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Seedling mortality in *quercus leucotrichophora* A. Camus, *pinus roxburghii* D. Don and *shorea robusta* Gaertn forest of Kumaun Himalaya, India

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Abstract: The studies on plant demography hold a considerable significance in plant ecology. Natural regeneration of different plant species through seeds depend primarily upon seed production, germination capacity of seeds and successful establishment of seedling. Successful regeneration of tree species might be considered to be a function of three major components; ability to initiate new seedlings, ability of seedlings and saplings to survive and ability of seedlings and saplings to grow. Several environmental stresses are known to affect the seedling growth but water stress isbelieved to be a major one. The canopy density and soil conditions also affect the growth of seedling.This study comprises three study sites located at29^{o} 22' N latitudes and 79^{o} 29' E longitudes along an elevation transect of 350 – 2500 m in Kumaun Himalaya. This region has certain characteristic climatic features. Though it falls under sub-tropical latitude, the abrupt rise in mountains creates a temperature comparable to that of a temperate climate. The seedling dynamics were studied at sal forest, banj oak forest and chir pine forest. For the computation of seedling mortalityand other characteristics, 2x2m permanent quadrats wereestablished in sal, chir-pine and banj oak forest. A total of 12 quadrats were placed in the stand (3 quadrats in each site). To record the mortality of the seedlings, all the seedlings of the year 2008 present in twelve quadrats in each forest were tagged. Their mortality was observed monthly from January 2009 – December 2009. Results show that mortality was very low (20%) at sal forest as compared to banj oak forest (25%) and chir pine forest (35%). The chir pine forest was heavily affected by human disturbance. So the seedling population was more affected if compared to two other sites. Since the biotic stress was negligible there was very little mortality during the study period in banj oak and sal forest suggesting that if biotic stress and natural disturbance is minimum, the rapid regeneration of *Q. leucotrichophora* and *S. robusta* would be possible.Current study provides information on the seedling dynamics in three forests types in the Kumaun Himalaya. Results show seedling mortality was very low (20%) at sal forest if compared to banj oak forest (25%) and chir pine forest (35%) so the rapid regeneration of *Q. leucotrichophora* and *S. robusta* would be possible.

Keywords: Seedling Mortality, Banj Oak Forest, Chir Pine Forest, Sal Forest, Kumaun Himalaya

1. Introduction

Regeneration of forest trees generally depends upon the ability of trees to provide seeds, ability of seeds to germinate and ability of seedlings to grow and survive in the under canopy environment where soil moisture and light may often be limiting (Good and Good 1972). The primary requirement for successful regeneration for all tree species in that viable seeds should reach the ground in adequate number (Zasada Iet al., 1978). The effect of environment on seed germination is very complex because of interaction of external and internal factors which modify the rate and magnitude of germination (Rao, 1984). However, among the various environmental factor water, temperature and light are of paramount importance which influence the seed germination (Downs 1964, Mc Lemore 1968, Toole and Borthwick 1968, Rollin 1971).

In regard to the seedling growth of Indian oaks Troup (1921) has made pioneering work. The regeneration of oaks in Kumaun Himalaya is reported to be unsatisfactory mainly because of biotic disturbance (Singh and Singh 1985). Upreti (1982) has reported that oaks in Kumaun Himalaya

regenerate well when disturbance is limited. Others who have recorded the regeneration status of central Himalayan oaks are Saxena (1979) and Rao (1984). Singh et al., (1985) have emphasized on the role of "coppicing" a type of vegetative propagation in oak regeneration.

2. Description of the Study Area

2.1. Study Site and Vegetation

This study comprises three study sites located between 29o 22' N latitudes and 79o 29' E longitudes along an elevation transect of 350 – 2500 m in Kumaun Himalaya (Fig. 1). The degree of evergreeness increases with elevation (Singh and Singh 1987). In general, from lower to higher elevations dominantion of following forest prevailed: Sal (*Shorea robusta*) forests below 1000m; Chir pine (*Pinus roxburghii*) forest between 1000m – 100m; Banj oak (*Quercus leucotrichophora*) forests between 1600 – 2200m.

