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Impact of climatic variables on the growth of *Bauhinia variegata* growing in the Mid-Hill zone of Himanchal Pradesh

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Abstract
The study exclusively dealt with how climate change is affecting growth rate of *Bauhinia variegata* tree species of mid-Himalayan region. The whole investigation was carried out in the campus of Dr YS Parmar University of Horiculture and Forestry, Nauni. The growth rings were analyzed for desired tree species. The variation in climate parameters (temperature and rainfall) were also studied and analyzed with the results to see their impact on growth. The investigation revealed that the climate change has a significant effect on the growth behavior of the species. Temperature was found to have more effect on growth rate of different tree species than rainfall.. Among temperature variables, rainy season and spring season temperature mostly affect growth rate of species. Over all the species was found to be sensitive to the climate condition of that particular area. The growth rate was affected by different seasonal temperature and rainfall.

Keywords: Climate change, temperature, rainfall, growth rate

Introduction

Climate change is widely recognized as a significant threat to biodiversity and ecosystem services. The direct and indirect effects of increased temperature, changing rainfall patterns and rising sea levels are expected to significantly increase extinction rates for a wide range of taxa, although the vulnerability of individual species will vary depending up on the level of exposure to climate change, their sensitivity to that change and their ability to adapt to that change. Identifying exactly which species, or groups of species, are most vulnerable to climate change represents an important first step towards developing climate adaptation plans for biodiversity and for the people who depend upon it. Researchers across disciplines have observed shifting phenology at multiple scales, including earlier spring flowering in individual plants and an earlier spring green-up' of the land surface revealed in satellite images. The climate triggered modifications could adversely affect wood properties and wood quality (Olivar *et al*, 2015) [8]. Over the last century, the global temperature has increased as a result of increasing anthropogenic carbon emission into the atmosphere. This change in climatic condition may lead to change in forest structure and composition as well as potential change in wood production and carbon sequestration (Kientz and Moran, 2017) [6]. Climate change may also lead to changes in critical day length for plants (Van Dijk and Hautekeete, 2007) [10] or changes in geographic distribution (Walther *et al*., 2002). Annual ring growths are dependent upon the environmental factors of a particular area (Luong *et al*, 2013) [7]. Various studies have been carried out to know the impact of climatic factors on tree growth indices and it has been revealed that the tree growth indices are positively correlated to temperature and precipitation of a particular site (Dang and Lieffers 1989) [1]. Tree ring widths are strongly related to the growing season temperature and precipitation (Gutierrez, 1989) [4].

Bauhinia variegata, commonly known as Kachnar, is a multipurpose tree species of Fabaceae family. Understanding the growth dynamics of a species in plantations is crucial for forest management (Die *et al*, 2015) [2]. Hence a study was made to observe how the species is coping up with the changing climatic conditions of that particular area. The main purpose of the present investigation was to study how the variability in temperature and rainfall of different season has affected the growth of B. variegata grown in the mid hill zone of Himachal Pradesh.

Materials and Methods

The experimental site falls in the mid-hill zone of Himachal Pradesh at an elevation of 1250m above mean sea level.

There is considerable variation in the temperature. May and June are the hottest months with temperature varying between 29-31ºC whereas December and January are coldest months recording temperature as low as 2ºC. The area receives an average annual rainfall of 1150 mm, most of which is received in the months of July and August.

For the species 3 representative discs were selected from the tree at DBH point. Stems or replications (R1, R2 and R3) were studied and in each stem 4 lines (n1, n2, n3 and n4) were marked in perpendicular directions. Cross dating was done, the center of pith was taken as starting point for each replication (n1, n2, n3 and n4). The distance of each annual ring from center was measured which gives the MAI at each age and the distance between two successive rings are to be measured for calculating CAI. From the recorded data of CAI the regression equations were prepared between diameter, basal area and volume against age. The regression line having highest value of regression coefficient (R2) was selected as best fitted equation. Detrended analysis was carried out to nullify the age effect. Prediction equations were developed by comparing the detrended CAI with average temperature, total rainfall, growing season Temperature and rainfall of each species and Seasonal temperature and rainfall (Summer, Rainy Winter and Spring). Correlation and regression analysis was carried out between the detrended CAI and all the climatic variables. Diameter and diameter increment at each age was calculated from the radius of the rings. Basal area and basal area increment at each age was calculated by using the following formula (BA= πr^2). Volume of the species was calculated by using the volume equations specified for that tree i.e. V/D2 = 0.007602/ D2 - 0.033037/D +1.838567 + 4.483454D3 (FSI, 2009).

