MoWR FUNDED PROJECT

ON

Screening Superior Genotypes of Eucalypts for Biodrainage through Ecophysiological Approaches

Completion Report

Submitted
by
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PROJECT COMPLETION REPORT

1.	Name and address of Institute.	Forest College and Research Institute Tamil Nadu Agricultural University Kothagiri road Mettupalayam - 641 301 Tamil Nadu
2.	Name and address of the PI and other investigators	
	Principal Investigator	**Dr. A.Balasubramanian, Ph.D.** Professor (Forestry) Forest College & Research Institute Mettupalayam - 641 301
	Co-Principal Investigator	**Dr. M. Paramathma, Ph.D.** Director of Research Tamil Nadu Agricultural University Coimbatore - 641 003 **Dr. K.K. Suresh, Ph.D.** Professor & Head Department of Silviculture & Agroforestry Forest College & Research Institute Mettupalayam - 641 301 **Dr. K.T. Parthiban, Ph.D.** Associate Professor (Forestry) Forest College & Research Institute Tamil Nadu Agricultural University Mettupalayam - 641 301 **Dr. C. Vijayalakshmi, Ph.D.** Professor and Head Department of Crop Physiology Tamil Nadu Agricultural University Coimbatore - 641 003
3.	Title of the scheme	**Screening superior genotypes of Eucalypts for bio-drainage through ecophysiological approaches**
4.	Financial details. (Sanctioned cost; amount released; expenditure; unspent balance (if any) and return of unspent balance.	Attached in **Annexure- I**
5.	Original objectives and methodology as in the sanctioned proposal.	i) Selection and multi locational testing of superior genotypes of *Eucalyptus tereticornis* and *E. camaldulensis* for effective bio-drainage using ecophysiological parameters. ii) Studying the transpirational rate and other physiological

		behaviour of selected clones, defining the limits of their productivity in different season. iii) Comparing the bio-drainage efficacy of selected genotypes of *Eucalyptus tereticornis* and *E. camaldulensis* with *Eucalyptus saligna*.
6.	Any changes in the objectives during the operation of the scheme.	No
7.	All data collected and used in the analysis with sources of data.	The project involved selection of plus trees in Eucalyptus for high biodrainage efficiency and testing their superiority. Both were field work and involved collection of data in the field level. Hence, all the data were collected in the field relating to the research work. These collected data were subjected for appropriate statistical analysis and the results are presented in Annexure – II.
8.	Methodology actually followed. (observations, analysis, results and inferences)	Attached in **Annexure- II**
9.	Conclusions/ Recommendations	Attached in **Annexure- III**
10.	How do the conclusions/ recommendations compare with current thinking	Attached in **Annexure- IV**
11.	Field tests conducted.	Attached in **Annexure- V**
12.	Software generated, if any.	Nil
13.	Possibilities of any patents/ copyrights. If so, then action taken in this regard.	Attached in **Annexure- VI**
14.	Suggestions for further work	Attached in **Annexure- VII**
15.	Explanation for expert comments	Attached in **Annexure- VIII**

Annexure- I

Financial details

S.No	Expenditure head	Sanctioned cost (A)	Amount released (B)	Expenditure (C)	Balance (B-C)	Return of unspent balance
1.	Salary	5,20,000	4,46,000 (2004) + 4,10,000 (2005) + 3,00,000 (2006) + 2,29,000 (2007) + 2,41,000 (2009)	5,36,346*		The balance amount will be returned after the acceptance of completion report
2.	TE	2,75,000		2,61,623		
3.	Infrastructure	1,70,000		1,38,629		
4.	Experimental charges & contingence	6,61,450 (5,84,000+77,450)		6,27,015		
	Overhead charges	3,00,000		-		
5.	**Total**	**19,26,000**	**16,26,000**	**15,63,613**	**62,387**	

*The excess expenditure is due to the increase in salary of SRF by the ministry after implementation of the project. This expenditure was done based on the approval from the ministry.

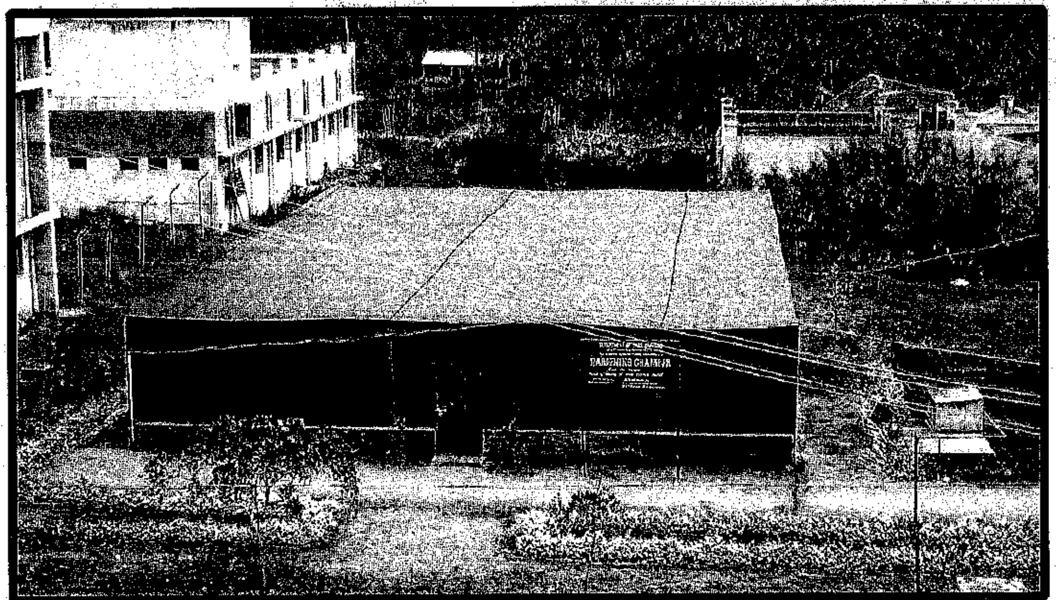
14/7/16
Scheme officer / 14/07/16 **Office superintendent** / 14/7/16 **HOD**

SP 14/7/16

14/7/16
DEAN (FORESTRY)

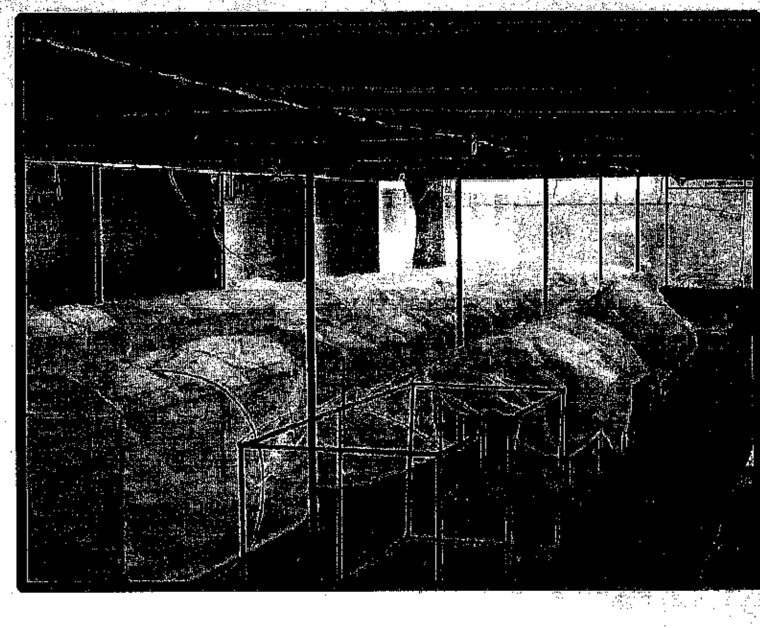
INFRA STRUCTURE DEVELOPMENT

HARDENING CHAMBER



INSIDE VIEW
OF THE
CHAMBER

HARDENING CHAMBER
WITH
FOGGING FACILITY



Annexure - II

Methodology and Results

The following research progress has been made since the inception of the project.

1. Selection of Candidate Plus Tree (CPTs)
2. Vegetative propagation of CPTs
3. Clone bank assemblage
4. Mass multiplication of assembled clones
5. Field testing for biodrainage efficiency

METHODOLOGY

1) Selection of CPTs

About 41 candidate plus trees (CPTs) were selected from nine sources *viz.*, Ramanathapuram, Nagercoil, Tiruchendur, Mettupalayam, Sivagangai, ITC clones, Ariyalur, Pudukottai and all clones have been selected by adopting the following methodology.

a) Base population variability study

In all the six locations, the natural variability exhibited by the populations was studied by placing sample plots. A sample plot size of 10 m x 8 m was placed in the plantation, likewise three sample plots were placed randomly in a population. One plot has accommodated 20 trees and in all the 20 trees height, diameter at breast height (DBH), volume upto DBH and total volume were estimated. Besides, the physiological characters that dictate biodrainage efficiency were also measured. The physiological characters like transpiration, photosynthesis, stomatal conductance and inter cellular CO_2 concentration (CINT) were measured in all 20 trees in a sample plot. Using these data, the population variability in terms of mean, standard deviation, coefficient of variation and range (minimum, maximum) were estimated. The above parameters were worked out by the following methodologies.

SELECTED CPT

FELLING

OF

SELECTED CPTS

MARKING

OF

CPTS

Statistical values of the base population

The characters of the base population in terms of its statistical values viz., mean, range (minimum and maximum) standard deviation and coefficient of variation were calculated using the method given by Goulden (1952).

Mean

Mean of a plot was calculated by dividing the sum of all observations with the total number of observations.

$$\text{Mean of a plot (M)} = \frac{\sum X}{n}$$

where

$\sum X$ – sum of X character

n – number of observation

$$\text{Plantation mean} = \frac{n_1M_1 + n_2M_2 + n_3M_3}{n_1 + n_2 + n_3}$$

where

M_1, M_2, M_3 are mean of sample plots 1, 2, 3 respectively

n_1, n_2, n_3 are number of observations / tree respectively in 1, 2, 3 plots

Range

The difference between the minimum and maximum values for all characters in all the sample plot.

Standard deviation (SD)

The standard deviation is the square root of the arithmetic average of the squares of deviations from the mean.

$$\text{S.D. of sample plot} = \sqrt{\frac{\sum (x_i - \overline{x})^2}{n - 1}}$$

where

x_i = individual observation

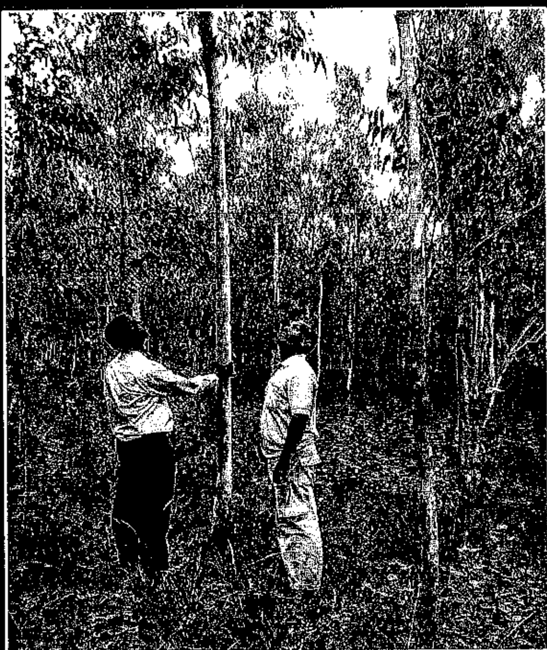
$\overline{x}$ = mean of the sample plot

