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Regeneration Problem in *Quercus leucotrichophora* A. Camus in Nainital Forest Division of Kumaun Himalaya

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ABSTRACT

Quercus leucotrichophora A. Camus (banj oak) has a great importance in sustaining the livelihoods of the people, regulating the ecosystem services (mainly recharge of springs) and maintaining biodiversity in the central Himalayan region. The objective of the present study was to determine the regeneration status of Q. leucotrichophora in Nainital forest division of central Himalayan region. To assess the regeneration status, two contrasting aspects were selected. At each aspect, two patches were identified and in each patch complete enumeration was carried out for forest tree species. The regeneration was categorised into three categories on the basis of height. Q. leucotrichophora seedling density ranged between 5.2 and 20.3 ha^{-1}. The failure of banj oak to regenerate in the Nainital catchment is a case of environmental semi-surprise. Presence of regeneration in the shade of boulders and small shrubs in the canopy gaps of over-wood suggest that this oak requires canopy gaps for regeneration. Chronic anthropogenic disturbances, early seed maturation, prolonged drought because of delay in winter rainfall and premature seed fall influenced by wild animals could be the reasons for low regeneration. We hypothesized that rise in temperature and resultant enhanced evapo-transpiration desiccates the seed more rapidly in the soil seed banks due to global temperature rise. Therefore, we conclude that if immediate measures are not taken for the conservation of this important species, Q. leucotrichophora may disappear from its natural elevational range in near future.

Key word: *Oak; regeneration; density; evapo-transpiration; conservation*

INTRODUCTION

Plant regeneration is a complex and dynamic process. This process includes many factors (e.g. flowers, pollination, seed maturity stage, emergence and establishment, planting practices, vegetation management and silvicultural system etc.) that depend upon abiotic environment. Seedling establishment is the earliest and critical life history stage, most sensitive to micro environment and available resources particularly soil moisture. Specifically, it has been suggested that differences in seedling and juvenile performance involve a number of strategic tradeoffs that restrict a species to optimal performance at a narrow range of the successional gradient, and thus these differences are critically important in explaining community structure and dynamics[1,12,18]. Recent global climate change can lead to variation in flowering, fruiting, seed development, maturation which can consequently affected the germination and stand development. Indian Himalayan region is especially vulnerable to the impact of global warming[30]. Erratic rainfall patterns and availability of water may become limiting factor for plant growth further aggravated by anthropogenic activities. It is also been documented that Himalayan ecosystems are degrading and the consequences of degradation will be more precarious since they are considered as ecologically fragile[17].

The regeneration of such degraded ecosystems is extremely difficult due to the physical instability and environmental characteristics of the area[24].

Quercus (oak) is a large genus of great importance in the northern hemisphere. Oak forests occupy approximately 20,000Km^2 areas in the Central Himalaya between 1000 and 3000 m elevations[31] and are considered as a key stone species. Oak forests are designated as the climax communities in cooler climates and kept under the classification category in low to mid-montane hemi-sclerophyllous broadleaf forest with concentrated summer leaf drop[26]. Oaks have an important place in the Himalayan region because of their significant contribution in soil and water conservation, sustaining rural ecosystems[20], maintaining biodiversity[21] and other ecosystem services. Himalayan Oak forests are under chronic anthropogenic disturbances[24,28] due to indiscriminate harvesting[20] and are facing the danger of extinction. *Quercus leucotrichophora* A. Camus is the dominant Oak species in the central Himalaya distributed between 1200-2300 m in the Himalayas. *Q. leucotrichophora* is used by the local inhabitants for fodder, fuel wood, agricultural implement and leaves for animal bedding. Acorns (seeds) make wildlife food for animals like *Macaca mulata* (Monkeys), *Presbytis entellus* (Langurs), *Pteropus giganteus* (Flying foxes) and many species of birds. These forests are important for inflow and spring recharge of water for drinking and domestic uses of local residents. The future of these forests depends upon the regeneration. There are reports that banj oak is not regenerating in Nainital forest division. The objective of the present study was to determine the regeneration status and behaviour of *Q. leucotrichophora* in two aspects of Nainital forest division of central Himalaya.

