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MODELLING THE GROWTH OF TEAK AND REAL – TIME MONITORING OF TREE HEALTH IN STM TEAK PLANTATIONS

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ABSTRACT

The works executed by the Kerala Forest Research Institute in collaboration with Sterling Tree Magnum (India) Limited, referred as STM, with the overall objective of developing a Management Information System (MIS) for plantations owned by STM are reported. Although the works were initiated with considerable enthusiasm and expectations from both sides and some progress made, the activities had to be stopped before its fruitful completion because of lack of interest and continued financial support from STM. The report describes the works that could be accomplished between the initiation of the project in January 1997 and the formal termination of the project in July 1999.

During the period under reference, a comprehensive format for gathering data from the plantations and an effective data processing and information retrieval system were developed considering the general structure of the plantations and the requirements of the management. The data were obtained from ten plantations of STM. The data included location details, several attributes related to growth and health of trees, soil status, input operations carried out and weather conditions in the plantations. The basic operational unit identified was a 'block' of around 15 ha or less in extent in which planting was simultaneous and management uniform. Summary reports were generated and supplied to STM for plantations for which data were made available, from time to time. These reports included information at the block level on various features related to the crop, site and input variables. Later, the programmes developed for generating summary reports were handed over to STM for use at site. Subsequently, the programmes were further extended to make the information retrieval more interactive allowing the user to specify the location and nature of information required and obtain information on many derived variables from the data available.

Based on the data supplied by STM, the overall mean annual increment (MAI) of height in STM plantations during the initial three years of growth was found to be 2.42 m compared to 2.07 m under site quality I of All India Yield Table for teak. The effect of better management seemed to be getting better with increasing age.

Attempts were made to assemble the data required for estimating the response-input relation in the required format. The form of the response function, the methods of parameter estimation and input optimization were identified. Unfortunately, the data available were inadequate to extract any useful information in this regard. Description of the methods that can be followed and some preliminary results obtained are reported for illustrative purposes.

1. INTRODUCTION

Teak (*Tectona grandis*) is traditionally grown in India under rainfed conditions without much of inputs other than initial tending and periodical thinning operations. Occasionally, removal of loranthus and climbers and trees affected by borers is also practised where such problems assume some order of significance. Growing teak under intensive management like many agricultural crops is relatively a recent phenomenon. The effort seems to be justified in view of the high demand for teak timber and also by the high monetary returns expected from such ventures. However, there is very little information as to how teak would perform under intensive management with respect to growth, resistance to pests and diseases and also the quality of timber produced. Sterling Tree Magnum (India) Limited has plunged into a large scale experiment in this area by attempting to grow teak with high levels of inputs promising high returns for the investors. Naturally, the performance of the trees in these plantations was of utmost importance both from a scientific point of view and also from the side of the management. As part of their concern to assess the status of their plantations from time to time, STM initiated attempts to develop a management information system and thereby optimise the input levels for maximizing the long term profits. Technical expertise was sought from the Kerala Forest Research Institute (KFRI) and the project started off with the expectation of bringing out many useful information in respect of performance of teak under intensive management. Unfortunately, the project activities had to be stopped after a while due to lack of continued interest and financial support from the part of STM. The project was initiated in January 1997 and the data were supplied by STM till June 1998. This report covers the works accomplished until the termination of the project in July 1999.

STM has raised teak plantations in different parts of India. These plantations, located in widely different agroclimatic zones, received high levels of inputs. The plantations are monitored periodically for growth and related parameters generating a vast amount of data which can be utilised to understand the key factors operating in the growth process.

The specific objectives with which this project was undertaken were:

(i) to estimate the status of teak trees periodically in STM plantations using real-time data.

(ii) to assess the effects of different input variables on growth of teak.

(iii) to develop a process based growth prediction model for teak under intensive management for short term predictions of growth.

Descriptions of the strategy employed for the collection, organisation and processing of the data in order to meet the above objectives can be found in the following chapters. Under the present project, it was also envisaged to develop a Geographic Information System (GIS) for the STM plantations and carry out the corresponding analysis. GIS are useful in dealing with data having a spatial reference. Using GIS, spatial pattern and joint variation among several characteristics can be studied which can bring out information

useful to the management. Works on GIS require data on spatial location of objects in the form of latitude, longitude or even maps. Maps indicating the exact spatial location of individual blocks are considered preferable over mere information on their latitude and longitude. However, works on this component could not be initiated because the required information was not supplied by STM.

2. MATERIALS AND METHODS

The data from each plantation were collected periodically by STM and supplied to Kerala Forest Research Institute (KFRI) for processing. The data structure and the methods employed for its collection and processing are described in the following.

2.1. Data structure

The basic operational unit for management identified by STM was a block which is of about 15 ha or less, planted simultaneously and managed uniformly. There could be a number of such blocks in a plantation. Data on several features like location details, growth attributes, soil status, input levels and weather parameters are gathered by STM, the details of which are given below. The frequency of reporting was fixed as twice in an year with an interval of six months, the first one being concurrent with the month of planting.

The measurements related to the above aspects were organised at three resolution levels; block, tree and weather station with the corresponding data files. Each plantation was supposed to have a weather station for recording the more important measurements related to weather conditions. For convenience in data entry, the block level file was split into two; one with a single record for each block and the other with multiple records for a block. Thus, the four files were the following.

BLOCKF. DBF : Block level data with single record for a block
BLOCKS.DBF : Block level data with multiple records for a block
TREE. DBF : Tree level data
WEATHER.DBF : Daily weather record for each meteorological station

The contents of the above files with respect to the field names and the nature of information stored are given below.

BLOCKF.DBF

REPFROM - Starting date of reporting period
REPTO - Ending date of reporting period
BLK_CODE - A distinct number assigned for a block which is not to be duplicated
STATE - The State in which the block is resident
DISTRICT - The District in which the block is resident
PLN_NAME - Name of the plantation in which the block is resident
BLK_NAME - Name of the block
LATI - Latitude in degrees and minutes
LONG - Longitude in degrees and minutes
ELEV - Elevation of the block above msl in metre
SLOPE - Slope category of the block
DOPT - Date of planting of teak in the block
SOPM - Source of planting material-seed source

SP_RR	- Spacing (row to row) in metre
SP_PP	- Spacing (plant to plant within a row) in metre
TOEXT	- Extent of the block in hectare
NOTPB	- Number of trees planted in the block
NOTSB	- Number of trees surviving in the block at the time of counting
DOCOT	- Date of counting of trees
TEXTURE	- Soil texture class
PH30	- Soil pH at 0-30 cm
OC30	- Organic carbon (%) at 0-30 cm depth
AVN30	- Available N (kg/ha) at 0-30 cm depth
AVP30	- Available P (kg/ha) at 0-30 cm depth
AVK30	- Available K (kg/ha) at 0-30 cm depth
AVCA30	- Available Ca (kg/ha) at 0-30 cm depth
AVMG30	- Available Mg (kg/ha) at 0-30 cm depth
AVZn30	- Available Zn (ppm) at 0-30 cm depth
AVFe30	- Available Fe (ppm) at 0-30 cm depth
AVCu30	- Available Cu (ppm) at 0-30 cm depth
AVMn30	- Available Mn (ppm) at 0-30 cm depth

BLOCKS.DBF

REPFROM	- Starting date of reporting period
REPTO	- Ending date of reporting period
BLK_CODE	- A distinct number assigned for a block which is not to be duplicated
CROP_OPR	- Intercrop raised or other operations done in the block
OPRFROM	- Starting date of the duration of the crop/operation in the block
OPRTO	- Ending date of the duration of the crop/operation in the block
PR_MA_TP	- Type of product harvested or type of material applied, type of weeding done etc.
QTY	- Quantity harvested or applied
UNIT	- Unit for the QTY (to be kept the same for a variable over the blocks)
REMARKS	- Any additional points to be conveyed

TREE.DBF

REPFROM	- Starting date of reporting period
REPTO	- Ending date of reporting period
BLK_CODE	- A distinct number assigned for a block which is not to be duplicated
DOM	- Date of measurement
TREE_NO	- Sample tree number which is not to be changed once assigned

GBH	- Girth at breast-height (cm) of the tree
HEIGHT	- Total height (m) of the tree
CW1	- Crown width (m) of the tree in the direction of maximum width
CW2	- Crown width (m) of the tree in the direction perpendicular to that of CW1
DM_PEST	- Damage due to pests (Yes/No)
TP_PEST	- Type of pest, if known
DM_DIS	- Damage due to diseases (Yes/No)
TP_DIS	- Type of disease, if known
DM_MECH	- Mechanical damage (Yes/No)
RE_MECH	- Reason for mechanical damage
PR_FORK	- Presence of forking (Yes/No)
RE_FORK	- Reason for forking, if known
FLOWER	- Presence of flowers on the tree (Yes/No)
FRUIT	- Presence of fruits on the tree (Yes/No)
FOLIAGE	- Presence of foliage on the tree (Yes/No)
REMARKS	- Additional points to be conveyed

WEATHER.DBF

REPFROM	- Starting date of reporting period
REPTO	- Ending date of reporting period
MET_STN	- Location of the meteorological station
DATE_OBS	- Date of observation
RAIN	- Total rainfall (mm) for the day
MI_T	- Minimum temperature (^{0}C) of the day
MX_T	- Maximum temperature (^{0}C) of the day
MI_RH	- Minimum relative humidity (%) of the day
MX_RH	- Maximum relative humidity (%) of the day

2.2. Status reports on plantations

Computer programmes were prepared to process the above data and to generate block level summary reports at any particular measurement occasion furnishing information related to various aspects of the crop growth and the management. The computations involved in generating the various summary statistics are detailed below.

2.2.1. Growth attributes

The basic set of biometrical measurements recorded at the tree level included girth at breast-height (gbh), total height and crown width which are measured on one per cent of the trees randomly selected from each block. Additionally, a complete count of trees is made in each block periodically.

Let the trees selected from a block be numbered from i = 1, 2, …, n. Let g_i represent the gbh in cm of the ith tree, h_i represent the height in m and w_i represent the corresponding crown width in m. The area of block is designated by A. Let N be the total number of surviving trees

in a block and n be the number of trees measured in a block. The various quantities at the block level are computed as follows (Chaturvedi and Khanna, 1982).

Survival : The survival percentage was based on the total count in each block on the number of live trees in relation to the number of trees planted.

Stocking : Observations on the number of trees surviving at the time of counting was utilized to compute the stocking per ha for each block.

Crop height : Crop height is measured as the mean height of the trees in the block.

$$\bar{h} = \frac{\sum_{i=1}^{n} h_i}{n} \qquad (1)$$

Coefficient of variation (CV) in height : The *CV* in height was obtained as the ratio of standard deviation in height to the mean height of trees in each block.

$$CV = (s_h/\bar{h})100 \qquad (2)$$

where $s_h = \sqrt{\frac{\sum_{i=1}^{n}\left(h_i - \bar{h}\right)^2}{n-1}}$

Actual Mean Annual Increment (AMAI) in height : The crop height value at any age was divided by the corresponding age in years to obtain the AMAI in height.

Expected Mean Annual Increment (EMAI) in height : The crop height reported in the All India Yield table for teak (Anonymous,1970) against site quality class I was taken as a standard for calculating the expected MAI in height.

Increase over control: The expected MAI for site quality class I was taken as control and the increase was obtained as

$$\text{Increase over control} = \left(\frac{AMAI}{EMAI} - 1\right)100 \qquad (3)$$

Crop diameter : Crop diameter was calculated as the diameter corresponding to mean basal area.

$$\text{Crop diameter } d = \frac{1}{\pi}\sqrt{\frac{\sum_{i=1}^{n} g_i^2}{n}} \qquad (4)$$

Basal area : Basal area ha^{-1} was worked out using the formula

$$\text{Basal area ha}^{-1} = \frac{N\sum_{i=1}^{n} g_i^2}{n\pi 40000\, A} \qquad (5)$$

Crown diameter : Crown diameter was measured for each sample tree in two directions perpendicular to each other. Crown width1 (w_1) is the maximum width of the crown measured on the ground by dropping perpendiculars from the edges of the crown and crown width2 (w_2) is the crown width measured in the diametrically opposite direction to that of maximum width. Then mean crown width of *n* trees in a block is calculated as

$$w = \sqrt{\sum_{i=1}^{n} \frac{\left(w_{1i}^2 + w_{2i}^2\right)}{2n}} \qquad (6)$$

Crown overlapping : Crown overlapping between rows was identified by comparing crown diameter of the stand to spacing between rows. Similarly, crown overlapping within rows was judged by comparing the crown diameter to within row espacement.

2.2.2. Health and phenology

Damage on trees in each block due to pests, diseases and mechanical causes are reported as the percentage number of trees affected by the same out of the number of trees on which such observations were made. The percentage of number of trees having forking, flowering, fruiting and foliage are also reported for each block. The general formula in these cases is

$$p = (x/n)\ 100 \qquad (7)$$

where p = percentage of trees falling in a specified category in the block
x = number of trees falling in the specified category in the block
n = number of trees on which the observation is made in the block

2.2.3. Soil attributes

The figures available on soil properties like texture, pH, organic carbon content and other macro and micro elements like N, P, K, Ca, Mg, Zn, Fe, Cu, Mn etc. are reported for each block as obtained from STM. The textural classification is based on the feel method as reported by STM.

2.2.4. Weather details

Annual figures for total rainfall, minimum and maximum temperature and minimum and maximum relative humidity are reported for each block in the summary report. These values were generated from the monthly figures furnished by STM on the weather parameters. However, from a daily weather record, more information can be generated in this regard.

