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TREE RING STUDIES FROM SOME CONIFERS AND PRESENT CONDITION OF FORESTS OF SHANGLA DISTRICT OF KHYBER PAKHTUNKHWA, PAKISTAN

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Abstract

Dendroecological investigations were carried out for different sites of Shangla District, using 3 conifer tree species i.e. *Pinus wallichiana*, *Abies pindrow* and *Cedrus deodara*. Wood samples were subjected to dendrochronological processes, analyzed under microscope and measured on Velmax measuring system attached to a computer. Growth rate at every 10 years interval were determined and its variation in various dbh classes were investigated. The present findings showed that age and growth rate varies from species to species and site to site, even among the individuals of a single species growing in a same site. It was shown that growth rate decreased after 18th century. It was observed that small dbh tree was not necessarily younger than large dbh trees. Present study shows that age increases roughly with increasing tree size but also agreed with previously workers that dbh is not a good indicator of age in multisized and multiaged population.

Kay words: Dendroecology, Pine trees, Growth rate, Shangla, Velmax measuring system.

Introduction

Dendroecology is an important sub branch of Dendrochronology established by Theodar Harting & Robert Harting in late 1800's and Bruno Huber (1940-1960) in Germany. Fritts & Swetnam (1989) recognized Dendroecology as a sub branch of dendrochronology and important approach for evaluating past and present condition of forest. Past disturbances events can be correctly dated using annual growth rings variations of trees. Lorimer & Frelich (1989) reported that 100 percent increase or decrease in growth rate which last at least 15 years often interpreted as a response to major disturbance in closed forests. In this sub branch annual tree-rings are being used to solve various problems of forest history, succession, distributional limits of species, interaction of multiple disturbances, management, conservation, forest productivity, forest ecology, ecosystem and population dynamics. Due to the huge amount of research work, refined methodology and techniques Schwengruber (1996) included dendrohydrology, dendroclimatology, dendroglaciology and dendromorphology under the heading of dendroecology. Speer (2010) worked under this domain to identify the frequency of insect outbreaks. Fire, winds throw anthropogenic disturbances, forest decline while stand wise age structure was presented by Abrams & Black (2000) and Brown *et al*., (2000). In Pakistan Ahmed (1988, 1989), Ahmed *et al*., (1990a, 1990b and 1991) initiated these studies, presenting population dynamics of forest tree species. The main advantage of dendroecology is that it provides one of the largest forest history records on annual basis. Worbes *et al*., (2003) reported historical dynamics of seasonally dry tropical forests in Cameroon by determining age and growth rates of trees of all species. Age and growth rate studies of Pine tree species from different areas of Pakistan were presented by Ahmed *et al*., (2009a), Bokhari *et al.*, (2010, 2013), Zafar *et al*., (2010), Khan (2011), Siddiqui (2011), Nazim (2011), Wahab (2011), Akbar (2013), Hussain (2013), Iqbal *et al*., (2017), Khan (2017) and Iqbal (2017). However no attempt was made to explore the detracts of growth rate. Therefore present studies were conducted in Shangla forests to explore variation in growth rate from seedling to mature tree, variation in growth rate with increasing dbh and variation in age in different dbh size classes.

Materials and Methods

Wood samples in the form of cores were obtained from *Pinus wallichiana*, *Abies pindrow* and *Cedrus deodara* trees following standard dendrochronological techniques, described in Ahmed (2014). Many trees of each species were sampled at each location and cores were kept in drinking straws to prevent damages. Cores were then prepared in the laboratory using methods described by Stocks & Smiley (1968) and twenty cores from each species were selected to examine under microscope. Cross-dating was conducted following Fritts (1976) to assign each annual ring to its proper calendar year and to detect any possible missing or double rings. These cores were measured on stage velmax measuring equipment to check the variation in time; each core was measured on the basis of ten years interval from pith to bark side. This way every ten years interval, growth rate variation was calculated.

2. Variation in growth rate in different dbh classes was carried out on the basis of one centimeter interval of the seedling stage and then on 5 cm intervals for trees. In each dbh class growth rate were determine with its standard errors. Annual rings in these intervals were counted under binocular microscope and obtained growth rates in different dbh classes.

3. Similarly in the same way rings were counted which take tree to reach up to 1.5m height following Ahmed (1984). All adder rings representing age of the different dbh classes. Mean and standard error of all these growth rates and age of three species were computed and shown by bar graphs.

Table. 1. Conifer species and characteristics of study sites from District Shangla forests.

