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**M Vijayabhama**Forest College and Research  
Institute, Mettupalayam,  
Tamil Nadu, India**K Baranidharan**Forest College and Research  
Institute, Mettupalayam,  
Tamil Nadu, India**R Ravikumar**Forest College and Research  
Institute, Mettupalayam,  
Tamil Nadu, India**K Divya**Forest College and Research  
Institute, Mettupalayam,  
Tamil Nadu, India**Corresponding Author:****M Vijayabhama**Forest College and Research  
Institute, Mettupalayam,  
Tamil Nadu, India

## Volume and growth model for *Neolamarckia cadamba* plantation in Coimbatore district of Tamil Nadu

**M Vijayabhama, K Baranidharan, R Ravikumar and K Divya**

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### Abstract

The study was conducted to identify the volume, growth attribute factors and design to construct the growth models of *Neolamarckia cadamba* plantation in Coimbatore district of Tamil Nadu. Different age stages of plantations viz., two to three, three to four, four to five eleven to twelve, twelve to thirteen, thirteen to fourteen, fourteen to fifteen, and fifteen to sixteen years were used for the study. Biometric parameters were collected on each plantation such as tree girth, tree height and tree diameter by using measuring tape and Haga altimeter respectively during 2018, 2019 and 2020. The study was carried out farmer's plantation of Narashipuram & Devanathapuram and FC&RI, Mettupalayam of Coimbatore district to develop the growth model for *Neolamarckia cadamba*. The average volume of Kadam in Thondamuthur plantations was 1.147m<sup>3</sup> it was in the age class 17-18 years. In Narashipuram plantation, the volume was 0.523m<sup>3</sup> at 14-15 years. In FC&RI, Mettupalayam the volume was 0.0893m<sup>3</sup> at age class 3-4 years. Deriving growth model for fast growing and high yielding Kadam trees would help the farming community to easily predict the volume as well as yield. The study results concludes that power model is the Best-fit for volume growth prediction equation developed for *Neolamarckia cadamba* plantation in Coimbatore district of Tamil Nadu  $Y = 18.299 x^{2.5108}$

**Keywords:** *Neolamarckia cadamba*, Biometric parameters, volume, growth model

### 1. Introduction

*Neolamarckia cadamba* commonly known as kadam, it is a large, tall, handsome, deciduous sometime evergreen or semi-evergreen tree, with a straight, cylindrical bole and a disciplined crown of horizontal spreading branches which are more or less whorled. It can reach a height up to 45 meters and carries great, religious meaning for both, Hinduism and Buddhism. The name of the Kadam tree refers to the Kadamba Dynasty (345-525), nowadays the South West Indian state of Karnataka, where the tree was considered as a holy tree. The highly fragrant Kadam flowers, the sweet scent is reminiscent of Champaca and Neroli, get a size of about 5.5 cm in diameter and are used for perfume production. In recent years, Kadam (*Neolamarckia cadamba*) wood is in great demand for multifaceted use. With increase in demand for consumption, the Kadam cultivation is being encouraged by many wood industries. The tree has generally a thin plank buttresses at the base. Bark is thick but smooth in young trees, becoming darker, exfoliating in longitudinal fissures in older trees. Foliage consists of 13 to 30 cm by 5 to 15 cm, elliptic- oblong, shining, opposite, simple leaves. Flowers are small, orange-coloured in dense terminal globose heads, 2.5-5 cm in diameter. The wood is white to creamy white, odourless, light in weight (545 kg/cum at 12% moisture content), straight-grained and medium and even textured. It is moderately strong, can be seasoned easily; but susceptible to sap- stain quickly after conversion, non-durable; can be easily and completely treated with preservatives. Treated timber is quite durable. It saws and works easily under tools. The wood is extensively used for ceiling boards, light construction work, packing cases, planking, carving and turnery. The wood makes good veneers and plywood suitable for the manufacture of grade IV commercial plywood and tea chest plywood. It is also suitable for both match boxed and splints. The species is very fast growing especially in the initial years. Rate of growth is very rapid in the earlier years; on an average it gives a maximum girth increment of 15 cm per annum up to the 9th year, the height increment averages 3 m per annum for the first six or eight years after which the growth becomes slower.