2.2.5. Input/Cropping operations

The available data on input are summarised on yearly basis with reference to the date of planting. The major features covered are preplanting operations, irrigation, fertilizers applied, manuring, pruning, weeding, ameliorative treatments carried out, intercrops grown and plant protection activities undertaken.

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2.3. Information retrieval system

The fixed format of the report generating system developed first for creating summary reports at block level was later modified to provide an interactive information retrieval system, which was considered more useful for practical applications especially when consecutive measurements are available. Using this programme, it was possible to specify any plantation in the reported data set and retrieve the block-wise information on any particular feature at different stages of the crop growth. Since the reported data were not concurrent with the date of planting in each block, quite often interpolation had to be done for many items. The information attributes were classified into six groups according to their nature. The menu items and the corresponding attributes are described below.

Site: The permanent features of the site (block) were grouped under this menu item which included the following features.

- Latitude
- Longitude
- Elevation
- Extent
- Slope
- Date of planting
- Spacing

Growth: The attributes related to growth and survival were grouped under this title.

- Stocking
- Survival
- Crop height
- CV in height
- AMAI in height
- EMAI in height
- Increase over control
- Crop diameter
- Basal area per ha
- Crown diameter
- Crown overlapping

Health/Phenology: All measurements related to tree health and phenology come under this head.

- Pests
- Diseases
- Mechanical damage
- Forking
- Flowering
- Fruiting
- Foliage

Soil: The information on soil status was put under this group.

- Texture
- Soil pH
- Organic carbon
- Soil Nitrogen
- Soil Phosphorous
- Soil Potassium
- Soil Calcium
- Soil Magnesium
- Soil Iron
- Soil Copper
- Soil Manganese
- Soil Zinc

Weather**:** All the available information on weather were put under this menu item.

- Total rainfall
- Min. temperature
- Max. temperature
- Min. relative humidity
- Max. relative humidity

Input/cropping**:** This menu item covered information on the input operations and intercrops raised in each block.

- Pre-planting operations
- Ameliorative treatments
- Manure type
- Manure quantity
- Irrigation
- Fertiliser type
- Fertiliser quantity
- Weeding
- Intercrop
- Plant protection
- Pruning

In addition to the above, provision was given in the main menu to read out the optimum levels of inputs required for maximizing the current annual increment in any particular block.

2.4. Optimization of inputs

The first step towards the construction of a growth simulation model ideally is that of estimating a function relating the growth increment in a particular period with the initial crop

and soil status, the kind of management executed and the weather conditions existed during that period.

In the initial stages of plantation establishment, height growth is a good indicator of crop growth and hence the current annual increment (CAI) in crop height was chosen as the response variable. Variables like gbh or basal area are not suitable for the purpose during the early stages of tree growth as the stands acquire nonzero values of such measures only when trees cross the 1.37 m limit. Measurements on initial soil status were not available for many blocks and hence these were also deleted from the model. Also the use of weather variables in the model would presuppose a sub-model for forecasting weather, the estimation of which requires long years of data on weather variables. Lack of appropriate data in this regard led to the elimination of weather variables also from the model.

Thus the model finally contained CAI of height as the regressand and age of the stand, initial height and a set of input variables as regressors. The model was of the following form.

$$y = \beta_0 + \sum_{i=1}^{p} \beta_i x_i + \sum_{i=1}^{p} \beta_{ii} x_i^2 + \sum_{i<j}^{p} \beta_{ij} x_i x_j \qquad (8)$$

where y = CAI in height (m)

x_i's are the set of independent variables given in Table 1

β's are the regression coefficients

Table 1. The set of independent variables used in the response function

Variable	Unit
$x1$: (Age)	year
$x2$: (Initial crop height)	m
$x3$: (Spacing within rows)	m
$x4$: (Spacing between rows)	m
$x5$: (Preplanting operations)	yes/no
$x6$: (Ameliorative treatments)	yes/no
$x7$: (Organic manure)	kg/plant
$x8$: (Water)	l/year
$x9$: (Fertilizer Nitrogen)	g/plant
$x10$: (Fertilizer Phosphorous)	g/plant
$x11$: (Fertilizer Potassium)	g/plant
$x12$: (Weeding)	yes/no
$x13$: (Intercrop)	yes/no
$x14$: (Plant protection)	yes/no
$x15$: (Pruning)	yes/no

The significant variables in model (8) were identified through stepwise regression (Montgomery and Peck, 1982).

When a satisfactory response function is established, it is possible to characterize the nature of response surface and find out the optimum levels of the input variables. The levels of x_i's which maximize the predicted response can be identified through the following equation (Montgomery, 1991).

$$\mathbf{x_0} = -\frac{1}{2}\mathbf{B^{-1}b} \tag{9}$$

where $\mathbf{b}$ is a (p x 1) vector of the first order regression coefficients and $\mathbf{B}$ is (p x p) matrix whose main diagonal elements are pure quadratic coefficients (β_{ii}) and the off-diagonal elements are one half the mixed quadratic coefficients ($\beta_{ij}, i \neq j$) *i.e.*

$$\mathbf{b} = \begin{bmatrix} \beta_1 \\ \beta_2 \\ . \\ . \\ . \\ \beta_p \end{bmatrix} \qquad \mathbf{B} = \begin{bmatrix} \beta_{11} & \beta_{12}/2 & . & . & . & \beta_{1p}/2 \\ & \beta_{22} & . & . & . & \beta_{2p}/2 \\ & & . & & & \\ & & & . & & \\ & & & & . & \\ & & & & & \beta_{pp} \end{bmatrix}$$

The predicted response at the stationary point can be computed using the following equation.

$$\hat{y}_0 = \beta_0 + \frac{1}{2}\mathbf{x'_0\, b} \tag{10}$$

To characterize the response surface, it is necessary to express the fitted model (8) in canonical form as shown in equation (11).

$$\hat{y} = \hat{y}_0 + \lambda_1 w_1^2 + \lambda_2 w_2^2 + \ ... \ + \lambda_p w_p^2 \tag{11}$$

where w_i's are the transformed independent variables and λ_i's are the eigen values or characteristic roots of the matrix $\mathbf{B}$. The variables $\mathbf{x}$ are related to the canonical variables $\mathbf{w}$ by

$$\mathbf{w} = \mathbf{M}'(\mathbf{x} - \mathbf{x}_0) \tag{12}$$

where $\mathbf{M}$ is a (k x k) orthogonal matrix. The columns of $\mathbf{M}$ are the normalised eigenvectors associated with the (λ_i). That is, if $\mathbf{m}_i$ is the ith column of $\mathbf{M}$, then $\mathbf{m}_i$ is the solution to

$$(\mathbf{B} - \lambda_i \mathbf{I})\mathbf{m}_i = \mathbf{0} \tag{13}$$

for which $\mathbf{m}'_i\mathbf{m}_i = 1$.

The nature of the response surface can be determined from the stationary point and the sign and magnitude of the λ_i's. Suppose that the stationary point is within the region of exploration

for fitting the second-order model. If the λ_i's are all positive, then $\mathbf{x_0}$ is a point of minimum response. If the λ_i's are all negative, then $\mathbf{x_0}$ is a point of maximum response and if the λ_i's have different signs, then $\mathbf{x_0}$ is a saddle point.

3. RESULTS AND DISCUSSION

3.1. Status reports on plantations

During the period under reference, data were received from ten plantations listed below.

	Plantation name	*District*	*State*	*Total extent* (ha)
1.	Andipatti	Mannar Tirumalai Naicker	Tamil Nadu	55.60
2.	Bandhugaon	Koraput	Orissa	19.87
3.	Gandarvakottai	Pudukottai	Tamil Nadu	48.59
4.	Kalakad	Mannar Tirumalai Naicker	Tamil Nadu	47.15
5.	Kanavaipatty	Theni	Tamil Nadu	32.75
6.	Karuthapillaiyur	Tirunelveli	Tamil Nadu	33.89
7.	Kurupam	Vijaya Nagaram	Andra Pradesh	62.88
8.	Sangamvalsa	Vijaya Nagaram	Andra Pradesh	82.15
9.	Thirumoorthy	Coimbatore	Tamil Nadu	53.75
10.	Vittaneri	Sivaganga	Tamil Nadu	33.49

The summary reports on these plantations are given in Appendix 1. These summary reports speak for themselves. Except in the case of growth attributes and soil status which display the status of trees/soil at the time of measurement, all other variables like weather details and input/cropping operations have reference period of successive years from planting date. For the sake of simplicity, reports of only the first set of growth measurements and the input operations for the first year for each block are included in this report for illustration of the nature of the summary reports.

As a matter of interest, the crop height attained in plantations of different age levels were regressed on age to know the general rate of height growth in STM plantations. The SPSS output on the equation fitted is given in Table 2.

Table 2. Results of regression of crop height on age (SPSS output).

Variables in the equation					
Variable	B	SE B	Beta	T	Sig T
AGE	2.416566	0.052748	0.980346	45.814	0.0000
Analysis of variance					
Source	DF	Sum of squares	Mean square	F	Prob. F
Regression	1	2195.76239	2195.76239	2098.88036	0.0000
Residual	85	88.92351	1.04616		
Adjusted R square 0.96062					

Around 96 per cent of the variation in crop height is explained by age. A comparison of the fitted equation with the expected line for site quality class I as per the All India Yield Table for teak is provided in Figure 1. The fitted equation was

$$\bar{h} = 2.4165\, a$$

where $\bar{h}$ = crop height of trees in a block (m)
a = age of trees in a block (year)

The overall mean annual increment (MAI) of height in STM plantations during the initial three years of growth was 2.42 m compared to 2.07 m under site quality I of All India Yield Table. The effect of better management seemed to be getting better with increasing age.

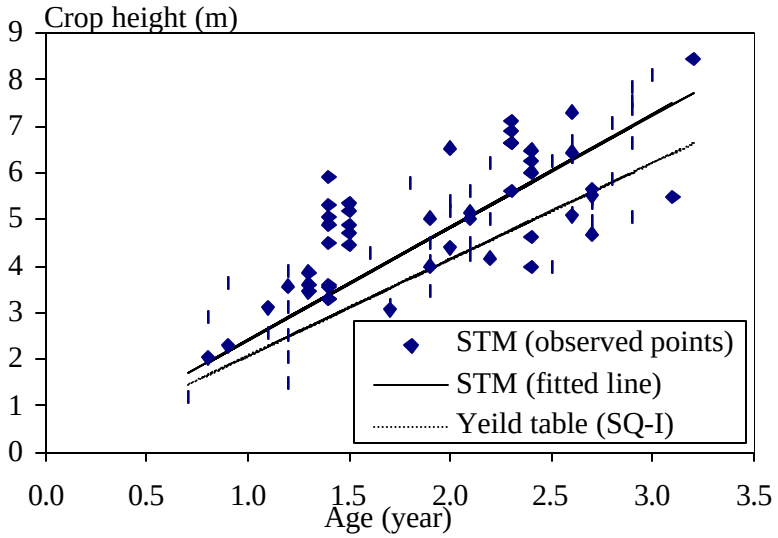


Figure 1. Change in crop height with age in STM plantations in relation to that of All India Yield Table for teak.

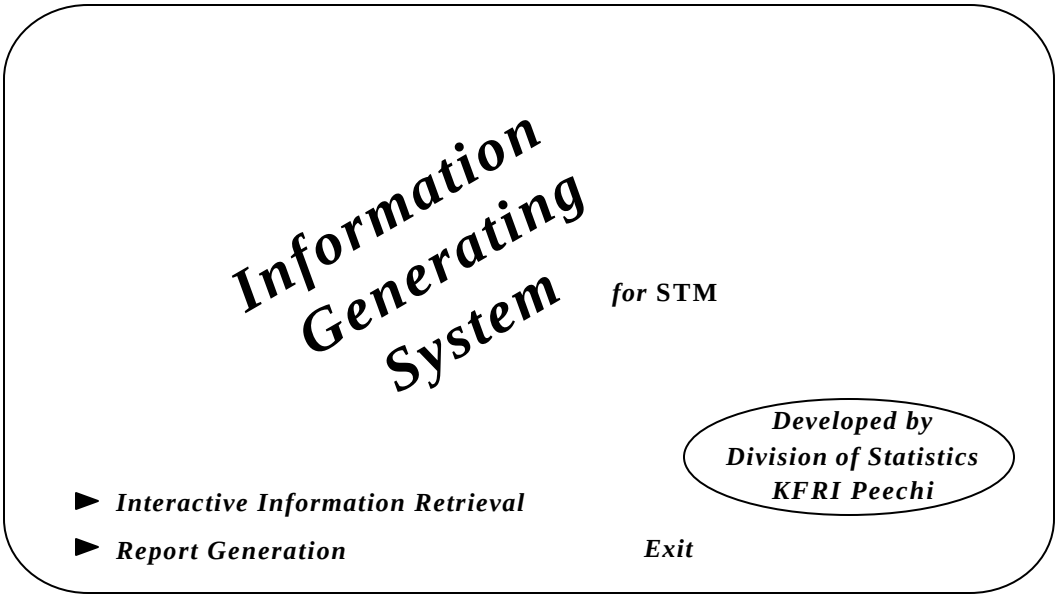
3.2. Information retrieval system

The information retrieval system developed had two major facilities *viz*., interactive information retrieval and report generation. Together they formed the 'Information Generating System'. Through the interactive information retrieval component, it is possible to specify a particular plantation and obtain periodical data on any specified attribute of all blocks in that plantation. The report generation component on the other hand summarizes all the available information pertaining to a particular plantation at a particular measurement time. The latter was the same as that given in Appendix I.

