CHAPTER V

NUTRIENT (N, P AND K) CONTENT IN PRE-FLOWERING, FLOWERING AND POST FLOWERING CULMS OF *Dendrocalamus hamiltonii* IN ARUNACHAL PRADESH AND *Melocanna baccifera* IN MIZORAM

5.1 INTRODUCTION

Bamboo grows as a predominant understory species in forest ecosystems of northeast India and represents one of the important forest types in the tropical and subtropical region (Rao and Ramakrishnan 1989, Zhou 1999, Lei 2001, Liu 2001). Distribution and growth in bamboo are mainly governed by rainfall, temperature, altitude and soil, where high rainfall and high relative humidity promotes healthy growth (Sharma 1985). Gregarious or mass flowering of bamboo is generally followed by the death of clumps, consequently, leading to drastic changes in forest dynamics and environmental conditions (Chen 1973, Das 1976, Banik 1989, Alam 1997, Ramanayake and Yakandawala 1998, Marod *et al.* 2002, Marchesini *et al.* 2009).

Nutrients are significant contributor in supporting life where nitrogen, phosphorus and potassium are among the most essential macro elements that limit growth, yield and reproduction in plants and play key roles in functioning of ecosystem (Uchimura 1980, Kinhal 1985, Huang 1987). According to Shanmughavel *et al.* (1997) nitrogen is required in large quantity followed by potassium and phosphorus. There is a significant chemical and structural changes in parenchyma and fibre tissues of bamboo culm (Fu and Banik 1995), cell wall thickening (Liese 1995), increase or decrease in certain nutrient ions (Chen *et al.* 1987) and decrease in moisture during different growth and development phases (Espiloy 1994, Sattar *et al.* 1994). Liese (1991) reported that due to the deposition and accumulation of metabolic residues in metaxylem and sieve tubes of bamboo culms result decrease in water uptake through xylem vessels and nutrient uptake and translocation through phloem. Finally it leads to their lodging and breakdown of the transport system resulting death of culms (Liese 1995, Liese and Weiner 1995). Nitrogen is an important component of proteins that build cell
material and plant tissue. In addition, it is necessary for the functioning of biochemical pathways including chlorophyll complex, enzymes and nucleic acids (Charles et al. 1999). Phosphorus is also an essential component of proteins, enzymes and nucleic acids and acts as a biological energy. Potassium demonstrates its versatility by activating at least 60 different enzymes involved in plant growth and development (Sathish et al. 2012). Potassium plays a major role in the water and nutrient transport in the xylem and phloem vessels in plants and is essential in protein synthesis and also serves as a complex functionary element in photosynthesis (Armstrong 1998, Anonymous 1998). Potassium also improves the hardiness and durability of plants (Qiu and Maoyi 1987).

Due to the long intermast period, studies on the relation between nutrients and flowering phenomenon in bamboos are very meagre and their role in bamboo flowering or post flowering death of bamboos are yet to investigate. This necessitates the assessment of the nutrient content when bamboo endures through different phases such as pre-flowering i.e. vegetative phase, flowering i.e. reproductive phase and post-flowering i.e. senescence or death phase. Considering these facts, the study has been carried out to understand the status of the three important macro nutrients N, P and K in the culms of Dendrocalamus hamiltonii and Melocanna baccifera growing in their natural habitats of Arunachal Pradesh and Mizoram, respectively of Eastern Himalayas, India.

