Annexures
Annexure. 1: HTML source code of the homepage of Tree Growth Modelling Website.

```html
<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.01 Transitional//EN"
"http://www.w3.org/TR/html4/loose.dtd">
<html>
<head>
<title>Welcome to Tree Growth Modelling: Indian Experiences</title>
<meta http-equiv="Content-Type" content="text/html; charset=iso-8859-1">
<style type="text/css">

.style1 { 
    color: #FFFFFF; 
    font-weight: bold; 
    font-size: 24px; 
}
.style2 { font-size: 16px}
.style10 {color: #006633; font-weight: bold; font-size: 12px; }
.style21 { 
    color: #336633; 
    font-family: "Times New Roman", Times, serif; 
    font-size: 12px; 
}
body { 
    background-color: #FFFFFF; 
    background-image: url(images/ACEXPDTN-ed.jpg); 
}
.style11 { 
    color: #FFFFFF; 
    font-size: 12px; 
}
a:link { 
    color: #336633; 
}
.a:visited { 
    color: #336633; 
}
.style15 {color: #336633; font-family: "Times New Roman", Times, serif; font-size: 12px; }
.style22 {font-size: 10px; color: #006600; font-weight: bold; }
.style23 { 
    color: #336633; 
    font-size: 12px; 
}
.style24 { font-size: 16px; 
    font-weight: bold;
```
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    <table width="246" border="0">
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        <td background="images/ACRICEPR.GIF"></td>
      </tr>
    </table>
  </td>
</tr>
</table>
<table>
<thead>
<tr>
<th>Definition of modelling</th>
<th>Types of modelling</th>
<th>Model Development process</th>
<th>Tree Growth Modelling Techniques</th>
<th>Models Relevant to agroforestry</th>
<th>Model Refinement</th>
<th>Data simulation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
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<td></td>
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<td></td>
</tr>
</tbody>
</table>
This site entitled "Tree Growth Modelling: Indian Experiences" has been designed with the basic objective of providing a platform where the user can have the basic concepts used in the development of tree growth models at one end and the comprehensive collection of already developed model for a specific tree species at other end so as to use them directly for prediction purposes. There are a number of fast growing tree species like Eucalyptus, Poplar etc. That have been widely accepted by the Indian farmers in agroforestry/block plantations. The basic reason for adoption being the short rotation nature which provides substantial returns at early age. Keeping these considerations in mind, at the initial phase of development of this site, we have concentrated on Eucalyptus species modelling only because of two reasons: Firstly NRCAF is underway on execution of a mega project on Eucalyptus based systems for semi-arid regions of India and secondly this forms a part of Ph.D. programme of my research scholar working on "Documentation, analysis and modelling of Eucalyptus based system for development of consolidated models at national / national level". However other important agroforestry species like Poplar, Quinine, Neem, Albizia etc. will be added in near future.

Dr. Ajit
NATIONAL SYMPOSIUM
on
AGROFORESTRY KNOWLEDGE FOR SUSTAINABILITY, CLIMATE MODERATION AND CHALLENGES AHEAD
15 – 17 DECEMBER, 2008
NATIONAL RESEARCH CENTRE FOR AGROFORESTRY, JHANSI - 284 003
e.mail:orgsec@gmail.com, Phone: 2730214(Off), 09415179658 (M), Fax: (0510) 2730364
Ref: Nat Sym/Abst
Date: 06 October 2008

To
Ms. Jabeen

Sub.: Acceptance of your abstract for presentation during National Symposium on “Agroforestry Knowledge For Sustainability, Climate Moderation and Challenges Ahead”

I am happy to inform you that abstract submitted by you for presentation during National Symposium on “Agroforestry Knowledge For Sustainability, Climate Moderation and Challenges Ahead” from 15 – 17 DECEMBER, 2008 at NRCAF, Jhansi has been accepted. The mode of presentation will be Poster. You are requested to prepare full length paper as per the guidelines provided with the first circular. You are also requested to send your registration fee, full length paper and travel programme at the earliest to the organizing secretary. The organizing committee is looking forward for your valuable participation in the National Symposium. The topic and theme of your abstract is as under:

Generalized models for prediction of aboveground biomass for Eucalyptus species in India in the theme 1.4 as per detailed in the circular of the symposium.

