DOI: https://doi.org/10.3329/jbcbm.v10i1.74594 *J. biodivers. conserv. bioresour. manag.* **10**(1), 2024

ASSESSMENT OF SOIL FERTILITY IN JUTE (*Corchorus olitorius* L.) CULTIVATED LAND AND NUTRITIVE VALUE OF ITS PLANT PARTS

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Abstract

The samples of soil, leaves, and shoots of jute were collected from twenty spots of jute (variety BJRI-Tossa-8) fields from different locations in the Narail district of Bangladesh under AEZ-12 during the year 2022. The study intended to evaluate the soil's physicochemical properties and nutrient concentrations in jute leaves and shoots of 120 days old plants (at the harvesting time of the plant). The soil pH was neutral to slightly alkaline (6.6 to 7.4), with organic matter content from 1.03 to 1.71%. Electrical conductivity was found non-saline which was 40 to 150 µS/cm at 0 to 15 cm depth. The dominant soil textural class was clay. The total N, P, and S in soils were found to be 0.21 to 0.31%, 0.027 to 0.0283% and 0.0002 to 0.0023%, respectively and available N, P, and S were found to be 0.0058 to 0.0087%, 0.0007 to 0.0018%, and 0.0001 to 0.0006%. The nutritional values of N, P, and S in leaves ranged from 3.00 to 11.75%, 0.2281 to 0.5627%, and 0.0056 to 0.0197%, respectively. The total N, P, and S concentrations in the shoots were 0.17 to 5.07%, 0.0012 to 0.2935%, and 0.0002 to 0.0011%, respectively. The study indicated that jute leaves are enriched in nutrition and may be a good source of nourishment for human health. This research also illustrated that the jute field had low to medium fertility soil status. It is suggested that the farmers of AEZ-12 should follow the fertilizer recommendation doses in jute cultivation for higher fiber yield and allow sufficient decomposition of jute roots and debris to sustain succeeding crop production and soil fertility. The study has given new information and guidelines for the researcher for future investigation.

Key words: *Corchorus olitorius* L.; Fertility status; Nutrient content; Organic matter.

INTRODUCTION

Jute (*Corchorus olitorius* L.) fiber holds significant economic significance in Bangladesh, playing a pivotal role in the nation's economy and serving as a major income source for numerous rural families (Akter *et al.* 2020). The contribution of jute leaves is also pronounced for its diversified good quality. It is used as a vegetable consumption by the people in the country. Jute leaves are used for medicinal purposes. The leaves contain an abundance of antioxidants that have been associated with protection from chronic diseases, such as heart problems, cancer, diabetes and hypertension, dysentery as well as other medical conditions (Islam 2013). *C. olitorius* leaves contain various phytochemicals, such as cardiac glycosides, terpenes, flavonoids, fatty acids, hydrocarbons, and phenolics. Research has demonstrated that different extracts of *C. olitorius* display a wide range of health benefits, including anti-inflammatory, hepatoprotective, antihyperlipidemic, immunostimulant, antitumor, antimicrobial, antidiabetic, analgesic, wound-healing, and cardioprotective activities (Abdel-Razek *et al.* 2020). Additionally, jute mallow leaves play a crucial role in addressing malnutrition-triggered diseases, especially in rural children, due to their rich nutritional profile (Wenhold *et al.* 2012). It serves as a crucial export commodity and an essential industrial resource due to its numerous advantageous properties (Islam and Ali 2017). In the 2020-21 period, Bangladesh witnessed a total jute production of 310.057 thousand metric tons, with a significant portion (242.492 thousand metric tons) exported overseas, contributing to the nation's economy (BBS 2022). Derived from two species, *Corchorus capsularis* L. and *Corchorus olitorius* L., within the family Tiliaceae, containing more than 30 species (Islam and Ali 2017), jute cultivation thrives in various regions of Bangladesh, with notable areas including greater Faridpur, Narail, Tangail, Jessore, Dhaka, Sirajganj, Bogra and Jamalpur. Among these areas, jute cultivation has gained popularity in the Narail district which is situated in the southwestern region of Bangladesh. However, the sustainable productivity of jute hinges upon the fertility and nutrient status of the soil due to its cultivation. Understanding soil fertility and nutrient status in jute cultivating areas, particularly in the Narail district, is essential for devising effective management strategies to enhance productivity, ensure sustainability and mitigate environmental degradation.