5.2 MATERIALS AND METHODS

Detail analyses on chemical parameters (NPK) in the culms of Dendrocalamus hamiltonii from East Siang District of Arunachal Pradesh and Melocanna baccifera from Mamit district of Mizoram, respectively, were carried out considering pre-flowering, flowering and post-flowering culms during 2008-2010. Representative culms of the two bamboo species were randomly collected from respective states on seasonal basis during October 2008 - July 2010, in which three replicate sampling sites comprising of representative sample culms in clumps were identified for each phase, i.e. pre-flowering, flowering and post-flowering phases. Collected culm samples were dried and ground in the form of powder using Willey’s mill. Powdered
samples of different culm age group for each clump were mixed thoroughly for respective study sites and phases. Determination of plant nitrogen content in culms was carried out through micro-Kjeldhal method as described by Allen et al. (1974) using KEL PLUS nitrogen analyzer (PELICAN equipment Chennai) and manual titration. Phosphorus and potassium content in culm were determined through tri acid digestion in KEL PLUS digestion system followed by UV-VIS spectrophotometry and flame photometry, respectively following Allen et al. (1974).

All the data were statistically analysed using multiway ANOVA to understand their significant levels in variation, and changes in plant chemical parameters during pre-flowering, flowering and post-flowering phases.

5.3 RESULTS

Nitrogen, Phosphorus and Potassium content in the culms of *D. hamiltonii* and *Melocanna baccifera* during pre-flowering, flowering and post-flowering phases are presented in Figure 5.1 and 5.2 respectively. N, P and K content were significantly higher in the pre-flowering culms than the flowering and post flowering culms in both bamboo species. The concentration of N, P and K in the culms of *Dendrocalamus hamiltonii* and *Melocanna baccifera* during the three phases i.e. pre-flowering, flowering and post-flowering phases were in the order of NF>FL>PF.

5.3.1 CULM NITROGEN CONTENT

Temporal variation in culm nitrogen content in *D. hamiltonii* and *M. baccifera* during pre-flowering, flowering and post-flowering phases is presented in Figure 5.1A and Figure 5.2A, respectively. Culm nitrogen content varied significantly among the three phases (F= 185.38 and 434.13, respectively, P< 0.001), where the value was significantly higher during the pre-flowering phase (mean value1.02% and 0.85%, respectively for *D. hamiltonii* and *M. baccifera*) with a sharp decline during flowering (0.37% and 0.48%, respectively) and post-flowering phases (0.29% and 0.40%, respectively) in both bamboo species. However, in *D. hamiltonii* the difference in culm nitrogen content during flowering and post-flowering phases were insignificant. Culm nitrogen content show significant variation among the sampling months in both bamboo species (F= 12.98, P< 0.001).
Values of culm nitrogen content was highest during April and lowest during January in both species in pre-flowering phase, however, in flowering and post-flowering phases, culm nitrogen content decreased gradually since the first sampling months and lowest was recorded during the last sampling month of the study in both species (Figure 5.1A and Figure 5.2A). There was also a significant change in culm nitrogen content in all the three phases in both bamboo species from first study year to the second study year (F= 11.57 and 135.12, respectively, P< 0.001). There was a significant variation in culm N content due to the interaction between the phases and sampling months in D. hamiltonii forests (F= 15.04, P< 0.001), whereas, no such significant values due to interactions between or among variables were observed in D. hamiltonii.

5.3.2 CULM PHOSPHORUS CONTENT

Figure 5.1B and 5.2B presents the temporal variation in culm phosphorus content in D. hamiltonii in Arunachal Pradesh and M. baccifera in Mizoram during pre-flowering, flowering and post-flowering phases. Phosphorus content in culms varied significantly among the three phases in both bamboo species (F= 405.45 and 319.83, respectively, P< 0.001), where highest P value was recorded during April (0.3% and 0.34%, respectively for D. hamiltonii and M. baccifera) and lowest during October (0.19% and 0.28%, respectively) in pre-flowering culms of both species (F= 4.55, P< 0.01 and 3.87, P< 0.05, respectively). In case of flowering and post-flowering culms, there was a gradual decline in P content from first sampling month to the last sampling month. Culm P content was significantly higher during the pre-flowering phase to that of flowering and post-flowering phases in both species. In M. baccifera highest P content was recorded in pre-flowering culms followed by flowering and post-flowering culms. There was a significant change in culm P content in all the three phases from first study year to the second study year in both bamboo species (F= 7.47, P< 0.01 and F= 92.5, respectively, P< 0.001). There was a significant variation in culm P content in D. hamiltonii and M. baccifera due to the interactions between the phases and sampling months (F= 10.63, P< 0.001 and F= 3.42, P< 0.01,
respectively), and phases and years of study (F= 30.65 and 46.97, respectively, \( P< 0.001 \)).

