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Geochemical analysis of forest floor leaf litters of Madhupur *Sal* forest of Bangladesh

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A B S T R A C T

An experiment was conducted in Lahoria and Rasulpur beats of Madhupur Sal forest of Bangladesh to study the geochemical analysis of forest floor leaf litters with varying stands. The study was followed by completely randomized design (CRD) with four replications. The experiment consisted of three treatments like pure stand, plantation stand and mixed stand. A quadrate sample of 10 × 10 m^2 plot size was determined to collect the leaf litter samples from the forest floor for chemical analysis. The chemical properties of leaf litters such as organic carbon, total N, C: N, phosphorus, potassium, calcium, magnesium, sulphur, boron, iron and zinc were determined following standard methods. The result revealed that the organic carbon, C: N, phosphorus, potassium, magnesium, sulphur, boron, iron and zinc content was the highest (39.04%, 59.12, 548.76 ppm, 0.53%, 745.74 ppm,0.25%, 50.75 ppm, 94.38 ppm and 36.31 ppm, respectively) in the mixed stand and the lowest (37.67%, 35.87, 293.26 ppm, 569.19 ppm, 0.22%, 27.77 ppm in case of organic carbon, C: N, phosphorus, magnesium, sulphur, zinc, respectively) both in the plantation stand and in the pure stand (0.30%, 37.57 ppm, 68.36 ppm in case of potassium, boron, iron, respectively). The content of total nitrogen was the highest (1.05%) in the plantation stand and the lowest (0.65%) in the pure stand while the content of calcium was the highest (0.32%) in the pure stand and the lowest (0.27%) was found both in the mixed stand and plantation stand. Therefore, it can be concluded that the geochemical characteristics of forest floor leaf litters of Madhupur Sal forest was well in the pure stand of natural forest (Sal tree) rather than the plantation forest (exotic tree species).

INTRODUCTION

Bangladesh is located in south Asia and surrounded with India and Myanmar. It is a densely populated and small country with an area of 147,570 km^2 (BEC 2015). According to the latest economic census in 2015, the population of the country was 157.9 million. The economy of the country draws its strength and stability mostly from agriculture. The capacity of our land is decreasing day by day due to intensive cropping and use of high input technologies. As a result, there is a tremendous pressure on the natural resources of the country. The current forest land of Bangladesh is 1.44 million hectares which are 14% of the total land area (FRA 2010). Forestry plays an important role in maintaining environmental equilibrium and socio-economic condition of people. A country needs 25% of forest land of its total area for ecological stability and sustainability. Unfortunately, Bangladesh is endowed with only 17.08% (BFD 2014) of unevenly distributed forests. The central region where the population density is the highest has the least forest resources, thus, substantial depletion of forest resources has occurred in the last few decades, and now it is reduced to less than 0.02 ha per person, one of the lowest ratios in the world (BBS 2014).

Sal forests a 'Tropical Moist Deciduous Forest' type mainly distributed in the south and southeast Asia, occurs gregariously on the southern slopes of the Himalayas and is distributed in Bangladesh, India and Nepal (Gautam and Devoe 2006). In Bangladesh Sal forests cover an area of about 121,000 ha which is about 32% of the total forest land (BFD 2014). The major Sal forests lie in the districts of Mymensingh and Tangail called Madhupur range, and that of Gazipur is called Bhawal

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range. The principal plant species of the Sal forests is *Shorea robusta* which is one of the most important timber yielding plants. The Sal forests of Bangladesh are a source of a variety of products, which varies from subsistence needs to commercially valuable aspects. Moreover, every year this Sal forests falling huge amount of leaf litter on the forest floor which plays a significant role to enrich the forest soil with different nutrients.