Organic matter in the soil acts as a reservoir for plant nutrients, significantly impacting soil properties and microbial activities crucial for successful cultivation (Bhardwaj *et al.* 2011). However, over the past two decades, there has been a notable decrease in the average organic matter content of topsoil, ranging from 20 to 46%, primarily attributed to intensive cultivation practices (Gani *et al.* 2017). Jute leaves are commonly utilized as a leafy vegetable across numerous Asian, African, and European nations (Furumuto *et al*. 2002). These leaves boast a rich composition of active nutrient compounds, including protein, fat, carbohydrates, fiber, ash, calcium, potassium, iron, sodium, phosphorus, beta-carotene, thiamine, riboflavin, niacin and ascorbic acid (Islam 2013). Particularly in Bangladesh, where leafy vegetables are scarce during early summer, jute leaves serve as a valuable resource to meet the demand for such greens (Tareq *et al.* 2020). Furthermore, jute leaves have been recognized for their medicinal properties and wide-ranging antibacterial effects, contributing to their utilization in the treatment of various ailments (Ngomuo *et al.* 2017).

The application of organic manure has been shown to enhance crop yield (Qulsum *et al*. 2020), improve soil quality and increase soil organic matter content (Islam *et al.* 2010). Additionally, incorporating plant and animal residues into soil improves soil health (Moebius-Clune *et al.* 2016). Combining chemical and organic fertilizers offers greater benefits and promotes sustainable production, with chemical fertilizers exerting fewer adverse effects on soil health and the environment (Chen 2006). Jute stands as a vital crop for Bangladesh's economy, with implications spanning nutrition, agriculture and industry. This study aimed to understand soil fertility and jute nutrient status to ensure the continued success of jute cultivation in Bangladesh and beyond.

MATERIAL AND METHODS

The study area

The study area of Lohagara upazila under Narail district has a total of 284.91 square kilometers (110.00 sq. miles) situated between the Nabaganga and Madhumati rivers; it borders Magura district to the north, Dhaka division to the east, Kalia upazila to the south, and Narail Sadar (BBS 2015). The study area belongs to the Low Ganges River Floodplain under AEZ-12 (SRDI 2021). It covers low land, medium-high land and high land. The soil of the study area is calcareous, with a general fertility level of low to medium. The cropping intensity is rice, jute in the kharif season and pulses, wheat, mustard, linseed, and boro rice in the rabi season (FRG 2018). Jute cultivation during the kharif-1 season is common practice in that area. The jute field was chosen for the study, where only the newly developed BJRI tossa jute-8 (Rabi) is cultivated.

Seed availability

Farmers reported that some obtained their seeds from the Faridpur regional station of the Bangladesh Jute Research Institute. A good number of cultivators sown their production seed and few others purchased from the neighboring seed growers.

Fertilizer management

A history of fertilizer application methods for BJRI Tossa Jute-8 was obtained from growers in the study area. Most reported applying only urea as a top dressing 6 to 7 weeks after sowing. Only four farmers used farmyard manure and MoP as a basal application before sowing, along with a blanket dose of urea spread at 42 days of plant age. None followed the recommended fertilizer dosage for this variety.

Inter culture operations

Farmers performed weeding and thinning, and applied insecticides and pesticides as needed. The drainage system was maintained using a spade, hoe and a local tool called khurpi (mini device). The standard plant population, ranging from 300,000 to 350,000 plants, was kept by the growers in each jute plot.