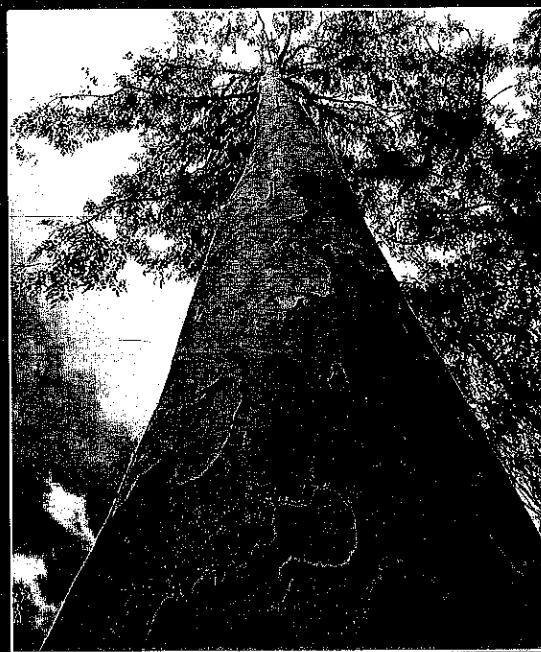
n = number of observations in the sample plot

a) Selection of candidate plus trees (CPTs)

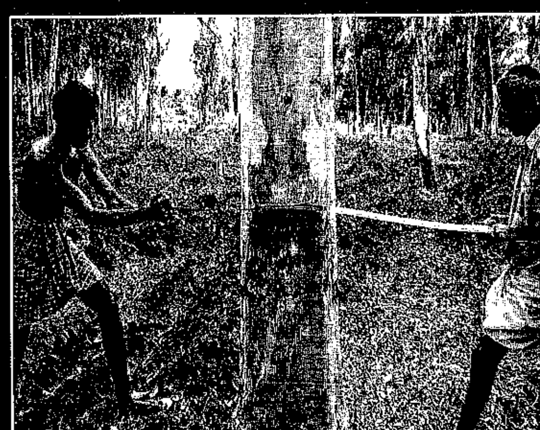
All the plantation sources subjected for selection are in the coastal areas of Tamil Nadu as it has been proposed in the project proposal. In all the sources the plantations were selected in such a way that they were raised in the very high water table area. However, few locations like Sivagangai and Mettupalayam sources are from inland sources. Besides, already clonal assemblage of ITC at Forest College and Research Institute, Mettupalayam has also been subjected for selection.

Plate 1.Selection of CPT





Selection



Cutting the trees

Marking

The selection of CPTs was done in following two phases:

i) Selection of CTs

ii) Selection of Candidate Plus Trees (CPTs)

i) Selection of CTs (First Phase Selection)

In the first phase, Candidate Trees (CTs) were selected and in the next phase CPTs were selected from CTs. Before selecting the CTs in the base population, the entire plantation was thoroughly perambulated to study the status of tree growth in relation to the variation in topographic and edaphic characteristics. Based on Gardne (1961) recommendation, the entire plantation was divided into grids to check the soil heterogeneity. In each grid, phenotypically superior trees with good height, collar diameter (CD), diameter at breast height (dbh), clear bole with high self pruning capacity, fewer number of branches and with no pest and disease incidence were selected. The selected trees were serially numbered and were designated as Candidate Trees (CTs). These selected CTs were subjected for measuring various growth and physiological traits as described below.

1) Physiological parameters

i) Transpiration

ii) Stomatal conductance

iii) Photosynthesis

iv) Internal CO_2 concentration (CINT)

2) Growth parameters

i) Height

ii) Diameter of breast height (DBH)

iii) Volume up to DBH

iv) Total volume

The above physiological parameters were measured using portable photosynthesis system CID, Inc (made in USA).

Selection of candidate plus trees (CPTs) (Second Phase Selection)

During the second phase of selection, the CPTs were selected from CTs. The following methodology was followed to work out the selection index for selecting CPTs.

Total tree volume

Total tree volume was calculated using quarter girth formula as described by Chaturvedi and Khanna (1982).

$$\text{Total tree volume} = (g/4)^2 \times 1 \ (m^3)$$

where

g = Girth at breast height (m)

l = Tree height (m)

Volume upto DBH

Volume upto DBH is the volume of bole from the ground level to the height upto 1.37 m. This was calculated using Smalian's formula given by Chaturvedi and Khanna (1982).

$$\text{Volume up to DBH} = \frac{S_1 + S_2}{2} \times l \ (m^3)$$

where

$S_1 = (BD/2)^2 \times \pi \ (cm^2)$ (BD = basal diameter)

$S_2 = (DBH/2)^2 \times \pi \ (cm^2)$ (DBH = diameter at breast height)

l = 1.37 m (breast height length)

Working of weightage of traits

Correlation coefficient was worked out by keeping transpiration as dependent character and all others as independent characters.

$$\text{Correlation coefficient (Weightage)} = \frac{\text{Covariance } X_1.X_2}{\sigma X_1 \,.\, \sigma X_2}$$

Where,

X_1 Covariance of transpiration of tree

X_2 Covariance of i^{th} character of tree

X_1 Standard deviation of transpiration of that tree

X_2 Standard deviation of i^{th} character of that tree

Like wise, the weightage will be worked out for transpiration vs all other characters which are mentioned earlier.

Selection index

Using multiple regression, the following selection index will be developed.

$$SI = X_1R_{(1,8)} + X_2R_{(2,8)} + X_3R_{(3,8)} + X_4R_{(4,8)} + X_5R_{(5,8)} + X_6R_{(6,8)} + X_7R_{(7,8)} + X_8R_{(8,8)}$$

Where,

X_1 Stomatal conductance

X_2 Photosynthesis

X_3 Internal CO_2 concentration (CINT)

X_4 Height

X_5 Diameter at breast height (DBH)

X_6 Tree volume

X_7 Volume upto DBH

X_8 Transpiration

$R_{(1,8)}$ Correlation coefficient for stomatal conductance Vs transpiration

$R_{(2,8)}$ Correlation coefficient for photosynthesis Vs transpiration

$R_{(3,8)}$ Correlation coefficient for internal CO_2 concentration (CINT) Vs transpiration

$R_{(4,8)}$ Correlation coefficient for height Vs transpiration

$R_{(5,8)}$ Correlation coefficient for diameter at breast height (DBH) Vs transpiration

$R_{(6,8)}$ Correlation coefficient for tree volume Vs transpiration

$R_{(7,8)}$ Correlation coefficient for volume upto DBH Vs transpiration

$R_{(8,8)}$ Correlation coefficient for transpiration Vs transpiration

The tree scoring highest selection index was selected and has been designated as Candidate plus trees (CPTs)

b) Vegetative propagation of CPTs

The candidate plus trees (CPTs) of *Eucalyptus tereticornis* that have been already selected from five different locations *viz.*, Nagercoil, Sivagangai, Ramanathapuram, Tiruchendur and Mettupalayam were mass multiplied through two nodal cuttings collected from the coppice shoots of selected CPTs. Coppice shoots were collected from the selected CPTs with two nodes and the leaves were half pruned to avoid water loss. The exercised nodal cuttings were transported to propagation chamber by placing in a gel of Jalsakthi kept in ice boxes. In the propagation chamber, the two nodal cuttings were washed thoroughly with sterile water at propagation chamber and soaked in 0.1 per cent Bavistin for 30 minutes to avoid pathogenic infection. The basal cut end of the cuttings was dip-smeared with IBA (Indole Butyric Acid) 4000 ppm powder concentration (and planted in poly cups filled with presoaked vermiculite as rooting medium. The poly cups were kept inside polytunnels under shade net environment condition. The polytunnels were placed on a leveled surface filled with sand to a depth of one foot. The sides of the tunnels were tightly tucked with sand after keeping the poly cups in to the tunnel. The humidity inside the polytunnels was maintained at 80 to 85 per cent by misting with

Plate 3. Collection of Coppice shoots

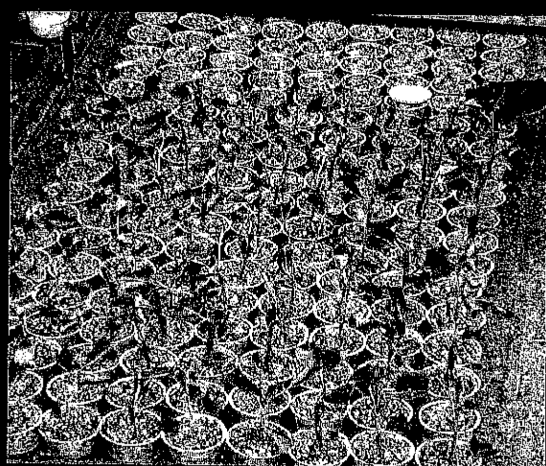
Coppice collection from CPT's

Leaf pruning

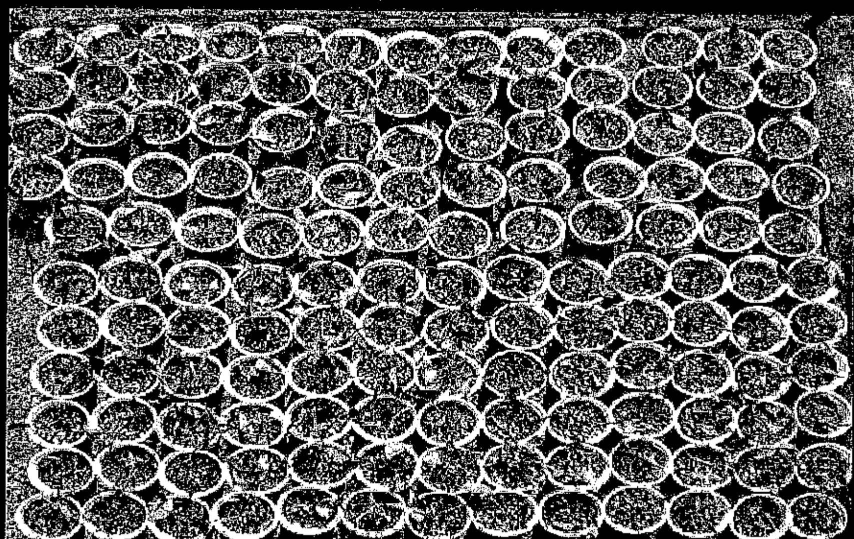
Half leaved pruned cuttings

Plate 4.Preparation and Planting of Cuttings

Two nodal cuttings preparation



IBA cuttings Treated



Planted cuttings

water in to the tunnels by opening the sides of the tunnels. Depending on the weather condition and season, the shade for polytunnels was regulated with single layer or double layer shade net in the hardening chamber. The plastic cups with cuttings were assessed for rooting after 20-25 days of planting. The rooted cuttings were transplanted to polybags filled with pot mixture (sand: soil: FYM in the ratio of 1:1:1). After ensuring the good establishment of the rooted cuttings in the polybags, the hardening of cuttings was done in three phases. Initially, the rooted cuttings were hardened inside the hardening chamber under double layer shade net; secondly, the hardened clones were slowly moved to the single layer shade net inside the hardening chamber. Finally, the clones were moved outside the hardening chamber to expose them for full sunlight. After three months of hardening in full sunlight, the clones were planted in the clonal bank