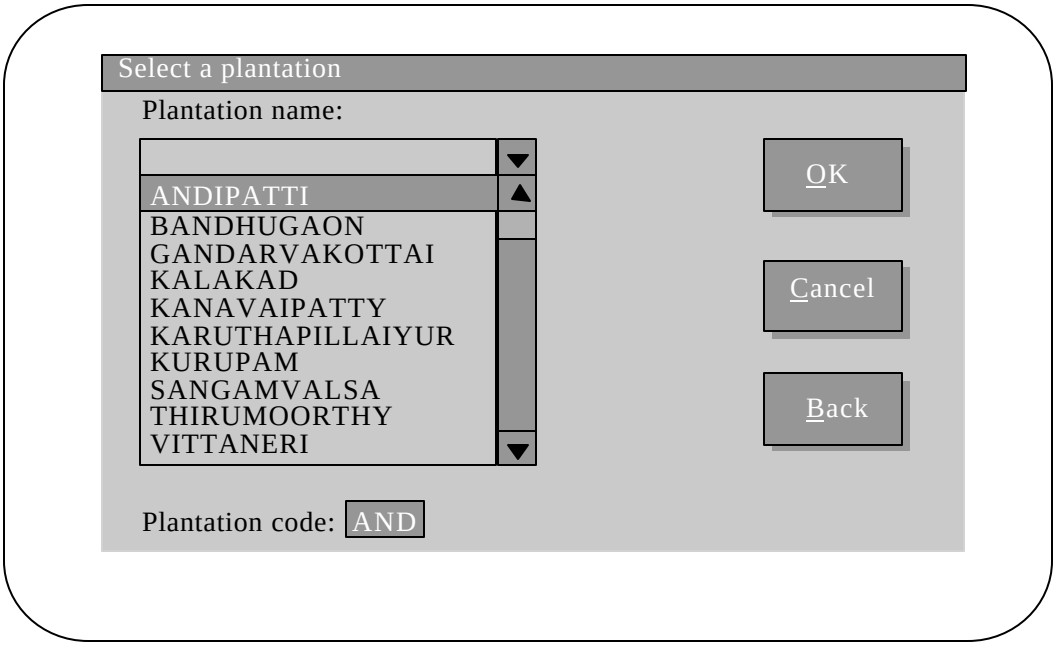
The working of the interactive information retrieval system is illustrated below for the following two cases. The first one retrieves information on the height growth in different years in different blocks of Andipatty plantation. The second case illustrates the retrieval of information on the quantity of fertilizers applied in the same plantation in different years.

Illustration I : Retrieving height data for different blocks of Andipatty plantation

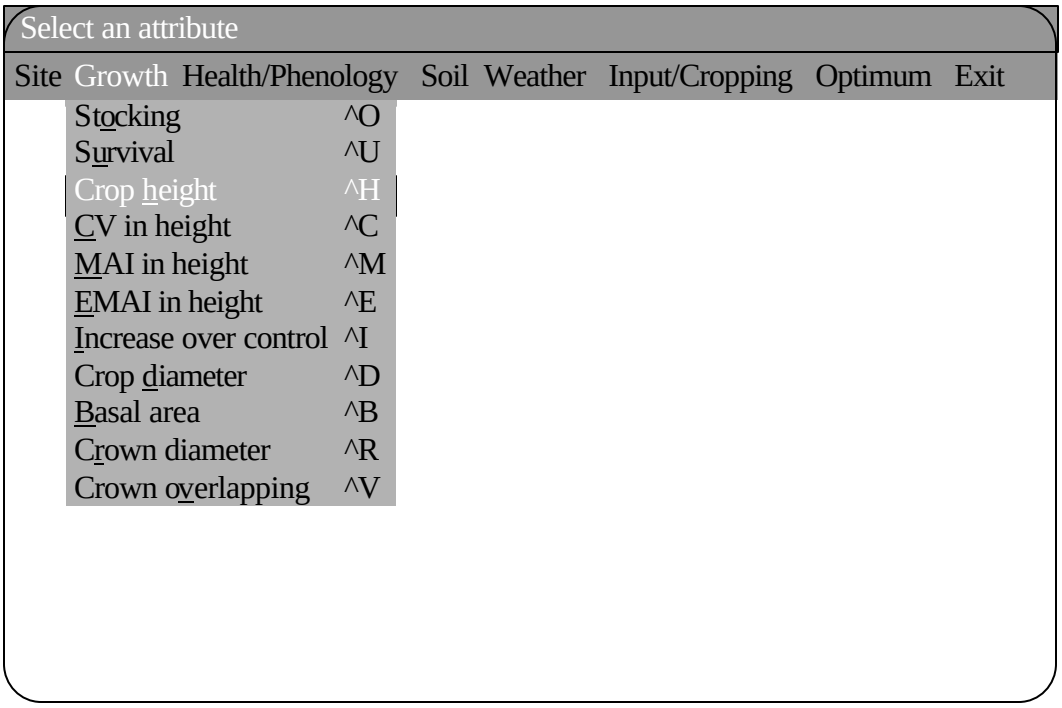
Screen 1 : By clicking the icon for the information generating system on the desktop, the following screen can be obtained. Click on the word *Interactive Information Retrieval* on the logo to get the second screen.



Screen 2 : Select the plantation of interest from the list and click the OK button. Alternatively, the plantation code can be entered followed by clicking of the OK button.



Screen 3 : Select the attribute named 'Growth' from the main menu and obtain the list of related characters. Click on 'Crop height' to get the next screen.



Screen 4 : This screen displays the required information on Andipatty plantation.

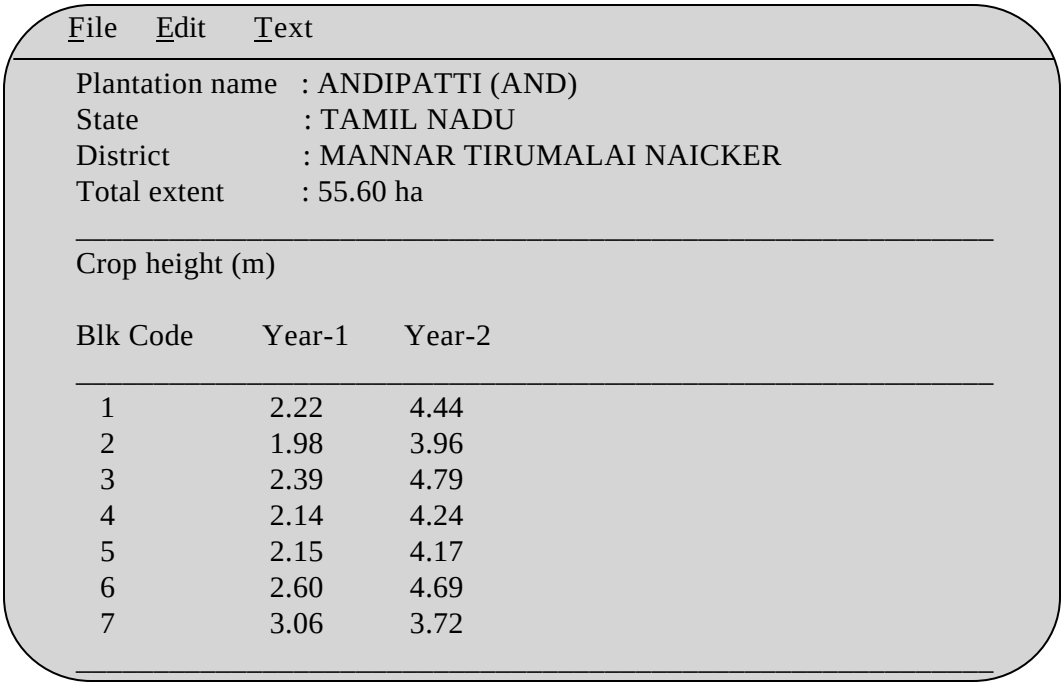
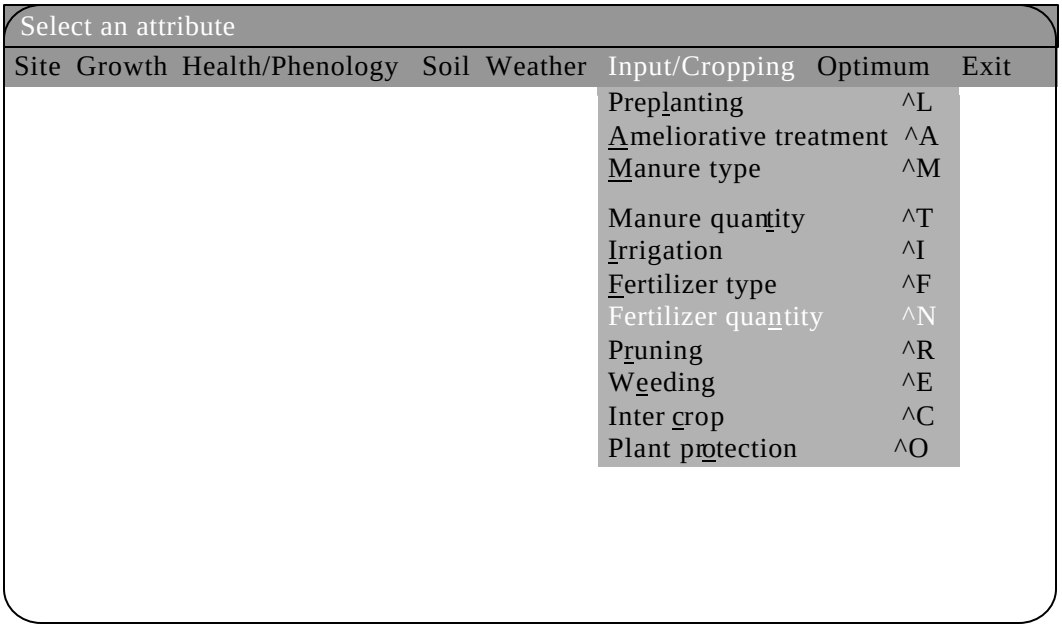


Illustration II : Retrieval of information on the quantity of fertilizers applied in Andipatty plantation in different years.

Screen 1 : If one is continuing from the previous example, just go back to the main menu by closing the last screen shown, choosing the 'Close' option from 'File' menu. If one is starting afresh, then arrive at the main menu by following the initial steps shown under Illustration I. Click on the title, 'Input/Cropping' , and get the list of operations. Choosing the item, 'Fertilizer quantity', will produce the desired information.



Screen 2: This screen displays the quantity of N, P and K applied in different years in Andipatty plantation.

File Edit Text

Plantation name : ANDIPATTI (AND)
State : TAMIL NADU
District : MANNAR TIRUMALAI NAICKER
Total extent : 55.60 ha

Fertilizer Quantity (g/plant)

Blk Code	Year-1			Year-2		
	N	P	K	N	P	K
1	34.50	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	36.80	27.00	30.00
3	36.80	27.00	30.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00

3.3. Optimization of inputs

Although data from many blocks were reported by STM, the complete set of data with respect to the variables shown in Table 3 were available only from 52 blocks with repeated measurements on growth and other characteristics. There were 87 data points for the regression analysis. The range of the individual variables used in the regression is given in Table 3.

Table 3. Range of variables used in the regression.

Variable	Unit	Minimum	Maximum
$x1$: (Age)	year	0	2
$x2$: (Initial crop height)	m	0	5.59
$x3$: (Spacing within rows)	m	1.30	1.80
$x4$: (Spacing between rows)	m	2.50	3.00
$x5$: (Preplanting operations)	yes/no	0	1
$x6$: (Ameliorative treatments)	yes/no	0	1
$x7$: (Organic manure)	kg/plant	0.00	11.00
$x8$: (Water)	l /year	0.00	3276
$x9$: (Fertilizer Nitrogen)	g/plant	0.00	211.60
$x10$: (Fertilizer Phosphorous)	g/plant	0.00	205.20
$x11$: (Fertilizer Potassium)	g/plant	0.00	305.40
$x12$: (Weeding)	yes/no	0	1
$x13$: (Intercrop)	yes/no	0	1
$x14$: (Plant protection)	yes/no	0	1
$x15$: (Pruning)	yes/no	0	1

The results of the stepwise regression obtained through SPSS, connecting the CAI of height with age, initial crop height and the various input variables are given in Table 4.

Table 4. Results of stepwise regression of CAI in height on age, initial crop height and input variables (SPSS output).

Variables in the equation					
Variable	B	SE B	Beta	T	Sig T
$x3$	2.110386	0 .404794	0.392494	5.213	.0000
$x4x5$	0.460216	0.058457	1.000701	7.873	.0000
$x5x5$	1.220880	0.182827	-0.871830	-6.678	.0000
$x8x9$	2.60711E-06	7.8485E-07	0.260793	3.322	.0013
(Constant)	-0.887521	0.602514		-1.473	.1446
Analysis of variance					
Source	DF	Sum of squares	Mean square	F-Value	Prob. F
Regression	4	15.45527	3.86382	25.26575	0.0000
Residual	82	12.54003	0.15293		
Adjusted R square : 0.53022					

The fitted line could thus represented as

$$I_{\bar{h}} = -0.8875 + 2.1104\ x3 + 0.4602\ x4\ x5 - 1.2209\ x5\ x15 + 0.0000026\ x8\ x9$$

where $I_{\bar{h}}$ = CAI in crop height

x's are as explained in Table 3.

