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# Response analysis of *Quercus leucotrichophora* seedlings along the nutrient gradient

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**Abstract.** This study includes the response analysis of *Quercus leucotrichophora* along a nutrient gradient. Seedlings of *Quercus leucotrichophora* were grown along the nutrient gradient which constituited the lower and higher range of Central Himalayan forest. Height growth,dry mass, leaf weight ratio, leaf production,leaf area, leaf drop and foliar nitrogen concentration showed significant positive correlation ($P<0.05$ and $P<0.01$) with soil nutrient levels whereas root: shoot ratio, nitrogen retranslocation and above ground productivity per g of leaf nitrogen showed negative correlation ($P<0.05$ and $P<0.01$) with soil nitrogen levels.

*Key-words: Quercus leucotrichophora*, plant nutrition

## Introduction

*Quercus leucotrichophora* generally occurs on nutrient rich sites (Troup 1921) and is often regarded as a dominant in forest climax communities (Singh and Singh 1987, 1992) of the Central Himalaya. Nutrient gradients are complex causing indirect effects even if only one nutrient is used. Plant species show marked differences in physiological and ecological responses along nutrient gradients, and these differences can offer valuable insights into plant community organisation (Parrish and Bazzaz 1982). Nitrogen appears to have been the first mineral nutrient to be specially recognised as necessary for plant growth (Russel 1961), and it is now generally accepted that nitrogen is one of the most important and most generally deficient soil nutrient factors limiting the growth of plant species (Black 1957; Gay and Dwyer 1965; Owsensby et al. 1970; Lawes and Gilbert 1980). THis study evaluates the response analysis of *Quercus leucotrichophora* seedling along the nutrient gradient.

## Materials and methods

Seeds of *Q. leucotrichophora* were collected during the winters (Troup 1921) from the current crop of single tree to avoid genetic variations. The soil was collected from the oak forest stand to a depth of 15 cm. This soil was air dried and sieved through a wire mesh (2x2 mm) and analysed for nitrogen by Micro-Kjeldahl method (Misra 1968).

To develop a nutrient gradient five nutrient levels were maintained as (1) very low -$N_1$; low -$N_2$; intermediate -$N_3$; high -$N_4$ and very high -$N_5$. $N_1$ and $N_5$ represents lower and higher values in forest of this region. The whole study was performed in a glass house. In each bag 5-6 seeds were sown but only two seedlings per bag were allowed to grow. The bags were moved from one place to another to avoid self-shading of the plant.

The individuals were separated into their component parts and oven dried at 60˚C to obtain the initial dry mass. Observations for height growth (up to shoot apex) was recorded at monthly interval. For dry mass the plants were harvested at the end of the experiment. The roots were washed and different parts of the plants (leaves, stems and roots) were separated and dried at 60˚C in an oven till constant weight. Leaf weight ratio and relative growth rate were determined by Evans (1972).

*Leaf weight ratio*

The leaf weight ratio (LWR) was calculated by dividing leaf dry weight to total seedling dry weight, i.e.,

$$LWR = \frac{LW}{w}$$

where LW = total leaf dry weight (g) and w= total seedling dry weight (g).

*Relative growth rate:*
The relative growth rate was calculated as

$$RGR(gg^{-1}d^{-1}) = \frac{\log_e w_2 - \log_e w_1}{T_2 - T_1}$$

where $w_1$ and $w_2$= dry weight of time $T_1$ and $T_2$, $T_2$-$T_1$= number of days in the sampling. Statistical analisysis was done by following Snedecor and Cochran (1968).

## Results

*Height growth and dry mass*

The height and dry mass (Table 1) of *Quercus leucotrichophora* increased from $N_1$ to $N_4$ nutrient level and then declined at $N_5$ nutrient level. Height growth and dry mass showed significant positive correlation with soil nitrogen levels ($P<0.05$).

