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Age and Growth relation of mangrove Avicennia marina (Forssk.) Vierh. in Gulf of Kachchh (GoK), India

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A B S T R A C T

A. marina belongs to Avicenniaceae family and the specie is widely distributed in intertidal zone of coastal region of Gulf of Kachchh (GoK) region. The goal of the study was to develop the relation between Age and Growth (A&G) in thisspecies in GoK. Therefore, mangrove plantation sites (n=25) under the jurisdiction of Marine National Park and Sanctuary (MNP&S) were selected; from 06 to 31 yearold mangrove plantation period i.e. year 2007-08 to 1983-84. The field data was collected during October to December, 2014. From each site 100 individuals of the species were measured with regard to parameters such as Collar Girth (CG), Girth at Breast Height (GBH) and Height of the plant. During the plantation period, average CG varied from 12.2±1.4cm to 161±17.5cm and average height ranged from55.052 ±3cm to 554.28±60cm (0.5 m to 5.5 m) was recorded in the GoK. Whereas, the GBH was recorded from plantations of year 1995 which ranged between 25.4±1.4to 86.2±12.3cm. Present study also showed yearly increment in various parameters viz. Heights (17 cm/yr), CG (2.96 cm/yr), and, GBH (3.18 cm/yr).

Key words: *Age and Growth, Mangrove, Avicennia marina (Forssk.) Vierh., Gulf of Kachchh,India*

Introduction

Mangroves are taxonomically diverse assemblage of wood plant communities belonging to several unrelated angiosperm families with special adaptations to saline conditions(Silva and Balasubramaniam, 1985). Mangrove is special type of ecosystem found alongwith estuarine sea coast and river mouth in tropical and subtropical areas (Sajish, 2012).Among the all mangroves, Avicennia marina (Forssk.) Vierh belongs to Avicenniaceae family and it is the most dominant mangrove species in the Gulf of Kachchh (GoK) region accounting for 90% covers. Also it represents the second dominant mangrove genus worldwide specially in harsh climatic areas (Duke, 2001).

The species is considered as tree habit in the Mangroves, extraordinarily adaptable with a wide latitudinal range closely associated with its flexible growth pattern. It is common throughout the Indo-Pacific region within a latitudinal range of 30ºN to 38ºS (Duke, 2001).

Growth of plant in the context of individual plants means anirreversible change with time mainly in size often in the form and occasionally in number(Hunt, 2003). In forest ecosystems, it is common practice to determine the age of tree and to relate it to the tree growth performance(Rixen, et al., 2004). The plant growth generally depends on a multitude of environmental factors including soil, competition and human factors etc. (Nazim, et al., 2013).

The patterns of growth over the life span of tree vary according to which dimension is measured while pattern of growth vary according to tree species and growing conditions (David, et al., 2013; Herault et al, 2011 and Duke, 2006). Regular annual changes in the length of the mangrove seedlings can be used reliably to determine their age and to estimate their growth rate (Duarte, et al., 1999).Present work focused on the establishment of age and growth relation of Avicennia marina (Forssk.) Vierh.species in the Gulf of Kachchh.

Study Area

This study was conducted in mangroves forest areas in Marine National Park and Sanctuary (MNP&S), Jamnagar in the Gulf of Kachchh. The MNP&S is located along the southern shore of GoK between 22^0 to 23^0 N latitudes and 68^0 E to 70^0E

longitudes from the Okha in the west to vicinity of Navlakhi in the east, is rich in ecological sensitive habitats such as mangroves and coral reefs (Fig. 1). The present study comprised in 6 forest ranges of MNP&S i.e. Jamnagar, Jodiya, Khambaliya, Sikka, Bhatiya and Dwarka.