Results and Discussion

In the present investigation tree-ring chronologies were constructed and the dendroclimatic signals over the last century were studied. 12 chronologies developed from mature trees of B. variegata. Growing under similar climatic condition. All specimens showed very clear growth rings and cross-dating between radii of a tree was successful for all the trees. The growth behaviour such as diameter increment, basal area increment and volume increment (CAI and MAI) was calculated and described in tables (Table-1). CAI and MAI of the species were plotted in graphs (Figure 1) against age. After that response of chronology to several climatic factors was examined.

Statistical analysis: The correlation of all the climatic variables with detrended CAI was calculated.(Table- 2) The spring season temperature was found to have the best correlation (Correlation coefficient=0.57) with the detrended CAI of B. variegata. Variability in CAI of the species in relation to spring temperature and average temperature variation during different years have been depicted in graphs (Figure2 and 3). Linear regression analysis was also done between the detrended CAI of each species and the climatic variables where CAI was taken as dependent variable and all other climatic variables were independent. The regression value (R2) was found to be 0.998 which means that there is 99.8% effect of climatic variables up on CAI. The species was found to have significant relation with average temperature, growing season rainfall and spring season temperature at 10% level of significance which dignifies that growth of the species is mostly affected by these 3 climatic parameters (Table-3). The findings of our study revealed that rainy season and spring season temperature were positively correlated with growth rate of B. variegata whereas the summer season temperature did not show significant relationship with the species. This result is in agreement with the findings of Nijland *et al*. (2011) who observed a strong positive relation of stem growth with May-June precipitation. The summer season rainfall had negative correlation with the growth rate of the species. This result goes in accord with Dang and Lieffers (1989) [1] who also reported that summer precipitation values had a negative impact on growth of Picea mariana in Alberta. In the present work of research decline in growth rate was noticed, which may be the outcome of increasing minimum temperature rate and declining or constant trend of rainfall over past decades. Rainfall during these years may be insufficient to ameliorate the negative effect of increasing temperature. Jump *et al*. (2006) [5] also suggested that the observed decline in growth of Fagus sylvatica in the Montseny mountains of Catalonia (northeast Spain) was result of warming temperature and constant precipitation. The present course of work left us with the conclusion that annual tree-ring growth is closely related to climatic variability i.e. variation in temperature and rainfall. This result goes with those of Trout *et al*., 2006 where successful cross-dating and correlation between tree ring chronology and climate indicated that annual ring formation in B. spiciformis trees were sensitive to climate change.

Table 1: Growth behaviour of *B. variegata* in mid-hill zone of Himachal Pradesh

Age	Radius(cm)	Diameter (cm)	Diameter increment (cm)	BA (cm^2)	BA increment (cm^2)	Volume (cm^3)	CAI (cm^3)	MAI (cm^3)
2001	0.30	0.60	0.60	0.28	0.28	1.63	1.63	1.63
2002	0.57	1.13	0.53	1.01	0.73	8.90	7.27	4.45
2003	0.68	1.35	0.22	1.43	0.42	14.40	5.50	4.80
2004	0.98	1.95	0.60	2.98	1.55	40.29	25.89	10.07
2005	1.25	2.50	0.55	4.91	1.92	81.66	41.36	16.33
2006	1.64	3.28	0.78	8.46	3.56	178.74	97.08	29.79
2007	1.93	3.87	0.58	11.74	3.27	287.01	108.27	41.00
2008	2.49	4.98	1.12	19.49	7.76	601.09	314.08	75.14
2009	2.93	5.85	0.87	26.86	7.37	961.36	360.26	106.82
2010	3.30	6.60	0.75	34.19	7.33	1370.16	408.80	137.02
2011	3.68	7.35	0.75	42.41	8.21	1880.93	510.77	170.99
2012	4.20	8.40	1.05	55.39	12.98	2788.94	908.00	232.41
2013	4.60	9.20	0.80	66.44	11.05	3649.07	860.13	280.70
2014	4.83	9.67	0.47	73.35	6.91	4224.18	575.11	301.73
2015	5.11	10.22	0.55	81.94	8.58	4975.95	751.77	331.73
2016	5.49	10.98	0.77	94.70	12.76	6165.45	1189.50	385.34
2017	5.93	11.85	0.87	110.23	15.53	7722.50	1557.05	454.26

