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Estimation of Age and Growth Rate of *Pinus gerardiana* Forest Trees, Wildly Grown in Shinghar Zhob Area Balochistan-Pakistan by Using Dendro-chronological Approach

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Abstract

The aim of study was to determine the age and growth rate of *Pinus gererdiana* trees which are wildly grown in Shinghar Zhob Area of Balochistan-Pakistan through different Dendro-chronological Approach. Wood samples in the form of cross-sections and cores were obtained from 40 living *Pinus gerardiana* trees to determine their age, growth rates and ring width characteristics from all sites of the study area. Results showed that the age and growth rates varied greatly from tree to tree and site to site and even in the same sized trees. Rings of this species were annual nature with distinct and clear ring boundaries. Cross dating was not achieved only in young trees in while old trees were mostly rotten in the centre and showed poor matching. The presence of false rings, missing rings, wedge out, lack of ring pattern consistency and lobate growth around the tree was observed in *Pinus gerardiana*. The result indicated that at least 4 cores, a suitable site-selection and sample of tree rings in the form of trunks section may improve ring with characteristics and can successfully be used in dendrochronological studies. It is shown that largest tree, in terms of diameter, is not necessarily the oldest. Highest growth rate in *Pinus gerardiana* in years/cm and cm/year was recorded at locations Zarjangal and Branga while the lowest was found from the Marmanda Ghar and three other sites also.

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Introduction

Dendrochronology is a rapidly growing, multidimensional, multidisciplinary and applied science in developed world. Dendrochronological investigations are frequently used in silviculture, forestry, ecology, structure and population dynamics studies. Growth is an important factor to understand the management of forest and forest cover (Worrell and Malcolm, 1990). The maximum age of plant species can be strongly affected by the growth stipulation (Castagneri *et al.,* 2013). The age structure of trees also plays a vital role on population dynamics. The tree age distribution would be helpful for the management of forest and increasing of recruitments (Agren and Zackrisson, 1990). Additionally, fast growth rates and large diameter size of plant species seem clearly to benefit the vigor of trees (Lanner, 2002). Age and growth rates are widely used in silviculture, ecology and forestry. According to Lafon and Speer, (2002) the science of dendrochronology has enhanced our understanding of environmental change, succession and forest stand dynamics. Tree-ring studies in old-growth forests are valuable sources of information regarding the natural history of forest species (Rentch *et al.,* 2003a, b), as well as the natural disturbance dynamics and development patterns for forest types in a region. Currie, (1991) advocated that the forest structure and composition are strongly correlated with environmental factors such as climate and topography. Fricker *et al.,* (2006) demonstrated that age structure of a stand provides an understanding of important ecological processes taking place during stand development. The age of trees have been estimated by historical records, estimation from tree size, ring counting at breast height and ground level, pith node counting, and dendrochronological cross dating (Cook and Kairiukstis, 2010). Nonetheless, no attempt is made to correlate the growth rate of conifer species with the environmental factors. One of the central principles is "Cross dating" which allows missing or false rings to be identified by comparison of ring width sequences between trees. Recent applications of dendrochronological techniques in the world is used to know the reconstruction of the past climate and events like fires, flooding, droughts, river-flow changes, landslides and volcanic eruption can be traced in tree-ring sequences (Schweingruber,1998). Dendrochronology is still a challenge in dry temperate regions, because tree rings are often irregular, narrow, may be missing or exhibit unclear boundaries and growth (Wils and Eshetu, 2007).Dendrochronological studies were initiated around 1986 in Pakistan, however systematic studies started from 2005. Handful results are published using Dendrochronological techniques in the country during this period. The tree-ring research in Pakistan is in initial stage of development and generally dealt with gymnospermic species.

The main objective of this investigation was to estimate age, growth rates and ring width characteristics by using the dendrochronological techniques of Chilghoza pine trees of Shinghar area of Baluchistan, Pakistan, with extrapolation for missing, false rings and the time required for tree (*Pinus gerardiana*)to reach the height at which wood samples (cores) were taken for estimation.

