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Effects of tobacco cultivation on chemical properties of agricultural soils

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Abstract. Tobacco is grown intensively in the north western region of Bangladesh. The farmers in that region in Bangladesh receive less production of the next crop of tobacco and experience economical loss. In order to determine the impact of tobacco cultivation on soils, 20 soil samples (10 from tobacco cultivated land and 10 from non-tobacco cultivated land) were collected from the study area. The samples were analyzed for soil pH, organic matter, humidity, macronutrients (N, P, K, S, Ca and Mg) and micronutrients (Zn, Fe, Mn, Cu and B). The concentration of available phosphorus (23.22 µg/g), total nitrogen (0.084 %), calcium (798 µg/g), magnesium (438 µg/g), zinc (1.00 µg/g), manganese (1.70 µg/g), boron (0.17 µg/g), soil pH, organic matter and humidity were higher in tobacco cultivated land than those of the non-tobacco cultivated land. In contrast, concentration of total potassium (148.2 µg/g), copper (2.40 µg/g) and iron (10.82 µg/g) in tobacco lands were lower than those of the non-tobacco land. The highest available sulfur (10.47 µg/g) was observed in tobacco cultivated lands. Soil magnesium level increased with increasing pH although the potassium level decreased with the increase of pH of the tobacco cultivated soils. Future studies are required to determine the effects of tobacco cultivation on the quantity and variety of microorganisms in soils.

Introduction

Bangladesh is one of the highest tobacco consuming countries in the world. According to Global Tobacco Surveillance System (2009), which was conducted on adult tobacco consumer around the world, it is estimated that over 46.3 million people ages 15 and older consume tobacco products, including over 43% of all men and nearly 29% of women (Barkat and Chowdhury, 2012). There are varieties of tobacco users in Bangladesh, ranging from youth to adult, from male to female, differing variety of different products. Men are much more likely to smoke than women, with smoking prevalence among men at nearly 45%, as compared to 1.5% among women (GYTS, 2008). During the 1960's arable fields in Bangladesh were cultivated with food crops, but after the liberation in 1971, tobacco cultivation was started by American tobacco companies in Teesta, Nilphamari and Rangpur District (Sarkar and Haque, 2001).

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Tobacco cultivation has many negative impacts both on the environment and tobacco growers, but these adverse impact is experienced differently by developed, developing and underdeveloped countries in the world (Arcury et al., 2006; Reichert et al., 2019). Tobacco cultivation has a lot of impact on the environment such as deforestation, environmental pollution due to use of agrochemicals and depletion of soil fertility (Yanda, 2010). The crop is a heavy feeder on soil nutrients and as a result depletes soil nutrient very fast compared to other crops, thereby making such soils unsuitable for healthy plant growth (Moula et al., 2018; Trenbath, 1986; Yanda, 2010). It depletes soil nutrients so much fast that subsequent food crops do not benefit from the residual fertilizer applications. Tobacco plants require more chemical fertilizer and pesticides, which absorb phosphorus, potassium and nitrogen more than any other crops, which decrease soil fertility than any other cultivating crops (Kutub and Falgunee, 2015). Topping and suckering are two types of specific cultivation methods use to gain high level of nicotine and more leaves that reduce the soil fertility (Geist, 1999).

Energy and fuel wood crisis concerns caused by tobacco cultivation is increasing, which was started after 1970s in America (Muller, 1978; Goodland et al.,1984). The excessive synthetic fertilizer use in tobacco cultivation causes environmental degradation that was also experienced during green revolution (Ganiger et al., 2012). Soil is a heterogeneous body and varies in characteristics. Different soils have different requirements for fertilizers, liming, and irrigation and tillage practices depending on the physical and chemical characteristics of soils. Evaluation of physical and chemical characteristics of soil is helpful for economic use of fertilizers and irrigation water which, in turn, may help in maximizing crop production (Scotter et al., 1979). Keeping all these views in mind, we aimed to reveal the effects of tobacco cultivation in two agricultural soils in Bangladesh.

