation and production in Bangladesh have expanded by 99.68% and 219.4%, respectively, over the last decade. The study aimed to assess the impact of tobacco cultivation on soil fertility and to compare the soil fertility status of tobacco-based (TB) and non-tobacco-based (NTB) cropping fields. The study also compared the tobacco production cost and the financial cost-effectiveness of ranchers' land utilized for tobacco farming. The researchers used soil nutrient index (SNI) to analyze the soil fertility level of TB and NTB cropping fields. A total of 40 soil samples (20 TB and 20 NTB) were collected randomly from farmers' fields in Mirpur Upazila of Bangladesh's Kushtia district. Socio-demographic and financial data from 50 tobacco ranchers were collected from the investigation territory via a well-structured questionnaire. Soil nitrogen, phosphorus, sulfur, calcium and magnesium levels in TB fields were significantly lower than in NTB fields. Soil organic matter and pH in TB fields are substantially higher than in NTB fields. There was no substantial change in electrical conductivity or potassium. Based on the SNI results, the soil fertility in both cases was rated as medium. The average total cost of production for tobacco cultivation was 122190 BDT per acre of land. The average yield, all-in income, and net income per acre of land were 1292kg, 172851 BDT, and 50661 BDT, respectively, with a benefit-cost proportion of 1.42. Tobacco growers may benefit from reviewing the study's findings in making informed decisions on fertilizer applications for crops other than tobacco.

1 Introduction

Tobacco farming is expanding very quickly in Bangladesh where tobacco cultivation and production has increased by 99.68% and 219.4%, respectively over the last 10 years (BBS 2016, 2020). The development territory extends to 26 out of 64 districts in Bangladesh and Kushtia district positions first in tobacco cultivation followed by Lalmonirhat and Nilphamari (BBS 2020).

Tobacco cultivation triggers critical unfortunate results on the surrounding environment alongside causing health hazards for tobacco farmers. Tobacco cultivating prompts consumption of soil fertility (Lecours et al. 2012), deforestation and ecological interruptions (Pius 2010; Ali et al. 2015; WHO 2017; Rahman et al. 2019). Exhaustion of soil nutrients is likely a result of the more huge info prerequisite to the tobacco crop (Hoyos et al. 2015). The tobacco plant consumes a large amount of soil nutrients and exhausts them at a faster rate than most other crops. The lingering fertilizer treatments have little effect on succeeding food harvests (Geist 2018). To achieve high leaf output and quality, the tobacco plant requires more nutrients, such as nitrogen (N), phosphorous (P), potassium (K), calcium (Ca), magnesium (Mg), and sulfur (S) (Ali et al. 2015). Researchers have reported a decrease in soil supplements such as K, P, and S (Xu et al. 2008; Farooq et al. 2014; Moula et al. 2018; Lisuma et al. 2020) as well as an increase in total soil-N and Ca content following tobacco growing (López-Lefebvre et al. 2001; Farooq et al. 2014; Lisuma et al. 2020).

Soil analysis evaluates the existing fertility status and gives data in regards to nutrient accessibility in soils, which frames the reason for sustainable soil and fertilizer management to expand crop yields and

support ideal soil health. For reasonable soil management, the rancher should understand what corrections are needed to advance the productivity of the soil (Kavitha and Sujatha 2015). An appraisal of the soil fertility status by utilizing a soil nutrient index could give key data to improve procedures and successful strategies for the future to accomplish sustainable agriculture.

The tobacco companies generally assert that tobacco farming creates productive work open doors and revenue for tobacco farmers yet this sector has debate. Nevertheless, throughout the time and among the various crops cultivated in Bangladesh, tobacco is playing a continuously significant role in creating work and pay possibilities for farmers and furthermore supporting in accepting imperative foreign cash for the country. Despite the fact that tobacco farming has been viewed as moneymaking by a few, the gatherings against tobacco cultivation allies considers it as a crop which is irksome, socially, monetarily and ecologically. Investigations in various tobacco-cultivating nations have analyzed the monetary occupations of tobacco farmers (Appau et al. 2019; Hasan 2019; Rahman et al. 2019; Rahman et al. 2019), the components that shape farmers' choices to cultivate tobacco, and financial options in contrast to tobacco production.