Materials and methods

Field surveys were conducted during 2017-2018 in different valleys of the Zhob district, Balochistan (Fig. 1). Although many forest areas were fragmented, and look like over mature stands but during this study only healthy, sound and trees of different size with no sign of injury in each stands were selected over an area of approximately 2 hectares, especially located on steep slopes and crest ridges. Wood samples in the form of cores were obtained at the level of breast height from various locations of Zhob *Pinus gerardiana* forest. Elevations and aspect of sampling sites were recorded using GPS. Choosing a suitable borer increment cores are sampled with increment borers include Haglop (Sweden). Several cores were obtained from selective stands in the study area. Dendrochronological methods of Fritts, (1976) was followed for the determination of ages, growth, and ring width characteristics. Sample collection and preparation were carried out according to the method out lined by Stocks and Smiley, (1968) and Ahmad, (1984). Wood samples (cores) were taken from those individual trees which were free from severe competition and situated on dry ground. The diameter at breast height (Dbh) and the height of the cores were measured. Every sampled tree and core was numbered.

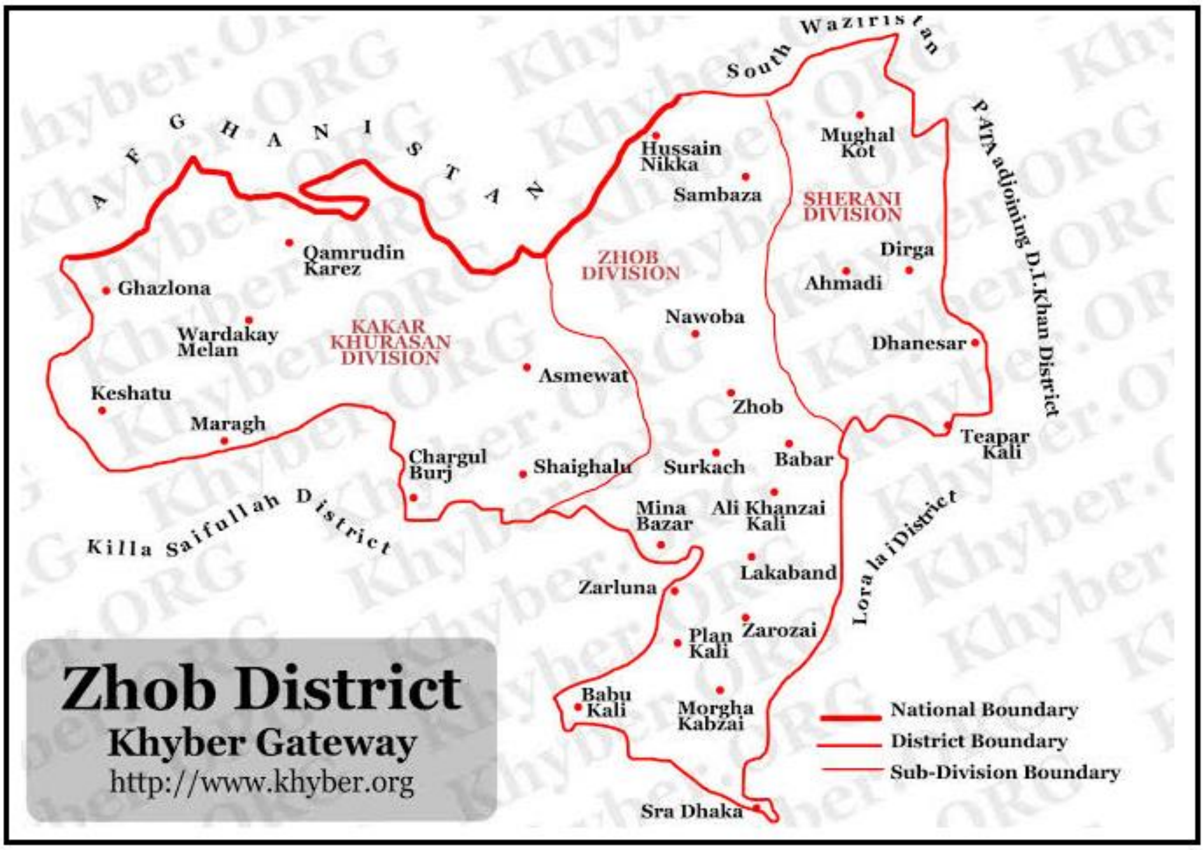

Fig. 1. Googol Map of district Zhob (study area) Balochistan-Pakistan.