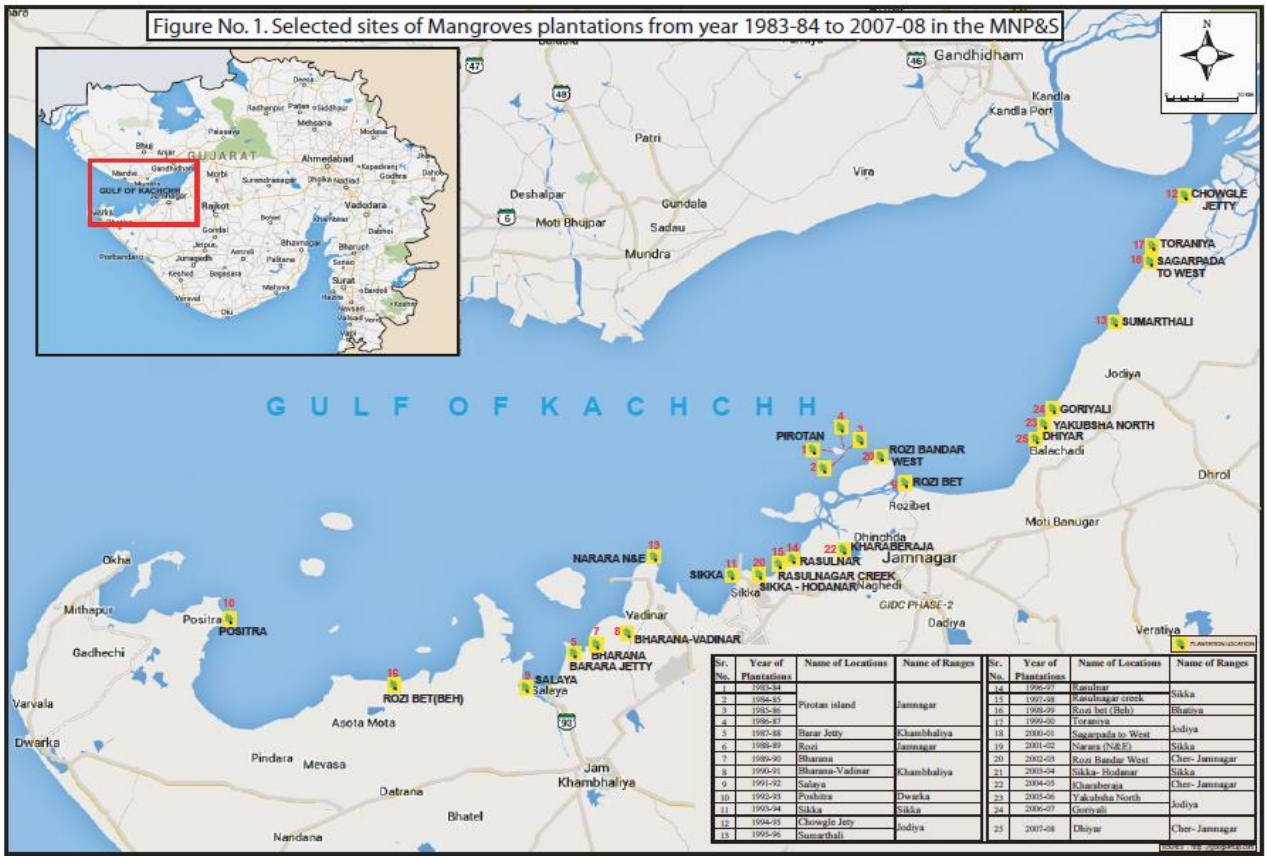

Table 1: Locational Details of Sampled

SN	Name of Ranges	Name of Sites	Year of Plantations	Total Area (ha.)	GPS Coordinates North	East
1	Jamnagar	Pirotan	1983-84	7	22^0 36’ 14.1”	69^0 57’ 52.7”
2	Jamnagar	Pirotan	1984-85	1.3	22^0 36’ 87.4”	69^0 57’ 12.5”
3	Jamnagar	Pirotan	1985-86	4.1	22^0 35’ 88.3’’	69^0 57’ 70.2”
4	Jamnagar	Pirotan	1986-87	17	22^0 35’ 80.1	69^0 57’ 55.0”
5	Khambhaliya	Barar Jetty	1987-88	50	22^0 21’ 30.0”	69^0 38’ 05.7”
6	Jamnagar	Rozi	1988-89	76.32	22^0 33’ 292”,	70^0 02’ 29.5”
7	Khambhaliya	Bharana	1989-90	51.46	22^0 21’ 45.8”	69^0 39’ 32.4”
8	Khambhaliya	Bharana-Vadinar	1990-91	50	22^0 22’ 55.3”	69^0 41’ 59.2”
9	Khambhadiya	Salaya	1991-92	50	22^0 19’ 0.97”	69^0 35’ 9.82”
10	Dwarka	Positra	1992-93	70	22^0 24’ 8.6”	69^0 12’ 0.2”
11	Sikka	Sikka	1993-94	32.7	22^0 26’ 50.6”	69^0 49’ 48.8”
12	Jodiya	ChowgleJety	1994-95	44	22^0 54’ 49.1”	70^0 23’ 16.0”
13	Jodiya	Sumarthali	1995-96	100	22^0 44 48.1”	70^0 18’ 0.77”
14	Sikka	Rasulnar	1996-97	25	22^0 27’ 55.9”	69^0 53’ 55.5”
15	Sikka	Rasulnagar Creek	1997-98	200	22^0 27’ 37.0”	69^0 53’ 32.6”
16	Bhatiya	Rozi bet (Beh)	1998-99	125	22^0 19’ 21.6”	69^0 25’ 94.7”
17	Jodiya	Toraniya	1999-00	300	22^0 49’ 59.4”	70^0 20’ 64.7”
18	Jodiya	Sagarpada(West)	2000-01	150	22^0 49’ 41.4”	70^0 20’ 35.5”
19	Sikka	Narara (N&E)	2001-02	100	22^0 28’ 093”	69^0 43’ 37.2”
20	Jamnagar	Rozi Bandar West	2002-03	150	22^0 35’ 45.1”	070^0 01’ 32.3”
21	Sikka	Sikka- Hodanar	2003-04	275	22^0 26’ 48.3”	69^0 51’ 032”
22	Jamnagar	Kharaberaja	2004-05	20	069^0 57’ 59.3”	22^0 29’ 00.9”
23	Jodiya	Yakubsha North	2005-06	100	22^0 37’ 12.9”	70^0 12’ 32.2”
24	Jodiya	Goriyali	2006-07	100	22^0 37’ 43.9”	70^0 12’ 59.2”
25	Jamnagar	Dhiyar	2007-08	85	22^0 36’ 35.3”	70^0 12’ 09.0”
Total			25	2183.8	-	-

Sites

Material And Methods

Field visits were programmed after the collection of plantation details from Administrative Office of Marine National Park and Sanctuary (MNP&S), Jamnagar. The field survey was conducted in the month of October to December, 2014, for primary data collection a total of 27 days were spent in the field. Year wise plantation sites from the 1983-84 to 2007-08 