Effect of Plant Densities on Biomass Production of Fast Growing Tree Species in Konkan Region, Maharashtra

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ABSTRACT

Field experiment was conducted to evaluate the effect of different plant densities of three fast growing tree species for biomass production. The *Acacia auriculiformis*, *Casuarina equisetifolia* and *Leucaena leucocephala* were planted in June, 1988 at 1x1, 2x1 and 2x2 meter spacing for maximum biomass production. The pooled data for three years(after 17 years of planting) revealed that there was significant difference in height, DBH and biomass. The maximum biomass/ha was recorded in *Acacia auriculiformis* at 1x1 m spacing (347.1 t/ha) followed by *Casuarina equisetifolia* at 1x1 m spacing (318.2 t/ha). The maximum gross return (per ha per year) was recorded in *Acacia auriculiformis* (Rs. 33,567) and *Casuarina equisetifolia* (Rs. 32, 343) planted at 1x1 m spacing.

Key words : *Biomass, Acacia auriculiformis, Casuarina equisetifolia, Leucaena leucocephala, spacing, tree species.*

1. INTRODUCTION

Competition is one of the most important processes that determines the growth and size distribution of an individual tree (Richardson, 1993). Plant spacing influences growing habit of individual tree and are often used as a measure of competition (Ford, 1975). The growing space largely influence tree growth and the yield of a stand as a whole (Evans, 1992). Initial spacing and the manipulation of growing space influence tree and stand development as a whole and explained more than 50 % variations in volume production (Okojie *et al.*,1988). However, the influence of spacing depends on a number of factors like type of species, site characteristics, climatic conditions, management objectives, silvicultural techniques, harvesting methods and the length of rotation. Therefore, optimum stand density is primarily a function of the growth potential of the site and the management practices. Though per hectare yields can be substantially great at higher plant population (Cannel, 1983), but poor availability of water and soil nutrient may limit the productivity.

Acacia auriculiformis, Casuarina equisetifoila and *Leucaena leucocephala* are the nitrogen fixing fast growing tree species. Among these *Casuarina equisetifolia* is an important fuel wood species with high calorific value (Kondas *et al.*, 1985). *Leucaena leucocephala* is an important fodder tree species having rich source of protein, whereas *Acacia auriculiformis* can be grown in degraded and marginal wasteland. To fulfill the requirement of timber, fuel and fodder of Konkan region of Maharashtra the trial was conducted with the objective to find out the optimum spacing for maximum biomass production of these tree species.

2. MATERIAL AND METHODS

The field experiment was initiated at forestry research farm, College of Forestry, Dr. B.S. Konkan Krishi Vidyapeeth, Dapoli with three tree species *viz., Acacia auriculiformis, Casuarina equisetifoila* and *Leucaena leucocephala* during June, 1988 by adopting 1x1, 2x1 and 2x2m spacings. Dapoli is situated in Sub-tropical region on 17 ° 40' to 17 ° 45' North latitude and 73° 16' to 73° 19' East longitude having elevation of 250 m above mean sea level. The average rainfall ranges from 3500 to 4000 mm with temperature 10-35 °C and humidity 66-97%.

Tree species were planted by digging a pit of 45 x 45 x 45 cm size. The spacings of 1x1, 2x1 and 2x2 m gave rise to population of 10,000, 5000 and 2500 plants per hectare, respectively. The basal dose of single super phosphate @ 50 g/pit was applied. Besides 20 g of Choloropyriphos/pit was used by thoroughly mixing with the soil to protect the seedlings from termite attack at the time of planting. Irrigation was provided for first two years at monthly interval during summer season. The experiment was laid out in RBD with three replications. The soil of the experimental field was lateritic, fairly homogenous with good drainage and moderately acidic in reaction with pH 5.6. The observations on height, DBH, log length were recorded annually in the month of December. One representative plant from each treatment and replication of a plot was harvested during year 2000, 2003 and 2005 for recording fresh weight of above ground biomass (stem, leaves, branches). Sun drying was followed to record the dry biomass. The data were statistically analyzed as per Panse and Sukhatme (1985).

For computation of log volume, log length and diameter (larger, smaller, middle point) of the tree species was measured. The cross sectional area 'A' is computed as $A = \pi/4 \times D^2$ where $\pi = 3.1415$, D= Av. diameter.