MATERIAL AND METHODS

The study patches are located between 29°22′50.4″ and 29^{0}23′28.6″ N and 79°27/10.1// and 79^{0}27′58.5″ E along at elevational gradient between 2050 to 2250m asl. The dominant forest vegetation was banj oak mixed with *Q. floribunda* Lindley (telonj), *Rhododendron arboreum* Smith (buransh), *Acer oblongum* Wallich ex DC. (putli), *Litsea umbrosa* Nees (litsea) having canopy cover about 60 %. Average annual precipitation was 1317 mm of which two third occurs during rainy season. Mean annual temperature was 14.9^{0}C with mean minimum temperature of coldest month was 5.2^{0}C (January) and mean maximum temperature of warmest month was 21.9^{0}C (June) during the study period. However, variation in daily temperature is marked and it varied between -3.0^{0}C (January) to 33^{0}C (May). Rock types are calcarious slates, ferruginous shales, argillaceous limestone, dolomite and sandstone[14].

Methods

To assess the regeneration status two contrasting aspects viz. south-western and north-eastern were selected. Two patches were selected at each aspect, having >60% dominance of banj oak. Two patches NE (A) and NE (B) were selected at north-eastern aspect and other two patches SW (C) and SW (D) were selected on south-western aspect. The altitude of patches varied from 2050 m to 2216 m asl. Geographic coordinates, patch size and aspects are given in Table 1. Geographic coordinates and altitude were taken by GPS (Garmin made). Density of banj oak tree, in each selected patches, was estimated by placing ten quadrats of 10 m×10 m and calculated following Curtis and McIntosh[6] and basal area was estimated as $c^2/4\pi$ where c is the circumference at breast height (1.37 m) and π is 3.14. Canopy density was calculated by spherical densiometer. Complete enumeration was carried out in each patch and regenerating seedling were categorised into three categories on the basis of height[26]. These are (i) up to 50 cm, new recruits, sensitive to drought and trampling (ii) 50 cm to 100 cm, more or less established but suffer from browsing and (iii) 100 cm to 150 cm fully established tall seedlings.

RESULT AND DISCUSSION

Across the patches density of banj oak tree ranged between 142.8 and 214.3 individuals ha^{-1} and basal area from 8.2 to 19.6 m^2 ha^{-1} (Table 2). The values of tree density in the selected patches was low compared to reported 320-1560 individual ha^{-1} whereas basal area values, except in SW (D) patch, were within the earlier reported ranges 12-74 m^{2}ha^{-1} [7,21,22,25,29]. Tree density was higher at NE (B) patch whereas low at NE (A) patch. Basal area was high in NE (A) patch and low in SW (D) patch. The higher basal area with low density in NE (A) and SW (C) patch indicated that the trees were large and mature in age compared to other patches. Greater density and comparatively low basal area of NE (B) patch indicated that tree are less in cbh and younger in age. Canopy density ranged between 50 and 65 % in all the studied patches. It was higher in SW(C) patch and least in SW (D) patch (Table 2).

Regeneration of different species at different patches is given in Figure 1. *A. oblongum* was the dominant regenerating specie in NE (A) patch and *Q. floribunda* in SW (C) patch and SW (D) patch whereas banj oak and *Q. floribunda* had similar regeneration in NE (B) patch. Other most commonly regenerating species were *R. arboreum* and *L. umbrosa*. Total seedling density (ha^{-1}) showed that it was below 60 in all the studied patches. Seedling density of banj oak in different patches ranged between 5.2 and 20.3 ha^{-1}. This indicates that neither banj oak nor the other species are regenerating adequately in these patches, which is a great concern for future stand development (Figure 2). Seed production, herbivore and micro-site limitation have been postulated as possible causes of the regeneration failure commonly found in Oak stands, especially after anthropogenic disturbances[4,5,19,23,34]. Estimation of acorn (seed) production and germination indicated that seed fall density was 57 m^{-2} of which 60% germinated under controlled condition. Therefore, seed production is not a problem but the germination and subsequent seedling survival is the biggest problem. Seeds of banj oaks can be categorized as recalcitrant and lose their viability below 34% moisture content. Presence of low number of seedling up to 50 cm height showed that the fallen seeds could not germinate. This may be due to moisture loss and rapid desiccation of seeds in the absence of soil moisture due to prolonged post monsoon drought period and delay in winter rainfall coupled with earlier seed maturation. Joshi and Tewari[11] have reported that the winters in Himalaya region are getting milder but no significant change in temperature has been reported during the summer time. The percentage of seed germination and normal seedling development is tightly linked to the water content of seeds after the winter period, revealing that *in situ* desiccation is a major cause of mortality[10]. However, maximum seedling density was found in B patch which is moderately disturbed in terms of human activities compared to other patches. Disturbance has adverse effect on the regeneration[7,13,24,28] of Himalayan forests. According to Thadani and Ashton[32] inadequate light in the understory of dense canopy cover is a limiting factor influencing regeneration. They also concluded that moderate disturbance appear to benefit the regeneration.