were identified with the help of local staffs during the field visit. Coordinates of each plantation sites were recorded by using Global Positioning System (GPS, Garmin). A total of 25 plantation sites were selected from six forest ranges of MNP&S which are shown in the in Fig. 1.From each location total 100 plants were randomly measured and a total of 2500 plants were considered to develop A&G in A. marina. Primary data collection was employed by random sampling technique and fordifferentiation between natural and artificial plant, various criteria were used i.e.plantation model, spacing of plants (2mt distance between plants), uniformity in canopy cover/growth, uniformity in Girth at Breast Height (GBH), Collar Girth (CG) and Height.

Result And Discussion

Table 2 shows the plantation year, locations and calculated average ± SD of different growth parameters (i.e. CG, GBH and Height) of the A. marina. The variation in CG of the plants varied from12.2±1.4cm to 161±17.5cm. Four plantation sites were selected from Pirotan island and the data showed wide difference in average CG i.e. 52cm in between 1983-84 to 1984-85 plantation year. Perhaps, for CG naturally grown trees were enumerated for the year 1983-84 which showed maximum growth whereas, remaining successive years' data were found in descending order in Pirotan Island.

In 06 to 31-year-old mangrove plantations, the height of A.marina ranged from 55.052 ±3cm to 554.28±60cm (0.5 m to 5.5 m). The results showed that after 30 years plantation period the height specific to this region was less as compare to the mangroves forests of eastern India, i.e., 3 to 18m whereas in other regions, such as South Sumatra Philippines and Mexico, height of mangroves were observed to be 55m, 25-30m and 17m (Pool et al., 1977). Pneumatophore root system in A.marina supports horizontal spreading of tree, resulting in reduction of vertical growth in GoK.

The GBH of stem was recorded from the plantation year 1993-94 to 1983-84 andit showsaverage value in the rang of The GBH varied from 25.4±1.4to 86.2±12.3 cm in GoK. Remaining plantations year showed profuse branching patterns in A. marina in GoK.

