CHAPTER VIII

SUMMARY

The present work was undertaken to study the seed and seedling ecology of three important tree species viz. *Podocarpus neriifolia*, *Acer laevigatum* and *Syzygium tetragonum* of subtropical semi-evergreen forest of northeast India with particular emphasis on the effect of light and temperature on seed germination, role of light and soil water and nutrient levels on seedling growth and nutrients concentration, accumulation and their use efficiency.

The field study was carried out in two sacred groves (viz. Urkhla and Khloo Langdoh located at Jowai town (latitude 25°26' 32" N, longitude 92°12'E, altitude 1200-1300 m asl), representing subtropical semi-evergreen broad-leaved forest and in the net-house of the Department of Botany, North Eastern Hill University, Shillong (latitude 25°34' N, longitude 91°45' E, altitude 1450 m asl). Seeds of *Podocarpus neriifolia* and *Acer laevigatum* were collected from Urkhla sacred grove while that of *Syzygium tetragonum* from Khloo Langdoh. However, field experiments were conducted at Khloo Langdoh because Urkhla is surrounded by human habitation and much disturbed.

1. Seed germination

After 30 days of air drying, the seeds of *Podocarpus neriifolia* and *Syzygium tetragonum* lost 28% and 50% moisture respectively. *Acer laevigatum* lost only 2% moisture.
The germination percentages of *Acer*, *Podocarpus* and *Syzygium* seeds immediately after collection were 85%, 82% and 92% respectively. The time taken for initiation of germination was 2 days in *Podocarpus neriifolia*, 9 days in *Syzygium tetragonum* and 10 days in *Acer laevigatum*. Germination was completed by 21, 20 and 24 days in *Podocarpus neriifolia*, *Syzygium tetragonum* and *Acer laevigatum* respectively.

Germination percentage decreased with increase in storage time. In *Acer* it decreased from 74% at 30 days to 9% at 150 days whereas in *Syzygium* the seeds became non-viable after 60 days of storage and in *Podocarpus neriifolia* seeds did not germinate beyond 30 days of storage.

Germination rate was high at 25°C both in light and dark in all the three species. The germination of *Acer laevigatum* seeds in dark at 20°C, 25°C and 30°C was 82, 86 and 78% respectively. The corresponding values under light condition were 76, 84 and 75%. Similarly, *Podocarpus* and *Syzygium* seeds showed higher germination at 25°C both in light and dark.

II. Effect of gap and understorey

**Seedlings Survival**

Survival of transplanted seedlings of all three species was poor in the understorey than in the gap. At the end of 360 days there was 67% mortality in *Acer laevigatum*, 58% in *Syzygium tetragonum* and only 37% in *Podocarpus neriifolia* in the understorey. In gap, *Acer laevigatum* (58%) and *Syzygium tetragonum* (50%) seedlings experienced higher mortality than *Podocarpus neriifolia* (16%) after 360 days.
Seedling growth

Root and shoot growth of the three species was significantly ($P<0.001$) higher in gap than the forest understorey.

Mean leaf area and leaf biomass per unit area (LMA; mg/cm$^2$) was significantly ($P<0.01$) higher in gap than forest understorey condition in all the species. In gap the LMA was 18.4 mg/cm$^2$ in *Acer laevigatum* followed by *Syzygium tetragonum* (5.4 mg/cm$^2$) and *Podocarpus neriifolia* (5.1 mg/cm$^2$). The corresponding values in forest understorey were 14.3, 3.0 and 3.6 mg/cm$^2$.

At the end of 360 days seedlings in gap had a dry mass of 2838 mg/plant in *Syzygium tetragonum*, 952 mg/plant in *Podocarpus neriifolia* and 516 mg/plant in *Acer laevigatum* seedlings. The corresponding values in the understorey were 97, 160 and 124 mg/plant.

In all three species root: shoot ratio was higher in gap than the understorey.

*Syzygium tetragonum, Acer laevigatum* and *Podocarpus neriifolia* seedlings showed 5.5, 4.5 and 2.8 times, respectively, higher relative growth rate (RGR; mg day$^{-1}$ plant$^{-1}$) in gap than in the forest understorey during the first four month of growth. Thereafter the seedlings did not exhibit significant difference in RGR.

Nutrient concentration, accumulation and use efficiency

Nitrogen concentration in *Podocarpus neriifolia* and *Syzygium tetragonum* seedlings was higher in the forest understorey while *Acer laevigatum* recorded higher N concentration in gap. N concentration was higher in leaf followed by root and stem. It
decreased significantly (p< 0.05) with the increase in age of the seedlings of all three species.

Phosphorus concentration was higher in leaf followed by stem and root in all three species. Seedlings under forest understorey had significantly (P<0.01) higher P concentration than those in the gap. The concentration decreased with age of the seedlings in both gap and understorey.

The leaf had higher K concentration followed by stem and root in all three species both in gap and forest understorey. With age concentration decreased in Syzygium both in gap and forest understorey while in Podocarpus and Acer there was no significant difference due to age and forest habitats.