Majority of the banj oak seedlings were confined and survived in the shade of boulders and small shrubs in canopy gaps of mature wood. Shade has been hypothesized to have a positive effect under drought[9] conditions by maintaining plant water status[2,3] which provide a mechanism for establishment and regeneration processes[16]. The reduced canopy cover has a direct effect on the seed production, but it may also indirectly effect regeneration through changes in the under-storey vegetation and soil properties[33]. Absence of significant regeneration in the under-canopy of *Arundinaria falcata* (dwarf bamboo) in NE (A) patch is also a reason of concern. The question arises does *A. fulcata* competes with regenerating seedlings for nutrients or creates a dense shade that is critical for poor survival or exert other effects on the soil needs further investigation. Absence of regeneration in completely open canopy may be due to enhanced solar irradiance that creates drought conditions as a result of faster desiccation and viability loss of seeds. The impact of drought under high-light conditions is presumably greater as a result of tissue desiccation due to high temperature and photo-oxidative stress that has a direct impact on seedling survival and growth[8]. Proportional representation of different category seedlings is given in Figure 3. The structure indicated that except at NE (B) patch, the conversion of first category to second is poor. This could be due to recent change in winter rainfall pattern and milder winter temperature[27]. Banj oak seeds mature in winter and germinated following spring and summer. Weed competition during the rainy season and extended post monsoon drought due to delay in rainfall seems to be major limiting factor for poor conversion of first (seedlings) to second (sapling) category.

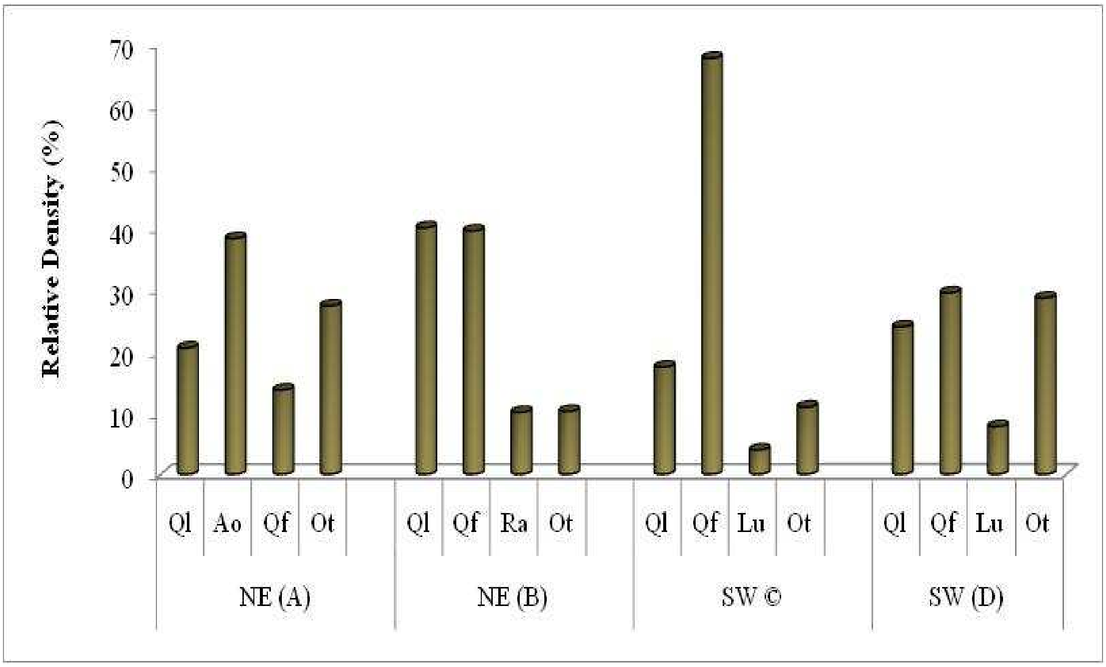
Table 1. Physiographic characters of *Q. leucotrichophora* in different patches