Litter fall is characterized as fresh, undecomposed and easily recognizable plant debris. This can be anything from leaves, cones, needles, twigs, bark, seeds or nuts, logs, or reproductive organs. The type of litter fall is most directly affected by ecosystem type. For example, leaf tissues account for about 70% of litter fall in forests, but woody litter tends to increase with forest age. Leaf litter has a tremendous importance in the forest. It increases the growth of the trees and acceleration of the biological function of the organism in the soil. Besides, it promotes the physical improvement of the soil as well as enhances the production of the crops. Litter aids in soil moisture retention by cooling the ground surface and holding moisture in decaying organic matter. The flora and fauna working to decompose leaf litter also aid in soil respiration. A litter layer of decomposing leaf biomass provides a continuous energy source for macro- and micro-organisms. As litter decomposes, nutrients are released into the environment and enriched the soil health. So, our prime concern is to ensure the soil fertility along with maintaining well decomposition of the leaf litter of the forest. Some studies on soil and leaf litter nutrients and their effects on crops have been carried out for individual forest by Iltuthmish et al. (2006), Chowdhury et al. (2007), Zaman et al. (2008), Haider et al. (2009), Sarker et al. (2010), Hossain et al. (2011), and Mondol (2013) in Bangladesh. However, the information on geochemical analysis of forest floor leaf litters of Madhupur Sal forest of Bangladesh is still in small pockets. Therefore, it was deeply concerned necessary to the analyzed chemical constituents of leaf litter on the forest floor of the Madhupur Sal forest of Bangladesh with varying tree stands.

MATERIALS AND METHODS

The study was conducted in Madhupur Sal forest (Figure 1) under Madhupur Upazila in Tangail district. It is located at 24.30° to 24.50° North latitude and 90° to 90.10° East longitudes. Rasulpur Beat and Lohoria Beat under Madhupur Sal forest were selected as a specific study area with a view to collecting forest floor leaf litter samples. The topography of the area is characterized by plain land and low hills rising 3.0-4.5 m above the surrounding field locally known as 'chalas' which are intersected by numerous depressions or 'baids'. The annual rainfall ranges from 203-229 cm and the annual temperature ranges from 10-34°C. The humidity of the areas varies between 60 and 86%.