This investigation centers around the evaluation of the impact of tobacco farming on soil fertility status utilizing soil nutrient index approach and comparison of tobacco based (TB) with non-tobacco based (NTB) cropping pattern field. Additionally, the study emphasizes the influences of tobacco cultivation on the farmers' socio-economic conditions and the cost-effectiveness of tobacco production in the study area.

2 Materials And Methods

2.1 Study Area

Kushtia district of Bangladesh was picked purposively as the investigation territory since this locale positions first in tobacco cultivation in Bangladesh (BBS 2020). The study comprised of two sections (i) soil sample was collected from both TB and NTB cultivating fields to assess the fertility status of the soil, and (ii) a well-structured questionnaire survey was directed to discover the farmer's profitability in the study territory because of tobacco cultivation.

2.2 Soil Sampling and Analysis

The fields were chosen arbitrarily by finding out if the farmers cultivate tobacco or not. Soil samples were taken at 0–15 cm depth from 9 places in each field, mixed systematically to form a composite soil sample for each TB and NTB cultivating field independently, and a total of 40 fields (20 TB, 20 NTB) were chosen. The soils were air-dried, visible roots and garbage were removed, and the larger aggregates were delicately crushed with a wooden hammer before being put through a 0.5-mm sieve. Approximately 0.5 kg of composite soil samples were placed in fresh polythene sacks, labeled, and stored for analysis. A glass electrode pH/EC meter was used to determine the pH and EC of the soil (D-54, Horiba, Japan) (Jackson 1958). Walkley and Black's wet oxidation method (Walkley and Black 1934) was used to

quantify soil organic carbon (OC), and the OM was estimated by multiplying the percent value of OC by the traditional Van- Bemmelen's factor of 1.724. Total N of soil was assessed by the Micro-Kjeldahl technique (Jackson 1958), available soil P and S was estimated by using a spectrophotometer (T60U, UV-apparent spectrophotometer, PG Instruments Ltd) (Page et al. 1982; Olsen 1954), exchangeable K was determined by using flame photometer (PFP7 Flame Photometer, JENWAY) (Jackson 1958). Available Ca and Mg were determined by titrimetric method (Imamul Huq and Alam 2005).

2.3 Valuation of Soil Fertility Status through Soil Nutrient Index (SNI)

Soil fertility, or the amount of plant nutrients in the soil, is mostly determined by soil quality and health. It is critical to obtain a single number for each nutrient when comparing the degrees of soil fertility of one region to those of another. The SNI value is a measurement of the soil's ability to give nutrients to plants (Singh et al. 2016). A few scientists have updated and enhanced the SNI technique given by Parker et al. (Parker et al. 1951; Shetty et al. 2008; Pathak 2010; Chase and Singh 2014; Amara et al. 2017; Patil et al. 2017). This index is used to determine the fertility status of soils based on samples from each of the three classes: low, medium, and high fertility. The SNI was assessed for the soil samples studied using the following formula:

$$\text{Nutrient Index (NI)} = (\text{NI} * 1 + \text{Nm} * 2 + \text{Nh} * 3) / \text{Nt}$$

Where,

NI, Nm, and Nh denote the number of tests in the low, medium, and high nutritional status categories, respectively. Nt denotes the total number of tests performed on a given region.

2.4 Survey Design and Data Collection

A random sampling technique was applied for picking sample and 50 ranchers were chosen for the study. Essential information was gathered with care and alert through face-to-face interviews with the respondents. Preceding meeting, the goals of the examination were disclosed to every single tobacco farmers. Subsequently, they were persuaded that the examination was absolutely a scholastic one and was not prone to adversely affect their cultivating.

2.5 Data Analysis Techniques

To examine profitability and production proficiency in tobacco production in the inquiry territory, a benefit-cost analysis (BCA) and a Cobb-Douglas production model were used.

2.5.1 Farmers' Profitability of Tobacco Farming

To estimate the expense and get back from tobacco farming, accessible information on cost and return made by tobacco farmers was utilized to compute with exactness. Family-level data on socioeconomics, financial profiles of respondents, and information associated with tobacco cultivation, such as land,

labor, fertilizer, pesticides, other factor costs, loan facility, and other tobacco handling-related data, tobacco cost, and profitability of tobacco cultivation, were gathered. The farmers' financial gain was calculated by subtracting the sales revenue of tobacco from the costs of all out-of-pocket inputs utilized in tobacco growing.