	Species name	Fig No.	Locations	Latitude	Longitude	Elev	Aspect
(A) Growth rate variation in time	*Abies pindrow*	1a	Bahadar Sar	34° 64′08.5″	72° 69′52.3″	2810	S
	Abies pindrow	1b	Bakht Banda	34° 49′49.3″	72° 49′08.2″	2359	S
	Abies pindrow	1c	Shalkho Forest	34° 51′13.7″	72° 39′36.3″	2556	R.Top
	Cedrus deodara	1d	Munz Bund	34° 50′28.6″	72° 44′58.6″	2014	W
	Cedrus deodara	1e	Chaat Naala	34° 50′56.7″	72° 50′03.5″	2089	N
	Pinus wallichiana	1f	Nakhtaro Ghar	34° 53′55.3″	72° 37′19.4″	1990	N/ W
	Pinus wallichiana	1g	Shangla Top	34° 53′51.4″	72° 35′36.5″	2540	S/ W
	Pinus wallichiana	1h	Yakh Tangay	34° 49′45.3″	72° 37′15.4″	2260	N/ E
(B) Variation in growth rate in different Dbh classes	*Abies pindrow*	2a	Bahadar Sar	34° 64′08.5″	72° 69′52.3″	2810	S
	Abies pindrow	2b	Bakht Banda	34° 49′49.3″	72° 49′08.2″	2359	S
	Abies pindrow	2c	Shalkho Forest	34° 51’13.7″	72° 39′36.3″	2556	R.Top
	Cedrus deodara	2d	Munz Bund	34° 50′28.6″	72° 44′58.6″	2014	W
	Cedrus deodara	2e	Chaat Naala	34° 50′56.7″	72° 50′03.5″	2089	N
	Pinus wallichiana	2f	Nakhtaro Ghar	34 ° 53′55.3″	72° 37′19.4″	1990	N/ W
	Pinus wallichiana	2g	Shangla Top	34° 53′51.4″	72° 35′36.5″	2540	S/ W
	Pinus wallichiana	2h	Yakh Tangay	34° 49′45.3″	72° 37′15.4″	2260	N/ E
(C) Variation in age in different Dbh classes	*Abies pindrow*	3a	Bahadar Sar	34° 64′08.5″	72° 69′ 52.3″	2810	S
	Abies pindrow	3b	Bakht Banda	34° 49′49.3″	72° 49′08.2″	2359	S
	Abies pindrow	3c	Shalkho Forest	34° 51′13.7″	72° 39′36.3″	2556	R.Top
	Cedrus deodara	3d	Munz Bund	34° 50′28.6″	72° 44′58.6″	2014	W
	Cedrus deodara	3e	Chaat Naala	34° 50′56.7″	72° 50′03.5″	2089	N
	Pinus wallichiana	3f	Nakhtaro Ghar	34° 53′55.3″	72° 37′19.4″	1990	N/ W
	Pinus wallichiana	3g	Shangla Top	34° 53′51.4″	72° 35′36.5″	2540	S/ W
	Pinus wallichiana	3h	Yakh Tangay	34° 49′45.3″	72° 37′15.4″	2260	N/ E

Key to abbreviations: Elev = Elevation, S = South, N = North, W = West, E = East, R.Top = Ridge top, Fig = Figure No.

Results

Species name and characteristics of the sampling sites are given in Table 1. Trees were distributed from 1990 meters to 2810 m above sea level on different aspects i.e. N, E, W and South.

Variation in growth rate with time: Growth rates of trees during different periods of life time were shown from Figs. 1a to 8a. Results of *Abies pindrow* and *Pinus wallichiana* were shown from 3 different locations, while *Cedrus deodara* was presented from two sites. Due to small sample size species of other stands or forests are not presented.

Fig. 1a reveals *Abies pindrow* pure forest from Bahadar Sar forest showing different growth rate on the basis of 10 years interval. The growth rate was observed in the 1st five classes (1841 to 1890) was high which was gradually decreased with the passage of time up to 2010. The fast growth rate was observed from year 1840-1850 which was 4.7cm/year, while the slow growth rate 2.2 cm/year was found within 1881 to 1890 period which was significantly different than the previous class. The growth rate in the next classes from 1891 to 2010 was almost similar, but significantly different than previous classes. The lowest (0.8 cm/year) growth rate among all these classes was in year 1991-2000 which was significantly different than all other classes. Fig. 1b shows different periods of tree growth rate cm/ 10 year of *Abies pindrow* from Bakht Banda near Chakesar area forest. In the first three classes the highest growth rate 3.3 cm/10 year was from the periods 1861-1870 and during 1881-1890 while the low growth rate was found in the class 1871-1880 which is 2.8 cm/10 years and significantly different from other classes. The growth rate decreased in the next stage of tree from 1891 up to 2010 which may be due to destruction of forest or anthropogenic disturbances, intraspecific competition and depletion of nutrients. The lowest growth rate 1.1 cm/10 years was found in the class 2001-2010, which was the slowest growth rate among the whole periods of the time. It was significantly different from all other classes. Fig. 1c described *Abies pindrow* tree growth rate on the basis of 10 years interval from Shalkho Forest. The growth rate in first six period’s from 1841 to 1900 showing better growth rate which was decreased gradually. The highest growth rate 4.3 cm/10 years was observed in class 1841-1850 while the lowest growth rate 2cm/ 10 years among these classes was found in 1891-1900 which is significantly different than previous class. The growth rate decreased in the next classes from 1901 up to 2010 which is almost similar among each other and significantly different than previous classes. The slowest growth rate 0.8 cm/10 years was observed from 1991-2000 which was the slowest growth rate of the whole periods and significantly different from the rest of the classes.

Fig. 1d shows *Cedrus deodara* sampled from Munz Bund Forest near Dherai area. Here periods ranges from 1881 to the year 2010, showing different growth rates cm/10 years. In these periods the highest growth rate 3.3 cm/year was observed in class 1881-1890, while the lowest growth rate 1.1 cm/ 10 years was found in class 1991-200 which is almost similar to class 2001-2010 but significantly different from previous classes. It indicated the disturbance factor of the forest in recent years. Fig. 1e reveals *Cedrus deodara* pure stand sampled from Chaat Nala Forest near Karora. The growth rate in the first three classes 1841 to 1870 was better which gradually decreased in the next classes. The highest growth rate 5.1 cm/10 years was found in class 1841-1850 which is the highest growth rate of these trees in the forests. The lowest growth rate 0.9 cm / 10 years was found in class 1981-1990, 1971-1980 and 1cm/10 years in 1931-1940 which was significantly different from previous classes.