*Leaf weight ratio and root: shoot ratio*

Leaf weight ratio (LWR) increased up to $N_4$ nutrient level and then declined at $N_5$ level (Table 1). Leaf weight ratio showed significant positive correlation ($P<0.01$) with soil nitrogen level, whereas, root: shoot ratio showed vice-versa to leaf weight ratio. Root: shoot ratio showed significant negative correlation with soil nitrogen.

*Leaf production, leaf area and leaf drop*

Leaf number, leaf area and leaf drop increased with increasing soil nitrogen levels. All these parameters showed significant positive correlation ($P<0.01$) with soil nitrogen (Table 2).

*Leaf area ratio and specific leaf mass*

Leaf area ratio increased from $N_1$ to $N_2$ then declined to $N_4$ level where as at $N_5$ level leaf area ratio increased. Specific leaf mass declined from $N_1$ to $N_2$ level and then increased at $N_3$ level and then declined afterwards (Table 2).

*Foliar nitrogen concentration*

Foliar nitrogen concentration increased from $N_1$ to $N_5$ nutrient level along the nutrient gradient. Foliar nitrogen concentration showed significant positive correlation with soil nitrogen level (Table 3). Above ground productivity per g nitrogen (AGP g $g^{-1}$ leaf nitrogen) declined with increasing nitrogen levels (Table 3). Above ground productivity per g nitrogen showed significant negative correlation ($P<0.01$) with soil nitrogen levels.

*Nitrogen retranslocation*

Nitrogen retranslocation declined with increasing soil nitrogen levels. Nitrogen retranslocation showed significant negative correlation ($P<0.01$) with soil nitrogen levels.

## Discussion

*Quercus leucotrichophora* is the most important late succesional species (Singh and Singh 1987) between 1,200-2,200m elevation. It is an evergreen with single year leaf life span (Ralhan *et al.* 1985). The latesuccesional *Q. leucotrichophora* is associated with nutrient rich sites (Chaturvedi

| Nutrient level | Height growth (cm seedling) | Shoot (g seedling) | Root | Total | Root:shoot ratio | Relative growth rate |
|---|---|---|---|---|---|---|
| $N_1$ | 8.30 | 0.474±0.040 | 0.749±0.048 | 1.224 | 1.59±0.060 | 0.0011 |
| $N_2$ | 13.08 | 0.999±0.024 | 1.445±0.026 | 2.444 | 1.45±0.026 | 0.0015 |
| $N_3$ | 17.95 | 1.800±0.084 | 2.319±0.107 | 4.052 | 1.29±0.023 | 0.0018 |
| $N_4$ | 20.97 | 2.991±0.057 | 3.240±0.125 | 6.231 | 1.08±0.035 | 0.0021 |
| $N_5$ | 18.75 | 2.235±0.105 | 2.648±0.060 | 4.883 | 1.19±0.029 | 0.0020 |

**Table 1.** Growth parameters of *Quercus leucotrichophora* seedlings along the nutrient gradient

| Nutrient level | Leaf number (number seedling$^{-1}$) | Leaf area ($cm^2$ leaf) | Leaf drop(%) | Leaf area ratio | Specific leaf mass ($gcm^{-2}$) |
|---|---|---|---|---|---|
| $N_1$ | 4.2±0.307 | 6.29±0.111 | 10.8 | 21.583 | 122.644 |
| $N_2$ | 12.7±0.919 | 9.99±0.581 | 20.64 | 51.912 | 54.227 |
| $N_3$ | 16.5±0.992 | 11.06±0.619 | 28.21 | 45.037 | 67.017 |
| $N_4$ | 27.7±2.789 | 11.420±0.546 | 36.50 | 50.768 | 64.520 |
| $N_5$ | 27.8±1.352 | 14.47±1.002 | 47.05 | 82.381 | 36.717 |