2.5.2 Benefit-Cost Analysis

In assessing the expense viability of tobacco cultivation, the study employed BCA procedure referenced below (Haider 2015; Jahan and Islam 2016; Basu and Roy 2018).

$$BC = \frac{\text{DirectBenefit(DB)}}{\text{DirectCost(DC)}} = \frac{\sum_{i=1}^n DB_i}{\sum_{k=1}^n DC_k} \quad (1)$$

Here, BC = benefit-cost ratio; DB = direct benefit; DC = direct cost; $n = 1$ for DC (production cost); $n = 1$ for DB (revenue earnings)

2.5.3 Production Function Model

To evaluate the tobacco production scheme's production proficiency, the Cobb-Douglas production model in the form below was used (Ahmed and Garnett 2011).

$$\text{Log}Y_i = \log_a + b_1 \log X_{1i} + b_2 \log X_{2i} + b_3 \log X_{3i} + b_4 \log X_{4i} + b_5 \log X_{5i} + \log U_i$$

where, Y = Total yield from tobacco cultivation (kg/acre); X_1 = tobacco seedling (BDT/acre); X_2 = fertilizer (BDT/acre); X_3 = pesticide (BDT/acre); X_4 = irrigation (BDT/acre); X_5 = labor (BDT/acre); U_i = disturbance term; a = constant; $b_1 \dots b_4$ = coefficient of the related variables; i = observations (1, 2, 3 n)

2.6 Statistical Analysis

The produced soil information was analyzed statistically by analysis of variance. Mean comparisons were performed employing an ANOVA ensured least significant difference (Tukey) ($p < 0.05$) test. Simple correlation analysis was performed between the contemplated attributes (Steel et al. 1997). Gathered information from questionnaire survey were investigated and summed up with the end goal of tabulation using the statistical software MINITAB 18 and Microsoft office Excel 2010.

3 Results And Discussion

3.1 The Impact of Tobacco Farming on Soil Fertility

The average pH value was 7.43 ± 0.10 for TB soil whereas it was 7.17 ± 0.19 in NTB soil. Soil in the TB field was slightly alkaline in nature and it was neutral in NTB field. Based on soil EC values both TB and NTB fields were non-saline (Table 1). The OM content of TB land varied from 1.07 to 3.03% with average of $2.18 \pm 0.50\%$ indicating low (10%) to medium (90%) soil OM and the NTB soils were categorized very low (90%) to low (10%) (Ahmmed et al. 2018). The mean value of total soil N from TB field was $0.06 \pm$

0.03%, which was below the critical limit value (0.12%) (Ahmmed et al. 2018). The N content in TB field was categorized as very low (85%) to low (15%) whereas it was categorized as low (95%) to medium (5%) in NTB soils (Ahmmed et al. 2018). The average P value in TB and NTB fields were 31.9 ± 10.8 and 47.3 ± 9.88 mg/kg, respectively. The K and S level of the TB soils was 0.43 ± 0.11 meq/100g and 17.8 ± 6.80 mg/kg, respectively, whereas in NTB soils it was 0.47 ± 0.08 meq/100g and 38.3 ± 6.14 mg/kg, respectively. The level of exchangeable Ca and Mg in TB soils was 1.64 ± 0.83 meq/100g and 1.40 ± 0.42 meq/100g, respectively, whereas in NTB soils it was 3.58 ± 0.69 meq/100g and 2.24 ± 0.51 meq/100g, respectively (Table 1). Similar to N, the Ca content in TB soil was below the critical limit value (2 meq/100g) (Ahmmed et al. 2018).

