

Growth Versus Storage in *Quercus leucotrichophora* and *Pinus roxburghii* Seedlings in Response to Changes in Nutrient and Water Availability

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ABSTRACT

In this paper, growth and storage of carbon and nitrogen in seedlings of banj oak (*Quercus leucotrichophora* A. Camus) and chir pine (*Pinus roxburghii* Sarg.) have been compared across different levels of nutrient and water availabilities. Four nutrient (144, 264, 384 and 504 mg of NPK fertilizer per kg soil) and three watering (21 days, 14 days and 7 days interval) treatments were applied to seedlings. At low watering levels, seedling dry mass of both the species decreased towards higher nutrient level. However, at high watering level, dry mass increased with increasing water availability. When water availability was increased in a constant nutrient environment, dry mass of seedling increased with increase in water availability. Both the species showed a similar pattern of storing nitrogen instead of increasing biomass particularly at low watering levels. However, at each nutrient level, growth and storage increased with increasing moisture availability. As compared to *Q. leucotrichophora*, seedlings of *P. roxburghii* favoured growth over storage (according to its more competitive strategy), although this species accumulated more carbon and nitrogen towards the higher nutrient level.

Key words: Seedling, *Q. leucotrichophora*, *P. roxburghii*, growth, water, nutrient.

INTRODUCTION

During the extensive reforestation programmes, plantations of forest tree seedlings are being promoted in spite of their poor out planting performance. Among, initial seedling size or biomass of forest species has been related to post planting survival (Bargali and Bargali, 1999; Perez *et al.*, 2007) to the ability to out compete other plant species and to the potential for new root production (Jobidon *et al.*, 2003; Bargali and Singh, 1996). In addition, after disturbance, carbon stock is important for both resprouting (Huddle and Pallardy, 1999) and respiration during period of resource shortage (Bargali *et al.*, 1992; Joshi *et al.*, 1997). On the other hand, nitrogen storage affects the rate of growth after planting in the field (Malik and Timmer, 1998) and seedling capacity to recover foliage after disturbances (Bloom *et al.*, 1985).

Seedling biomass, carbon and nitrogen storage may change in response to resource availability but only few studies have addressed integrated response of biomass, carbon and nitrogen storage to resource availability (Perez *et al.*, 2007; Salifu and Timmer, 2003; Bargali and Singh, 1995; Bargali and Singh, 1996). Growth and storage may compete for Carbon and Nitrogen (Chapin *et al.*, 1990; Herms and Mattson, 1992), but resource availability may alter the proportion at which both resources are captured and stored. The aim of the present study was: i) to assess the response of growth, carbon and nitrogen reserve of seedling of *Quercus leucotrichophora* and *Pinus roxburghii* to changes in nutrient and water availabilities during their first year of growth; ii) to compare growth versus storage in fast growing early successional *P. roxburghii* and slow growing late successional *Q. leucotrichophora*.

MATERIAL AND METHODS

Species

Q. leucotrichophora (Banj oak) and *P. roxburghii* (Chir pine) are two dominant forest forming tree species of the Central Himalayan region between 1200 to 2200 m elevations. Both are evergreen species with similar periodicities of leafing, leaf fall and leaf longevities being just more than one year (Ralhan *et al.*, 1995). While *Q. leucotrichophora* is regarded as the major late successional species of the Central Himalayan region (Bargali *et al.*, 2014; 2015), *P. roxburghii* is referred as early successional species in view of the framework of basic plant strategies provided by Grime (1977).

Experimental design

The experiments were performed with first year seedlings because this is the plant life stage when selective pressures are stronger (Reich *et al.*, 2003). Seedlings of *Q. leucotrichophora* and *P. roxburghii* were raised from the seeds of current year crop and transferred to polyethylene bags (each containing 1 kg prepared soil containing sieved oak forest soil and commercial san in 1:3 ratio). Before starting treatments, ten individuals of each species were separated into their component parts and oven dried to obtain the initial dry mass. The experiment was carried out under glasshouse condition with temperature ranging from 5 °C (minimum) in December- January to 35 °C (maximum) in June.

