ASSESSMENT OF FERTILITY POTENTIAL lNDEX OF SOME SOILS OF MOHESHKHALI BETEL LEAF (*Piper betle* L.) ESTATE

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Abstract

Fifteen soil samples (0-15cm depth) and fifteen betel leaf samples from Bara Moheshkhali, Choto Moheshkhali, Hoanak, Kalmarchora, Shaplapur union of Moheshkhali upazila, Cox's Bazar district were collected on December-January (2020-2021). It was collected for the purpose of evaluating the color, particle density, moisture content, texture, pH, EC and organic matter content of soils and total nitrogen, phosphorous, potassium and sulfur of the soils and total protein content, nitrogen, phosphorus, potassium and sulfur of leaves. Maximum sampled soil was containing yellowish red color when moist and showed brown color when dried. Some of them were flood plain soil and that's why showed grey color during dry and moist condition. Mean particle density was 2.49 g/cm3 and mean moisture content was 13.95%. Average sand, silt and clay were 65.08%, 18.56% and 19.26%, respectively. The texture of the soils was sandy loam to clay loam. The sand was by far the dominant fraction in the soils. Mean pH value was 5.63, organic matter was 0.30% and EC was 99.38µS/cm. Mean total nitrogen, phosphorus, potassium and sulfur of the soils were 0.04, 0.46, 0.25 and 0.26%, respectively. The mean concentration of protein, nitrogen, phosphorus, potassium and sulfur in the betel leaf samples were 20.56, 3.29, 0.39, 0.79 and 0.20%, respectively. This investigation focuses on the fertility status and physico-chemical properties of soil in betel leaf garden of only hilly island of Bangladesh, Moheshkhali.

***Key words*:** Assessment; Fertility index; Moheshkhali; Betel leaf.

INTRODUCTION

Moheshkhali is an upazila of Cox's Bazar district in the division of Chittagong, Bangladesh and located at 21.5500^0N and 91.9500^0E. It has a total area of 362.18 km^2. It is the only hilly island of Bangladesh. This island is blessed with various types of natural resources including fertile soil. High ground and especially fertile soil are best for betel (Sripradha 2014), the hilly region of Moheshkhali is a perfect place for betel leaf cultivating. In fact, Moheshkhali is famous for its sweetened betel leaf. The island has a moist tropical climate with a long wet season (April-October) and a relatively short dry season (November-March). The mean annual precipitation, temperature, and relative humidity are 3,627 mm, 25.7°C, and 70 to 90 %, respectively (Baul *et al.* 2020). This region is prone to cyclonic storms that occur during April-May and October-November (Baul *et al*. 2020).

The island has four subdivisions including active, young and old coastal plain, and hilly areas with piedmont plain. The geological deposition of sedimentation forms landmasses (Majlis 2013). The hilly areas of Moheshkhali have forest covers where several hills reach up to 23 m and there are low-lying valleys. Usually betel leaves are cultivated in these areas. The soil of these areas varies from clay to sandy loam and to some extent yellowish red sandy clay, with low pH. Hills are mainly composed of sands and various stones, including limestone, siltstone, and mudstone (DoE 1999).

Betel vine (*Piper betle* L.) belongs to the family Piperaceae, i.e. the Black Pepper family. Betel leaf is cultivated in a garden locally called "baroj". The vine is raised by vegetative propagation from the cutting under partially shaded and humid environment inside the baroj (Guha 2006). The baroj is covered with bamboo sticks and chan leaf (sun-grass). A sun-grass fence is used over the garden works as a greenhouse to supply optimum temperature, to keep the soil moist and to protect the leaves from over drying, excess rainfall, birds and dusts. The betel leaf needs soil with balanced pH. The soil is plowed in furrows. The furrows are usually 10 to 15-meter length, 75 centimeters in width and 75 centimeters in depth. Usually farmers apply khail (oil cakes), cow manure, wood ash are applied on the top soil. It is usually planted at the start of the monsoon season. It needs proper shade and irrigation to grow well. The betel leaf is usually cultivated in hilly area or comparatively upper land where good drainage is present (Das and Mohanty 2016). Betel leaf cannot sustain water logged condition. Moderate air circulation is also important because it keeps the baroj insect-free. Bamboo sticks are used to provide support to the vines. Three to six months after cultivation, when the vines reach 150-180 centimeters, the harvesting begins. If properly taken care of a betel leaf garden can produce leaf for over 6 years long.

