

## Research Article

# Relative Growth Rate of Tree Seedlings in Mixed Coniferous Forest of Swat, Pakistan

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### Abstract

The relative growth rate (RGR) is a significant attribute of plant species strategies. Species with high growth rate are more competitive in access to more resources while that with low growth rates are more conservative with limited resources. Relative growth rate (RGR) of trees particularly slows down with the increase in size of a tree because large allocation to structural material of the trunk required holding photosynthetic material up in the canopy. A new approach to separate size effects from intrinsic growth difference is implemented. To find out the relative growth rate this study was conducted in the mixed coniferous forest of Swat, Pakistan. Total hundred plots were selected at different ecological zones in which quadrates size 20x20 meter were selected. Growth rate, RGR per year and per month was measured. The highest growth rate was that of *Cedrus deodara* 29.27% per year. The highest relative growth rate (RGR) per year was that of *Pinus roxburghii* 1.41 g g<sup>-1</sup> y<sup>-1</sup>. The RGR per month was also measured and the highest was that of *Pinus roxburghii* 0.118 g g<sup>-1</sup> m<sup>-1</sup>. Relative growth rate (height and diameter) was calculated for all the species found in the study area. Promote the sustainable utilization of tree species, (*Cedrus deodara* and *Abies pindrow*) for local consumption and other commercial purpose that may be envisaged in the future from the natural forest.

**Keywords:** Growth rate; Relative Growth rate; Mixed coniferous forest; Volume of seedlings; Height and collar diameter



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### Introduction

Relative growth rate (RGR) is the growth rate related to the size of the population. It is also called exponential growth rate, or the continuous growth rate. RGR is a measure, used to quantify the speed of the plant growth (Ilyas *et al.*, 2012). Relative growth rate (RGR) is an essential attribute distinguishing Plant species strategy (Reich *et al.*, 2003). Species which have high growth rates they are more competitive in acquiring resources, whereas those species which have low growth rates are more conservative (Pugnaire and Valladares, 2007). In term of plant physiology, Relative growth rate (RGR) is a measure used to quantify the speed of plant growth. It is measured as the increase in the mass per above ground biomass per day, for example as g g<sup>-1</sup> d<sup>-1</sup>.

Several studies examined whether the status in relative growth rate reverses among pioneer and the shade tolerant species when grow under low light and high light environment (Kitajima and Bolker, 2003). Similarly, differences in (LLS) leaf life span, (LMR) leaf mass ratio, (SLA) specific leaf area and (LAR) leaf area ratio between the species of two functional groups were assessed (Reich *et al.*, 1991).

The analysis of the average (RGR) relative growth rate of tree seedlings is one of the methods use to compare the difference in growth that is the results of experimental treatments (Hunt, 2012). the main reason for examining (RGR) relative growth rates is to eradicate the growth differences which arises from differences in initial growth (South, 1995). One more reason to examine (RGR) relative growth rate was to identify the most efficient seedlings (Causton, 2012). To understand seed germination, requirements, establishment and growth of seedlings it is necessary to know about the critical stages in the regeneration of seeds (Kozłowski and management, 2002).

Earlier studies state that RGR (relative growth rate) on the living parts of woody vegetation was denoted by biomass increment first Year as **M1** and the increment in second Year 2 as **M2**. It could be similarly based on increase in annual height; diameter (or volume). The difference in the nature of biomass distribution between the persistent and evergreen species suggests that the characteristics of the RGR change may vary among leaf habits (Tomlinson *et al.*, 2012).

As the trees get older the RGR decrease with respect to time and with the increase of size of the tree due to the imperative customization of the structural material of the trunk required to retain the photovoltaic materials in the canopy. Nowadays here is a new approach which is to separate the effect of volume from fundamental growth differences (Philipson *et al.*, 2012). Some plant species differ in growth rate and most of them this variation is negatively associated with characteristics such as herbivore defenses (Hermes and Mattson, 1992).

Relative growth rate (RGR) is a standardized measure of growth rate with the benefit of avoiding the inherent differences as far as possible in scale between contrasting organisms so that their performances can be compared on an equitable basis (Hunt, 2012). Applications of RGR include the study of biomass, dry weight, and leaf area index (LAI), volume, basal area (BA) and stem diameter etc. Interestingly, this perception is closely interrelated to mortality rate of plants (Gillner *et al.*, 2013).