iii) Rooting of coppice shoots

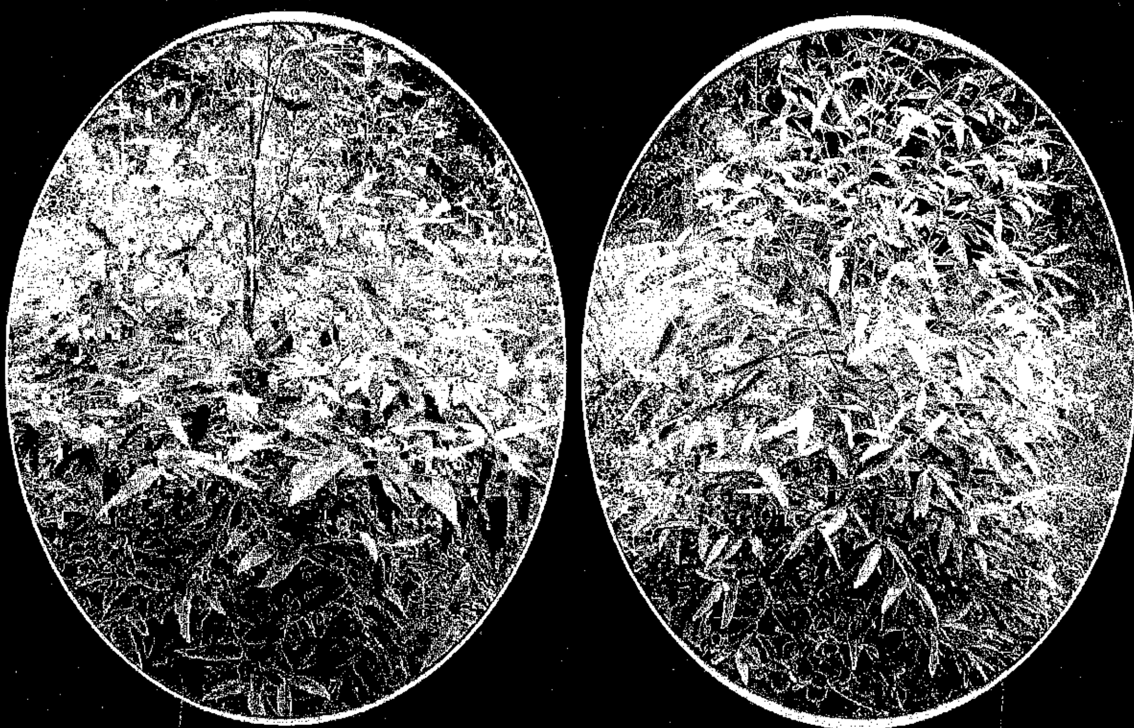
The rooting behaviour and rooting capacity of the clones were assessed in relation to clones and seasons. The seasonal behaviour on the rooting ability of the clones was studied from March 2005 to February 2006. All the 35 clones were studied for their rooting ability in three replications with 50 cuttings in each replication. The rooting experiment was conducted in Completely Randomized Design (CRD) inside the hardening chamber at Forest College and Research Institute, Mettupalayam. The rooted cuttings were carefully separated from the plastic containers with the rooting media without damaging the roots. The cuttings were washed in water to remove the rooting media. At each stage care was taken to avoid damage to the roots. The rooting parameters viz., root length, number of roots per cutting and shoot length were measured and recorded.

d) Hardening of rooted cuttings

The rooted cuttings were hardened by slowly releasing the air tight polythene sheets covered in the poly tunnel. The rooted cuttings were kept in the root trainer or plastic cups for one week in open space, then they were transferred to polybags filled with pot mixture. The pot mixture contains sand, soil and farm yard manure in the ratio of 1:1:1. To further harden the cuttings the polybags planted with rooted cuttings were kept inside the hardening chamber for two months. Then, the potted cuttings were slowly moved to open space for further hardening and subsequent field planting.

Plate 6.Raising *Eucalyptus saligna* -CSIR,Australia

Eucalyptus saligna seedlings ready for planting



Seedling in clonal bank

e) Clonal assemblage and establishment of Clonal garden

The well hardened clones in open space were planted in the clonal bank. Among the 41 clones tried for rooting, 32 clones were successfully multiplied through vegetative propagation; all the successfully rooted 32 clones were raised in three replications with 6 ramets in each replication in the clone bank in at Forest College and Research Institute, Mettupalayam. All the clones were planted in the clonal bank with a spacing 1 m x 1 m. The clones were assessed for their biometric and ecophysiological traits at monthly intervals.

i) *Eucalyptus saligna* assemblage from Australia

Besides, *Eucalyptus saligna* which is consider as water pumper and that has been widely present in the marshy low laying water logged areas in Australia was utilized for the present study. The seeds of *Eucalyptus saligna* was obtained from Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia and raised in nursery mother bed as per the silviculture practiced prescribed for nursery practices. The three leaf stage germinated seedlings in the raised bed were pricked out and transplanted in the poly bags and kept under hardening chamber for initial establishment. Eventually established seedlings were moved out to the full sunlight for further establishment. These seedlings were utilized for the biodrainage assessment.

ii) *Eucalyptus eurograndis* assemblage

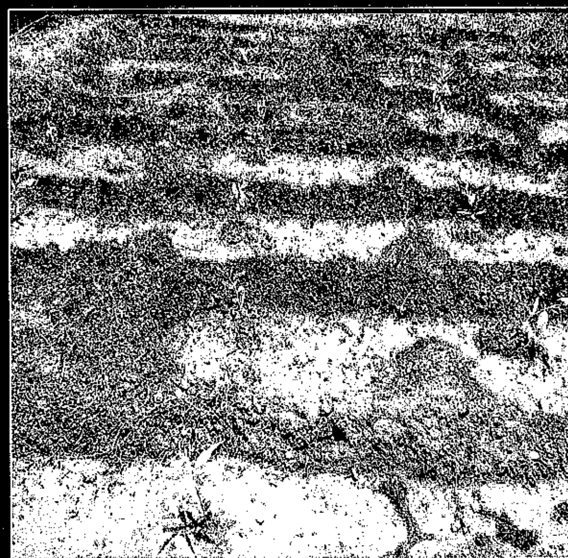
Eucalyptus eurograndis is a hybrid between *Eucalyptus europhylla* X *Eucalyptus grandis.* Two clones of eucalyptus europhylla namely EU-1 and EU-2 were obtained from Tamil Nadu Forest Department and utilized for biodrainage.

RESULTS

Variability in base population of Eucalypts

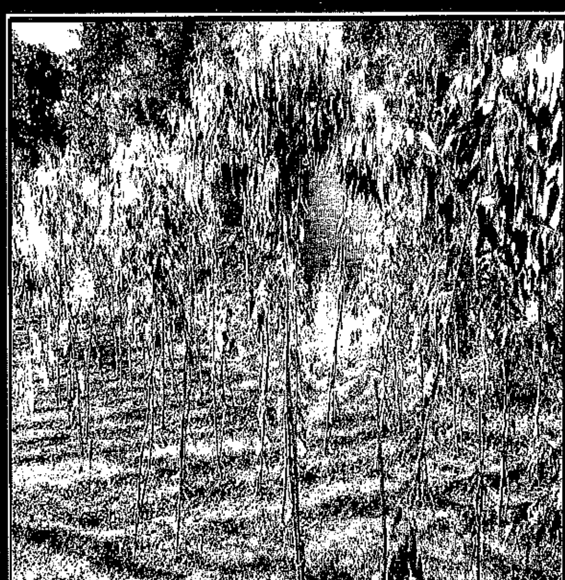
The variability in the base population of Eucalypts was studied in terms of growth and physiological parameters. The growth characters include height, DBH, volume upto DBH and total volume. The physiological characters include stomatal conductance, transpiration, photosynthesis and intercellular CO_2 concentration (CINT).

Plate 5.Clonal Bank Establishment



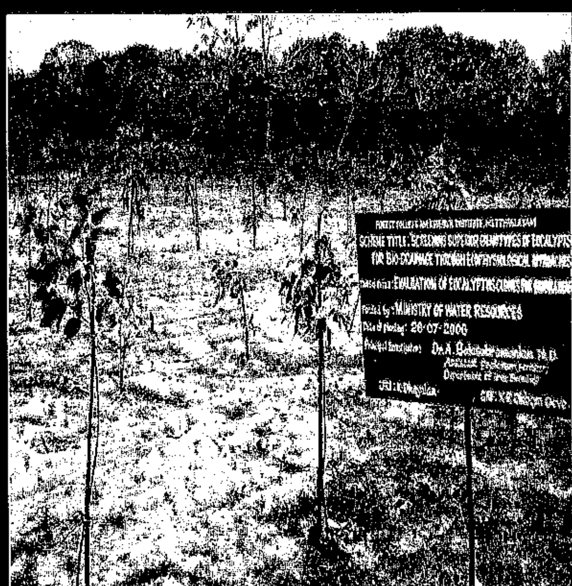
One MAP

3 MAP



6 MAP

Plate 7.Field Planting



a) Mettupalayam location

Total volume accounted highest coefficient of variation in all the sample plots ranges from 17.98 per cent (sample plot 3) to 53.37 per cent (sample plot 2). The minimum height of 4.3 m (sample plot 3) and maximum of 7.3 m (sample plot 2) was observed among the plots (Table 1). Among the physiological parameters, CINT accounted highest coefficient of variation of 27.83 per cent (sample plot 1).

b) Nagercoil location

The base population study at Nagercoil using sample plots revealed that the highest coefficient of variation of 81.75 per cent (sample plot 2) was accounted for volume followed by volume upto DBH 62.91 per cent (sample plot 2). Among the physiological parameters 32.42 per cent (sample plot 1) of coefficient of variation was observed in CINT, followed by transpiration (18.96%) in sample plot 1 (Table 2).

Maximum height range of 34.10 m was observed in sample plot 2 and minimum of 11.5 m was observed in sample plot 2. The lowest transpiration of 13.254 (sample plot 1 and 3) and highest transpiration of 25.95 m mol. m^{-2} s^{-1} (sample plot 3) was observed (Table 2).

c) Ramanathapuram location

In Ramanathapuram location also the highest coefficient of variation (47.57%) was observed in the total volume when compared to all other growth character. Like other location the volume upto DBH recorded highest coefficient of variation (29.7%) next to total volume. In this location, highest coefficient of variation 26.57 per cent was observed in photosynthesis (sample plot 1) followed by stomatal conductance 24.54 per cent (sample plot 2). The maximum transpiration of 15.3 m mol. m^{-2} s^{-1} was observed in sample plot 3 and minimum of 8.12 m mol. m^{-2} s^{-1} was observed in sample plot 2. The lowest height of 11.3 m was observed in sample plot 1 and maximum height of 19.5 m was observed in sample plot 3 (Table 3).

In the second location also three sample plots were laid to study the variability. The highest coefficient of variation of 29.34 per cent was observed in photosynthesis in sample plot 2 and the lowest coefficient of variation of 3.25 per cent was observed in sample plot 3 for height. The transpiration showed the maximum and minimum range of 12.55 m mol. m^{-2} s^{-1} and 8.26 m

Table 1. Variability in base population of Eucalypts - Mettupalayam location

SAMPLE PLOT 1

Character	Stomatal conductance (m mol m^{-2} s^{-1})	Photosynthesis (µ mol m^{-2} s^{-1})	CINT (ppm)	Transpiration (m mol m^{-2} s^{-1})	Height (m)	DBH (m)	Volume (m^3)	Volume upto DBH (m^3)
Mean	861.36	29.15	542.04	18.36	4.93	0.12	0.04	0.01
SD	93.11	7.22	150.88	2.91	1.06	0.02	0.02	0.00
CV%	10.81	24.76	27.84	15.85	21.48	13.21	40.90	26.81
Range(Minimum)	715.24	16.23	345.22	13.65	3.50	0.09	0.02	0.01
Range(Maximum)	935.43	37.27	719.55	23.16	6.50	0.15	0.09	0.02

SAMPLE PLOT 2

Character	Stomatal conductance (m mol m^{-2} s^{-1})	Photosynthesis (µ mol m^{-2} s^{-1})	CINT (ppm)	Transpiration (m mol m^{-2} s^{-1})	Height (m)	DBH (m)	Volume (m^3)	Volume upto DBH (m^3)
Mean	856.45	27.97	548.83	16.88	5.89	0.13	0.06	0.01
SD	97.54	6.65	112.09	2.03	0.94	0.03	0.03	0.01
CV%	11.39	23.79	20.42	12.05	15.92	19.83	53.37	39.86
Range(Minimum)	741.24	19.35	356.13	13.26	4.30	0.08	0.03	0.01
Range(Maximum)	1009.65	37.64	715.65	19.65	7.30	0.18	0.15	0.29

SAMPLE PLOT 3

Character	Stomatal conductance (m mol m^{-2} s^{-1})	Photosynthesis (µ mol m^{-2} s^{-1})	CINT (ppm)	Transpiration (m mol m^{-2} s^{-1})	Height (m)	DBH (m)	Volume (m^3)	Volume upto DBH (m^3)
Mean	880.10	27.19	546.28	17.33	5.08	0.12	0.04	0.01
SD	94.86	5.28	123.85	2.87	0.63	0.01	0.01	0.00
CV%	10.78	19.43	22.67	16.55	12.34	6.37	17.98	12.22
Range(Minimum)	721.26	17.99	301.29	13.25	4.30	0.10	0.02	0.01
Range(Maximum)	1011.65	37.56	698.35	21.65	6.10	0.13	0.06	0.01