Table 2: Growth rate (cm^3 tree^{-1} year $^{-1}$) of *B. variegata* in relation to various temperature (ºC) and rainfall (mm)

Age (years)	Detrended CAI	Average Temperature	Total rainfall	Growing Season Temperature	Growing Season Rainfall	Summer Temperature	Summer Rainfall	Rainy Temperature	Rainy rainfall	Winter Temperature	Winter Rainfall	Spring Temperature	Spring Rainfall
4	0.0002435	19.40	934.80	20.88	97.25	23.73	63.87	24.12	171.87	12.82	40.80	16.45	4.70
5	7.285×10^{-5}	18.81	906.10	21.00	105.70	23.47	14.47	24.10	194.80	12.25	26.33	13.78	99.65
6	8.092×10^{-6}	19.40	1009.00	21.19	95.71	23.35	68.93	24.15	181.30	13.35	32.73	15.25	75.35
7	6.109×10^{-6}	19.23	1120.00	21.21	88.98	24.28	37.27	24.20	171.13	13.22	3.33	13.75	201.00
8	3.931×10^{-7}	18.73	1191.80	20.52	134.74	22.15	131.93	23.33	231.97	13.12	18.40	15.03	15.70
9	2.761×10^{-7}	18.77	750.80	20.07	79.53	23.98	31.13	23.07	184.13	12.15	10.03	14.83	36.35
10	1.993×10^{-7}	18.91	1465.50	20.45	169.16	23.88	73.23	23.38	334.20	12.15	34.50	14.93	49.00
11	1.123×10^{-7}	17.93	858.10	20.16	115.33	22.13	81.20	23.10	161.13	11.67	17.13	13.00	39.85
12	2.552×10^{-8}	17.84	896.10	20.04	93.18	23.12	25.90	22.95	232.57	10.65	29.40	13.43	14.50
13	2.934×10^{-8}	18.28	1072.50	20.37	85.45	23.05	101.20	22.95	115.03	11.40	48.40	13.95	134.95
14	8.275×10^{-8}	17.84	1232.90	20.06	103.06	21.92	72.20	23.12	191.40	11.93	46.20	12.60	143.90
15	4.15×10^{-8}	18.39	992.60	20.63	73.85	22.03	60.50	23.62	137.70	12.45	27.60	13.63	140.30
16	1.273×10^{-8}	19.04	694.67	20.84	94.95	23.13	86.50	23.48	109.07	13.20	2.87	14.75	49.69
17	6.361×10^{-9}	18.45	1071.10	20.18	106.29	22.57	118.80	23.13	176.63	12.08	48.00	14.53	20.40
Correlation with CAI		0.44	-0.15	0.34	-0.06	0.30	-0.18	0.51	-0.05	0.20	0.23	0.57	-0.27

Table 3: Regression table for *B. variegata*

	Coefficients	Standard Error	P-value
Intercept	-8.20674×10^{-5}	0.000368879	0.860636
Average Temperature	-0.000857815	0.000131414	0.096775
Total Rainfall	-3.09706×10^{-7}	2.79693×10^{-7}	0.46761
Growing Season Temperature	-5.4177×10^{-5}	4.07441×10^{-5}	0.410503
Growing Season Rainfall	3.20558×10^{-6}	3.70001×10^{-7}	0.073158
Summer Temperature	0.00016601	2.99504×10^{-5}	0.113632
Summer Rainfall	-9.53125×10^{-8}	1.01516×10^{-6}	0.940403
Rainy Temperature	0.000332792	5.93345×10^{-5}	0.112324
Rainy Rainfall	-5.86954×10^{-7}	8.13651×10^{-7}	0.602155
Winter Temperature	0.000170764	3.40505×10^{-5}	0.125299
Winter Rainfall	1.5429×10^{-6}	7.02728×10^{-7}	0.272081
Spring Temperature	0.000240771	3.39458×10^{-5}	0.089168
Spring Rainfall	1.17746×10^{-6}	7.51146×10^{-5}	0.361504
R square= 0.998439981	F= 53.3348		