Fig. 1f shows different growth rate of *Pinus wallichiana* from Nakhtaro Ghar Machaar area. The highest growth rate was observed in the class 1861-1870 which was 5.1 cm/10 years, while the growth rate decreased in the next classes. Next period composed of three classes, ranged from year 1871 to 1900; significant difference was found among them. In these periods the low growth rate was observed in class 1881-1890. Growth rate in the next class i.e. 1910 again decreased and significantly different from previous classes. Next classes from year 1911 to 2010 the growth rate almost similar which is significantly different compared previous classes. The lowest growth rate 1.1cm/10 years among all classes was found in class 1981-1990. Fig. 1g presenting different growth rates of *Pinus wallichiana* trees from 1921 to 2010 on the basis of 10 year intervals from Shangla Top area. The growth rates of these forests were almost similar. The highest growth rate 5.8 cm/10 years was observed in the class 1921-1930 while the lowest growth rate of 2.9 cm/year was found in the class 1981-1990 among all periods of the tree species. These classes are significantly different from each other. Fig. 1h is *Pinus wallichiana* pure forest from Yakh Tangay forests. In these classes the highest growth rate 6.5 cm/10 years was observed in class 1911-1920 which gradually decreased in next classes. The lowest growth rate 1.5 cm/10 years was found in class 1991-2000 which is significantly different from previous classes. All these classes are significantly different than each other.

Variation in growth rate with Dbh: Different dbh size classes' vs growth rates of different trees were presented from Fig. 2a to 2h. *Abies pindrow* and *Pinus wallichiana* were sampled from three areas while *Cedrus deodara* from two different sites.

Fig. 2a described different dbh size classes of *Abies pindrow* and their growth rates from seedling stage to mature tree. The graph shows better growth rate in early classes or seedling stages than that of mature tree stages. The overall highest growth rate was observed in class 2 (4 cm dbh) size classes which was 2.36 year/cm, while the lowest growth rate was obtained in class 10 (60 cm dbh) trees which is 4.16 year/cm. The growth rate in the first five (2cm to 10cm dbh) classes was almost similar and no significant difference was observed. The growth rate decreased from next class to onward which shows significant difference from previous classes.

Different growth rate classes of *Abies pindrow* on the basis of dbh and growth rates are shown in Fig. 2b. The growth rate was observed 3.83 years/cm in the first class (2cm dbh size class). The growth rate is increased in the next two classes i.e. 2(4cm dbh) and 3(6cm dbh), which was significantly different than previous classes. The growth rate is almost same in these two classes. In the next four classes, 4 to 7 (8cm to 30 cm dbh) the growth rate increased, and highest growth rate was observed in the class 5 (10cm dbh) which was 3.48 year/cm while the lowest growth rate was 3.55 years/cm in class 6 (20cm dbh). These growth rates in these classes were mostly similar, but significantly different than previous classes. Another two classes 8 and 9 (40cm and 50cm dbh) the growth rate again decreased, these classes were significantly different than previous classes. The growth rate in these classes is almost similar to the growth rates of class 2 and 3. In last two classes 10 and 11 (60 and 70cm dbh), the growth further decreased. These classes are significantly different from previous classes. Overall highest growth rate was observed in class 5 (10cm dbh) which was 3.48 year/cm, while the lowest growth rate was observed in class 11(70cm dbh) with growth of 4.05 year/cm.

Fig. 2c shows different classes of dbh and growth rates year/cm in *Abies pindrow.* First five classes of seedling stage (2cm to 10cm dbh) showing better growth rate and almost similar trends. The growth rate suddenly decreased from next class 20 cm dbh onwards. These classes showed significant difference as compared to previous classes and even among them. The lowest growth rate 4.07 was observed in class 10 while the highest growth rate was found in class 2 (4cm dbh) which was 1.9 year/cm.

The graph (Fig. 2d) of *Pinus wallichiana* showed better growth rate in the early classes of the tree which was decreased in the next classes. Among first five periods ranged 1,2,3,4 and 5 (2,4,6,8 and 10cm dbh) the highest mean growth rate was 1 year/cm which was observed in class 2 (4cm dbh) which is the highest growth rate year/cm of the tree. The growth rate decreased in the next classes which was significantly different than previous classes. The lowest growth rate 3.6 years/cm among all other classes was found in class 11 (70 cm dbh). These classes are significantly different from previous classes.

Fig. 2e indicated mean growth rate of *Pinus wallichiana* in different dbh classes. In class first (2 cm dbh) the growth rate was found as 1.5 years/cm. The growth rate slightly increased in the next four classes i.e. 2,3,4 and 5 respectively. The growth rate decreased in the next classes 6,7,8,9 and 10 these classes are significantly different than previous classes. The lowest growth rate was 2.3 years, found in class 10 which was significantly different than all other classes. The growth rate again increased in the next two classes 11 and 12 (70 and 80 cm dbh) which is 1.8 and 1.6 years/cm. Significant difference was found among these classes and the previous classes.