Experimental

Material and Methods

The collected soil samples (about 500 g for each one) were air dried ground and sieved for analysis. The pH was measured by Soil pH and Moisture Meter (ZD% PM 0909, USA). The organic matter (OM) content was analyzed titrimetrically according to Walkley and Black's wet oxidation method (Walkley and Black, 1934). The iron (Fe) was determined by Rapid Colorimetric Technique (Huq and Alam, 2005). The exchangeable potassium in soil was determined by ammonium acetate extraction method (Sattar and Rahman). Total nitrogen (N) content of soil was determined by Micro kjeldahl method. Available soil phosphorus (P) was determined by Olsen's method. The samples were read with the help of a spectrophotometer at 660 nm wave length. The available sulphur (S) was analyzed by calcium chloride extraction method (Sattar et al., 1987). Total calcium (Ca) and magnesium (Mg) were determined by Ethylenediamene Tetra acetic acid titration. Available zinc (Zn), copper (Cu) and manganese (Mn) were determined by atomic absorption spectrophotometer (AAS, UNICAM 969) at the wavelengths of 213.9, 324.8 and 279.5, respectively (Huq and Alam, 2005). The boron (B) was analyzed according to Hot-water extraction method by dilute calcium chloride solution (Wolf, 1971).

Results and Discussion

Soil pH

Soil pH in tobacco cultivated land ranged from 7.65 to 7.45 (average 7.53). The values are higher than those of the previous study of Daulatpur (6.72), mirpur (6.99) and Jhenaidah soil (6.91), where soil pH increased slightly after harvesting of tobacco (Rana, 2014). On the other hand, in non-tobacco cultivated land soil pH range from 7.65 to 7.20 (average 7.46). Figure 1(a) shows sample wise variation of soil pH in tobacco cultivate and non-tobacco land. The highest value of pH (7.65) in tobacco cultivated land was found in the location 2 of sample 4 (Narayanpur and Daulatpur) and the lowest pH value (7.45) was found in the location 5 of sample9 at Shimulia, Mirpur. The highest value of pH (7.65) and the lowest pH value (7.20) in non-tobacco cultivated land were found in the same location 5 of sample 9 and 10 at Shimulia, Mirpur.Soil pH in the selected locations of Kushtia exhibit increasing and decreasing trend both for tobacco and non-tobacco land and the soil types are slightly alkaline in condition in all locations after harvesting of tobacco and other crops.

Available phosphorus (P)

In the present study available phosphorus in tobacco cultivated land range from 16.3μg/g to 32.95μg/g (average 23.22 μg/g), and in the non-tobacco cultivated land available phosphorus range from 15.4 μg/g to 38.7 μg/g (average 22.22 μg/g). Highest (32.95 μg/g) and lowest (16.3 μg/g) value of available phosphorusin tobacco cultivated land was found in the same location 4 of sample 8 and sample 7 atKhanpara, Bheramara. Highest value (38.69μg/g) of available phosphorus in non-tobacco cultivated land was found at sample9 (Shimulia, Mirpur) in location 5 and the lowest value (15.5 μg/g) of available phosphorus was found in the location 3 of sample6 (Shatbaria, Bheramara) (Figure 1b). There is a significant difference in the location 3 of sample 6. The values are higher than the previous study of Daulatpur (21.61 μg/g), Mirpur (22.39 μg/g) and Jhenaidah soil (26.22 μg/g) (Rana, 2014). Available phosphorus in soils of tobacco land may increased due application of excessive phosphate as fertilizer during tobacco cultivation. Excess phosphorus in plants may inhibit the uptake of iron, which is necessary for the development and function of chlorophyll and range of plant enzymes and proteins.

Exchangeable potassium (K)

Soil exchangeable potassium in tobacco cultivated land ranged from 120.9 μg/gto 226.2 μg/g (average 148.2 μg/g). Oppositely, in non-tobacco cultivated land exchangeable potassium range from 105.3 μg/g to 218.4 μg/g (159.9 μg/g), Figure 1(c) shows the significant difference in the location 3 and 4 of sample 6 and 8. The mean value (148.2 μg/g) of present studyis higher than the previous study of Kushtia (70.2 μg/g) (Kutub and Falgunee, 2015). Lower amount of exchangeable potassium in tobacco cultivated land may happen due to enhance uptake of K+ contents by tobacco plants.

