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Influence of Climatic Factor on the Carbon and Nitrogen Content in the Leaf Litter Biomass of Subtropical Ecosystem, North East India

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Abstract: ***The study about leaf litter is crucial for the study of nutrient input to the soil that contributes significantly to the nutrient cycle dynamics and stability of the existing ecosystem. It is of utmost importance to study the variation of carbon (C) and nitrogen (N) content in the leaf litter biomass as an influence by the seasonal variability of climate. Besides, the tropical forest has been experiencing the warming climate that influences the carbon cycle. In the present investigation, the estimatedtotal annual litter biomass carbon was found as 54.88 g C m^{-2} yr^{-1} to 225.26 g C m^{-2} yr^{-11}. The nitrogen content ranges from 9.37 ± 0.04 mg g^{-1} to 15.27 ± 0.21 mg g^{-1}. The leaf litter N and C as well as with the climatic factors were significantly correlated in all the studied grove. This study reveals that regional variability of leaf litter nutrient content is influenced by the warming climate that results in faster C cycle.***

Keywords: Litter, Biomass, carbon, nitrogen, climate

1. Introduction

Litter is the freshly fallen plant debristhat contributes significantly to the nutrient cycle dynamics and stability of the existing ecosystem. Carbon (C) and nitrogen (N) are regarded as the fundamental element in the litter chemistry. The productivity of vegetation and the thriving of soil organism, as well as the structure and spatio-temporal dynamics of the existing ecosystem, mainly depend on the availability of these fundamental elements. The tight coupling between C and N could shape the response of the ecosystem to climate change due to global warming [1]. About1.6 Pg N (2%) stored in soil and litter and the regional anthropogenic, as well as the climatic perturbation, could limit the availability of N and consequent repercussions in the carbon cycle [1, 2]. Litter being the main transferring agent of the element from vegetation to soil in forest ecosystem through the process of decomposition. Therefore, the estimation of litter chemistry is crucial for predicting the ecosystem dynamics under the prevailing climatic condition.

Ecological stoichiometry predicts the role of key element such as carbon (C), nitrogen (N) etc on trophic interactions [3]. In lowland forest ecosystem, the higher concentration of N was observed due to physiological traits [4]. It was also reported that leaf nutrients can vary substantially within an ecosystem at small spatial scales [5,6]. Therefore, the small forested area of the sacred groves which have a little degree of disturbance was selected in the present investigation. This will enable to draw out the impact of C & N content of dominant species in the changing scenario of the warming climate. Studies on the ecological dynamics are still lacking in the region though they provided the different aspects of ecological services. Thus, the present investigation aims to find out the C&N content in the leaf litter biomass, their variability among species and influence of climate on C & N content in the leaf litter of subtropical ecosystem.

2. Material and Method

Sacred groves of Manipur are small patches of the area having the forest, woodland or any other aquatic body conserved in the name of associated deities. The studied sacred groves are located at the valley area of Manipur which is located at the geographical belt of 24°43'13.64″ N and 93°55'50.13″E (SG-I, Chajinglakpa Sacred grove), 24°43'49.46″N and 93°50'31.69″E (SG-II, Chaning Lairembi Sacred grove) and 24°51'8.79″N and 94°04'32.60″E (SG-III, the Kalika lairembi Sacred grove).*Schima wallichii* (DC.) Korth., *Quercus serrata* Murray and *Lithocarpus dealbatus*(Hook.f. & Thomson ex Miq.) Rehde were found as a dominant species in SG-I, SG-II, SG-III respectively. Besides this, *Lannea coromandelica* (Houtt.) Merr. (SG-I) and *Syzygium praecox* (Roxb.) Rathakr. & N.C.Nair, being common and high stand density in SG-I and SG-II were also considered for the elemental analysis of C & N and effect on it under the warming climate

Litter was collected from these groves using litter trap of 1 m × 1m during the monthly interval (2013-14). Twelve permanent litter trap of the appropriate size was randomly placed in each of the studied groves. The biomass of the dominant species and co dominant species was estimated and further processed for carbon (C) and nitrogen (N) analysis. Total organic Carbon (C) concentration was estimated after heating in a muffle furnance at 750 ^{0}C and total carbon accumulation was quantified by multiplying the leaf litter biomass.Total nitrogen (N) was estimated following acid digestion and alkali distillation using Kjeltech distillation unit. Soil temperature was measured using a digital soil thermometer and soil moisture was estimated using the gravimetric method at different soil depth i,e. (0-10) cm, (10-20) cm and (20-30) cm soil layer. Climate data of one year for 2013-2014 was taken from ICAR, Imphal regional office. Statistical analysis and graphical representation were performed using SPSS 23 in order to find out the possible correlation between the variables taken.