N accumulation (mg plant⁻¹) in all plant parts was significantly (p<0.01) higher in gap than the forest understorey. Leaf accumulated maximum N followed by root and stem at both the places and it increased with age of the seedlings.

P and K accumulation was high in gap than the forest understorey in all species. The seedlings of all the three species under gap were more efficient in NPK use.

III. Effect of soil moisture level

Seedling growth

Significant progressive growth in shoot and root length with increasing soil moisture was observed only in Syzygium tetragonum.

The mean leaf area of Syzygium tetragonum increased significantly with the increase in soil moisture. However, LMA decreased in Acer laevigatum and increased in Syzygium tetragonum. Podocarpus neriifolia did not show a definite trend.
The dry mass of *Syzygium tetragonum* seedlings increased with increase in soil moisture level. In all species shoot dry mass was higher than root at all soil moisture levels.

The effect of soil moisture levels on root: shoot ratio was prominent only at the end of the experiment (360 days). It gradually decreased with increasing moisture level in all the species.

In all species maximum value of RGR was recorded at 120 days, thereafter it gradually declined. *Syzygium tetragonum* exhibited a marked increase in RGR (115 mg day\(^{-1}\) plant\(^{-1}\)) with the increase in soil moisture levels during the first four months of growth. As compared to this, the peak values of *Acer laevigatum* (106 mg day\(^{-1}\) plant\(^{-1}\)) and *Podocarpus neriifolia* (98 mg day\(^{-1}\) plant\(^{-1}\)) were low.

**Nutrient concentration, accumulation and use efficiency**

In all species, N concentration was more in leaf followed by root and stem, and different soil moisture levels had no significant effect on it. The concentration in different parts decreased significantly (p< 0.05) from 120 days to 360 days old seedlings.

The pattern of Phosphorus concentration was similar to that of N with higher value in leaf followed by stem and root in *Acer laevigatum* and *Syzygium tetragonum*. *Podocarpus neriifolia* seedlings had high concentration in leaf followed by root and stem. Soil moisture levels did not have significant effect on P concentration in different plant parts of all species. It decreased significantly (p< 0.05) from 120 to 360 days.

N accumulation was more in leaf followed by root and stem at all soil moisture levels in all the species. With the increase in age, there was an increase in N accumulation
except in the leaf of *Acer laevigatum*, where accumulation decreased in 360 days old seedlings at 30% soil moisture level. However, in *Syzygium tetragonum* N accumulation in all parts increased significantly (p< 0.01) with increase in soil moisture level.

P accumulation in *Syzygium tetragonum* increased with increasing soil moisture. It increased in all plant parts with age, except in *Acer laevigatum* that showed a decrease in the leaf at 360 days.

K accumulation did not vary between different plant parts in all three species. It increased with age in all plant parts, except in *Acer laevigatum* which showed a decrease in the leaf at 360 days.

Nitrogen use efficiency (NUE) and Potassium use efficiency (KUE) increased with increasing soil moisture level in *Podocarpus neriifolia and Syzygium tetragonum*.

Phosphorus use efficiency (PUE) decreased with increasing moisture level in *Acer laevigatum and Syzygium tetragonum*.

IV. Effect of soil NPK level

Seedling growth

Soil NPK levels did not have any significant effect on the growth of all three species.

*Acer laevigatum, Podocarpus neriifolia and Syzygium tetragonum* seedlings did not exhibit any significant variation in mean leaf area and LMA under different levels of NPK. Similarly there was no significant effect of NPK doses on dry mass accumulation of all the three species.
The effect of NPK levels on root: shoot ratio was distinct only at the end of the experiment. With the increase in NPK doses R:S ratio increased in *Podocarpus neriifolia* and decreased in *Acer laevigatum* while *Syzygium tetragonum* did not show any trend with almost the same value at different NPK levels.

RGR attained peak during the first four month of growth in all cases. The values were 106 mg day\(^{-1}\) plant\(^{-1}\) in *Syzygium tetragonum*, 101 mg day\(^{-1}\) plant\(^{-1}\) in *Acer laevigatum* and 81 mg day\(^{-1}\) plant\(^{-1}\) in *Podocarpus neriifolia*.

**Nutrient concentration, accumulation and use efficiency**

N concentration in different species and plant parts did not vary significantly at different soil NPK levels. However, it decreased with age in all cases. Leaf had higher N and P concentration in all species at all three NPK levels. It had no effect on K concentration.

Nitrogen accumulation was more in leaf followed by root and stem of all the species at all soil NPK levels. With the increase in age, there was an increase in N accumulation except in *Acer laevigatum* leaf where it decreased at 360 days.

There was no significantly difference in P accumulation with the increase in soil NPK levels in different plant parts of all three species.

K accumulation in *Podocarpus neriifolia* was more in leaf followed by root and stem at all soil NPK levels.

Nitrogen use efficiency increased with increasing soil NPK level in *Podocarpus neriifolia* and *Syzygium tetragonum*. 

83
Phosphorus use efficiency decreased in *Syzygium tetragonum* and potassium use efficiency decreased in *Podocarpus neriifolia* with increasing soil NPK levels.