Collection and preparation of soil, leaf, and shoot samples

During the 3rd week of September 2022 (at harvesting time), twenty soil samples were collected randomly from 0 to 15 cm depth after removing surface litter. A description of the twenty locations is presented in Table 1. Soil samples were taken with a steel-made auger from the field before the decomposition of roots and debris. The samples of leaf and shoot (3 replications for each location) were also collected from the study area in green-colored condition. The soil samples underwent air-drying, with any apparent roots and debris removed before further processing. To break down large aggregates, a wooden hammer was utilized, followed by sieving through a 2 mm mesh sieve. Subsequently, the samples were stored in polyethylene bags, appropriately labeled for identification. Concurrently, leaf and shoot samples were gathered from corresponding locations, also labeled, and transported to the laboratory in the Department of Soil, Water, and Environment at the University of Dhaka. Upon arrival at the laboratory, samples of leaves and shoots were processed involving wiping with soft tissues, air-drying, and subsequent oven-drying at 65ºC. Mechanical grinding was then employed to convert the samples into powder, which were finally stored in brown paper envelopes for subsequent analysis.

Table 1. Geographical location of the sampling spots of Lohagora upazila, Narail district, Bangladesh.

Locations	Latitude	Longitude	Locations	Latitude	Longitude
Spot1	23.208531^{0}N	89.650555^{0}E	Spot 11	23.234531^{0}N	89.658043^{0}E
Spot 2	23.225253^{0}N	89.622102^{0}E	Spot 12	23.199193^{0}N	89.678299^{0}E
Spot 3	23.203561^{0}N	89.589443^{0}E	Spot 13	23.195249^{0}N	89.629032^{0}E
Spot 4	23.168964^{0}N	89.552364^{0}E	Spot 14	23.226520^{0}N	89.621802^{0}E
Spot 5	23.152392^{0}N	89.574981^{0}E	Spot 15	23.244502^{0}N	89.639397^{0}E
Spot 6	23.189702^{0}N	89.622429^{0}E	Spot 16	23.241742^{0}N	89.628068^{0}E
Spot 7	23.178084^{0}N	89.630516^{0}E	Spot 17	23.257356^{0}N	89.623519^{0}E
Spot 8	23.161040^{0}N	23.161040^{0}E	Spot 18	23.271707^{0}N	89.627209^{0}E
Spot 9	23.210553^{0}N	89.660789^{0}E	Spot 19	23.269342^{0}N	89.645491^{0}E
Spot 10	23.216548^{0}N	89.639503^{0}E	Spot 20	23.283297^{0}N	89.633732^{0}E

Analysis of physico-chemical properties of soil and plant samples

The particle size of soil was analyzed following the hydrometer method (Bouyoucos 1962), and the textural class was determined using Marshall's triangular coordinate method following the USDA system. Soil pH was measured using a glass electrode pH meter (HANNA Instruments HI 2211 pH/ORP Meter), calibrated with buffer solutions at pH 7.0 and 4.0, with a soil-to-water ratio of 1:2.5. Electrical conductivity (EC) of soil samples was measured using a digital conductivity meter (EUTECH Instruments CON 700) with a soil-to-water ratio of 1:5 (Richards 1954). Organic carbon content was determined using the Wet Oxidation method (Walkley and Black 1934) and organic matter (OM) was calculated by multiplying the percent organic carbon by the van Bemmelen factor of 1.724 (Piper 1950).

Available nitrogen was determined using the Kjeldahl method (Marr and Cresser 1983), available phosphorus was determined colorimetrically using a spectrophotometer after developing a blue color with ascorbic acid and potassium antimony tartrate and available sulfur was determined turbidimetrically with $BaCl_2$ using Tween-80 as the suspending agent (Bardsley and Lancaster 1965). Total nitrogen in soil, leaf and shoot samples was determined using the micro Kjeldahl steam distillation method after acid digestion with H_2SO_4 (Bremner and Mulvaney 1982). Total phosphorus and sulfur were determined by digesting the samples with a mixture of concentrated HNO_3 and $HClO_4$ at a ratio of 2:1. Total phosphorus was measured using the vanadomolybdophosphoric yellow color method with a spectrophotometer (Jackson 1958) and total sulfur was measured using a spectrophotometer after developing turbidity with $BaCl_2$.

Statistical analysis

Leaf and shoot sample analyses were conducted utilizing Microsoft Excel 2019.