Total nitrogen (N)

Total nitrogen in tobacco cultivated land range from 0.07%

to 0.10% (average 0.08%). Alternatively, in non-tobacco cultivated land total nitrogen range from 0.07% to 1% (0.8%). Highest (0.10%) and lowest (0.07%) value of total nitrogen in tobacco cultivated land was found in location 5 of sample 9 (Shimulia, Mirpur) and location 3 of sample 5 (Shatbaria, Bheramara). Highest value (0.09%) of total nitrogen in non-tobacco cultivated land was found in sample10 (Shimulia, Mirpur) and lowest value (0.07%) was found in sample3 (Narayanpur, Daulatpur) in the location of 5 and 2 (Figure 1d). These values are similar with the previous study of Daulatpur (0.06%), Mirpur (0.11%) and Jhenaidha soil (0.09%) (Rana, 2014). Figure 1(d) shows the significant difference among the samples in the location 5 of sample 9. The highest amount of nitrogen content in tobacco cultivated land may occur due excess amount of nitrogenous manures and fertilizers used for tobacco cultivation.

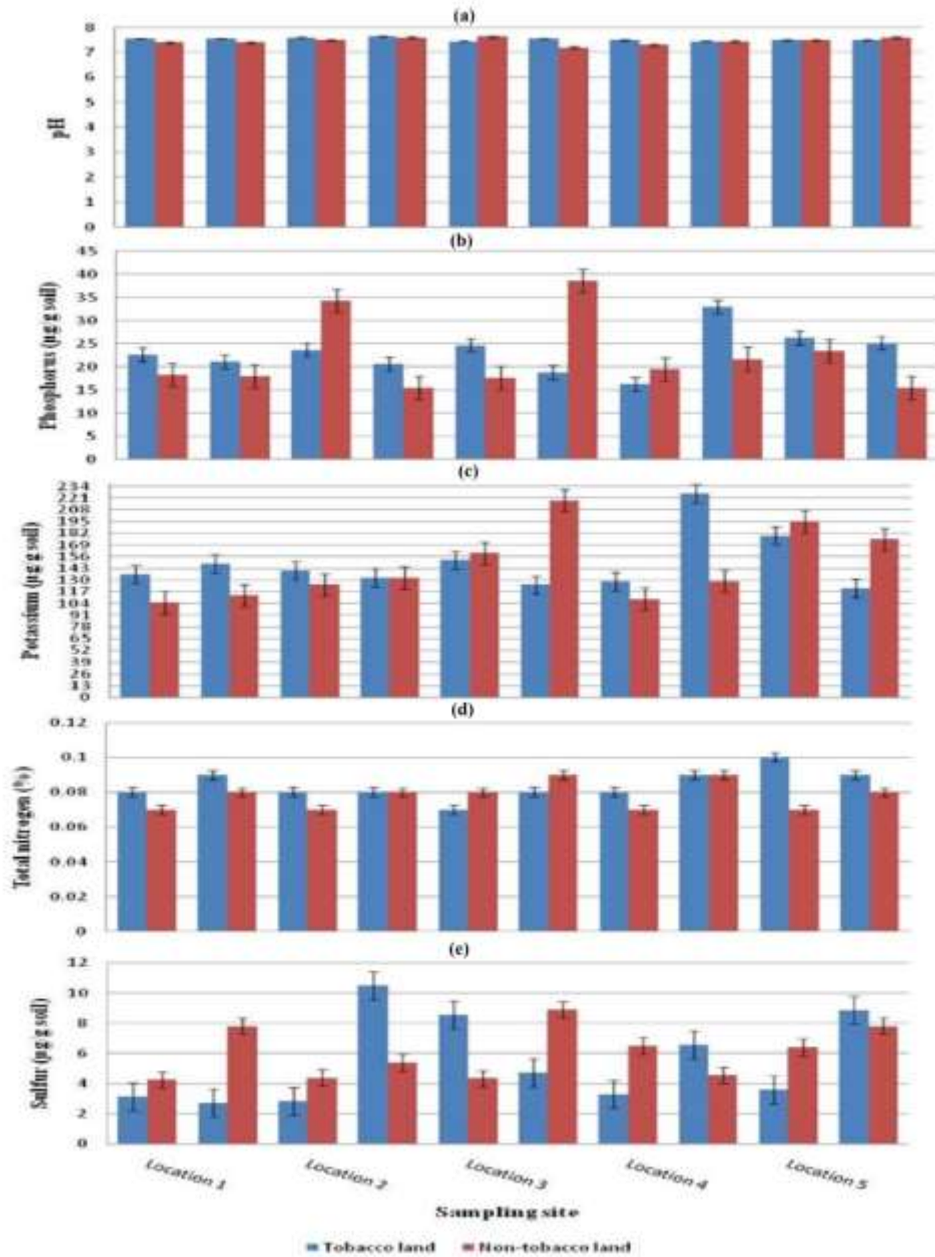

Figure 1. Variation of (a) soil pH, (b) phosphorus, (c) potassium, (d) total nitrogen and (e) sulfur in tobacco and non-tobacco cultivated lands of the study area.

Available sulfur (S)

In present study soil available sulfur in tobacco cultivated land range from 2.73 μg/g to 10.47 μg/g (average 5.45 μg/g). In contrary, in non-tobacco cultivated land available sulfur range from 4.23 μg/g to 8.90 μg/g (6.02 μg/g). As shown in Figure 1(e) highest value of available sulfur (10.47 μg/g) in tobacco cultivated land was found in sample 4 (Narayanpur, Daulatpur) and the lowest value (2.73 μg/g) was found in sample 2 (Rifayetpur, Daulatpur) in the location 1 and 2. Highest value (8.90 μg/g) of available sulfur in non-tobacco cultivated was found in sample 10 (Shimulia, Mirpur) and lowest value (4.23 μg/g) of available sulfur was found in sample 1 (Rifayetpur, Daulatpur) in the location of 5 and 1 respectively. The