Table 2. Variability in base population of Eucalypts - Nagercoil location

SAMPLE PLOT 1

Character	Stomatal conductance (m mol $m^{-2} s^{-1}$)	Photosynthesis (µ mol $m^{-2} s^{-1}$)	CINT (ppm)	Transpiration (m mol $m^{-2} s^{-1}$)	Height (m)	DBH (m)	Volume (m^3)	Volume upto DBH (m^3)
Mean	990.96	35.25	579.30	18.35	24.12	0.33	1.83	0.10
SD	83.14	4.44	187.83	3.48	5.03	0.08	1.25	0.05
CV%	8.39	12.60	32.42	18.96	20.85	25.61	68.54	50.04
Range(Minimum)	901.25	27.26	245.33	13.25	18.00	0.20	0.49	0.04
Range(Maximum)	1196.24	45.29	841.05	23.68	32.30	0.48	4.50	0.19

SAMPLE PLOT 2

Character	Stomatal conductance (m mol $m^{-2} s^{-1}$)	Photosynthesis (µ mol $m^{-2} s^{-1}$)	CINT (ppm)	Transpiration (m mol $m^{-2} s^{-1}$)	Height (m)	DBH (m)	Volume (m^3)	Volume upto DBH (m^3)
Mean	1004.22	37.07	704.78	19.62	23.73	0.31	1.83	0.09
SD	83.60	4.61	74.65	2.82	7.00	0.11	1.50	0.06
CV%	8.32	12.44	10.59	14.39	29.49	36.72	81.76	62.92
Range(Minimum)	905.13	27.21	548.37	16.25	11.50	0.10	0.06	0.01
Range(Maximum)	1197.25	45.19	846.24	24.88	34.10	0.48	5.00	0.20

SAMPLE PLOT 3

Character	Stomatal conductance (m mol $m^{-2} s^{-1}$)	Photosynthesis (µ mol $m^{-2} s^{-1}$)	CINT (ppm)	Transpiration (m mol $m^{-2} s^{-1}$)	Height (m)	DBH (m)	Volume (m^3)	Volume upto DBH (m^3)
Mean	961.50	35.45	636.38	18.49	19.61	0.28	1.07	0.07
SD	61.42	5.55	129.95	2.99	3.99	0.07	0.61	0.03
CV%	6.39	15.66	20.42	16.14	20.37	24.22	56.95	44.13
Range(Minimum)	901.26	27.24	375.27	13.25	13.00	0.15	0.19	0.02
Range(Maximum)	1011.65	37.56	698.35	21.65	6.10	0.13	0.06	0.01

Table 3. Variability in base population of Eucalypts - Ramanathapuram location 1

SAMPLE PLOT 1

Character	Stomatal conductance (m mol m^{-2} s^{-1})	Photosynthesis (μ mol m^{-2} s^{-1})	CINT (ppm)	Transpiration (m mol m^{-2} s^{-1})	Height (m)	DBH (m)	Volume (m^3)	Volume upto DBH (m^3)
Mean	682.2511	19.5361	307.2111	10.7424	12.8750	0.1662	0.2285	0.0238
SD	133.3658	5.1911	51.8600	1.9647	1.6597	0.0235	0.0803	0.0065
CV%	19.5479	26.5717	16.8809	18.2894	12.8909	14.1408	35.1257	27.2018
Range(Minimum)	458.3210	13.2540	205.4890	8.2560	11.3000	0.1252	0.0927	0.0132
Range(Maximum)	878.2450	27.5540	396.1780	13.9850	15.7000	0.1968	0.3439	0.0327

SAMPLE PLOT 2

Character	Stomatal conductance (m mol m^{-2} s^{-1})	Photosynthesis (μ mol m^{-2} s^{-1})	CINT (ppm)	Transpiration (m mol m^{-2} s^{-1})	Height (m)	DBH (m)	Volume (m^3)	Volume upto DBH (m^3)
Mean	707.58	25.80	343.46	9.03	13.21	0.17	0.23	0.02
SD	173.69	4.19	54.44	0.82	1.04	0.02	0.07	0.01
CV%	24.55	16.23	15.85	9.09	7.88	11.63	28.82	22.79
Range(Minimum)	423.26	15.27	216.60	8.12	11.50	0.13	0.13	0.01
Range(Maximum)	963.26	30.16	396.24	11.25	15.10	0.20	0.36	0.03

SAMPLE PLOT 3

Character	Stomatal conductance (m mol m^{-2} s^{-1})	Photosynthesis (μ mol m^{-2} s^{-1})	CINT (ppm)	Transpiration (m mol m^{-2} s^{-1})	Height (m)	DBH (m)	Volume (m^3)	Volume upto DBH (m^3)
Mean	694.05	23.87	309.90	9.63	13.52	0.17	0.26	0.03
SD	83.55	4.96	66.29	1.71	1.75	0.02	0.12	0.01
CV%	12.04	20.77	21.39	17.78	12.94	13.74	47.58	29.70
Range(Minimum)	523.69	16.35	212.25	8.24	11.50	0.14	0.16	0.02
Range(Maximum)	895.27	32.68	453.02	15.30	19.50	0.24	0.70	0.05

Table 4. Variability in base population of Eucalypts - Ramanathapuram location 2

SAMPLE PLOT 1

Character	Stomatal conductance (m mol m^{-2} s^{-1})	Photosynthesis (µ mol m^{-2} s^{-1})	CINT (ppm)	Transpiration (m mol m^{-2} s^{-1})	Height (m)	DBH (m)	Volume (m^3)	Volume upto DBH (m^3)
Mean	669.83	21.35	335.35	9.39	16.50	0.24	0.60	0.05
SD	170.31	5.64	57.51	0.98	0.80	0.02	0.12	0.01
CV%	25.43	26.44	17.15	10.43	4.82	8.71	20.74	17.53
Range(Minimum)	432.06	11.27	205.65	8.26	15.00	0.22	0.41	0.03
Range(Maximum)	874.24	29.24	399.26	12.55	17.50	0.28	0.82	0.06

SAMPLE PLOT 2

Character	Stomatal conductance (m mol m^{-2} s^{-1})	Photosynthesis (µ mol m^{-2} s^{-1})	CINT (ppm)	Transpiration (m mol m^{-2} s^{-1})	Height (m)	DBH (m)	Volume (m^3)	Volume upto DBH (m^3)
Mean	717.02	20.12	309.10	9.20	16.83	0.25	0.63	0.05
SD	142.79	5.90	53.58	1.26	0.78	0.03	0.16	0.01
CV%	19.91	29.33	17.34	13.70	4.65	10.18	25.03	20.83
Range(Minimum)	423.27	13.25	215.33	8.15	15.50	0.20	0.39	0.03
Range(Maximum)	895.76	33.26	394.26	12.55	19.00	0.30	1.05	0.08

SAMPLE PLOT 3

Character	Stomatal conductance (m mol m^{-2} s^{-1})	Photosynthesis (µ mol m^{-2} s^{-1})	CINT (ppm)	Transpiration (m mol m^{-2} s^{-1})	Height (m)	DBH (m)	Volume (m^3)	Volume upto DBH (m^3)
Mean	653.75	22.98	308.81	9.03	16.71	0.24	0.61	0.05
SD	137.83	5.09	64.73	0.82	0.54	0.02	0.13	0.01
CV%	21.08	22.16	20.96	9.09	3.25	9.61	21.09	18.89
Range(Minimum)	492.17	12.55	206.54	8.12	16.00	0.28	0.41	0.04
Range(Maximum)	873.27	30.16	394.27	11.25	17.50	8.20	0.80	0.07

Table 5. Variability in base population of Eucalypts - Ramanathapuram location 3

SAMPLE PLOT 1

Character	Stomatal conductance (m mol $m^{-2} s^{-1}$)	Photosynthesis (μ mol $m^{-2} s^{-1}$)	CINT (ppm)	Transpiration (m mol $m^{-2} s^{-1}$)	Height (m)	DBH (m)	Volume (m^3)	Volume upto DBH (m^3)
Mean	695.80	24.21	310.40	9.96	19.71	0.42	2.39	0.16
SD	150.00	4.73	55.83	1.61	2.86	0.10	1.36	0.07
CV%	21.56	19.54	17.99	16.18	14.52	23.25	57.05	46.12
Range(Minimum)	456.24	15.27	216.25	8.13	13.00	0.28	0.61	0.06
Range(Maximum)	893.27	31.55	401.24	13.02	24.00	0.62	5.76	0.33

SAMPLE PLOT 2

Character	Stomatal conductance (m mol $m^{-2} s^{-1}$)	Photosynthesis (μ mol $m^{-2} s^{-1}$)	CINT (ppm)	Transpiration (m mol $m^{-2} s^{-1}$)	Height (m)	DBH (m)	Volume (m^3)	Volume upto DBH (m^3)
Mean	690.84	24.32	272.92	9.31	18.69	0.41	2.08	0.15
SD	125.21	4.45	80.92	1.00	2.40	0.08	0.95	0.05
CV%	18.12	18.31	29.65	10.76	12.85	18.88	45.70	37.00
Range(Minimum)	482.36	17.24	125.24	8.05	15.30	0.30	0.85	0.08
Range(Maximum)	865.12	31.02	395.15	12.04	22.50	0.55	4.14	0.26

SAMPLE PLOT 3

Character	Stomatal conductance (m mol $m^{-2} s^{-1}$)	Photosynthesis (μ mol $m^{-2} s^{-1}$)	CINT (ppm)	Transpiration (m mol $m^{-2} s^{-1}$)	Height (m)	DBH (m)	Volume (m^3)	Volume upto DBH (m^3)
Mean	682.44	24.70	309.11	9.47	17.99	0.42	2.15	0.15
SD	138.74	4.33	58.40	1.34	3.34	0.08	1.21	0.06
CV%	20.33	17.52	18.89	14.12	18.60	19.99	56.46	40.33
Range(Minimum)	463.58	29.35	199.24	7.24	12.50	0.30	0.63	0.08
Range(Maximum)	852.17	30.66	395.23	13.27	24.00	0.62	5.76	0.33

mol. m^{-2} s^{-1} respectively. Similarly highest maximum and minimum range difference was observed in photosynthesis and intercellular CO_2 concentration (Table 4).

In the third location, the highest coefficient of variation of 57.05 per cent was observed for the volume in sample plot 1 and lowest coefficient of variation (10.76%) was observed for transpiration in the sample plot 2. The minimum height of 12.5 m was observed in sample plot 3 and maximum height of 24 m was observed in sample plot 1. A minimum photosynthesis of 15.27 μ mol m^{-2} s^{-1} was observed in sample plot 1 and maximum of 31.55 μ mol m^{-2} s^{-1} was observed in the same sample plot (Table 5).

d) Tiruchendur source

Location 1

In Tiruchendur highest coefficient of variation of 75.76 per cent (sample plot 1) was observed for volume and the lowest coefficient of variation of 9.72 per cent (sample plot 2) was observed for stomatal conductance. Highest standard deviation of 136.17 was observed for CINT in sample plot 2 and the lowest standard deviation of 0.021 was observed for volume upto DBH in sample plot 3. The height difference of 21.5 m (maximum in sample plot 1) and 7.0 m (minimum in sample plot 3) was observed (Table 6).

Location 2

In this location the highest coefficient of variation of 73.99 per cent was observed in sample plot 2 for volume and lowest coefficient of variation of 5.73 per cent was observed for stomatal conductance in sample plot 3. The minimum height of 8.8 m was observed in sample plot 3. Maximum height of 20.8 m was observed in sample plot 2.

Among the physiological parameters the coefficient of variation of 22.78 per cent was observed in CINT in the sample plot 2. Among the growth characters the minimum coefficient of variation of 15.94 per cent was observed in DBH in the sample plot 3 (Table 7).