The cores were kept in drinking straws to prevent possible damage and were air dried. Later, the cores were glued grooved mount so that tracheids were in a vertical position and were allowed to dry. These cores were sanded with a sanding machine with progressively finer grades of sand papers until a suitable polished surface was achieved. Many cores do not pass through the center or pith. In these cores reliability, missing radius and its years were calculated according to the method described by Ogden, (1980) and Ahmad, (1984). The missing radius were calculated from the growth rate of inner most 20 rings and added to the total age of the core. In this case the reliability of the core was also calculated by dividing the core length by the crude radius and expressing it as a percentage. This measure gives an idea how near the end of the core is to the presumed tree center and hence how reliable the age estimate. An attempt was made to establish cross-dating (in core) visually under the variable power binocular microscope. The radial uniformity of the trees and the ring width pattern of the site, was checked by cross-matching the cores from the same tree and with different trees. During this process missing rings and falls rings were identified in their correct sequence and each ring was properly dated in the year of its formations.

Results and discussion

Location and details of study area are given in Table 1. In every *Pinus gerardiana* forests an attempt was made to describe the age, growth rates and ring-with characteristics of the stand studied. Age of the largest tree, diameter of the oldest tree and overall growth rates of tree from particular site is shown in Table 2. The oldest 505 *year Pinus gerardiana* with 102 cm Dbh was recorded from Matalan near the Kohe-Sulemian mountain of District Sherani. A 52 Dbh tree of *Pinus gerardiana* was estimated 190 years old while from the same place another tree have 387 rings with 96 cm Dbh. Similarly largest tree 146 cm Dbh of another *Pinus gerardiana*tree with years196 was recorded from Mitiltan, while oldest tree 436 years with smaller size of 122 cm Dbh was recorded from the same valley.

Table 1. Summary of ecological sites and stands in Shinghar area Pinus gerardiana forest.

Site name	Latitude (N)	Longitude (E)	Elevation (M)	Aspect	Slope (o)	Canopy
Zahir Pangi	31° 35'	69° 36'	1937	S.E	30	Open
Khorjan Payal	31° 35'	69° 44'	2618	W.S	36	Open
Sarghondi	31° 35'	69° 43'	2623	E	36	Open
Sarghozi Nari	31° 35'	69° 44'	2639	E	36	Open
Branga	31° 35'	69° 43'	2414	N.E	33	Open
ShanaPayala	31° 34'	69° 43'	2490	S.E	33	Open
Gadki	31° 35'	69° 44	2563	E	34	Open
Shoro Koshti	31° 35'	69° 44'	2634	N.E	35	Open
Pati Wabti	31° 35'	69°44'	2625	N.E	35	Open
Daberi	31° 35'	69°44'	2631	W.N	35	Open
Loinashpa	31° 35'	69° 44'	2562	N	34	Open
Marmanda Ghar	31° 36'	69° 43'	2755	N	37	Open
Zarona	31° 36'	69° 43'	2816	W	39	Open
Palan Khan	31° 36'	69° 43'	2612	W.S	35	Open
Sur Kumar	31° 36'	69° 43'	2627	S	35	Open
Newshinghar	31° 32'	70° 00'	2200	W.S	35	Open
Takht-e-Suleiman	31° 32'	70° 00'	2970	W.S	36	Open
Matiltan	33° 35'	72° 40'	2350	W.E	35	Open

Table 2. Estimate age and growth rates of Pinus gerardiana in various Locations and age of largest tree, Dbh of oldest tree and overall growth rates.

