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Impact of tobacco cultivation on soil and human health in the agricultural ecosystem at Tangail region of Bangladesh

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ABSTRACT

The study was conducted to determine the impact of tobacco cultivation on soil and human health in the agricultural ecosystem at Bhuapur and Kalihati upazila of Tangail region from January to December 2019. Among them, 40 soil samples were collected, each 20 from Kalihati and Bhuapur Upazila. Among 20 samples, every 10 samples were collected from tobacco and non-tobacco land at a depth of 0 to 15 cm in Bhuapur, 0 to 15 and 15 to 30 cm in Kalihati Upazila. The soil pH, organic matter (OM), total nitrogen (N), available phosphorus (P), available sulfur (S), available zinc (Zn), exchangeable potassium (K), exchangeable magnesium (Mg) and exchangeable calcium (Ca) were analyzed in the laboratory of Soil Resource Development Institute (SRDI), Tangail. In Kalihati Upazila, tobacco land showed significantly higher content of OM, available N, available P, available Zn, exchangeable K and exchangeable Mg, whereas pH was low in non-tobacco land. Surface soil (0 to 15 cm) and tobacco land showed significantly higher content of S than sub-surface (15 to 30 cm) soil and non-tobacco land. On the other hand, there was no significant variation between tobacco and non-tobacco land on soil properties in Bhuapur Upazila. In both Upazilas, all the nutrients except exchangeable Ca and Mg were lower than optimum in tobacco and non-tobacco land, which was unsuitable for crop cultivation. The cost of production was higher in tobacco land than in non-tobacco land in both Upazilas. About 36% of farmers informed that they were suffering from various diseases due to tobacco cultivation and curing. Tobacco cultivation in these areas degrades soil health and the agricultural ecosystem and releases nicotine into the environment, hampering food safety and human health. The study indicated that tobacco cultivation should be replaced by other crops to protect soil quality and human health.

Keywords: Tobacco cultivation, Soil nutrients, Human health, Tangail region

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Introduction

Bangladesh is one of the largest tobacco-consuming countries in the world. Tobacco is grown throughout the country; the largest tobacco-growing areas are Rangpur, Kushtia, and Chittagong Hill tracts (Ali *et al.*, 2015). Employment in tobacco farming accounts for less than 0.5% of agricultural employment in Bangladesh (Hossain and Rahman, 2013). Tobacco is a relatively minor crop in overall agriculture in Bangladesh. In 2010, the acreage devoted to tobacco growing accounted for only 0.25% of acreage for all crop production. In 2009, the value of the tobacco grown was only 0.22% of the value of all agricultural production (GYTS, 2008). The acreage devoted to tobacco growing in Bangladesh has been falling steadily for most of the past three decades before rising sharply in 2010. Mainly British American Tobacco Bangladesh Company Limited (BATB) has been operating as a major sponsor of contract farming in tobacco cultivation since its beginning. This crop has regional dominance in the northwestern, mid-western, mid-south and southeastern parts of the country (Motaleb and Irfanullah, 2011). Tobacco was grown on 70,000 hectares in the season of 2013 in Bangladesh. In that year, about 38,000 hectares of additional land was used than in 2012 and 108,000 hectares of land was cultivated for tobacco in 2014 (PROGGA, 2014).

A significant number of people from Bangladesh are at great risk of using tobacco products, especially smoking tobacco. The readily available tobacco products in Bangladesh are a liable factor linked to tobacco production. Over time, tobacco production is increasing in Bangladesh. The identified tobacco-related illness in Bangladesh, tobacco cultivation has tremendous social and health bearing which often go unnoticed (WHO, 2007). About 63% of all deaths are caused by non-communicable diseases, among which tobacco products are considered one of the major risk factors (Pius, 2010). Mortality, as well as morbidity, is increased by tobacco smoking. Both tobacco production and supply are a cause for increased tobacco consumption. Globally, about 600,000 people die from second-hand smoke exposure each year. These deaths occur in densely populated, underdeveloped countries (WHO, 2011).