With kind regards,

Yours Sincerely

(A.K. Handa)
Organizing Secretary

Ms. Nighat Jabeen
Student
National Research Centre For Agroforestry Jhansi 284003, UP
NATIONAL SYMPOSIUM

on

AGROFORESTRY KNOWLEDGE FOR SUSTAINABILITY, CLIMATE MODERATION AND CHALLENGES AHEAD

15 – 17 DECEMBER, 2008

NATIONAL RESEARCH CENTRE FOR AGROFORESTRY, JHANSI - 284 003
e.mail: orgsec@gmail.com, Phone: 2730214(Off), 09415179658 (M), Fax: (0510) 2730364

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Designing and popularizing tree growth modelling website in Indian perspective in the theme 1.4 as per detailed in the circular of the symposium.

With kind regards,

Yours Sincerely,

(A.K. Handa)
Organizing Secretary

Ms. Nighat Jabeen
Student
National Research Centre For Agroforestry Jhansi 284003, UP
NATIONAL SYMPOSIUM
on
AGROFORESTRY FOR LIVELIHOOD SECURITY,
ENVIRONMENT PROTECTION & BIOFUEL PRODUCTION
16-18 DECEMBER, 2006

Abstracts

Organised by
INDIAN SOCIETY OF AGROFORESTRY
AND
NATIONAL RESEARCH CENTRE FOR AGROFORESTRY
JHANSI - 284 003
treatment, 40 kg N/ha, 80 kg P₂O₅/ha, 40 kg N+ 60 kg P₂O₅/ha and 40 kg N+ 50 kg P₂O₅/ha+ bacteria seed inoculation. Altogether 18 treatment combinations were applied in randomised block design with three replications. The observations on growth parameters viz. plant height, dry matter production per plant, tillers/plant in cencrus and branches/plant in cowpea were recorded at harvest. Besides this growth attributing parameters in aonla tree were recorded on plant height, canopy diameter and DBH at quarterly. The green and dry fodder yield was recorded at physiological maturity and 50% flowering stage of crop growth for each treatment. The crude protein content in dry matter of both crops was estimate by micro Kjeldahl method. The mean data analysis for three years revealed that plant height, dry matter accumulation, number of tillers/plant in cencrus and branches in cowpea and seed yield/plant in Cenchrus and cowpea were significantly increased with different intercropping row ratios of both the crops. However, maximum increase was with 1:1 row ratio followed by 1:2 and 2:1 row ratios, respectively. Similarly, green fodder, dry matter production and seed yields were increased remarkably under all the intercropping systems, except seed yield of cowpea under 1:2 and 2:1 intercropping systems. Integrated nutrient management had also significant effects on the growth parameters viz. plant height, DMA/plant, tillers/plant and seed yield/plant in Cenchrus and number of branches/plant and seed yield/plant of cowpea under aonla based hortipastoral system. However, the variation among the treatments with each other was remained at par for all the growth parameters except the treatments with seed inoculation and application of 40 kg N+ 60 kg P₂O₅/ha+ bacterial seed inoculation. Higher values of green fodder and dry matter production were obtained under 1:1 row ratio of cencrus and cowpea as compared to 1:2 and 2:1. But the higher seed yield and protein content were obtained with 1:2 row ratio followed by 1:1 and 2:1 row ratios. Application of 40 kg N/ha+60 kg P₂O₅/ha along with seed inoculation gave maximum production of green fodder, dry matter, seed yield and protein content than other treatments combinations, the next best treatment was when nitrogen and phosphorus were applied together. It can be concluded that judicious usage of biofertilizers together with nitrogen and phosphorus have better results in grass-legume mixed pasture as compared to their independent use. The aonla based intercropping system of cencrus and cowpea is a suitable alternative technique of hortipastoral system for higher fodder, food and fruit production in semi arid areas.

