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SOIL FERTILITY AND LEAF NUTRIENT STATUS OF LITCHI ORCHARD SITES

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Abstract

Twelve soil and twelve leaf samples were collected from twelve litchi (*Litchi chinensis* Sonn.) orchards from different locations of Dinajpur to evaluate some physico-chemical properties and nutrient status of soil, and concentration of nutrients in litchi leaf. The pH of the soil varied from very strong acidic to medium acidic (4.8 - 5.7), organic matter content varied from 0.84 - 1.88%, EC varied from 302.4 - 310.2 µS/cm. The dominant soil textural class was clay loam. The average particle density was 2.49g/cm^3. Total N, P, K and S in soils were 0.053 - 0.180%, 0.02 - 0.07%, 0.046 - 0.370 meq/100 g, and 0.015 - 0.028%, respectively. Available N, P, K, S, Zn, Fe, Mn and B in soils 30.40 - 57.8 mg/kg, 10.53 - 14.33 mg/kg, 0.03 - 0.32 meq/100 g, 20.03-34.80 mg/kg, 0.68-1.50 µg/g, 31.8 - 41.5 µg/g, 6.75 - 7.39 µg/g and 0.25-0.51 µg/g, respectively. The concentration of total N, P, K, S, Zn and Mn in the leaf were 1.74 - 2.20%, 0.11 - 0.188%, 0.104-0.198%, 0.129 - 0.430%, 12 - 14 µg/g and 30 - 74 µg/g, respectively. The overall results indicated that the fertility status of the soils under the litchi plantation in the Dinajpur area are medium fertile. So, farmers could be advised to grow litchi plants after applying amendments to the soils to improve the physico-chemical properties in the Dinajpur area of Bangladesh.

Introduction

Litchi (*Litchi chinensis* Sonn.) is one of the most important sub-tropical evergreen fruit tree belonging to the family Sapindaceae. Its cultivation is restricted to only a few countries in the world(1). Litchi has pleasant flavour, juicy pulp with attractive colour and delicious taste. Litchi is also an excellent source of vitamin C, and it also contains certain amount of protein, fat, pectin and minerals especially calcium, phosphorous and iron. It also has highly commercial value. It is also proclaimed as the "queen of fruits" due to its unique delectable taste and striking appearance. Litchi is adapted to the warm sub-tropics where summer is long and hot (temperature > 25^{0}C), with moderate precipitation (1200 mm) and high humidity. It can be grown on a wide range of soil types, but well

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drainage deep fertile loamy soil of high to medium high land is the best. However, it grows better in deep sandy loam soil. The major litchi growing countries in the world are China, India, Brazil, Malaysia, Thailand, Vietnam, Myanmar, Mauritius, South Africa, Australia, New Zealand, Madagascar, Bangladesh and Taiwan[2].

It is believed that litchi came from Burma to Bangladesh sometime in the early 19th century. Chinese varieties along with Indian cultivars like Mujaffarpuri and Bombai were introduced in the early 20th century from West Bengal through the efforts of nurserymen and plant traders. The fruits are harvested in bunches along with a portion of the branch and a few leaves to keep the quality of fruits. The yield of litchi in Bangladesh is quite low as compared to other litchi growing countries. Main litchi growing areas in Bangladesh are Dinajpur, Pabna, Lalmonirhat, Rajshahi *etc*. Dinajpur is a part of Barind tract which belongs to an old alluvial formation and usually composed of massive argillaceous beds of pale reddish brown colour that often turns yellowish on weathering. Kankar (lime nodules) are pisolitic ferruginous concretions occur throughout the soil. Locally the soils are rich in lime but deficient in nitrogen and phosphorus. The pH of the soils varies from 6.0 to 7.5[3].