Tobacco, a second major cause of death globally, causes 5.4 million premature deaths each year and within the 21st century, one billion people will die from tobacco use (WHO, 2008). In Bangladesh, 29.8% of people over 10 use tobacco (Islam, 2015). Tobacco production can enormously pollute the air, negatively affecting the indoor environment. As a result, most people living in that area suffer from allergic diseases. They risk adverse health effects due to chronic exposure to indoor air pollutants (Bernstein *et al.*, 2008). Tobacco plants exhaust soil nutrients (phosphorus, nitrogen, potassium); thus, tobacco mono-cropping requires substantial doses of chemical fertilisers. In addition, agrochemicals such as insecticides and herbicides are used extensively. Tobacco plots also contribute a lot to the accumulation of heavy metals in the soil (Moula *et al.*, 2018). Agricultural crops are being influenced by soil characteristics and distinct climate variables such as temperature, rainfall, humidity and day length (Islam *et al.*, 2020a; Jamil *et al.*, 2020; Mamun *et al.*, 2020; Shila *et al.*, 2021). After continuous tobacco cultivation, the soil becomes hard, dries up quickly or does not drain easily. The natural smell of the soil disappears and the soil colour changes. These observations are indicators of the loss of soil organic matter, changes in soil chemical properties and loss of water-holding capacity (Akter *et al.*, 2012).

It was hypothesized that tobacco cultivation might increase soil degradation, the risk to human health and hamper food safety in these regions. The present investigation was undertaken to study the effects of tobacco cultivation on soil and human health. Therefore, this study was carried out to i) know the soil physicochemical properties of tobacco and non-tobacco cultivable land, ii) find out the detrimental effect due to tobacco cultivation on farmers as well as on the environment and iii) compare soil physicochemical properties between tobacco and non-tobacco cultivable land.

Materials and Methods

Study area

The study area is located in Kalihati and Bhuapur Upazila of Tangail district (Fig. 1). The area of Kalihati Upazila is 301.22 km², located between 24°17' to 24°26'N latitudes and 89°45' to 90°11'E longitudes. The area of Bhuapur Upazila is 225.02 km², located between 24°23' to 24'°35'N latitudes and 89°44' to 89°54'E longitudes (BBS, 2011).

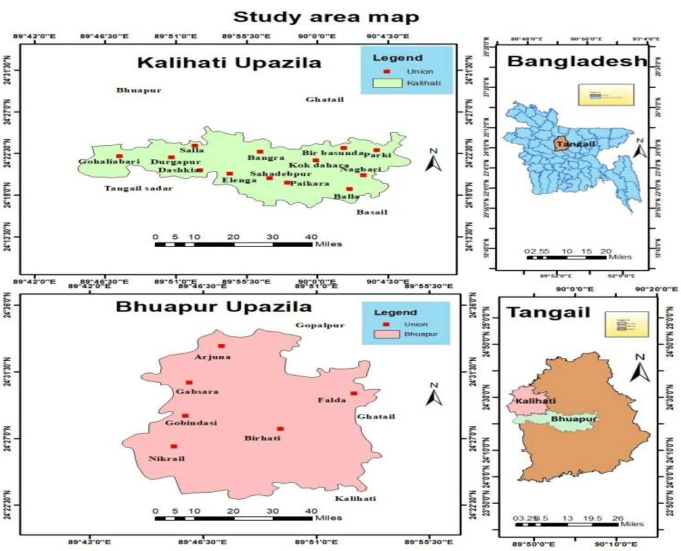

Fig. 1. Map showing the study area of Kalihati and Bhuapur Upazila, Tangail.

Sample collection

The study was conducted throughout the year of 2019. A total of 40 samples were collected from the surrounding study area. Among them, each 20 samples were collected from tobacco and non-tobacco land. The samples were collected from surface soil (0 to 15 and 15 to 30 cm depth) in Kalihati Upazila due to silt deposition in the rainy season. In Bhuapur Upazila, samples were collected from surface soil (0 to 15 cm depth) because there was no siltation. The samples were scraped from top to bottom with the help of an auger. Then about 250 g of soil was collected to give a representative sample, placed in sealed polythene bags and labelled, including the date of collection, location and code number of the soil sample and transferred to the laboratory for analysis. A survey was conducted among 100 respondents to determine the impact on health. Among them, 40 respondents were farmers and others were local people who were consuming smokeless tobacco such as zarda, sadapata, gul, etc.

Sample analysis

The soil samples were dried at room temperature. Then analysed the soil pH, organic matter (OM), total N, available P, available S, available Zn, exchangeable K, exchangeable Ca and exchangeable Mg in the laboratory of the Soil Resource Development Institute (SRDI), Tangail. Soil pH was determined by a digital pH meter, whereas the organic matter was resolved by Walkley and Black's wet oxidation method (Allison, 1965). The semi-micro Kjeldahl method determined total nitrogen, available phosphorous, potassium and sulfur were determined by using the Olsen method, by ammonium acetate extraction method and by calcium chloride extraction method (Sattar and Rahman, 1987), respectively. The zinc sample was determined by the 0.1N HCI (hydrochloric acid) extraction method. The Mg and Ca of the soil sample were determined by EDTA (Ethylenediamine Tetra Acetic acid) Titration (Huq and Alam, 2005).

