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Investigation of soil properties and pesticide intensity in crop lands at Tangail region of Bangladesh

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ABSTRACT

The study was conducted to investigate the soil properties and pesticide intensity in rice, banana and brinjal growing agricultural land of Delduar and Sakhipur upazila of Tangail district during July 2019 to June 2020. Forty five soil samples were collected from different crop land at the study area and analyzed in the Soil Resource Development Institute to determine the soil properties as pH, total 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). However, pesticide used intensity was also evaluated through questionnaire survey with farmers and stakeholders in the study area. Results showed that pH, OM, available N, exchangeable Ca and exchangeable Mg content were significantly higher in rice growing land than banana and brinjal. On the other hand, available P, exchangeable K and available Zn content were substantially higher in brinjal growing land than rice and banana. The OM showed significant positive correlation with soil pH, available N, available S, exchangeable Mg and exchangeable Ca (r=0.37, 0.99, 0.31, 0.59 and 0.63, respectively), indicated rice growing land built up these soil properties through increasing soil OM. The available P showed significant and positive correlation with K and Zn (r=0.55 and 0.74, respectively), but negative correlation with exchangeable Mg and exchangeable Ca (r=-0.53 and -0.32, respectively). The exchangeable K showed significant and positive correlation with available Zn (r=0.45) but negative correlation with exchangeable Mg (r=-0.37). The Mg showed significant negative correlation with available Zn (r=-0.45) but positive correlation with exchangeable Ca (r=0.87). Results also revealed that pesticide used intensity was higher in brinjal followed by banana and minimum in rice crop. Study suggests that farmers require up-to-date information on soil nutrient status so that they may use the proper utilization of fertilizers and avoid using excessive amounts of fertilizers and pesticides in their crop land.

Keywords: Soil fertility, Land use, Pesticide intensity, Organic matter

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Introduction

In Bangladesh, agriculture acts as a driving force of the national economy. In most of the developing countries, agricultural income plays a key role in the overall economic performance of the country, not only in terms of its contribution to gross domestic product, but also as a major source of foreign exchange earnings, providing employment to a large segment of the population (BBS, 2018). To meet the growing demand of foods, three different cropping seasons are practiced in Bangladesh (Islam *et al.*, 2020a). Modern agriculture is wholly dependent on the chemicals in the form of pesticides with aim to suppress plant and animal pests to protect agricultural and industrial products. Pesticides are bioactive, toxic substances and they directly or indirectly influence soil productivity and agro-ecosystem quality. Owing to the massive damage caused by pests to agricultural fields and crops, production often declines below the level of subsistence for farmers, which can eventually have adverse effects on the national economy (Imfeld and Vuilleumier, 2012).

About 70% pesticides are used only on rice fields (PAB, 2000) and most of the people of this country are directly or indirectly related to agriculture. Farmers rely on chemical pesticides including toxic chemicals compare to traditional and IPM method (Parveen and Nakagoshi, 2001). Thus, use of pesticides is increased over the years in this country (Meisner, 2004). Pesticide is so indispensable in agricultural production, about one-third of the agricultural products are produced by using pesticides (Liu *et al*., 2002). In a developing country like Bangladesh, more than 90% of farmers used pesticide without knowing its actual requirements, they used pesticide unnecessarily, indiscriminately and excessively at high concentration, and more frequent due to their ignorance and unconsciousness (Akhter *et al.,* 2016). In this process pesticide misuses become more and more serious, which has resulted in heavy environmental pollution and health risk of humans (Prasad *et al*., 2014). Many pesticides are not easily degradable, they persist in soil, leach to groundwater and runoff can carry pesticides into aquatic environment and contaminate the wide environment. Depending on their chemical properties they can enter the organism, bioaccumulate in food chains and consequently influence human health. Sprayed pesticides give effects other than on their target species, including effects on non-target sites such as air, water and the soil (Conway, 1984).

Soil fertility is an important factor, which determines the growth of plant. Soil fertility is determined by the presence or absence of chemical properties. The availability of chemical properties (micronutrients) is particularly sensitive to changes in soil environment. The factors that affect the contents of such micronutrients are organic matter, soil pH, lime content, sand, silt, and clay contents revealed from different research experiments (Nazif *et al.*, 2006). Soil fertility status is a complex and dynamics system that is the important quality indicator of soil. Pesticide application in most cases significantly affects the microbial properties of soil and the corresponding changes have been observed in soil-fertility as well (Cycon and Piotrowska-Seget, 2007). Thus, the study was attempted to know the soil fertility status of rice, banana and brinjal growing land, and to investigate the pesticide use intensity in rice, banana and brinjal crops.