COMPARISON OF INITIAL GROWTH AND YIELD OF EUCALYPTUS TERETICORNIS CLONES UNDER AGROFORESTRY SYSTEM VIS-À-VIS BLOCK PLANTATIONS IN SEMI-ARID CONDITIONS OF INDIA

Ajit, Ritu, Nighat Jabeen, Rajender Singh, A.K. Handa, Ram Newaj and O.P. Chaturvedi
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A field experiment for growth and yield analysis/modeling of Eucalyptus based systems in Bundelkhand region was initiated at NRCAF, Jhansi with four clones of Eucalyptus tereticornis (C-3, C-6, C-7 and C-10 obtained from ITC, Bhadradri, Andhra Pradesh) in different systems and spacing, namely agrisilviculture (5x4, 10x2, 10x5, 8x4, 5x5 m), compact block (3x3, 2.5x2.5 m) and boundary plantings (2.5 m). The growth observations were recorded every three months in the first year and after six month in second year onwards. Observed parameters include total height, DBH, CD and canopy of the each individual tree. A total of 1335 trees from the complete experiment were measured for the first year. However, from second year only 510 trees were marked from the whole experiment for further growth observation. Eight trees (two from each clone) were selected from compact block plantation of spacing 2.5 x 2.5 m and other eight were harvested from agrisilviculture.
NATIONAL SYMPOSIUM
ON
INTENSIVE FOREST FARMING:
THE STATE OF THE ART
(February 12-14, 2008)

Organiser
Department of Forestry and Natural Resources, PAU, Ludhiana - 141 004

Sponsor
Indian Council of Forestry Research and Education, Dehradun - 248 006

Organiser
Department of Forestry and Natural Resources
Punjab Agricultural University, Ludhiana - 141 004

Sponsor
Indian Council of Forestry Research and Education, Dehradun - 248 006
STATISTICAL PREDICTION OF HEIGHT THROUGH HEIGHT/DIAMETER MODELS FOR EUCALYPTUS TERETICORNIS IN CENTRAL INDIA

AJIT. RITU, N. JABEEN, A.K. HANDA AND Q.P. CHATURVEDI
NRCAF-Jhansi (UP) - 284 003
(ajit@nrcaf.ernet.in)

An experiment was initiated for the structural analysis and modeling of Eucalyptus based system at NRCAF, Jhansi during August, 2003 with the objective of studying the structure, biomass, productivity and modelling the growth of Eucalyptus based systems. The experiment was laid with three systems of Eucalyptus tereticornis namely agrisilviculture, block plantation and boundary plantation. Tree spacings considered in agrisilviculture were 5m x 4m, 10m x 2m, 10m x 5m, 8m x 4m and 5m x 5m; compact block are 3m x 3m and 2.5m x 2.5m and boundary plantation is 2.5 m. Wheat and blackgram were grown in the interspaces during rabi and kharif seasons, respectively. Four Eucalyptus clone namely C-3, C-6, C-7 and C-10 were obtained from ITC, Bhadrachalam and planted on 15th August, 2003. In this article, the development and validation of height-diameter models have been reported. Growth observations (diameter at breast height and height) were recorded quarterly in the first year and twice a year in the subsequent period. The MAI (Mean annual increment) of height and dbh was 4.01m and 4.2cm, respectively at the age of three years. Indeed, it becomes extremely tedious to accurately measure the height of large trees (more than 10 mt), whereas, the dbh (diameter at 1.37m height) can be easily measured and accordingly height-diameter models provide a handy tool for prediction of height on the basis of dbh values. The data recorded on diameter and height of marked trees for a period of two years (with more than 4400 observations) was initially used for developing height-diameter model. Allometric function was fitted to the observed data and the fitted function was of the form $Y=209.93* X^{0.709} \text{ with } R^2=0.96$, where Y is the height and X is diameter at breast height (X and Y are both measured in cm). With the objective of validating this model (developed utilizing the growth data of initial two years), the growth data of the 3rd year was clubbed with the initial 2 years data set and the resulting data set consisting of more than 5300 observations was used to develop the model and the resultant fitted allometric function was of the form $Y=212.80* X^{0.715}$ (with $R^2=0.96$), where Y is the height and X is diameter at breast height (X and Y are both measured in cm). The comparison of model parameters clearly revealed that the model developed utilizing three years data is almost the same as the model developed utilizing initial two years data and thus confirms the stability of the model. The proposed model can be used for predicting the height of standing trees without destructive harvesting, by simply measuring the diameter at breast height.