Table 6. Variability in base population of Eucalypts - Tiruchendur location 1

SAMPLE PLOT 1

Character	Stomatal conductance (m mol m^{-2} s^{-1})	Photosynthesis (μ mol m^{-2} s^{-1})	CINT (ppm)	Transpiration (m mol m^{-2} s^{-1})	Height (m)	DBH (m)	Volume (m^3)	Volume upto DBH (m^3)
Mean	879.62	33.97	545.06	17.65	13.66	0.22	0.48	0.05
SD	92.81	4.98	125.09	2.87	3.04	0.06	0.36	0.03
CV%	10.55	14.67	22.95	16.27	22.25	28.76	75.76	60.26
Range(Minimum)	711.26	25.36	357.95	12.55	8.60	0.14	0.13	0.02
Range(Maximum)	1128.35	39.66	698.32	21.66	19.00	0.36	1.23	0.11

SAMPLE PLOT 2

Character	Stomatal conductance (m mol m^{-2} s^{-1})	Photosynthesis (μ mol m^{-2} s^{-1})	CINT (ppm)	Transpiration (m mol m^{-2} s^{-1})	Height (m)	DBH (m)	Volume (m^3)	Volume upto DBH (m^3)
Mean	880.55	32.20	566.12	16.78	14.83	0.22	0.48	0.04
SD	85.61	4.59	136.19	2.58	3.74	0.06	0.32	0.02
CV%	9.72	14.25	24.06	15.38	25.25	28.25	65.96	53.84
Range(Minimum)	783.65	24.99	357.18	12.55	7.00	0.13	0.12	0.01
Range(Maximum)	1148.37	38.66	736.16	21.35	21.50	0.33	1.44	0.09

SAMPLE PLOT 3

Character	Stomatal conductance (m mol m^{-2} s^{-1})	Photosynthesis (μ mol m^{-2} s^{-1})	CINT (ppm)	Transpiration (m mol m^{-2} s^{-1})	Height (m)	DBH (m)	Volume (m^3)	Volume upto DBH (m^3)
Mean	859.88	30.79	509.93	18.04	13.20	0.22	0.45	0.04
SD	128.07	5.32	120.67	2.74	3.53	0.06	0.30	0.02
CV%	14.89	17.29	23.66	15.21	26.75	24.83	65.81	47.44
Range(Minimum)	723.55	20.46	268.27	14.24	7.00	0.13	0.10	0.01
Range(Maximum)	1138.26	40.26	698.28	21.98	19.50	0.31	1.13	0.08

Table 7. Variability in base population of Eucalypts - Tiruchendur location 2

SAMPLE PLOT 1

Character	Stomatal conductance (m mol m^{-2} s^{-1})	Photosynthesis (μ mol m^{-2} s^{-1})	CINT (ppm)	Transpiration (m mol m^{-2} s^{-1})	Height (m)	DBH (m)	Volume (m^3)	Volume upto DBH (m^3)
Mean	882.49	31.77	595.22	17.24	12.51	0.36	1.12	0.11
SD	112.11	5.55	102.31	2.32	2.42	0.08	0.78	0.05
CV%	12.70	17.48	17.19	13.46	19.37	21.26	70.01	46.43
Range(Minimum)	713.16	24.57	354.99	13.26	9.00	0.26	0.40	0.06
Range(Maximum)	1128.70	40.28	698.24	21.85	18.00	0.58	3.79	0.29

SAMPLE PLOT 2

Character	Stomatal conductance (m mol m^{-2} s^{-1})	Photosynthesis (μ mol m^{-2} s^{-1})	CINT (ppm)	Transpiration (m mol m^{-2} s^{-1})	Height (m)	DBH (m)	Volume (m^3)	Volume upto DBH (m^3)
Mean	919.49	30.88	530.20	16.69	12.25	0.32	0.86	0.09
SD	78.50	5.37	120.76	2.82	2.73	0.06	0.64	0.04
CV%	8.54	17.40	22.78	16.88	22.27	18.10	73.99	40.63
Range(Minimum)	812.25	21.27	298.13	10.27	9.00	0.25	0.37	0.05
Range(Maximum)	1137.56	38.46	694.27	22.55	20.80	0.51	3.33	0.30

SAMPLE PLOT 3

Character	Stomatal conductance (m mol m^{-2} s^{-1})	Photosynthesis (μ mol m^{-2} s^{-1})	CINT (ppm)	Transpiration (m mol m^{-2} s^{-1})	Height (m)	DBH (m)	Volume (m^3)	Volume upto DBH (m^3)
Mean	908.38	29.32	579.53	16.45	12.24	0.35	0.95	0.10
SD	52.05	4.96	103.90	2.79	2.00	0.06	0.46	0.03
CV%	5.73	16.92	17.93	16.96	16.31	15.94	47.68	33.34
Range(Minimum)	820.24	21.03	421.05	11.25	8.80	0.27	0.45	0.06
Range(Maximum)	979.65	39.12	698.13	20.15	15.50	0.50	2.37	0.14

e) ITC clones

Totally, 86 ITC clones were already assembled at this institute for various advance generation development for yield. In the assembled clones, selection was carried out by making transpiration as a major dependent character and all other physiological and growth characters as independent characters for biodrainage efficacy. The variability of 86 ITC clones in their physiological and growth characters were described in the Table 8. In the clones, the minimum transpiration of 10.269 m mol m^{-2} s^{-1} and maximum of 27.256 m mol m^{-2} s^{-1} were observed. Similarly, the height varied from 1.40 m to 9.60 m, these variations helped to identify the very best clones for higher biodrainage efficacy within the ITC populations.

f) Sivagangai Location

The presence of variability in the base population was studied by putting three random sample plots of 10 x 8 m each. Measurement of variability in the sample plots in terms of physiological and growth characters showed a minimum transpiration of 8.279 m mol m^{-2} s^{-1} (sample plot 3) and maximum transpiration of 12.434 m mol m^{-2} s^{-1} (sample plot 1). A maximum of 9.4 m height was recorded in sample plot (1) and a minimum of 7.5 m was recorded in sample plot 3. Similarly, a good variability was observed and described in terms of all physiological and growth characters in Table 9.

e) Pudukottai Location

In Pudukottai location the highest coefficient of variation (73.53 %) was observed in the total volume when compared to all other growth character. Like other location the volume upto DBH recorded highest coefficient of variation (49.99 %) next to total volume. In this location, coefficient of variation 18.68 per cent was observed in transpiration followed by photosynthesis 12.33 per cent).The maximum transpiration of 11.23 m mol. m^{-2} s^{-1} and minimum of 10.12 m mol. m^{-2} s^{-1} was observed in sample plot . The lowest height of 9.12 m was observed in sample plot 1and maximum height of 10.85 m was observed in sample plot (Table 10).

Table 8 Variability in base population of Eucalypts -ITC location

Character	Stomatal conductance (m mol m^{-2} s^{-1})	Photosynthesis (µ mol m^{-2} s^{-1})	CINT (ppm)	Transpiration (m mol m^{-2} s^{-1})	Height (m)	DBH (m)	Volume (m^3)	Volume upto DBH (m^3)
Mean	1065.70	43.82	676.38	18.66	6.57	0.04	0.01	0.00
SD	192.19	9.58	148.86	4.35	1.64	0.01	0.01	0.00
CV%	18.03	21.85	22.01	23.29	24.92	31.83	72.89	58.61
Range(Minimum)	812.36	25.24	365.13	10.27	1.40	0.01	0.00	0.00
Range(Maximum)	1498.35	59.25	892.15	27.26	9.60	0.07	0.03	0.00

Table 9. Variability in base population of Eucalypts -Sivagangai location

SAMPLE PLOT 1

Character	Stomatal conductance (m mol m^{-2} s^{-1})	Photosynthesis (μ mol m^{-2} s^{-1})	CINT (ppm)	Transpiration (m mol m^{-2} s^{-1})	Height (m)	DBH (m)	Volume (m^3)	Volume upto DBH (m^3)
Mean	701.16	18.54	379.45	9.24	8.04	0.08	0.04	0.01
SD	64.14	3.40	30.39	1.54	0.92	0.01	0.02	0.00
CV%	9.15	18.32	8.01	16.68	11.49	17.33	47.96	35.16
Range(Minimum)	523.69	16.35	409.57	10.25	7.70	0.09	0.04	0.01
Range(Maximum)	797.25	24.53	421.56	12.44	9.40	0.08	0.04	0.01

SAMPLE PLOT 2

Character	Stomatal conductance (m mol m^{-2} s^{-1})	Photosynthesis (μ mol m^{-2} s^{-1})	CINT (ppm)	Transpiration (m mol m^{-2} s^{-1})	Height (m)	DBH (m)	Volume (m^3)	Volume upto DBH (m^3)
Mean	709.65	18.80	375.02	9.17	7.90	0.08	0.03	0.01
SD	65.09	3.44	35.62	1.71	1.14	0.02	0.03	0.00
CV%	9.17	18.31	9.50	18.68	14.47	24.46	74.64	52.99
Range(Minimum)	582.35	15.48	300.16	9.75	8.50	0.07	0.03	0.00
Range(Maximum)	812.24	16.36	384.27	9.33	8.20	0.04	0.01	0.00

SAMPLE PLOT 3

Character	Stomatal conductance (m mol m^{-2} s^{-1})	Photosynthesis (μ mol m^{-2} s^{-1})	CINT (ppm)	Transpiration (m mol m^{-2} s^{-1})	Height (m)	DBH (m)	Volume (m^3)	Volume upto DBH (m^3)
Mean	725.50	19.44	372.45	9.29	7.98	0.09	0.04	0.01
SD	67.74	4.18	33.84	1.80	0.78	0.01	0.01	0.00
CV%	9.34	21.50	9.08	19.40	9.71	11.23	34.84	23.57
Range(Minimum)	568.32	21.35	346.26	8.28	7.50	0.07	0.03	0.00
Range(Maximum)	804.27	15.65	344.56	9.18	8.40	0.09	0.04	0.01

Table 10. Variability in base population of Eucalypts -Pudukottai location

Character	Stomatal conductance (m mol m^{-2} s^{-1})	Photosynthesis (µ mol m^{-2} s^{-1})	CINT (ppm)	Transpiration (m mol m^{-2} s^{-1})	Height (m)	DBH (m)	Volume (m^3)	Volume upto DBH (m^3)
Mean	743.1	21.45	406.36	10.73	9.77	0.12	0.08	0.011
SD	21.16	1.61	5.3	0.56	0.92	0.0058	0.01	0.002
CV%	8.17	12.33	7.49	18.68	14.47	23.54	73.53	49.99
Range(Minimum)	721.89	20	402.56	10.12	9.12	0.11	0.07	0.01
Range(Maximum)	764.21	23.18	412.42	11.23	10.85	0.12	0.09	0.012

Table 11. Variability in base population of Eucalypts - Ariyalur location

SAMPLE PLOT 1

Character	Stomatal conductance (m mol m^{-2} s^{-1})	Photosynthesis (µ mol m^{-2} s^{-1})	CINT (ppm)	Transpiration (m mol m^{-2} s^{-1})	Height (m)	DBH (m)	Volume (m^3)	Volume upto DBH (m^3)
Mean	882.49	31.77	595.22	17.24	12.51	0.36	1.12	0.11
SD	112.11	5.55	102.31	2.32	2.42	0.08	0.78	0.05
CV%	12.70	17.48	17.19	13.46	19.37	21.26	70.01	46.43
Range(Minimum)	713.16	24.57	354.99	13.26	9.00	0.26	0.40	0.06
Range(Maximum)	1128.70	40.28	698.24	21.85	18.00	0.58	3.79	0.29

f) Ariyalur Location

In Ariyalur location also the highest coefficient of variation (70.01 %) was observed in the total volume when compared to all other growth character. Like other location the volume upto DBH recorded highest coefficient of variation (46.43%) next to total volume. The maximum transpiration of 13.26 m mol. m^{-2} s^{-1} was observed in sample plot and minimum of 13.26 m mol. m^{-2} s^{-1} was observed in sample plot. The maximum photosynthesis of 40.27 μ mol m^{-2} s^{-1} was observed in sample plot and minimum photosynthesis of 24.56 m mol. m^{-2} s^{-1} was observed in sample plot .

