

# **DYNAMICS OF FINE ROOTS IN PINE FOREST ECOSYSTEM**

**ABSTRACT**

By  
**BABU JOHN**

**THESIS SUBMITTED  
IN FULFILMENT OF THE DEGREE OF  
DOCTOR OF PHILOSOPHY IN BOTANY  
OF  
NORTH-EASTERN HILL UNIVERSITY  
SHILLONG, INDIA**

1998

*DS*  
*581.49809/52*  
*JOH*

# **DYNAMICS OF FINE ROOTS IN PINE FOREST ECOSYSTEM**

**ABSTRACT**

By  
**BABU JOHN**



**THESIS SUBMITTED  
IN FULFILMENT OF THE DEGREE OF  
DOCTOR OF PHILOSOPHY IN BOTANY  
OF  
NORTH-EASTERN HILL UNIVERSITY  
SHILLONG, INDIA**

**1998**

---

Destruction of primary subtropical humid broadleaved forest at higher elevations of Meghalaya has paved the way for the development of secondary *Pinus kesiya* forests on disturbed sites. In fact, *Pinus kesiya* grows luxuriantly between 800-2000 m altitude in the entire north-eastern region of India. The species is commonly used for afforestation purposes because of its ability to establish and grow quickly on poor and denuded sites. The trees are usually planted at close spacing which favours natural pruning and helps in the production of straight and good quality logs.

The main objective of the present investigation was to study the dynamics of fine roots in pine forest ecosystem with special emphasis on their role in organic matter and nutrient (N & P) accumulation and turnover in soils supporting *Pinus kesiya* stands. The role of fine roots in soil organic matter and nutrient dynamics assumes greater significance in the light of their tremendous ability to grow on degraded sites which are characterised by relatively shallow infertile soil. The study was carried out in 6-, 15- and 23-year old pure pine stands located in and around North-Eastern Hill University Campus, Shillong (latitude 25°34'N, longitude 91°54'E and altitude 1500 m asl.) during 1995-1996.

The following major aspects have been covered under the present study :

1. Vertical distribution and seasonal dynamics of fine roots ( $<2$  mm diameter) and coarse roots ( $>2$  mm diameter) in terms of live and dead biomass.
2. Production of fine and coarse roots of pine tree as well as ground vegetation in the pine stands.
3. Resource quality of fine roots of pine trees, their decay and N and P mineralization patterns.
4. Storage of N and P in fine and coarse roots and their turnover in the soil.

### **Vegetation and soil characteristics**

All the three stands were characterised by the presence of two distinct vegetational layers, the upper tree layer comprising *Pinus kesiya* trees and the lower layer composed of grasses, ferns and a large number of annual and perennial weeds. The tree DBH was maximum (19.12 cm) in the oldest stand, but its density declined from 11020 individuals/ha in the 6-year old stand to 730 individuals/ha in the 23-year old stand. The tree seedling density was maximum (32 individuals/m<sup>2</sup>) in the 23-year old stand and minimum (3 individuals/m<sup>2</sup>) in the 6-year old stand.

Altogether 40 species were present in the ground flora of all the three forest stands. Their total density declined from 116 individuals/m<sup>2</sup> in the 6-year old stand to 75 individuals/m<sup>2</sup> in the 15-year old stand followed by an increase to 107

individuals/m<sup>2</sup> in the 23-year old stand.

Soil texture varied from sandy to sandy clay loam. Bulk density and water holding capacity of the soil increased from the 6-year old stand to the 23-year old stand. CEC, SOC, TKN and available-P decreased with increasing soil depth. TKN, SOC and available-P showed wide monthly variation, and the values were high during winter, and low during rainy season. A comparison of these parameters with that of the oak forest and grassland soils of the adjoining areas clearly revealed the low fertility level of the soil under pine forest ecosystem.

#### **Vertical distribution and seasonal variation in root mass**

The vertical distribution of tree fine roots expressed as percent of the total root mass up to 40 cm soil depth showed 32-51% accumulation in the 0-10 cm soil layer, 28-35% in 10-20 cm soil layer, 15-27% in 20-30 cm soil layer and 6.4-12% in 30-40 cm soil layer. Out of the total herbaceous fine roots, 65-66%, 20-26%, 9-14% and 4-6% were distributed in 0-10, 10-20, 20-30 and 30-40 cm soil depths, respectively. Similarly, a major portion (73-79%) of rhizomes was localised in the top 10 cm soil layer and their proportion declined to 2-4% in the 20-30 cm soil depth. Majority of the coarse roots were confined to the 10-30 cm soil layer.