5.3.3 CULM POTASSIUM CONTENT

Temporal variation in culm potassium content in *D. hamiltonii* in Arunachal Pradesh and *M. baccifera* in Mizoram during pre-flowering, flowering and post-flowering phases is presented in Figure 5.1C and 5.2C. Variations in culm K content in both bamboo species during the three phases were significant (F= 240.27 and 489.78, respectively, \( P< 0.001 \)), where pre-flowering culms had highest K concentration followed by flowering culms and lowest in post-flowering culms. In pre-flowering culms, highest culm K content was recorded during July (1.28% and 0.91%, respectively for *D. hamiltonii* and *M. baccifera*) with a gradual decrease and lowest during January (0.67% and 0.65%, respectively) in both bamboo species. Whereas, there was a gradual decrease in K content in the flowering culms and post-flowering culms of both bamboo species from first sampling to the last sampling. A significant decrease in culm for all the three phases from first year of study to the second year in both bamboo species was observed (F= 24.06 and 46.78, respectively, \( P< 0.001 \)). There was significant variation in culm K content due to the interactions between phases and sampling months (F= 7.67 and 16.07, respectively, \( P< 0.001 \)) and phases and years of study (F= 6.97, \( P< 0.01 \) and F= 24.01, \( P< 0.001 \), respectively) in both *D. hamiltonii* and *M. baccifera*.

5.4 DISCUSSION

This study has revealed that N, P and K content in the culms of both *D. hamiltonii* and *M. baccifera* was highest during pre-flowering (vegetative) phase followed by flowering and post-flowering phase irrespective of sampling months. This may be explained due to the very active physiological activities, such as photosynthesis, transpiration, respiration, etc. associated with vegetative growth during pre-flowering phase. Whereas, in flowering phase, most of the physiological activities that are carried out by leaves begin to cease due to senescence and leaf fall. Decrease in N, P and K content in culms from vegetative phase to reproductive phase may be resulted due to rapid translocation of highly essential nutrients to the developing flower buds.
and seeds which function as major nutrient sink (Ueda 1960, Kao 1972, Janzen 1976). This type of nutrient translocation and accumulation pattern was supported by the findings of Janzen (1976), Marschner (1995), Kumar et al. (2005) and Ramanayake (2006). However, decrease in culm nutrient content N, P, K from flowering to post-flowering phase and from the first sampling month towards the last sampling month may be explained due to lack of transpiration pull in absence of leaves associated with lodging effect in the tissue systems of rhizome and culm due to ageing effect which is supported by the findings of Janzen (1976). Shanmughavel and Francis (2001) also observed peak N, P and K concentration in the culm of few bamboo species during the bud stage which decline during organ development and expansion stage. During the induction of flower there is a switching of resources from vegetative to reproductive parts and stored nutrients are used up in the production of large number of inflorescent and finally for the development of seeds (Ramanayake 2006). Lowest N, P and K content in the culms in post-flowering phase may be explained due to excessive translocation of these nutrients stored in rhizome and other plant parts while developing the seeds associated with poor nutrient uptake but regular translocation to the aerial plant parts to fulfil their requirement for survival.