About 53 per cent of the variation in CAI in crop height is explained by the variables included in the regression. Age and crop height were absent in the final equation probably due to the poor range and spread of data with respect to these variables. Ideally, these two variables should be forced into the equation for optimization purposes as the interpretation of CAI will always be with reference to a particular age and initial crop status which is an indicator of past management. When these two variables were forced in, they had negative coefficients in the present case and hence were not considered in the final equation.

The variable $x3$ (Spacing within rows) had a linear positive coefficient on height growth indicating the need for larger espacement within rows. Positive interaction was recorded between $x4$ (Spacing between rows) and $x5$ (Preplanting operations) and between $x8$ (Water) and $x9$ (Fertilizer Nitrogen). A positive interaction between two variables in this context is indicative of higher height growth with higher values of any of the component variables in the interaction. A negative interaction was indicated in the cases of interaction between $x5$ (Preplanting operations) and $x15$ (Pruning). Generally higher values for the variables showing negative interactions are likely to bring down the response level. In the specific case mentioned here, preplanting operations combined with pruning is likely to bring down the height growth but in the absence of any one of these operations no specific increase in height is likely to happen.

The above statements were made purely for illustrative purposes. The poor range of data did not permit us to draw any valid conclusion to be used in practical applications. As the results of stepwise regression were not conclusive, no attempts were made to identify the optimum levels. However, similar analysis when conducted on a larger data set will lead to identification of the most relevant set of variables affecting the response. Using the estimated regression equation, optimum levels of inputs can be worked out for any particular site condition within the range of data.

4. CONCLUSIONS

Attempts made to develop a Management Information System for STM plantations and utilize the information obtained for making better management decisions have been described. An effective system for data collection and generation/retrieval of information useful to the management have been proposed and illustrated. It was quite unfortunate that the project had to be terminated in the middle for lack of continued interest from the sponsors. If taken to completion, the study would have led to valuable information on the performance of teak under intensive management and also optimal ways of managing the same. The report however contains descriptions on how such studies can be conducted.

Based on the measurements supplied by STM, it could be seen that height growth of teak under intensive management generally proceeds at a faster rate during the first few years of planting when compared to that obtainable under the best quality plantation sites as per the All India Yield Tables.

5. REFERENCES

Anonymous. 1970. Growth and Yield Statistics of Common Indian Timber Species. Forest Research Institute and Colleges, Dehra Dun. 328 p.

Chaturvedi, A.N. and Khanna, L.S. 1982. Forest Mensuration. International Book Distributors, Dehra Dun. 406 p.

Montgomery , D.C. and Peck, E.A. 1982. Introduction to Linear Regression Analysis. John Wiley and Sons, New York. 504 p.

Montgomery , D.C. 1991. Design and Analysis of Experiments. John Wiley and Sons, New York. 649 p.

APPENDICES

Appendix 1 Summary reports on individual plantations

(Note: Blanks under certain columns in the summary reports are due to non-reporting by STM.)

Plantation Name : ANDIPATTI (AND)
state : TAMIL NADU
District : MANNAR TIRUMALAI NAICKER
Total Extent : 55.60 ha

Growth attributes - I

Pln. Name	Blk No.	Extent (ha)	Spacing (mxm)	Date of planting	Age at counting (year)	Survival (%)	Stocking (trees/ha)
AND	1	9.12	2.70 x 1.50	18/12/94	0.98	100.00	2134
AND	2	8.65	2.70 x 1.50	10/01/95	0.91	100.00	1973
AND	3	6.15	2.70 x 1.50	25/01/95	1.88	100.00	2024
AND	4	6.77	2.70 x 1.50	10/01/95	1.92	100.00	2143
AND	5	8.46	2.70 x 1.50	31/01/95	1.86	100.00	2063
AND	6	11.79	2.70 x 1.50	10/05/95	1.09	100.00	2078
AND	7	2.77	2.70 x 1.50	01/05/96	1.09	100.00	2018

Growth attributes - II

Pln. Name	Blk No.	Age at measu. (year)	Crop ht. (m)	CV in ht. (%)	A(MAI) of ht. (m)	E(MAI) of ht. (m)	Inc.over control (%)
AND	1	1.98	4.3	18	2.21	2.07	7.01
AND	2	2.16	4.2	28	1.97	2.07	-4.61
AND	3	1.88	4.4	17	2.12	2.07	1.62
AND	4	1.92	4.1	19	2.13	2.07	3.16
AND	5	1.86	4.0	19	2.08	2.07	0.74
AND	6	1.56	4.2	21	2.59	2.07	25.20
AND	7	0.76	2.9	30	3.84	2.07	86.61

A(MAI) - Actual mean annual increment
E(MAI) - Expected mean annual increment

Growth attributes - III

Pln. Name	Blk No.	Crop dia. (cm)	Basal area (sq.m/ha)	Crown dia. (m)	Crown overlapping	
					Between row	Within row
AND	1	4.6	3.60	0.00	NO	No
AND	2	4.3	2.88	0.00	No	No
AND	3	4.7	3.58	0.00	NO	No
AND	4	4.3	3.24	0.00	No	No
AND	5	4.5	3.39	0.00	No	No
AND	6	4.3	3.02	0.00	No	No
AND	7	3.5	1.98	0.00	No	No

Health and phenology

Pln. Name	Blk No.	Pest (%)	Disease (%)	Mech. (%)	Forking (%)	Flower (%)	Fruit (%)	Foliage (%)
AND	1	0.00	0.00	0.00	0.00	0.00	0.00	100.00
AND	2	0.00	0.00	0.00	0.00	0.00	0.00	100.00
AND	3	0.00	0.00	0.00	0.00	0.00	0.00	100.00
AND	4	0.00	0.00	0.00	0.00	0.00	0.00	100.00
AND	5	0.00	0.00	0.00	0.00	0.00	0.00	100.00
AND	6	81.01	0.00	0.63	0.00	0.00	0.00	100.00
AND	7	0.00	0.00	0.00	0.00	0.00	0.00	100.00
AND	8	0.00	0.00	0.00	0.00	0.00	0.00	100.00

Soil attributes - I

Pln. Name	Elk No.	Texture	BD (g/cc)	pH	OC (%)	N (kg/ha)	P (kg/ha)	K (kg/ha)
AND	1		0.00	8.20	0.43	214.39	5.68	219.83
AND	2		0.00	7.60	0.48	188.95	5.68	283.30
AND	3		0.00	8.30	0.49	202.78	9.88	263.54
AND	4		0.00	7.30	0.06	170.67	10.62	204.26
AND	5		0.00	7.80	0.12	193.64	7.41	217.36
AND	6		0.00	7.60	0.09	168.70	9.88	209.45
AND	7		0.00	7.20	0.03	159.06	8.64	227.24
AND	8		0.00	0.00	0.00	0.00	0.00	0.00

Soil attributes - II

Pln. Name	Blk No.	Ca (kg/ha)	Mg (&/ha)	Zn (ppm)	Fe (ppm)	Cu (ppm)	Mn (ppm)
AND	1	2125.64	102.71	0.32	3.13	0.56	9.79
AND	2	2182.73	621.69	0.29	5.64	0.58	10.79
AND	3	3511.59	698.26	0.30	3.34	0.59	8.69
AND	4	3053.66	619.22	0.40	5.76	0.73	13.61
AND	5	4661.63	663.68	0.29	4.02	0.90	11.97
AND	6	2779.24	780.02	0.37	4.68	0.61	10.62
AND	7	1260.93	343.33	0.45	5.22	0.45	9.46
AND	8	0.00	0.00	0.00	0.00	0.00	0.00

Weather Details

Pln. Name	Blk No.	Tot.Rain (mm)	Min.Temp. (Deg. Cel)	Max.Temp. (Deg. Cel)	Min.RH (%)	Max.RH (%)	Data Status
AND	1	0	---	---	---	---	Incomplete
AND	2	22	0.00	---	22.00	100.00	Incomplete
AND	3	22	0.00	---	22.00	100.00	Incomplete
AND	4	22	0.00	---	22.00	100.00	Incomplete
AND	5	22	0.00	---	22.00	100.00	Incomplete
AND	6	33	0.00	---	19.00	100.00	Incomplete
AND	7	33	0.00	38.00	14.00	100.00	Incomplete
AND	8	656	0.00	41.50	30.00	100.00	incomplete

Input/Cropping operations during the 1 year of planting - I

Pln. Name	Blk No	Preplanting operations	Irrigation (lt./year)	Fertilizer
AND	1		3927	URE
AND	2		3674	
AND	3		4004	URE,MOP,MRP
AND	4		4004	
AND	5	URE,MOP,MRP	2912	
AND	6	WAT,URE,MOP,MRP,FYM,PMA,CPI,MA	1484	
AND	7		2555	

Input/Cropping operations during the 1 year of planting - II

Pln. Name	Blk No.	Manuring	Pruning
AND	1		Moderate
AND	2	CPI	No
AND	3		Moderate
AND	4		No
AND	5		Moderate
AND	6		No
AND	7		Moderate

Input/Cropping operations during the 1 year of planting - III

Pln. Name	Blk No.	Weeding	Ameliorative treatment
AND	1		
AND	2	Mec	
AND	3		
AND	4	Mec	
AND	5		
AND	6		
AND	7		

Input/Cropping operations during the 1 year of planting - IV

Pln. Name	Blk No.	Intercrop	Plant protection
AND	1		
AND	2		
AND	3		
AND	4		
AND	5		
AND	6	COW	
AND	7	COW	

Plantation Name : BANDHUGAON (BAN)
State : ORISSA
District : KORAPUT
Total Extent : 19.87 ha

Growth attributes - I

Pln. Name	Blk No.	Extent (ha)	Spacing (mxm)	Date of planting	Age at counting (year)	Survival (%)	Stocking (trees/ha)
BAN	1	1.38	2.70 x 1.64	15/01/96	1.22	100.00	2244
BAN	2	12.49	2.70 x 1.64	01/03/96	1.09	100.00	2277

Growth attributes - II

Pln. Name	Blk No.	Age at measu. (year)	crop ht. (m)	CV in ht. (%)	A(MAI) of ht. (m)	E(MAI) of ht. (m)	Inc.over control (%)
BAN	1	1.54	4.7	18	3.08	2.07	48.84
BAN	2	1.40	3.5	30	2.55	2.07	23.46

A(MAI) - Actual mean annual increment
E(MAI) - Expected mean annual increment

Growth attributes - III

Pln. Name	Blk No.	Crop dia. (cm)	Basal area (sq.m/ha)	Crown dia. (m)	Crown overlapping	
					Between row	Within row
BAN	1	4.6	3.89	1.14	No	No
BAN	2	3.7	2.50	1.02	NO	No

Health and phenology

Pln. Name	Blk No.	Pest (%)	Disease (%)	Mech. (%)	Forking (%)	Flower (%)	Fruit (%)	Foliage (%)
BAN	1	0.00	0.00	0.00	0.00	0.00	0.00	100.00
BAN	2	0.00	0.00	0.00	0.00	0.00	0.00	100.00

Soil attributes - I

Pln. Name	Blk No.	Texture	BD (g/cc)	pH	OC (%)	N (kg/ha)	P (kg/ha)	K (kg/ha)
RAN	1	SLO	0.00	6.70	0.28	380.38	9.88	108.68
BAN	2	SLO	0.00	E.50	0.29	303.81	9.88	12.37

Soil attributes - II

Pln. Name	Blk No.	Ca (kg/ha)	Mg (kg/ha)	Zn (ppm)	Fe (ppm)	Cu (ppm)	Mn (ppm)
BAN	1	1631.61	265.52	8.61	33.33	1.37	45.02
BAN	2	1445.69	265.77	6.39	23.16	0.92	3k.29

Weather Details,

Pln. Name	Blk No.	Tot.Rain (mm)	Min.Temp. (Deg. Cel)	Max.Temp. (Deg. Cel)	Min.RH (%)	Max.RH (%)	Data status
BAN	1	599	18.00	32.00	---	---	Incomplete
BAN	2	599	18.00	32.00	---	---	Incomplete

Input/Cropping operations during the 1 year of planting - I

Pln. Name	Blk No	Preplanting operations	Irrigation (lt./year)	Fertilizer
BAN	1	DAI,CCA	1825	DAP,URE,MRP,MOP
BAN	2	DAP,FAR,DAI,CCA	1820	DAP,URE,MRP,MOP,CAN

Input/Cropping operations during the 1 year of planting - II

Pln. Name	Blk No.	Manuring	Pruning
BAN	1	FAR,CPI,HPL	Yes
BAN	2	FAR,CPI,HPL	Yes

Input/Cropping operations during the 1 year of planting - III

Pln. Name	Blk No.	Weeding	Ameliorative treatment
BAN	1		
BAN	2		

Input/Cropping operations during the 1 year of planting - IV

Pln. Name	Blk No.	Intercrop	Plant protection
BAN	1	COW,CHI	
BAN	2	CHI,COW	

Plantation Name : GANDARVAKOTTAI (GKT)
State : TAMILNADU
District : PUDUKOTTAI
Total Extent : 48.59 ha