The litchi growers are interested in litchi production for its economic benefit but they are very much reluctant about the management of soils and trees. Soil pH, colour, drainage condition, texture, nutrient storage, nutrient availability *etc*. are vital properties of soil fertility in relation to yield. Deep, well drained loamy soil, rich in organic matter and having pH in the range of 5.0 to 7.0 is ideal for litchi cultivation[4]. The concentration of nutrients in leaves reflects the reserves in the rest of the plant. Understanding the changes of nutrients during the growth of the tree is very important to make the standards of nutrients in foliar[5]. Potassium and nitrogen content in leaf are closely related to plant nutrient status, flowering, yield, nutrition and growth of plant[6] meanwhile, nitrogen has high degree of interaction with potassium [7] and fruit yield and quality are closely related to K-N balance[8]. Therefore, considering the importance of litchi and in view of the above-mentioned facts, the present study was undertaken to assess the fertility status of some litchi orchard soils and the concentration of nutrients in the leaves of litchi plants.

Materials and Methods

The study area was Dinajpur which belongs to the old Himalayan piedmont plain (AEZ-1). Twelve soil (0-15 cm depth) and 12 leaf (terminal, green coloured) samples were collected from different sites of Dinajpur (Table1). Soil samples were air-dried, visible roots and debris were discarded, massive aggregates were broken by using a wooden hammer and sieved using 2 mm sieve. Samples were kept in polyethylene bags with proper labeling. Leaf samples were collected from the same locations, labeled and carried to the laboratory in the Dept. of Soil, Water and Environment, University of

Dhaka. In the laboratory, it was wiped with soft clothes, air-dried, oven-dried (65^0C) and powdered with a mechanical grinder and kept in brown paper envelops for analysis.

Textural analysis of soils was done by hydrometer method[9] and the textural class was determined from Marshall's triangular co-ordinate following the USDA system. A glass electrode pH meter calibrated with buffer pH 7.0 and 4.0 measured the pH of the soil suspension maintaining soil: water ratio of 1:2.5. Available nitrogen in soil samples was determined by Kjeldahl method[10], available phosphorus was determined colorimetrically by spectrophotometer after developing blue color using ascorbic acid and potassium antimony tartrate as color developing reagents, exchangeable potassium in soil was determined by the extraction with ammonium acetate (pH 7.0) using a flame photometer, available sulphur was determined by turbidimetric method with $BaCl_2$ using Tween-80 as the suspending agent of the sulphate precipitation. Total nitrogen in the soil samples was determined by micro-Kjeldahl steam distillation method after H_2SO_4 acid digestion [11]. For the determination of total P, K and S samples were digested with a mixture of concentrated HCl/HNO_3 (1:3). Total phosphorus was determined by spectrophotometer using vanadomolybdophosphoric yellow color method[12], total potassium was measured by a flame photometer and total sulphur was determined by spectrophotometer after developing turbidity with $BaCl_2$. The concentrations of total and available iron, boron, manganese and zinc were determined using an atomic absorption spectrometer (AAS) (VARIAN AA240). Standard errors are shown for leaf sample analysis.

Results and Discussion

Soils of twelve selected sites of Dinajpur were reddish yellow in colour at Fulbari, Sujalpur, Suihari, Mohobbotpur; brown in Kasba and Mashimpur; grayish brown in Darbarpur; very pale brown at Kaharol, Mohshail and Biral; pale brown at Awliapur and yellow at Ulipur.

Soils of twelve sites varied in texture from sandy loam at Sujalpur and Darbarpur; sandy silt loam at Fulbari, silty loam at Biral to clay loam at Kasba, Suihari, Kaharol, Mohobbotpur, Awliapur, Ulipur, Mashimpur. The percent sand of 12 soil samples were ranged from 22.73-61.03 with an average of 44.13% and that of silt were 20.2-52.03 with an average of 34.68% while the range of clay were 12.63-32.75 with an average of 21.18% (Table 1). The pH of the soils varied from strong acidic (4.8, Kaharol) to medium acidic (5.7), (Suihari and Mohshail). The soils of Fulbari and Ulipur was medium acidic; Sujalpur, Kaharol, Mohshail, Darbarpur and Mashimpur was strongly acidic; Kasba, Mohobbotpur, Awliapur was slightly acidic; Suihari and Ulipur was medium acidic. Organic matter content varied from 0.84% at Sujalpur to 2.01% at Kaharol. The average organic matter in the studied areas was 1.49%. The optimum organic matter for litchi growing soil is 1.72-5% [13].