According to (Ilyas *et al.*, 2012) the mixed coniferous of swat Pakistan is under severe pressure through anthropogenic activities such as deforestation, over grazing, logging and clearing or cutting of forest for agriculture land. The natural coniferous forest cover is declining at a rate of 0.75 percent (%) per annum (FAO and ISRIC, 2012). There is significant difference in relative growth rate of dominant species of the study area. For analyzing the status of forests, regeneration assessment is utmost important. Such studies contribute to planning, conserving and decision making in natural forest management and development programs. This information can be used for research, education, training, etc. Develop baseline data required for simple and effective monitoring systems to verify regeneration progress in coniferous forest of Swat.

## Methodology

### Sampling

Stratified random sampling method was used to choose the plots. Stratification was done on the base of density, elevation, slope and aspect. Quadrat size was 20x20 meter (400 m<sup>2</sup>). Survey was carried out during the spring and fall of the year (ersha Gebrehiwot and Master, 2003). Height and diameter of each seedling was measured in each plot and each plant was tagged.

### Relative growth rate

Relative Growth Rate (RGR) is a natural measure of growth efficiency which seems to factor out differences in size, per unit time. This per unit time may be a year a month or a day. It is also called continuous growth rate. Relative growth rate (RGR) is a compute, used to measure the plant growth.

Mean relative growth rate (RGR) was calculated as:

$$\text{RGR} = (\ln W_2 - \ln W_1) / (t_2 - t_1)$$

where  $\ln$  = natural logarithm,  $W$  = dry mass or size, and  $t$  = time, with index  $X_1$  = initial values, and index  $X_2$  = final values (Daisuke *et al.*, 2013a). Relative growth rate was calculated for each plant independently (Zar, 1999).

### Statistical analysis

Comparison of means was made by the Student's t-test. Regression analysis was conducted to determine the predictors of plant relative growth rates.

### Results and Discussion

Growth rate is a parameter which was measured by finding the volume of seedling in the first year and the second year. The formula for finding growth rate is Present growth or volume of seedling- past growth or volume divided by past growth or volume. Five dominant species were found in the study area and there growth rates are given in the table above. The highest growth rate per year is that of *Cedrus deodara* was 0.2927 per year. The growth rate of *Abies pindrow* was 0.2911, *Picea smithiana* 0.2895, *Pinus roxburghii* 0.2985 while the lowest was that of *Pinus wallichiana* 0.2817 per year (Table 1).

Table 1: Growth rate of dominant species.

S. No.	Species	Growth Rate per year	Growth Rate in percent
1	<i>Abies pindrow</i>	0.2911	29.11
2	<i>Cedrus deodara</i>	0.2927	29.27
3	<i>Picea smithiana</i>	0.2895	28.95
4	<i>Pinus roxburghii</i>	0.2895	28.95
5	<i>Pinus wallichiana</i>	0.2817	28.17

Relative growth rate is the measure of efficiency of production of a given unit of plant size per unit time or RGR is a measure, used to “quantify the increment of plant growth” per unit time (Philipson *et al.*, 2012).

The RGR is the increase in the diameter, Height and volume per year. Figure 2 shows the relative growth rate of the five dominant tree species of the study area. The highest RGR was that of *Pinus roxburghii* 1.41 g g<sup>-1</sup> y<sup>-1</sup>, while the lowest was that of *Abies pindrow* 1.35 g g<sup>-1</sup> y<sup>-1</sup>. The RGR of *Cedrus deodara* was 1.39 *Picea smithiana* 1.38 while that of *Pinus wallichiana* was 1.39 g g<sup>-1</sup> y<sup>-1</sup>. This study was compared with Daisuke *et al.* (2013) who found out the Relative growth rate (height) for different species in Sarawak Malaysia and was also compared with the study of (Rees *et al.*, 2010) who find out the relative growth rate with respect to size for different species.

The total RGR of the year was divided by 12 which give us the RGR per month. Figure 3 shows the monthly RGR of the five dominant species of the study area. The highest monthly RGR was that of *Pinus roxburghii* 0.1185 g g<sup>-1</sup> m<sup>-1</sup> while the lowest was that of *Abies pindrow* 0.1109 g g<sup>-1</sup> m<sup>-1</sup>. The Monthly RGR of *Cedrus deodara* was, 0.1161, *Picea smithiana* 0.1127 while that of *Pinus wallichiana* was 0.1153 g g<sup>-1</sup> m<sup>-1</sup>.