Sampling sites	Ave. DBH (cm)	Ave. Age in year	Ave. Oldest tree age in year	Ave. DBH of Oldest tree (cm)	Growth rate	
					Year/cm	cm/Year
Zahir Pangi	103.0 ±4.2	178 ±13.8	310.5±105.4	178.5±15.6	13.2 ±2.2	0.07±0.01
Sarghozi Nari	122.5 ±38.7	235±38.6	343.3±110.5	113.8±29.9	15.0 ±2.5	0.19 ±0.24
Branga	122.5 ±38.6	235 ±28.6	343.3±110.5	113.8±29.9	15.0 ±2.5	0.19 ±0.24
Shana Payala	130.0 ±0.00	218 ±82.8	310.0 ±17.0	114.0±15.7	13.8 ±2.3	0.07 ±0.01
Gadki	100.0 ±0.00	152 ±0.00	155 ±0.00	88.0 ±0.00	12.3 ±0.0	0.08 ±0.00
ShoroKoshti	179.0 ±1.41	203 ±143	405.5±136.5	111 ±63.6	14.9 ±4.5	0.06 ±0.02
Pati Wabti	193.3 ±71.0	260 ±45.1	450 ± 32.9	119.7±21.2	11.2 ±1.4	0.05 ±0.00
Daberi	214.7 ±42.7	120 ±41.7	92.57 ±48.2	25.33 ±6.4	13.5 ±4.8	0.07 ±0.02
Loinashpa	189.0 ±1.41	151±16.26	232.5 ±102	28.25 ±3.2	15.2 ±2.5	0.06 ±0.01
Zarjangal	187 ±4.24	196 ±50.9	300.5 ±0.70	31.5 ±3.5	17.9 ±9.3	0.06 ±0.02
Marmanda Ghar	150.1 ±26.7	110 ±32.5	75.48 ±40.3	14.48 ±4.2	7.7 ±1.0	0.37 ±0.44
Zarona	129 ±41.4	135 ±27.5	356.3 ±92.2	119 ±29.0	14.5 ±2.6	0.05 ±0.20
Palan khan	100 ±0.00	142 ±0.00	249.0 ±0.00	154 ±0.00	13.8 ±0.0	0.07 ±0.07
Surkumar	110 ±0.00	264 ±48.1	313.5 ±104	109 ±18.4	17.4 ±6.7	0.05 ±0.02
Newshinghar	52.15 ±4.4	234 ±76.4	256.0 ±14.2	145.5 ±4.9	12.0 ±2.6	0.08 ±0.00
Takht-e-sulieman	71.2 ±9.0	422 ±16.3	381.5 ±57.3	110 ±16.9	13.0 ±3.0	0.06 ±0.00
Matiltan	67.7 ±3.3	255 ±170	292 ±147.6	79.0 ±18.8	14.5 ±2.9	0.06 ± 0.01

A largest tree 156 cm Dbh of *Pinus gerardiana* tree with 309 years was recorded from Pati wabti oldest tree 505 years with smaller size 102 cm Dbh was recorded from the same location of study area. It indicate that age are greatly varied from tree to tree, site to site and even tow closely situated same sized of the same species. Like age, rate of the growth in *Pinus gerardiana* forest also varies greatly among the same sized trees even in the same area. Results in Figs 2 and 3 showed growth rates in year/cm and cm/year at various location in *Pinus gerardiana*.