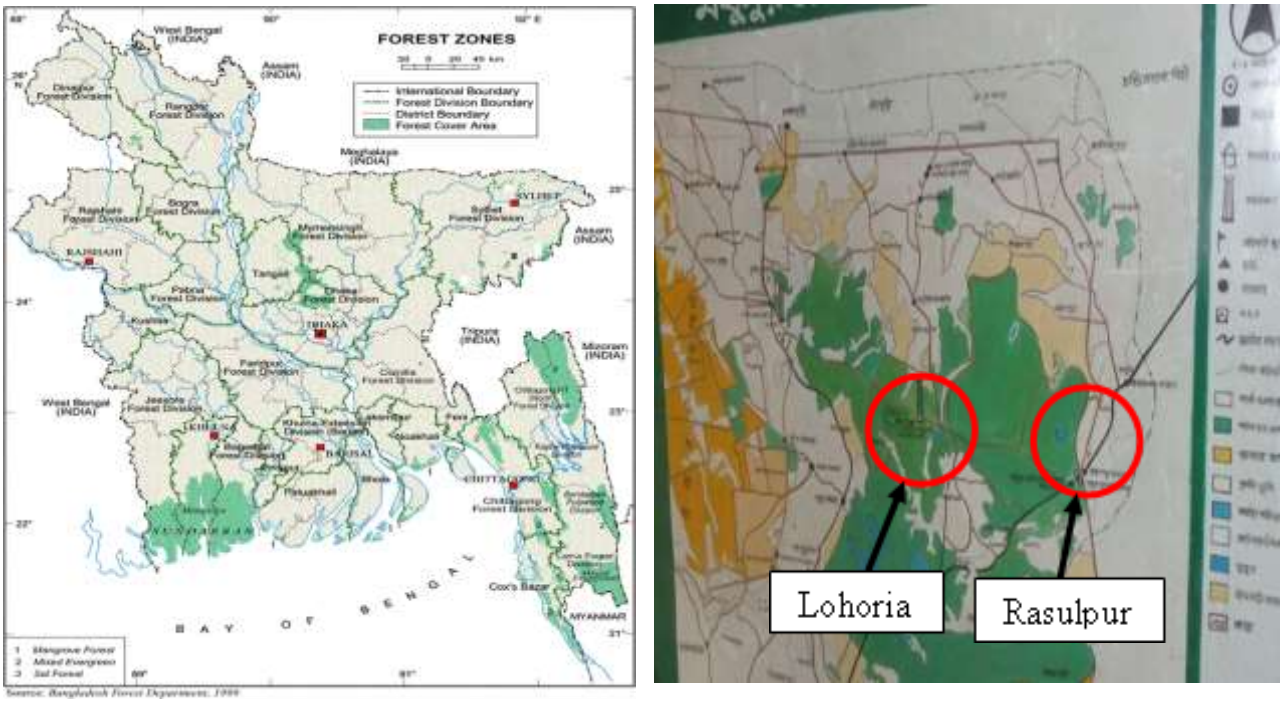

Figure 1.a (left). Map of major forest areas of Bangladesh where red circle on the map showing the study area (Source: Bangladesh Forest Department). **b (right).** Sampling areas of Rasulpur and Lohoria beats of Madhupur Sal forests (Source: Tangail forest division).

Sal (*Shorea robusta*) is the dominant species of this forest and usually, it forms 25% to 75% of the upper canopy in the natural habitat (Alam 1995). Besides, other associates like a mixture of Sonalu (*Cassia fistula*), Azuli (*Dillenia pentagya*), Koroi (*Albizia* spp), Bohera (*Terminalia bellirica*), Haritaki (*Terminalia chebula*), Kanchan (*Bauhinia acuminata*), Jarul (*Lagerstroemia speciosa*), Jam (*Syzygium* spp), etc. are grown. Presently participatory forestry program are being implemented here under the umbrella of social forestry programme with *Acacia* spp and *Eucalyptus* spp. Based on the above information and species distribution in the forests, three stands could be distinguished (Table 1) from the study area which was used as treatments in this study. Within the above sampling areas, a quadrate plots of 10×10 m^2 with four replications following random sampling for each stand commonly found throughout the Madhupur Sal forest that represent the characteristic tree species (Table 1). The treatments used for the study were designated like- T_1 = Pure stand, T_2 = Plantation stand and T_3 = Mixed stand.

The leaf litter sample collection was made following completely randomized design (CRD). Leaf litter samples were collected from the forest floor within each quadrate plot at selected locations of Madhupur Sal forest area. The leaf litter samples were collected by means of hand using hand gloves from different spots covering thoroughly to make a composite

sample. From the collected leaf litter samples, little branches, inert matter, undesired substances other than leaf litter were picked up and removed. Leaf litter from each sample was cut into a very tiny size with a view to rapid drying and then the samples were oven-dried. Each leaf litter sample was ground with the help of grinding machine. Then required and desired solutions were made using chemical agents. Organic carbon, total nitrogen, carbon nitrogen ratio, phosphorus, potassium, sulphur and boron of the leaf litter were determined by a wet combustion method, Micro-Kjeldahl method, Automated C: N analyzer, Olsen method, NH_4OAC extraction method, Turbidimetric method and Molybdenum Blue Color method respectively. Calcium and Magnesium were determined by NH_4OAC extraction method. Iron and Zinc were determined by DTPA method. The values from chemical analysis of leaf litters were tabulated and performed through a standard computer package statistical procedure WEB AGRI STAT PACKAGE (Jangam and Thali 2002). The Duncan's new Multiple Range Test (DMRT) was done to rank the mean values of analyzed leaf litter samples (Gomez and Gomez 1984).

Table 1. Various stands of Madhupur Sal forest and their characteristic species

Stands	Characteristic tree species
Pure stand	*Shorea robusta*
Plantation stand	*Acacia spp*, *Eucalyptus spp*
Mixed stand	*Shorea robusta, Albizia spp, Dillenia pentagya, Cassia fistula, Terminalia bellirica, Terminalia chebula, Bauhinia acuminata, Lagerstroemia speciosa, Syzygium spp,* etc.