Materials and Methods

Study area

The study area is located in Delduar and Sakhipur upazila of Tangail district, the central part of Bangladesh. The Delduar upazila is located at 24^{o}05´ to 24^{o}14´N latitudes and 89^{o}50´ to 89^{o}59´E longitudes, the Sakhipur upazila is located at 24^{o}11´ to 24^{o}26´N latitudes and 90^{o}04´ to 90^{o}18´E longitudes (Fig. 1). Main crops of the two upazila are rice, wheat, mustard, potato, onion, ginger, garlic, pulse and vegetables. The study was conducted during July 2019 to June 2020.

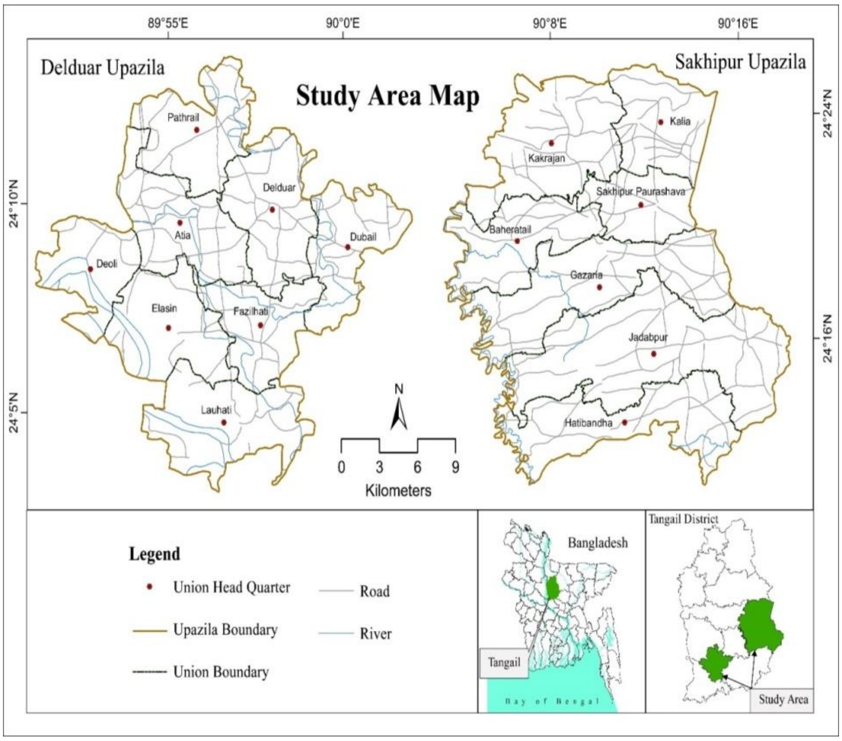

Fig. 1. Map showing the study area of Delduar and Sakhipur upazila of Tangail district.

Sample collection

Total 45 soil samples were collected from different crops land in the study area to know their nutritional status for crop production. Among them, 15 samples were collected from rice, 15 from banana and 15 from brinjal cultivated land. The samples were scraped from the top to bottom (0 to 10 cm) with the help of an auger. Then 250 g soil was taken to have a representative sample. All samples were placed in sealed polythene bags and labeled with date of collection, location and code number. From the collected samples, the gravels, pebbles, plant roots, leaves etc. were dried in air for 15 days by spreading on a clean piece of polythene bag then samples were mixed well, ground to pass through a 2-mm plastic sieve, and preserved in polythene bags for laboratory analysis. The primary information about the use of pesticide was collected through questionnaire survey techniques, which was conducted on three groups of respondents as i) farmers, ii) agrochemical dealers, and iii) Sub-assistant Agricultural Officer (SAAO) in the study area.

Sample analysis

The soil samples were dried in room temperature and carefully transported to the laboratory of Soil Resource Development Institute (SRDI), Tangail for analysis of soil pH, total organic matter (OM), total nitrogen (N), available phosphorus (P), available zinc (Zn), available sulfur (S), exchangeable potassium (K), exchangeable calcium (Ca) and exchangeable magnesium (Mg). The soil pH was determined by digital pH meter. The OM of soil sample was determined by Walkley and Black's wet oxidation method (Huq and Alam, 2005). Total N of soil samples were determined by semi-micro Kjeldhal method (Sattar and Rahman, 1987). The available P of soil was determined by using the Olsen method (Sattar and Rahman, 1987). The available Zn was determined by DTPA method (Roberts *et al.*, 1971). The available S in soil was determined by Calcium Chloride Extraction Method (Sattar and Rahman, 1987). The exchangeable K in soil was determined by ammonium acetate extraction method (Sattar and Rahman, 1987). The exchangeable Ca and Mg of soil samples were determined by EDTA (Ethylenediamene Tetra Acetic Acid) titration method (Huq and Alam, 2005).

