TREE RING STUDIES OF *PINUS WALLICHIANA* A.B. JACKS. OF KASHMIR POINT RESERVE FOREST OF TEHSIL MURREE: A DENDROCHRONOLOGICAL PERSPECTIVE

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ABSTRACT: The dendrochronological studies of *Pinus wallichiana* A. B. Jacks. of Kashmir Point Reserve Forest of Tehsil Murree, Pakistan were carried out. Due to the thickness and elevation of the forest, it was divided into upper and the lower stand. Fifty cores were taken from both stands. Using the Velmex Measuring System all the samples were cross dated. The sample cores had scares, cracks and narrow rings which represented that the plant had gone through temperature flux, wild fires, water scarcity etc. The regression analysis of the values was done and the corresponding graphs were plotted against age of trees and the Dbh of the trees. The results showed the variance in age and the growth rate. In upper stand minimum age of the tree was 14 years and the maximum age of the tree was 505 years and the variation in the Dbh was from 46.8 to 2.28. In lower stand minimum age of the tree was 64 years and the maximum age of the tree was 330 years. While the variation in the Dbh of lower stand was from 37.2 to 12. Similarly, the graphs were plotted against average growth rate of trees and the Dbh of trees. The variation in the growth rate of the upper stand was from 0.25 to 0.07 inch/year. The variation in the growth rate of lower stand was from 0.22 to 0.08 inch/year. According to the results of regression analysis the area was under stress conditions due to various environmental factors.

Key words: *Pinus wallichiana*, Velmex measuring system, Dbh, Regression analysis.

(Received 17.04.2021 Accepted 03.06.2021)

INTRODUCTION

Dendrochronology is the study of the age of tree by counting the tree rings. It not only tells us about the age but also different events occurred in the past i.e., floods, precipitation, volcanic eruptions, temperature fluctuations, droughts, etc. Basically, the wide application of the tree-ring analysis is for the determination of age of the tree, growth rate and study of relationship existing between variable environmental factors and the tree growth rate. The study of these climatic variables helps in making predictions of the future possible climatic trends. The measurement of the age is used in the determination of age class distribution of tree populations. Through which the inferences occurring on the dynamics of that populations are drawn. Hence dendrochronology is termed as the study of the chronological sequences of tree growth rings in relation of past occurred events. The origin of dendrochronology, it's methods, principles and the uses of this study have been reviewed by Fritts (1976). It also includes the possible predictions of climate change in near future, hydrological information of the area, and dynamics of the forests etc. (Hughes *et al*. 1982; Cook & Kairiukstis, 1990). Hence provides all possible ecological information and past events occurred in the surroundings. The cores of conifer species *Pinus wallichiana, Picea smithiana*, and *Abies pindrow* from three different sites in northern Pakistan to understand their radial growth pattern with the goal of finding a relationship between ring-width and climatic parameters like temperature, precipitation, and drought (Bhandari *et al.*, 2020). The reconstruction of Northeastern United States temperatures by using Atlantic White Cedar tree rings. They analyzed tree ring chronologies of Atlantic White Cedar (*Chamaecyparis thyoides*) as a potential regional paleo-temperature proxy. During the study, the selected species showed positive significant relationship with local and regional temperature (Pearl *et al*., 2017). The study of the growth rates of species at different sites was carried out and observed that there was a great difference in the growth rates of same species up to twice (e.g. *C. deodara* at Mushfar compared with Zairat). A general climate correlation pattern from all species was evident that starts with a strong negative relationship to temperature in the previous October, then turns towards positive during winter, and again becoming significantly negative by the current May (Ahmed *et al.*, 2011).

MATERIALS AND METHODS

Sampling: The trees selected for the sampling were healthy, damage free, erect and unbranched with uniform diameter for the study of dendrochronology. To avoid the ambiguity the rotten trees, branched or bent trees were rejected. The cores were extracted from the tree using the increment borer. The length of which were 12 and 14

inches. Two cores from opposite sides of the same tree were extracted using increment borer for the determination of the age and the growth rate. The cores were taken at the height of 1.3m or 4.3 ft above the ground level for the precise measurement of age and the estimation of the growth rate of the tree (Fritts, 1976). While taking the core the borer was always in straight position. The extraction of the core causes the formation of the small hole which is filled by the wax to avoid the fungal and the pathogenic attack. The tree should be sampled at the basal point but as we know that the increment borer touches the ground and it is unable to move and cause the problem in taking the cores precisely (Mares, 2009). That's why we take the cores at the breast height. Then the cores were preserved in the plastic straws. The both ends of the straws were closed by the paper tape at the both ends to protect the samples from any damage (Hart and Grissino-Mayer, 2008).