Keywords: Statistical prediction, height, model, central India
Height Estimation Model for Eucalyptus tereticornis Grown under Semiarid Conditions of India

Ajit, Ritu Srivastava, Nighet Jabeen, A.K. Handa, Rajendra Singh and O.P. Chaturvedi
National Research Centre for Agroforestry
Gwalior Road, Jhansi-284003 India

ABSTRACT
An experiment on structural analysis and modeling of Eucalyptus based system was initiated at NRCAF, Jhansi in 2003 with three systems (agroforestry, block plantation and boundary plantation) and four clones obtained from ITC Bhadrachalam. To estimate the height of large trees, three types of models viz Richards, Schumacher, Allometric were attempted with dbh as predictor and the R² values were almost comparable in the three systems. However, when these models were extrapolated to examine their behaviour outside the observed range of dbh, the allometric function resulted in reasonably acceptable predictions even quite outside the observed range also, whereas the other two namely Richards and Schumacher leads to merely constant estimation for the extrapolated region. Accordingly, the allometric models are proposed for estimating the height values by simply measuring the dbh of the standing Eucalyptus trees in these systems.

Key words: Eucalyptus, height diameter models, allometric equations, validation

1. INTRODUCTION
In forestry, mathematical equations form the basis of many prediction studies. Typical example of such equation are height prediction model based on diameter, such models gain importance as modern scientific management relies heavily on well defined growth and yield models that can be used to access the status of stands at any point of time. Eucalyptus tereticornis being exotic to India, its cultivation has spread to nearly the whole of the Indian subcontinent. Large-scale plantations of E. tereticornis were established between 1970 and 1985. Nearly 2% of the cultivable land in northwestern India is planted with E. tereticornis. The average productivity of E. tereticornis plantations is 10 m³/ha/year on forestlands and 15-20 m³/ha/year on farmlands. The average productivity of commercial clones is about 20-25 m³/ha/year and many farmers have achieved up to 50 m³/ha/year. In fact, for the computation of productivity of such plantations, precise measurements of growth attributes (height and diameter) are essential. It has been noticed during the course of experimentation that it becomes extremely tedious to accurately measure the height of large trees (more than 10 meter), whereas the dbh (diameter at 1.37m height) can be easily measured and accordingly height-diameter models provide a handy tool for prediction of height on the basis of dbh values. Recently height-diameter curves have been frequently developed in forestry studies (Sharma and Parton, 2007; Lootens et al., 2007; Casteo et al., 2006; Reed et al., 2003; Mehtatalo, 2005; Inoue and Yoshida, 2004; Sochacki et al., 2007). Bachpai et al., 2005 developed multiple regression models for prediction of height using dbh and age for Bambusa tulda Roxb. plus clumps in regions of Assam and Meghalaya. Tiwari and Gadow, 2003 developed a height-diameter relationship for Prosopis cineraria for the hot arid areas of India. Tewari et al., 2002, have attempted height-age and diameter-age for irrigated plantation of Rajasthan; Soares and Tome, 2002, have developed height-diameter equation for Eucalyptus in first rotation.