Fertilization Experiment

Four levels of nutrient were established by adding 144, 264, 384 and 504 mg of 12:32:16 NPK fertilizer to the bags. Hereafter referred as nutrient level N1, N2, N3 and N4, respectively.

Water stress experiment

Each of the nutrient level was subjected to a gradient of water stress by watering the bags at 21, 14 and 7 day intervals (referred to as W1, W2 and W3 water levels, respectively).

Growth measurements

Ten seedlings per species and treatment were harvested at random at the end of the experiment. Seedlings were separated into leaves, stems and roots. Roots were gently washed to

eliminate soil particles. All parts were oven dried at 60° for 48 h and weighed separately.

Chemical analysis

A 0.5 g composite sample of all replicate of a treatment of each component of a species was analysed for total nitrogen, using Kjel Auto VS-KTP Nitrogen analyzer based on micro kjeldhal technique (Peach and Tracey 1956, Misra 1968). The nitrogen mass of different component was computed as the products obtained by multiplying dry weight of component with their mean nitrogen concentration. Carbon stock was obtained from conversion of biomass using a conversion coefficient of 0.5 g C g DM⁻¹ (Arora *et al.*, 2011). The effects of treatment and species on biomass, C: N ratio, carbon and nitrogen content of the whole plant and each part were tested by means of a two-way analysis of variance (ANOVA). In addition, treatment effects on whole plant traits were further analysed within each species using a one-way ANOVA.

RESULTS AND DISCUSSION

In both the species highest nutrient level failed to increase seedling dry mass (FG1), possibly due to toxic effect of nutrient. Parrish and Bazzaz (1982) also reported death of common early and late successional species at highest nutrient level. In conformity to trend towards the decrease in net primary production (Odum, 1969) and lower net photosynthetic rates (Bazzaz, 1979), as succession proceeds, the maximum production levels were greater in the early successional *P. roxburghii* than in the late successional *Q. leucotrichophora*. The responses of both species to nutrient availability were modified by watering frequencies. At each nutrient level, dry mass increased with increasing watering frequencies (FG 1).

The ratio of water absorbing surface to transpiring surface (Root: shoot ratio) is probably more important than actual leaf or transpiring surface (FG2). At each nutrient and water level, allocation of mass to roots was greater in *Q. leucotrichophora* in comparison to early successional *P. roxburghii*, and a reverse trend for leaf weight ratios are in conformity to previously observed trends (Grime, 1977; Chaudhary, 1989; Bisht, 1990; Bargali, 1992). Root: shoot ratios were generally higher where

nutrient and water were limiting factors (i.e. N_1W_1 level), and lower where these factors were non limiting (N_4W_3 level). Increased nutrient availability is known to cause a reduction in root: shoot ratio in several plant species (Chaudhary, 1989; Bisht,

1990; Chapin, 1980). Similarly an increase in soil water availability causes a reduction in root: shoot ratios (Bisht, 1990; Rao, 1984; Bargali and Singh, 1995).