The log volume was computed by Newtons method (Anonymous, 2006).

$$V = (Al + 4 A_m + Au) \times L/6)$$

Where Al = Cross sectional area at butt end of log

Am = Cross sectional area at mid point of log

Au = Cross sectional area at top end of log

L= Log length

The volume of all the logs of a tree was added to calculate total volume of tree.

3. RESULTS AND DISCUSSION

Height and DBH

The height, DBH were significantly affected by different treatments (tree species x spacing) (Table 1). The maximum tree height was observed in *Casuarina equisetifolia* (19.27m) planted at 1x1m. spacing followed by *Casuarina equisetifolia* at 2x2 m. (19.20m). The maximum canopy height was observed in *Casuarina equisetifolia* at 2x2m. (12.30m). Significantly higher DBH was observed in *Acacia auriculiformis* at 2x2m. (15.5cm) which was at par with *Acacia auriculiformis* at 1x1m. (15.4cm). The lowest DBH was recorded in *Leucaena leucocephala* at 1x1m spacing (11.7cm) and *A. auriculiformis* planted at 2x1m (11.7m). Similarly, significant differences in plant height, collar diameter and crown diameter at different plant densities were also reported by Singh *et. al.*(2004).

Fresh biomass

There are significant differences in fresh biomass of stem, leaves and branches due to different treatment of tree species and spacing(Table 2). The stem fresh biomass was significantly higher in *Acacia auriculiformis* planted at 2x2 m spacing (143.33kg per tree) which was at par with *Acacia auriculiformis* at 1x1, 2x1 m spacing. Lowest stem biomass was recorded in *Leuceana leaucocephala* 1x1m (61.0kg per tree). The leaves and branch fresh biomass was significantly higher in *Acacia auriculiformis* is at 2x2m. Thus, *Acacia auriculiformis* planted at at 2x2 m spacing recorded maximum total fresh biomass (226kg per tree).

Table 1. Height and DBH of tree species (after 17 years of planting)

Treatment	Tree height (m)	Canopy height (m)	DBH (cm)	Canopy diameter (m)	
				E.W.	N.S.
T_1 *A. auriculiformis* 1 x 1 m	17.77	8.27	15.4	3.67	3.40
T_2 *A. auriculiformis* 2 x 1 m	16.83	6.07	11.7	3.83	2.73
T_3 *A. auriculiformis* 2 x 2 m	16.10	10.10	15.5	3.83	4.27
T_4 *C. equisetifolia* 1 x 1 m	19.27	10.60	11.7	4.67	3.93
T_5 *C. quisetifolia* 2 x 1 m	18.50	11.43	12.6	4.97	4.13
T_6 *C. equisetifolia* 2 x 2 m	19.20	12.30	12.8	5.17	4.33
T_7 *L. leucouphala* 1 x 1 m	10.07	6.33	11.7	4.07	4.07
T_8 *L. leucouphala* 2 x 1 m	11.43	8.30	11.9	4.73	4.53
T_9 *L. leucouphala* 2 x 2 m	12.33	7.13	12.0	4.33	6.23
SE. ±	0.86	0.98	0.80	0.37	0.61
CD at 5%.	2.60	2.94	2.93	N.S.	N.S.

Log volume

The DBH is the best predictor (Chellamuthu, 1994) of wood volume in *Casuarina equisetifolia.* The DBH showed maximum predominant direct effect along with significant and positive correlation (r= 0.9792) with the wood volume, which indicates the importance of DBH for its maximum contribution towards wood volume followed by bole height (Ravichandran and Balasubramanian, 2000).

The log length, DBH, volume of log was significantly affected due to tree species and spacing (Table 3). The per tree volume (m^3) was more in *Acacia auriculiformis* planted at 2x2 m (0.3139m^3/tree) which was at par with *Casuarina equisetifolia* at 2x1 m spacing (0.2879m^3/tree). The lowest volume per tree was recorded in *Leuceana leucocephala* at 2x2 m (0.1043 m^3 /tree). The maximum volume per hectare was recorded by *Acacia auriculiformis* at 1x1 m spacing (207.4

Table 2. Effect of different plant densities on fresh biomass of the tree species (after 17 years of planting)