Statistical analysis

At the end of data collection, data were compiled, tabulated and analysed through Microsoft excel 2010 and statistix 10 software. When significant differences existed between treatment means, comparison of the means using Duncan's Multiple Range Test (DMRT) at a 5% significance level. Various descriptive statistical measures include mean, LSD at 0.05%, analysis of variance (ANOVA).

Results and Discussion

Soil pH

In Kalihati Upazila, the main effect of land use was statistically significant, but the interaction effect of land use and soil depth showed non-significant on soil pH (Table 1). The pH was significantly higher in non-tobacco land (7.57) than in tobacco land (7.46) (Fig. 2). In Bhuapur Upazila, the effect of different land use showed non-significant on pH. However, pH was higher in tobacco land (6.70) than non-tobacco land (6.68) land. It means the pH value of both tobacco and non-tobacco land was neutral (6.70 to 6.68). The pH's optimum (6.6 to 7.3) value is suitable for all crop production (Ahmed *et al.*, 2018). The result revealed that both tobacco and non-tobacco cultivation lands were nearly neutral pH. It might be due to seasonally flooded and silt deposition each year in the rainy season. This finding was well corroborated with Kumar *et al.* (2019) and stated that in AEZ-7, pH status ranged from slightly acidic to slightly alkaline (5.70 to 7.65). The average pH value in tobacco cultivated land in Kushtia (Moula *et al.*, 2018) decreased from 7.86 to 7.44 after two consecutive years might be due to the use of potassium sulfate as a source of potassium and rapid adsorption of base captions and release of H+ ions. Kutub and Falgunee (2015) also found a similar trend in Kushtia, Bangladesh.

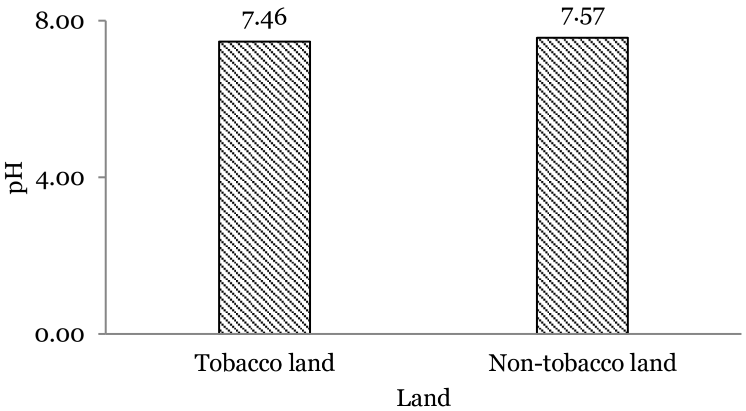

Fig. 2. The pH value of tobacco and non-tobacco land use in Kalihati upazila.

Table 1. ANOVA for different soil properties of tobacco and non-tobacco land at Kalihati upazila.

Source	pH	OM (%)	N (%)	P (µg/g)	S (µg/g)	Zn (µg/g)	K (meq/100g)	Ca (meq/100g)	Mg (meq/100g)
Land use	**	***	***	NS	**	***	**	NS	*
Soil depth	NS	NS	NS	NS	***	NS	NS	NS	NS
Depth ×Land	NS	NS	NS	NS	*	NS	NS	NS	NS

*Note: *p≤0.05, **p≤0.01, ***p≤0.001, ns = non-significant.*

Organic matter (OM)

A critical element that favorably influences soil fertility, agricultural output, and food security is soil organic carbon (SOC). However, present agricultural methods, extensive tillage, rising global temperatures and climate change have increased the possibility of SOC losses, which might have an impact on the availability of food. Therefore, varieties of management techniques have been consistently used to increase soil carbon absorption and sequestration (Dinesh *et al.*, 2022). In Kalihati Upazila, the main effect of land use was statistically significant. Still, the interaction effect of land use and soil depth showed non-significant on organic matter content in soil (Table 1). Organic matter status was significantly higher in tobacco land (1.46%) than non-tobacco land (0.96%) (Fig. 3). In Bhuapur upazila, the effect of different land use showed non-significant on OM. Still, OM status was higher in non-tobacco land (1.92) than tobacco land (1.89). It means the OM status of both tobacco and non-tobacco land was medium. The optimum (1.71 to 3.40) status) of organic matter is suitable for all crop production (Ahmed *et al.*, 2018). The result revealed that in both tobacco and non-tobacco cultivation land, OM status was lower than optimum condition. It might be due to seasonally flooded and the deposition of silt each year in the rainy season. This finding was well corroborated with Kumar *et al.* (2019) and found that in AEZ-7, Organic matter status ranged from very low to medium (0.76 to 2.33%). The OM value decreases from 1.95 to 1.78% for two consecutive years in the Kushtia district of Bangladesh (Moula *et al.*, 2018).