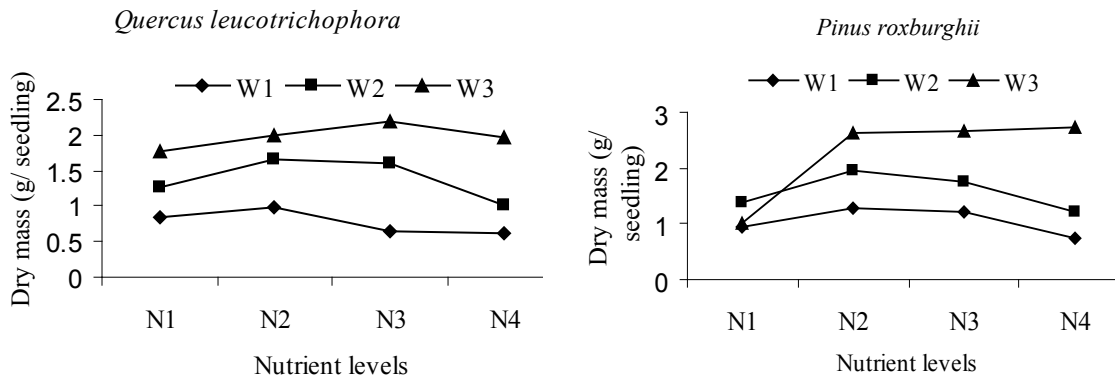


Fig. 1: Dry mass (g/ seedling) of *Q. leucotrichophora* and *P. roxburghii* seedlings as affected by nutrient and water availabilities

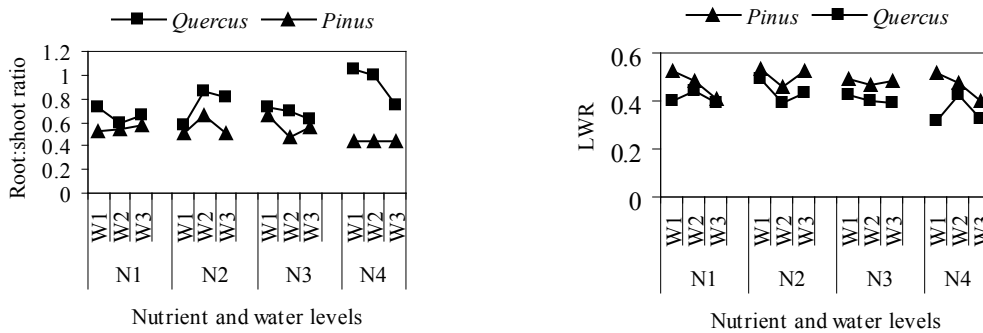


Fig. 2: Effect of fertilization and watering on Root: shoot ratio and Leaf weight ratio (LWR) of *Q. leucotrichophora* and *P. roxburghii* seedlings.

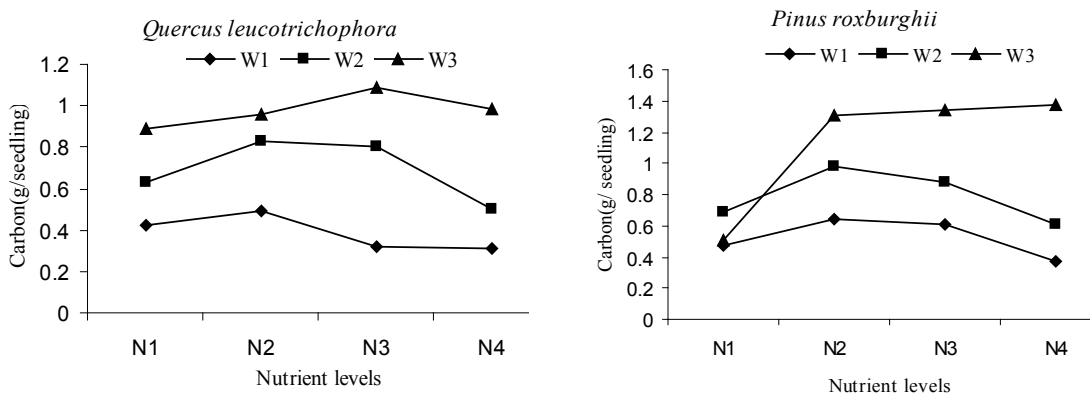


Fig. 3: Carbon stock (g/ seedling) of *Q. leucotrichophora* and *P. roxburghii* seedlings as affected by nutrient and water availabilities.

The carbon stock (g seedling⁻¹) also follow the same trend as described for seedling dry mass (FG3). These results indicate that lower carbon storage in high nutrient and lower water availability would decrease the capacity of seedlings to survive long stress periods or to recover from disturbances that rely on stored carbon (Chapin *et al.*, 1990).