Treatment		Fresh biomass (kg/tree)			
		Stem	Leaves	Branch	Total
T_1 *A. auriculiformis*	1 x 1 m	103.00	11.67	33.33	148.0
T_2 *A. auriculiformis*	2 x 1 m	111.00	12.33	42.00	165.33
T_3 *A. auriculiformis*	2 x 2 m	143.33	14.00	68.67	226.0
T_4 *C. equisetifolia*	1 x 1 m	99.00	8.00	21.33	128.33
T_5 *C. quisetifolia*	2 x 1 m	113.33	9.33	29.33	151.99
T_6 *C. equisetifolia*	2 x 2 m	129.33	11.33	30.33	170.99
T_7 *L. leucouphala*	1 x 1 m	61.00	1.00	11.67	73.67
T_8 *L. leucouphala*	2 x 1 m	77.67	2.67	15.33	95.67
T_9 *L. leucouphala*	2 x 2 m	90.00	3.00	18.00	111.00
SE. ±		14.91	1.41	5.25	-
CD at 5%		44.70	4.22	15.74	-

Table 3. Effect of different plant densities on log volume of tree species (after 17 years of planting)

Treatment		Log length (m)	Log DBH (cm)	Volume (m^3/tree)	Volume (m^3/ha)
T_1 *A. auriculiformis*	1 x 1 m	8.57	15.7	0.2074	207.4
T_2 *A. auriculiformis*	2 x 1 m	7.60	11.7	0.2031	101.5
T_3 *A. auriculiformis*	2 x 2 m	7.20	15.5	0.3139	104.5
T_4 *C. equisetifolia*	1 x 1 m	8.20	11.5	0.1714	171.4
T_5 *C. equisetifolia*	2 x 1 m	8.60	12.6	0.2879	143.9
T_6 *C. equisetifolia*	2 x 2 m	7.90	12.8	0.267	88.9
T_7 *L. leucocephala*	1 x 1 m	4.40	11.7	0.1103	110.3
T_8 *L. leucocephala*	2 x 1 m	3.73	11.9	0.1043	52.1
T_9 *L. leucocephala*	2 x 2 m	4.53	12.0	0.1474	49.1
SE. ±		0.68	0.79	0.011	-
CD at 5%		2.05	2.39	0.035	-

m^3/ha) followed by *Casuarina equisetifolia* at 1x1 m spacing (171.4 m^3 /ha) and lowest in *Leuceana leucocephala* at 2x2 m (49.1 m^3/ha).

Total biomass and economics

There was a significant difference in dry biomass of stem and branches due to different tree species and spacing (Table 4). The maximum stem and branch biomass was recorded in T1 *i.e*, *Acacia auriculiformis* planted at 1x1m (713.3 t/ha) followed by *Casuarina equisetifolia* at 1x1 m spacing (687.3 t/ha).

The gross income was higher in *Acacia auriculiformis* 1x1 m (Rs. 5,70,640/ha) followed by *Casuarina equisetifolia* 1x1 m (Rs. 5, 49, 840/ha) of the 17 years old trees. The maximum gross return was also recorded in *Acacia auriculiformis* 1x1m (Rs. 33,567/ha/year) followed by *Casuarina equisetifolia* 1x1m (Rs. 32,343/ha/year).

Thus, the study revealed that for production of maximum biomass and gain more return, *Acacia auriculiformis* or *Casuarina equisetifolia* can be planted at 1 x1 m spacing. Similar results were also recorded by Vergheese *et al.* (1999).

Table 4. Effect of different plant densities on total biomass and monitory return of different tree species (after 17 years of planting)

Treatment	Total boimass (stem & branch) (t/ha)	Gross income* (Rs/ha)	Gross returns in (Rs/ha/year)
T_1 *A. auriculiformis* 1 x 1 m	713.3	5,70,640	33569
T_2 *A. auriculiformis* 2 x 1 m	384.3	3,07,440	18084
T_3 *A. auriculiformis* 2 x 2 m	252.3	2,01,840	11873
T_4 *C. equisetifolia* 1 x 1 m	687.3	5,49,840	32343
T_5 *C. equisetifolia* 2 x 1 m	396.0	3,16,800	18635
T_6 *C. equisetifolia* 2 x 2 m	223.3	1,78,640	10508
T_7 *L. leucocephala* 1 x 1 m	426.6	3,49,280	20545
T_8 *L. leucocephala* 2 x 1 m	255.0	2,04,000	12000
T_9 *L. leucocephala* 2 x 2 m	155.0	124000	7294
SE. ±	50.29	-	-
CD at 5%	15.6	-	-

*(Biomass @ Rs. 800/t)

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