Preparation of the samples for microscopic study: After drying the core samples, they were mounted on the wooden core mount with the glue in order to continue further studies of the chronologies. After applying glue, the paper tape was pasted until the glue dried. After 2-3 days the tape was removed and the glue was dried. Now the cores were sanded using fine sand papers of various girt i.e., 50 girt, 120 girt, 220 girt, 320 girt and 400 girt. After sanding the cores were polished to make each cell clear for view. For measuring the cross dated cores Velmex Measuring System was used (Pilcher, 1990). VOORTECH'S Measure J2X was installed and cables of the system were attached to measure the tree rings. For microscopic studies the sample cores were placed one by one on system stage and stereomicroscope was used to see the clear images in the laptop. The width between the rings and the number of the rings was counted by the system automatically (Volney and Mallet, 1992; Yamaguchi, 1991). The most important part of the dendrochronological research is the cross dating (Fritts and Swetnam, 1989). The width of the rings was compared from year to year for cross dating.

RESULTS AND DISCUSSION

Kashmir Point Reserve Forest was divided into two stands, upper and the lower stand depending on evaluation. Measuring the cores under the Velmex Measuring System following results were obtained.

Variations in Age, Growth Rate and Dbh of *Pinus wallichiana* in upper stand of Kashmir Point Reserve Forest: In table-1 the details of the age of plants, Dbh and the growth rate of the cored *Pinus wallichiana* from the upper stand of the Kashmir Point Reserve Forest is given. Cores were arranged as they were collected in a sequence. The results showed the variance in age and the growth rate. The minimum age of the tree was 14 years and the maximum age of the tree was 505 years. The variation in the growth rate was from 0.25 to 0.07 inch/year. While the variation in the Dbh was from 46.8 to 2.28.

Table 1: Age and Growth rate of *Pinus wallichiana* in upper stand of Kashmir Point Reserve Forest Tehsil Murree.

Sample No.	Rings (year)	Growth (mm)	Avg. Growth rate (mm)	Avg. Growth Rate (In)	Circumference (ft)	Dbh (ft)	Dbh (In)	Age (Years)
Pw-1	87	175.8	2.02	0.079	11	3.5	42	288
Pw-2	90	239	2.65	0.109	11.2	3.5	42	393
Pw-3	93	258.9	2.78	0.109	12	3.8	45.6	462
Pw-4	101	275.6	2.72	0.107	12.4	3.9	46.8	505
Pw-5	54	245.3	4.54	0.17	5.2	1.6	19.2	184
Pw-6	66	214.3	3.24	0.127	4.9	1.5	18	151
Pw-7	105	323.3	3.07	0.17	6	1.9	22.8	287
Pw-8	68	266.6	3.9	0.153	5.9	1.8	21.6	224
Pw-9	69	242	3.5	0.137	6	1.9	22.8	215
Pw-10	49	108.5	2.2	0.086	6	1.9	22.8	96
Pw-11	47	106.8	2.2	0.086	5	1.5	18	72
Pw-12	50	182.2	3.6	0.14	4.9	1.56	18.72	131
Pw-13	47	165.3	3.5	0.13	11.6	3.69	44.28	270
Pw-14	59	207.6	3.5	0.13	4	1.2	14.4	110
Pw-15	50	183.7	3.6	0.14	5.8	1.8	21.6	151
Pw-16	37	125.2	3.3	0.12	4.6	1.4	16.8	74
Pw-17	43	128.5	2.9	0.22	4.5	1.4	16.8	158
Pw-18	62	248.3	4	0.25	4	1.2	14.4	223
Pw-19	55	180	3.2	0.12	4.6	1.4	16.8	110
Pw-20	38	164.5	4.3	0.16	6	0.19	2.28	14
Pw-21	53	145.5	2.7	0.106	6	1.9	22.8	128

Pw-22	59	145.8	2.4	0.09	12	3.8	45.6	242
Pw-23	94	205.2	2.1	0.08	6.6	2.1	25.2	189
Pw-24	77	230	2.9	0.11	11.6	3.6	43.2	366
Pw-25	78	164.6	2.11	0.08	10	3.1	37.2	232

*Pw (*Pinus wallichiana*); **Dbh (Diameter at breast height)

Depending upon the age of plants we divided them in to different age category. The table is given below.