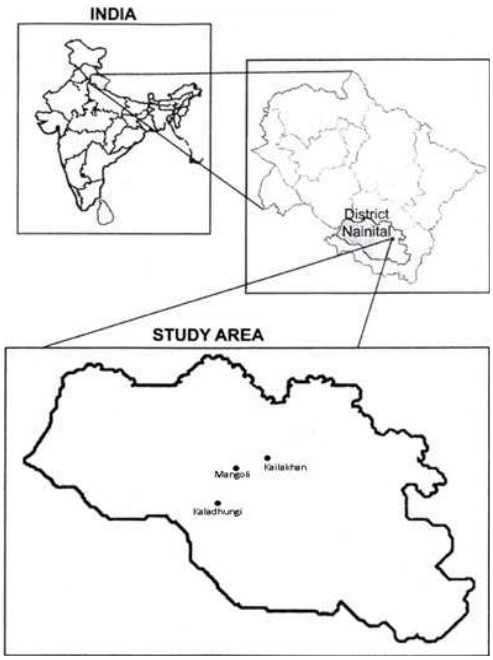

Fig 1. *Location map of the study area*

3. Materialsand Methods

3.1. Climate of the Study Area

This region has certain characteristic climatic features. Though it falls under sub-tropical latitude, the abrupt rise in mountains creates a temperature comparable to that of a temperate climate. Data obtained from the State Observatory at Nainital for the study years (2008–09) indicate that within the elevation transect of 1000-2500 m the mean monthly maximum temperatures range from 14°C in November to 30°C in May; mean monthly minimum temperatures from -2°C in January to 16°C in October and mean monthly rainfall ranges from 4 mm in December to 611 mm in August. The winters are severe and frosts are common from December to February. Data obtained from the O/I Agromet Observatory, Pantnagar indicated that within the elevation transect of 400-1200 m the mean monthly maximum temperatures range from 20°C in January to 36°C in May; mean monthly minimum temperatures from 7°C in January to 26°C in July and mean monthly rainfall ranges from 1 mm in January to 148 mm in August. Also, temperatures increase with decreasing elevation (Fig. 2).

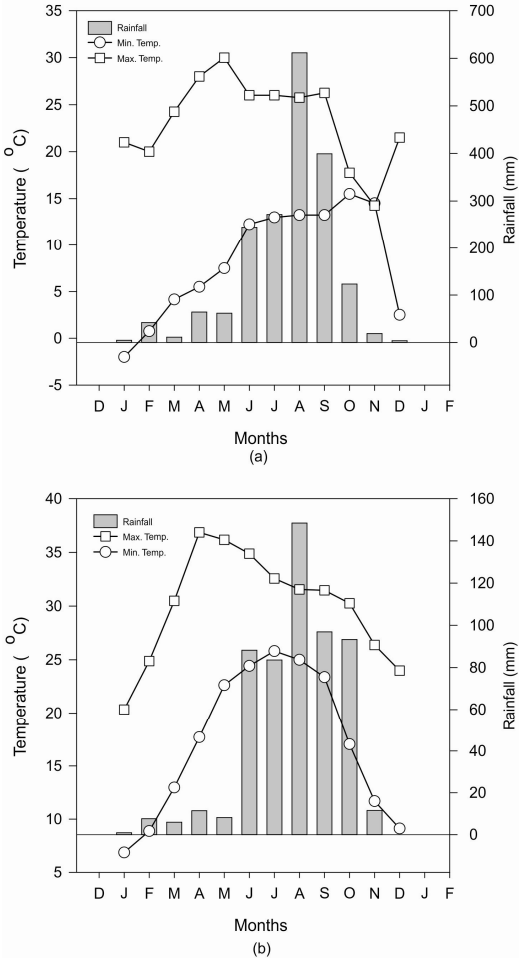

Fig 2. *Meteorological data for high altitude (a) and lower altitude (b)*

3.2. Soil

The Soil was sandy loam, with sand percentage being highest at 400-900 m elevation and lowest at 1600-1700 m elevation. An increasing trend with elevation was found for soil organic matter content ($r = 0.67$, $P < 0.05$), clay ($r = 0.89$, $P < 0.01$) and water holding capacity ($r = 0.84$, $P < 0.01$). Soil pH ranging between 5.1 to 7.9. Among the soil nutrient the available Nitrogen concentration increases with increasing elevation ($r = 0.81$, $P < 0.05$). Available Phosphorus was maximum in the soil of high elevation sites, occupied by forest of oaks (Quercus spp.) and least in low elevation site occupied by Sal (*Shorea robusta*) forest. The soil of oak forests was markedly richer in available Potassium than those of other forest types such as Sal forest and Chir pine forest (*Pinus roxburghii*) (Kumar, 2011).

4. Methods

The seedling dynamics were studied at sal forest, banj oak forest and chir pine forest. For the computation of seedling mortalityand other characteristics, 2x2m permanent quadrats was established in sal, chir-pine and banj oak forest. A total of 12 quadrats were placed in the stand (3 quadrats in each site). To record the mortality of the seedlings, all the seedlings of the year 2008 present in twelve quadrats in each forest were tagged. Their mortality was observed monthly from January 2009 – December 2009. Attempts were made to ascertain the causes of the seedling mortality (Joshi, 1990).

5. Results

In January 2009 the total number of seedling present in 12, 2 x 2m quadrats at each site was 90 at banj oak forest, 60 at chir pine forest, 72 at sal forest. At banj oak forest the total number of seedling decreased to 78 in month of March, 66 in April, 52 in May-June, 42 in July and after July all the seedling remained constant throughout the study period. At chir pine forest the number of seedling decreased to 52 in month of February, 40 in March, 24 in May, 14 in June and after June all the seedling remained constant throughout the study period. At sal forest the number of seedling decreased to 66 in month of March, 54 in April-May, 24 in June and after June all the seedling remained constant throughout the study period.