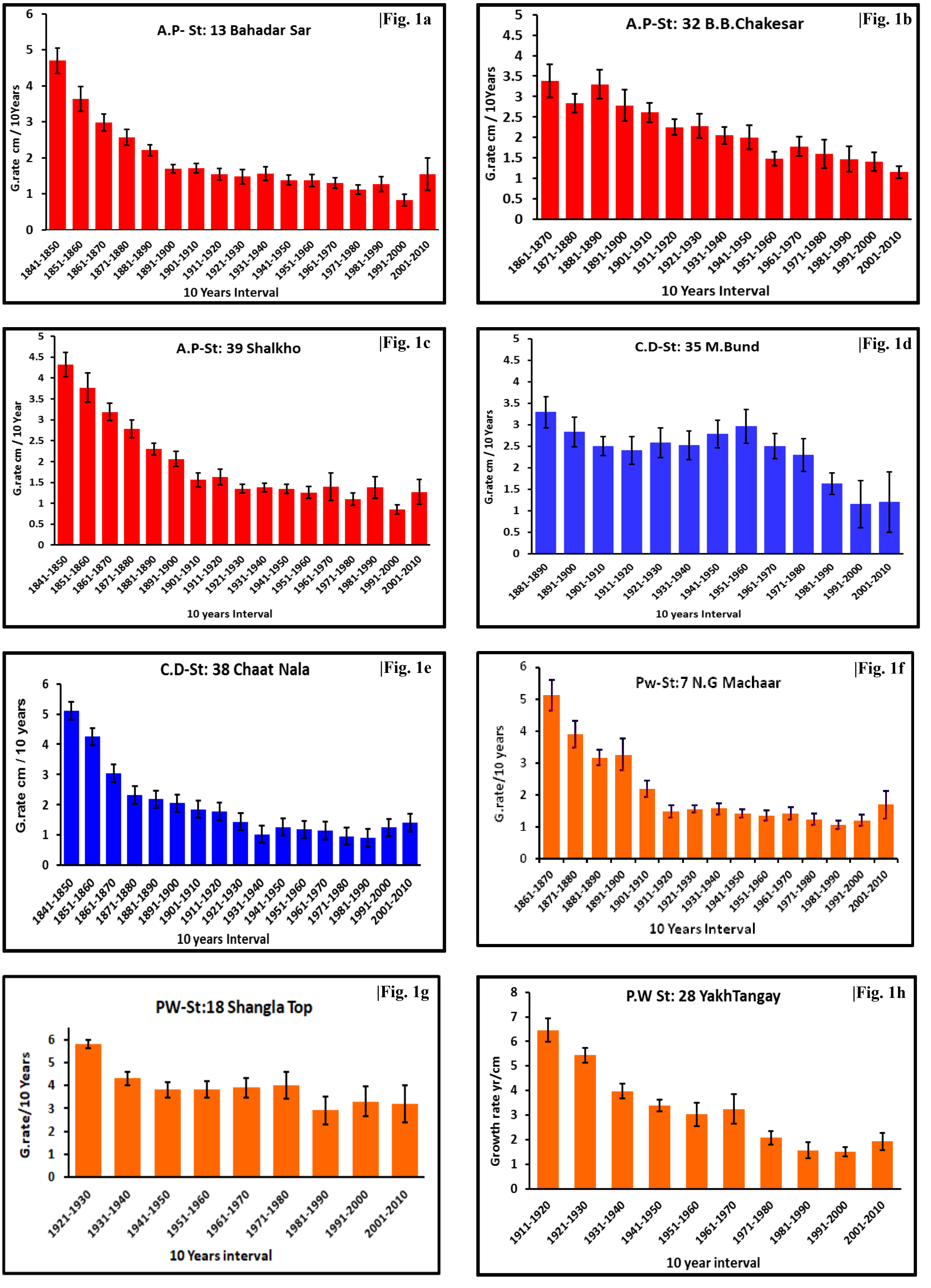

Fig. 1a to 1h showing growth rate variation in every 10 years interval for *Abies pindrow* (Ap), *Cedrus deodara* (Cd) and *Pinus wallichiana* (Pw) at various localities.