Table 2: Distribution of trees on the bases of age.

Years	Number of Trees
1-50	1
51-100	3
101-150	4
151-200	5
201-250	5
251-300	3
301-350	0
351-400	2
401-450	0
451-500	1
501-550	1

Regression analysis of Dbh against Age and Dbh against growth rate of *Pinus wallichiana* present in upper stand: The linear regression along with correlation coefficient of the samples between Dbh and Age of *P. wallichina* was positive. The correlation between Dbh and Growth rate of *P. wallichiana* at this collection site was negative. As shown in the fig.1 and fig.2.

Variations in Age, Growth Rate and Dbh of *Pinus wallichiana* present in Lower stand of Kashmir Point Reserve Forest: In table 3. the details of the age of plants, Dbh and the growth rate of the cored *Pinus wallichiana* from the upper stand of the Kashmir Point Reserve Forest is given. Cores were arranged as they were collected in a sequence. The results showed the variance in age and the growth rate. The minimum age of the tree was 64 years and the maximum age of the tree was 330 years. The variation in the growth rate was from 0.22 to 0.08 inch/year. While the variation in the Dbh was from 37.2 to 12.

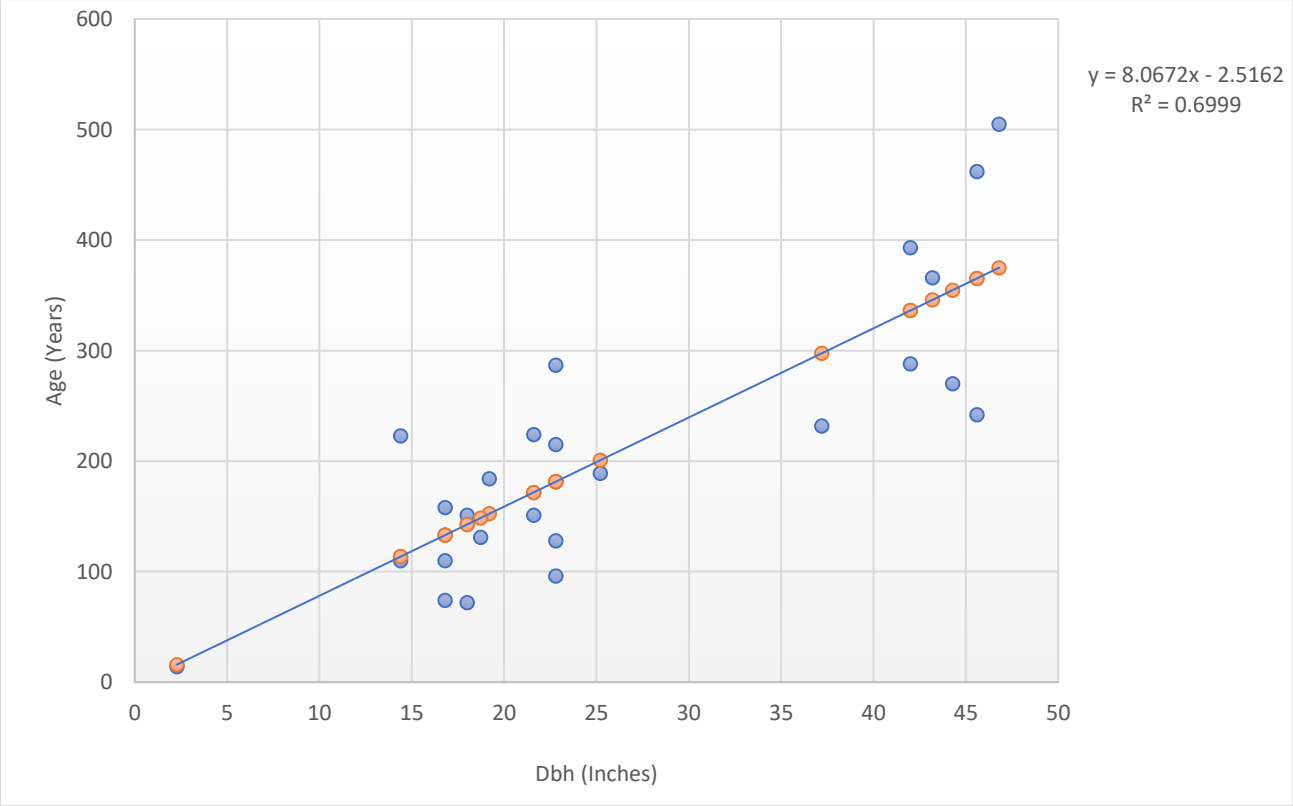

Fig 1: Correlation between age (years) and the Dbh (Inc) of *Pinus wallichiana* present in upper stand Kashmir Point Reserve Forest Tehsil Murree

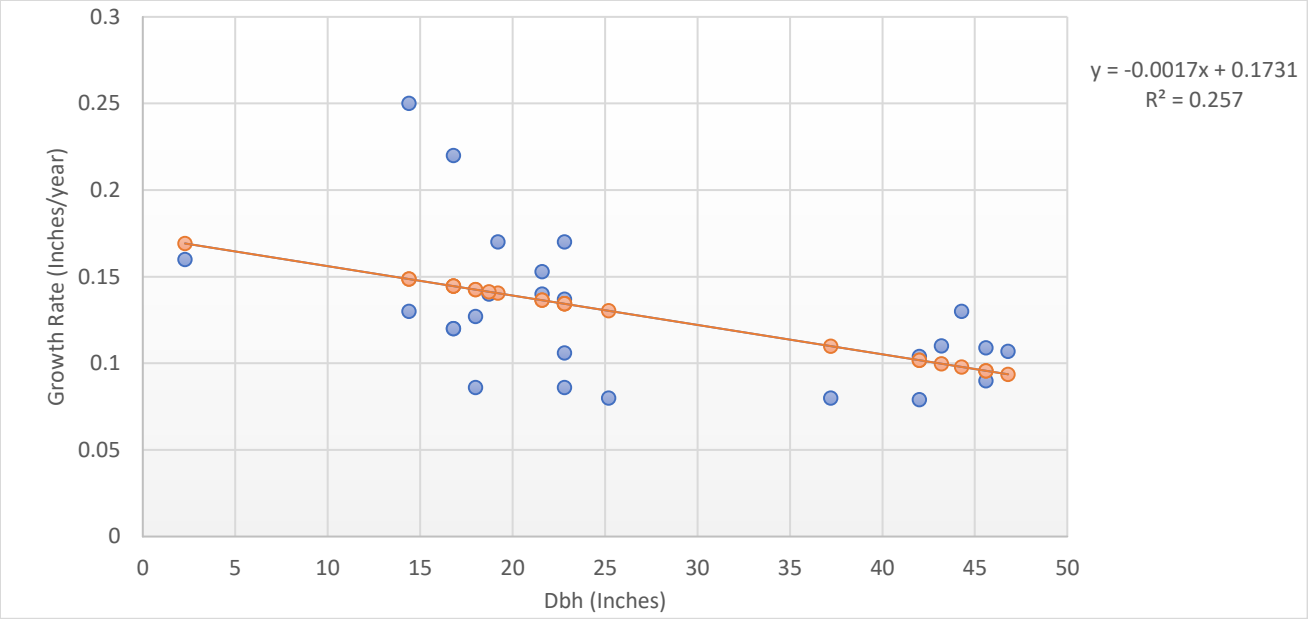

Fig 2: Correlation between growth rate (inches/years) and the Dbh (Inches) of *Pinus wallichiana* present in upper stand Kashmir Point Reserve Forest Tehsil Murree

Table 3: Age, Growth Rate and Dbh of *Pinus wallichiana* of Kashmir Point Reserve Forest Tehsil Murree.