With increase in demand for consumption, the Kadam cultivation is being encouraged by many wood industries. Deriving of volume and growth model for fast growing and high yielding Kadam would help the farming community to easily predict the volume. The present study emphasizes to construct the volume growth prediction models of *Neolamarckia cadamba* plantations in Coimbatore district of Tamil Nadu.

The volume and growth model will be highly useful for farming community to find the volume of different age gradations. Finding average volume of different fields of Coimbatore district of Tamil Nadu.

## 2. Materials and Methods

### 2.1. Materials

### 2.2. Location

The experiment was conducted at Thondamuthur, Narasipuram, FC&RI, Mettupalayam of Coimbatore District located at  $11^{\circ} 0.618^{\circ}$  N latitude and  $76^{\circ} 45.114^{\circ}$  longitudes and at an altitude of 545m above mean sea level.

### 2.3. Weather and Climate

The mean rainfall of the region is 500-700 mm, distributed over 46 rainy days with North East monsoon contributing 60%, South West monsoon contributing 20% and summer showers 20% of the total rainfall. The mean maximum and minimum temperatures are  $34.5^{\circ}$  C and  $22^{\circ}$  C respectively.

### 2.4. Equipment

- The Altimeter
- Tree calipers and Measuring Tapes

### 2.5. Methodology

#### 2.5.1. Tree height

The total height of trees was measured by using Haga altimeter and ocular method for all the trees row,  $3.5 \times 1.5$  m and  $1.5 \times 1.5$  m respectively. The height was measured in all spacing of plantation and expressed in meter.

#### 2.5.2. Girth at Brest height (GBH)

All the experimental trees, marked at 1.37 m from ground level. Then the girth at breast height was taken by using tailors tape (Chaturvedi and Khanna, 1982) [3] and expressed in cm. Radius can be calculated from girth by using the formula

$$R = G/2\pi$$

#### 2.5.3. Diameter at Breast Height

The dbh of trees measures at 1.37m from ground level. Diameter can be calculated from radius by using the formula

$$2 * R.$$

#### 2.5.4. Determination of tree volume

##### Volume of standing tree

The volume of standing tree was estimated using the following formula and expressed in cu.m the volume was measured for all trees with spacing of  $3.5 \times 1.5$  m and  $1.5 \times 1.5$  m for the seeding based.

$$V = \pi r^2 h$$

Where,

V= Volume of standing trees

r = radius at breast height

h = Total height of tree

### Volume to Weight conversion

For this volume to Weight conversion one more parameter is needed. That is density value of the particular wood.

$$\text{Density} = \frac{\text{Weight}}{\text{Volume}}$$

$$\text{Weight} = \text{Density} * \text{Volume}$$

Density of the wood was determined by taking random samples. After getting density volume was multiplied. By following these procedures the yield value is converted from volume table to weight table.

### 2.5.5. Best fit equations for biomass prediction

Data on fresh weight of all the biomass components of sample trees were used to develop prediction equations by using easily measurable growth parameters like dbh, height and  $d^2h$  (Spurr's combined variable). Prediction equations can, in future, be applied to estimate stand biomass for which growth parameters are available.

Five different models viz., (1) straight line ( $y = a + bx$ ), (2) polynomial

( $y = a + bx^2 + cx$ ), (3) logarithmic ( $y = a + b \log x$ ), (4) power ( $y = ax^b$ ) and (5) exponential ( $y = ae^{bx}$ ) were tried using dbh, height and  $d^2h$  as independent variables (x). These prediction equations can, in future, be applied to estimate stand biomass for which growth parameters are available. The best-fitting model in each case was selected using  $R^2$  values as criteria.