Table 1. Particle size distribution of twelve litchi garden soils under Dinajpur district.

Sites	Soil separates			Textural class	Sand/Silt ratio	Silt/Clay ratio
	% Sand	% Silt	% Clay			
Fulbari	45.47	40.20	14.32	Sandy silt loam	1.13	2.81
Sujalpur	61.03	21.20	17.77	Sandy loam	2.87	1.19
Kasba	27.44	46.20	26.40	Clay loam	0.59	1.75
Suihari	38.68	43.22	18.09	Clay loam	0.89	2.39
Darbarpur	52.41	34.95	12.63	Sandy loam	1.50	2.76
Kaharol	57.25	23.04	19.71	Clay loam	2.48	1.17
Mohobbotpur	22.73	52.03	25.24	Clay loam	0.43	2.06
Mohshail	55.28	24.10	20.62	Sandy clay loam	2.29	1.17
Awliapur	44.41	32.22	23.36	Clay loam	1.38	1.38
Ulipur	41.73	32.22	26.04	Clay loam	1.29	1.23
Mashimpur	36.45	30.79	32.75	Clay loam	1.18	0.94
Biral	46.75	36.01	17.23	Silty loam	1.30	2.09
Range	22.73-61.03	21.20-52.03	12.63-32.75	_	0.43-2.87	0.94-2.81
Mean	44.13	34.68	21.18	_	1.44	1.74

The available N content in the soils ranged from 30.4 mg/kg at Mohshail to 57.8 mg/kg at Awliapur. Total N content in soil was less when the pH was less than 6.0. The average total N content was 0.11% which indicated that the study area was in the critical stage because the standard level of total N in soil is 0.32% and the critical value is 0.12%. These soils are deficient in nitrogen. Nitrogen has a profound influence on fruit set, fruit retention, length, diameter and weight of fruit. Thus, it is recommended to use organic fertilizer in the study area as much as possible to avail N as well as organic matter in the soil.

Total phosphorus content ranged from 0.02-0.07% with an average of 0.05%. The available phosphorus content ranged from 10.53-14.33 µg/g while the average was 12.06 µg/g. The standard level of P for crop cultivation is 21 µg/g when the critical value is 5 µg/g[14]. Available P status of Bangladesh soils varies from very low (<7.5 µg/g) to very high (>37.5 µg/g), while most of the soil P status falls between low (7.5-15.0 µg/g) and medium (15.1-22.5 µg/g) [14]. In the lower pH, the availability of P is reduced due to the presence of Fe and the P is replaced by Fe [15]

Table 2. Some chemical properties and NPK status of twelve litchi garden soils under Dinajpur district.

Sites	pH	EC (µS/cm)	Organic matter (%)	Nitrogen		Phosphorus		Potassium		Sulphur	
				Available (mg/ kg)	Total (%)	Available (µg/g)	Total (%)	Exchangeable (meq/100 g)	Total (meq/100 g)	Available (µg/g)	Total (%)
Fulbari	5.1	310.2	1.65	52.7	0.180	12.77	0.043	0.08	0.160	22.04	0.017
Sujalpur	4.9	302.9	0.84	42.8	0.063	12.14	0.069	0.07	0.046	22.02	0.025
Kasba	5.2	306.9	1.04	47.8	0.074	10.94	0.048	0.32	0.050	30.02	0.028
Suihari	5.7	305.6	1.88	51.2	0.158	13.47	0.069	0.07	0.067	34.80	0.021
Darbarpur	5.3	309.6	1.68	47.3	0.124	11.15	0.033	0.08	0.061	20.87	0.028
Kaharol	4.8	305.4	2.01	42.8	0.147	11.98	0.039	0.03	0.070	27.45	0.020
Mohobbotpur	5.1	302.4	0.96	52.7	0.167	11.64	0.037	0.07	0.059	25..60	0.028
Mohshail	5.7	305.7	1.81	30.4	0.053	10.85	0.041	0.23	0.260	26.47	0.022
Awliapur	5.5	302.9	1.54	57.8	0.017	10.53	0.061	0.18	0.170	26.90	0.025
Ulipur	5.6	305.7	1.65	51.6	0.132	11.44	0.070	0.05	0.259	27.10	0.026
Mashimpur	5.0	303.3	1.66	40.6	0.153	14.33	0.057	0.08	0.370	20.03	0.018
Biral	5.4	304.5	1.18	54.4	0.112	13.49	0.020	0.30	0.250	21.03	0.015
Range	4.8-5.7	302.4-310.2	0.84-2.01	30.4-57.8	0.053-0.180	10.53-14.33	0.02-0.07	0.03-0.32	0.046-0.370	20.03-34.80	0.015-0.028
Mean	5.27	305.4	1.49	47.67	0.11	12.06	0.05	0.13	0.15	25.36	0.022