Present study deals with the development of height-dbhm model under different systems, utilizing the data of initial years of growth, for application to a much wider range (viz maturity and even senescence age).

2. MATERIALS AND METHODS
2.1 Study site and experimental details
The experiment is being carried out at the Central Research Farm of National Research Centre for Agroforestry, Jhansi which is located at an elevation of 300 m above sea level and is situated between 24°11’ N latitude and 78°17” E longitude having tropical semi arid climate with mean annual rainfall of 900 mm. More than 75% of the rainfall is received during monsoon season (last week of June to first week of September). Mean maximum temperature ranges from 47.4° C (June) to 23.5° C (December) and mean minimum temperature from 27.2° C (June) to 4.1° C (December). The soil of the experimental area is sandy loam with low organic carbon, nitrogen, phosphorous and medium to high in potassium. The study was initiated in
August, 2003 with the objective of studying the structure, biomass, productivity and modelling the growth of Eucalyptus based systems. The experiment was laid with three systems of *Eucalyptus tereticornis* namely agrisilviculture (AS), block plantation (CB) and boundary plantation (BP). Tree spacings considered in agrisilviculture are 5x4 m, 10x2 m, 10x5 m, 8x4 m and 5x5 m; compact block are 3x3 m and 2.5x2.5 m and boundary plantation is 2.5 m. Wheat and Black gram were grown in the interspaces during Rabi and Kharif seasons respectively under boundary plantations and agrisilviculture systems. Four Eucalyptus clone namely C-3, C-6, C-7 and C-10 were obtained from ITC, Bhadrachalam (A.P) and planted in field during August, 2003. In this article, the development and validation of height-diameter models have been reported. Growth observations (dbh-diameter at breast height and height) were recorded quarterly in the first year and twice a year in the subsequent period.

### 2.2 Data and observations

The available data includes the tree wise observations on height in meter taken from the ground level to tip of the shoot of the main bole and dbh (diameter at breast height) in centimeter taken at a height of 1.37m at the main bole) for a period of 28 months. During the first year, observations were recorded four times in a year on 1335 trees distributed over the three systems viz agrisilviculture, compact block and boundary plantation. Whereas from second year onwards observations were recorded twice a year on 510 selected trees distributed proportionally over the three systems.

#### 2.3 Statistical analysis and candidate function

Systat software (Wilkinson et al., 1996) was used for computation of descriptive statistics (mean, SD, skewness, kurtosis etc) and fitting of non-linear equations (estimates of model parameters, asymptotic standard error of estimate, confidence interval, R² values) and plotting of various graphs pertaining to residual diagnostics and model validation (probability plot of residuals, auto correlation plots etc.)

The following functions were attempted to fit the observed data:

<table>
<thead>
<tr>
<th>Name of function</th>
<th>Functional form</th>
<th>Parameter interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allometric</td>
<td>Height = a*(DBH)^b</td>
<td>a = Scaling parameter, b = Power coefficients</td>
</tr>
<tr>
<td>Richards</td>
<td>Height = a*(1-exp(-k*DBH)) ( \frac{1}{(1-m)} )</td>
<td>a = Asymptote, k = Rate of approach to the asymptote, m = Shape parameter</td>
</tr>
<tr>
<td>Schumacher</td>
<td>Height=1.37+a*exp(-b/DBH)</td>
<td>a = Asymptote, b= Shape parameter</td>
</tr>
</tbody>
</table>

### 3. RESULTS AND DISCUSSION

The observed values for height and dbh exhibited the approximate normality of variates (Table-1) under study. To get an idea of the shape of the function to be fitted on the data, a scatter plot of height vs dbh was initially drawn. It was clear from this scatter plot that the candidate functions usually adopted for modeling height-dbh curves viz Richards, Schumacher and Allometric/power will fit well the observed pooled data set(AS+CB+BP).