Table 2: Measurement of different parameters of A .marina at various location

SN	Name of Ranges	Nameof Locations	Year of Plantations	Average ± SD of 100 selected plants		
				CG (cm)	GBH (cm)	Height(m)
1	Jamnagar	Pirotan	1983-84	161±17.5	86.2±12.3	554.28±60
2	Jamnagar	Pirotan	1984-85	109.2±10.8	54.8±8.7	523.9±30
3	Jamnagar	Pirotan	1985-86	89.3±11.2	50.4±5.6	500.0±30
4	Jamnagar	Pirotan	1986-87	80.1±2.8	49.1±4.9	500.1 ± 30
5	Khambhaliya	Barar Jetty	1987-88	75.7±1.5	38.1±1.1	399.02±20
6	Jamnagar	Rozi	1988-89	37.3±1.4	29.9±2.8	452.45± 90
7	Khambhaliya	Bharana	1989-90	45.1±2.8	30.5±1.4	405.53 ±10
8	Khambhaliya	Bharana-Vadinar	1990-91	39.9±1.3	28.6±1.3	400.09 ±10
9	Khambhadiya	Salaya	1991-92	39.6±2.9	28.1±2.8	258.4 ±30
10	Dwarka	Poshitra	1992-93	39.5±3.0	28.2±2.7	397.6 ±30
11	Sikka	Sikka	1993-94	36.9±1.1	25.4±1.4	395.89 ±10
12	Jodiya	Chowgle Jetty	1994-95	30.4±4.7	NA	226.75±53
13	Jodiya	Sumarthali	1995-96	28.5±1.3	NA	263.69±10
14	Sikka	Rasulnar	1996-97	40.2±1.1	NA	400.94±11
15	Sikka	Rasulnagar creek	1997-98	37.5±1.5	NA	375.84±14
16	Bhatiya	Rozi bet (Beh)	1998-99	35.3±3.0	NA	261.1±28
17	Jodiya	Toraniya	1999-00	30.1±3.1	NA	239.7±28
18	Jodiya	Sagarpada to West	2000-01	25.32±3.79	NA	217.4±72
19	Sikka	Narara (N&E)	2001-02	35.1±2.71	NA	258.4 ±29
20	Jamnagar	Rozibandar West	2002-03	34.4±0.61	NA	255.1 ±30
21	Sikka	Sikka- Hodanar	2003-04	27.6±1.6	NA	225.01 ±10
22	Jamnagar	Kharaberaja	2004-05	14.4±1.5	NA	176.40 ±10
23	Jodiya	Yakubsha North	2005-06	21.7±7.3	NA	210.3±50
24	Jodiya	Goriyali	2006-07	16.6±4.7	NA	207.53±50
25	Jamnagar	Dhiyar	2007-08	12.2±1.4	NA	55.052 ±3