Selection of candidate trees (CTs)

The whole selection was done in two phases as described above. During the first phase of selection, the good growing trees with desired phenotypes in a population were selected. The selected trees were designated as candidate trees (CTs). The CTs were serially numbered and all their growth characters like height, DBH, total volume and volume upto DBH were measured. The physiological characters like transpiration, photosynthesis, CINT and stomatal conductance were also measured in the selected trees. These data were utilized to construct the selection index using multiple regression equation. Accordingly, in the present study at Tiruchendur 6 CTs were selected in location 1 and 7 CTs in location 2. In Nagercoil 6 CTs were selected in *E. camaldulensis* plantation and 7 CTs were selected in *E. tereticornis* plantation. In Ramanathapuram 6, 5 and 7 CTs were selected in location 1, location 2 and location 3 respectively. In Mettupalayam selection was resorted among provenance population and a total of 7 CTs were selected. Among the 86 ITC clones, 8 clones were selected as candidate clones (CTs) during the initial stage of screening. Sivagangai, which enjoys less than 500 mm rainfall is considered as one of the driest districts of Tamil Nadu, the Tamil Nadu Plantation Corporation (TAFCORN) and the farmers are extensively growing Eucalyptus as one of the livelihood crop. In the project, 50 acre Eucalyptus population was identified to select high efficacy biodrainage efficacy clones. Among the 50 acres of population about 15 top performing trees were identified as candidate trees (CTs). The phenotypic characters along with selection index have been described for all selected CPTs from all sources in Table 10-A to 10-J.

Selection of candidate plus trees (CPTs)

In the second phase of selection candidate plus trees (CPTs) were selected from candidate trees (CTs). Among the CTs, the trees, which were scored highest selection index, were selected and marked as CPTs. Accordingly, in the present study, totally 29 CPTs were collected from six different geographically separated locations. In Tiruchendur, three CPTs were selected from location 1 and two from location 2. In Nagercoil, one CPT was selected from *E. camaldulensis* population and three CPTs from *E. tereticornis* population were selected. In Ramanathapuram, one CPT was from location 1, location 2, location 3 each. In Mettupalayam source, five CPTs were selected (Table 9).

During the second selection, among the eight candidate clones of ITC, top three clones were identified as candidate plus clones (CPTs) for their highest biodrainage efficacy. In the Table 10-I, the growth and physiological characters of CTs of ITC were enlisted.

From the 15 CTs enlisted in Table 10-J for the Sivagangai location with their growth and physiological characters, nine top CPTs were finally selected. In the Table 11, the growth and physiological characters of all finally selected CPTs were enlisted.

Table 12. Details of finally selected candidate plus trees

Sl. No.	Clone No.	Stomatal conductance (m mol m^{-2} s^{-1})	Photosynthesis (μ mol m^{-2} s^{-1})	CINT (ppm)	Transpiration (m mol m^{-2} s^{-1})	Height (m)	DBH (m)	Volume (m^3)	Volume upto DBH (m^3)	Selection index
1	MTP 1	935.42	18.54	719.54	20.95	4.50	0.15	0.06	0.01	484.32
2	MTP 2	912.45	37.26	711.65	22.65	5.80	0.10	0.04	0.96	479.85
3	MTP 3	912.35	29.45	709.35	19.54	6.50	0.14	0.08	0.83	475.31
4	MTP 4	854.36	26.54	720.23	17.65	4.30	0.12	0.03	0.26	466.87
5	MTP 5	834.26	21.54	711.65	23.15	5.30	0.13	0.06	0.61	464.45
6	MTP 6	916.41	22.53	706.25	17.23	4.80	0.13	0.07	0.14	458.32
7	MTP 7	814.13	25.37	716.12	18.16	5.10	0.13	0.04	0.15	476.18
8	MTP 8	904.13	28.45	711.23	18.35	6.15	0.14	0.07	0.18	462.13
9	NGL 1	1197.25	45.18	839.65	23.68	34.10	0.48	5.00	0.20	770.80
10	NGL 2	1184.23	43.27	846.23	24.88	33.50	0.47	4.61	0.18	768.11
11	NGL 3	1128.69	34.18	698.05	21.06	20.00	0.27	0.93	0.06	683.63
12	NGL EC 4	1187.28	46.32	846.28	25.95	27.60	0.34	2.01	0.09	922.24
13	RMD 1	895.26	32.68	453.02	15.29	19.50	0.24	0.70	0.04	535.10

14	RMD 2	879.26	33.26	381.26	12.54	19.00	0.29	1.04	0.07	118.24
15	RMD 3	893.26	29.35	272.35	12.54	24.00	0.62	5.76	0.32	343.62
16	RMD 4	864.26	28.43	289.41	13.14	21.15	0.29	4.72	0.14	456.19
17	TCR 1	1137.56	38.45	694.26	22.54	20.80	0.50	3.32	0.21	449.65
18	TCR 2	987.15	29.65	298.12	18.65	11.50	0.32	0.73	0.08	413.37
19	TCR 3	985.23	37.15	345.68	15.24	12.00	0.29	0.65	0.07	405.61
20	TCR 4	1148.36	38.65	683.26	21.34	21.50	0.32	1.43	0.09	708.42
21	TCR 5	1005.26	24.98	725.07	15.65	13.50	0.24	0.48	0.48	634.03
22	ITC 3	1498.35	58.34	865.12	26.15	8.60	0.06	0.01	0.31	387.09
23	ITC 284	1472.68	57.15	892.15	25.96	9.10	0.05	0.01	0.25	385.85
24	ITC 286	1465.29	59.24	859.49	26.59	9.60	0.07	0.03	0.00	381.49
25	SGC 1	797.24	24.53	421.56	12.43	9.40	0.10	0.06	0.01	315.73
26	SGC 2	793.24	24.91	419.58	12.59	11.30	0.13	0.12	0.01	315.49
27	SGC 3	801.26	25.64	416.38	11.94	9.70	0.11	0.07	0.01	315.09
28	SGC 4	795.64	24.89	418.69	12.54	9.20	0.10	0.05	0.01	314.71
29	SGC 5	791.23	25.91	418.26	11.94	10.30	0.11	0.07	0.01	314.02
30	SGC 6	793.54	24.86	415.90	11.59	10.43	0.12	0.09	0.01	313.03

31	SGC 7	789.26	15.62	419.16	9.13	7.50	0.09	0.03	0.01	305.46
32	SGC 8	812.23	16.35	384.27	9.33	8.20	0.07	0.02	0.00	300.23
33	SGC 9	756.32	14.26	417.56	8.16	8.30	0.09	0.04	0.01	297.16
34	PD 6	764.21	21.19	404.12	10.84	9.12	0.12	0.08	0.01	284.14
35	PD 9	743.21	20.00	412.42	11.23	10.85	0.12	0.09	0.01	304.57
36	PD 10	721.89	23.18	402.56	10.12	9.35	0.11	0.07	0.01	299.89
37	ALR 1	892.52	24.14	638.43	12.15	7.15	0.12	0.07	0.04	328.53
38	ALR 2	840.13	22.42	620.38	10.24	6.47	0.11	0.03	0.03	298.46
39	ALR 5	820.46	20.64	606.87	8.95	5.59	0.01	0.02	0.02	273.58
40	KK 1	825.52	24.19	412.13	10.64	9.10	0.11	0.06	0.01	304.09
41	KK 2	810.28	22.87	406.87	9.94	8.75	0.11	0.05	0.01	298.52

VEGETATIVE PROPAGATION OF CPTs

Felling of CPTs for Coppice Shoot Induction

All the CPTs selected in all the locations were felled after taking all physiological and growth parameters. The felling was exercised at the height of 1.5 to 2 m from the base of the tree so as to enable more area for more coppice shoots production. In order to facilitate more number of coppice shoots, pollarding has also been done in Tiruchendur location. The felling of CPTs was done in such as way that a slant cut with saw to enable smooth surface and also to protect the stumps from felling damage. This also helps in avoiding of splitting the stumps.

The rate of coppice shoots production was examined in terms of bud initiation, number of coppice shoots production and time taken by each CPTs to produce coppice shoots of desired size. These parameters were recorded in all CPTs of all location in two seasons viz., rainy season and summer season.

The stumps of CPTs in Ramanathapuram location (Clone No. FCRI RMD-3) and Tiruchendur location (Clone No. FCRI TCR-1 and FCRI TCR-4) were dried.

Rooting and Assemblage of Clones

The rooting methodology is described in the materials and methods. As per the methodology described, all the clones selected, which are felled for induction of coppice shoots were subjected for rooting by using single nodal coppice shoots. The coppice shoots collected from the respective locations were kept in stock absorb and brought to the hardening chamber at Forest College and Research Institute, Mettupalayam, placing them in the ice box. The cut end of the single nodal coppice shoots were treated with IBA – 4000 ppm and kept in poly tunnel environment with vermiculite as a rooting medium. The cuttings were observed for their rooting capacity in terms of rooting percentage, number of roots and time taken for rooting.

The rooting percentage of all the clones is described in the Table 12. The results showed that maximum rooting of percentage was observed in Mettupalayam, ITC and NGC sources. The poor rooting percentage was observed from Ramanathapuram sources.

The rooting percentage of all the clones was studied in two different seasons. During winter season, especially from November to December, more than 97% rooting was observed in

Table 13. Mean performance of clones with respect to rooting percentage

S.no	Clone No.	Age of Mother trees (yrs)	Mar	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.
1	MTP - 1	4	23.52	15.05	15.99	30.56	15.52	19.27	15.23	96.17	95.64	95.20	94.91	94.42
2	MTP - 2	4	14.67	18.14	29.90	24.79	14.32	27.34	26.82	95.42	97.20	96.23	95.31	95.72
3	MTP - 3	4	18.51	21.99	17.08	20.51	19.28	27.62	31.98	96.22	96.52	96.98	95.37	95.75
4	MTP - 4	4	16.78	32.37	20.16	22.19	17.25	29.67	25.44	94.92	97.55	96.84	95.24	96.20
5	MTP - 5	4	32.57	37.58	39.66	41.76	37.26	46.68	66.42	98.94	99.33	99.17	98.14	97.25
6	MTP - 6	4	28.90	33.24	20.22	28.22	15.66	35.07	42.70	95.66	96.28	93.19	94.97	91.74
7	MTP- 7	4	33.14	32.15	19.21	27.65	24.45	28.64	38.94	97.23	96.34	95.24	94.26	94.76
8	MTP-8	4	19.35	25.54	19.69	29.37	23.75	26.37	40.10	95.43	96.78	95.81	93.78	95.87
9	NGL - 2	15	16.77	20.09	32.66	24.32	11.78	28.12	16.18	90.05	91.68	90.59	89.87	89.14
10	NGL - 3	15	19.90	19.50	26.46	22.75	25.19	36.90	43.32	91.12	90.67	90.87	89.90	91.77
11	NGL - 4	15	15.62	13.40	27.40	24.91	20.47	34.82	14.05	61.66	67.35	62.50	63.51	61.93
12	RMD - 2	8	13.48	20.53	25.46	15.76	18.69	16.65	18.69	33.57	38.13	38.44	32.85	34.29
13	RMD - 3	27	9.72	12.68	10.60	7.19	8.60	19.93	10.47	37.97	34.73	37.21	33.35	36.97
14	TCR - 1	25	14.91	11.08	12.14	10.58	24.15	23.63	19.48	93.60	92.40	92.99	91.00	88.70
15	TCR - 2	25	13.12	12.86	13.71	17.77	28.52	25.71	21.35	68.74	66.69	68.98	63.72	61.84
16	TCR - 3	25	15.30	13.58	15.40	16.93	36.49	22.13	24.11	90.66	92.65	92.12	89.66	87.39