Table 1
Statistic characteristics of soil variables in TB and NTB fields

Soil variables	Tobacco based soil				Non-tobacco based soil			
	Mean	Max.	Min.	SD	Mean	Max.	Min.	SD
pH	7.43 ^a	7.71	7.32	± 0.10	7.17 ^b	7.43	6.86	± 0.19
EC (dS/m)	0.08 ^a	0.09	0.06	± 0.01	0.08 ^a	0.10	0.07	± 0.01
OM (%)	2.18 ^a	3.03	1.07	± 0.50	0.75 ^b	1.03	0.47	± 0.14
Total N (%)	0.06 ^b	0.13	0.01	± 0.03	0.14 ^a	0.19	0.10	± 0.02
Av. P (mg/kg)	31.9 ^b	52.2	16.0	± 10.8	47.3 ^a	69.9	33.2	± 9.88
Ex. K (meq/100g)	0.43 ^a	0.71	0.28	± 0.11	0.47 ^a	0.67	0.37	± 0.08
Av. S (mg/kg)	17.8 ^b	31.3	6.17	± 6.80	38.3 ^a	50.4	30.1	± 6.14
Ex. Ca (meq/100g)	1.64 ^b	3.18	0.20	± 0.83	3.58 ^a	4.98	2.12	± 0.69
Ex. Mg (meq/100g)	1.40 ^b	2.12	0.76	± 0.42	2.24 ^a	3.14	1.36	± 0.51

The numbers followed by the same letter in the different column showed non-significantly different at confidence level of 5%. Where, EC = electrical conductivity; OM = organic matter; N = nitrogen; Av. P = available phosphorus; Ex. K = exchangeable potassium; Av. S = available sulfur; Ex. Ca = exchangeable calcium; Ex. Mg = exchangeable magnesium; Max.= maximum; Min.= minimum; SD = standard deviation

3.2 Relationship among the Studied Soil Variables

Soil pH had a significant and positive relationship with OM, but a negative relationship with N, P, Ca, and Mg; a non-significant and positive relationship with K, but a negative relationship with EC. N, P, Ca, and Mg were favorably connected with EC, while OM and K were adversely linked but not significantly. OM was shown to be strongly linked with N, P, Ca, and Mg, as well as insignificantly but negatively linked with

K, P, K, Ca, and Mg were all significantly and positively linked with N. P was found to have a substantial and positive relationship with K, Ca, and Mg. K had a non-significant positive correlation with Ca and Mg. Mg and Ca had a substantial positive correlation (Table 2).

Table 2
Pearson correlation coefficient matrix among the studied soil variables

Soil variables	pH	EC	OM	N	P	K	Ca
EC	-0.213 (p = 0.187)						
OM	0.518 (p = 0.001)	-0.177 (p = 0.275)					
N	-0.581 (p = 0.000)	0.087 (p = 0.595)	-0.771 (p = 0.000)				
P	-0.398 (p = 0.011)	0.016 (p = 0.922)	-0.466 (p = 0.002)	0.594 (p = 0.000)			
K	0.057 (p = 0.729)	-0.240 (p = 0.136)	-0.152 (p = 0.349)	0.406 (p = 0.009)	0.343 (p = 0.030)		
Ca	-0.476 (p = 0.002)	0.053 (p = 0.747)	-0.771 (p = 0.000)	0.608 (p = 0.000)	0.391 (p = 0.013)	0.042 (p = 0.796)	
Mg	-0.512 (p = 0.001)	0.177 (p = 0.275)	-0.679 (p = 0.000)	0.524 (p = 0.001)	0.357 (p = 0.024)	0.239 (p = 0.137)	0.590 (p = 0.000)

3.3 Valuation of Soil Fertility Status

To compare the levels of soil fertility in one region with those in another, a single value for each nutrient is required (Amara et al. 2017). The SNI of both the TB and NTB fields was computed using soil nutrient ratings of low (L), medium (M), and high (H). The fertility status was low if the index value was less than 1.67, medium if it was between 1.67 and 2.33, and high if it was greater than 2.33 (Parker et al. 1951; Shetty et al. 2008; Pathak 2010; Chase and Singh 2014; Amara et al. 2017; Patil et al. 2017). Based on SNI, between TB and NTB field, soil pH was high in TB soil and medium in NTB soil. In both the cases,

soil total N and EC was low while available P, exchangeable K and exchangeable Mg were high. The level of OM was medium in TB soil and low in NTB soil. Available S fertility status was medium in TB soil and high in NTB soil. Level of exchangeable Ca was low in TB soil and medium in NTB soil (Table 3).