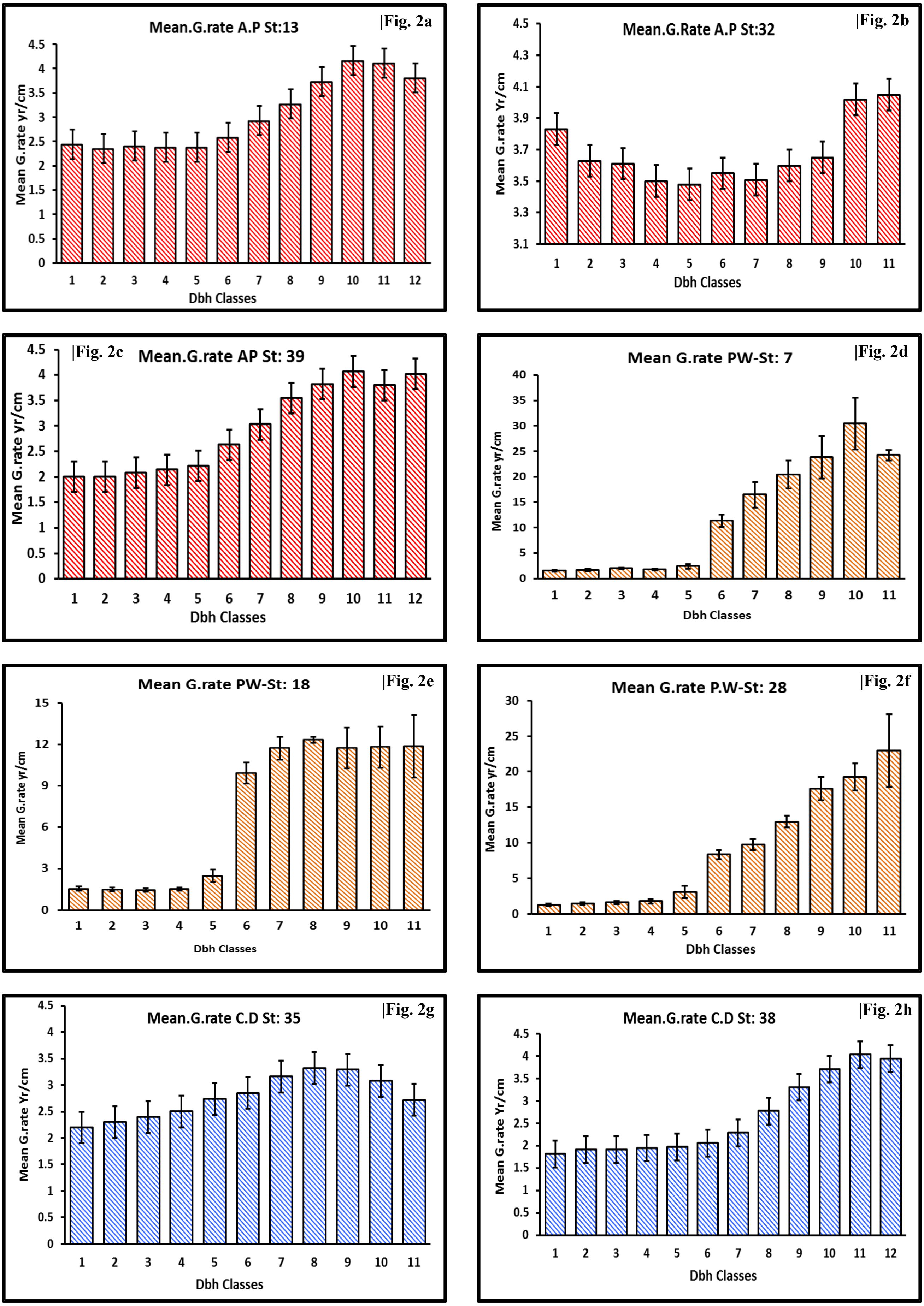

Fig. 2a to 2h presented variation between dbh and mean growth rates.

Fig. 2f presented different dbh classes of *Pinus wallichiana* based on mean growth rates. Overall, these classes shows better growth rate in early periods of the tree except few classes where the growth rate was decreased. The growth rate in the first five classes was almost similar and no significant difference was found among them. The highest growth rate was observed in the class 3 which was 1.4 years/cm. The growth rate decreased in the next classes which is significantly different than previous classes. The lowest growth 2.4 years/cm rate was observed in class 10.

Fig. 2g showed dbh and growth rates of *Cedrus deodara* in different classes. Early classes showed better growth rate which is gradually decreased in next classes. The highest growth rate was found in class 1(2cm dbh) which is 2.2 years/cm. The lowest growth rate 3.32 years/cm was observed in class 8 (40cm dbh). No significant difference was found among these classes. These classes showed better growth rate of the forest.

Fig. 2h postulated mean growth rates of *Cedrus deodara* on the basis of dbh classes. First five classes which were the seedling stage of the trees showing better growth rates. These classes showed almost similar growth rates. The highest growth rate was observed in class 1(2cm dbh) which is 1.8 year/cm. The growth rate decreased in the next classes from 7 to 12 which are significantly different than previous classes. The lowest growth rate among all classes which was 4 years/cm found in class 11.

Variation in age with Dbh: Dbh size classes vs mean age of three tree species, *Abies pindrow* and *Pinus wallichiana* from three locations while *Cedrus deodara* from two sites were shown from Fig. 3a to 3h.

In Fig. 3a age was increasing with increasing dbh size classes. In the seedling stage i.e. 2,4,6,8 and 10 the age differed slightly. The age increased in the tree stage with increasing dbh size classes from 20 cm to 80 cm dbh trees. The age was computed 25.9 years in (20 cm dbh) which is significantly different from previous classes. In the next classes from 30 cm to 80cm dbh size classes the mean ages were calculated as 43.9, 65.4, 93.1, 124, 144 and 152 years respectively which are significantly different from each other. The highest mean age was observed in the class of 80 cm dbh which is 152 years.

Fig. 3b described mean ages of *Abies pindrow* in various dbh size classes. The age observed in the first five classes which is the seedling stage of the tree (2,4,6,8 and 10cm) was 3.8, 7.2,10.8,14 and 17.4 years respectively. In the next classes of tree stage from 20 cm to onward the growth rate increased gradually as increasing dbh size classes. All these classes are significantly different than each other. The highest mean age was observed 141.6 years of 70cm dbh size classes and also significantly different than all other classes.