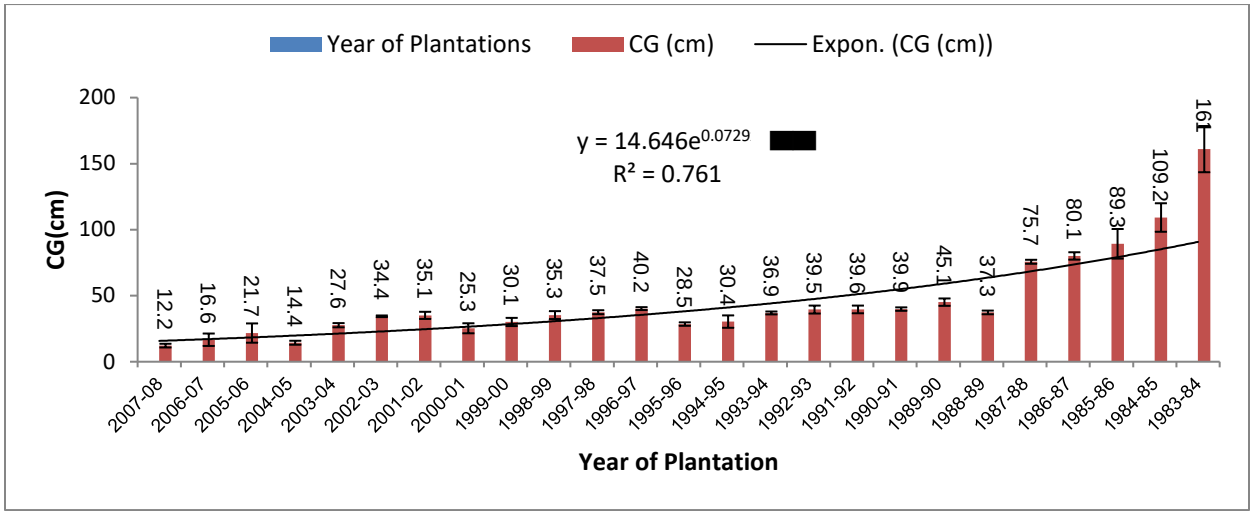

Figure 1 Average of Collar Girth (in cm) in year wise plantation

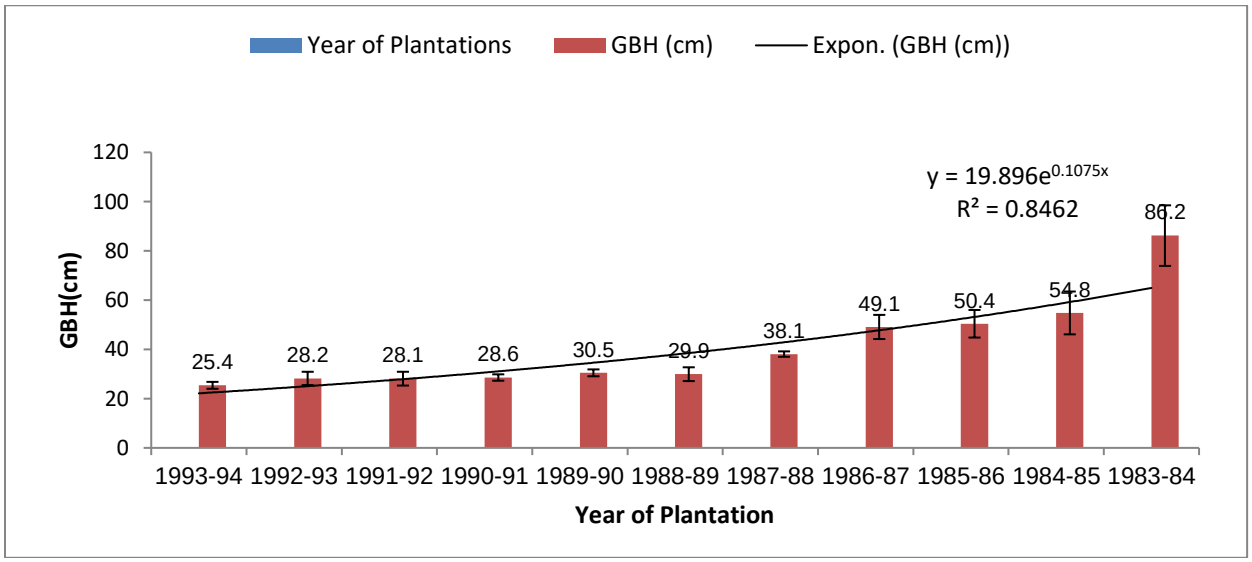

Figure 2 Average GBH (cm) in year wise plantation

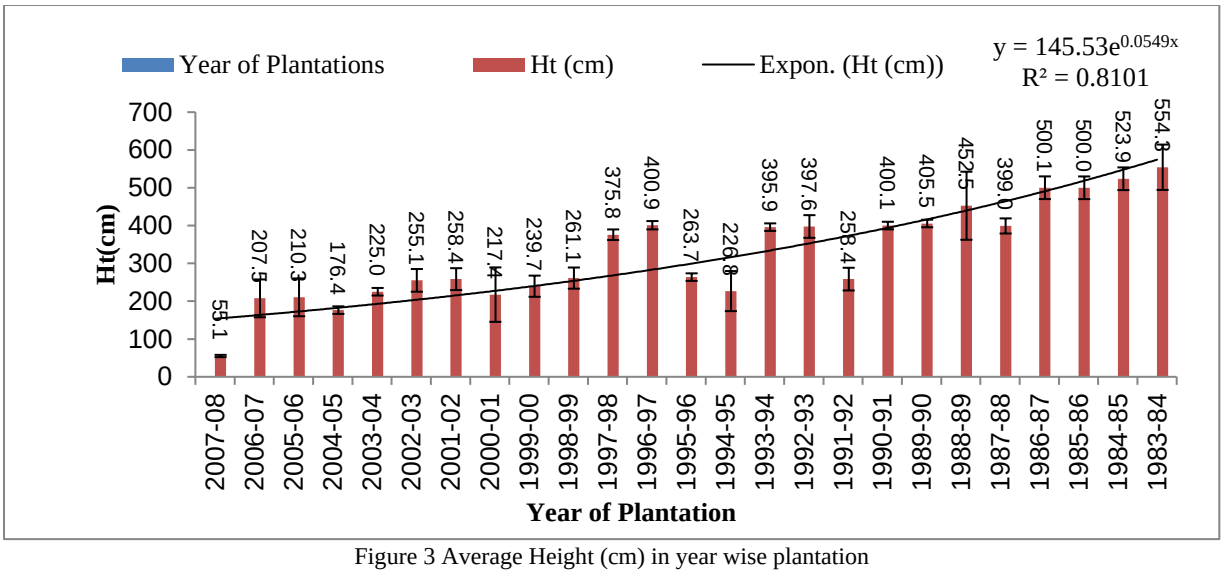

Figure 3 Average Height (cm) in year wise plantation

Correlation Coefficient (r^2) was calculated for CG and plantation years and the CG showed positive correlation i.e. r^2= 0.793with respect of increasing year (2007-08 to 1983-84). Likewise, GBH and Height are also showing positive correlation i.e r^2=0.895 and r^2= 0.680 respectively for increasing year (2007-08 to 1983-84).

Analysis of data indicated that only GBH of plant shows the uniform trend of increasing girth with the increasing age which has been observed from 1983-84 till the 1993-94. But CG shows fluctuation into growth in many year intervals as shown in fig. 1 and table 2. Likewise, height also showed variation (less growth) in the plantation year of 2004-05, 200-01, 1999-00, 1987-88 and 1994-95 to 1990-91, respectively (Fig. 3). These variations may due to several factors like, environmental factors and inundation period, more root biomass production than shoot biomass, location of plantation near a Salt industry etc. At the plantation site of Rasulnar, Rasulnar creek and Rozi bet (1996-97, 1997-98, 1998-99) soil substratum was silt loamy, very soft mud with favourable inundation period which lead to constructive growth in height (Table .2) One of the most important factors responsible for fluctuation in growth may be due to mislocation of plantation sites, wrong or lack of plantation registers and treatment maps. David, et al., 2013; Herault et al, 2011 and Duke, 2006 also revealed that the patterns of growth over the life span of tree vary according to which dimension is measured while pattern of growth vary according to tree species and growing conditions. Average growth increment were also calculated through power equation for all parameters i.e CG, GBH and Height. The Table 3 shows that the increments per year in various parameters are 16.4cm/yr for Height, 2.96 cm/yr for CG and 3.18 cm/yr for GBH.