Table 2. Status of different properties of tobacco and non-tobacco cropland at Bhuapur Upazila.

Land	pH	OM (%)	N (%)	P (µg/g)	S (µg/g)	Zn (µg/g)	K (meq/100g)	Ca (meq/100g)	Mg (meq/100g)
Tobacco land	6.70	1.89	0.094	18.33	19.66	0.61	0.19	6.48	4.10
Status	Neutral	Medium	Very low	Optimum	Medium	Low	Medium	High	Very high
Non-tobacco land	6.68	1.92	0.096	27.35	19.83	0.52	0.16	6.80	4.16
Status	Neutral	Medium	Very low	High	Medium	Low	Medium	High	Very high
% CV	4.45	25.87	25.71	69.77	54.59	24.09	22.52	35.19	40.73
LSD at 0.05	0.30	0.50	0.02	16.12	10.91	0.13	0.04	2.36	1.70
Optimum	6.6-7.30	1.71-3.40	0.27-0.36	18.10-24.00	27.10-36.00	1.35-1.80	0.27-0.36	4.51-6.00	1.13-1.50

Note: CV= coefficient of variation, LSD= Least significance difference.

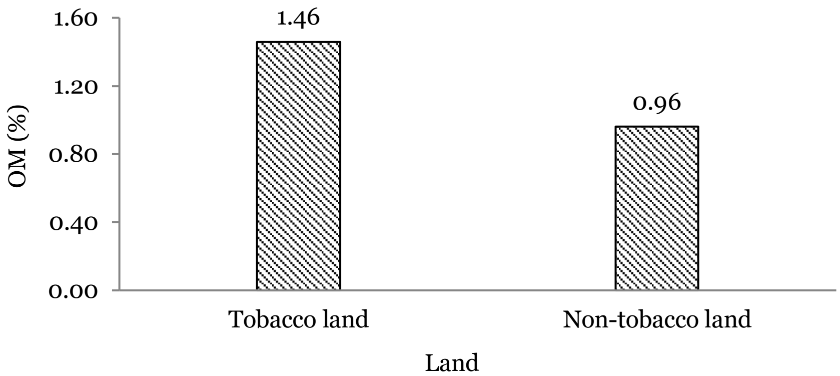

Fig. 3. Status of organic matter in tobacco and non-tobacco land use at Kalihati upazila.

Total nitrogen (N)

In Kalihati upazila, the main effect of land use showed statistically significant but soil depth and the interaction effect of land use and soil depth showed non-significant on N content (Table 1). Total nitrogen (N) status was significantly higher in tobacco land (0.07%) than non-tobacco land (0.04%) (Fig. 4). In Bhuapur upazila, the effect of different land use showed non-significant on TN content. However, nitrogen status was higher in non-tobacco land (0.096%) than tobacco land (0.094%). It means the nitrogen status of both tobacco and non-tobacco land was very low. The optimum (0.271 to 0.360%) status of nitrogen is suitable for all crop production (Ahmed *et al.*, 2018). The result reveled that both tobacco and non-tobacco cultivation lands were lower than optimum condition. It might be due to the low OM status of this land. This finding was well corroborated by Kumar *et al.* (2019). They stated that in AEZ-7, total nitrogen status ranged from very low to low (0.12 to 0.02%).

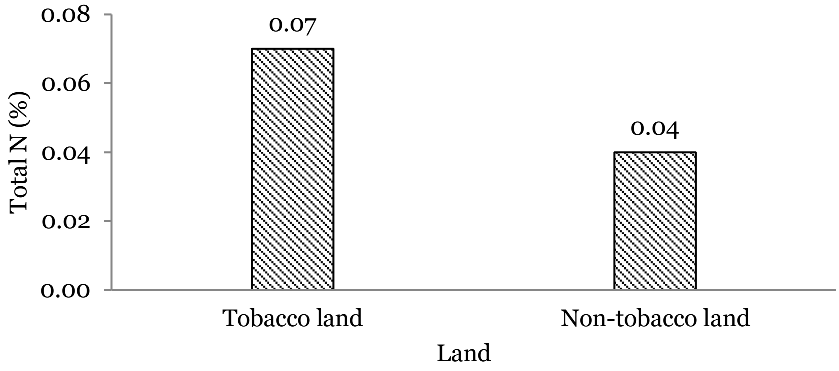

Fig. 4. Total nitrogen status of tobacco and non-tobacco land use in Kalihati upazila.