According to Jana (1996), Khoshoo *et al.* (1981), Samanta (1994) and Sharma (1996), this edible leaf has achieved an esteemed position in the human society right from the dawn of civilization, particularly in the countries like Bangladesh, Burma, China, India, Indonesia, Malaysia, Nepal, Pakistan, Philippines, South Africa, Sri Lanka, Thailand etc., where leaves are traditionally used for chewing with many other ingredients like sliced areca nut, slaked lime, coriander, aniseed, clove, cardamom, sweetener, coconut scrapings, ashes of diamond, pearl, gold and silver (Ayurvedic preparations), jelly, pepper mint, flavouring agent, fruit pulp etc. (CSIR 1996). Betel quid is regarded as an excellent mouth freshener and mild vitalize (Aishwarya *et al.* 2016).

Piper betel leaves are well-off in moisture, protein, fats, minerals, vitamins and in phytochemical and also antioxidants. It helps in curing and treatment of various diseases like halitosis, boils and abscesses, conjunctivitis, constipation, headache, hysteria, itches, mastitis, mastoiditis, leucorrhoea, otorrhoea, ringworm, swelling of gum, rheumatism, abrasion, cuts and injuries etc. (Shukla *et al*. 2015).

The hilly areas of Moheshkhali are fertile enough for cultivating betel leaf. Soil health deterioration is a common phenomenon for betel gardens in Bangladesh. This investigation focuses on the fertility status and physico-chemical properties of soil in the betel leaf garden of Moheshkhali. This study will definitely give an idea about betel leaf and its related soil which can be of great help in assessing soil fertility program for betel leaf growing areas in the country.

MATERIAL AND METHODS

Collection and processing of soil and leaf samples

Fifteen soil samples (0-15 cm depth) were collected after removing surface litter from fifteen different spots of Moheshkhali hilly region of Bangladesh in Dec-Jan 2020-21. The spots were Spot 1: Adharghona; Spot 2: Dhoisshyakhata; Spot 3: Dhapua; Spot 4: Debangapara 1; Spot 5: Borchora; Spot 6: Monipur; Spot 7: Uttarpara; Spot 8: Bottoli; Spot 9: Adinath temple; Spot 10: Panirchora; Spot 11: Kydabad; Spot 12: Hindu Para; Spot 13: Lombaghona; Spot 14: Timibazar; and Spot 15: Debangapara 2. Then these samples were labeled and carried properly in eco-friendly jute bags to the laboratory for analysis. These samples were placed on trays and air-dried. After drying, the lump of collected soil was broken using pestle and mortar, and sieved using 2 mm sieve. After that, the samples were kept in a piece of brown paper with proper labeling. Fifteen betel plants were chosen from the above spots for leaf testing. An overview of six months old betel leaf garden is presented in Fig. 1. Fifteen young leaf samples (deep green) were collected from the top of the plants wiped with soft white clothes, air-dried, oven-dried and powdered in a mechanical grinder and kept in brown paper envelops with appropriate labeling for chemical analysis in the laboratory of the Department of Soil, Water and Environment at the University of Dhaka.

Fig.1. A view of six month old cultivated betel leaf in a commercial garden.