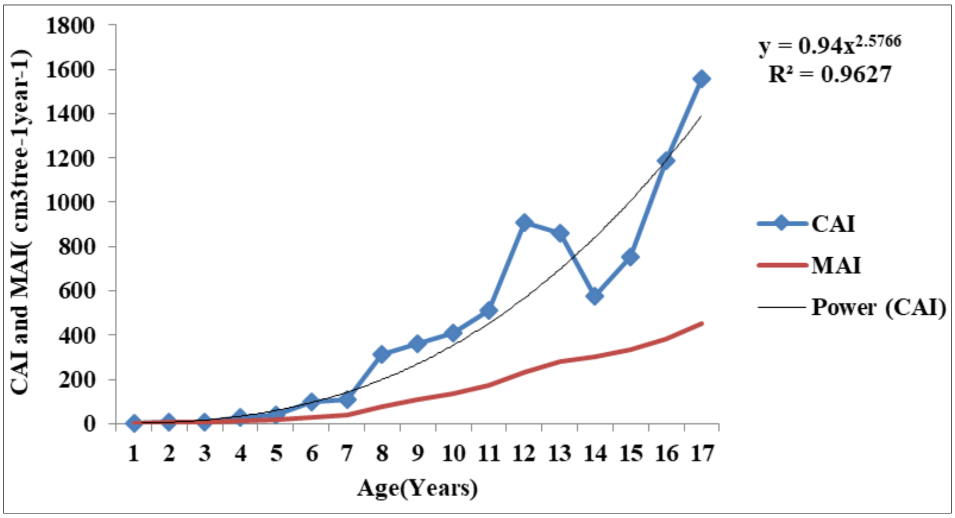

Fig 1: Current annual increment (CAI) and Mean annual increment (MAI) curve of *B. variegata* for mid hill condition of HP

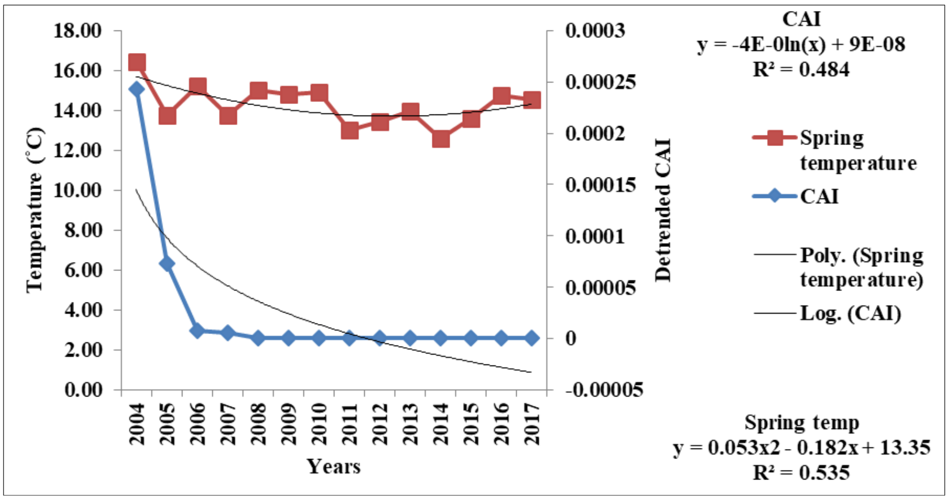

Fig 2: Variability in CAI (Current annual increment) of *B. variegata* in relation to spring temperature variation during different years