Table 3: Calculated values of increment in Height (m), Collar Girth (cm), GBH (cm) of A.marina

SN	Year of Plantation	Height (cm)	Height Increment (cm)	Collar Girth (cm)	Collar Girth Increment (cm)	GBH (cm)	GBH Increment (cm)
1	2007-08	178	9	16.96	1.23	NA	NA
2	2006-07	187	10	18.19	1.32	NA	NA
3	2005-06	197	10	19.55	1.41	NA	NA
4	2004-05	207	11	20.93	1.52	NA	NA
5	2003-04	218	11	22.44	1.63	NA	NA
6	2002-03	229	12	24.07	1.75	NA	NA
7	2001-02	240	12	25.82	1.87	NA	NA
8	2000-01	253	13	27.69	2.01	NA	NA
9	1999-00	266	14	29.7	2.15	NA	NA
10	1998-99	279	14	31.85	2.31	NA	NA
11	1997-98	294	15	34.16	2.48	NA	NA
12	1996-97	309	16	36.63	2.66	NA	NA
13	1995-96	325	17	39.29	2.85	19.98	2.1
14	1994-95	341	17	42.14	3.06	22.08	2.32
15	1993-94	359	18	45.19	3.28	24.4	2.57
16	1992-93	377	19	48.47	3.51	29.97	2.84
17	1991-92	396	20	51.99	3.77	29.8	3.13
18	1990-91	417	21	55.76	4.04	32.94	3.46
19	1989-90	438	22	59.8	4.34	36.4	3.83
20	1988-89	460	24	64.13	4.65	40.23	4.23
21	1987-88	484	25	68.78	4.99	44.46	4.68
22	1986-87	509	26	73.77	5.35	49.13	5.17
23	1985-86	535	27	79.12	5.74	54.3	5.71
24	1984-85	562	29	84.86	6.15	60.01	6.31
25	1983-84	591	0	91.01	0	66.32	0
Average	-	-	16.4	-	2.96	-	3.56

NA- Not available

Conclusion

This study showed that when age of the plantations increases, the exponential trend line of all 3 growth parameters also increases. Correlation Coefficient (r^2) between age and various parameters also showed positive correlation i.e. r^2= 0.793, r^2=0.895 and r^2= 0.680 for CG, GBH and Height, respectively from the plantation year of 2007-08 to 1983-84).

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