Table 3
Distribution of SNI and soil fertility rating (SFR) based on SNI

Soil variables	Tobacco based soil		Non-tobacco based soil	
	SNI	SFR	SNI	SFR
pH	3.0	H	2.3	M
EC (dS/m)	1.0	L	1.0	L
Organic matter (%)	1.9	M	1.0	L
Total N (%)	1.0	L	1.1	L
Available P (mg/kg)	2.8	H	3.0	H
Exchangeable K (meq/100g)	3.0	H	3.0	H
Available S (mg/kg)	1.8	M	3.0	H
Exchangeable Ca (meq/100g)	1.1	L	1.9	M
Exchangeable Mg (meq/100g)	2.7	H	3.0	H
SNI = Soil nutrient index; SFR = soil fertility rating; L = Low; M = Medium; H = High				

3.4 Effect of Tobacco Cultivation on Farmer's Profitability

3.4.1 Households' Characteristics

Tobacco farmers' age ranged from 27 to 59 years, with the mean of 43.2 years. Farmers were illiterate to having tertiary education but the average farmers' education level was just above seven years. Tobacco farmers' family size of the study area ranged from 3 to 10 persons, with an average household size is just above 5 persons including all members. Average cultivated land size was 2.1 acre and ranged from 1.0 to 3.7 acre (Table 4).

Table 4

Household features, total cost and revenue profitability and benefit-cost ratio in tobacco cultivation per acre of land in the study area

	Items	Mean	SE Mean	CoefVar	Min	Max
Household features	Age (years)	43.2	1.2	19.3	27.0	59.0
	Education (schooling years)	7.2	0.5	46.9	0.0	17.0
	Family size (person)	5.1	0.2	26.9	3.0	10.0
	Cultivated land (acre)	2.1	0.1	35.2	1.0	3.7
Cost (BDT)	Land lease	19894	2933	104.2	2121	48030
	Seedling	1318	161.0	86.2	0	2424
	Fertilizers	24158	449.0	13.2	18182	30303
	Pesticides	1227	30.7	17.7	909	1515
	Irrigation	5891	103.0	12.4	3939	7273
	Leaf curing process	29263	177	4.3	26727	32242
	Transport	2552	40.0	11.1	1818	3333
	Total labor	32848	2418.0	52.0	10606	53030
	Others	5039	68.4	9.6	4136	5652
Total cost (BDT)		122190	1048.0	6.1	104576	133621
Revenue (BDT)	Tobacco by-product	3485	186.0	37.7	1515	6061
	Selling dry plant	1255	32.1	18.1	909	1818
	Price/kg	130	0.5	2.5	125	135
	Tobacco leaf (kg)	1292	14.2	7.8	1152	1515
	Yield return	168111	1946.0	8.2	147394	204545
Total revenue (BDT)		172851	1924.0	7.9	151333	209394
Net revenue (BDT)		50661	2024.0	28.3	28318	86076
Benefit-cost ratio (BCR)		1.42	0.019	9.21	1.22	1.81
SE Mean = standard error of mean (n = 50); CoefVar = coefficient of variation; Min = minimum; Max = maximum						

3.4.2 Economic Indicators

This sub-section describes total cost (TC), total revenue (TR), net revenue (NR) and benefit-cost ratio (BCR) involved in tobacco cultivation per acre of farmer's land.

Input costs

The input cost involved are land preparation, land lease, seedling, fertilizers, pesticides, irrigation, leaf curing process (house making materials, wood etc.), transport for marketing, total labor and so on. The average total cost for tobacco cultivation is 122190 BDT per acre of land ranged from 104576 to 133621 BDT (Table 4).

Total revenue

Returns heads from tobacco cultivation are tobacco leaf (yield), selling tobacco by-product, and dry plants. Average total revenue per acre of land from tobacco is 172851 BDT ranged from 151333 to 209394 BDT. Average total yield per acre of land is 1292 kg and ranged from 1152 to 1515 kg. The mean yield return is 168111 BDT and ranged from 147394 to 204545 BDT from per acre of land (Table 4).

3.4.3 Economic Profitability of Tobacco Farming

Based on the cost and revenue data from this study, the average production cost (including all sources of cost), sales revenue of tobacco leaf and by-products, and average profit and rate of profit (profit as a proportion of cost) per acre of land were computed. Tobacco net revenue averaged 50661 BDT, ranging from 28318 BDT to 86076 BDT. The profit margin as a percentage of the total cost of manufacturing is 41.5 percent. The average benefit-to-cost ratio is 1.42 BDT, with values ranging from 1.22 to 1.81 BDT (Table 4).