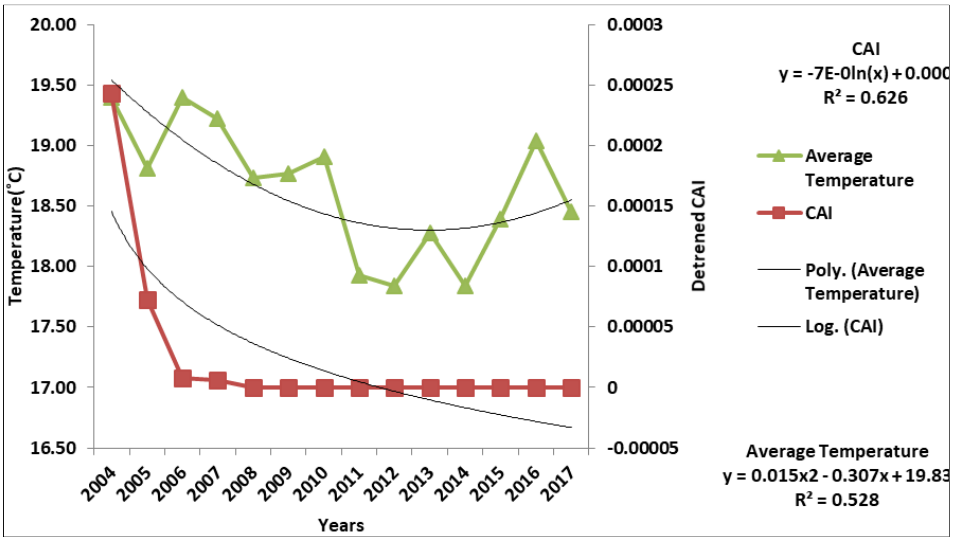

Fig 3: Variability in CAI (Current annual increment) of *B. variegata* in relation to Average temperature variation during different years.

Conclusion

Growth rate (Current annual increment) of B. variegata was found to be positively correlated with various categories of temperature i.e. average temperature, growing season temperature, summer, rainy and spring season temperatures. But the best correlation coefficient of growth rate was found with spring season temperature. All the climatic variables altogether affected the growth of this tree species by 99% (R2=0.998). So it is a climate sensitive species which can be taken into consideration while making any plantation of the species in that particular site.

References

1. Dang QL, Lieffers VJ. Climate and annual ring growth of black spruce in some *Alberta petlands*. Canadian Journal of Botany. 1989; 67:1885-1889.
2. Die A, Ridder MD, Cherubini P, Kouame FN, Verheyden A, Kitin P *et al*. Tree rings show a different climatic response in a managed and a non-managed plantation of Teak (*Tectona grandis*) in West Africa. Iawa Journal. 2015; 36:409-427.
3. FSI, India of Sate Forest Report, Forest Survey of India (Ministry of Environment Forest and Climate change), Dehradun. 2009, 192.
4. Gutierrez E. Dendroclimatological study of *Pinus sylvestris* L. in southern Catalonia (Spain). Tree-Ring Bulletin. 1989; 49:1-9.
5. Jump A, Hunt JM, Penuelas J. Rapid climate change related growth decline at the southern range edge of *Fagus sylvatica*. Global Change Biology. 2006; 12:2163-2174.
6. Kientz MA, Moran EV. Climate Impacts on Tree Growth in the Sierra Nevada. Forests. 2017; 8:1-18.
7. Luong TH, Janga KS, Lima HW, Choib WJ, Lee KH. Correlation of tree ring growths of four major species with climate changes in South Korea. Forest Science and Technology. 2013; 9:180-186.
8. Olivar J, Rathgeber C and Bravo F. Climate change, tree-ring width and wood density of pines in Mediterranean environments. Iawa Journal. 2015; 36:257-269.
9. Trouet V, Coppin P, Beeckman H. Annual growth ring patterns in *Brachystegia spiciformis* reveal influence of precipitation on tree growth. Biotropica. 2006; 38(3):375-382.
10. Van Dijk H and Hautekeete N. Long day plants and the response to global warming: rapid evolutionary change in day length sensitivity is possible in wild beet. Journal of Evolutionary Biology. 2007; 20:349-357.
11. Walther GR, Post E, Convey P, Menzel A, Parmesank C, Beebee TJC, Fromentin JM. Ecological responses to recent climate change. Nature. 2002; 416:389-395.