Wide monthly fluctuations were observed in tree fine roots, herbaceous fine roots, coarse roots and rhizomes in all the three forest stands. When monthly data were pooled on the seasonal basis, a seasonal pattern with a high mean biomass

during the rainy season and a low during the spring season was clearly evident. The annual means of the fine root and coarse root biomass were maximum in the 6-year and 23-year old stand, respectively.

The contribution of herbaceous fine roots to the total fine root mass was 56% in the youngest stand and 32% in the other two stands.

### **Root production**

The annual fine root production was maximum (1054.69 g/m<sup>2</sup>/yr) in the 6-year old and minimum (732.16 g/m<sup>2</sup>/yr) in the 15-year old stand. The coarse root production increased from 169.06 g/m<sup>2</sup>/yr in the 6-year old stand to 651.72 g/m<sup>2</sup>/yr in the 23-year old stand. As a result, the maximum root production (1434.87 g/m<sup>2</sup>/yr) was recorded in the oldest stand. The annual root turnover rate, though low (0.73 yr<sup>-1</sup>), did not vary between the stands.

### **N and P concentration**

N and P concentration in fine roots was significantly higher than the coarse roots. Similarly, herbaceous fine roots had a higher N and P concentration than the rhizome. Live roots always had higher N and P concentration than the dead roots. They showed minor monthly variation without definite seasonal trend.

### **N and P accumulation**

The accumulation of N and P varied between months and declined sharply with increasing soil depth in all the three stands. Nutrient accumulation was

maximum during the rainy season and minimum during the spring season. The annual means of N and P storage were maximum in the 23-year old stand and minimum in the 15-year old stand. Herbaceous vegetation contributed about 71% to the total N and P stock in the youngest stand, while in the older stands the major contribution (ca. 70%) to the total nutrient stock in roots was by pine.

Annual N and P input to the soil by tree roots increased with stand age from 6-year old stand (27.94 N & 6.35 P kg/ha) to 23-year old stand (48.96 N & 13.35 P kg/ha), while the inputs by the herbaceous vegetation decreased. The annual turnover rates of  $k_N$  was 0.76, 0.73 and 0.73 and  $k_P$  was 0.76, 0.70 and 0.72 in 6-, 15- and 23-year old stands, respectively.

### **Weight loss**

During decay, tree fine roots passed through three distinct phases. The initial phase lasted upto 30 days with a slow rate of weight loss (1.13 mg/day), followed by a phase of rapid weight loss (4.1 mg/day) from 30-90 days and the third phase characterized by a slow weight loss (0.7 mg/day) lasted for 90-450 days.

### **N and P mineralization**

Similar to the weight loss pattern, N and P were mineralized in three distinct phases. An initial decline in N and P concentrations marked a phase of nutrient release. This was followed by a phase of nutrient immobilization when a

marginal increase in N and P concentration was recorded in the decaying roots. This was again followed by a phase of mineralization.

Organic matter accumulation increased from 3908 kg/ha in the 6-year old stand to 5769 kg/ha in the 23-year old stand annually. And the same was in evidence with respect to the annual production of roots (12237, 11301 and 14248 kg/ha in 6-,15- and 23-year old stands, respectively). The accumulation of N (18.73-26.21 kg/ha) and P (4.56-7.02 kg/ha) increased from 6-year old stand to 23-year old stand. Annual input of N ranged from 57-65 kg/ha and of P from 14.00-17.21 kg/ha. A comparison between the above values on roots and those obtained by Das (1980) on litter (Table 7.4) clearly shows that roots play more important role than the litter in organic matter and nutrient accumulation in *Pinus kesiya* forests stands of varying ages.

NEHU LIBRARY  
Acc No..... 103737  
Acc By.....  
Date..... 30-8-07  
Class by.....  
Sub.Heading by.....  
Enter by.....  
Transcribed by.....