values are lower than the previous study of Daulatpur (21.78 μg/g), Mirpur (10.96 μg/g) and Jhenaidah soil (12.2 μg/g) (Rana, 2014). Excessive sulfur in non-tobacco land may indicate that the enhance amount of sulfur addition in soil for the cultivation of oil crops, legume, forage and some vegetables as their growth require more available sulfur.

Calcium (Ca)

In the present study calcium in tobacco cultivated land range from 522 μg/g to 1356 μg/g(average 798 μg/g). On the other hand in non-tobacco cultivated land soil calcium range from 490μg/g to 1046 μg/g(630 μg/g). As shown in Figure 2(a) there is a far difference in the location of 2 (sample 3). The values of present study are lower than the previous study of Kushtia, where soil calcium range was 690 μg/g to 2272 μg/g (Akter, 2003). This increment in calcium content in tobacco cultivated soil might be due to application of calcium as an additive while applying phosphorous from TSP and SSP and sulfur from gypsum fertilizer.

Magnesium (Mg)

Soil magnesiumin tobacco cultivated land range from 253.2 μg/g to 631.2 μg/g (average 438 μg/g). On the other hand in non tobacco cultivated land soil magnesium ranged from 234.2 μg/g to 514.8 μg/g (404.4 μg/g). Highest value of magnesium (631.2 μg/g) in tobacco cultivated land was found at sample 10 (Shimulia, Mirpur) and lowest value (253.2 μg/g) was found at sample4 (Narayanpur, Daulatpur) in the location of 5 and 2. Highest value (514.8 μg/g) of magnesium in non-tobacco cultivated land was found at sample3 (Narayanpur, Daulatpur) and lowest value (234 μg/g) of magnesium was found at sample8 (Khanpara, Daulatpur) in the location of 2 zand 4 (Figure 2b). The values are higher than the previous study of Kushtia, where soil magnesium ranged from 86.4 μg/g to 301.2 μg/g (Akter, 2011). Interestingly, we detect high pH in tobacco cultivated land. High level of magnesium in soil may create potassium deficiency in plant tissue.