Statistical analysis

After receiving the soil parameters laboratory test results from SRDI, data were compiled, tabulated and analyzed through Microsoft Office Excel software and SPSS (version 20.0). Pearson's correlation analysis was done to illustrate the interrelationships between the soil properties.

Results and Discussion

Soil pH

Rice growing land showed significantly highest pH (5.85) which was similar with brinjal growing land (5.79), whereas banana growing land showed the lowest pH (5.53) (Fig. 2). Neutral pH (6.6 to 7.3) is the optimum for all the agricultural crop production (Ahmed *et al.*, 2018). Soil pH of rice and brinjal growing land were slightly acidic whereas it was strongly acidic in banana growing land (Table 1). The result is well corroborated with Kumar *et al.* (2019), they found that rice cultivated medium high and medium low land had slightly acidic, whereas vegetables cultivated high land was strongly acidic in Tangail region of Bangladesh. In Kalihati upazila of Tangail, soil pH ranged from 4.85 to 6.74 (Islam *et al.*, 2020b). Excessive acidity is detrimental to soil health, which increases soil toxicity and fixed available phosphorous (Hart *et al.*, 2013).

Table 1. Soil fertility status of different crops growing lands in the study area.

Crops land	pH	OM (%)	N (%)	P (μg g^{-1})	Zn (μg g^{-1})	S (μg g^{-1})	K (meq 100g^{-1})	Ca (meq 100g^{-1})	Mg (meq 100g^{-1})
Rice	5.85 A	2.16 A	0.10 A	10.23 C	0.84 B	35.53 A	0.14 C	9.04 A	2.04 A
Status	SlA	Medium	Low	Low	Low	High	Low	Very high	Very high
Banana	5.53 B	1.64 B	0.08 B	68.12 B	3.79B	30.23 A	0.29 B	4.88 B	0.77 B
Status	StA	Low	Very low	Very high	Very high	High	Optimum	Optimum	Medium
Brinjal	5.79 A	1.83 B	0.09 B	127.21 A	4.97 A	32.78 A	0.39 A	6.09 B	0.95 B
Status	SlA	Medium	Very low	Very high	Very high	High	High	High	Medium
Optimum	6.60-7.30	1.71-3.40	0.27-0.36	22.51-30.00	1.35-1.80	22.51-30.00	0.27-0.36	4.51-6.00	1.12-1.50
% CV	5.88	19.84	19.17	45.53	54.41	30.76	42.55	35.56	31.59
LSD	0.2519	0.2793	0.0134	23.337	1.3025	7.5577	0.0872	1.7753	0.2962

Note: SlA=Slightly Acidic, StA= Strongly Acidic.

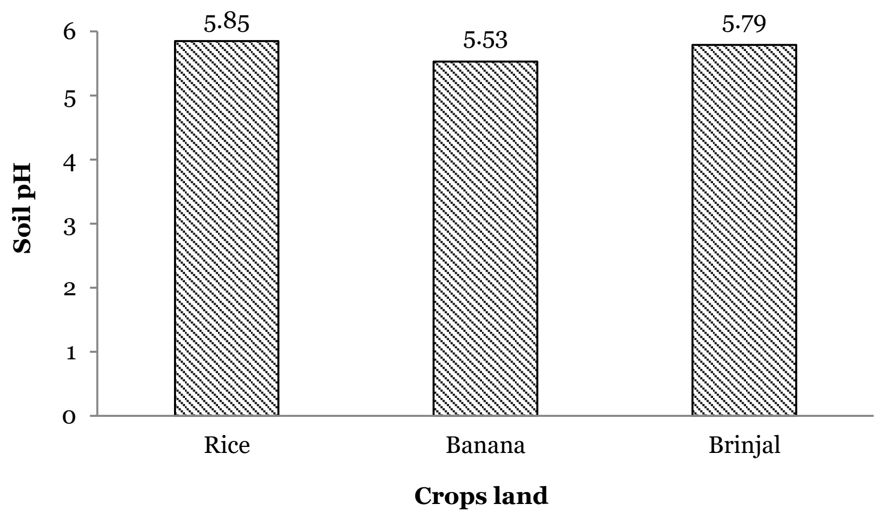

Fig. 2. The pH of different crops growing lands in the study area.

Organic matter (OM)

Rice growing land showed significantly highest OM (2.16%) whereas banana growing land showed lowest (1.64%), which was similar with brinjal growing land (1.83%) (Fig. 3). About 3.4% OM is suitable for almost all agricultural crop production (Ahmed *et al.*, 2018). The OM status of rice and brinjal growing land were medium, whereas it was low in banana growing land (Table 1). The result reveled that OM status depleted in all crop growing lands. It might be due to quick decomposition of OM in wet land rice cultivation and high oxidation rate of high land soil. Rice is cultivated in medium high land to very low land but banana and brinjal are cultivated in high land only. The decomposition rate of OM is higher in high land than other land types. That is why high land showed low OM status than others land. The OM ranged from 1.86 to 3.65% with an average of 2.30% i.e., medium status in nature (Islam *et al.*, 2020b). The OM was lower in high land (2.11%) than medium high land (2.31%) and medium low land (2.33%) (Kumar *et al.*, 2019).