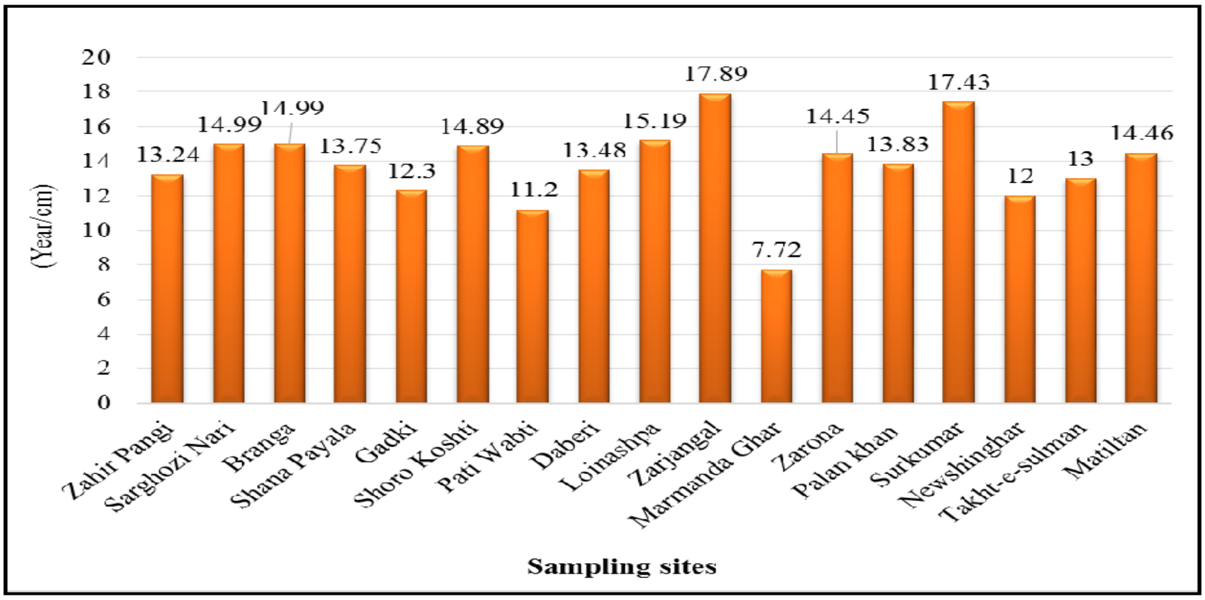

Fig. 2. Growth Rate (Year/cm) of *Pinus gerardiana* in various study sites.

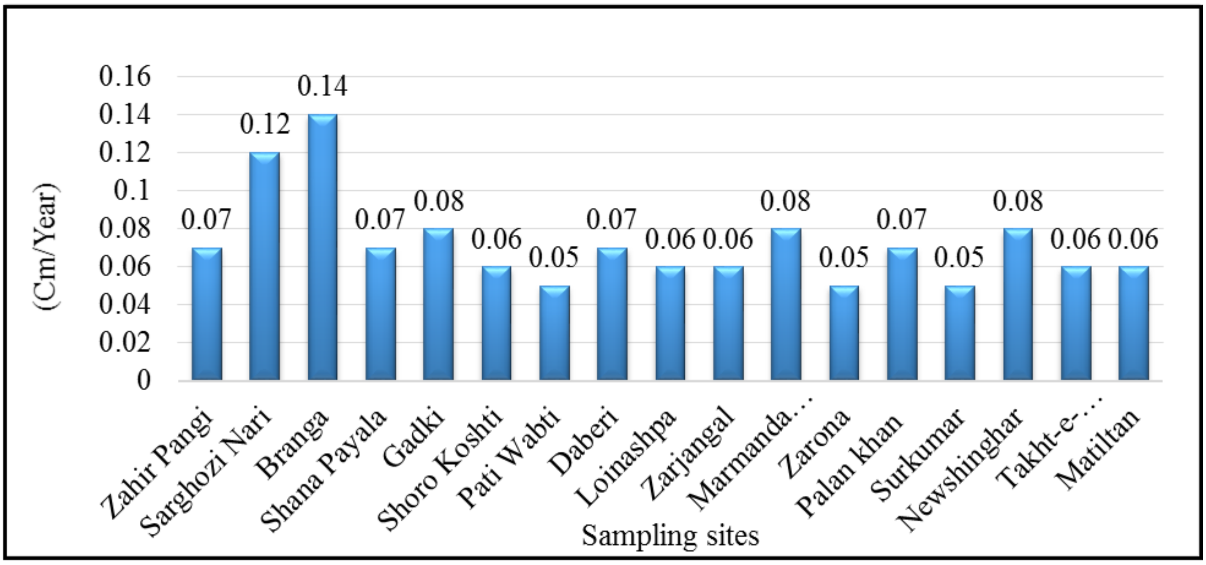

Fig. 3. Growth Rate (cm/year) of *Pinus gerardiana* in various study sites.