**Table 2.** Average leaf number (including leaf shed), leaf area, leaf drop, leaf area ratio and specific leaf mass in *Quercus leucotrichophora* seedlings along the nutrient gradient

| Nutrient level | Foliar N(%) | Foliar N content(g) | AGP $gg^{-1}$ | N retranslocation leaf N(%) |
|---|---|---|---|---|
| $N_1$ | 0.466±0.067 | 0.0015±0.00006 | 338.571 | 60.0 |
| $N_2$ | 0.799±0.115 | 0.0055±0.00017 | 181.636 | 56.0 |
| $N_3$ | 1.866±0.176 | 0.0228±0.00094 | 78.947 | 33.3 |
| $N_4$ | 2.532±0.133 | 0.0542±0.00084 | 55.184 | 24.4 |
| $N_5$ | 3.598±0.115 | 0.0531±0.00310 | 42.090 | 20.6 |

**Table 3.** Foliar nutrient content, above ground productivity per gram nitrogen (AGP $gg^{-1}$ leaf nitrogen) and percent nutrient retranslocation along the nutrient gradient

1983; Rawat 1983). Height growth and dry mass of *Q. leucotrichophora* increased up to N4 and then declined at N5 lvel, may be due to the higher-concentration of soil nutrients. High nutrient availability is reported to have toxic affects on some evergreen species (Specht 1963; Musick 1978).

With increased fertility, normally root: shoot ratio should decline (Luckwill 1960; Nielsen and Cunnigham 1964; Brouwer 1966; Hocking 1972; Reddy *et al*. 1976; Chapin 1980; Chaudhari 1989). This pattern is also reported for our study. Root: shoot ratio showed significant negative correlation ($P<0.01$) with soil nitrogen levels. Allocation of comparratively greater proportion of mass to root in late succesional species (Monk 1966; Rao 1984; Bisht 1990; 1992) and reverse trend of leaf weight ratio are in confirmity with previosly observed trends (Grime 1977; Abrahason 1979), Greater allocation to belowground parts is a feature associated with persistence of perennials in which resource imbalances in environment can be compensated for by draining on internal resource reserves; and the perennial organs can buffer the plant from environmental variations during growing seazon (Zangeral and Bazzaz 1983). The root: shoot ratios were relatively lower towards the higher portion of the nutrient gradient. Several authors have reported a decrease in root: shoot ratio of plants treated withN fertiliser (Hosking 1972; Reddy *et al*. 1976; Luxmoore 1971; Chapin 1980). Parrish and Bazzaz (1982) have explained the decrease in proportion of biomass in root of perennial species with increasing nutrient concentration in three ways, i.e., the plants could have some sort of feedback system enabling them to reduce root growth if a small root system could provide enough nutrient and water for shoot, or the higher concentrations of nutrients could also kill the root tips, limiting root growth. It is also possible that the plant limits its root system in order to avoid passively absorbing so much nutrient that tissue concentration becomes supra-optimal for growth.

Leaf production and leaf area increased soil nitrogen levels. The growth of leaves has long been known to be sensitive to application of nitrogen which increases leafiness in many crops (Terry *et al*. 1983). Robson and Deacon (1978) reported that increased nitrogen supply resulted in faster leaf elongation, greater leaf length and area. Increase in leaf drop with increasing fertility indicates that life span of leaves declined in response to increased nutrient availability (Al-Muflie *et al*. 1977; Chapin 1980; Mooney and Gulmon 1982; Shaver 1983). There exists significant positive correlation ($P<0.01$) between soil nitrogen (mg $kg^{-1}$) and leaf nitrogen concentration (Fig. 1). The trend was consistent with generally reported tendency for tissue nitrogen to increase with soil nitrogen availability (Chapin 1980).