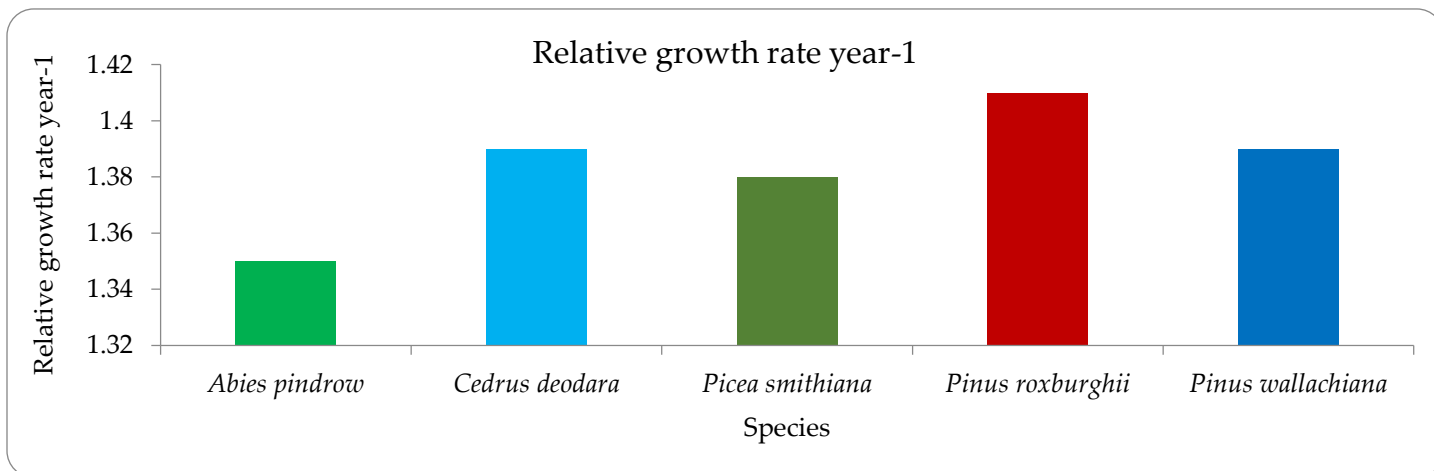


Figure 2: Relative growth rates per year.

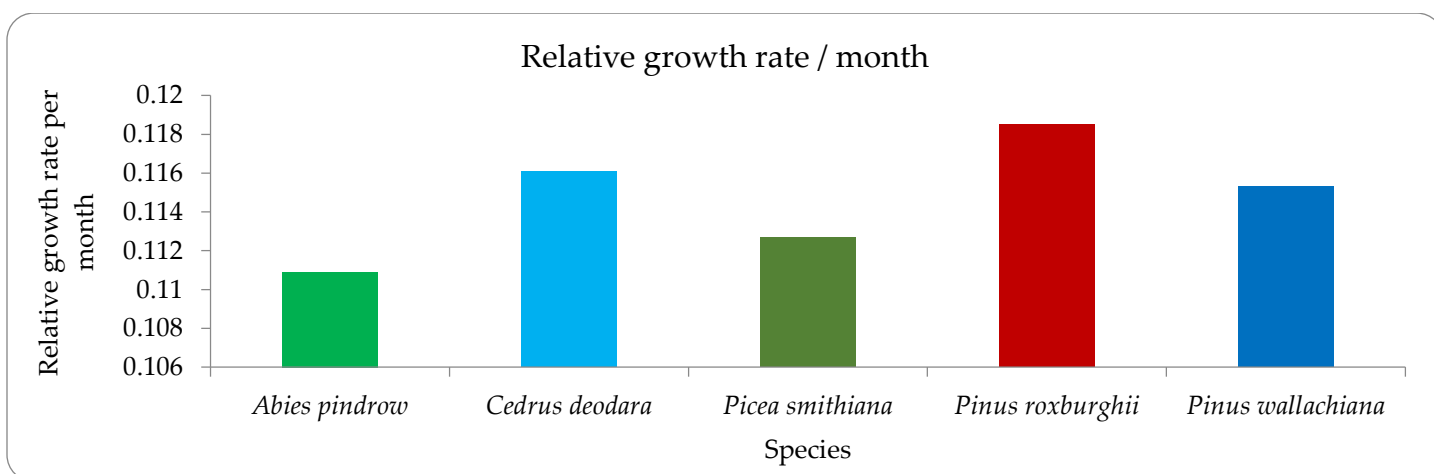


Figure 3: Relative Growth rate per month.

