SUMMARY

The thesis embodies scientific information on some of the important and hitherto less understood aspects of regeneration of Rudraksh (*Elaeocarpus ganitrus*), an endangered tree species, growing in the tropical rain forests of Arunachal Pradesh. The studies presented in the thesis focus on the following aspects.

1) Species richness, population structure and regeneration status of tree species in relation to different degree of anthropogenic disturbances.

2) Population structure and regeneration status of Rudraksh in the undisturbed and disturbed (highly disturbed, moderately disturbed and mildly disturbed) forest stands.

3) Fruit set, dispersal and nut bank dynamics of Rudraksh in the four forest stands.

4) Growth of nursery grown seedlings when transplanted in the forest stands under different ecological conditions with a view to find out suitable sites for transplantation.

5) Survival and growth of seedlings in the green house condition.

6) The nuts of Rudraksh being very hard possess nut coat dormancy. Different methods were investigated to enhance the germination.

7) Vegetative propagation through application of different hormones on the branch/stem cuttings.

Tree diversity and population structure in the undisturbed and human impacted forest stands

Species richness, tree density, basal area, population structure and distribution pattern were investigated in the undisturbed, mildly disturbed, moderately disturbed and highly disturbed stands of tropical rain forests of

Arunachal Pradesh. The species richness was highest in the mildly disturbed forest stand (54 species per hectare) and lowest in the highly disturbed stand. The stand density was highest in the undisturbed stand (5442 stems per hectare belonging to 28 families and 51 genera) and lowest in the highly disturbed stand (338 stem per hectare belonging to 14 families and 16 genera). Fabaceae, Dipterocarpaceae and Clusiaceae were the dominant families, and these three families contributed 53% of the total density in the undisturbed stand, 51% in the mildly disturbed stand, 42% in the moderately disturbed and 49% in the highly disturbed stand. Basal area was highest (104.60 m^2 per hectare in the undisturbed stand) and lowest (18.60 m^2 per hectare) in the moderately disturbed stand. Species composition and distribution pattern of tree species were more or less similar in the undisturbed, mildly disturbed and moderately disturbed stands with *Dipteriocarpus macrocarpus, Shorea assamica, Terminalia chebula, Vatica lancefolia,* and *Bischofia javanica,* as the canopy species and *Elaeocarpus ganitrus, Mesua ferrea* and *Canarium* sp. as the sub-canopy species.

Out of the 47 species in the undisturbed stand only 26 were found to be regenerating. Twenty species showed good regeneration, 1 species had fair regeneration and 5 species showed poor regeneration. No regeneration was recorded for other species. In the mildly disturbed stand, out of 54 species 36 species were found regenerating out of which, 23 species had good

regeneration, 9 showed fair regeneration and 4 had poor regeneration. Out of 42 species in the moderately disturbed stand, 22 were found regenerating and good regeneration was recorded in 11 species, 7 species showed fair regeneration and 4 species had poor regeneration. No regeneration was recorded in the highly disturbed stand.

Population structure and regeneration status of Rudraksh

Population structure and regeneration status of Rudraksh (*Elaeocarpus ganitrus*) was carried out in the aforesaid forest stands. The mean density of adult trees was 16 trees per hectare. Total population of the species was greater in the undisturbed stand as compared to other stands. The regeneration was recorded in the undisturbed, mildly disturbed and moderately disturbed stands, while the regeneration was absent in the highly disturbed stand. The basal area was highest in the undisturbed stand (4190 cm^2/ha), followed by mildly and highly disturbed stands (2564 & 2785 cm^2/ha) and least (1875 cm^2/ha) in the moderately disturbed stand. Seedling survival and growth was more in the undisturbed stand. No cut stump was recorded in the undisturbed and highly disturbed stands.

Resprouting ability of the cut stumps with less diameter was more in the natural stands as compared to the plantation.

Fruit set, dispersal and nut bank dynamics in relation to cultural disturbances

Flower and fruit production and dispersal system of Rudraksh were investigated during 1997-99 in four stands of a tropical rain forest exposed to varying degrees of disturbance. Flower and fruit production in Rudraksh significantly increased with the increase in girth of fruiting trees. The year-wise variation in flower and fruit production was also significant. Production of flowers and fruits also differed significantly in the four forest stands experiencing different degrees of disturbance; it was highest in the moderately disturbed forest and lowest in the undisturbed forest. The mean fruit weight (both with pulp and without pulp) of Rudraksh varied significantly among the stands; it decreased with the increasing disturbance index. The number of fruits per unit area of the forest floor decreased significantly with increase in distance from the parent tree crown in all the four stands. 40-70% of the total fruits produced by Rudraksh disappeared during the fruit fall period. Disappearance of fruits was mainly attributable to the eating of fruit pulp by certain birds and other animals which drop the nuts away from the parent tree. The disappearance of fruits was also attributable to hoarding by rodents.