3. Result

Distinct seasonality in litterfall pattern was observed with a minimum in summer and start increasing at the end of rainy season and maximum in a winter season. Litterfall pattern was coincident with decreased soil moisture and soil temperature.

Species wise total nitrogen content in the dominant species, *Schima wallichii*, *Quercus serrata*, *Lithocarpus dealbatus*, *Lannea coromandelica* and *Syzygium praecox*ranged from 9.37 ± 0.04mg $g^{-1}$to 15.27 ± 0.21 mg g^{-1}(Tab.1). There occur distinct interspecific variation among the selected species because of different physiological trait for adaptation in the niche specialized unit of habitat space.

The carbon concentration was taken as 0.47 % for all the species by averaging the carbon concentration of different species as there was no distinct variation in the litter carbon content of different selected species. The total litter biomass carbon ranged from 54.88 g C m^{-2} yr^{-1} to 225.26 g C m^{-2} yr^{-1} (Tab.1). The variability in the litter productivity is related with the stem density in each of the studied grove. However, *Schima wallichii* showed competitive dominance among the species.

Table 1: The litter biomass carbon (g C m^{-2} yr^{-1}) and the corresponding elemental total nitrogen concentration (mg g^{-1}) of the selected dominant species

Species name	SG-I	SG-II	SG-III
Schima wallichii	225.26 ± 2.72 (10.06 ± 0.06)	224.87 ± 2.98 (10.37 ± 0.11)	152.60 ±1.66 (9.51± 0.07)
Quercus serrata	-	134.11 ± 2.56 (15.27 ± 0.21)	98.40 ± 1.36 (13.20 ± 0.17)
Lithocarpus dealbatus	-	-	72.21 ± 0.86 (9.37 ± 0.04)
Syzygium praecox	135.56 ± 1.86 (10.30 ± 0.07)	59.22 ± 1.02 (14.12 ± 0.34)	-
Lannea coromandelica	54.88 ± 0.74 (9.72 ± 0.06)	-	-

*()indicates the total nitrogen concentration; ± SE;

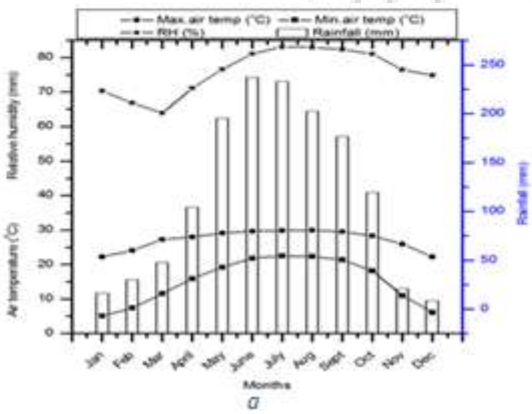


Figure 1 (a): Climatic facors showing ppt, MT, RH in the studied area during the sampling period (2013-14).

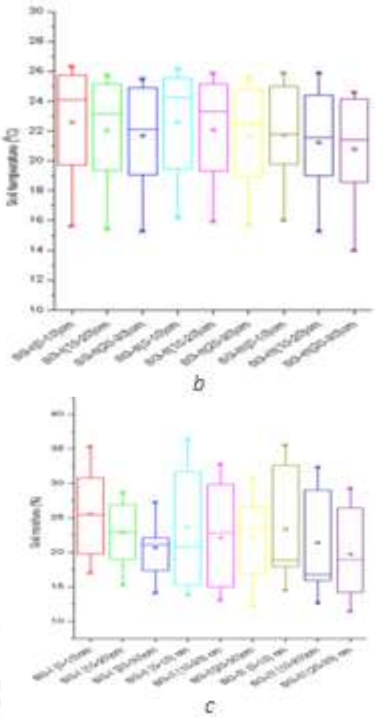
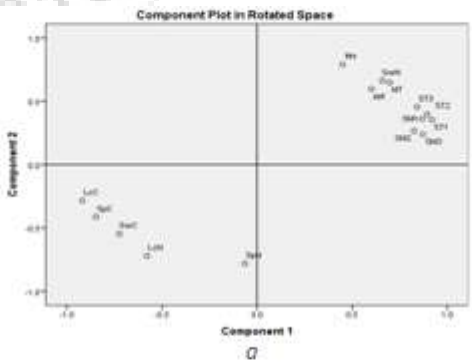


Figure 1 (b) & (c): Soil temperature (b) and Soil moisture (c) in different soil depth in the studied area during the sampling period

The climate data showed distinct seasonality with the warm moist rainy season from June to October. During March to May (summer season), the observed gradual increase in relative humidity (RH)), air temperature (AT) and rainfall while start decreasing from November to February (winter season) (Fig.1a). The layer wise soil temperature (ST) (Fig.1b) and soil moisture (SM) (Fig.1c) showed that upper surface has been experiencing highest ST and SM and decrease with the increase of depth.