The nutritional theory in respect to bamboo flowering states that “flowering and fruiting are the result of physiological imbalance due to poor growth of the vegetative cells brought about by an imbalance of carbon-nitrogen ratio” (Sharma 1994, Songkram 1996). However, theory on death of bamboos after flowering may not be the only genuine reason supported by nutrient deficiency scenarios, where modification in plant morphology takes place occasionally. In general bamboos do not produce new vegetative shoots from preceding year of initiation of flowering; where regular leaf shedding takes place and subsist food reserves stored in the rhizome supported by photosynthates from a very few leafy culms (Kurz 1876, Troup 1921, Deogun 1936, Janzen 1976, Zhang and Ma 1991). Growth and development in bamboo are averted due to transformation of apical meristem into massive inflorescence followed by seeding (Ramanayake 2006). Similar
findings on change in nutrient sink from leaves to reproductive parts were also reported (Mooney 1972, Stephenson 1981, Obeso 2002, Miyazaki et al. 2007). Marschner (1995) pointed out that P deficiency significantly reduces leaf area without affecting chlorophyll content; while such modification in leaf morphology was not observed when a bamboo proceeds toward flowering. In case of bamboos older leaves begin to fall without any development of young rhizomes and new leaf resulted to considerably reduction in leaf number and become prone to insect and other pest infestations. Quality of poles after flowering becomes weak, fragile and prone to fire hazards. As a consequence of flowering, both *D. hamiltonii* and *M. baccifera* were observed to die due to the cessation of nutrient uptake, as in the case of other bamboo species (Janzen 1976, Ramanayake 2006, Takahashi et al. 2007). Both bamboo species produce large quantity of seeds during the mass flowering period. The death of bamboo culms followed by the death of rhizomes after flowering is yet not very clear, although, significant role of P and other essential nutrients during the cessation of life in bamboos were reported by many authors (Plank 1989, Anonymous 1999b, Provin and Pitt 2005, Bond 2012). A gradual decrease in K was also seen in flowering and post-flowering culms in comparison to the pre-flowering culms and such reduction in K may affect water and nutrient transport systems and many other physiological activities including functioning of enzyme and plant hormones (Marschner et al. 1996, Anonymous 1998). In case of pre-flowering individuals, variation in nutrient (NPK) content in the culms may be explained due to variation in the available form of nutrients in the soil nutrient pool associated with the influence of microclimate during their uptake and translocation to different organs.

Impact of bamboo flowering on forest dynamics, particularly in the first years of post flowering is not very clear (Makita 1996). Although, Marchesini et al. (2009) mentioned that bamboo flowering may alter the micro-environmental condition by increasing light availability, air and soil temperature in the forest understory, whereas soil moisture may decrease due to increased evapotranspiration and finally may alter plant composition and the forest type. In forest ecosystem, nutrient dynamics mainly depends
on litter and soil organic matter dynamics. Poor Nitrogen content in the soils of post-flowering bamboo habitats were reported by many authors, which was resulted due to less inputs of fast decomposing bamboo foliaged, fine roots, etc. (Krankina et al. 1999, Hyvonen et al. 2000, Embaye et al. 2005, Takahashi et al. 2007). After mass flowering both the bamboo species died within few months, and the death biomass such deposited were readily burnt to reduce the rodent menace caused by mass flowering and fruiting in bamboos. Such bamboo habitats are either converted to jhum field or allowed to remain as fellow land unless new regenerants succeed over the land mass. This belief may have severe impact on the soil nutrient pool, biodiversity as well as bio-geochemical cycles in that locality. This study has provided information on the temporal variation of N, P and K, three essential macronutrients during three important phases of the life cycle of D. hamiltonii and M. baccifera. Concentration of culm nutrient content during flowering and post-flowering phases was contradictory with the normally growing bamboos under vegetative (pre-flowering) phase. Though, nutrient content in a healthy bamboo fluctuate during growth and establishment phases but are balanced immediately after attaining maturity (Shanmughavel and Francis 2001). Further, there is a need of detail studies to confirm significant role of soil nutrient pool in switching from vegetative phase to reproductive phase in bamboos. It is also important to work out nutrient allocation pattern in different bamboo parts during the onset of flowering till seed set and death of individuals which may enable us to decipher the biological enigma on bamboo flowering.

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