Available phosphorus (P)

In Kalihati upazila, the main effect of different land use, soil depth and the interaction effect of land use and soil depth showed non-significant on available P (Table 1). Available P content was higher in tobacco land (12.38 µg/g) than non-tobacco land (7.32 µg/g). In Bhuapur upazila, the effect of different land use showed non-significant on available P content. Nevertheless, available P content was higher in non-tobacco land (27.35 µg/g) than in tobacco land (18.33 µg/g). It means the available P status of non-tobacco land was high and tobacco land was optimum. The optimum (18.1 to 24.0 µg/g) status of available P is suitable for all crop production (Ahmed *et al.*, 2018). The result revealed that non-tobacco land was higher than optimum condition. This finding was well corroborated by Kumar *et al.* (2019). They stated that in AEZ-7, available P status ranged from very low to low (2.63 to 8.73 µg/g). The average P value decreases from 13.98 to 9.10 µg/g, which was 34.90% decrease and significant (Moula *et al.*, 2018).

Available sulfur (S)

In Kalihati Upazila, the main effect of land use was statistically significant on available S content (Table 1). Available S status was significantly higher in tobacco land (15.8 µg/g) than non-tobacco land (9.81 µg/g) (Fig. 5). It means the available S status of both tobacco and non-tobacco land was low. The result revealed that tobacco and non-tobacco cultivation lands were lower than optimum condition. It might be due to the excess use of manures and fertiliser in tobacco-cultivated land. This finding was well corroborated by Kumar *et al.* (2019). They stated that in AEZ-7, available S status ranged from low to medium (7.66 to 15.75 µg/g). The main effect of soil depth was statistically significant on available S (Table 1). The available sulfur content was significantly higher in 0 to 15 cm (17.05 µg/g) than 15 to 30 cm soil depth (8.57 µg/g) (Fig. 6).

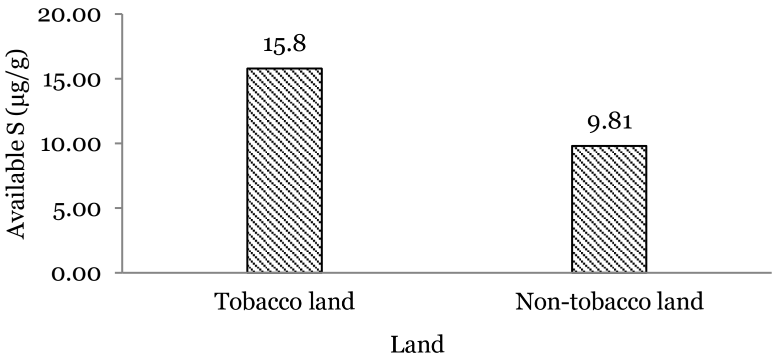

Fig. 5. Effect of land use on available sulfur content in Kalihati upazila.

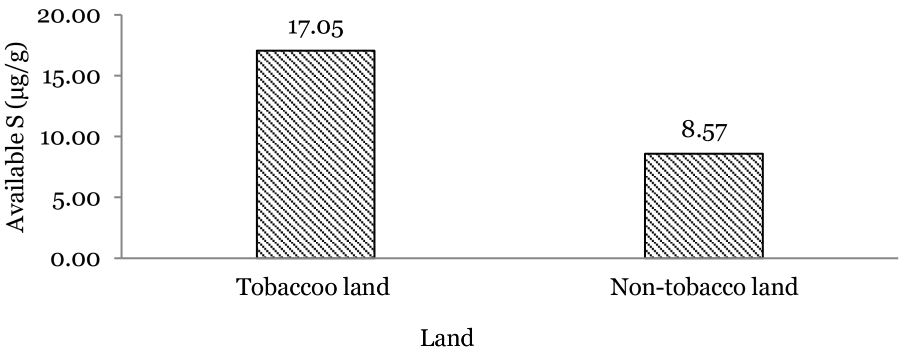

Fig. 6. Effect of depths on sulfur status of tobacco and non-tobacco land in Kalihati upazila.