Aspect	Name of sites	Patch size (Ha)	Altitude (m)	Latitude (N)	Longitude (E)
North-eastern	NE (A)	6.0	2050	$29^0 22^/ 50.4^{//}$	$79^0 27^/ 32.0^{//}$
North-eastern	NE (B)	12.5	2210	$29^0 23^/ 28.6^{//}$	$79^0 27^/ 10.1^{//}$
South-western	SW (C)	10.2	2216	$29^0 23^/ 26.7^{//}$	$79^0 27^/ 57.4^{//}$
South-western	SW (D)	6.0	2100	$29^0 23^/ 07.9^{//}$	$79^0 27^/ 58.5^{//}$

Table 2. Density (Tree ha^{-1}), basal area (m^2 ha^{-1}) and canopy density (%) of *Q. leucotrichophora* in different patches

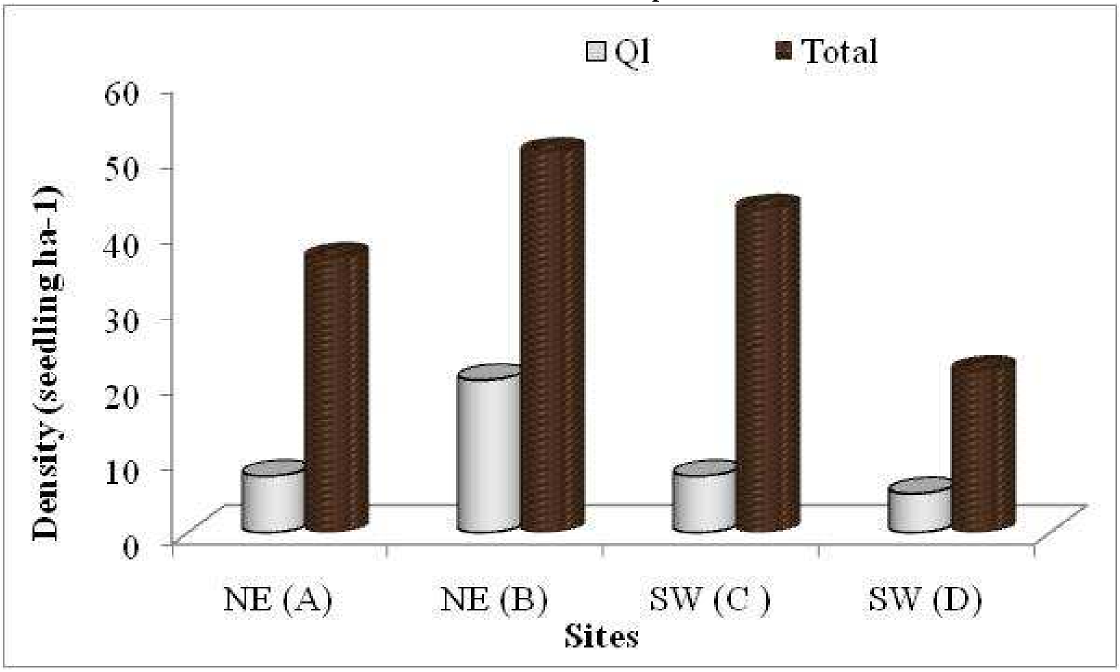
Name of sites	Density (Tree ha^{-1})	Basal area (m^2 ha^{-1})	Canopy density (%)
NE (A)	142.8	19.6	56.2
NE (B)	214.3	11.4	50.5
SW (C)	185.7	19.3	64.7
SW (D)	157.1	8.2	50.2