Sample No.	Rings (year)	Growth (mm)	Avg. Growth rate (mm)	Avg. Growth Rate (In)	Circumference (ft)	Dbh (ft)	Dbh (Inc)	Age (Years)
Pw-1	87	181.3	2.08	0.08	7.3	2.3	27.6	192
Pw-2	84	235.3	2.8	0.11	8.6	2.7	32.4	299
Pw-3	74	225.8	3.05	0.12	10	3.1	37.2	330
Pw-4	52	196.4	3.7	0.14	5	1.5	18	131
Pw-5	67	181.5	2.7	0.106	5.4	1.7	20.4	145
Pw-6	44	131.4	2.98	0.117	5.5	1.7	20.4	105
Pw-7	46	172.8	3.75	0.147	5.1	1.6	19.2	130
Pw-8	92	233	2.53	0.099	5.3	1.68	20.16	187
Pw-9	90	228.3	2.53	0.099	6.1	1.94	23.28	207
Pw-10	67	159	2.3	0.09	6	1.9	22.8	137
Pw-11	80	166.4	2.08	0.08	5	1.6	19.2	123
Pw-12	77	216.3	2.8	0.11	5.8	1.8	21.6	183
Pw-13	45	142.3	3.16	0.12	6.3	2	24	129
Pw-14	44	151.8	3.45	0.13	3.4	1	12	68
Pw-15	55	206.3	3.7	0.14	7	2.2	26.4	203
Pw-16	53	155.4	3.9	0.15	5	1.5	18	143
Pw-17	56	152.8	3.7	0.14	5	1.6	19.2	150
Pw-18	52	156.5	3	0.11	5	1.6	19.2	110
Pw-19	59	263.4	4.4	0.17	5	1.6	19.2	192
Pw-20	39	160	4.1	0.16	3.9	1.2	14.4	90
Pw-21	40	146.6	3.665	0.14	3.5	1.1	13.2	74
Pw-22	47	264.7	5.63	0.22	4.3	1.3	15.6	161
Pw-23	52	128	2.46	0.098	4	1.2	14.4	72
Pw-24	42	149.2	3.55	0.13	4.9	1.5	18	98
Pw-25	38	160.8	4.23	0.16	5.6	1.7	20.4	124

*Pw (*Pinus wallichiana*); **Dbh (Diameter at breast height)

Depending upon the age of plants we divided them in to different age category. The table is given below.

Table 4: Distribution of trees on the bases of age.

Years	Number of Trees
1-50	0
51-100	5
101-150	11
151-200	5
201-250	2
251-300	1
301-350	1

Regression analysis of Dbh against Age and Dbh against growth rate of *Pinus wallichiana* present in lower stand Kashmir Point Reserve Forest Tehsil Murree: The linear regression along with correlation coefficient of the samples between Dbh and Age of *P. wallichiana* was positive. The correlation between Dbh and Growth rate of *P. wallichiana* at this collection site was negative. As shown in the fig.3 and fig.4.