The interaction effect of land use and soil depth also showed statistically significant on S content (Table 1). Available sulfur status was significantly higher in tobacco land with 0-15 cm (22.28 µg/g) and lower in non-tobacco land with 15 to 30 cm (7.81 µg/g) (Fig. 7). It means the available S status of tobacco land was medium and non-tobacco land was very low. The available S value decreased from 16.22 (2015) to 10.89 µg/g (2016) which was 32.86% less than the initial value (Fig. 5) and the difference is very much significant in tobacco-cultivated land (Moula *et al.*, 2018). In Bhuapur Upazila, the effect of different land use showed non-significant on available S content. However, available S status was higher in non-tobacco land (19.83 µg/g) than in tobacco land (19.66 µg/g). It means that the available S status of both tobacco and non-tobacco land was medium. The optimum (27.10 to 36.00 µg/g) status of S is suitable for all crop production (Table 2). The result revealed that both tobacco and non-tobacco cultivation lands were lower than optimum conditions. It might be due to seasonally flooded, intensive crop cultivation and deposition of silt each year in the rainy season.

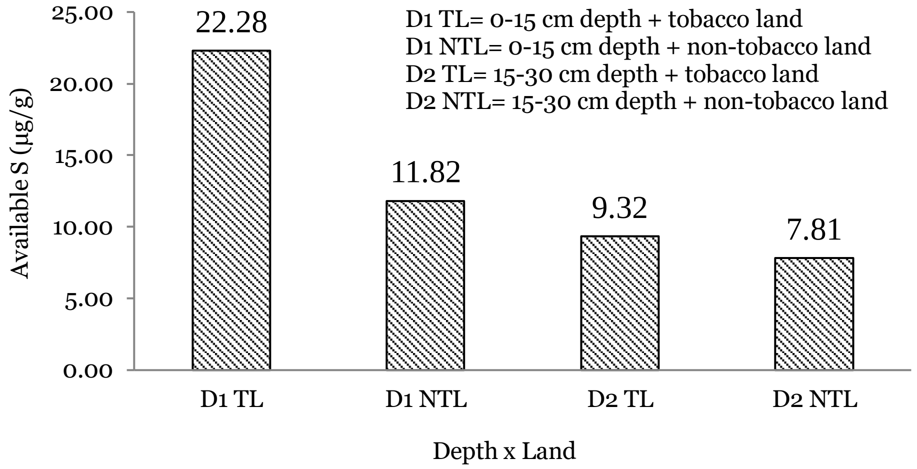

Fig. 7. Effect of soil depths and land use on available S status in Kalihati upazila.

Available zinc (Zn)

In Kalihati upazila, the main effect of land use showed statistically significant but soil depth and the interaction effect of land use and soil depth showed non-significant on available Zn content (Table 1). Available Zn status was significantly higher in tobacco land (0.42 µg/g) than in non-tobacco land (0.23 µg/g) (Fig. 8). In Bhuapur Upazila, the effect of different land use showed non-significant on available Zn content. Available Zn status was higher in tobacco land (0.61 µg/g) than in non-tobacco land (0.52 µg/g). It means the available Zn status of both tobacco and non-tobacco land was low. The optimum (1.351 to 1.800 µg/g) status of available Zn is suitable for all crop production (Ahmed *et al.*, 2018). The result revealed that both tobacco and non-tobacco cultivation lands were lower than optimum conditions. It might be due to seasonally flooded, imbalanced fertiliser use and silt deposition each year in the rainy season. This finding was well corroborated by Kumar *et al.* (2019). They stated that in AEZ-7, available Zn status ranged from medium to optimum (0.24 to 1.44 µg/g). The Zn status decreased from 0.70 to 0.53 µg/g, which is 24.58% less in tobacco-cultivated land (Moula *et al.*, 2018).

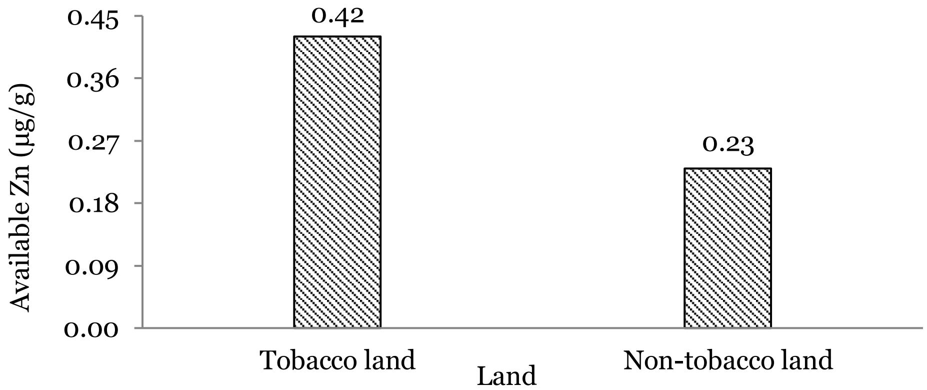

Fig. 8. Available Zn content of tobacco and non-tobacco land use in Kalihati upazila.