Growth attributes - I

Pln. Name	Blk No.	Extent (ha)	Spacing (mxm)	Date of planting	Age at counting (year)	Survival (%)	Stocking (trees/ha)
GKT	1	8.34	2.70 x 1.50	01/01/95	2.34	100.00	2468
GKT	2	7.15	2.70 x 1.50	18/01/95	2.30	99.54	2461
GKT	3	6.42	2.10 x 1.50	28/01/95	2.27	99.97	2467
GXT	4	6.11	2.70 x 1.50	25/03/95	2.12	99.94	2448
GKT	5	6.28	2.70 x 1.50	29/01/95	2.28	100.00	2370
GXT	6	6.22	2.70 x 1.50	21/02/95	2.21	100.00	2375
GKT	7	4.00	2.70 x 1.50	11/04/95	2.09	100.00	2470
GKT	8	4.07	3.00 x 1.50	21/01/96	1.31	94.96	2106

Growth attributes - II

Pln. Name	Blk No.	Age at measu. (year)	Crop ht. (m)	CV in ht. (%)	A(MAI) of ht. (m)	E(MAI) of ht. (m)	Inc.over control (%)
GKT	1	2.16	6.2	15	2.86	2.01	38.27
GKT	2	2.12	5.6	18	2.66	2.01	28.33
GKT	3	2.09	5.0	24	2.40	2.07	16.22
GKT	4	1.94	5.0	19	2.59	2.01	25.34
GKT	5	2.09	5.1	17	2.47	2.07	19.26
GKT	6	2.02	5.4	14	2.67	2.07	28.91
GKT	7	1.89	4.5	22	2.38	2.07	15.02
GXT	8	1.11	2.5	44	2.30	2.07	11.30

A(MAI) - Actual mean annual increment
E(MAI) - Expected mean annual increment

Growth attributes - III

Pln. Name	Blk No.	Crop dia. (cm)	Basal area (sq.m/ha)	Crown dia. (m)	Crown overlapping	
					Between row	Within row
GKT	1	5.4	5.71	0.80	No	No
GKT	2	5.0	4.98	0.41	No	No
GKT	3	4.7	4.42	0.44	No	No
GKT	4	4.8	4.50	0.44	No	No
GKT	5	5.0	4.67	0.45	No	No
GKT	6	5.2	5.10	0.49	No	No
GKT	7	4.4	3.90	0.35	No	No
GKT	8	3.1	1.68	0.18	No	No

Health and phenology

Pln. Name	Blk No.	Pest (%)	Disease (%)	Mech. (%)	Forking (%)	Flower (%)	Fruit (%)	Foliage (%)
GKT	1	21.76	0.00	0.00	0.00	0.00	0.00	100.00
GKT	2	14.18	0.00	0.00	0.00	0.00	0.00	100.00
GKT	3	6.76	0.00	0.00	0.00	0.00	0.00	100.00
GKT	4	9.63	0.00	0.00	0.00	0.00	0.00	100.00
GKT	5	5.52	0.00	0.00	0.00	0.00	0.00	100.00
GKT	6	12.85	0.00	0.00	0.00	0.00	0.00	100.00
GKT	7	33.14	0.00	0.00	0.00	0.00	0.00	100.00
GKT	8	32.02	0.00	0.00	0.00	0.00	0.00	100.00

Soil attributes - I

Pln. Name	Blk No.	Texture	BD (g/cc)	pH	OC (%)	N (kg/ha)	P (kg/ha)	K (kg/ha)
GKT	1	SLO	0.00	5.10	0.15	291.46	22.23	98.80
GKT	2	SLO	0.00	4.70	0.25	276.64	29.64	207.48
GKT	3	SLO	0.00	4.90	0.28	276.64	22.23	79.04
GKT	4	SLO	0.00	4.70	0.22	234.65	29.64	98.80
GKT	5	SLO	0.00	5.10	0.22	261.82	14.82	88.92
GKT	6	SLO	0.00	5.00	0.28	261.82	27.17	207.48
GKT	7	SLO	0.00	4.70	0.28	261.82	14.82	79.04
GKT	8	SLO	0.00	4.60	0.28	276.64	24.70	88.92

Soil attributes - II

Pln. Name	Blk No.	Ca (kg/ha)	Mg (kg/ha)	Zn (ppm)	Fe (ppm)	Cu (ppm)	Mn (ppm)
GKT	1	397.67	318.63	0.18	2.42	0.67	18.04
GKT	2	177.84	79.04	0.23	2.66	0.77	23.22
GKT	3	177.84	79.04	0.16	1.31	0.61	11.32
GKT	4	308.75	160.55	0.17	1.54	0.68	11.54
GKT	5	486.59	54.34	0.24	2.34	0.83	15.14
GKT	6	222.30	185.25	0.28	2.74	0.79	23.40
GKT	7	308.75	212.42	0.16	1.07	0.83	3.00
GKT	8	397.67	54.34	0.29	2.92	0.77	26.50

Weather Details

Pln. Name	Blk No.	Tot.Rain (mm)	Min.Temp. (Deg. Cel)	Max.Temp. (Deg. Cel)	Min.RH (%)	Max.RH (%)	Data Status
GKT	1	0	---	---	---	---	incomplete
GKT	2	9	30.00	32.00	30.00	68.00	Incomplete
GKT	3	9	30.00	32.00	30.00	68.00	Incomplete
GRT	4	9	30.00	37.00	24.00	68.00	Incomplete
GKT	5	9	30.00	32.00	30.00	68.00	Incomplete
GKT	6	9	30.00	37.00	30.00	68.00	Incomplete
GRT	7	38	30.00	37.00	24.00	68.00	Incomplete
GRT	8	1177	27.00	38.00	24.00	92.00	Incomplete

Input/Cropping operations during the 1 year of planting - I

Pln. Name	Blk No	Preplanting operations	Irrigation (lt./year)	Fertilizer
GKT	1	/	2912	URE,MRP,MOP
GKT	2		2912	URE,MRP,MOP
GKT	3		2912	URE,MRP,MOP
GKT	4		2920	URE,MRP,MOP
GKT	5		2912	URE,MRP,MOP
GKT	6		2912	URE,MRP,MOP
GKT	7		2920	URE,MRP,MOP
GKT	8		2920	

Input/Cropping operations during the 1 year of planting - II

Pln. Name	Blk No.	Manuring	Pruning
GKT	1	FYM	Moderate
GKT	2	SOM	Moderate
GKT	3	SOM	Moderate
GKT	4	SOM	Moderate
GKT	5	SOM	Moderate
GKT	6	SOM	Moderate
GKT	7	NCA	Moderate
GKT	8	SOM,FYM	Moderate

Input/Cropping operations during the 1 year of planting - III

Pln. Name	Blk No.	Weeding	Ameliorative treatment
GKT	1	Manual	LIM
GKT	2	Manual	LIM
GKT	3	Manual	LIM
GKT	4	Manual	LIM
GKT	5	Manual	LIM
GKT	6	Manual	LIM
GKT	7	Manual	LIM
GKT	8	Manual	

Input/Cropping operations during the 1 year of planting - IV

Pln. Name	Blk No.	Intercrop	Plant protection
GKT	1	QHE	
GKT	2	GHE	
GKT	3		
GKT	4		
GKT	5		
GKT	6		
GKT	7		
GKT	8	GHE	

Plantation Name : KALAKAD (KAL)
State : TAMIL NADU
District : MANNAR TIRUMALAI NAICKER
Total Extent : 47.15 ha

Growth attributes - I

Pln. Name	Blk No.	Extent (ha)	Spacing (mxm)	Date of planting	Age at counting (year)	Survival (%)	Stocking (trees/ha)
KAL	1	5.48	2.50 x 1.80	14/10/95	1.13	100.00	2223
KAL	2	8.51	2.50 x 1.80	25/10/95	1.10	100.00	2224
KAL	3	5.99	2.70 x 1.66	02/11/95	1.08	100.00	2222
KAL	4	5.77	2.70 x 1.66	15/11/95	1.04	100.00	2224
KAL	5	3.40	2.70 x 1.66	02/12/95	1.00	100.00	2223
KAL	6	8.18	2.70 x 1.66	05/01/96	0.90	100.00	2224
KAL	7	4.73	2.70 x 1.66	08/02/96	0.81	100.00	2224
KAL	8	5.09	2.70 x 1.66	16/02/98	0.79	100.00	2222

Growth attributes - II

Pln. Name	Blk No.	Age at measu. (year)	Crop ht. (m)	CV in ht. (%)	A(MAI) of ht. (m)	E(MAI) of ht. (m)	Inc.over control (%)
KAL	1	1.39	5.0	7	3.62	2.07	74.84
KAL	2	1.19	3.5	31	2.61	2.07	25.91
KAL	3	1.16	3.8	21	3.33	2.07	60.66
KAL	4	1.13	3.1	32	2.14	2.07	32.39
KAL	5	1.08	3.6	24	2.06	2.07	38.27
KAL	6	1.17	3.1	21	2.66	2.07	28.43
KAL	7	0.90	2.2	23	2.55	2.07	23.12
KAL	8	0.87	3.6	30	4.15	2.07	100.51

A(MAI) - Actual mean annual increment
E(MAI) - Expected mean annual increment

Growth attributes - III

Pln. Name	Blk No.	Crop dia. (cm)	Basal area (sq.m/ha)	Crown dia. (m)	Crown overlapping	
					Between row	Within row
KAL	1	5.0	4.51	0.42	No	NO
KAL	2	3.7	2.47	0.80	No	NO
KAL	3	4.2	3.11	0.42	NO	NO
KAL	4	3.6	2.39	0.41	No	No
KAL	5	3.8	2.59	0.46	NO	NO
KAL	6	3.3	1.96	0.49	No	NO
KAL	7	2.4	1.05	0.41	No	NO
KAL	8	3.8	2.57	0.50	No	NO

Health and phenology

Pln. Name	Blk No.	Pest (%)	Disease (%)	Mech. (%)	Forking (%)	Flower (%)	Fruit (%)	Foliage (%)
KAL	1	0.00	0.00	0.00	0.00	0.00	0.00	100.00
KAL	2	0.00	0.00	0.00	0.00	0.00	0.00	100.00
KAL	3	0.00	0.00	0.00	0.00	0.00	0.00	100.00
KAL	4	0.00	0.00	0.00	0.00	0.00	0.00	100.00
KAL	5	0.00	0.00	0.00	0.00	0.00	0.00	100.00
KAL	6	0.00	0.00	0.00	0.00	0.00	0.00	100.00
KAL	7	0.00	0.00	0.00	0.00	0.00	0.00	100.00
KAL	8	0.00	0.00	0.00	0.00	0.00	0.00	100.00

Soil attributes - I

Pln. Name	Blk No.	Texture	BD (g/cc)	pH	OC (%)	N (kg/ha)	P (kg/ha)	K (kg/ha)
KAL	1		0.00	6.30	0.10	255.64	2.47	237.12
KAL	2		0.00	6.30	0.06	213.65	3.70	148.20
KAL	3		0.00	6.50	0.12	200.07	4.94	88.92
KAL	4		0.00	6.60	0.11	221.06	7.41	108.68
KAL	5		0.00	6.90	0.11	172.90	2.47	108.68
KAL	6		0.00	6.40	0.25	249.47	2.47	172.90
KAL	7		0.00	5.40	0.21	263.05	6.17	212.42
KAL	8		0.00	6.80	0.19	228.47	2.47	153.14

Soil attributes - II

Pln. Name	Blk No.	Ca (kg/ha)	Mg (kg/ha)	Zn (ppm)	Fe (ppm)	Cu (ppm)	Mn (ppm)
KAL	1	464.36	306.28	0.00	0.00	0.00	0.00
KAL	2	397.67	251.94	0.00	0.00	0.00	0.00
KAL	3	221.06	65.45	0.00	0.00	0.00	0.00
KAL	4	510.05	158.08	0.00	0.00	0.00	0.00
KAL	5	333.45	211.18	0.00	0.00	0.00	0.00
KAL	6	842.27	145.73	0.00	0.00	0.00	0.00
KAL	7	597.74	212.42	0.00	0.00	0.00	0.00
KAL	8	997.88	211.18	0.00	0.00	0.00	0.00

Weather Details

Pln. Name	Blk No.	Tot.Rain (mm)	Min.Temp. (Deg. Cel)	Max.Temp. (Deg. Cel)	Min.RH (%)	Max.RH (%)	Data Status
KAL	1	162	0.00	37.00	0.00	---	Incomplete
KAL	2	162	0.00	37.00	0.00	---	Incomplete
KAL	3	294	0.00	37.00	0.00	---	Incomplete
KAL	4	294	0.00	37.00	0.00	---	Incomplete
KAL	5	506	0.00	37.00	0.00	50.00	Incomplete
KAL	6	506	0.00	37.00	0.00	58.00	Incomplete
KAL	7	506	0.00	37.00	0.00	58.00	Incomplete
KAL	8	506	0.00	37.00	0.00	58.00	Incomplte

Input/Cropping operations during the 1 year of planting - I

Pln. Name	Blk No	Preplanting operations	Irrigation (lt./year)	Fertilizer
KAL	1		2920	URE,SSP,MOP
KAL	2		2920	URE,SSP,MOP
KAL	3		2920	URE,SSP,MOP
KAL	4		2920	URE,SSP,MOP
KAL	5		2912	URE,SSP,MOP
KAL	6		2640	URE,SSP,MOP
KAL	7		2368	URE,SSP,MOP
KAL	8	NCA	2304	URE,SSP,MOP

Input/Cropping operations during the 1 year of planting - II

Pln. Name	Blk No.	Manuring	Pruning
KAL	1	NCA,SOM	Moderate
KAL	2	NCA,SOM	Moderate
KAL	3	NCA,SOM,FYM	Moderate
KAL	4	NCA,SOM,FYM	Moderate
KAL	5	NCA,SOM,FYM	Moderate
KAL	6	NCA	Moderate
KAL	7	FYM,NCA	Moderate
KAL	8	SOM,FYM	Moderate