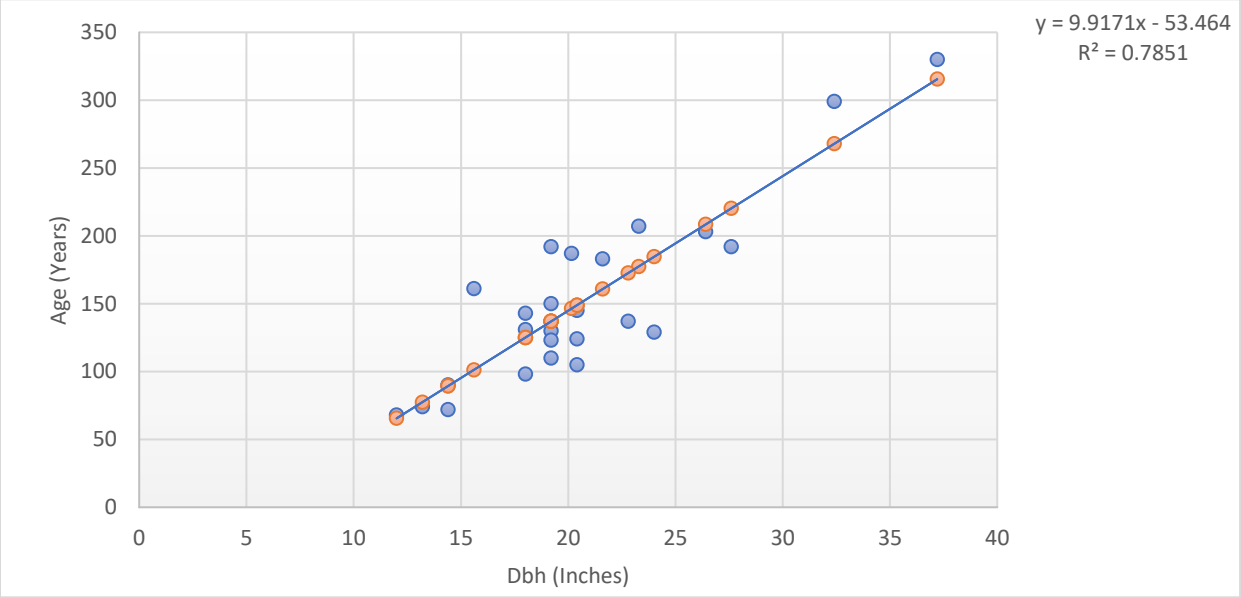

Fig-3: Correlation between age (years) and the Dbh (Inc) of *Pinus wallichiana* present in Lower stand Kashmir Point Reserve Forest Tehsil Murree.

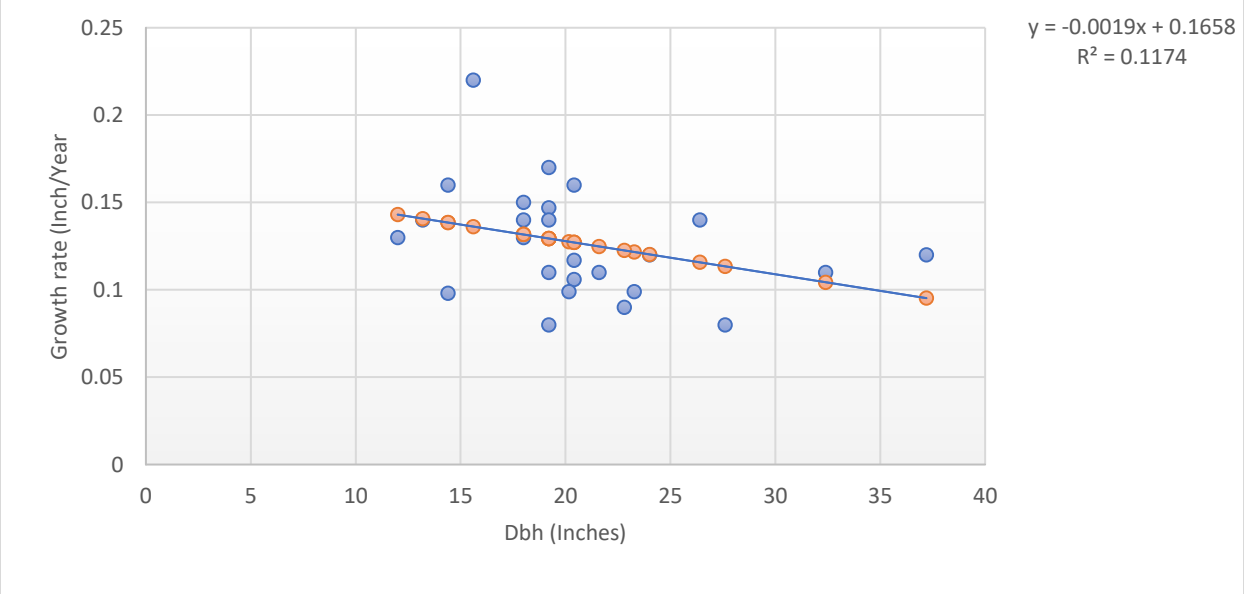

Fig 4: Correlation between growth rate (inches/years) and the Dbh (Inches) of *Pinus wallichiana* present in Lower stand Kashmir Point Reserve Forest Tehsil Murree