Nitrogen retranslocation from leaves showed significant negative correlation with the soil nutrient levels and leaf nitrogen concentration (Fig 2 & 3). Ralhan a Singh (1987) also found a negative correlation between leaf nitrogen concentration and nutrient retranslocation, however, Chapin *et al.* (1983) found reverse pattern of this between these parameters and concluded that the high nutrient retranslocation efficiency is not an important adaptation to nutrient streed but is characteristic of most species. Seedlings in highest nutrient level required a large leaf area to produce a gram of dry matter (high leaf area ratio); thus the seedling must have had a low net photosynthetic rate per unit leaf area. On the other hand slight variation in leaf area ratio from $N_1$ to $N_3$ level indicates that the increase in growth from this treatment resulted mainly due to increase in total leaf area rather than any modification of the photosynthetic rate. Reich *et al.* (1992) considered specific leaf mass as an useful index of construction cost of leaves

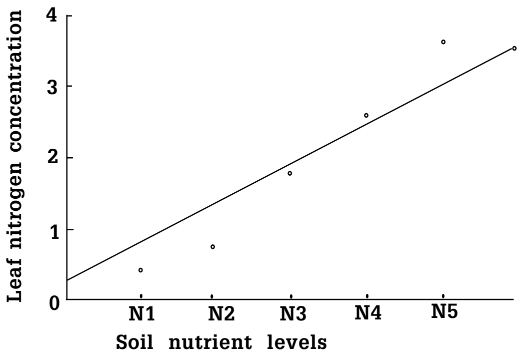


**Fig. 1.** Relationship betwen soil nutrient levels and leaf nitrogen concentration. $L = 0.093 + 0.0016N$; $r= 0.99$, $P < 0.01$.

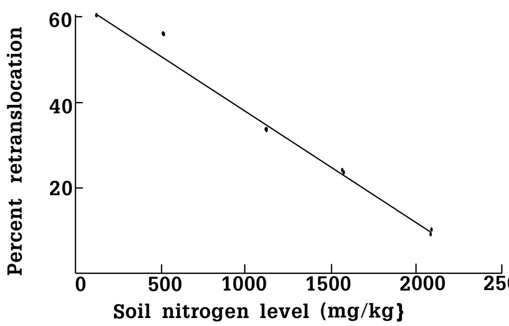


**Fig. 2.** Relationship between percent retranslocation and soil nitrogen levels. $R = 63.4-0.023N$; $r=-0.97$; $P<0.01$

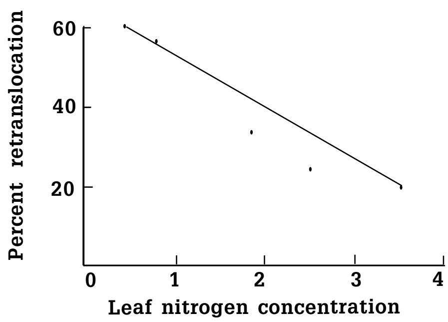


**Fig. 3.** Relationship between percent retranslocation and leaf tissue N concentration. $R=64.3-13.7N$, $r=0.96$; $P< 0.01$

on area basis (SLM is positively related to cost). SLM was lowest at highest nutrient level. Aboveground productivity per g of leaf nitrogen declined with increasing nitrogen levels. The adverse effect of lower nutrient levels on growth could not be attributed directly to inadequate nutrition since higher soil nutrients in the foliage. This suggests that the nutrients could not be utilised for growth because of limited carbohydrate production Values of the aboveground productivity per g of leaf nitrogen also support this phenomenon, as nitrogen concentration in leaves was highest at highest nutrient level but productivity per g leaf nitrogen concentration in leaves was highest at highest nutrient level but productivity per g leaf nitrogen was lowest.

*Quercus leucotrichophora* is the most important late successional species (Singh and Singh 1987) and it conserves biodiversity of the central Himalayan region so this study becomes more important as it analyses the response of *Q. leucotrichophora* sedlings along the nutrient gradient which covers the higher and lower ranges of this region. This is clear from our study that the performance of *Quercus leucotrichophora* seedlings was best at $N_3$, $N_4$ nutrient levels if the other factors like light and moisture are not limiting.

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