The parameter estimates along with other related statistics of the Richards function fitted on pooled data has been compiled in Table 2, and the resultant equation was Height=18.03*[1-exp (0.089*dbh)] \( \frac{1}{(1-0.09)} \) with R^2 (obs. vs pred.) = 0.95. Similarly the parameter estimates of schumacher and allometric functions have been compiled in Table 2, and the resultant equations were Height =1.37 + 18.95*exp (-6.79/dbh) with R^2 (obs. vs pred.) = 0.94 for schumacher and Height = 1.76*(dbh)^0.8 with R^2 (obs. vs pred.) = 0.97 for allometric functions respectively. The plots of these fitted functions along with the observed data points have been compiled in Fig.1. It is clear from the above computations and the graphs of the fitted functions that the R^2-values are comparable for all the three functions but was observed to be maximum for allometric one. However, as has been pointed out by other researchers also in the recent articles (Ajit et al., 2006; Prajneshu and Chandran, 2005), that R^2 value alone should not be used to judge the best fitting function and it is equally important to consider the validation and more importantly the behavior of the fitted function outside the observed range of the independent variate. Accordingly, to judge the prediction capabilities of these functions in the extrapolated region, the function curves for the three-fitted function were drawn (Fig.2).
Table 1. Summary characteristics of growth attributes on the observed data set.

<table>
<thead>
<tr>
<th>Measured variable</th>
<th>Average (Min, Max.)</th>
<th>Standard Deviation</th>
<th>Skewness</th>
<th>SE of Skewness</th>
<th>Kurtosis</th>
<th>SE of Kurtosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height</td>
<td>6.09 (1.08-14.90)</td>
<td>3.615</td>
<td>0.689</td>
<td>0.045</td>
<td>-0.55</td>
<td>0.090</td>
</tr>
<tr>
<td>dbh</td>
<td>5.04 (0.20-14.33)</td>
<td>3.690</td>
<td>0.530</td>
<td>0.045</td>
<td>-0.84</td>
<td>0.090</td>
</tr>
</tbody>
</table>

Table 2. Estimation of parameters of various functions fitted on pooled dataset (AS+CB+BP).

<table>
<thead>
<tr>
<th>SN</th>
<th>Fitted Function</th>
<th>Parameter</th>
<th>Estimate value</th>
<th>Standard Error</th>
<th>Confidence interval Min</th>
<th>Confidence interval Max</th>
<th>R² value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Allometric</td>
<td>A</td>
<td>1.76</td>
<td>0.015</td>
<td>1.73</td>
<td>1.79</td>
<td>0.97</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B</td>
<td>0.78</td>
<td>0.004</td>
<td>0.78</td>
<td>0.79</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Richards</td>
<td>A</td>
<td>18.03</td>
<td>0.240</td>
<td>17.50</td>
<td>18.50</td>
<td>0.95</td>
</tr>
<tr>
<td></td>
<td></td>
<td>K</td>
<td>0.089</td>
<td>0.001</td>
<td>0.08</td>
<td>0.09</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>M</td>
<td>0.011</td>
<td>0.009</td>
<td>0.00</td>
<td>0.03</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Schumacher</td>
<td>A</td>
<td>18.95</td>
<td>0.150</td>
<td>18.60</td>
<td>19.20</td>
<td>0.94</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B</td>
<td>6.79</td>
<td>0.060</td>
<td>6.66</td>
<td>6.91</td>
<td></td>
</tr>
</tbody>
</table>

Fig.1. Different function fitted to model Height - DBH relationship on the pooled dataset (AS+BP+CB).

Fig.2. Extrapolated predictions of height growth with respect to DBH for different functions fitted on pooled dataset.
It is very clear from these comparative extrapolated prediction graphs of the three fitted functions that the allometric function results in reasonably acceptable estimations even quite outside the observed range also, whereas the other two namely richards and schumacher leads to merely constant estimation of size for the extrapolated range. Therefore the allometric function which meets both, the criteria's of high R²-value and reasonably acceptable extrapolated predictions, was preferred over the other two.