Production efficiency

In the econometric regression model of the Cobb-Douglas production function, R^2 is 0.93, implying that the independent variables in the model can explain 93% of the variation in tobacco output. The model's F-value (108.38) was highly significant ($p < 0.001$), indicating that all of the descriptive variables were necessary for understanding the production system's fluctuations (Table 5).

Table 5
Efficiency measurement of tobacco production

Variables	Unit	Coef	SE Coef	T-Value	P-Value	VIF
Seedling (X_1)	(BDT/acre)	0.2248	0.0609	3.69	0.001	4.79
Fertilizer (X_2)	(BDT/acre)	0.01813	0.00493	3.68	0.001	6.36
Pesticide (X_3)	(BDT/acre)	0.0861	0.0960	0.90	0.375	4.70
Irrigation (X_4)	(BDT/acre)	0.0472	0.0215	2.19	0.034	7.38
Labor (X_5)	(BDT/acre)	-0.00141	0.00155	-0.91	0.368	2.06
Constant		77	131	0.58	0.562	
R^2	0.93					
F-Value	108.38					
P-Value	0.000					
Observations	50					
Mean VIF	5.06					

3.5 Farmers' Opinions about Tobacco Farming

Farming is the main occupation for majority of the farmers. The farmers' opinions are summarized as the percentage of the total respondents. 58% of the farmers grow tobacco in their own land and 66% of the respondents have taken training course on tobacco cultivation. For tobacco cultivation, 82% of the farmers are motivated by different tobacco companies and 74% of the farmers get loan from the companies. 76% of the farmers sell tobacco leaf to the company and the rest of the farmers sell to the market. Regarding health issue, 70% of the farmers think that tobacco farming is harmful for health and it was found that 50% of the tobacco growers, 38% of the family members and 32% of female members are addicted to tobacco. 72% of the farmers think tobacco cultivation pollutes the environment particularly air. 62% of the respondents told that tobacco cultivation need higher amounts of fertilizer and they apply more fertilizer than the recommended dose. Commonly used fertilizers are urea, TSP (triple super phosphate), DAP (diammonium phosphate) and SOP (sulphate of potash). Furthermore, tobacco plants attract more pests and insects, necessitating the use of additional pesticides in tobacco production. Tobacco cultivation, according to 68% of farmers, declines soil productivity since it necessitates more fertilizer for the next crop. An opposite and 90% of the respondents think that tobacco cultivation has no detrimental effect on next crop. This might be due to high application of fertilizer to the next crop. 80% of the farmers consider that the tobacco cultivation is more profitable than most other crops and 54% farmers think that they get more money at a time.