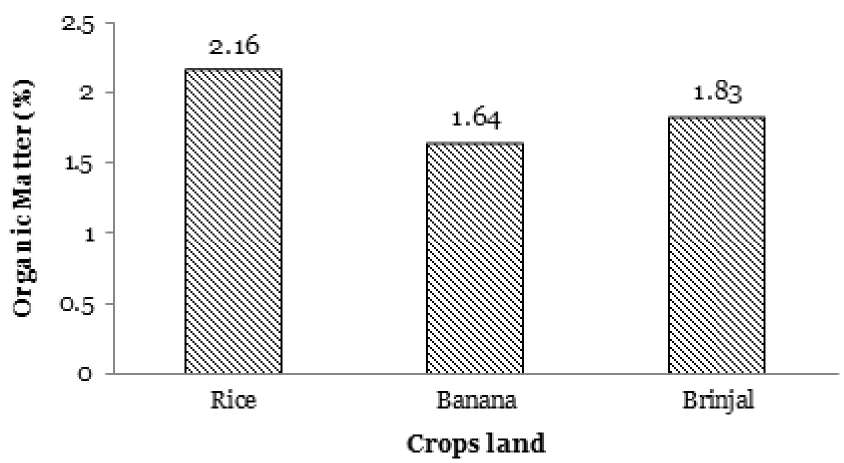

Fig. 3. The organic matter status of different crops growing lands in the study area.

Total nitrogen (N)

Rice growing land showed significantly highest total N (0.10%) in soil, whereas banana growing land showed lowest (0.08%), which was similar with brinjal growing land (0.09%) (Fig. 4). More than 0.27% is the optimum level of total N for all the agricultural crop production (Ahmed *et al.*, 2018). Total N of banana and brinjal growing land were very low whereas it was low in rice growing land (Table 1). It might be due to de-nitrification, leaching and immobilization of nitrogen from the soil. According to Islam *et al.* (2020b), total N in soil ranged from 0.09 to 0.18% with a mean of 0.12% which was below the optimum level. Total N was lower in high land (0.11%) than medium high (0.12%) and medium low land (0.12%) in Tangail district (Kumar *et al.*, 2019).

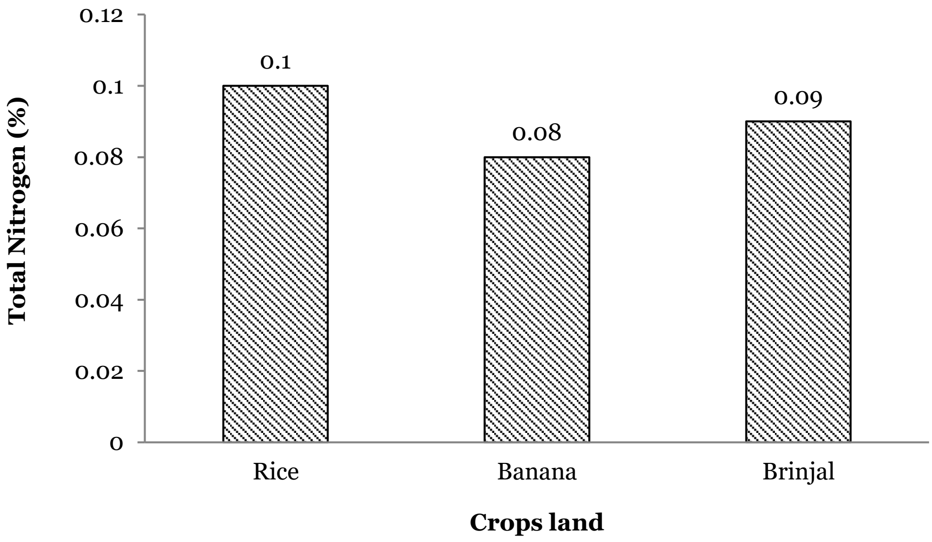

Fig. 4. Total nitrogen status of different crops growing lands in the study area.