RESULTS AND DISCUSSION

The chemical composition of forest floor leaf litters in the study area was evaluated with respect to organic carbon, primary nutrients, secondary nutrients and micronutrients (Fe, B and Zn) and the results obtained are presented and discussed in the following sections.

Organic Carbon

Organic carbon content of forest floor leaf litters of Madhupur Sal forest area was greatly influenced due to the stand characteristics (Table 2). The organic carbon content in the pure stand, plantation stand and mixed stand was recorded as 38.88%, 37.67% and 39.04% respectively. Organic carbon content in leaf litter of mixed stand was the highest (39.04%) which was statistically similar with the organic carbon content in leaf litter of pure stand (38.88%) (Table 2). The content of organic carbon was the lowest (37.67%) in the plantation stand. Relevant results also found by Shunula and Whittick (2001), who found that the carbon increased during first seven days and then decreased in leaf litters from three families such as Avicenniaceae (*Avicennia marina*), Sonneratiaceae (*Sonneratia alba*) and Rhizophoraceae (*Ceriops tagal*) of mangroves in Zanzibar. Again, Khatun et al. (2010) reported that the organic carbon content in the leaf litters of *Acacia auriculiformis*, *Terminalia bellirica*, *Gmelina arborea* and *Shorea robusta* of Madhupur Sal forest were 4.56, 5.21, 3.85 and 3.43%, respectively which was very much supportive to the study result.

Primary Nutrients (N, P, and K)

The forest floor leaf litters of the Madhupur Sal forest contains statistically very less amount of total nitrogen (Table 2). The content of total nitrogen in the pure stand, plantation stand, and mixed stand was determined as 0.65, 1.05 and 0.68% respectively. The total nitrogen content in the leaf litter of the plantation stand (1.05%) statistically differed from the total nitrogen in the leaf litter of both the pure stand (0.65%) and mixed stand (0.68%). The comparatively the lowest (0.65%) content of total nitrogen was found in the pure stand which was statistically similar to the mixed stand (0.65%) (Table 2). Rawat et al. (2009) found the similar findings about total nitrogen in the leaf litter, who stated that the mineral nutrients like total nitrogen concentration released from leaf litters to soil were found the maximum in the protected area compared to the unprotected area. Campo et al. (2013) also determined that the N content of litter fall in the tropical dry forest, tropical evergreen forest, and Mediterranean temperate forest were 15.9, 16.4, 13.1 mg N g^{-1}, respectively.

The result showed that the phosphorus content in the pure stand, plantation stand and mixed stand leaf litters of Madhupur Sal forest was recorded 489.96, 293.26 and 548.76ppm, respectively. The content of phosphorus was the highest (548.76ppm) in the mixed stand and the lowest (293.26 ppm) in the plantation stand. The result referred that the phosphorus content in leaf litter of mixed stand (548.76) statistically differed from the phosphorus content in leaf litter of both of plantation stand (293.26 ppm) and pure stand (489.96 ppm) (Table 2). The same finding was found by Rawat et al. (2009), who stated that the amount of standing litter biomass varied both in the protected and unprotected sites and was highest in the protected area of Himalayan alpine ecosystem. They also reported that the mineral nutrients like phosphorus concentration and released to soil was found maximum in the protected area compared to the unprotected area. Khatun et al. (2010) also reported that the phosphorus content in the leaf litters of Madhupur Sal forest of Bangladesh was 0.04, 0.13, 0.14 and 0.05 µg/g for *Acacia auriculiformis*, *Terminalia bellirica*, *Gmelina arborea* and *Shorea robusta,* respectively. Silva et al. (2007) also found that the total P in *Rhizophora mangle* trees accounted for 145±14 kg ha^{-1} which was 23% of the total P in the mangrove forest in Northern Brazil. The estimated average export rates for P through leaf litter were 0.5 kg ha^{-1} yr^{-1}.