Organic matter

In present study soil organic matter in tobacco cultivated land range from 2.0% to 1.40% (average 1.68%), respectively. On the other hand in non-tobacco cultivated land soil organic matter range from 1.80% to 1.30% (1.57%) (Figure 2c). Highest value of organic matter (2.0%) in tobacco cultivated land found at the sample 9 (Shimulia, Mirpur) and the lowest value (1.30%) found at the sample 5 (Shatbaria, Bheramara) in the location of 5 and 3. Highest value of organic matter (1.80%) in non-tobacco cultivated land was found at the sample 10 (Shimulia, Mirpur) and the lowest organic matter value (1.30%) was found at sample 6 (Shatbaria, Bheramara) in the location of 5 and 3. The values are slightly higher than the previous study of Daulatpur (1%), Mirpur (1.40%) and Jhenaidha soil (1.53%) (Rana, 2014). Enhancement of OM content in soils of the selected tobacco land of Kushtia district may increase due to the addition of organic manures and crop residues after harvesting.

Soil humidity

In current study soil humidity in tobacco cultivated land range from 1.86% to 3.08% (average 2.29%). On the other hand, in non-tobacco cultivated land soil humidity range from 2.16% to 2.68% (2.38%) (Figure 2d). The highest value of soil humidity (3.10%) in tobacco cultivated land found in the location 2 of sample 4 (Narayanpur, Daulatpur) and the lowest value (1.86%) was found in location 5 of sample 10 (Shimulia, Mirpur). Highest value of soil humidity (2.68%) in non-tobacco cultivated land was found at the sample 3 (Narayanpur, Daulatpur) and the lowest value (2.16%) was found at sample 1 (Rifayetpur, Daulatpur) in the location of 2 and 1 respectively. Soil humidity in non-tobacco cultivated land may slightly high because of the water uptake capacity of tobacco plant is higher than the other plants.

Zinc (Zn)

Table 1 presents the values of zinc in tobacco and non-tobacco cultivated land. In the present study soil zinc in tobacco cultivated land range from 0.86μg/g to 1.16 μg/g (average1μg/g), respectively. On the other hand in non-tobacco cultivated land soil zinc range from 0.81 μg/g to 1.08μg/g(0.98μg/g). Highest value of zinc (1.16 μg/g) in tobacco cultivated land was found at sample9 (Shimulia, Mirpur) and lowest value (0.86 μg/g) was found at sample 5 (Shatbaria, Bheramara) in the location of 5 and 3. Highest value (1.08 μg/g) in non-tobacco cultivated land was found at sample 1 (Rifayetpur, Daulatpur) and lowest value (0.81 μg/g) was found at sample4 (Narayanpur, Daulatpur) in the location of 1 and 2. The values are similar with the previous study of Kushtia soil (1.22μg/g) (Akter et al., 2012). Zn is considered most toxic in soils in terms one of the food chain input. These metals may cause contamination of food crops planted after tobacco cultivation, which may lead to health problems in human beings and other animals (Oloo,2016).

Iron (Fe)

Table 1 presents the values of iron in tobacco and non-tobacco cultivated land. In the present study, soil iron in tobacco cultivated range from 6.8µg/g to 16.2 µg/g (average 10.82µg/g), respectively. On the other hand, in non-tobacco cultivated land iron range from 9.38 µg/g to 19.46 µg/g (14.94µg/g), respectively. The values are higher than the previous study of Kushtia soil (7.62µg/g) (Akter et al., 2012).This finding indicate that tobacco cultivation reduce the soil fertility by increasing soil pH as the activity of Fe decreases with the incensement of soil pH (Lindsay, 1974).