DISCUSSION

In Pakistan *Pinus wallichiana* shows a high directly proportional relation between the age and Dbh as compared to other conifers i.e., *Taxus wallichiana, Cedrus deodara*, *Pinus roxburghii*, *Abies pindrow*, *Picea smithiana* etc. Ahmed and Sarangezai (1991) said that the diameter is usually a poor indicator of the age in many trees. As known some species diameter increases with the increase in age of tree but still in many species the diameter is much variable. Due to human or natural disturbances or other environmental disturbances, adequate nutrients and suitable conditions of the environment play a vital role in the growth rate of certain species (Siddiqui *et al.*, 2013). The fast growth rate and the large diameters may be observed in some plants it may be due to some factors i.e., increased competition, reduction in generation time, increased short term survival probability, and attainment of earlier reproductive size.

Ahmed and Sarangezai (1991) found that the correlation between altitude and growth rate was significantly negative. Temperature and precipitation have a significant role in determining the growth of the tree. In high temperatures of summer, the growth is negatively affected and relative increase is found during the precipitation season. The precipitation during the winter and spring shows a great positive affect on the growth rate. During rainfalls, growth rate gives strongest response (Ahmed *et al*., 2012).

The weather records of past century from the Western Himalayan region showed the annual increase in atmospheric temperature mean with winters warming at faster rate. The growth of vegetation in upper ecotonal zones were already on climatic threshold and were sensitive to change in climate variations limiting the growth of vegetation. To study and investigate the climate change impact on the tree-line dynamics of Himalayan pine (*Pinus wallichiana* A.B. Jack). 12 tree line sites of the different ecological setting were investigated, which were widely distributed in Westren Himalaya, India in monsoon-shadow zones and monsoon zones (Yadava *et al.*, 2017).

The flood history of the Dhur River, Bhutan was examined during 2018 World Dendro field week. The data of the past events from the villages along the stream will help in knowing the flood history of the area which in future will help managers to prepare for future events. Total 29 trees were studied in a stretch of 2 km along the Dhur River. Two cores were extracted from each of the 29 trees from following six species (*Populus ciliata, Picea spinulosa, Tsuga dumosa, Quercus semecarpifolia, Pinus wallichiana* and *Rhodendron arboretum*). The traumatic rings or flood scares from two trees identified large floods occurred in past 1967, 1989 and 2009 years (Speer *et al*., 2019).

Three different conifer species i.e., *Pinus wallichiana, Cedrus deodara* and *Abies pindrow* from different sites of Shanghla District were studied for the dendrochronological assessment. The study included the growth rate of trees after every 10 years of interval. The variations occurring in dbh were also investigated. Following studies revealed that the growth rate and the age factors varied from site to site, species to species and even in between the individuals of same species growing in a common site. The observations resulted that after 18th century there was a decrease in the growth rate. The dbh didn't identified that the tree with smaller dbh was not necessarily younger to the tree with large dbh. Hence the dbh is not a good indicator of the age of tree (Iqbal *et al*., 2020).

Conclusion: It is concluded from the results that the growth rate of *Pinus wallichiana* (blue pine) is greatly affected by surrounding environmental factors i.e., precipitation, temperature, moisture content etc. The dendrochronological study of *Pinus wallichiana* (blue pine) help greatly in the paleoclimatic reconstruction of chronologies. The regression analysis shows that there is positive correlation between age and Dbh of *P. wallichiana*. But on the other hand, there is a negative correlation between Dbh and the Growth rate of *Pinus wallichiana.* The results showed that Dbh is not a clear indicator of tree-age. The trees with similar Dbh may vary in the age, the tree with smaller Dbh may have more age than the tree with larger Dbh despite of their presence in same location.

Recommendations: This research work mainly focuses on the dendrochronological study of *Pinus wallichiana* (blue pine) of Kashmir Point Reserve Forest, Tehsil Murree. Following recommendations have been evaluated from the research work:

- In order to understand the dynamics of the area still there is need of more study of the area. Hence, more dendrochronological studies of *Pinus wallichiana* (Blue pine) is recommended.
- Collection of more tree chronologies of the undistributed and mature trees will help in more accurate climatic studies of the area.
- Enlightens the pathway to studies of the climatic factors that influence the tree growth i.e., precipitation, temperature and other climatic factors.

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