Available phosphorus (P)

Brinjal and Banana growing land showed significantly highest available P (127.21 μg g^{-1} and 68.12 μg g^{-1}), whereas rice growing land showed lowest (10.23 μg g^{-1}) available P (Fig. 5). The optimum level of available P is 22.51 to 30.00 μg g^{-1} for all the agricultural crop production (Ahmed *et al.*, 2018). Available P of banana and brinjal growing land were very high, whereas it was low in rice growing land (Table 1). Islam *et al.* (2020b) recorded mean available P was 3.50 μg g^{-1}, which indicated very low status of nutrient in Kalihati upazila of Tangail. Available P was higher in high land (11.06 μg g^{-1}) than medium high land (5.29 μg g^{-1}) and medium low land (7.78 μg g^{-1}) in Tangail (Kumar *et al.*, 2019).

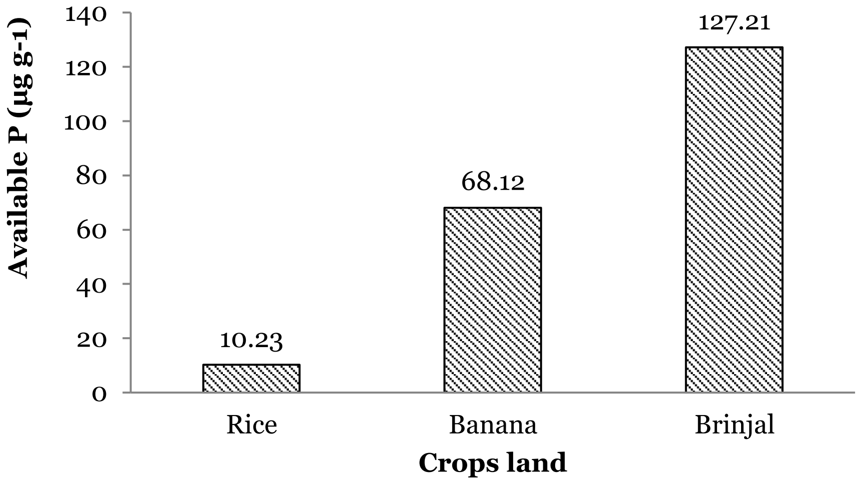

Fig. 5. Available phosphorus status of different crops growing lands.

Available zinc (Zn)

Brinjal growing land showed significantly highest Zn (4.97 μg g^{-1}), whereas rice growing land showed lowest (0.84 μg g^{-1}) and brinjal growing land was almost similar with banana (3.79 μg g^{-1}) growing land (Fig. 6). The optimum level of Zn is 1.35 to 1.80 μg g^{-1} for all the agricultural crop production (Ahmed *et al.*, 2018). Available Zn level of banana and brinjal growing land were very high, whereas it was low in rice growing land (Table 1). Available Zn content of rice growing land was not suitable but banana and brinjal growing land were suitable. According to Islam *et al.* (2020b), available Zn ranged from 0.94 to 6.35 μg g^{-1} with a mean of 3.25 μg g^{-1}, which was above the optimum (very high) range and considered more than adequate for crop production. Available Zn was higher in high land (1.56 μg g^{-1}) than medium high land (1.49 μg g^{-1}) and medium low land (0.96 μg g^{-1}) in Tangail district (Kumar *et al.*, 2019).

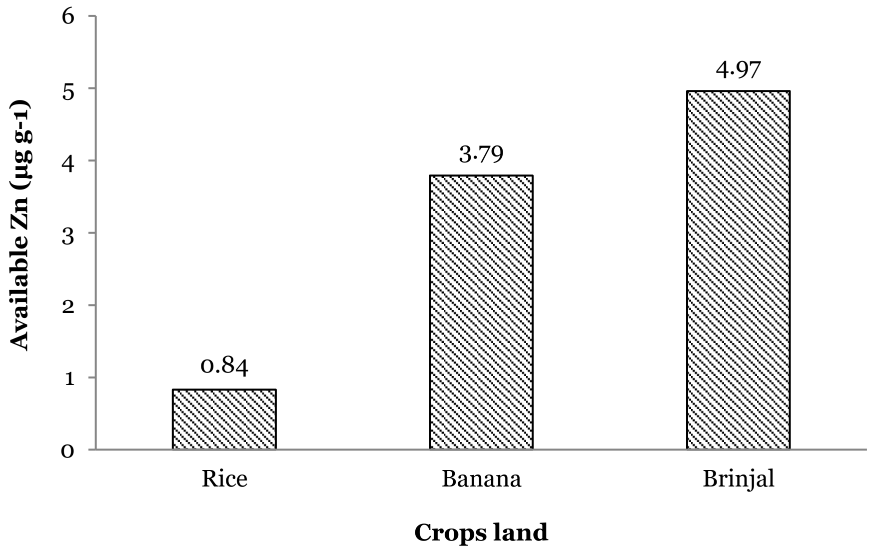

Fig. 6. Available zinc status of different crops growing lands.