Fig. 3c showed different age and dbh size classes of *Abies pindrow*. First group consists of five classes, 2,4,6,8 and 10 cm dbh size classes. These classes contain mean ages of 2, 4, 6.2, 8.5 and 11.06 years mean ages respectively. Next class 20 cm dbh size class having 26.3 years age, the age increased in this class and it was significantly different from previous classes. In the next classes 30 cm to 80 cm dbh the age was gradually increased as increasing dbh size classes. As the age is increasing with increase in dbh classes the last class 90 cm dbh having 160 years age, which is the highest mean age among all other classes.

Fig. 3d showed different age classes of *Pinus wallichiana* on the basis of dbh size classes. Age increased with increase in dbh size classes. In the seedling stage (2 cm to 10 cm dbh) the lowest age was observed in class 2 cm dbh which was 1.1 year while the highest age 6.4 years was observed in 10 cm dbh. These classes are almost similar age classes. The growth rate increase in further classes of tree stages from 20 cm to 70cm dbh size classes. These classes were significantly different from each other.

Mean ages of *Pinus wallichiana* in different dbh size classes were shown in Fig. 3e. The age was almost similar in the seedling stage. The age increased in the next classes of tree with increase in dbh size classes. The highest age 68 years/cm was observed in class 60 cm dbh which was significantly different than all other classes. Age decreased in the next two classes 70 and 80 cm dbh and significantly different from other classes. It indicates the disturbance factor of the forest was environmental or human interference.

Fig. 3f showed different dbh size classes of *Pinus wallichiana* tree species with respect to age. First five classes 2 cm, 4cm, 6cm, 8cm and 10 cm dbh size classes contain 1.4, 3,4.2 5.7 and 7.2 years/cm mean ages respectively, there was no significant difference between these classes. The age increased in the next classes with increase in dbh size classes. The highest mean age 73 years was found in the (70 cm dbh) class, which was the highest mean age of the trees.

Different age of *Cedrus deodara* on the basis of dbh size classes were shown in Fig. 3g. The mean ages observed in the first five classes were almost similar, while it was gradually increased with increase in dbh size classes. The age was further increased in the next classes of tree stage which was significantly different than previous classes. The highest mean age 95.3 years / cm was observed in 70 cm dbh size class.

Fig. 3h depicted different dbh size classes of *Cedrus deodara* tree species showing variation in different size classes with respect to age. First five classes 2 cm, 4cm, 6cm, 8cm and 10cm dbh size classes contain 1.8, 3.8, 5.7, 7.8 and 9.8 years mean age respectively. There is no significant difference between these classes. Increase age with increase in dbh size classes of tree stage. All these classes are significantly different than each other. The highest mean age was observed in 80 cm dbh size class, which is 157 years old.