Physico-chemical properties analysis of soils

Soil moisture content was determined by the Gravimetric method (Miller and Donahue 1965). The collected soil samples were taken to the laboratory, and later oven dried at 100°C for 24 hours. The oven dry weight was then subtracted from the initial weight and the values expressed as percentages. The matrix colour of soil was evaluated by visual examination in outdoor sunlight with the Munsell colour chart. Soil particle density was determined by the Pycnometer method (Black 1965). The particle size analysis of the soils was done by the Hydrometer method and textural classes were determined by Marshall's triangle coordinate curve (Bouyoucos 1962). The pH of the soil samples was determined in the laboratory by mixing soil with distilled water in the ratio of 1:2.5. The resulting suspension was then shaken for half an hour and then allowed to stand for one hour and measured by using a pH meter at 25°C (Jackson 1958). The electrical conductance (EC) was measured by using a digital conductivity meter (Richards 1954). Fifteen grams of soil sample were mixed with 30 ml of distilled water and then the suspension was filtered through Whatman No.1 filter paper. The filtrate was then stirred intermittently and then allowed to stand for 30 minutes for the complete dissolution of soluble salts. The soil water mixture was again allowed to stand so that soil settled down. Finally, electrical conductance was recorded by inserting conductivity cell in it. The organic carbon content of soils was determined by the Wet Oxidation method (Walkley and Black 1934). The organic matter was calculated by multiplying the percent organic carbon with the Van Bemmelen factor 1.72. For nitrogen, 2g of soil sample were digested in a Kjeldahl digestion flask (Marr and Cresser 1983); for potassium, sulfur and phosphorus 2g of soil sample were digested with nitric-perchloric acid. The phosphorus of the digest was determined by vanadomolybdophosphoric yellow color method at 430 nm using a spectrophotometer (model DR 5000) (Olsen *et al.* 1954). The potassium of the digest was determined by using JENWAY flame photometer (model PFP 7) (Pratt 1965). The sulfur of the digest was determined by using turbidimetric method (Bardsley and Lancaster 1965).

The nutrient content and protein content in leaf

For nitrogen, 0.2g of leaf sample was digested in a Kjeldahl digestion flask (Marr and Cresser 1983); for potassium, sulfur and phosphorus, 0.2g of leaf sample was digested with nitric-perchloric acid. The phosphorus of the digest was determined by the vanadomolybdophosphoric yellow color method at 430nm using a spectrophotometer (model DR 5000) (Olsen *et al.* 1954). The potassium of the digest was determined by using JENWAY flame photometer (model PFP 7) (Pratt 1965). The sulfur of the digest was determined by using the turbidimetric method (Bardsley and Lancaster 1965). The protein contents were determined by multiplying a factor of 6.25 with nitrogen contents (Magomaya *et al*. 2014).

Statistical analysis: All statistical analyses were calculated using Minitab, version 17.

RESULTS AND DISCUSSION

Morphological, physical and chemical properties

The matrix colour of the soils was found to be a mixture of brown, red, yellowish brown and gray. Moisture content ranged from 4.23-21.39% with an average of 13.95%. Soil moisture has a profound effect on soil microbial activity which in turn enhances soil organic carbon content (Liu *et al.* 2009). The particle density of the soil sample ranged from 2.15-2.95 g/cm^3 with an average of 2.49 g/cm^3. Soil texture may affect productivity in a variety of ways, i.e. by affecting moisture availability, soil temperature, nutrient supply and the accessibility of soil organic matter to microbial decomposition (Schimel *et al.* 1996). The soil texture of the samples from betel garden in Moheshkhali is sandy loam to clay loam (Table 1), which may favour betel leaf plantation.

There were variations in soil pH levels from the soil samples analyzed. Average pH of the soil samples was 5.63 which is moderately acidic (Table 2). The pH ranged from 5.24-6.17. A well-drained fertile sandy or sandy loam or sandy clay soil with pH range of 5.6 –8.2 is considered suitable for betel cultivation (CSIR 1996, Guha and Jain 1997). Electrical conductivity (EC) is a measurement that correlates with soil properties that affect productivity including soil texture, cation exchange capacity, drainage conditions, organic matter level, salinity and subsoil characteristics. Electrical conductivity ranges from 35.10 to 269 µS/cm with an average of 99.38 µS/cm. Soil acidity affects crop growth in two ways: directly by acidity effect and indirectly by affecting nutrient availability (Hasan *et al*. 2020).

Table 1. Physical properties of some soils of Betel Leaf Garden, Moheshkhali, Chittagong, Bangladesh.