The result from the ANOVA revealed that the content of potassium in the pure stand, plantation stand and mixed stand was recorded as 0.30, 0.52 and 0.53% respectively (Table 2). The highest (0.52%) content of potassium was found in the mixed stand which was statistically similar to the plantation stand, while the lowest content of Potassium was found in the in the pure stand (Table 2). Qiu et al. (2012) got the nearly similar findings, who reported that the nutrient dynamics of leaf litters of jarrah (*Eucalyptus marginata Donn ex Sm*.) and banksia (*Banksia menziesii R. Br*) in a forest to Wetland Hill slope followed the order K ≈ Mg ≈ S >Ca> P. Singh and Chaturvedi (2009) also found that the average content of K^+ was 0.39% in the tree litter of Nilgiri reserve forest, India.

Carbon Nitrogen ratio (C: N)

The average carbon nitrogen ratio of forest floor leaf litters in the Madhupur Sal forest was significantly affected due to various stand composition. The results revealed that the C: N in the pure stand, plantation stand and mixed stand was recorded 59.50, 35.87 and 59.12, respectively. The carbon nitrogen ratio in leaf litter of the pure stand was the highest (59.50) which was statistically similar to the mixed stand and dissimilar to the plantation stand (35.87). The carbon nitrogen ratio was the lowest (35.87) in the plantation stand (Table 2). Shunula and Whittick (2001) found that C:N ratio was almost constant in *Avicennia* and *Sonneratia* at 50:1 but was more variable in *Ceriops*, increasing from 80:1 to 160:1 in the first week of decomposition, before falling to 100:1. Singh and Chaturvedi (2009) also noted that average carbon nitrogen ratio (C:N) was 19.41 in the tree leaf litter of Nilgiri biosphere reserve. Again,

Campo et al. (2013) found that the C: N content of litter fall in the tropical dry forest, tropical evergreen forest and Mediterranean temperate forest were 29.6, 28.7 and 35.9, respectively.

Secondary Nutrients (Ca, Mg and S)

The content of calcium in the forest floor leaf litters of Madhupur Sal forest was recorded as 0.32, 0.27 and 0.27% in the pure stand, plantation stand and mixed stand, respectively (Table 2). There was a non-significant difference among pure stand, plantation stand and mixed stand calcium content on the forest floor leaf litters of Madhupur Sal forest (Table 2). The highest (0.32) content of Ca was found in the pure stand and the lowest (0.27) was found in the both of mixed and plantation stand (Table 2).

The magnesium content in the leaf litter of Madhupur Sal forest was recorded as 0.22, 0.22 and 0.25% in the pure stand, plantation stand and mixed stand, respectively (Table 2). The highest (0.25) content of Mg was found in the mixed stand and the lowest (0.27) was found in the both of pure and plantation stand. The result showed that there was a non-significant difference among the magnesium content in pure stand, plantation stand and mixed stand forest floor leaf litters of Madhupur Sal forest (Table 2).

The sulphur content on the forest floor leaf litters of the Madhupur Sal forest was varied according to the stand composition. The result revealed that the sulphur content in leaf litter of mixed stand was the highest (745.74 ppm) which statistically differed from the sulphur in leaf litter of both the plantation stand (569.19 ppm) and pure stand (655.18 ppm) (Table 2). Khatun et al. (2010) found that the Sulphur content in the leaf litters of *Acacia auriculiformis*, *Terminalia bellirica*, *Gmelina arborea* and *Shorea robusta* in the leaf litters of Madhupur Sal forest were 0.12, 0.12, 0.14 and 0.08 µg/g, respectively which was supportive to the present findings.

Micronutrients (Fe, B and Zn)

The result showed that the highest (94.38 ppm) Fe content was found in the mixed stand and the lowest (68.36 ppm) was in the pure stand (Table 2). The Fe content in the mixed stand was statistically similar to the Fe content in the leaf litter of plantation stand and statistically dissimilar to the iron content in leaf litter of mixed stand (Table 2). Relevant result was found by Salmanaca et al. (1998), who found that the elemental mobility in the leaf litter was Fe < Zn.