RESULTS AND DISCUSSION

Soil separates

A significant proportion of the soil under investigation exhibited clay particle enrichment. The presence of sand particles was observed, with an average value of 65.78%, while silt was also detected with a mean value of 24.86%. However, sand content varied between 0.81% and 31.25%, with a mean value of 9.36% (Table 2).

Table 2. Particle size distribution of soil (0 to 15 cm) of different jute fields.

Locations	Soil separates			Textural classes	Sand/silt ratio	Silt/clay ratio
	Sand (%)	Silt (%)	Clay (%)			
Spot 1	2.51	26.42	71.07	Clay	0.1	0.37
Spot 2	5.02	28.31	66.67	Clay	0.18	0.42
Spot 3	31.25	18.63	50.12	Clay	1.68	0.37
Spot 4	18.30	22.76	58.97	Clay	0.8	0.39
Spot 5	18.90	24.42	56.68	Clay	0.77	0.43
Spot 6	7.40	25.10	67.50	Clay	0.3	0.37
Spot 7	5.50	27.42	67.08	Clay	0.2	0.41
Spot 8	7.30	15.42	77.28	Clay	0.47	0.2
Spot 9	6.03	13.26	80.71	Clay	0.45	0.16
Spot 10	5.30	46.21	48.49	Silty clay	0.11	0.95
Spot 11	2.50	29.07	68.43	Clay	0.09	0.42
Spot 12	22.00	22.65	55.35	Clay	0.97	0.41
Spot 13	4.80	20.10	75.10	Clay	0.24	0.27
Spot 14	9.10	29.57	61.33	Clay	0.31	0.48
Spot 15	1.61	31.15	67.24	Clay	0.05	0.46

Spot 16	10.42	24.27	65.31	Clay	0.43	0.37
Spot 17	4.90	24.82	70.28	Clay	0.2	0.35
Spot 18	16.22	26.53	57.25	Clay	0.61	0.46
Spot 19	0.81	21.51	77.68	Clay	0.04	0.28
Spot 20	7.40	19.60	73.00	Clay	0.38	0.27
Range	**0.81-31.25**	**13.26-46.21**	**48.49-80.71**	**-**	**0.1-1.68**	**0.16-0.95**
Mean	**9.36**	**24.86**	**65.78**	**-**	**0.419**	**0.392**

Soil pH, electrical conductivity, and organic matter

The soil samples exhibited various pH levels, spanning from neutral to slightly alkaline, with an average pH of 7.0 (Table 3). None of the soil samples displayed salinity, as indicated by electrical conductivity values below the critical threshold of 400 µS/cm (Hardie and Doyle 2012). The electrical conductivity of the samples ranged from 40 to 150 µS/cm, with a mean value of 75 µS/cm. Soil organic matter affects the nutrient availability of soil. Organic matter contents varied from 1.03 to 1.71% with an average of 1.46% (Table 3).

Table 3. Soil pH, electrical conductivity, and organic matter status of different jute fields.

Locations	pH	EC (µS/cm)	OC (%)	OM (%)
Spot 1	7.1	70	0.99	1.71
Spot 2	7.1	80	0.99	1.71
Spot 3	7.0	90	0.88	1.52
Spot 4	6.9	70	0.82	1.41
Spot 5	7.1	150	0.98	1.69
Spot 6	7.0	80	0.99	1.71
Spot 7	7.1	50	0.86	1.48
Spot 8	7.0	40	0.60	1.03
Spot 9	6.9	80	0.66	1.14
Spot 10	7.4	80	0.70	1.21
Spot 11	7.0	70	0.99	1.71
Spot 12	6.9	70	0.67	1.16
Spot 13	7.0	60	0.95	1.64
Spot 14	6.8	60	0.76	1.31
Spot 15	6.9	80	0.85	1.47
Spot 16	6.9	70	0.98	1.69
Spot 17	6.8	120	0.75	1.29
Spot 18	6.8	70	0.96	1.66
Spot 19	6.6	40	0.75	1.29
Spot 20	6.8	70	0.81	1.40
Range	**6.6-7.4**	**40-150**	**0.60-0.99**	**1.03-1.71**
Mean	**7.0**	**75**	**0.85**	**1.46**