Location	Moisture content (%)	Colour	Colour name	Particle density (gcm-3)	% Sand	% Slit	% Clay	Textural Class	Sand/ Silt Ratio	Silt/ Clay Ratio
Adharghona	21.18	5YR 5/6	Yellowish red	2.57	64	20	16	Sandy loam	3.2	1.25
Dhoisshyakhata	12.15	5YR 5/6	Yellowish red	2.55	48.5	30	21.5	Loam	1.62	1.39
Dhapua	17.47	10YR 6/3	Pale brown	2.59	88.5	2.5	9	Loamy sand	35.4	0.27
Debangapara 1	6.26	5YR 5/6	Yellowish red	2.61	61	25	14	Sandy loam	2.44	1.78
Borchora	13.27	10YR 6/3	Pale brown	2.2	88.5	2.5	9	Loamy sand	35.4	0.27
Monipur	13.13	5YR 5/6	Yellowish red	2.62	63.5	15	21.5	Sandy clay loam	4.23	0.69
Uttarpara	17.16	5YR 5/6	Yellowish red	2.33	43.5	32.5	24	Loam	1.34	1.35
Bottoli	8.65	5YR 5/6	Yellowish red	2.53	41	37.5	21.5	Loam	1.09	1.74
Adinath temple	14.36	5YR 5/6	Yellowish red	2.95	59	20	21.5	Sandy clay loam	2.95	0.93
Panirchora	21.39	5YR 5/6	Yellowish red	2.22	78.5	5.5	16	Sandy loam	14.27	0.34
Kydabad	15.11	5YR 5/6	Yellowish red	2.37	55	23.5	21.5	Sandy clay loam	2.34	1.09
Hindu Para	12.69	5YR 5/6	Yellowish red	2.61	71	7.5	21.5	Sandy clay loam	9.47	0.35
Lombaghona	12.92	5YR 5/6	Yellowish red	2.7	71	21	24	Sandy loam	3.38	0.88
Timibazar	19.21	5YR 5/6	Yellowish red	2.45	77.5	1	21.5	Sandy clay loam	77.5	0.05
Debangapara 2	4.23	5YR 5/6	Yellowish red	2.15	38.5	35	26.5	Clay loam	1.1	1.32
Mean	**13.95**	**-**	**-**	**2.49**	**65.08**	**18.56**	**19.26**	**-**	**13.05**	**0.91**

Nutrient status of soil and betel leaf

Nutrient analysis of the soil samples showed that total nitrogen content ranged from 0.02-0.06% with an average of 0.04%. Total phosphorus content was from 0.19% to 0.93% with an average of 0.64%. Total potassium content of the soil samples ranged from 0.02% to 0.78% where the average content was

0.25%. Total sulfur content was from 0.16% to 0.39% with an average of 0.26%. These values are presented in Table 2. Results varied significantly at 0.05% level. The nutrient status was low. It might happen due to acidity and uptaking nutrients by betel vine.

The percentage of organic matter ranged from 0.05% to 0.69% with an average of 0.3%. Organic matter content in Bangladesh soils is generally around 1% in most and around 2% in few soils (Islam 2008). The carbon status of Bangladesh soils is not only poor, but also decreasing day by day. The depletion of soil organic matter was from 9 to 46% in different regions of Bangladesh over the last 20 years from1970 to 1990 (Miah 1993). Soil organic matter mineralization and release substantial quantity of N, P, S and very important of micronutrients (Hasan *et al*. 2020).

The price and test of betel leaf are determined by its quality. The chemical composition of betel leaf is influenced by soil and environmental characteristics of the betel garden. The nutrient analysis of leaf samples showed that the nitrogen content ranged from 2.27% to 4.64% with an average of 3.29%. Phosphorus content ranged from 0.06% to 0.82% with an average of 0.39%. Potassium content ranged from 0.24%-1.25% with an average of 0.79%. Sulfur content ranged from 0.1% to 0.32%. The mean Sulfur content in the leaf was 0.20%. These values are presented in Table 3. Results varied significantly ($p \leq 0.05$). Phosphorus plays important role in all crop biochemical process; *viz*. photosynthesis, respiration, energy storage and transfer, cell division, cell enlargement and nitrogen fixation. Potassium is associated with the movement of water, nutrients and carbohydrates in plant tissue. It is involved with enzyme activation within the plants which affect protein, starch and ATP production (Hasan *et al*. 2020).

Table 2. pH, organic matter, total nitrogen, phosphorus, potassium and sulfur of some soils of Moheshkhali betel garden, Chittagong, Bangladesh.