Total K content varied from 0.046-0.370 meq/100g. The exchangeable K content in the experimental area ranged from 0.03-0.32 meq/100g. The mean value of exchangeable K content was 0.13 meq/100g. For litchi grown soil exchangeable K content is needed from 0.5 to 1.0 meq/100 g[13]. Most of the farmers do not apply potassium fertilizer and, as a result, lands become deficient in potassium. Total S content ranged from 0.015-0.028 while the average was 0.022%. The available S content in the litchi orchard soils ranged from 20.03-34.80 µg/g while the average value of available S content was found 25.36 µg/g. The standard value of available S for crop cultivation is 31.5 µg/g and the critical value is 10 µg/g[14]. Results revealed that most of the samples contained a lower level of S than the standard value but not in critical range.

Table 3. Available Zinc, Iron, Manganese and Boron content of twelve litchi garden soils under Dinajpur district.

Sites	Zn (µg/g)	Fe (µg/g)	Mn (µg/g)	B (µg/g)
Fulbari	0.68	35.74	7.39	0.25
Sujalpur	0.71	31.80	6.81	0.31
Kasba	1.10	40.25	7.25	0.49
Suihari	1.50	39.12	7.10	0.28
Darbarpur	1.03	41.50	6.75	0.33
Kaharol	0.75	38.47	6.85	0.45
Mohobbotpur	0.88	32.65	7.18	0.51
Mohshail	0.95	34.80	7.35	0.35
Awliapur	0.98	34.81	6.89	0.42
Ulipur	0.81	37.20	6.87	0.40
Mashimpur	0.87	35.15	7.10	0.37
Biral	0.79	33.59	7.19	0.41
Range	0.68- 1.50	31.80- 41.50	6.75- 7.39	0.25- 0.51
Mean	0.92	36.26	7.06	0.38

Available Zn content in the studied soils ranged from 0.68-1.50 µg/g. Higher pH reduces the availability of Zn in soil[15]. BARC reported that the standard level of Zn for crop cultivation is 1.25 µg/g when the critical value is 0.6 µg/g[,15]. The available Fe content in soil ranged from 31.8-41.5 µg/g. The suitable Fe content in soil for crop production is 9.1-12.0 µg/g[16] The micronutrient cations *viz.* iron, manganese and zinc, are most soluble and available under acid conditions[15]. Higher pH level reduces the availability of Fe in soil and in lower pH (< 6.0) the level of Fe is increased. Since the result of the study area showed a lower pH in all samples, so the higher concentration of Fe was found in soil.

Table 4. Nutrient concentrations in the leaves of the twelve litchi garden under Dinajpur District.