During post-fruit fall period, a large proportion (55-99%) of the remaining fruit population disappeared, and the magnitude of disappearance increased with the increase in disturbance index. During this period not a single nut was found germinated. In general, about 80% of the total fruits produced by Rudraksh

disappeared from the forest floor. This includes the nuts damaged by insects especially by ants and termites. The fruit disappearance decreased significantly with the increase in distance from the parent tree. Disappearance also differed significantly among the forest stands. It was highest in the highly disturbed stand and lowest in the undisturbed stand. Disappearance of fruits largely depended upon the quality of fruits. The ripe fruits with their pulp intact disappeared more than the unripe fruits without pulp. Soil nut bank of Rudraksh significantly varied in different forest stands showing a decrease with the increase in disturbance index. Nut bank in soil was maximum in the undisturbed stand and minimum in the highly disturbed stand. More than 85% nuts of the soil nut bank were predated.

Regeneration of Rudraksh: germination strategies

Rudraksh nuts are provided with a very hard coat which prevents germination. The nuts show nut-coat dormancy. In order to find out the most effective means to overcome this type of dormancy in Rudraksh, nuts were subjected to different types of scarification and other relevant treatments. Altogether, 25 treatments were tested involving mechanical scarification such as making cracks by vise, chemical scarification with sulfuric and nitric acid treatments for 10, 20, 30 minutes, dipping in animal excreta and fermentation for 1, 2 and 3 weeks. The nuts were also subjected to fire treatments, weathering,

and soaking in warm and hot water. The results showed that the hard nut coat, which acts as a barrier to water intake, is the root cause of dormancy that can be broken by different treatments which cause damage to nut coat or make it soft. The best (40%) and quick (19 days required for germination to commence) germination was obtained when the cracks were made with nutcoat by vise. The nuts subjected to this treatment germinated within 49 days after sowing. The other treatments that helped in germination of Rudraksh nuts were: soaking in hot water, dipping in animal excreta for 1-3 weeks and fermentation of nutcoat by putting the nuts in pits filled with cowdung and leaf litter for 10-30 days. It was observed that one to four seedlings may emerge from a single nut. The seedling growth was influenced significantly by the number of seedlings that emerged from a single nut. The growth was significantly greater if only one seedling emerged from the nut than when the number of seedlings emerging from a single nut was more. However, survival did not differ significantly due to seedling clustering.

The germination experiment indicates that cracks made by vise is the best method because of its low cost, ease with which it can be used, and its efficacy in inducing germination in the nuts of Rudraksh. Hence, this method can be recommended for use in nurseries for raising the seedlings of Rudraksh.

Growth and survival of Rudraksh seedlings: Effect of forest canopy on the transplanted seedlings

An experiment was carried out to study the survival and growth of the nursery seedlings transplanted in the forest stands having dense, sparse and open canopy. The transplants exhibited better growth in terms of shoot length, collar diameter, leaf number and leaf area and survival in dense than in sparse and open canopy. The pathogen and herbivory attack on seedlings were more in the open forest stand whereas spider webs were more commonly seen on the transplanted seedlings under the dense canopy.

Vegetative propagation of Rudraksh through branch cuttings

Branch cuttings of Rudraksh were treated with 100, 200 and 500 ppm (mg/l) solutions of each of the three hormones viz. IAA (Indole-3 acetic acid), IBA (Indole-3 buteric acid), NAA (Naphthalene acetic acid) and 2, 4-D (Dicholorophenoxy acetic acid) for 24 hours in the month of February, May, August, and November, 1999-2000 and observations on sprouting and rooting were recorded after 30, 45, 60 days from the date of planting of the cuttings. Sprouting was recorded only in those cuttings which were planted in February and May. However, the cuttings planted in February sprouted better than those planted in May. The highest sprouting was observed in the cuttings treated with IBA_{500}. No rooting was recorded in of the sprouted cuttings and they died within 45 days.

The fundamental scientific information gathered on various aspects of population structure, regeneration status, fruit set, nut dispersal, nut population dynamics, nut germination and seedling fitness may be utilized for management of Rudraksh populations in the tropical rain forest of Arunachal Pradesh and elsewhere. As Rudraksh shows sporadic occurrence and its natural regeneration is poor, there is a strong need to formulate strategies for its conservation. The present study could be useful in this respect.