5.1. Banj Oak Forest

At banj oak forest the average number of seedling was 7.5 m^{-2} in January and February (i.e. 75,000 seedling ha^{-1}) while in March it was decreased to 6.5 seedlings m^{-2}. Thus 13.33% seedling mortality occurred in March. In April the seedling was decreased to 5.5 m^{-2}, thus 26.66% seedling mortality occurred in April. In May and June the number of seedling was decreased to 4.3 m^{-2} thus 42.66% seedling mortality occurred. In July the number of seedling was decreased to 3.5 seedling m^{-2}, thus the seedling mortality was 53.33% in month of July. After July no seedling mortally occurred (Fig. 3).

5.2. Chir Pine Forest

At chir pine forest the average number of seedling was 5.0 m^{-2} in January and February (i.e. 50,000 seedling ha^{-1}). In month of March it was decreased to 4.3 seedling m^{-2}, thus 14% seedling mortality occurred. In April the number of seedling was reduced to 3.3 seedling m^{-2}, thus 34% seedling mortality occurred. In June seedling was reduced to 2.0 seedling m^{-2} thus 60% mortality occurred. In June the seeding number was reduced to 1.3 m^{-2} thus 74% seedling mortality occurred and remained constant through the study period (Fig. 3).

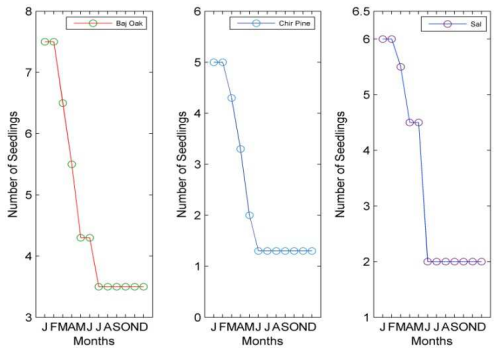

Fig 3. *Decline in average number of seedlings m^{-2} during the study in banj oak, chir pine and sal forest*

5.3. Sal Forest

At sal forest the average number of seeding was 6.0 m^{-2} in January and February (i.e. 60,000 seedling ha^{-1}). In March the seedling number was decreased to 5.5 seedling m^{-2}, thus 8.33% seedling mortality occurred. In April the number of seedling was reduced to 4.5 seedling m^{-2}, thus 25% seedling mortality occurred. In June the seedling was reduced to 2.0 seedling m^{-2}, thus about 66.66% seedling mortality occurred. After June no seedling morality occurred (Fig. 3).

Table 1. *Average number of seedlings per m^2 and their mortality in banj oak forest during the study period.*

Month	Average	Mortality	Cumulative mortality (%)
January	7.5000	-	-
February	7.5000	1	25
March	6.5000	2	50
April	5.5000	3.2	80
May	4.3000	3.2	80
June	4.3000	4	100
July	3.5000	-	-
August	3.5000	-	-
September	3.5000	-	-
October	3.5000	-	-
November	3.5000	-	-
December	3.5000	-	-

Table 2. *Average number of seedlings per m^2 and their mortality in chir pine forest during the study period.*

Month	Average	Mortality	Cumulative mortality (%)
January	5	-	-
February	5	0.7	18.92
March	4.3	1.7	45.95
April	3.3	3	81.08
May	2	3.7	100
June	1.3	-	-
July	1.3	-	-
August	1.3	-	-
September	1.3	-	-

Table 3. *Average number of seedlings per m2 and their mortality in sal forest during the study period.*

Month	Average	Mortality	Cumulative mortality (%)
January	6	-	-
February	6	0.5	12.5
March	5.5	1.5	37.5
April	4.5	1.5	37.5
May	4.5	4	100
June	2	-	-
July	2	-	-
August	2	-	-
September	2	-	-

The extent of seedling mortality shows a sharp rise in mortality from February to April in banj oak and chir pine forest and April to May in sal forest. In banj oak forest 100% cumulative mortality occurred in month of June (Table 1) compared to chir pine and sal forest where 100% cumulative mortality occurred in month of May (Table 2 and 3).

6. Conclusion

Seedling germination and seedling establishment are the very critical phases in the life cycle of a species (Ramakrishnan 1972, Harper and White 1974). The duration and simple conditions and the rate at which the seed is able to respond to these are major factor which determine the germination and establishment in the field condition (Harper, 1965). The regeneration potential of the vegetation largely depends upon the size of seed crop, seedling establishment and their survival. The average number of seedling surviving until December 2009 was 3.5 m^{-2} for banj oak forest, 1.3 m^{-2} for chir pine forest and 2.0 m^{-2} for sal forest. However, the value was lower at chir pine forest (1.3 m^{-2}) and higher at banj oak forest (3.5 m^{-2}).

In the present study seedling mortality was very low (20%) at sal forest compared to banj oak forest (25%) and chir pine forest (35%). The chir pine was forest was heavily affected by human disturbance. So the seedling population was more affected compared to two other sites. Since the biotic stress was negligible there was very little mortality during the study period in banj oak and sal forest suggesting that if biotic stress and natural disturbance is minimum, the rapid regeneration of *Q. leucotrichophora* and *S. robusta* would be possible.

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