To judge the accuracy of prediction, the developed allometric equation was thoroughly evaluated through residual diagnostics. The error of prediction termed as residual is computed as the difference in the observed and predicted values. Theoretically, the residual should be independently and normally attributed with mean zero and constant variance. These assumptions were evaluated through pertinent graphs (Fig.3). The plot of residuals against their expected values clearly portrayed the normality of residuals. The plot of residual vs. independent variate confirmed that the residual are not continuously being over/under estimated and the plot of residual against estimate indicated that the residual have constant variance. Thus the proposed allometric equation fulfilled the regression requisites.

![Residual plots](image)

Fig. 3. Different plots of residual diagnostics for the allometric function fitted to the pooled dataset.

The allometric function for the pooled data (including all the three systems i.e AS+CB+BP) resulted in Height = 1.76*(dbh) 0.78 with R² (obs. vs pred.)=0.97. To compare the three systems height-DBH models based on allometric functions were also fitted separately system wise (Fig.4) and the resultant equations (Table-3) are:

```
Height = 1.87*(dbh) 0.75 with R² =0.96 for agrisilviculture
Height = 1.61*(dbh) 0.82 with R² =0.95 for compact block
Height = 1.65*(dbh) 0.81 with R² =0.97 for boundary plantation respectively.
```

To compute the growth performance in totality, all the three fitted allometric curves (agrisilviculture, compact block and boundary plantation), were drawn in one single frame (Fig. 5), and it is clear from this plot that growth was better in agrisilviculture for the first year, whereas compact block and boundary plantation picked up the growth in the second year. The proposed models can be used for predicting the height of standing trees at any stage without destructive harvesting, by simply measuring the diameter at breast height.

<table>
<thead>
<tr>
<th>S.N.</th>
<th>System</th>
<th>Parameters</th>
<th>Estimate Value</th>
<th>Standard Error</th>
<th>Confidence Interval Minimum</th>
<th>Confidence Interval Maximum</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Agrisilviculture</td>
<td>A.</td>
<td>1.87</td>
<td>0.020</td>
<td>1.83</td>
<td>1.90</td>
<td>0.96</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B.</td>
<td>0.75</td>
<td>0.005</td>
<td>0.74</td>
<td>0.76</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Compact Block</td>
<td>A.</td>
<td>1.61</td>
<td>0.030</td>
<td>1.55</td>
<td>1.67</td>
<td>0.95</td>
</tr>
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<td></td>
<td></td>
<td>B.</td>
<td>0.83</td>
<td>0.009</td>
<td>0.82</td>
<td>0.85</td>
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</tr>
<tr>
<td>3</td>
<td>Boundary Plantation</td>
<td>A.</td>
<td>1.65</td>
<td>0.030</td>
<td>1.58</td>
<td>1.73</td>
<td>0.97</td>
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<tr>
<td></td>
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<td>B.</td>
<td>0.81</td>
<td>0.010</td>
<td>0.79</td>
<td>0.83</td>
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</tbody>
</table>
Fig. 4. Allometric function fitted on individual datasets under the three systems.

Fig. 5. Comparison of the fitted allometric equation in different systems.

All used functions (allometric, richards and schumacher function) based on the criteria of $R^2$ (obs. vs pred.) values, gave comparable results. The allometric function lead to the reasonably acceptable predictions when these functions were validated on the criteria of extrapolated estimations outside the observed range followed by schumacher function and richards's function ranked at the last. Since model selection using nonlinear regression is an inherently subjective process, and somewhat data dependent, basing the final evaluation of the model on the validation procedure through pertinent graphs and extrapolated prediction seems to be a viable alternative when the prime objective of modeling exercise is prediction.

REFERENCES


Field Photographs
*Eucalyptus tereticornis* in different agroforestry systems
Root system of different clones of *Eucalyptus tereticornis*