Sites	N (%)	P (%)	K (%)	S (%)	Zn (µg/g)	Mn (µg/g)
Fulbari	1.74 ± 0.14	0.14 ± 0.01	0.198 ± 0.10	0.129 ± 0.10	12 ± 0.12	39 ± 0.22
Sujalpur	2.20 ± 0.10	0.130 ± 0.02	0.185 ± 0.10	0.327 ± 0.14	14 ± 0.14	35 ± 0.25
Kasba	1.60 ± 0.11	0.120 ± 0.02	0.104 ± 0.20	0.339 ± 0.12	12 ± 0.26	44 ± 0.28
Suihari	2.01 ± 0.84	0.154 ± 0.10	0.133 ± 0.10	0.231 ± 0.11	14 ± 0.25	36 ± 0.21
Darbarpur	2.13 ± 0.28	0.188 ± 0.01	0.185 ± 0.12	0.325 ± 0.17	13 ± 0.20	35 ± 0.25
Kaharol	1.70 ± 0.16	0.137 ± 0.03	0.198 ± 0.13	0.233 ± 0.10	13 ± 0.14	39 ± 0.26
Mohobbotpur	2.16 ± 0.23	0.110 ± 0.02	0.150 ± 0.10	0.247 ± 0.15	12 ± 0.28	74 ± 0.27
Mohshail	1.12 ± 0.13	0.157 ± 0.01	0.146 ± 0.10	0.141 ± 0.10	14 ± 0.17	38 ± 0.18
Awliapur	1.80 ± 0.11	0.160 ± 0.01	0.138 ± 0.10	0.428 ± 0.01	12 ± 0.21	55 ± 0.22
Ulipur	1.02 ± 0.15	0.177 ± 0.10	0.173 ± 0.13	0.233 ± 0.01	14 ± 0.11	51 ± 0.25
Mashimpur	1.05 ± 0.12	0.120 ± 0.03	0.110 ± 0.01	0.430 ± 0.12	13 ± 0.14	30 ± 0.170
Biral	1.97 ± 0.41	0.172 ± 0.02	0.187 ± 0.12	0.370 ± 0.17	12 ± 0.16	46 ± 0.20
Range	1.02 - 2.20	0.11 - 0.188	0.104 - 0.198	0.129 - 0.430	12 - 14	30 - 74
Mean	1.71	0.15	0.16	0.28	12.9	43.5

'±' Standard error.

Table 5. The optimum soil properties and leaf nutrient concentrations for litchi garden[13].

Soil		Leaf	
Parameters	Values	Parameters	Values
pH	5.5-6.0	Nitrogen	1.5 - 1.8%
Organic matter	1.72-5.0%	Phosphorus	0.14 - 0.3%
Electrical conductivity	< 0.20 dS/m	Potassium	0.7 - 1.1 %
Available N	10 mg/kg	Manganese	40 - 250 µg/g
Available P	100 to 300 mg/kg	Zinc	12 - 30 µg/g
Exchangeable K	0.5 to 1.0 meq/100 g	-	-
Available B	1 to 2 mg/kg	-	-
Available Mn	10 to 50 mg/kg	-	-
Available Zn	2 to 15 mg/kg	-	-

Available Mn content in the studied soil ranged from 6.75-7.39 µg/g. The optimum available Mn content in the litchi grown soil ranged from 10 to 50 mg/kg[13]. Available B content in the orchards ranged from 0.25-0.51 µg/g in the soil with an average of 0.38 µg/g. The standard level of B for crop cultivation is 0.53 µg/g when the critical value is 0.2 µg/g[14].

Nutrition is the base of fruit growth and development, yield formation, and quality improvement. Nitrogen level in the litchi leaves ranged from 1.74-2.2 % with an average of 1.71% (Table 4). The optimum level of N in the litchi leaves ranged from 1.5-1.8%[13]. Phosphorus level in the litchi leaves ranged from 0.11-0.188 % with an average of 0.15%. The optimum level of P in the litchi leaves ranged from 0.14-0.30 %[13]. Potassium levels in the litchi leaves ranged from 1.104-1.198% with an average of 0.16%, S ranged from 0.129-0.430 with an average of 0.28%, Zn ranged from 12-14 µg/g with an average of 12.9 µg/g and Mn ranged from 30-74 µg/g with an average of 43.5 µg/g.

The overall results indicated that the fertility status of the soils under twelve litchi orchards is moderately fertile in Dinajpur area.

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