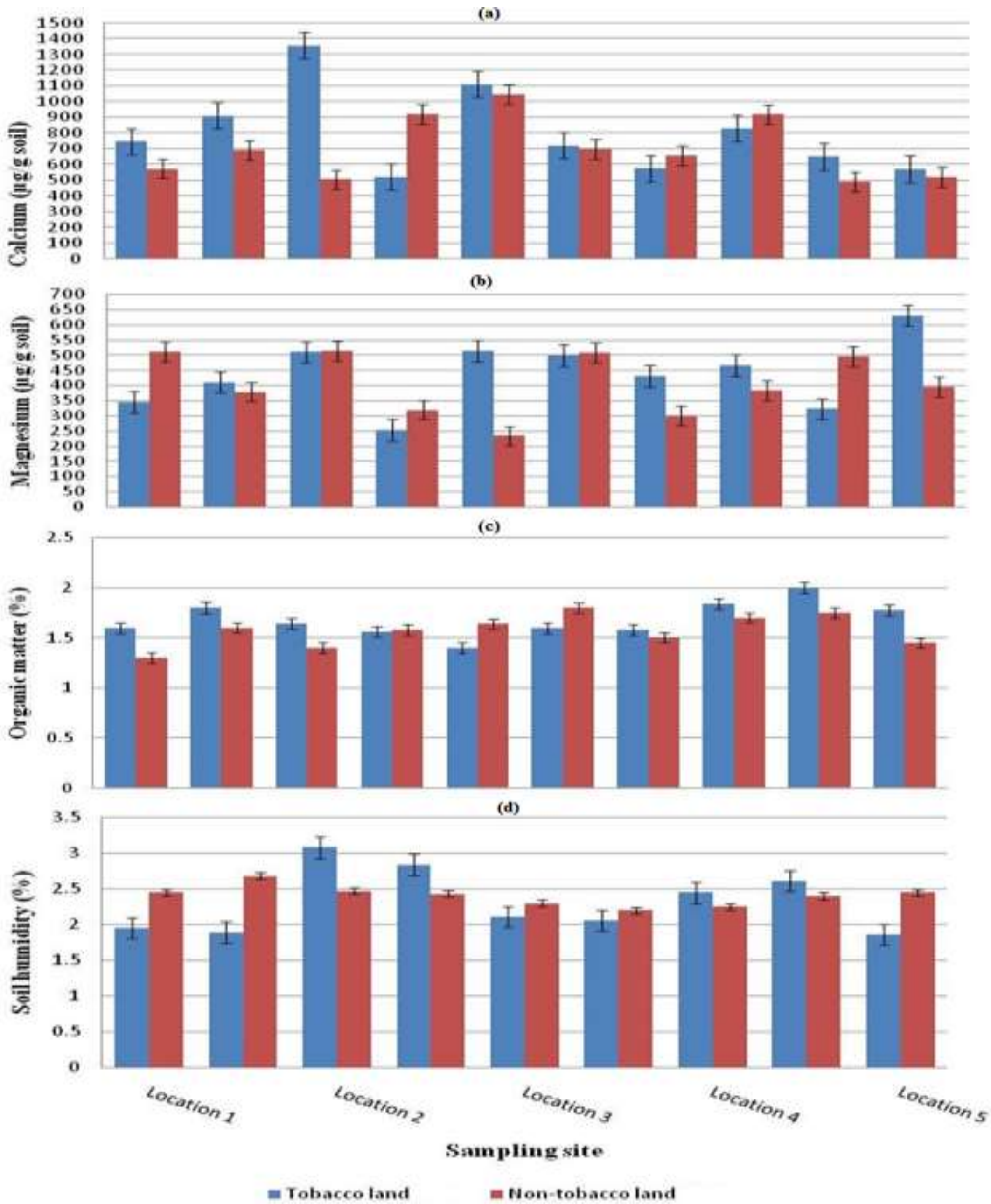

Figure 2 Variation of (a) calcium, (b) magnesium, (c) organic matter and (d) soil humidity in tobacco and non-tobacco cultivated lands of the study area.

Manganese (Mn)

Table 1 represents concentration of manganese in tobacco and non-tobacco cultivated land. In the present study, soil manganese in tobacco cultivated land range from 0.98 µg/g to 2.49 µg/g (average 1.7µg/g), respectively. On the other hand in non-tobacco cultivated land soil manganese range from 0.76 µg/g to 1.84 µg/g (1.29µg/g). The values are lower than the previous study of Kushtia soil (2.67µg/g) (Akter et al., 2012). Higher concentration of manganese in tobacco cultivated land may happens due to application of more phosphate and nitrate containing fertilizer in agricultural field. In this study declare that concentration manganese increase with the increase of soil pH, when pH is high (>7), uptake of Mn by plant is inhibited, as a result Mn deficiency occurs in plants.