Input/Cropping operations during the 1 year of planting - III

Pln. Name	Blk No.	Weeding	Ameliorative treatment
KAL	1	Mechanical	
KAL	2	Mechanical	
KAL	3	Mechanical	
KAL	4	Mechanical	
KAL	5	Mechanical	
KAL	6	Mechanical	
KAL	7	Mechanical	
KAL	8	Mechanical	

Input/Cropping operations during the 1 year of planting - IV

Pln. Name	Blk No.	Intercrop	Plant protection
KAL	1		
KAL	2		
KAL	3		
KAL	4		
KAL	5		
KAL	6		
KAL	7		
KAL	8		

Plantation Name : **KANAVAIPATTY (KAN)**
State : **TAMILNADU**
District : **THENI**
Total Extent : 32.75 ha

Growth attributes - I

Pln. Blk Name No.	Extent (ha)	Spacing (mxm)	Date of planting	Age it counting [year]	Survival (%)	Stocking (trees/ha)
KAN 1	1.27	2.70 x 1.66	09/10/95	1.60	92.59	2086
KAN 2	5.96	2.70 x 1.66	29/05/96	0.95	96.83	2046
KAN 3	4.80	2.70 x 1.66	11/10/95	1.55	100.00	1835
KAN 4	5.85	2.70 x 1.66	16/12/95	1.27	100.00	2222
KAN 5	6.15	2.70 x 1.66	07/06/96	0.32	100.00	2220
KAN 6	5.60	2.70 x 1.66	13/11/95	1.38	100.00	2250
KAN 7	3.12	2.70 x 1.66	07/12/95	1.32	100.00	2250

Growth attributes - II

Pln. Blk Name No.	Age at measu. (year)	Crop ht. (m)	CV in ht. (%)	A(MAI) of ht. (m)	E(MAI) of ht. (m)	Inc.over control (%)
KAN 1	1.39	4.4	31	3.22	2.07	55.40
KAN 2	0.76	2.0	33	2.68	2.07	29.49
KAN 3	1.39	3.3	49	2.38	2.07	15.07
KAN 4	1.21	2.0	67	1.70	2.07	-17.97
KAN 5	0.73	1.2	68	1.64	2.07	-20.77
KAN 6	1.30	3.4	36	2.56	2.07	28.33
KAN 7	1.23	3.5	35	2.39	2.07	39.67

A(MAI) - Actual mean annual increment
E(MAI) - Expected mean annual increment

Growth attributes - III

Pln. Blk Name No.	Crop dia. (cm)	Basal area (sq.m/ha)	Crown dia. (m)	Crown overlapping	
				Between row	Within row
KAN I	4.3	3.08	0.00	No	No
KAN 2	2.2	0.83	0.00	NO	No
KAN 3	3.5	1.85	0.00	No	No
KAN 4	2.3	0.93	0.00	No	No
KAN 5	1.5	0.43	0.00	No	No
KAN 6	3.7	2.47	0.00	No	No
KAN 7	3.9	2.68	0.00	No	No

Health and phenology

Pln. Name	Blk No.	Pest (I)	Disease (%)	Mech. (%)	Forming (%)	Flower (%)	Fruit (%)	Foliage (%)
KAN	1	0.00	0.00	[illegible]	0.00	0.00	0.00	100.00
KAN	2	0.00	0.00	[illegible]	0.00	0.00	0.00	100.00
KAN	3	0.00	0.00	[illegible]	0.00	0.00	0.00	100.00
KAN	4	0.00	0.00	[illegible]	0.00	0.00	0.00	100.00
KAN	5	0.00	0.00	[illegible]	0.00	0.00	0.00	100.00
KAN	6	0.00	0.00	[illegible]	0.00	0.00	0.00	100.00
KAN	7	0.00	0.00	[illegible]	0.00	0.00	0.00	100.00

Soil attributes - I

Pln. Name	Blk No.	Texture	BD (g/cc)	pH	OC (%)	N (kg/ha)	P (kg/ha)	K (kg/ha)
KAN	1		[illegible]	8.40	0.41	387.79	9.88	424.84
KAN	2		[illegible]	8.20	0.21	442.13	24.70	582.92
KAN	3		[illegible]	8.00	0.14	330.98	9.88	207.48
KAN	4		[illegible]	6-90	0.17	400.14	4.94	296.40
KAN	5		[illegible]	7.20	0.21	345.80	4.94	296.40
KAN	6		[illegible]	8.00	0.12	414.96	7.41	345.80
KAN	7		[illegible]	8.00	0.24	414.96	7.41	345.80

Soil attributes - II

Pln. Name	Blk No.	Ca (kg/ha)	Mg (kg/ha)	Zn (ppm)	Fe (ppm)	Cu (ppm)	Mn (ppm)
KAN	1	2257.58	810.09	1.04	2.80	3.48	19.32
KAN	2	11065.60	531.05	[illegible]	2.58	2.12	14.62
KAN	3	1284.40	54.34	[illegible]	4.45	1.57	13.62
KAN	4	1195.48	160.55	[illegible]	11.64	1.66	23.36
KAN	5	1151.02	318.63	[illegible]	13.30	1.84	20.42
KAN	6	1459.77	424.84	[illegible]	5.28	0.94	16.56
KAN	7	1904.37	790.40	[illegible]	5.30	0.88	15.00

Weather Details

Pln. Name	Blk No.	Tot.Rain (mm)	Min.Temp. (Deg. Cel)	Max.Temp. (Deg. Cel)	Min.RH (%)	Max.RH (%)	Data status
KAN	1	476	0.00	[illegible]	0.00	98.00	Incomplete
KAN	2	308	0.00	[illegible]	0.00	82.00	Incomplete
KAN	3	476	0.00	[illegible]	0.00	98.00	Incomplete
KAN	4	493	0.00	[illegible]	0.00	98.00	Incomplete
KAN	5	287	0.00	[illegible]	0.00	82.00	Incomplete
KAN	6	493	0.00	[illegible]	0.00	98.00	Incomplete
KAN	7	493	0.00	[illegible]	0.00	98.00	Incomplete

Input/Cropping operations during the 1 year of planting - I

Pln. Name	Blk No	Preplanting operations	Irrigation (lt./year)	Fertilizer
KAN	1		1352	COM,URE
KAN	2		1354	URE,SSP,MOP
KAN	3		1460	URE,SSP,MOP
KAN	4		524	URE
KAN	5	FYM	588	FAC
KAN	6		0	
KAN	7		0	

Input/Cropping operations during the 1 year of planting - II

Pln. Name	Blk No.	Manuring	Pruning
KAN	1	SOM,FYM	Moderate
KAN	2	FYM	Moderate
KAN	3	FYM	Moderate
KAN	4	FYM	Moderate
KAN	5	FYM	Moderate
KAN	6		No
KAN	7		No

Input/Cropping operations during the 1 year of planting - III

Pln. Name	Blk No.	Weeding	Ameliorative treatment
KAN	1	Strip,Manual	
KAN	2	Manual,Chemical	
KAN	3	Manual	
KAN	4	Manual	
KAN	5	Manual,Chemical	
KAN	6		
KAN	7		

Input/Cropping operations during the 1 year of planting - IV

Pln. Name	Blk No.	Intercrop	Plant protection
KAN	1		
KAN	2		
KAN	3		
KAN	4		
KAN	5		
KAN	6		
KAN	7		

Plantation Name : KARUTHAPILLAIYUR (KPR)
State : TAMILNADU
District : TIRUNELVELI
Total Extent : 33.89 ha

Growth attributes - I

Pln. Name	Blk No.	Extent (ha)	Spacing (mxm)	Date of planting	Age at counting (year)	Survival (%)	Stocking (trees/ha)
KPR	1	5.74	2.50 x 1.30	16/11/94	2.70	99.77	3065
KPR	2	5.72	2.50 x 1.30	09/04/95	2.22	99.80	3064
KPR	3	7.73	2.50 x 1.30	27/04/95	2.17	98.37	3025
KPR	4	5.76	2.50 x 1.30	10/02/95	2.38	99.50	3057
KPR	5	7.03	2.50 x 1.30	23/08/95	1.85	99.57	3062
KPR	6	1.91	2.50 x 1.30	03/05/96	1.16	98.96	2595

Growth attributes - II

Pln. Name	Blk No.	Age at measu. (year)	Crop ht. (m)	CV in ht. (%)	A(MAI) of ht. (m)	E(MAI) of ht. (m)	Inc.over control (%)
KPR	1	2.62	5.0	13	1.93	2.07	-6.64
KPR	2	2.23	5.0	18	2.25	2.07	8.60
KPR	3	2.18	4.1	24	1.91	2.07	-7.60
KPR	4	2.39	4.6	18	1.93	2.07	-6.49
KPR	5	1.88	3.4	28	1.87	2.07	-9.68
KPR	6	1.16	2.5	27	2.17	2.07	5.13

A(MAI) - Actual mean annual increment
E(MAI) - Expected mean annual increment

Growth attributes - III

Pln. Name	Blk No.	Crop dia. (cm)	Basal area (sq.m/ha)	Crown dia. (m)	Crown overlapping	
					Between row	Within row
KPR	1	5.1	6.36	1.69	No	Yes
KPR	2	4.9	5.81	1.72	No	Yes
KPR	3	4.1	4.15	1.53	No	Yes
KPR	4	4.6	5.21	1.67	No	Yes
KPR	5	4.0	3.92	1.16	No	No
KPR	6	2.5	1.37	0.90	No	No

Health and phenology

Pln. Name	Blk No.	Pest (%)	Disease (%)	Mech. (%)	Forking (%)	Flower (%)	Fruit (%)	Foliage (%)
KPR	1	0.00	0.00	0.00	0.00	0.00	0.00	100.00
KPR	2	0.00	0.00	0.00	0.00	0.00	0.00	100.00
KPR	3	0.00	0.00	0.00	0.00	0.00	0.00	100.00
KPR	4	0.00	0.00	0.00	0.00	0.00	0.00	100.00
KPR	5	0.00	0.00	0.00	0.00	0.00	0.00	100.00
KPR	6	0.00	0.00	0.00	0.00	0.00	0.00	100.00

Soil attributes - I

Pln. Name	Blk No.	Texture	BD (g/cc)	pH	OC (%)	N (kg/ha)	P (kg/ha)	K (kg/ha)
KPR	1	CLO	0.00	6.30	0.26	330.98	7.41	98.80
KPR	2	CLO	0.00	6.60	0.16	318.63	0.00	138.32
KPR	3	CLO	0.00	6.00	0.22	345.80	12.35	118.56
KPR	4	CLO	0.00	6.40	0.22	330.98	4.94	276.64
KPR	5	m	0.00	6.20	0.22	318.63	7.41	276.64
KPR	6	CLO	0.00	6.80	0.13	360.62	2.47	207.18

Soil attributes - II

Pln. Name	Blk No.	Ca (kg/ha)	Mg (kg/ha)	Zn (ppm)	Fe (ppm)	Cu (ppm)	Mn (ppm)
KPR	1	1768.52	264.29	0.56	11.12	0.48	26.70
KPR	2	706.42	293.93	0.67	11.06	0.48	23.94
KPR	3	726.18	452.01	0.56	12.72	0.65	30.80
KPR	4	928.12	558.22	0.39	13.30	0.76	31.96
KPR	5	839.80	345.80	0.22	8.42	0.52	20.38
KPR	6	706.42	397.67	0.30	7.52	0.40	18.74

Weather Details

Pln. Name	Blk No.	Tot.Rain (mm)	Min.Temp. (Deg. Cel)	Max.Temp. (Deg. Cel)	Min.RH (%)	Max.RH (%)	Data status
KPR	1	0	---	---	---	---	Incomplete
KPR	2	0	---	---	---	---	Incomplete
m	3	0	---	---	---	---	Incomplete
KPR	4	0	---	---	---	---	Incomplete
KPR	5	0	---	---	---	---	Incomplete
KPR	6	35	0.00	44.00	35.00	92.00	Incomplete

Input/Cropping operations during the 1 year of planting - I

Pln. Name	Blk No	Preplanting operations	Irrigation (lt./year)	Fertilizer
KPR	1		1456	
KPR	2		1460	
KPR	3		1460	
KPR	4		1466	
KPR	5		1460	
KPR	6		972	

Input/Cropping operations during the 1 year of planting - II

Pln. Name	Blk No.	Manuring	Pruning
KPR	1		No
KPR	2		No
KPR	3	CPI	No
KPR	4	CPI	No
KPR	5		No
KPR	6	CPI,FYM	No

Input/Cropping operations during the 1 year of planting - III

Pln. Name	Blk No.	Weeding	Ameliorative treatment
KPR	1		
KPR	2		
KPR	3		
KPR	4		
KPR	5		
KPR	6	Mechanical	

Input/Cropping operations during the 1 year of planting - IV

Pln. Name	Blk No.	Intercrop	Plant protection
KPR	1		
KPR	2		
KPR	3		
KPR	4		
KPR	5		
KPR	6		

Plantation Name : KURUPAM (KUR)
State : ANDHRA PRADESH
District : VIJAYANAGAARAM
Total Extent : 62.88 ha