Macronutrient concentrations in soil

The available N content in the soils ranged from 0.0058 to 0.0087% with an average of 0.0071%. The total N content was from 0.21 to 0.31% with an average of 0.26% (Table 4). In half of the analyzed jute soils, phosphorus deficiency was observed. The critical thresholds for phosphorus available in soil were determined through radioisotopic studies and were established at 24 kg P_2O_5/ha or 0.0012% (Goswami *et al*. 1971) in soils conducive to jute cultivation. Available phosphorus levels ranged from 0.0007 to 0.0018%. The phosphorus deficiency was correlated with lower pH levels, as adsorption occurs due to reactions with iron and aluminum (Muindi 2019). Optimal phosphorus availability is typically achieved in soils with a pH ranging from 6.0 to 6.5 (Tisdale *et al*. 1985). The total phosphorus content ranged from 0.0207 to 0.0283% with an average of 0.0246% (Table 4). The total sulfur content varied between 0.0002% and 0.0023% with an average of 0.0004%. The available sulfur content in the examined soils where jute was cultivated ranged from 0.0001% to 0.0006% with an average value of 0.002%. The critical limit for soil-available sulphur (SO_4-S) was estimated to be 8.5 ppm (Saha *et al*. 1998). The findings indicate that all samples analyzed exhibited S concentrations below both the standard and critical values.

Table 4. Soil macronutrient status of jute-grown fields in the study area.

Locations	Available N (%)	Total N (%)	Available P (%)	Total P (%)	Available S (%)	Total S (%)
Spot 1	0.0076	0.24	0.0013	0.0260	0.0002	0.0005
Spot 2	0.0074	0.25	0.0014	0.0268	0.0001	0.0002
Spot 3	0.0071	0.31	0.0018	0.0283	0.0002	0.0003
Spot 4	0.0080	0.30	0.0015	0.0245	0.0002	0.0003
Spot 5	0.0079	0.25	0.0015	0.0245	0.0006	0.0023
Spot 6	0.0082	0.25	0.0010	0.0222	0.0001	0.0003
Spot 7	0.0069	0.25	0.0011	0.0252	0.0001	0.0002
Spot 8	0.0060	0.22	0.0012	0.0237	0.0001	0.0003
Spot 9	0.0079	0.27	0.0010	0.0245	0.0001	0.0002
Spot 10	0.0087	0.23	0.0014	0.0222	0.0001	0.0002
Spot 11	0.0068	0.25	0.0014	0.0245	0.0002	0.0003
Spot 12	0.0072	0.30	0.0012	0.0237	0.0001	0.0002
Spot 13	0.0068	0.23	0.0009	0.0222	0.0001	0.0003
Spot 14	0.0062	0.21	0.0010	0.0222	0.0002	0.0004
Spot 15	0.0069	0.30	0.0007	0.0268	0.0001	0.0002
Spot 16	0.0071	0.27	0.0009	0.0252	0.0001	0.0002
Spot 17	0.0061	0.28	0.0015	0.0252	0.0001	0.0003
Spot 18	0.0067	0.28	0.0008	0.0275	0.0002	0.0003
Spot 19	0.0058	0.24	0.0010	0.0207	0.0001	0.0002
Spot 20	0.0069	0.22	0.0011	0.0252	0.0001	0.0002
Range	**0.0058-0.0087**	**0.21-0.31**	**0.0007-0.0018**	**0.0207-0.0283**	**0.0001- 0.0006**	**0.0002-0.0023**
Mean	**0.0071**	**0.26**	**0.0012**	**0.0246**	**0.0002**	**0.0004**

Nutrient status in the leaf and shoot of jute

The nitrogen content in jute leaves varied between 3.00 and 11.75%, averaging at 6.38%. Similarly, phosphorus levels ranged from 0.2281 to 0.5627% with an average of 0.3887%. The sulfur content in jute leaves ranged from 0.0056 to 0.0197%, averaging 0.0115% (Table 5).

Table 5. Nutritent concentration in the leaves of jute plants grown in different plots of study area.