Available sulfur (S)

Rice growing land showed highest available S (35.53 µg g⁻¹) which was statistically similar with brinjal (32.78 µg g⁻¹) growing land, whereas banana growing land showed the lowest (30.23 21.00 µg g⁻¹) (Fig. 7). The optimum level of available S is 22.51 to 30.00 µg g⁻¹ for all the agricultural crop production (Ahmed *et al.*, 2018). Available S level of rice, banana and brinjal growing land were high which is suitable for crop production.

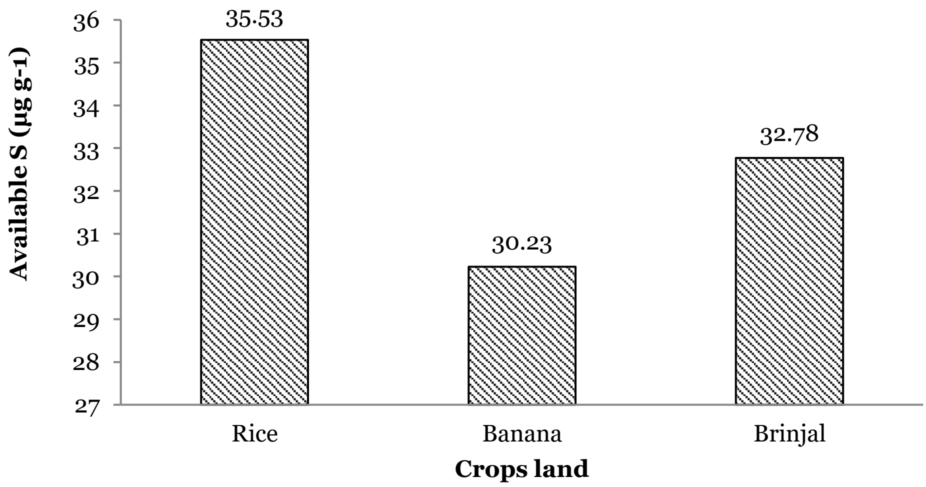

Fig. 7. Available sulfur status of different crops growing lands.

Exchangeable potassium (K)

Brinjal growing land showed significantly highest K (0.38 meq 100g⁻¹) where rice growing land showed lowest (0.14 meq 100g⁻¹) exchangeable potassium (Fig. 8). The optimum K is 0.27 to 0.36 meq 100g⁻¹ for all the agricultural crop production (Ahmed *et al.*, 2018). Potassium level of brinjal growing land was high whereas it was low and optimum in rice and banana growing land, respectively (Table 1). Potassium status of rice growing land is not suitable but banana and brinjal growing land is suitable for crop production. This might be due to excessive use of K containing fertilizer in these two crops land. According to Islam *et al.* (2020b), the mean exchangeable K level was low (0.19 meq 100g⁻¹) in Kalihati upazila of Tangail. This study is well agreed with another study where they found that the exchangeable K was higher in high land (0.21 meq 100g⁻¹) than medium low land (0.19 meq 100g⁻¹) and medium high land (0.19 meq 100g⁻¹) in Tangail district (Kumar *et al.*, 2019).

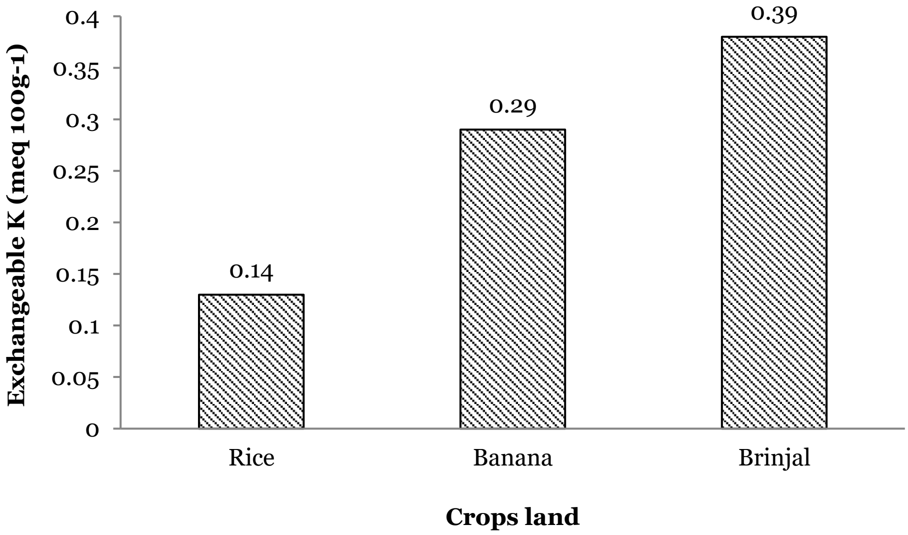

Fig. 8. Exchangeable potassium status of different crops growing lands.