Growth attributes - I

Pln. Name	Blk No.	Extent (ha)	Spacing (mxm)	Date of planting	Age at counting (year)	Survival (%)	Stocking (trees/ha)
KUR	1	10.53	2.70 x 1.50	30/08/95	0.60	100.00	1722
KUR	2	8.77	2.70 x 1.50	28/09/96	0.42	100.00	1171
BUR	3	13.67	2.70 x 1.60	06/09/96	0.50	100.00	2264
KUR	A	8.37	2.70 x 1.50	20/09/95	0.46	100.00	2246
KUR	5	8.68	2.70 x 1.60	23/08/95	0.38	100.00	1932
KUR	8	12.86	2.70 x 1.60	22/09/96	0.41	100.00	1270

Growth attributes - II

Pln. Name	Blk No.	Age at measu. (year)	Crop ht. (m)	CV in ht. (%)	A(MAI) of ht. (m)	E(MAI) of ht. (m)	Inc.over control (%)
KUR	1	1.43	4.9	12	3.42	2.07	66.10
KUR	2	1.36	5.9	7	4.33	2.07	109.16
B U R	3	1.43	6.3	16	3.71	2.07	78.28
KUR	4	1.37	4.8	17	3.36	2.07	61.82
KUR	5	1.45	5.1	9	3.57	2.07	72.68
KUR	8	1.46	6.3	13	3.67	2.07	77.08

A(MAI) - Actual m a n annual increment
E(MAI) - Expected m a n annual increment

Growth attributes - III

Pln. Name	Blk No.	Crop dia. (cm)	Basal area (sq.m/ha)	Crown dia. (m)	Crown overlapping	
					Between row	Within row
KUR	1	4.5	2.81	0.00	No	No
KUR	2	5.5	2.82	0.00	No	No
KUR	3	4.9	4.36	0.00	No	No
KUR	4	4.9	4.30	0.00	No	No
KUR	5	4.7	3.44	0.00	No	No
KUR	6	4.8	2.36	0.00	No	No

Health and phenology

Pln. Name	Blk No.	Pest (%)	Disease (%)	Mech. (%)	Forking (%)	Flower (%)	Fruit (%)	Foliage (%)
KUR	1	0.00	0.00	0.00	0.00	0.00	0.00	100.00
KUR	2	0.00	0.00	0.00	0.00	0.00	0.00	100.00
KUR	3	0.00	0.00	0.00	0.00	0.00	0.00	100.00
KUR	4	0.00	0.00	0.00	0.00	0.00	0.00	100.00
KUR	5	0.00	0.00	0.00	0.00	0.00	0.00	100.00
KUR	6	0.00	0.00	0.00	0.00	0.00	0.00	100.00

Soil attributes - I

Pln. Name	Blk No.	Texture	BD (g/cc)	pH	OC (%)	N (kg/ha)	P (kg/ha)	K (kg/ha)
KUR	1		0.00	6.10	0.22	261.82	2.47	128.44
KUR	2		0.00	5.80	0.25	234.65	7.41	118.56
KUR	3		0.00	5.60	0.22	20.74	2.47	118.56
KUR	4		0.00	7.10	0.40	318.63	2.47	286.52
KUR	5		0.00	5.80	0.22	261.82	2.47	167.96
KUR	6		0.00	6.00	0.31	360.62	7.41	177.84

Soil attributes - II

Pln. Name	Blk No.	Ca (kg/ha)	Mg (kg/ha)	Zn (ppm)	Fe (ppm)	Cu (ppm)	Mn (ppm)
KUR	1	1328.86	291.46	0.00	0.00	0.00	0.00
KUR	2	531.05	266.76	0.00	0.00	0.00	0.00
KUR	3	664.43	79.04	0.00	0.00	0.00	0.00
KUR	4	664.43	318.63	0.00	0.00	0.00	0.00
KUR	5	664.43	345.80	0.00	0.00	0.00	0.00
KUR	6	1017.64	424.84	0.00	0.00	0.00	0.00

Weather Details

Pln. Name	Blk No.	Tot.Rain (mm)	Min.Temp. (Deg. Cel)	Max.Temp. (Deg. Cel)	Min.RH (%)	Max.RH (%)	Data Status
KUR	1	752	0.00	30.00	0.00	---	Incomplete
KUR	2	862	0.00	30.00	0.00	---	Incomplete
KUR	3	862	0.00	30.00	0.00	---	Incomplete
KUR	4	862	0.00	30.00	0.00	---	Incomplete
KUR	5	752	0.00	30.00	0.00	---	Incomplete
KUR	6	752	0.00	30.00	0.00	---	Incomplete

Input/Cropping operations during the 1 year of planting - I

Pln. Name	Blk No	Preplanting operations	Irrigation (lt./year)	Fertilizer
KUR	1	WAT,SOM,LIM	416	URE,MRP,MOP
KUR	2	WAT,SOM,LIM	358	URE,MRP,MOP
KUR	3	WAT,SOM,LIM	434	URE,MRP,MOP
KUR	4	WAT,LIM	404	URE,MRP,MOP
KUR	5	WAT,MOP,LIM	130	URE,MRP,MOP
KUR	6	WAT,LIM	192	URE,MRP,MOP

Input/Cropping operations during the 1 year of planting - II

Pln. Name	Blk No.	Manuring	Pruning
KUR	1	SOM	No
KUR	2	SOM	No
KUR	3	SOM	No
KUR	4	SOM	No
KUR	5	COM	No
KUR	6	COM	No

Input/Cropping operations during the 1 year of planting - III

Pln. Name	Blk No.	Weeding	Ameliorative treatment
KUR	1		
KUR	2		
KUR	3		
KUR	4		
KUR	5		
KUR	6		

Input/Cropping operations during the 1 year of planting - IV

Pln. Name	Blk No.	Intercrop	Plant protection
KUR	1	RGR,COW,BGR	
KUR	2	BGR	
KUR	3	GGR,COW,RGR	
KUR	4	COW,CHI	
KUR	5		
KUR	6	RGR,GGR	

Plantation Name : SANGAMVALSA (SAN)
State : ANDHRA PRADESH
District : VIJAYANAGARAM
Total Extent : 82.15 ha

Growth attributes - I

Pln. Name	Blk No.	Extent (ha)	Spacing (mxm)	Date of planting	Age at counting (year)	Survival (%)	Stocking (trees/ha)
SAN	1	4.70	2.70 x 1.50	19/12/94	1.29	99.74	2087
SAN	2	12.28	2.70 x 1.50	04/09/94	1.58	98.54	2253
SAN	3	12.36	2.70 x 1.60	29/12/94	1.26	97.58	2304
SAN	4	10.78	2.70 x 1.60	27/12/94	1.27	99.88	2448
SAN	6	7.98	2.70 x 1.50	30/12/94	1.26	99.77	2094
SAN	6	6.75	2.70 x 1.50	11/02/96	1.13	97.88	2319
SAN	7	11.49	2.70 x 1.50	20/04/95	0.96	99.97	2425
SAN	8	15.82	2.70 x 1.50	13/07/95	0.73	99.97	2140

Growth attributes - II

Pln. Name	Blk No.	Age at measu. (year)	Crop ht. (m)	CV in ht. (%)	A(MAI) of ht. (m)	E(MAI) of ht. (m)	Inc.over control (%)
SAN	1	2.02	7.3	13	2.80	2.07	36.38
B A N	2	2.92	7.8	10	2.10	2.07	30.26
SAN	3	2.60	8.8	11	2.59	2.07	24.98
SAN	4	2.60	6.3	13	2.43	2.07	17.57
SAN	6	2.00	6.4	12	2.48	2.07	19.84
SAN	0	2.44	0.2	13	2.56	2.07	23.03
SAN	7	2.28	5.0	17	2.47	2.07	19.55
SAN	8	2.06	6.1	20	2.54	2.07	22.79

A(MAI) - Actual =man annual increment
E(MAI) - Expected mean annual increment

Growth attributes - III

Pln. Name	Blk No.	Crop dia. (cm)	Basal area (sq.m/ha)	Crown dia. (m)	Crown overlapping	
					Between row	Within row
SAN	1	6.5	7.04	1.01	No	No
SAN	2	6.9	8.55	1.06	No	No
SAN	3	6.0	6.87	0.84	No	No
SAN	4	5.5	5.98	1.11	No	No
SAN	5	5.9	5.74	1.18	No	No
SAN	6	5.7	5.92	0.95	No	No
SAN	7	5.0	4.80	1.02	No	No
SAN	8	4.6	3.67	1.01	No	No

Health and phenology

Pln. Name	Blk No.	Pest (%)	Disease (%)	Mech. (%)	Forking (%)	Flower (%)	Fruit (%)	Foliage (%)
SAN	1	0.00	0.00	0.00	0.00	0.00	0.00	100.00
SAN	2	0.00	0.00	0.00	0.00	0.00	0.00	100.00
SAN	3	0.00	0.00	0.00	0.00	0.00	0.00	100.00
SAN	4	0.00	0.00	0.00	0.00	0.00	0.00	100.00
SAN	5	0.00	0.00	0.00	0.00	0.00	0.00	100.00
SAN	6	0.00	0.00	0.00	0.00	0.00	0.00	100.00
SAN	7	0.00	0.00	0.00	0.00	0.00	0.00	100.00
SAN	8	0.00	0.00	0.00	0.00	0.00	0.00	100.00

Soil attributes - I

Pln. Name	Blk No.	Texture	BD (g/cc)	pH	OC (%)	N (kg/ha)	P (kg/ha)	K (kg/ha)
SAN	1	SLO	0.00	6.30	0.26	469.30	19.76	167.96
SAN	2	SLO	0.00	5.70	0.19	345.80	22.23	170.43
EM	3	CLO	0.00	5.60	0.26	363.09	12.35	138.32
EM	4	SLO	0.00	5.80	0.25	387.79	34.58	113.62
SAN	5	SLO	0.00	5.80	0.21	318.63	19.76	98.80
SAN	6	SLO	0.00	5.50	0.32	375.44	19.76	123.50
SAN	7	SLO	0.00	5.50	0.15	333.45	19.76	83.98
SAN	8	SLO	0.00	5.40	0.29	335.92	17.29	138.32

Soil attributes - II

Pln. Name	Blk No.	Ca (kg/ha)	Mg (kg/ha)	Zn (ppm)	Fe (ppm)	Cu (ppm)	Mn (ppm)
SAN	1	884.26	212.12	0.71	11.26	1.26	26.36
SAN	2	197.81	284.05	0.71	12.27	0.84	47.81
SAN	3	1711.71	462.01	0.85	13.99	1.08	55.81
SAN	4	1440.01	412.49	5.88	11.13	0.84	38.31
SAN	5	686.66	306.28	0.62	10.50	0.54	34.83
SAN	6	1128.79	279.11	0.72	11.92	1.12	60.17
SAN	7	797.81	385.32	1.31	16.09	0.80	5.62
SAN	8	812.63	291.46	3.81	13.79	1.01	52.87

Heather Details

Pln. Name	Blk No.	Tot.Rain (mm)	Min.Temp. (Deg. Cel)	Max.Temp. (Deg. Cel)	Min.RH (%)	Max.RH (%)	Data Status
SAN	1	0	—	—	—	—	Incomplete
SAN	2	0	—	—	—	—	Incomplete
SAN	3	0	—	—	—	—	Incomplete
SAN	4	0	—	—	—	—	Incomplete
SAN	5	0	—	—	—	—	Incomplete
SAN	6	0	16.00	34.00	15.00	100.00	Incomplete
SAN	7	38	16.00	38.00	11.00	100.00	Incomplete
SAN	8	291	16.00	42.00	11.00	100.00	Incomplete

Input/Cropping operations during the 1 year of planting - I

Pln. Name	Blk No	Preplanting operations	Irrigation (lt./year)	Fertilizer
SAN	1		3640	VAM,DSP,MSP,URE,MRP,SSP
SAN	2		3640	VAM,DSP,MSP,URE,MRP
SAN	3		3640	VAM,DSP,MSP,URE,MRP
SAN	4		3640	MRP,VAM,DAP,MOP,URE
SAN	5		3640	MRP,VAM,DAP,MOP,SSP,URE
SAN	6	SEV	3640	DAP,VAM,MOP,MRP,URE
SAN	7	CCA	3650	VAM,MOP,DAP,URE,MRP
SAN	8		1460	VAM,DAP,URE,MRP,MOP

Input/Cropping operations during the 1 year of planting - II

Pln. Name	Blk No.	Manuring	Pruning
SAN	1	SOM	Severe
SAN	2	SOM	Severe
SAN	3	SOM	Severe
SAN	4	SOM	Severe
SAN	5	SOM	Severe
SAN	6	SOM	Severe
SAN	7		Severe
SAN	8	FAR	Severe

Input/Cropping operations during the 1 year of planting - III

Pln. Name	Blk No.	Weeding	Ameliorative treatment
SAN	1	Manual,Mechanical	CCA,RPH
SAN	2	Manual	CCA,RPH
SAN	3	Manual,Mechanical	CCA
SAN	4	Manual,Mechanical	CCA
SAN	5	Manual,Mechanical	CCA
SAN	6	Manual,Mechanical	CCA
SAN	7	Manual,Mechanical	CCA
SAN	8	Manual,Mechanical	CCA

Input/Cropping operations during the 1 year of planting - IV

Pln. Name	Blk No.	Intercrop	Plant protection
SAN	1	GGR	
SAN	2		
SAN	3	GGR	
SAN	4		
SAN	5		
SAN	6		
SAN	7	GGR	
SAN	8	MES,NIG	

Plantation Name : THIRUMOORTHY (TIR)
State : TAMILNADU
District : COIMBATORE
Total Extent : 53.75 ha