### Development of growth Model

Various tree growth models viz., Linear, Exponential, Logistic, Gompertz, Champman- Richards, Slodaba and Weibull were tried to derive the growth function of by using easily measureable and keen variables (dbh and volume) (Prasad and Rawat. 1992; Ajit *et.al.*, 2000, Pant 2001) [6, 1, 4]. Based on the predicting ability and co efficient of determinations ( $R^2$ ) value, the validity of the different models will be tested Panse and Sukhatme (1967) [5].

## 3. Results and Discussion

*Neolamarckia cadamba* is mainly used for pulp and paper and pencil making in India. It is one of the important raw material that contributing to pulp requirement of the paper making industry and pencil industry. The study results revealed that it was observed that Diameter (cm) of Kadam was contributing more for volume aspect than height (m) in Coimbatore district. Therefore diameter plays a dominant role for volume than the height. (Table 1) (Fig1).

### 3.1. Thondamuthur Plantations in Coimbatore District

Based on the biometric observation during 2020, the average volume of three age classes in Thondamuthur kadam plantations viz.,  $1.14 \text{ m}^3$ ,  $0.951 \text{ m}^3$  followed by  $0.982 \text{ m}^3$  respectively 18, 17 and 16 years old. Among the three plantations in Thondamuthur, highest value of coefficient of determination  $R^2$  (0.986) and Standard error (0.017) was observed in 18 years old plantation, it was followed by 16years old plantation with  $R^2$  (0.945) and standard error (0.064) and  $R^2$  (0.966) and standard error (0.018) was in 17 years old plantations The study results revealed that the plantations in Thondamuthur were highly significant with respect to DBH and volume. The overall volume growth

model for Kadam plantations (2018, 2019 & 2020) are power model. (Table.4) (Fig 1).

### 3.2. Narasipuram plantations in Coimbatore District

The biometric observation during 2020 reveals that the average volume of Narasipuram Kadam plantations viz., 1.165 m<sup>3</sup> and 0.829 m<sup>3</sup> respectively in 15 and 14 years old plantation. The highest value of coefficient of determination R<sup>2</sup> (0.954) and standard error (0.033) was observed in 15 year old plantation. It was followed by 14 year old plantation with R<sup>2</sup> (0.681) and standard error (0.083) (Table.4)

### 3.3. FC&RI plantations, Mettupalayam in Coimbatore district

The biometric data recorded 2020 reveals, in Forest College and Research Institute, Mettupalayam, among the four plantations, 8 years old plantation in Agro forestry field has rerecorded average volume was 0.455m<sup>3</sup> recorded the highest value of coefficient of determination R<sup>2</sup> (0.968) and standard error (0.010) when compared to the volume of 0.433 m<sup>3</sup> in 7 year old plantation at Progeny evaluation trial with R<sup>2</sup> (0.877) and standard error (0.008). (Table 4)

### 3.4. Growth model for *Neolamarckia cadamba* plantations

The biometric observation of different age class of Kadam plantations in different context like Thondamuthur, Narasipuram and FC&RI, Mettupalayam recorded during 2018, 2019 and 2020. Based on the statistical analysis, the results reveal that 2002, 2003 and 2004 year Kadam plantations in Thondamuthur were highly significant with the high R<sup>2</sup> value of and standard error than Narasipuram and FC&RI, Mettupalayam. Among the independent variables used, dbh was identified as the most reliable variable for the growth components. Among the growth models tried for

Kadam plantations in Coimbatore district, power equation was found to be superior over all the other models for prediction of volume. Various tree growth models viz., Linear, Exponential, Logistic, Gompertz, Champman-Richards and Weibull were tried to derive the growth function of dbh. Based on the predicting ability and co efficient of determination (R<sup>2</sup>) value, the validity of different models were tested and it was found that Power growth model was best fitted for the present study.

#### Power Growth Model

$$y = ax^b$$

Where,

y = dbh in cm

a and b = Estimated parameters

x = Time

A growth model was derived by taking dbh (Cm) as a function of age for the Kadam plantations. The R<sup>2</sup> varied from 0.900 to 0.996.