17	TCR - 4	25	10.77	11.53	17.80	26.73	16.84	20.78	26.44	66.89	64.70	66.11	63.80	63.41
18	ITC - 3	3	19.43	20.21	20.30	24.06	15.57	40.49	31.56	95.90	95.23	95.69	94.57	92.46
19	ITC- 284	3	16.26	26.68	29.98	30.81	17.52	35.01	30.05	95.28	95.50	96.08	93.39	93.79
20	ITC - 286	3	14.37	27.65	21.31	40.23	36.17	36.81	28.53	94.18	94.51	95.00	93.35	91.76
21	SG - 1	2.5	22.73	22.89	22.33	17.19	16.00	20.54	29.42	97.02	98.33	97.38	96.68	95.86
22	SG - 2	2.5	18.15	26.74	23.89	14.77	25.91	23.24	33.34	96.02	98.34	97.03	96.18	94.69
23	SG - 3	2.5	23.23	23.18	31.80	24.63	24.15	20.80	39.22	96.83	97.15	96.11	95.99	93.63
24	SG - 4	2.5	26.53	27.81	25.30	16.40	29.51	33.66	33.20	97.42	97.57	96.52	96.50	96.05
25	PD 6	2.5	30.27	20.91	24.39	13.67	26.91	26.51	32.07	96.58	96.67	96.17	95.63	95.42
26	PD 9	2.5	18.49	23.28	16.89	21.88	18.59	34.47	24.93	97.61	97.42	97.08	96.52	96.25
27	PD 10	3.0	19.34	20.05	23.96	24.94	42.19	36.89	28.48	97.56	96.82	97.49	96.19	96.16
28	ALR 1	3.0	16.51	29.82	23.69	30.37	42.75	35.07	31.23	97.42	97.09	96.93	96.26	95.01
29	ALR 2	3.0	15.77	15.64	20.22	19.80	21.59	39.34	45.25	97.12	97.53	97.04	96.33	96.29
30	ALR 5	3.0	16.78	15.68	21.43	22.35	21.46	36.87	38.94	95.66	96.43	96.57	96.45	96.72
31	KK 1	2.5	14.56	12.35	15.45	18.65	19.78	38.18	37.54	95.35	96.75	96.87	96.83	96.45
32	KK 2	2.5	16.32	21.24	20.19	21.47	38.10	35.00	27.49	96.56	96.84	96.41	96.00	96.10
	CD (0.05)		5.2	10.85	7.37	8.72	7.71	14.6	12.93	21.55	0.77	6.11	6.04	6.11

all the sources except in Ramanathapuram and Sivagangai. During summer, from February to March less than 20% rooting was observed in all the sources.

The assemblage by rooting of coppice shoots from different sources of CPTs is under progress. The hardening of the rooted clones and shifting them to polybags for field planting is also under progress.

Details of finally selected candidate plus trees

About 41 candidate plus trees (CPTs) were selected from nine sources viz., Ramanathapuram(RMD), Nagercoil (NGL), Tiruchendur(TCR), Mettupalayam(MTP), Sivagangai(SG), ITC clones , Ariyalur(ALR), Pudukottai(PD) and Kantharvakottai (KK) Cuttings taken from 42 CPTs were used for clonal multiplications for assessing the efficiency of biodrainage.

Mean performance of clones with respect to rooting percentage

Totally twenty seven CPTs that were already selected were multiplied through two nodal coppice shoot cuttings. The two nodal cuttings obtained from the coppice shoot of mother trees were rooted by dipping the cut end of cuttings in IBA (4000 ppm). All the CPTs were subjected for rooting study and the rooting behaviour of all the clones is illustrated in the Table 13. The rooting potential of all the clones were studied in terms of rooting per cent, root length, shoot length and number of roots.

Effect of season on rooting

The rooting potential of all the clones were studied in relation to different seasons and monthly interval. The result on the seasonal variations in rooting ability of the nodal cuttings is presented in the Table 13. All the rooting parameters that were studied showed a significant variation with respect to season as described below.

Rooting percentage

All the clones exhibited rooting in all the months of study with significant variation in rooting percentage among all the clones during the period of study. The highest percentage of rooting (99.33) was observed during the month of November for the clone MTP- 5, while, the lowest percentage of rooting was exhibited during the month of June by clone RMD-3 (7.19%) followed by TCR-4 (10.58%) (Table 13). The rooting behaviour of all the clones showed a tendency that maximum mean percentage of rooting (89.59) was observed during the month of November, while, the minimum was recorded for the month of March (18.93).

Clonal response on rooting ability

The clonal ability for rooting was studied for all the clones at monthly interval. The behaviour of each clones on rooting showed significant variation to season. On the contrary, rooting ability of the clones also showed independency in rooting. The results of the rooting response of the clones are illustrated in the Table 13. Marked differences were observed among the clones in the rooting behaviour.

Percentage of rooting

The rooting percentage among the clones ranged from 7.19 per cent (RMD-3) to 99.33 per cent (MTP-5). All the clones had responded to rooting with varying percentage. The maximum rooting percentage was exhibited by the clone MTP- 5.

Age of the parent tree on rooting

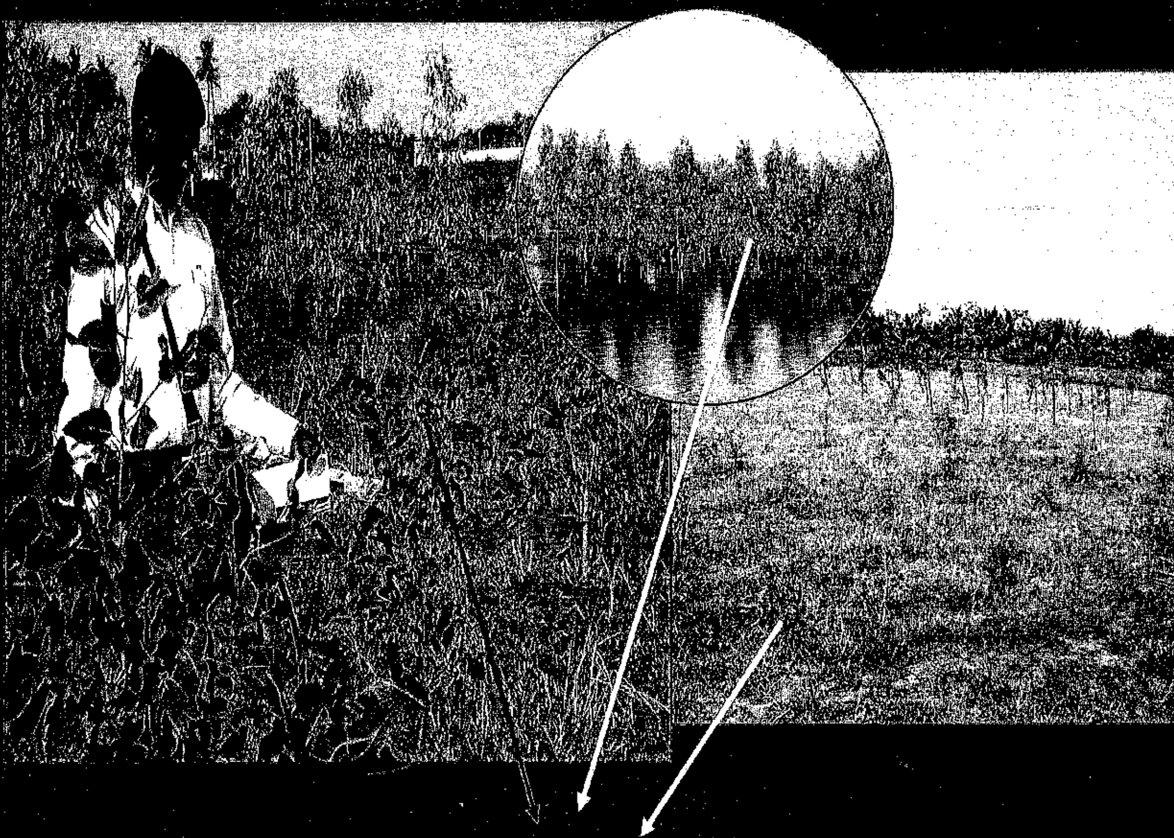
The variation among the clones for rooting with respect to age was also studied. The results showed a remarkable effect of age on rooting. The data presented in the Table 2 shows that the age of the mother plant has a direct bearing on the rooting ability in Eucalypts. The trees of younger age showed a good rooting percentage compared to the mother trees of age 25 years and above. A maximum rooting percentage of 99.33 (MTP-5) was obtained for the nodal cuttings from the trees age of four years, followed by 98.34 per cent for SG-4 (2.5 years). The rooting percentage of younger aged trees varies from 14.37 per cent to 99.33 per cent during the period of study. While, the trees of age more than 25 years showed a poor rooting ability. The mother tree of the clone RMD-3 (27 years) showed the lowest rooting percentage ranging from 7.19 per cent to 37.97 per cent throughout the year. Whereas, the maximum rooting percentage was exhibited by the clone MTP-5 of age four years which ranged from 32.57 per cent to 99.33 per cent. However, the TCR clones of 25 years and NGL clones of 15 years exhibited a moderate rooting percentage, but they are significantly lower than that of younger aged trees.

Table 14. Rooting ability of poor performing clones*

Clone No.	Age of the Mother tree(yrs)	Mar	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mean
NGL-1	15	-	-	-	-	-	-	-	4.68	7.32	7.59	5.26	6.49	6.268
TCR -5	25	-	-	-	-	-	-	-	5.24	6.38	6.94	5.12	5.94	5.924
RMD-1	8	-	-	-	-	-	-	-	3.12	4.58	5.27	5.01	5.07	4.61
RMD-4	8	-	-	-	-	-	-	-	2.13	3.94	3.17	3.28	3.79	3.262
SGC 5	2.5	-	-	-	-	-	-	-	4.23	3.18	4.12	3.54	3.85	3.784
SGC 6	2.5	-	-	-	-	-	-	-	2.15	2.76	3.21	2.89	3.01	2.804
SGC 7	2.5	-	-	-	-	-	-	-	3.12	3.33	3.21	3.45	3.38	3.298
SGC 8	2.5	-	-	--	-	-	-	-	2.18	2.91	2.82	2.24	2.17	2.464
SGC 9	2.5	-	-	-	-	-	-	-	2.22	2.32	2.64	2.54	2.78	2.5

* Data not subjected for statistical analysis

Plate 9.Suceptible Clones



Suceptible Clones

NGL 3
TCR 2
SG 3

PD 9
ALR 2
ALR 5

There was no significant variation in the number of roots, root length and shoot length among the clones with respect to age. In all the clones, the root length, shoot length and number of roots were almost on par with each other (Table 13).

Rooting ability of poor performing clones

The clonal ability for rooting was studied for all the clones at monthly interval. The behavior of each clones on rooting showed significant variation to season. The results of the poor response rooting of the clones are illustrated in the Table 14. The Clones NGL-1, TCR-5,RMD-1,RMD-3,SGC-5, SGC-6,SGC-7,SGC-8 and SGC-9. Among the poor performing clones the clone RMD-3 has very low rooting performance with low rooting per cent value of 2.13 in the October month followed by SGC-8 with rooting per cent of 2.18 in October month.

Establishment of clonal bank

Among the 41 clones tried for rooting from five different sources, 32 clones were successfully developed for rooting. These rooted 32 clones were planted in the clone bank in CRBD design for clone bank establishment at Forest College and Research Institute, Mettupalayam on May, 2005. This serve as a resource for biodrainage efficiency screening the clones through biometrical and ecophysiological traits.

Methods

Field experiment

The ramets of all the clones were planted in the field during August 2006 as a biodrainage evaluation trail at Tamil Nadu Rice Research Institute, Aduthurai and at Agriculture Engineering College and Research Institute, Kumulur during February 2007 (Plate 1). The both fields were laid out in Completely Randomized Black Design (CRBD) with three replications and a spacing of 3m x 2m. The biometrical and ecophysiological observations were recorded at three monthly intervals to evaluate the clones for biodrainage efficiency.