Boron content of forest floor leaf litter of Madhupur Sal forest was recorded as 37.57, 41.22 and 50.75 ppm, respectively (Table 2). The result revealed that the boron content in leaf litter of mixed stand was the highest (50.75 ppm) which statistically differed from the boron content found in the leaf litter of both pure stand (37.57 ppm) and plantation stand (41.22 ppm) (Table 2). The content of boron was statistically similar to the pure stand and plantation stand due to lower microbial activities as well as the abundances of physical inertness. Subrado (2014) found that leaf micronutrients such as B contents mirrored that of leaf N and P contents.

The ANOVA showed that there was a significant difference among pure stand, plantation stand and mixed stand Zn content values in the leaf litters of Madhupur Sal forest (Table 2). The zinc content in the forest floor leaf litters of the Madhupur Sal forest was recorded as 33.27, 27.77 and 36.31 ppm in the pure stand, plantation stand and mixed stand respectively. The highest (36.31 ppm) Zn content was found in leaf litter of mixed stand and the lowest (27.77 ppm) was in the plantation stand (Table 2). Khatun et al. (2010) found that the Zinc (Zn) content in the leaf litters of *Acacia auriculiformis*, *Terminalia bellirica*, *Gmelina arborea* and *Shorea robusta* of Madhupur Sal forest leaf litters were 34, 38, 75 and 62 µg/g, respectively.

Table 2. Organic carbon, C: N, macro and micronutrients contents of forest floor leaf litters of different stands in the Madhupur *Sal* forest

Treatments	OC (%)	Macronutrients							Micronutrients		
		Primary nutrients			C:N	Secondary nutrients					
		Total N (%)	P (ppm)	K (%)		Ca (%)	Mg (%)	S (ppm)	Fe (ppm)	B (ppm)	Zn (ppm)
Pure stand	38.88a	0.65b	489.96b	0.30b	59.50a	0.32	0.22	655.18b	68.36b	37.57b	33.27b
Plantation stand	37.67b	1.05a	293.26c	0.52a	35.87b	0.27	0.22	569.19c	87.92a	41.22b	27.77c
Mixed stand	39.04a	0.68b	548.76a	0.53a	59.12a	0.27	0.25	745.74a	94.38a	50.75a	36.31a
Level of significance	**	**	**	**	**	NS	NS	**	**	**	**

Note: Figures followed by the same letter(s) in the same column do not differ significantly at ($P \leq 0.01$) according to DMRT; NS= Non-significant

CONCLUSION

From the results of study it is appeared that the nutrient status are higher in undisturbed forest sites i.e. pure stand and mixed stand compare to the plantation stand in the forest floor leaf litters of Madhupur Sal forest. The plantation forestry or participatory forestry activities with *Acacia* spp and *Eucalyptus* spp in the Madhupur Sal forest are lowering the nutrient status on the forest floor leaf litters. Therefore, it also may be concluded that for sustainable forest coverage we have to conserve our natural forest and Bangladesh government should take the necessary steps to conserve forest for maintaining the sustainable nutrient status of the forest floor leaf litter.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interests regarding the publication of this paper.

REFERENCES

Alam MK. 1995. Diversity in the woody flora of Sal forests of Bangladesh. Bangladesh J For Sci, 24(1):41-52.

BBS (Bangladesh Bureau of Statistics). 2014. Statistical Year Book of Bangladesh. Bangladesh Bureau of Statistics, Ministry of Planning, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh.

BEC (Bangladesh Economic Census). 2015. Ministry of Finance, Government of the People's Republic of Bangladesh.

BFD (Bangladesh Forest Department). 2014. Ministry of Environment and Forest, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh.

Campo J, Gallardo JF, Hernandez G. 2013. Leaf and litter

nitrogen and phosphorus in three forests with low P supply. Eur J For Res, 133:121-129.

Chowdhury MAH, Mohiuddin KM, Fancy R, Chowdhury AHMRH. 2007. Micronutrient release pattern of some tree leaf litters in Rajendrapur forest soil. Bangladesh J Crop Sci, 18(2):381-386.

FRA (Forest Resource Assessment). 2010. Country Report, Bangladesh. Forestry Department, Food and Agriculture Organization of the United Nations, Rome, Italy.