The results indicated that the pH value of TB soil was significantly higher than that of NTB soil (Table 1). On considering soil pH, 25% of TB soils were within neutral range and 75% were within slightly alkaline whereas 85% of NTB soils were within neutral range and 15% were within slightly alkaline. This result is in good agreement with the findings of Salam et al. (Salam et al. 2021). However, opposite findings were also reported (Kutub and Falgunee 2017; Moula et al. 2018). Both TB and NTB soils were non-saline in nature and the entire analyzed sample's EC value was below 1.0 dS/m (Ahmmed et al. 2018). Higher EC value in NTB fields was reported (Salam et al. 2021). Based on SNI, soil OM content is medium in TB soil and low in NTB soil (Table 1). Similar result with this finding was stated (Salam et al. 2021). However, opposing finding was also reported (Moula et al. 2018). High amount of residues like root biomass left after harvest leaving more chances of OM accumulation in the TB soil. In addition, low input of organic fertilizer and crop residues thereby less chances of OM accumulation in NTB soil. It was found that the total soil N content was significantly differed from TB and NTB farming fields and it was significantly lower in TB farming fields than that of NTB farming fields (Table 1). Though, SNI value showed that the SFR is low for both the cases. The low N level could be due to poor soil management. Furthermore, the amount of N in the soil is affected by temperature, rainfall, and altitude. Moreover, continual and intensive cultivation, which results in significant crop removal and insufficient replenishment, may be the cause of high levels of N shortage in soils (Amara et al. 2017). A study on consecutive 2-year data analysis reported that soil N was decreased in tobacco field in the second year and the N content was lower in tobacco field than non-tobacco field (Salam et al. 2021). An increase in total soil-N level has also been reported after tobacco cultivation (López-Lefebvre et al. 2001; Farooq et al. 2014; Lisuma et al. 2020). Findings showed that tobacco cultivation resulted a decrease in soil available P and S. The P levels in TB cropping pattern fields were included in the category of medium (20%), optimum (30%), and high (50%) whereas the category was high (15%) to very high (85%) for all the NTB fields (Ahmmed et al. 2018). Lesser content of available P and S was also reported in TB fields after tobacco cultivation which is supportive to this result (Moula et al. 2018; Lisuma et al. 2020; Salam et al. 2021). However, the SNI value for P revealed that the SFR is high in both situations (Table 3), possibly due to the large phosphate fertilizer input throughout time. High soil P levels not only reduce the availability and uptake of vital nutrients by plants, but they also pollute the soil and water. The decline in soil S in tobacco fields could be attributable to the high plant demand for this nutrient for metabolic activities (Höller et al. 2010), as well as a lack of adequate S input and constant S removal by crops. Exchangeable K value of TB soils were the category of high (50%) to very high (50%) whereas the categories were optimum (25%), high (35%) and very high (40%) in NTB soils (Ahmmed et al. 2018). There was no significant change of average K value in TB and NTB soils (Table 1) but significantly higher K value in NTB soil was stated (Salam et al. 2021). Similar to P, the SFR for K is high for both the cases (Table 3).

Significant and negative correlation between soil pH and N indicated that an increase in soil pH decreases N, which might be due to volatilization loss of N with rise of soil pH (Bhat et al. 2017). Similar results were also reported indicating significant and negative correlation between soil pH and N (Khokhar et al. 2012; Patil et al. 2015). Based on SNI value, the soil fertility was characterized as medium in both TB and NTB soils.

The study shows that the profit relies upon so many factors some of them are cost on seedlings, fertilizer and pesticides, labor, irrigation, production, price and so on. Though tobacco cultivation has some short term momentary beneficial outcomes tobacco cultivation has some adverse consequences on soil fertility, water quality, environment, deforestation and health. Wood burning during tobacco leaves curing process discharges noxious smoke in the atmosphere. Above all, when the opportunity costs of having family labor, own property, and other resources are considered, tobacco farming is clearly not a profitable endeavor for farmers. The production of food crops has been decreasing with time because of augmentation of tobacco production. The government and others working on tobacco control should offer significant monetary help by assisting with expanding admittance to credit and guaranteeing a superior market facility to sell their other healthier agricultural harvests. To manage the tobacco pandemic in Bangladesh, these factors must be addressed, as well as incentives for tobacco farmers to switch to other sources of income. We didn't measure the environmental costs of tobacco cultivation as well as the implied costs (e.g., free family labor, health costs), which is a key shortcoming of this study.

4 Conclusions

In TB fields, soil total N, available P and S, and exchangeable Ca and Mg content were significantly lower than in NTB fields, whereas soil pH and OM content were significantly greater. Moreover, N and Ca content were below the soil's critical limit value. The decrease in soil N, P, S, Ca, and Mg, despite higher fertilization than the required dose in tobacco fields, indicated that tobacco is a heavy nutrient feeder crop for these nutrients. Farmers are enticed to participate in and continue tobacco production by the possibility of owing family employment, advanced loan, and a buy-back assurance from tobacco companies. Tobacco cultivation deteriorates soil fertility reducing the succeeding crops yield. The government and NGOs working on tobacco control should offer significant monetary help and guaranteeing a superior market facility to sell their other healthier agricultural products.

Declarations

Data Availability Not applicable

Competing Interests

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Author Contributions

All the authors contributed equally in this study. The study's inception and design were aided by all of the writers. Jagadish Chandra Joardar supervised the whole research work. Data collection and analysis were performed by Kaniz Fathema. Sudipa Basu and Jagadish Chandra Joardar did the statistical analysis and interpretation of the results. Sudipa Basu and Jagadish Chandra Joardar wrote the first draft of the manuscript, and all writers provided feedback on prior versions. The final manuscript was read and approved by all authors.

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