Locations	Nitrogen (%)	Phosphorous (%)	Sulphur (%)
Spot 1	3.57	0.3396	0.0144
Spot 2	6.21	0.2781	0.0114
Spot 3	8.85	0.3127	0.0116
Spot 4	6.97	0.3704	0.0118
Spot 5	3.92	0.3742	0.0120
Spot 6	7.18	0.2742	0.0085
Spot 7	3.00	0.3896	0.0116
Spot 8	5.03	0.4935	0.0158
Spot 9	9.60	0.2858	0.0111
Spot 10	6.76	0.2550	0.0083
Spot 11	5.89	0.2281	0.0073
Spot 12	3.60	0.3935	0.0056
Spot 13	8.49	0.5088	0.0077
Spot 14	11.75	0.4704	0.0169
Spot 15	5.65	0.5050	0.0097
Spot 16	4.65	0.3781	0.0114
Spot 17	9.12	0.4588	0.0197
Spot 18	4.61	0.3819	0.0124

Spot 19	8.84	0.5627	0.0101
Spot 20	3.99	0.5127	0.0116
Range	**3.00-11.75**	**0.2281-0.5627**	**0.0056-0.0197**
Mean	**6.38**	**0.3887**	**0.0115**

The nitrogen content in jute shoots varied between 0.17 and 5.07%, averaging 1.46%. The phosphorus content ranged from 0.0012 to 0.2935%, averaging 0.0577%. Similarly, the sulfur content ranged from 0.0002 to 0.0011%, averaging 0.0004% (Table 6).

Table 6. Nutrient concentrations in the shoots of jute plants grown in different plots in the study area.

Locations	Nitrogen (%)	Phosphorous (%)	Sulphur (%)
Spot 1	4.00	0.0012	0.0002
Spot 2	0.19	0.0396	0.0003
Spot 3	0.18/	0.0012	0.0004
Spot 4	0.24	0.0050	0.0004
Spot 5	0.17	0.0127	0.0003
Spot 6	0.48	0.0165	0.0004
Spot 7	0.28	0.0165	0.0003
Spot 8	4.30	0.0012	0.0003
Spot 9	3.89	0.0242	0.0002
Spot 10	1.98	0.0319	0.0002
Spot 11	5.07	0.0319	0.0004
Spot 12	4.49	0.0358	0.0003
Spot 13	0.27	0.0050	0.0003
Spot 14	0.69	0.0050	0.0003
Spot 15	0.35	0.0088	0.0009
Spot 16	0.23	0.2050	0.0011
Spot 17	0.33	0.1781	0.0004
Spot 18	0.27	0.1281	0.0004
Spot 19	0.24	0.1127	0.0003
Spot 20	0.21	0.2935	0.0002
Range	**0.17- 0.07**	**0.0012-0.2935**	**0.0002-0.0004**
Mean	**1.46**	**0.0577**	**0.0011**

It is crucial to follow the standard values of key macronutrients in soil for optimal jute cultivation while ensuring soil health and sustained productivity (Table 7). These benchmarks are essential for ensuring proper nutrient management in jute cultivation process practices.

Table 7. Standard values of some macronutrients for jute in soils (FRG 2018).

Soil analysis interpretation	Nutrient recommendation (kg/ha)		
	N	P	S
Optimum	0-30	0-5	0-8
Medium	31-60	6-10	9-16
Low	61-90	11-15	17-24
Very Low	91-120	16-20	25-32

The soils of jute cultivated land of the study areas at Narail district under the Agro-ecological zone 12 (AEZ-12) were found low to moderate fertility levels, with deficiencies noted in phosphorus and sulfur. It might be the cause of the low fertilizers used by the farmers in the jute fields and the collection of the soil before the decomposition of roots and debris. If the current practice of using little to no fertilizer continues in AEZ-12, it may result in reduced fiber yield, depletion of soil productivity, and negative impacts on future jute crops. It is therefore suggested that the farmers of

AEZ-12 should follow the fertilizer recommendation doses in jute cultivation and SRDI guidelines to sustain crop production. This study revealed that jute leaves contain high nutritional value and can improve human health by taking daily dishes as vegetables and making other recipes. Also, it has created new information and guidelines for the researcher for future investigation.

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(Manuscript received on 27 March, 2024)