Exchangeable potassium (K)

In Kalihati upazila, the main effect of land use showed statistically significant but soil depth and the interaction effect of land use and soil depth showed non-significant on exchangeable K content (Table 1). Exchangeable K status was significantly higher in tobacco land (0.18 meq/100g) than non- tobacco land (0.12 meq/100g) (Fig. 9). In Bhuapur upazila, the effect of different land use showed non-significant on exchangeable K content. However, exchangeable K status was higher in tobacco land (0.19 meq/100g) than non-tobacco land (0.16 meq/100g). It means exchangeable K status of both tobacco and non-tobacco land was medium. The optimum (0.271 to 0.36 meq/100g) status of exchangeable K is suitable for all crop production (Ahmed *et al.,* 2018). The result revealed that both tobacco and non-tobacco cultivation lands were lower than optimum conditions. It might be due to seasonally flooded, imbalanced used of fertiliser and deposition of silt each year in the rainy season. This finding was well corroborated by Kumar *et al.* (2019). They stated that in AEZ-7, exchangeable K status ranged from very low to high (0.08 to 0.40 meq/100g). According to Islam *et al.* (2020b), the mean exchangeable K level was low (0.19 meq/100g) in Kalihati Upazila of Tangail.

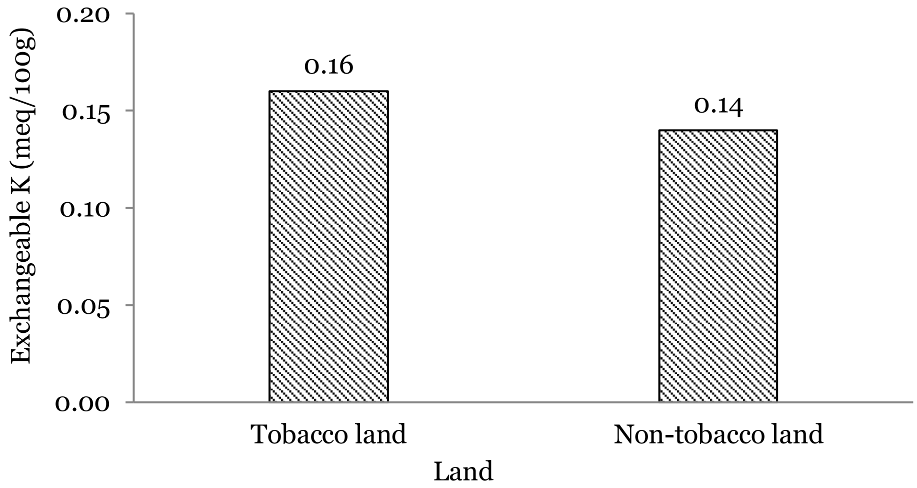

Fig. 9. Exchangeable potassium status of tobacco and non-tobacco land use in Kalihati upazila.

Exchangeable calcium (Ca)

In Kalihati upazila, the main effect of different land use, soil depth and the interaction effect of land use and soil depth showed non-significant on exchangeable Ca (Table 1). Exchangeable Ca status was higher in non-tobacco land (6.38 meq/100g) than in tobacco land (4.93 meq/100g). In Bhuapur Upazila, the effect of different land use showed non-significant on exchangeable Ca status. But exchangeable Ca status was non-significantly higher in non-tobacco land (6.80 meq/100g) than tobacco land (6.48 meq/100g). It means the exchangeable Ca status of both tobacco and non-tobacco land was high. The optimum (4.51 to 6.0 meq/100g) status of exchangeable Ca is suitable for all crop production (Ahmed *et al.,* 2018). The result revealed that both tobacco and non-tobacco cultivation lands were higher than optimum condition. This finding was well corroborated with Kumar *et al.* (2019). They stated that in AEZ-7, exchangeable Ca status ranged from medium to very high (2.50 to 2.67 meq/100g). The mean Ca content was found optimum (5.72 meq/100g) in all types of lands in Kalihati upazila (Islam *et al.*, 2020b).

Exchangeable magnesium (Mg)

In Kalihati upazila, the main effect of land use was statistically significant, but soil depth and the interaction effect of land use and soil depth were non-significant on Mg content (Table 1). Magnesium status was significantly higher in non-tobacco land (4.16 meq/100g) than tobacco land (2.26 meq/100g) (Fig. 10). In Bhuapur upazila, the effect of different land use showed non-significant on Mg content. However, Mg status was higher in non-tobacco land (4.16 meq/100g) than tobacco land (4.10 meq/100g). It means Mg status of both tobacco and non-tobacco land was very high. The optimum (1.126 to 1.5 meq/100g) status of exchangeable Mg is the suitable for all the crop production (Ahmed *et al.,* 2018). The result reveled that both tobacco and non-tobacco cultivation lands were higher than optimum condition. This finding was well corroborated with Kumar *et al.* (2019). They stated that in AEZ-7, exchangeable Mg status ranged from optimum to very high (1.31 to 2.42 meq/100g). According to Islam *et al.* (2020b), the mean Mg (2.07 meq/100g) was found very high in Kalihati upazila of Tangail.