Growth attributes - I

Pln. Name	Blk No.	Extent (ha)	Spacing (mxm)	Date of planting	Age at counting (year)	Survival (%)	Stocking (trees/ha)
TIR	1	5.74	3.00 x 1.50	19/10/96	0.41	100.00	1783
TIR	2	4.64	2.75 x 1.64	27/09/96	0.47	100.00	2485
TIR	3	4.33	2.75 x 1.64	31/07/96	0.45	100.00	1745
TIR	4	6.54	2.75 x 1.64	07/12/95	1.01	100.00	1977
TIR	5	4.09	2.76 x 1.64	17/10/96	1.02	100.00	1809
TIR	6	3.40	2.76 x 1.64	16/08/96	0.32	100.00	2072
TIR	7	6.64	3.00 x 1.60	30/10/96	0.11	100.00	1998
TIR	8	6.66	3.00 x 1.60	04/10/96	0.18	100.00	1987
TIR	11	6.88	3.00 x 1.60	09/11/96	0.09	100.00	1747
TIR	12	6.94	3.00 x 1.50	06/11/96	0.09	100.00	1988

Growth attributes - II

Pln. Name	Blk No.	Age at measu. (year)	Crop ht. (m)	CV in ht. (%)	A(MAI) of ht. (m)	E(MAI) of ht. (m)	Inc.over control (%)
TIR	1	0.00	0.0	0	0.00	2.07	***.**
TIR	2	0.00	0.0	0	0.00	2.07	***.**
TIR	3	0.00	0.0	0	0.00	2.07	***.**
TIR	4	1.23	1.4	61	1.21	2.07	-41.47
TIR	5	0.00	0.0	0	0.00	2.07	***.**
TIR	6	0.00	0.0	0	0.00	2.07	***.**
TIR	7	0.00	0.0	0	0.00	2.07	***.**
TIR	8	0.00	0.0	0	0.00	2.07	***.**
TIR	11	0.00	0.0	0	0.00	2.07	***.**
TIR	12	0.00	0.0	0	0.00	8.07	***.**

A(MAI) - Actual mean annual increment
E(MAI) - Expected mean annual increment

Growth attributes - III

Pln. Name	Blk No.	Crop dia. (cm)	Basal area (sq.m/ha)	Crown dia. (m)	Crom overlapping	
					Between row	Within row
TIR	1	0.0	0.00	0.00	No	No
TIR	2	0.0	0.00	0.00	No	No
TIR	3	0.0	0.00	0.00	No	No
TIR	4	1.8	0.52	0.00	No	No
TIR	5	0.0	0.00	0.00	No	No
TIR	6	0.0	0.00	0.00	No	No
TIR	7	0.0	0.00	0.00	No	No
TIR	8	0.0	0.00	0.00	No	No
TIR	11	0.0	0.00	0.00	No	No
TIR	12	0.0	0.00	0.00	No	No

Health and phenology

Pln. Name	Blk No.	Peat (%)	Disease (%)	Mech. (%)	Forking (%)	Flower (XI	Fruit (%)	Foliage (%)
TIR	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TIE	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TIE	3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TIR	4	0.00	0.00	0.00	0.00	0.00	0.00	100.00
TIR	5	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TIE	6	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TIE	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TIE	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TIE	11	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TIE	12	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Soil attributes - I

Pln. Name	Blk No.	Texture	BD (g/cc)	pH	OC (%)	N (kg/ha)	P (kg/ha)	K (kg/ha)
TIE	1	SL	0.00	7.00	0.13	249.47	2.41	98.80
TIE	2	SL and CL	0.00	7.10	0.13	222.30	2.47	138.32
TIR	3	Clay	0.00	7.80	0.16	222.30	2.47	326.04
TIE	4	CL	0.00	8.20	0.51	249.47	2.47	701.48
TIR	5	Clay and CL	0.00	7.10	0.29	261.82	4.94	464.36
TIR	6	Clay and Cl	0.00	7.50	0.22	249.47	2.47	217.36
TIR	7	Clay	0.00	6.70	0.22	303.81	0.00	375.44
TIE	8	Clay	0.00	7.20	0.26	249.41	4.94	355.68
TIP.	11	SL	0.00	7.80	0.03	209.95	2.47	158.08
TIP.	12	CL and SL	0.00	6.80	0.03	291.46	4.94	128.44

Soil attributes - II

Pln. Name	Blk No.	Ca (kg/ha)	Mg (kg/ha)	Zn (ppm)	Fe (ppm)	Cu (ppm)	Mn (ppm)
TIE	1	2479.88	391.67	0.22	4.20	0.65	6.69
TIR	2	1328.86	424.84	0.25	4.51	0.77	11.39
TIE	3	4707.82	1089.27	0.25	1.04	0.94	9.40
TIR	4	4381.78	143.47	0.38	1.80	0.74	9.64
TIE	5	3806.27	503.88	0.30	8.17	0.55	4.58
TIE	6	5886.01	345.80	0.35	5.46	0.61	11.24
TIR	7	2655.25	1007.76	0.28	9.83	0.28	6.06
TIE	8	3141.84	1062.10	0.21	16.34	0.21	8.96
TIE	11	2833.09	370.50	0.20	1.37	0.58	7.68
TIE	12	2521.81	209.95	0.26	8.77	0.76	8.12

Weather Details

Pln. Name	Blk No.	Tot.Rain (mm)	Min.Temp. (Deg. Cel)	Max.Temp. (Deg. Cel)	Min.RH (%)	Max.RH (%)	Data Status
TIE	1	386	23.00	29.00	0.00	---	Incomplete
TIE	2	1043	23.00	31.00	0.00	---	Incomplete
TIE	3	1066	23.00	31.00	0.00	---	Incomplete
TIE	4	1066	23.00	31.00	0.00	---	Incomplete
TIR	5	386	23.00	29.00	0.00	---	Incomplete
TIR	6	1066	23.00	31.00	0.00	---	Incomplete
TIE	7	386	23.00	29.00	0.00	---	Incomplete
TIE	8	386	23.00	29.00	0.00	---	Incomplete
TIP.	11	215	23.00	28.00	0.00	---	Incomplete
TIE	12	215	23.00	28.00	0.00	---	Incomplete

Input/Cropping operations during the 1 year of planting - I

Pln. Name	Blk No	Preplanting operations	Irrigation (lt./year)	Fertilizer
TIR	1		852	
TIR	2		940	
TIR	3		1172	
TIR	4		1460	URE,MOP,SSP
TIR	5		860	
TIR	6		1108	
TIR	7		808	
TIR	8		912	
TIR	11		768	
TIR	12		772	

Input/Cropping operations during the 1 year of planting - II

Pln. Name	Blk No.	Manuring	Pruning
TIR	1		No
TIR	2	CPI,FYM	No
TIR	3	CPI,FYM	No
TIR	4	NCA,FYM,CPI	No
TIR	5	CPI,PMA	No
TIR	6		No
TIR	7		No
TIR	8		No
TIR	11	FYM,CPI	No
TIR	12	FYM,CPI	No

Input/Cropping operations during the 1 year of planting - III

Pln. Name	Blk No.	Weeding	Ameliorative treatment
TIR	1	Manual,Mechanical	
TIR	2	Manual	
TIR	3	Manual,Mechanical	
TIR	4	Manual	GYP
TIR	5	Manual	
TIR	6	Manual	
TIR	7	Manual	
TIR	8	Manual	
TIR	11	Manual	
TIR	12	Manual	

Input/Cropping operations during the 1 year of planting - IV

Pln. Name	Blk No.	Intercrop	Plant protection
TIR	1	LAB	
TIR	2		
TIR	3		
TIR	4	PUM	
TIR	5		
TIR	6		
TIR	7		
TIR	8		
TIR	11		
TIR	12		

Plantation Name : VITTANERI (VIT)
State : TAMILNADU
District : SIVAGANGA
Total Extent : 33.49 ha

Growth attributes - I

Pln. Name	Blk No.	Extent (ha)	Spacing (mxm)	Date of planting	Age at counting (year)	Survival (%)	Stocking (trees/ha)
VIT	1	7.58	3.00 x 1.50	28/09/96	0.81	100.00	1661
VIT	2	11.53	3.05 x 1.50	19/07/96	0.95	100.00	1764
VIT	3	14.38	3.00 x 1.50	12/08/96	0.87	100.00	1692

Growth attributes - II

Pln. Name	Blk No.	Age at measu. (year)	crop ht. (m)	CV in ht. (%)	A(MAI) of ht. (m)	E(MAI) of ht. (m)	Inc.over control (%)
VIT	1	1.2	3.8	26	3.07	2.07	48.55
VIT	2	1.4	4.4	17	3.06	2.07	48.02
VIT	3	1.3	3.3	20	2.38	2.01	14.97

A(MAI) - Actual mean annual increment
E(MAI) - Expected mean annual increment

Growth attributes - III

Pln. Name	Blk No.	Crop dia. (cm)	Basal area (sq.m/ha)	Crown dia. (m)	Crown overlapping	
					Between row	Within row
VIT	1	1.4	0.29	2.32	No	Yes
VIT	2	1.7	0.40	2.93	No	Yes
VIT	3	1.3	0.25	2.88	No	Yes

Health and phenolagy

Pln. Name	Blk No.	Pest (%)	Disease (%)	Hech. (%)	Forking (%)	Flower (%)	Fruit (%)	Foliage (%)
VIT	1	0.00	0.00	0.00	0.00	0.00	0.00	100.00
VIT	2	0.00	0.00	0.00	0.00	0.00	0.00	100.00
VIT	3	0.00	0.00	0.00	0.00	0.00	0.00	100.00

Soil attributes - I

Pln. Name	Blk No.	Texture	BD (g/cc)	pH	OC (%)	N (kg/ha)	P (kg/ha)	K (kg/ha)
VIT	1	SLO	---	7.15	0.20	264.29	18.52	143.26
VIT	2	SLO	---	7.10	0.30	326.04	2.17	148.20
VIT	3	SLO	---	6.28	0.28	294.54	19.14	143.26

Soil attributes - II

Pln. Name	Blk No.	Ca (kg/ha)	Mg (kg/ha)	Zn (ppm)	Fe (ppm)	Cu (ppm)	Mn (ppm)
VIT	1	1793.22	227.24	0.52	8.90	1.09	30.18
VIT	2	1151.02	345.80	0.43	4.35	0.45	11.33
VIT	3	885.19	159.93	0.69	10.20	1.46	32.66

Weather Details

Pln. Name	Blk No.	Tot.Rain (mm)	Min.Temp. (Deg. Cel)	Max.Temp. (Deg. Cel)	Min.RH (%)	Max.RH (%)	Data Status
VIT	1	439	14.00	43.00	34.00	100.00	Incomplete
VIT	2	358	14.00	43.00	38.00	100.00	Incomplete
VIT	3	371	14.00	43.00	34.00	100.00	Incomplete

Input/Cropping operations during the 1 year of planting - I

Pln. Name	Blk No	Preplanting operations	Irrigation (lt./year)	Fertilizer
VIT	1	FYM,COI	2548	URE,SSP,MOP
VIT	2	FYM,COI	3276	URE,SSP,MOP
VIT	3		2730	URE,SSP,MOP

Input/Cropping operations during the 1 year of planting - II

Pln. Name	Blk No.	Manuring	Pruning
VIT	1		Moderate
VIT	2		Moderate
VIT	3		No

Input/Cropping operations during the 1 year of planting - III

Pln. Name	Blk No.	Weeding	Ameliorative treatment
VIT	1		GYP
VIT	2		
VIT	3		GYP

Input/Cropping operations during the 1 year of planting - IV

Pln. Name	Blk No.	Intercrop	Plant protection
VIT	1	COW(28/09/96 to 25/11/96)	MON,END
VIT	2	COW(17/08/96 to 07/10/96, 17/08/96 to 21/12/96),AGO(19/02/97 to 15/05/97)	HON ,END
VIT	3	COW(21/08/96 to 20/11/96)	

Appendix II Abbreviations used in summary reports

Ameliorative treatments

CCA	- Calcium Carbonate
GYP	- Gypsum
LIM	- Lime

Fertilisers

CAN	- Calcium Ammonium Nitrate
COM	- Complex fertilizers
DAP	- Di-ammonium Phosphate
DSP	- DAP spray
FAC	- Factamphos
MOP	- Muriate of Potash
MRP	- Mussourie Rock Phosphate
MSP	- MOP spray
SSP	- Single Super Phosphate
URE	- Urea
VAM	- Vesicular Arbuscular Mycorrhiza

Intercrops

AGU	- Ash gourd
CHI	- Chillies
COW	- Cowpea
GHE	- Gherkin
GGR	- Green gram
GRO	- Groundnut
LAB	- Lab - Lab
MAI	- Maize
MES	- Mesta
NIG	- Niger
PUM	- Pumpkin
RGR	- Red gram
TPU	- *Tephrosia purpurea*
WAT	- Watermelon

Manuring

CPI	- Coir pith
COM	- Concentrated Organic Manure
FAR	- Farmboon

FYM - Farm Yard Manure
HPL - Humus plus
NCA - Neem Cake
PMA - Poultry Manure
SOM - Super Organic Manure

Plant protection

END - Endosulphan
MON - Monocrotophos

Pruning

MSR - Multiple Shoots Removal
RSR - Recessive Shoots Removal

Soil texture classes

C or CLA - Clay
CL or CLO - Clay Loam
LOA - Loam
S or SC or SAN - Sandy
SL or SLO - Sandy Loam