The growth rate of *Pinus gerardiana* at different location in year/cm and cm/year were recorded in the ranged between 7.72 – 17.89 and 0.05 – 0.14 respectively. The maximum growth rate in year/cm and cm/year was found at locations Zarjangal and Branga while the lowest was noted at the locations of Marmanda Ghar and Pati Wabeti, Zarona and Surkumar respectively. Only a few age/diameter estimates, using modern dendrochronological technique, have been published in Pakistan Ahmed (1988) presented age of some planted tree species of Quetta and found significant relation between diameter and age. Ahmed *et al.,* (1990) calculated age of 14 to 17 years for 2 to 3 cm Dbh *J. excelsa* saplings. Ahmad *et al.,* (1990) estimate the average age of *J. excelsa* trees (from 20 to 30 Dbh) was 160 years. A *Pinus gerardiana* tree of 66.5 cm Dbh had 600 rings, while another tree of 124 cm Dbh was only 361 year old (Ahmed *et al.,* 1991). Dendrochronological approach was also used to estimate age and growth rate of various species from Himalayan range of Pakistan by Ahmad and Sarangzai, (1991). Ahmed *et al.,* (2009) presented age and growth rate data from 39 locations from various gymnosperm trees.

A tree of *Picea smithiana* with 140 cm Dbh was 281 years old while *Cedrus deodara* with 180 cm dbh was 533 years old.

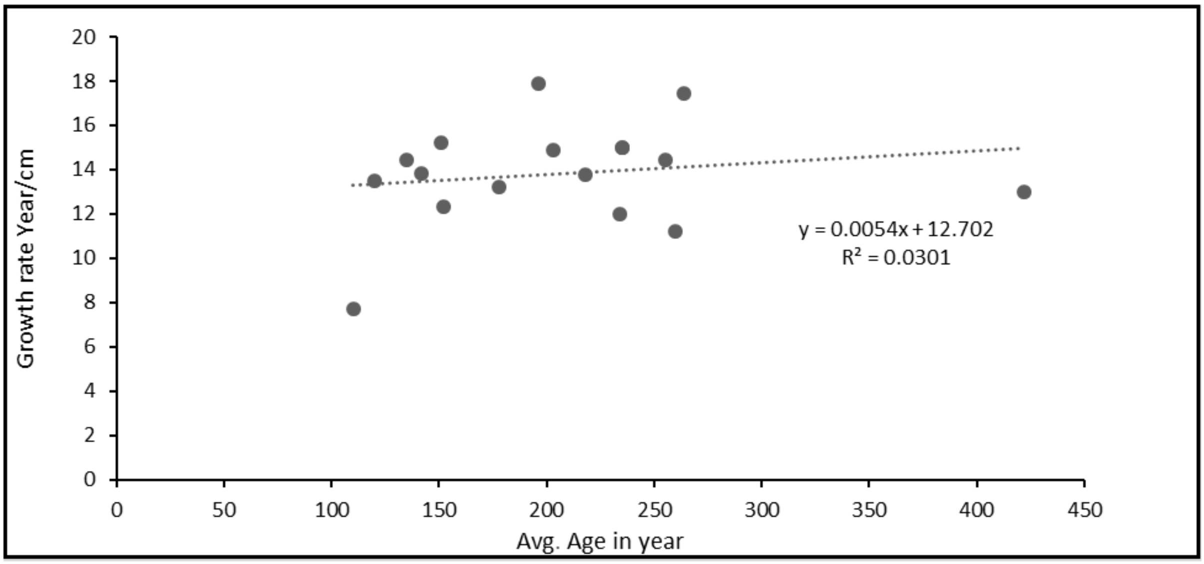

Fig. 4. Average age VS Growth rate regression of *Pinus gerardiana*.