Location	pH	EC (µS/cm)	Organic matter (%)	Nitrogen (%)	Phosphorus (%)	Potassium (%)	Sulphur (%)
Adharghona	5.27	98.4	0.57%	0.04	0.51	0.04	0.29
Dhoisshyakhata	5.48	111.6	0.34%	0.07	0.27	0.39	0.37
Dhapua	6.17	43	0.22%	0.03	0.46	0.27	0.16
Debangapara 1	5.81	75.2	0.05%	0.06	0.53	0.29	0.32
Borchora	5.45	54.7	0.05%	0.02	0.19	0.14	0.27
Monipur	6.01	63.2	0.23%	0.02	0.4	0.02	0.26
Uttarpara	5.54	50.2	0.36%	0.03	0.93	0.16	0.2
Bottoli	5.24	126.7	0.04%	0.03	0.38	0.19	0.39
Adinath temple	5.89	67.1	0.49%	0.03	0.38	0.06	0.26
Panirchora	5.7	269	0.36%	0.05	0.64	0.35	0.18
Kydabad	5.63	68.9	0.26%	0.03	0.35	0.34	0.33
Hindu Para	5.85	38.6	0.13%	0.03	0.32	0.21	0.04
Lombaghona	5.3	234	0.35%	0.04	0.53	0.43	0.26
Timibazar	5.39	155.1	0.69%	0.04	0.79	0.02	0.32
Debangapara 2	5.71	35.1	0.35%	0.05	0.24	0.78	0.25
Mean	**5.63**	**99.38**	**0.30%**	**0.04**	**0.46**	**0.25**	**0.26**
LSD 5%	**NS**	**NS**	**0.001**	**0.003**	**0.03**	**0.01**	**0.01**

Islam *et al.* (2020) reported that the maximum and minimum amount of protein were obtained in $VC_{15ton/hac}$, $K_{20kg/hac}$, $P_{10kg/hac}$ and control treatment 24.60% and 11.00%, respectively in spinach (*Spinacia oleracea*) leaf. The protein content ranges from 14.19 % to 29% with 20.56% average value.

Fertility status of Moheshkhali soil

Moheshkhali soil is included in AEZ (Agro Ecological Zone) 23. The fertility status of AEZ 23 ranges from very low to optimum (Table 4).

Table 3. Nutrients concentration in the betel leaves of Moheshkhali.

Location	Protein Content (%)	Nitrogen (%)	Phosphorus (%)	Potassium (%)	Sulphur (%)
Dhoisshyakhata	17.19	2.75	0.27	0.24	0.2
Dhapua	23.44	3.75	0.43	0.78	0.18
Debangapara1	25.5	4.08	0.72	0.85	0.26
Borchora	29	4.64	0.27	0.95	0.06
Monipur	21.94	3.51	0.38	0.7	0.1
Uttarpara	22.63	3.62	0.43	1.25	0.18
Bottoli	19.94	3.19	0.48	0.83	0.22
Adinath temple	22.06	3.53	0.38	0.8	0.32
Panirchora	20.88	3.34	0.82	0.97	0.17
Kydabad	19.75	3.16	0.45	0.95	0.29
Hindu Para	15.75	2.52	0.17	0.24	0.25
Lombaghona	14.19	2.27	0.09	0.34	0.27
Timibazar	21.38	3.42	0.46	1.09	0.12
Debangapara2	17.06	2.73	0.06	1.3	0.14
Mean	**20.56**	**3.29**	**0.39**	**0.79**	**0.2**
LSD at 5%	**NS**	**0.01**	**0.01**	**0.01**	**0.03**

The yield and quality of betel leaf can be increased by proper nutrient management. Moreover, nutrient availability throughout the crop growth period from the applied sources has considerable importance (Fahim *et al.* 2017).

Table 4. Soil fertility status of AEZ 23 (BARC 2018).

Major land type	Soil pH	Soil organic matter	N	P	K	S	Ca	Mg	Zn	B	Mo
High land	3.9-6.2	L-M	VL-L	VL-L	L-M	L-M	M-Opt	M-Opt	L-M	L-M	M
Medium high land	4.4-6.2	L-M	VL-L	VL-L	L-M	L-M	M-Opt	M-Opt	L-M	L-M	M
Medium low land	4.5-6.2	L-M	VL-L	VL-L	L-M	L-M	M-Opt	M-Opt	L-M	L-M	M

Though the soils had enough organic matter, but nutrient status was lower than that of the critical value. Integrated nutrient management (INM) is always advantageous from a long-term perspective both in terms of cost of production and soil health (Debanath *et al*. 1985).This study is expected to furnish valuable clues to upgrade productivity through a fair utilization of mineral and organic fertilizers to improve the stock of the plant nutrient in soil to sustain profitable production of betel leaf.

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