Exchangeable calcium (Ca)

Rice growing land showed significantly highest Ca value (9.04 meq $100g^{-1}$) whereas banana growing land showed lowest (4.88 meq $100g^{-1}$) and this was statistically similar with brinjal growing land (Fig. 9). Exchangeable Ca content of rice, banana and brinjal growing land were very high, optimum and high (Table 1) which is suitable for crop production. In other study of the mean Ca content was found optimum (5.72 meq $100g^{-1}$) in all types of lands in Kalihati upazila (Islam *et al.*, 2020b). Kumar *et al.* (2019) reported that exchangeable Ca was lower in high land (4.56 meq $100g^{-1}$) than medium low land (5.23 meq $100g^{-1}$) in Tangail district, which supports the present study.

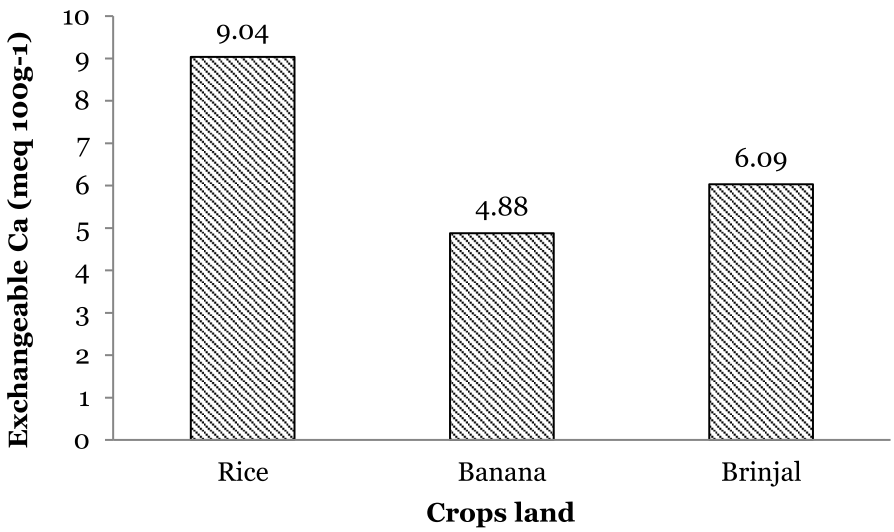

Fig. 9. Exchangeable calcium status of different crops growing lands.

Exchangeable magnesium (Mg)

Rice growing land showed significantly highest Mg (2.04 meq $100g^{-1}$) whereas banana growing land showed lowest (0.77 meq $100g^{-1}$) and this was similar with brinjal growing land (Fig. 10). Exchangeable Mg status of banana and brinjal growing land were medium but rice growing land was very high which is suitable for crop production (Table 1). According to Islam *et al.* (2020b), the mean Mg (2.07 meq $100g^{-1}$) was found very high in Kalihati upazila of Tangail. Kumar *et al.* (2019) found that exchangeable Mg was lower in high land (1.31 meq $100g^{-1}$) than medium low land (1.37 meq $100g^{-1}$) in Tangail district.

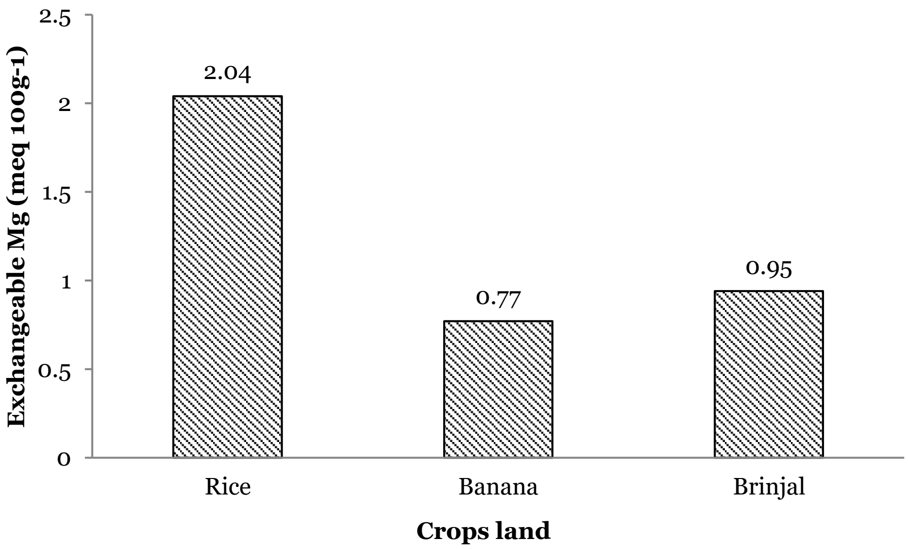

Fig. 10. Exchangeable magnesium status of different crops growing lands.