Component plot derived from rotation method of varimax with kaiser normalization showed that the abiotic and climatic factors influenced in the functional



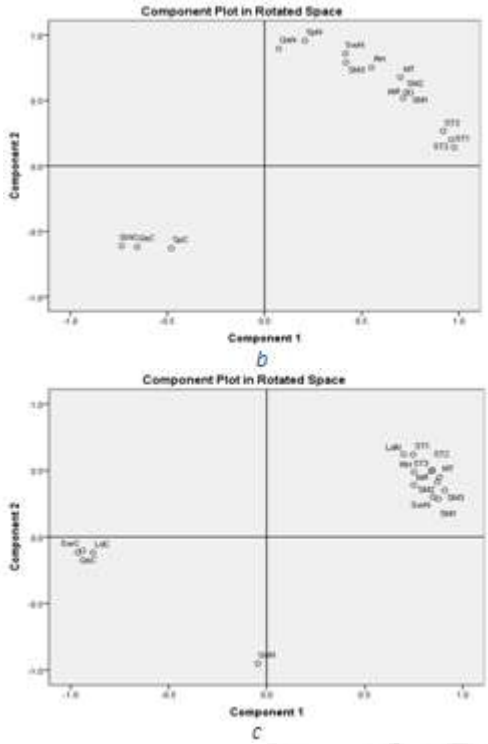


Figure 3: Component plot derived from rotation method of varimax with kaiser normalization showed that the abiotic and climatic factors influenced in the functional trait of plant species rather than carbon accumulation however variation was observed in the correlation.(a- SG-I; b-SG-II; c-SG-III) Abb used: Sw = Schima wallichii Qs= Quercus serrata Sp= Syzygim praecox, Ld= Lithocarpus dealbatus, Lc= Lannea coromandelica, Suffix N and C indicates Leaf litter nitrogen and biomass carbon, ppt- monthly precipitation, MT- mean ambient temperature, RH- relative humidity, ST and SM – soil temperature and soil moisture while prefix 1, 2 and 3 indicates soil layer of (0-10) cm, (10-20) cm and (20-30)cm respectively

Trait of plant species rather than carbon accumulation, however, variation was observed in the correlation (Fig.2a,b,c). This showed that the leaf litter nitrogen content of different species was influenced by abiotic and climatic factors though some species showed negative correlation due to adaptive speciation under the influence of rising temperature.

4. Discussion

Litterfall represents an important role in ecosystem dynamics including carbon accumulation and canopy cover [7]. The distinct ecosystem C & N stoichiometry in the leaf litter biomass reflect the physiological traits and strategies at ecosystem scale adaptation mechanism which is consistent with the study reported by [6] in the nutrient poor lowland rainforest. Here, the findings of leaf litter biomass, SM & ST comparable with other studies reported [8, 4]and it was influenced by climatic factors, topography and vegetation cover [8]. Variation in the leaf litter chemistry N and little variation of interspecific carbon content was observed in the present investigation, which is influenced by climatic factors. It is also reported that environmental factors influenced the variation of litter chemistry mainly C and N in the Neotropical rainforest [6].

Species have a wide range of adaptive strategies in terms of nutrient acquisition and resorption physiology to environmental constraints in a homogeneous environment at a local scale. The interspecific variation in the leaf litter chemistry of N observed might be related with the niche partitioning and adaptive responses to selection pressures in a nutrient limited tropical soil with a rich and highly bio-diverse ecosystem which is in agreement with other tropical forest [9]. It was also reported that the sacred groves of Manipur have been regarded as a storehouse of the gene pool with a diverse flora and fauna [10]. The long term high N deposition through litterfall accounts for higher productivity and sequestration [1]. Here in this study, the orthogonal relationship showed a high correlation between C and N though N and climatic factor had a strong correlation. Hence, the terrestrial N deposition could alter the carbon cycle in a changing scenario of the warming trend of climate.

5. Conclusion

Climatic factors influenced the variability of C & N concentration in leaf litter biomass of different species in the subtropical small forested ecosystem. Due to variation in litter chemistry, species showed different physiological traits as an adaptive mechanism at a small spatial scaleunder the influence of climate. However, uncertainty exists whether leaf litter N concentration fastens or weaken C cycle. Therefore, further study about the impact of rising atmospheric temperature on leaf litter traits and nutrient concentration should be beneficial from the present investigation.

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