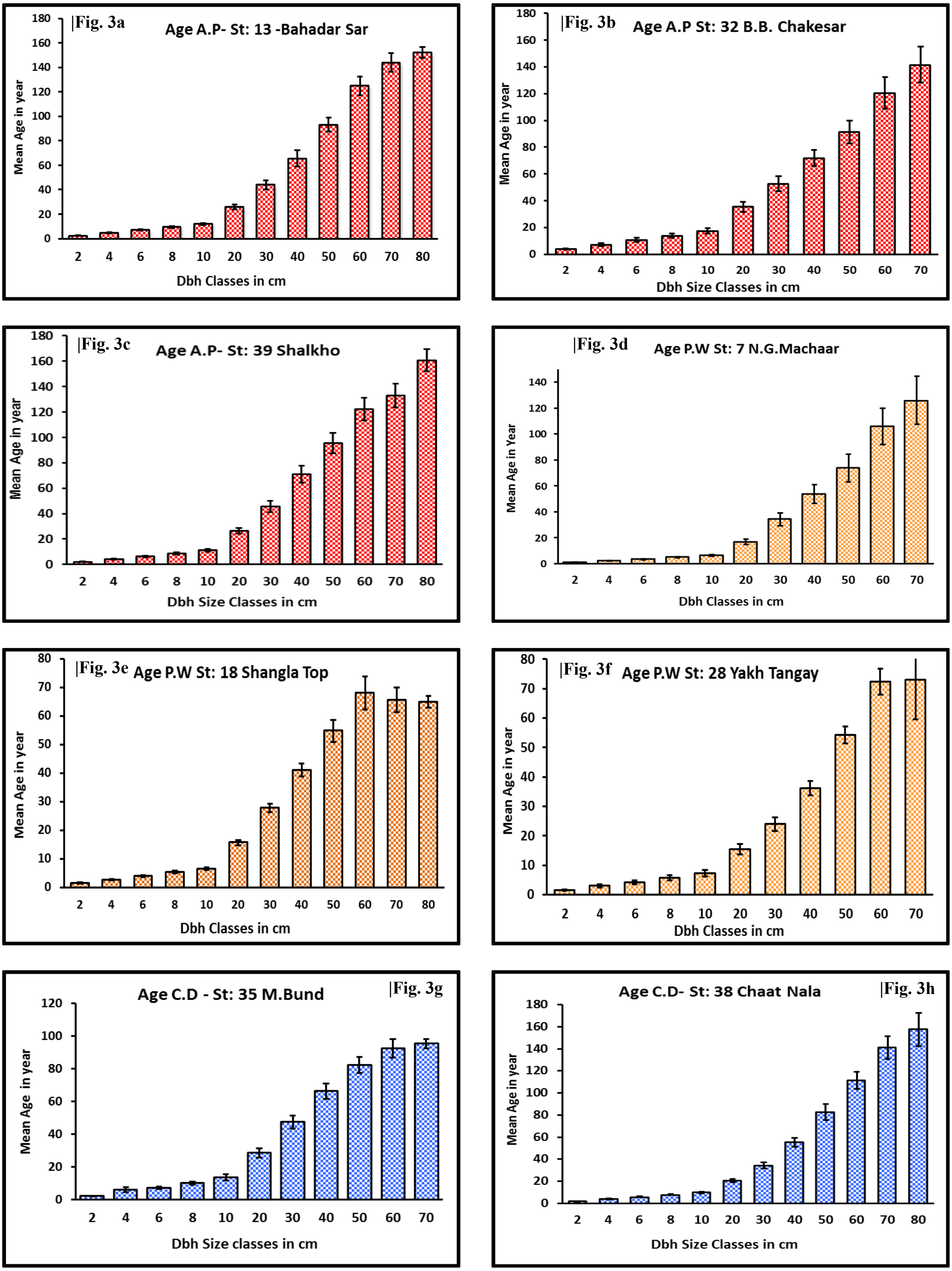

Fig. 3a to 3h shows the variation of dbh size classes vs. mean age (years / cm).

Key to abbreviations: P.W = *Pinus wallichiana*, A.P = *Abies pindrow*, C.D = *Cedrus deodara*, Dbh = diameter at breast height, G. rate = growth rate.

Discussion

Variation in growth rate with time: Growth rate and forest health depend on environmental characteristics of that particular area where it is confined. Anthropogenic disturbances also play a key controlling role which has direct effect on forest populations. In a same species variation of growth rate in different period of life shows the variation in one of the above or combination of above mentioned factor. Low growth rate show unsuitable environmental condition while fast growth indicates suitable condition around growing trees. Growth rate may vary even in a similar aged tree of a same species in a similar environmental condition (Ahmed 1984). Growth rate may vary due to the differences in internal physiology and genetics of individual trees.

Abies pindrow shows similar pattern of growth from two sites. It is indicated that growth rate in the past was slow which gradually increased in the recent years. Every 10 years period growth rate was different which may be significantly different or similar to the nearby age classes, but it is significantly higher in recent years to past. These forests have a long history of disturbances. In the past when disturbances was minimal due to thick forest, closed canopy and competition trees growth was slow, as the disturbances like legal/illegal cutting and grazing increased, competition among trees has reduced hence tree show higher growth. Another site of *Abies pindrow* show almost similar growth. This site also indicates some significant difference in growth rate in different periods with neighbor age classes. Different sites may face different intensity of disturbances.

Among all sites one location i.e. Chaat Naala having *Cedrus deodara* trees showed older age. If only common period is compared one site has a continuous and gradual increase in growth rate from past to recent years, while other sites have no pattern. Slow and fast growth in different times showed that this area is severely disturbed in different time period. Over all this species also showed slow growth in past while fast growth in recent years. In the light of prolong history of anthropogenic disturbances and the increased growth in recent classes, the only possible reason of variation of growth may be the disturbances. The forest history showed that the growth rate was significantly slow in the initial stage of the tree, but with passage of time the growth is continuously increased. It is indicated that these forests show high anthropogenic disturbances including grazing, forest fire, climatic effects, land sliding and also earth quakes occur in the area. Although *Abies pindrow* species were located on large area (Shalkho) in the form of thick forest, but due to rotten and damaged stem wood samples were not included. These evidences demonstrated the anthropogenic activities and local climatic effect on these forests as described by various investigators (Harper, 1977; Ahmed, 1984; Ahmed *et al.,* 1990a,b and 1991). *Cedrus deodara* the national tree of Pakistan is almost vanished from Shangla District, only in a few areas it was distributed with low density.

Many workers i.e. Ahmed (1988), Ahmed *et al*., (1991), Ahmed and Naqvi (2005), Ahmed & Sarangzai (1991,19992), Ahmed *et al.,* (2009, 2010), Khan *et al*.,(2008), Bokhari (2011), Bokhari *et al*., (2010, 2013), Zafar *et al*., (2010), Sarangzai & Ahmed (2011), Ahmed & Shaukat (2012), Khan *et al*., (2013), Siddiqui *et al*., (2013), Iqbal *et al.,* (2017) and recently Khan (2017) reported variation of growth rates in different periods of past in different pine species. Similar results were also reported from overseas. These growth rates were due to climatic variability of the past but in Pakistan beside these factors anthropogenic disturbances were also one of the main factors. Most of our wood samples obtained from *Abies pindrow, Pinus wallichiana* and *Cedrus deodara* which initiated their life around 1850 (during little ice-age) when mountain glaciers expended to their greatest extent. Amoroso *et al*., (2012) concluded that extremely slow growth during this period was due to pronounced cooling. However our results do not agree with their findings who reported slow growth in that period. In those years fast growth may be related with 18^{th} century disturbances, logging as reported by various workers (Esper *et al*., 2002; Devi *et al*., 2008). Logging presumably reduces intra and interspecific competition.

Variation in growth rates with Dbh: The growth rate shows variation in different dbh classes. In some classes the growth rate was observed high, which shows favorable growth conditions, while in some classes it is decreased. This situation is not an ideal situation for the growth of these conifers tree species. This should be due to the environmental conditions, manmade interference, like huge cutting of tree species, overgrazing and fire. The mean annual ring width observed between different species under different disturbances revealed that there was a significant difference in width of mean annual rings between these species. However, the mean annual ring widths of similar species under different disturbances did not differ significantly.