### 3.5. Validity of Model (Chi-Square goodness of fit test)

By using the method of Ordinary Least Square (OLS) the derived model was tested. The chi-square calculated and table values used were analyzed, and it was found not significant. Therefore the above test indicated that the power model was the best for the present study. Moreover the R<sup>2</sup> value varied from 0.933 to 0.996. And it was significant both at 1 per cent and 5 per cent so both the tests indicated that the model was very well suited for the present study similar finding were also recorded by Baranidharan 2012<sup>[2]</sup> in Casuarina Species

**Table 1:** Biometric parameters of *Neolamarckia cadamba* plantations in Coimbatore district of Tamil Nadu during 2018

Location and Age of the Plantations	Mean Height (m)	Mean diameter (m)	Mean Volume (m <sup>3</sup> )
T1- 16 years	15.78	0.265	0.803
T2- 15 years	11.0	0.229	0.429
T3- 14 years	15.8	0.208	0.466
N1- 13 years	14.8	0.199	0.366
N2- 12 years	13.4	0.164	0.302
FC&RI 1- 6 years	5.80	0.121	0.135
FC&RI 2-5 years (Drip Irrigation)	6.81	0.086	0.058

**Table 2:** Biometric parameters of *Neolamarckia cadamba* plantations in Coimbatore district of Tamil Nadu during 2019

Location and Age of the Plantations	Mean Height (m)	Mean diameter (m)	Mean Volume (m <sup>3</sup> )
T1- 17 years	16.4	0.32	0.988
T2- 16 years	12.5	0.305	0.684
T3- 15 years	16.6	0.267	0.697
N1- 14 years	15.5	0.235	0.503
N2- 13 years	15.3	0.242	0.527
FC&RI 1- 7 years	7.1	0.216	0.196
FC&RI 2- 6 years (Drip Irrigation)	6.8	0.167	0.164

**Table 3:** Biometric parameters of *Neolamarckia cadamba* plantations in Coimbatore district of Tamil Nadu during 2020

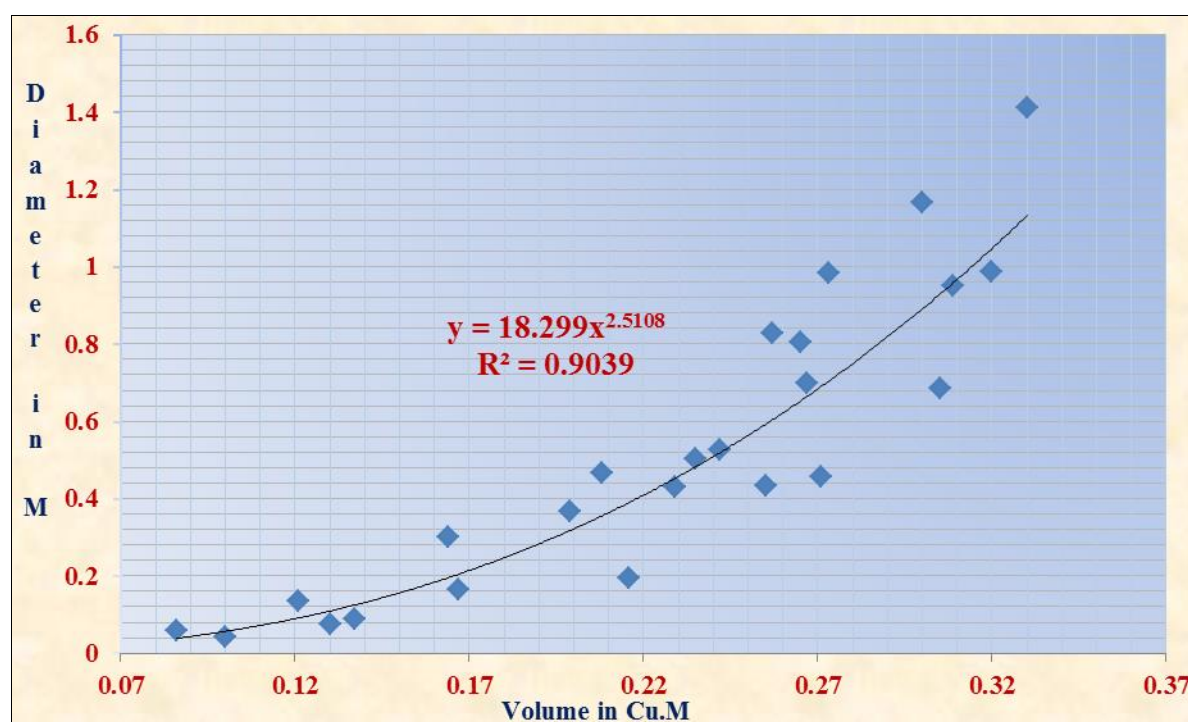
Location and Age of the Plantations	Mean Height (m)	Mean diameter (m)	Mean Volume (m <sup>3</sup> )
T1- 18 years	16.5	0.330	1.147
T2- 17 years	12.7	0.309	0.951
T3- 16 years	16.8	0.273	0.982
N1- 15 years	16.5	0.300	1.165
N2- 14 years	16.0	0.257	0.829
FC&RI 1- 8 years	7.9	0.271	0.455
FC&RI 2- 7 years (Drip Irrigation)	9.0	0.255	0.433