Pesticide intensity

Application of pesticide frequency was different in different land use pattern in the study area. The highest pesticide application frequency (4 times per crop) was found in brinjal and the lowest was found in rice (2 times per crop) and it was about three times per crop in banana production (Fig. 11). According to Sabur and Molla (2001), more pesticides are applied for all crops like potato, brinjal followed by rice and comparatively less pesticides used for banana (sagar) and mango production.

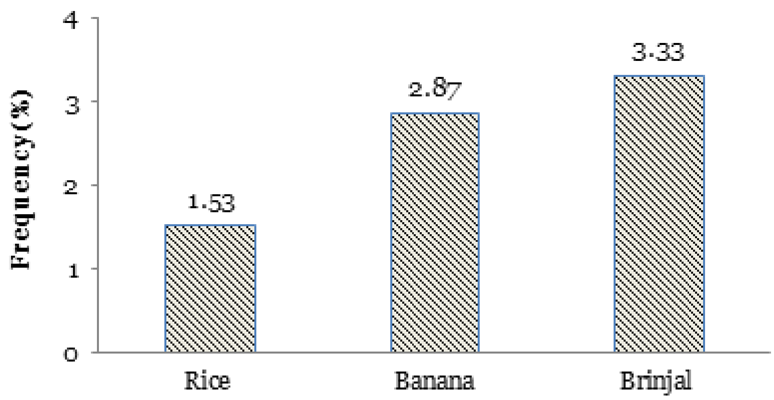

Fig. 11. Pesticide use intensity in different crops (rice, banana and brinjal).

Table 2. Correlations among the soil properties of different crops growing lands.

	pH	OM	N	P	K	S	Zn	Mg	Ca
pH	1								
OM	0.37*	1							
N	0.39**	0.99***	1						
P	-0.05ns	-0.20ns	-0.18ns	1					
K	-0.05ns	0.005ns	-0.03ns	0.55***	1				
S	-0.03ns	0.31*	0.31*	-0.05ns	0.07ns	1			
Zn	0.05ns	-0.12ns	-0.11ns	0.74***	0.45**	-0.14ns	1		
Mg	0.54***	0.59***	0.60***	-0.53***	-0.37*	0.17ns	-0.45**	1	
Ca	0.72***	0.63***	0.63***	-0.32*	-0.21ns	0.06ns	-0.27ns	0.87***	1
*P ≤ 0.05, **P ≤ 0.01, ***P ≤ 0.001, ns= non- significant									

Note: OM= Organic matter, N= Available N, P= Available P, K=Exchangeable K, S= Available S, Zn= Available Zn, Mg= Exchangeable Mg, Ca= Exchangeable Ca.

Organic matter, available N, exchangeable Mg and exchangeable Ca showed a significant positive correlation (r=0.37, 0.39, 0.54, 0.72) with pH. Available N, available S, exchangeable Mg and exchangeable Ca showed a significant positive correlation (r=0.99, 0.31, 0.59, 0.63) with OM. Available S, exchangeable Mg and exchangeable Ca showed a significant positive correlation (r=0.31, 0.60, 0.63) with available N. Exchangeable P and available Zn showed a significant positive correlation (r=0.55, 0.74) with available P, but a significant negative correlation with exchangeable Mg and exchangeable Ca (r=-0.53, -0.32). Available Zn showed a significant positive correlation (r=0.45) with exchangeable K. Exchangeable Ca showed a significant positive correlation (r=0.87, $P \leq 0.001$) with exchangeable Mg (Table 2).

Conclusions

The pH of rice and brinjal growing land was slightly acidic, and OM levels were medium, which was suitable for cultivation, but it was low in banana growing land, which posed a threat to banana production. Available N status of banana and brinjal growing land were very low whereas it was low in rice growing land, which was lower than optimum level that means more fertilizer will be required for agricultural crop production. Available P status of banana and brinjal growing land were very high that is suitable for banana and brinjal cultivation whereas it was low in rice growing land that is not suitable for rice cultivation. Exchangeable K status of brinjal growing land was high whereas it was low and optimum in rice and banana growing land. Available S status of rice, banana and brinjal growing land were high which is suitable for crop production. Available Zn status of banana and brinjal growing land were very high whereas it was low in rice growing land. Exchangeable Ca status of rice, banana and brinjal growing land were very high, optimum and high which is suitable for crop production. Exchangeable Mg status of banana and brinjal growing land were medium but rice growing land was very high which is suitable for crop production. The highest pesticides were applied in brinjal and lower in rice. To minimize loss of soil nutrients and degradation of soil quality by using excessive use of pesticide, some recommendations can be raised as making farmers awareness about soil fertility and adverse effect of pesticides and ensure soil health suitable eco-friendly policy should be taken.

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