Gautam KM, Devoe N. 2006. Ecological and anthropogenic niches of Sal (*Shorea robusta* Gaertn. f.) forest and prospects for multiple-product forest management–a review. Forestry, 79(1):81-101.

Gomez KA, Gomez AA. 1984. Duncan's Multiple Range Test. Statistical Procedure for Agricultural Research. Second edition, A Wiley Inter- Science Publication, Johan and Sons, New York. pp. 202-215.

Haider SMS, Khatun MF, Chowdhury MAH, Islam MS, Talukder MZA. 2009. Effects of different tree leaf litters on growth and yield of okra in Madhupur Forest Soil. J Innove Dev Strategy, 3(3):55-60.

Hossain M, Siddique MRH, Rahman MS, Hossain MZ, Hasan MM. 2011. Nutrient dynamics associated with leaf litter decomposition of three agroforestry tree species (*Azadirachta indica, Dalbergia sissoo,* and *Melia azedarach*) of Bangladesh. J Forestry Res, 22(4):577-582.

Iltuthmish AHM, Chowdhury MAH, Mohiuddin KM, Chowdhury AHMRH. 2006. Macronutrient release pattern from soils added with leaf litters of some forest trees. *Progress Agric,* 17(1):81-87.

Jangam AK, Thali P. 2002. WASP-Web Agri Stat Package. ICAR Research Complex for Goa, Ela, Old Goa, Goa. 403 402. India. Available at: http://www.icargoa.res.in/wasp/

Khatun MF, Chowdhury MAH, Islam MS, Haider SMS, Talukder MZA. 2010. Effects of different tree leaf litters on growth and yield of Okra in Madhupur Forest Soil. Int J Expt Agric, 1(1):5-11.

Mondol MMA. 2013. Study on soil, plant species and encroachment status of Sal forest in Bangladesh. Dissertation, Bangladesh Agricultural University, Mymensingh.

Rawat N, Nautiyal BP, Nautiyal MC. 2009. Litter production pattern and nutrients discharge from decomposing litter in a Himalayan alpine ecosystem. New York Sci J, 2(6):54-67.

Salmanca EF, Kaneko N, Katagiri S. 1998.Nutrient dynamics in decomposing forest leaf litter: A comparison of field and laboratory microcosm approach. J For Res, 3:91-98.

Sarkar UK, Saha BK, Goswami C, Chowdhury MAH. 2010. Leaf litter amendment in forest soil and their effect on the yield quality of red amaranth. J Bangladesh Agril Uni, 8(2):221-226.

Shunula JP, Whittick A. 2001. A note on leaf litter degradation and nitrogen and carbon release in species from three families of mangroves in Zanzibar. In: Richmond MD (ed) Marine Science Development in Tanzania and Eastern Africa, J. Francis. Zanzibar, Tanzania. IMS; WIOMSA no. 1, pp. 227-232.

Silva CAR, Oliveira SR, Rego RDP, Mozeto AA. 2007. Dynamics of phosphorus and nitrogen through in a litter fall and decomposition in a tropical mangrove forest. Mar Environ Res, 64(4):524-534.

Singh JN, Chaturvedi SP. 2009. Assessment of mineral content of leaf litter of Nilgiri biosphere reserve and its impact on properties of sodic soil. Indian Forester, 135(7):905-913.

Subrado MA. 2014. An experiment on relationship between leaf micro and macro nutrients in top canopy tree in a mixed forest in the upper Rio Negro in Amazon region. American J Plant Sci, 5:1423-1431.

Qui S, McComb AJ, Bell RW. 2012. Leaf litter decomposition and dynamics in woodland and wetland conditions along a forest to wetland hill slope. ISRN Soil Science. Available at: http://dx.doi.org/10.5402/2012/346850

Zaman AHMR, Mohiuddin KM, Fancy R, Chowdhury AHMRH, Chowdhury MAH. 2008. Decomposition of some tree leaf litters in Rajendrapur forest soils under laboratory condition. *Bangladesh* J *Progress Sci Technol,* 6(1):133-136.