**Table 4:** Biometric parameters of *Neolamarckia cadamba* plantations in Coimbatore district of Tamil Nadu

Location	Year								
	2018			2019			2020		
	Height (m)	Diameter (m)	Volume (m <sup>3</sup> )	Height (m)	Diameter (m)	Volume (m <sup>3</sup> )	Height (m)	Diameter (m)	Volume (m <sup>3</sup> )
T1	15.78	0.265	0.803	16.4	0.32	0.988	16.5	0.330	1.41
T2	11.0	0.229	0.429	12.5	0.305	0.684	12.7	0.309	0.951
T3	15.8	0.208	0.466	16.6	0.267	0.697	16.8	0.273	0.982
N1	14.8	0.199	0.366	15.5	0.235	0.503	16.5	0.300	1.165
N2	13.4	0.164	0.302	15.3	0.242	0.527	16.0	0.257	0.829
FCRI 1	5.80	0.121	0.135	7.1	0.216	0.196	7.9	0.271	0.455
FCRI 2	6.81	0.086	0.058	6.8	0.167	0.164	9.0	0.255	0.433

**Table 5:** Regression Analysis of Diameter and Volume of the Plantations

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95%	Upper 95%
Intercept	-0.4821	0.1376	-3.502	0.0022	-0.769329	-0.194931	-0.769330	-0.194932
Diameter	4.546	0.5687	7.993	1.18006E-07	3.360276	5.733259	3.360274	5.733256

**Fig 1:** Volume Prediction Models for Kadam

#### 4. Conclusion

The study was concluded that the yield of Kadam plantations in Coimbatore district was highly significant. With respect to the regression analysis, 2004 plantation of Thondamuthur which was having high value, it reveals that the performance of *Neolamarckia cadamba* plantations was higher than all plantations in Coimbatore district. Diameter plays a dominant role in growth of volume prediction in Coimbatore district of Tamil Nadu. Based on the biometric observations recorded during 2018, 2019 and 2020 and analyzed in SPSS, EXCEL and MINITAB, it was concluded that diameter plays a vital role in growth of Kadam plantations. Therefore using DBH is one of the most independent variable for finding growth volume of the trees. Among the growth models tried for Kadam plantations in Coimbatore district, power equation was found to be superior over all the other models for prediction of volume. The growth model developed for *Neolamarckia cadamba* plantation in Coimbatore district of Tamil Nadu was  $Y = 18.299 x^{2.5108}$  where (X = Diameter)  $R^2$  is (0.9039) and Standard Error is (0.303), well suitable for all the plantations in Coimbatore district. Through this volume equation model tree growing farmer can able to find their

plantation present productivity and profitability at any point of time.

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