Ninety three percent (3.75 billion ha) of forest area globally is composed of naturally regenerating forests and only 7 percent (%) (290 million ha) is planted (FAO, 2020). The forest cover in the Himalaya is influenced by changes in the stand structure, distribution, pattern and regeneration status (Kumar *et al.*, 2019).

To recognize the general value of forests in view of their reduction at extraordinary rates, forest conservation has emerged as a primary goal. It is universally recognized that forest reduction has many environmental, social and economic consequences, one of which is the loss of biodiversity (Jha *et al.*, 2000).

The forest was divided into 3 categories, dense, moderate and open. When the forest cover was more than 70 percent by trees we called it dense forest. If it was more than 40 percent covered by trees it was considered moderate while when the forest cover was less than 40 percent we called it open forest. The availability of sunlight affect the natural regeneration so the light level was divided into 3 levels according to the forest, when the forest was dense there was low light penetration and we called it low light level. When the forest is moderate we called it medium light and when the forest is open and light intensity is high it was considered high light level.

The highest RGR (diameter) was that of *Pinus roxburghii* which is considered the fast growing species among conifers while the lowest RGR was that of *Abies pindrow* which grows slowly. This study was compared with the results of (Daisuke *et al.*, 2013b) who

calculated the RGR for *Dryobalanops beccarii*, 0.348 and for *S. virescens* 0.401 in the forest of Sarawak Malaysia. The highest average annual Relative growth rate was that of *Pinus roxburghii* following by *Pinus wallichiana* while the lowest was calculated for that of *Abies pindrow*. *Pinus roxburghii* is the fast growing while *Abies pindrow* is slow growing specie. Gillener et al. (2013) stated that relative growth rate is an important parameter which shows us the present and future productivity of specie. The relative growth rate was varied between the species. Species with high growth rate are more competitive while species with low growth rate are conservative (Poorter and Garnier, 2007).

Growth is a natural phenomenon in the increase in height and diameter or volume of a plant per unit time. In this study relative growth rate for all the dominant species was calculated. According to given data, the RGR of *Abies pindrow* was  $1.35 \text{ g g}^{-1} \text{ y}^{-1}$ , *Cedrus deodara*  $1.39 \text{ g g}^{-1} \text{ y}^{-1}$ , *Picea smithiana*  $1.38 \text{ g g}^{-1} \text{ y}^{-1}$ , *Pinus roxburghii*  $1.41 \text{ g g}^{-1} \text{ y}^{-1}$  and the *Pinus wallichiana* was calculated  $1.39 \text{ g g}^{-1} \text{ y}^{-1}$ . The highest (RGR) was recorded for that of *Pinus roxburghii*  $1.41 \text{ g g}^{-1} \text{ y}^{-1}$ . While the lowest RGR was recorded for *Abies pindrow* was  $1.35 \text{ g g}^{-1} \text{ y}^{-1}$ . The *Abies pindrow* is a slow growing species and its mortality rate is also high due to the palatability by the rodents such as porcupine etc.

Relative growth rate was compared to the study of (Daisuke et al., 2013b). Who calculated Relative growth rate for different species in Sarawak Malaysia and was also compared with the study of (Rees et al., 2010).

### Conclusion

Relative growth rate (height and diameter) was calculated for all the species found in the study area. The result of the study was to find out the relative growth rate (RGR) in mixed coniferous forest of Swat, so the *Pinus roxburghii* have the highest relative growth rate (RGR) per year  $1.42 \text{ g g}^{-1} \text{ y}^{-1}$ , and also per month which is  $0.1185 \text{ g g}^{-1} \text{ m}^{-1}$  while the lowest relative growth rate was of the *Abies pindrow*  $1.331 \text{ g g}^{-1} \text{ y}^{-1}$  and the monthly Relative growth rate is  $0.1109 \text{ g}^{-1} \text{ m}^{-1}$ .

### Conflict of Interest

The authors have not declared any conflict of interest.

### Authors Contributions

All the authors contributed equally in the manuscript.

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