Fig. 1: Major regenerating species and their proportional presentation in different *Q. leucotrichophora* dominant patches



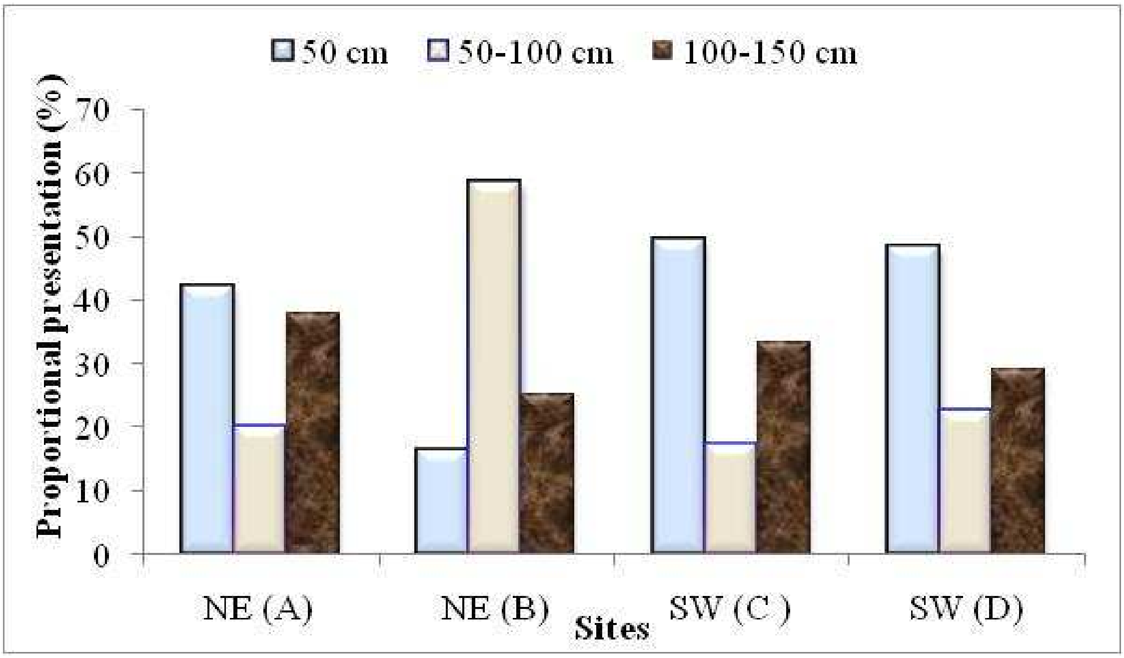
Ql = *Q. leucotrichophora*, Ao= *A. oblongum*, Qf= *Q. floribunda*, Ra= *R. arboreum*, Lu =*L. umbrosa* and Ot= other species. Site names as per Table 1.

Fig. 2: Seedling density (ha^{-1}) of Ql (*Q. leucotrichophora*) in light shaded bars and other species in dark shaded bars in different patches



Site names as per Table 1.

Fig. 3: Percentage of different category seedlings in different height classes of *Q. leucotrichophora* in different patches



Site names as per Table 1.

CONCLUSION

Studies in the Himalayas indicate that winters are getting milder[15,30] and rainfall pattern has becomes erratic during winters. Under such situation seed germination and regeneration of the moisture dependent Oaks will be under threat. Rise in temperature and resultant enhanced evapo-transpiration desiccates seeds more rapidly in soil seed banks. Such conditions are likely to be more pronounced in the coming future due to atmospheric temperature rise brought about climate change. The study highlights that conservation of slow growing banj-oak is the biggest challenge against continuous anthropogenic disturbances as well as changing climatic conditions. The failure of banj oak to regenerate in the Nainital division is a case of environmental semi-surprise. A larger study based on more sites is however, required to draw a conclusion regarding the regeneration problem in *Q. leucotrichophora*. This is a preliminary study which highlights the regeneration problem in this important *Quercus* species, which forms climax forests in central Himalayan region. The possible effects of the loss of this species from this altitudinal zone or its shift to upper zone on biodiversity, spring discharge and several ecosystem services emanating from these forests, need further and more elaborate investigation.

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