Total seedling nitrogen mass (g seedling⁻¹) was greater for *Q. leucotrichophora* than for *P. roxburghii* at lowest nutrient level, while towards higher nutrient level, nitrogen mass was greater for *P. roxburghii* (FG4). At low nutrient level *P. roxburghii* showed growth over storage as indicated by greater dry mass of seedling. Higher nitrogen storage in *P. roxburghii* seedlings could allow faster growth after transplanting in the field, as nitrogen storage allows faster subsequent growth (Malik and Timmer, 1998; Salifu and Timmer, 2003) and improve ability to

recover from defoliating disturbance (Bargali and Bargali, 2000).

C: N ratio decreased with increasing nutrient level (FG5), and remains unaffected by water availability. These results suggest that seedling growth was not limited in low nutrient level, and addition of external nutrient supply may promote luxury consumption (Salifu and Jacobs, 2006) and accumulation on nitrogen in plant tissue for future use (Chapin *et al.*, 1990; El Omari *et al.*, 2006; Bargali *et al.*, 2005; Singh *et al.*, 2005).

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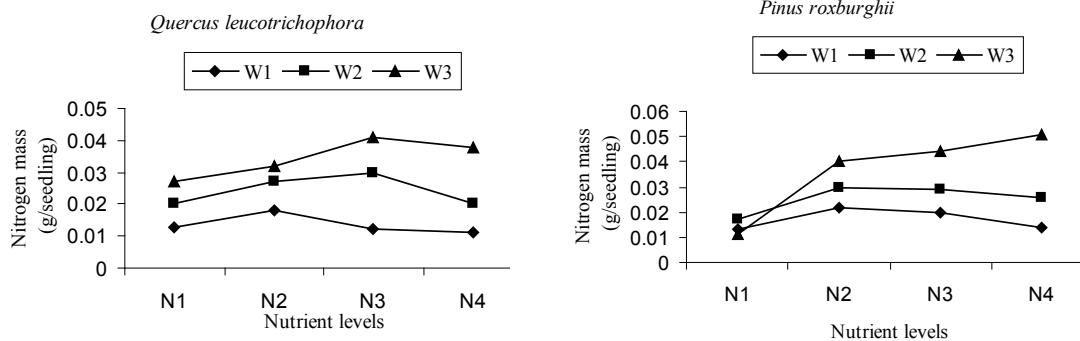


Fig. 4: Nitrogen mass (g/ seedling) of *Q. leucotrichophora* and *P. roxburghii* seedlings as affected by nutrient and water availabilities.

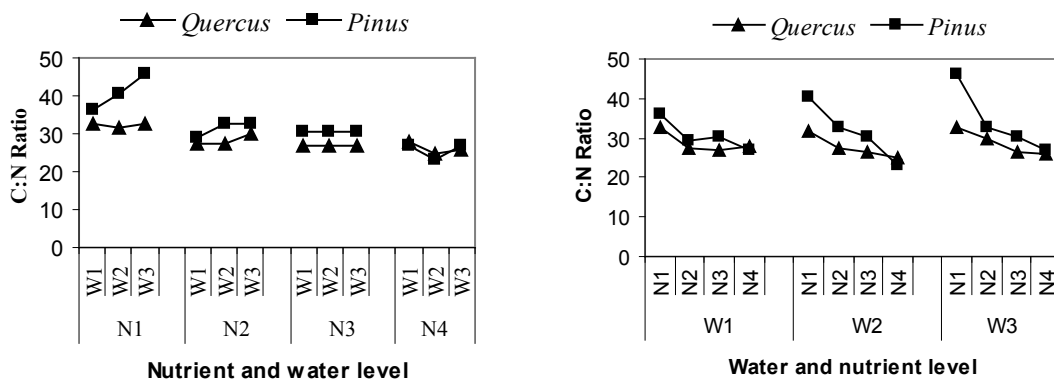


Fig. 5: Effect of fertilization and watering on Carbon: Nitrogen: ratio (C:N) of *Q. leucotrichophora* and *P. roxburghii* seedlings.

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