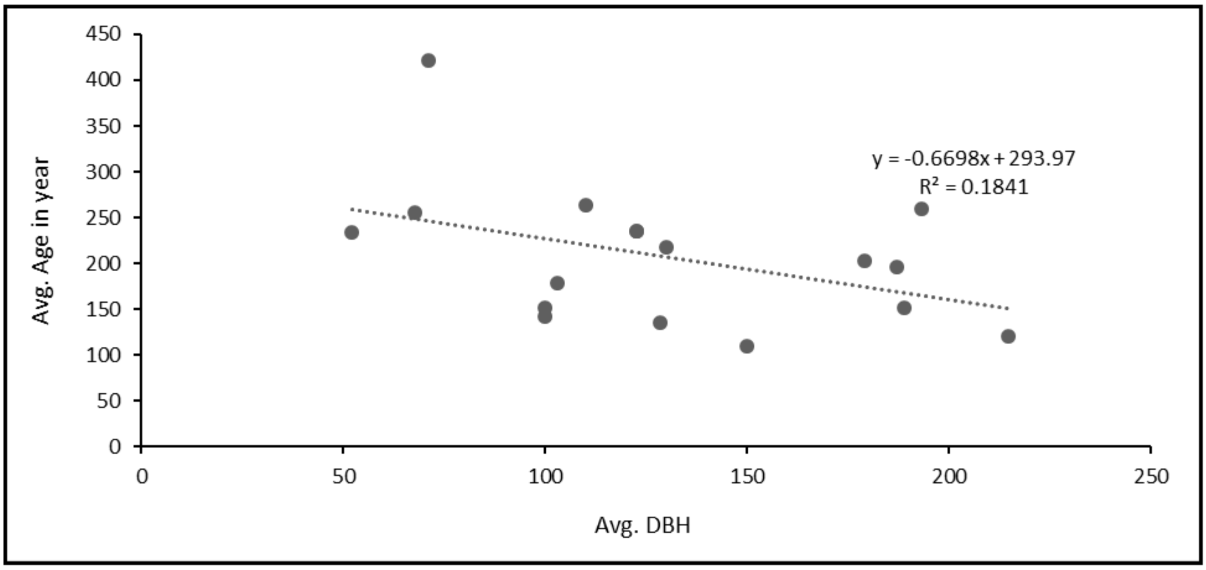

Fig. 5. DBH VS Average age regression of *Pinus gerardiana*.

The growth rate is also not predictable from the diameter in general, growth rate is the product of the various factors (climatic and non-climatic, genetic competition, etc) and detailed investigations by which useful predictions and conclusions can be made, need to be undertaken. Through previous data on the age and growth rate of dry temperate species scanty results are comparable in most cases. It is suggested that largest tree is not necessarily the oldest tree of the population same is true for the oldest tree. Most of the larger trees were found rotten in centre, swollen and badly damaged near the base, probably as a result of human disturbances. False rings were rare while many missing rings were recorded in the slow growing trees. Ring of this species were annual in nature with distinct ring boundaries, cores indicating lack of ring clarity on the outer margins. In the inner part of the core large amount of resin and other dark materials obscure ring development. Cross-dating was possible in young trees while larger trees showed poor cross-dationg. Generally a narrow ring patter was observed in most of the individuals. The results indicate that average age (year) is very weakly but positively correlated to the growth rate (year/cm) i.e. with the increase in the age of *Pinus* there is a minute increase in the growth rate (year/cm), however, Dbh (cm) and Average age (year) are negatively correlated, claiming that with the increase in the age of the plant the Dbh may decrease or remain unaffected (Figs. 4 and 5).

Conclusion

It has been concluded that the largest tree, in terms of diameter, is not necessarily the oldest. Age and growth rates diverse importantly from tree species to species and location to location and even in the similar sized trees. Rings of this species were annual nature with distinct and clear ring boundaries. Cross dating was not achieved only in young trees in while old trees were mostly rotten in the centre and showed poor matching.

The presence of false rings, missing rings, wedge out, lack of ring pattern consistency and lobate growth around the tree was observed in *Pinus gerardiana*. Highest growth rate in *Pinus gerardiana* in years/cm and cm/year was recorded at locations Zarjangal and Branga while the lowest was found from the Marmanda Ghar.

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