Abies pindrow shows better growth rate in the initial classes of seedling stage, while the growth rate was gradually decreased with increase in dbh size classes. Slow and fast growth rates of conifer trees were estimated and compared with earlier studies. *Abies pindrow* showed slowest growth rate which is similar to the results obtained by Ahmed & Sarangzai (1991). They stated that *Abies pindrow* is a slow growing tree of moist temperate areas. Ahmed *et al.,* (2009) also suggested that *Abies pindrow* is a slow growing tree which is related to its genetic characteristics.

The second species *Cedrus deodara* also shows different growth rate in different classes of dbh. *Cedrus deodara* showed fast growth rate in the early classes of tree, but the growth rate becomes slow in the next classes with increase in dbh. Siddiqui (2011) studied dbh and growth rates of dominant conifer trees from moist temperate areas of Himalayan and Hindukhush range of Pakistan. He estimated highest growth rate (1.4 years/cm) for *Cedrus deodara* while slowest growth rate (10.17 year/cm) was recorded from Patriata 1. Khan (2011) studied dbh and growth rate of some tree species from the forests of Chitral district. Wahab (2011) presented age and growth rates of tree species from District Dir. Akbar *et al.,* (2013) carried out extensive work on dendrochronology and some other aspects of Gilgit-Baltistan forests. According to Hussain (2013) growth rate decreased with the increase in dbh, which may be due to old age and natural disturbances. Ahmed *et al.,* (2009a) found highest overall growth rate of C*edrus deodara* (2.65 ± 0.19 year/cm) also found the same trend that small dbh trees show faster or better growth. According to them it decreases with increasing size of trees, may be due to the climate extremes.

Variation in age with different size classes: In this study the mean age in different dbh classes are explained. According to Daubenmire (1968) diameter is a good indicator of age and the past history of a particular stand is predictable. In general, the diameter of a tree is dependent on age and there is strong correlation between the two variables; with increasing age, the tree will also increase in diameter. According to Lieberman & Lieberman (1987) it is not possible to conclude that the largest tree in a population is the oldest tree. Trees of the same age could have huge difference in their diameter or trees with similar diameter could significantly differ in their age (Ahmed, 1984) and Worbes *et al*., 2003). The result from this study clearly showed that two similar sized trees may strongly differ in their age even when growing at the same site.

Failure of regeneration is a non-ideal situation of the forest growth. The regeneration of these forests is poor and are in critical situation. Some gaps were also noticed in the small and middle size classes. This may be due to illegal cutting, overgrazing and anthropogenic disturbances. In the study area, flat distribution is reported from some stands. However, fewer individuals in small size class indicated poor recruitments in the area. Wahab *et al*., (2008) reported this type of distribution pattern in *Picea smithiana* forest from Afghanistan. Ahmed *et al*., (2010b) also found the similar situation in *Cedrus deodara* from the Hindu Kush and Himalayan regions of Pakistan. Ahmed *et al*., (1990a, 1990b) and Ahmed *et al*., (1991) calculated age in differenet sizes of Juniper and Chilghoza pine trees from Balochistan. Ahmed & Sarangzai (1991, 1992) also concluded ages of different species from 19 different locations of moist and dry temperate Himalayan range of Pakistan.

According to Daniels (2003) stand age structure of dead and alive trees provides composition and past condition of a forest. Some other researchers presented structure of six Gymnospermic species from 41 different mature forests of Pakistan (Ahmed & Naqvi, 2005; Khan *et al*., 2008). Ahmed *et al.,* (2009b) presented age and dbh structure of various Himalayan pine tree species of Pakistan. Wahab *et al*., (2008) measured age in different dbh size classes of Dangam District of Afghanistan. Hussain (2013) evaluated ages of *Picea smithiana* from Stak valley, Central Karakorum National Park. Bokhari *et al*., (2013) investigated ages of pine trees from Azad Jammu and Kashmir, Pakistan. Siddiqui *et al.,* (2013) estimated different ages of dominant conifer from moist temperate areas of Himalayan and Hindukush range of Pakistan. Seedling age of *Pinus wallichiana* from Ganji valley District Skardu Gilgit-Baltistan, Pakistan was carried out by Akbar *et al*., (2015). They noticed great variation in age structure in different time periods or at different size classes. Growth rate significantly decreased from past to present periods.

It may be anticipated that due to illegal cutting of trees, reduced competition among trees, would have resulted. It is suggested that due to extreme disturbances, present status and situation, present different rates of recruitments is not ideal for the future of the forest, so each forest should be treated on individual basis and could be managed after full protection of seedlings. Law and order situation should be improved and take some special action against timber mafia. Awareness and further research is needed for the management and also to explore the regeneration potential of these valuable forests.

Conclusion

On the basis of the above results and discussion we have concluded that growth rate with time on the basis of every 10 years intervals was fast in the period 1841-1850, while it was found decreased in the recent years, it may be due to competition among and within species, disturbance and depletion of nutrients. Global warming may also be a factor. Variation in age and growth rate of different tree species of the forests in different dbh size classes indicating that diameter is not a good indicator of age or growth rate in the natural forests.

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