Table 1. Values of micronutrients in different sample site both tobacco and non-tobacco land

Sampling site	Tobacco cultivated soil (µg/g)					Non-tobacco cultivated land (µg/g)				
	Zn	Fe	Mn	Cu	B	Zn	Fe	Mn	Cu	B
Location 1	0.98	6.88	1.55	2.56	0.15	1.08	13.48	0.86	2.53	0.06
	1.05	11.27	2.09	1.64	0.26	0.98	16.54	0.76	4.51	0.08
Location 2	1.11	16.28	1.37	1.89	0.24	1.03	11.05	1.09	2.61	0.12
	0.96	13.56	1.49	1.92	0.11	0.81	9.38	1.54	3.87	0.14
Location 3	0.86	12.08	0.98	1.54	0.08	0.94	16.28	1.62	1.98	0.19
	0.94	10.58	1.16	2.63	0.15	1.04	19.46	1.84	3.56	0.23
Location 4	0.88	9.67	1.84	3.15	0.23	0.95	12.25	0.90	2.54	0.15
	1.08	8.61	2.19	2.44	0.08	1.02	15.01	0.95	3.57	0.07
Location 5	1.16	10.85	2.49	1.58	0.18	0.95	16.50	1.50	2.50	0.20
	1.06	8.44	1.88	3.26	0.19	0.95	19.45	1.80	4.50	0.10

Available copper (Cu)

In the present study available copper in tobacco cultivated land range from 1.54 µg/g to 3.26 µg/g (average 2.4µg/g). On the other hand in non-tobacco cultivated land available copper range from 1.98 µg/g to 4.51 µg/g (3.21µg/g). The values in the location 1 of sample 2 which are significantly difference (Table 1). The values are higher than the previous study of Kushtia soil (0.56µg/g) (Akter et al., 2012). The availability of copper was found decreased in tobacco cultivated land than the non-tobacco cultivated land which might be due to excess uptake of Cu by tobacco plants (Jahiruddin and Cresser, 1990).

Boron (B)

Table 1 shows the values of boron in tobacco and non-tobacco cultivated land. In the present study soil boron in tobacco cultivated land range from 0.08 µg/g to 0.26 µg/g (average 0.17µg/g). On the other hand in non- tobacco cultivated land soil boron range from 0.06 µg/g to 0.23 µg/g (0.13µg/g). The highest value of boron (0.26 µg/g) in tobacco cultivated land was found at sample2 (Rifayetpur, Daulatpur) and lowest value of boron (0.08 µg/g) was found at sample 5 (Shatbaria, Bheramara) in the location of 1 and 3. Highest value of boron (0.23 µg/g) in non-tobacco cultivated land was found at sample9 (Shimulia, Mirpur) and lowest value of boron (0.06 µg/g) was found at sample 1 (Rifayetpurr, Daulatpur) in the location of 5 and 1. The valus are similar with the previous study of Kushtia soil (0.14µg/g) (Akter et al., 2012). Jahiruddin et al., (1992) reported that wheat yield has been increasing due to application of Boron containing fertilizer and concluded that inherent boron level of Bangladeshi soils has been declining over time. The reason for boron decrease might be mainly due to crop uptake because farmers usually do not apply any boron containing fertilizer.

Our results have revealed that the tobacco cultivation slightly degrades the quality of soil that has been also reported by Moula et al. (2018) and Reichert et al. (2019). The changes in soil physical and chemical properties due to tobacco although very slight. We need further studies to see whether the major effects on soil microbes are present due to tobacco cultivation in soils.

Conclusion

The tobacco cultivation in soils decreases the quality of soils to grow the next crop in the same agricultural land. It is observed from our study that the sulfur concentration in soils were significantly high in tobacco cultivated soils than the non-tobacco cultivated soils. The mean value of organic matter (OM) and calcium in tobacco cultivated land was higher than the non-tobacco land. Soil exchangeable potassium (K+) was lower in tobacco land compared to the non-tobacco cultivated land. The study advises that there is little change in the physical and chemical parameters of soils due to tobacco cultivation in agricultural lands. We assume that the crop reduction in tobacco cultivated lands might be not due to the changes in physical and chemical properties but due to the changes in microbial community. The tobacco cultivation might create toxicity for beneficial microorganisms. So future study is warranted to determine the effects of tobacco cultivation on the toxicity of tobacco plants on microorganisms.

Conflict of Interest

The authors declare that there is no conflict of interest.

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