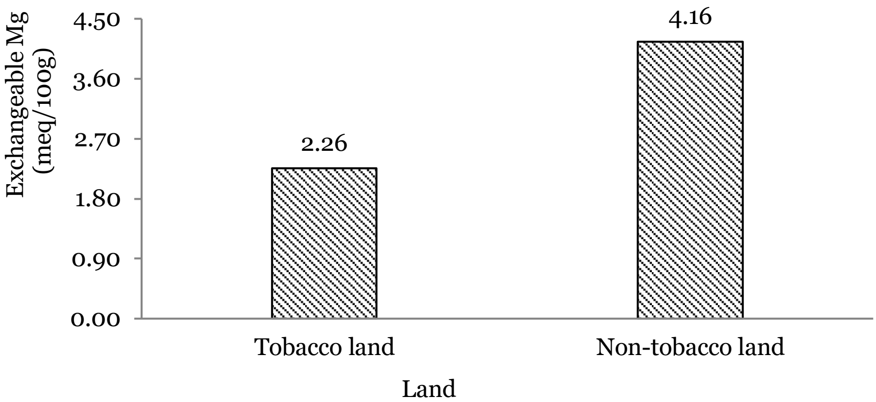

Fig. 10. Exchangeable Magnesium status of tobacco and non-tobacco land use in Kalihati Upazila.

Impact on human health

One hundred individuals participated in a survey, 40 of them were farmers, while the rest were locals using smokeless tobacco products like zarda, sadapata, gul, etc. The farmer claimed that they followed appropriate safety precautions during curing. Some tobacco farmers are dealing with a number of illnesses, mostly respiratory and skin-related. Among them, 9% of them have coughing fits, 14% have dental decay, 5% have hand sores and 8% have allergies (Table 3). A total of 64% of those surveyed in the study region don't know the health impacts and are unaware of the number of diseases that happened during treatment and when smokeless tobacco was used.

Table 3. Health problems of tobacco farmers and local people due to tobacco consumption.

Sl.	Disease	Percentage (%)
1	Coughing	9
2	Tooth decay	14
3	Sores in hand	5
4	Allergy	8
5	No problem	64

Conclusions

In Kalihati Upazila, non-tobacco land showed significantly higher pH value and Mg status, whereas tobacco land showed lower. Similarly, tobacco land showed significantly higher OM, N, K, S, and Zn content in the soil, whereas non-tobacco land showed lower. Calcium and Phosphorus content was insignificant in respect of land use. Surface soil (0 to 15 cm) showed significantly higher S content, whereas 15 to 30 cm soil depth showed lower. Other soil properties showed a non-significant effect in respect of soil depth. Surface soil with tobacco land showed significantly higher S content, whereas non-tobacco land and 15 to 30 cm soil depth showed lower. On the contrary, in Bhuapur Upazila, land use showed non-significant on soil properties. In Kalihati Upazila, the pH value of both tobacco and non-tobacco land was slightly alkaline. The organic matter status of tobacco land was low and non-tobacco land was very low, which was lower than optimum level. However, N, P, K, S and Zn status of both tobacco and non-tobacco land were lower than optimum conditions. Only Ca and Mg status showed higher than optimum level. The nutrient statuses were higher in 0 to 15 cm depth than 15 to 30 cm depth. On the contrary, in Bhuapur upazila, the pH value of both tobacco and non-tobacco land was neutral, and suitable for all crop production. The organic matter status of both tobacco and non-tobacco land was medium. The nitrogen status of both tobacco and non-tobacco land was very low which was lower than the optimum level. The phosphorus status of non-tobacco land was high, and tobacco land was optimum. The potassium status of both tobacco and non-tobacco land was medium that was not suitable for all the crop production. The sulfur status of both tobacco and non-tobacco land was medium which was lower than optimum level. Zinc status of both tobacco and non-tobacco land was low which was lower than optimum level. Calcium status of both tobacco and non-tobacco land was high which was higher than optimum condition. Magnesium status of both tobacco and non-tobacco land was very high which was higher than optimum level. This study recommended that tobacco land should be replaced by other food or cash crops so that soil health can be conserved, food security of these regions can be protected and finally human health can be maintained safely.

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