Mass multiplication for raising field trail:

Two nodal cuttings from the coppice shoots of selected candidate plus trees (CPTs) which were raised in clonal garden of Forest College and Research Institute, Mettupalayam and

Plate 8.Overview of Field Experiment

mass multiplied by the methods described by Verma (1994). The leaves of two nodal cuttings were half pruned to avoid water loss. In the propagation chamber, the two nodal cuttings were washed thoroughly with sterile water replated and soaked in 0.1 per cent Bavistin for 30 minutes to avoid pathogenic infection. The basal cut end of the cuttings was dip smeared with IBA (Indole Butyric Acid) 4000 ppm powder concentration (Verma *et al*., 1996) and planted in poly cups filled with presoaked vermiculate as rooting medium. The poly cups were kept inside poly tunnels under shade net environment condition. The humidity inside the poly tunnels was maintained at 80 to 85 per cent by misting with water in to the tunnels by opening the sides of tunnels. After 20-25 days of planting, the rooted cuttings were transplanted to poly bags filled with pot mixture (Sand: Soil: FYM in the ration of 1:1:1). After ensuring the good establishment of the rooted cuttings in the poly bags, the hardening of cuttings was done in three phases. Initially, the rooted cuttings were hardened inside the hardening chamber under double layer shade net; secondly, the hardened clones were slowly moved to the single layer net and finally they were exposed to open environment. After three months of hardening the clones were planted in field.

Evaluation for biodrainage efficiency

The vegetatively propagated clones were screened for their biodrainage efficacy was assessed in terms of both biometric and eco-physiological traits as per the methods described below.

Biometrical traits

The following biometric observations were made at 3 monthly intervals for 33 clones of *Eucalyptus tereticornis* and *E. camaldulensis* and three seed sources (one from Australia, i.e., *E. saligna*) with the total of 36 sources which were raised in the two experiments.

Height

The plant height was measured using measuring scale from the ground level to the tip of the stem and the mean was expressed in meter (m).

Plate 16. Plantation at 4 year after MAP

Aduthurai

Kumulur

Measuring biometric observations

Basal diameter

The basal diameter was measured at base of the stem (near ground level) using digital vernier calliper and the mean was expressed in centimeter (cm).

Volume index

Volume index = $(\text{Basal Diameter})^2 \times \text{Height}$

(Hatchell, 1985; Manavalan, 1990)

Ecophysiological traits

The ecophysiological traits of the clones were measured using a Portable Photosynthesis System (PPS, model CI-301 CO_2 gas analyzer, CID, and Inc. USA). The measurements were made on fully matured leaves (5-6 leaves from the bud) from April 2007 to March 2008. The ecophysiological estimations *viz.*, transpiration rate, photosynthesis, stomatal conductance and inter cellular CO_2 concentration (CINT), was measured on a sunny day between 10.00 AM to 11.00 AM as per the procedure described below.

Transpiration

The transpiration rate was measured using Portable Photosynthesis System (PPS, model CI-301 CO_2 gas analyzer, CID, and Inc. USA) and expressed as m mol m^{-2} s^{-1}.

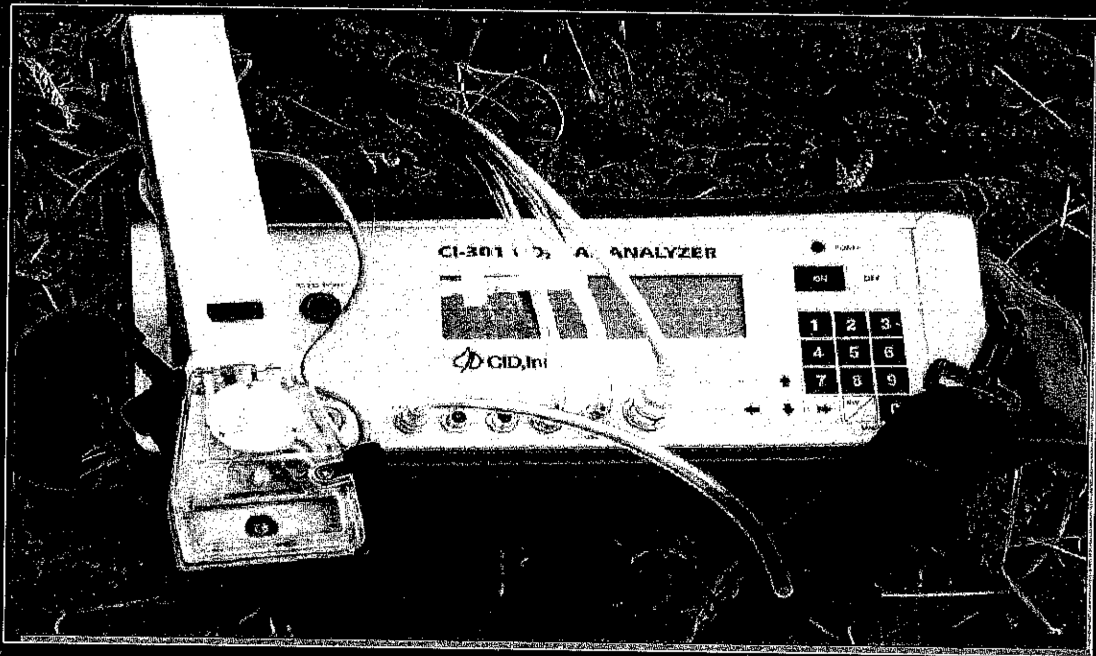
Photosynthesis

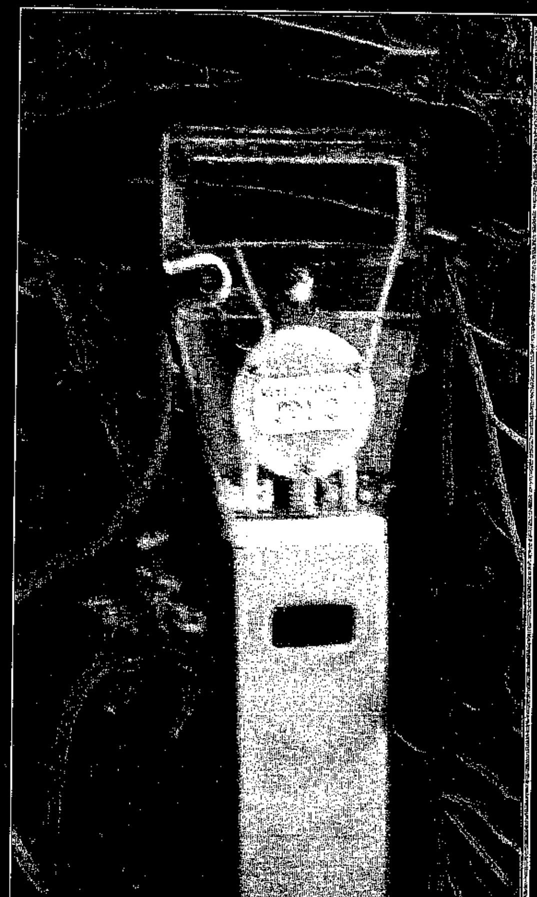
The photosynthetic rate of the entire clone was measured using the Portable Photosynthesis System (PPS, model CI-301 CO_2 gas analyzer, CID, and Inc. USA). The PPS measures the uptake of CO_2 and estimates the photosynthetic productivity using infra red gas analyzer (IRGA). It is expressed in μ mol m^{-2} s^{-1}.

Stomatal conductance

The stomatal conductance was measured using the Portable Photosynthesis System (PPS, model CI-301 CO_2 gas analyzer, CID, and Inc. USA) and expressed in m mol m^{-2} s^{-1}.

Plate 17. Measuring Ecophysiological Traits





Inter cellular CO_2 concentration (CINT)

The inter cellular CO_2 concentration is a measure of photosynthetic efficiency and measured using Portable Photosynthesis System (PPS, model CI-301 CO_2 gas analyzer, CID, and Inc. USA) and expressed in terms of ppm.

Diurnal variation estimation on ecophysiological traits

The behaviour of ecophysiological traits *viz.*, transpiration, photosynthesis, stomatal conductance and intercellular CO_2 concentration were studied with respect to diurnal changes on a sunny day using Portable Photosynthesis System (PPS, model CI-301 CO_2 gas analyzer, CID, and Inc. USA). These measurements were made at an hourly interval from 8.00 AM to 5.00 PM. The diurnal variation study was conducted for all the clones from April 2007 to March 2008. These measurements were made when the clones were irrigated up to field condition level.

Estimation for stable isotope of carbon

Leaf samples of various clones were collected, air dried and oven dried. The samples were powdered for quantifying the stable isotope ratios of carbon ($^{13}C/^{12}C$). The carbon content was estimated by using Isotope Ratio Mass Spectrometer (IRMS) technique.

IRMS facility is capable of quantifying the stable isotope ratios of carbon ($^{13}C/^{12}C$) in solid organic materials. Combustion and pyrolysis of organic matter is catalyzed by specific catalysts in the elemental analyzer. Stable isotope ratios of carbon can be analyzed on a continuous flow (CF) basis. This is achieved by interfacing the IRMS in series with a continuous flow device that introduces the sample gas in tandem with the reference gas.

This feature enhances the accuracy of the determination of stable isotope ratios. The IRMS has an internal precision as measured by the standard deviation which is better than 0.05 per cent for carbon fraction.

Statistical analysis

The data gathered from the field experiments were subjected to statistical analysis and tabulated separately. Estimates of mean, coefficient of variation and standard error were worked out using the method described by Panse and Sukhatme (1978). The significance test was carried out by referring to the standard 'F' table described by Snedcor (1961).

Mean

The mean for height and basal diameter was calculated by dividing the sum of all the observations with the total number of observations.

$$\text{Mean (m)} = \sum X / N$$

Where,

$\sum X$ = Sum of X character

N = number of observations

Variability parameters

The variability estimates *viz.*, GCV, PCV, heritability and genetic advance are calculated as follows. The variability parameters were estimated for the biodrainage attributes *viz.*, height, transpiration rate, stomatal conductance and volume index. The phenotypic value of height recorded at three monthly intervals during the study period was used for the analysis.

Phenotypic and genotypic variances and co-variances

These parameters were estimated as per the method described by Johnson *et al.* (1955).

$$\text{Genotypic variance} = \sigma^2 g = (M_1 - M_2)/r$$

$$\text{Phenotypic variance} = \sigma^2 p = \sigma^2 g + \sigma^2 e$$

Where,

M_1 = Mean sum squares for species

M_2 = Mean sum squares for error

$\sigma^2 g$ = Genotypic variance

$\sigma^2 e$ = Environmental variance

Phenotypic and Genotypic coefficients of variances (PCV and GCV) were computed following Burton (1952).

$$PCV\ \% = \frac{(\text{Phenotypic Variance})^{1/2}}{\text{General mean}} \times 100$$

$$GCV\ \% = \frac{(\text{Genotypic Variance})^{1/2}}{\text{General mean}} \times 100$$

Heritability

Heritability in the broad sense (h^2) was calculated using the formula suggested by Lush (1940) and expressed in percentage.

$$h^2 \text{ (broad sense)} = (\sigma^2 g / \sigma^2 p)$$

$$\text{Heritability percentage} = h^2 \times 100$$

Genetic advance

The genetic advance was calculated using the formula given by Johnson *et al.*, (1955).

$$\text{Genetic advance} = \sigma^2 g / \sigma^2 p$$

Where

$\sigma^2 g$ = Genotypic variance

k = Selection differential (2.06) at 5% level of significance.

$\sigma^2 p$ = Phenotypic variance

GA as percentage of mean = GA / Grand mean x 100

Correlation studies

The degree of relationship between two traits can be assessed using correlation coefficients. Phenotypic and genotypic correlation coefficients were calculated according to the method suggested by Goulden (1952). These correlation studies were carried out for the traits *viz.*, transpiration rate, height, stomatal conductance and volume index.

Phenotypic correlation

$$rp\ 1.2 = \frac{\text{Phenotypic covariance between 1 and 2}}{(\text{Phenotypic variance of 1 and phenotypic variance of 2})^{1/2}}$$

Genotypic correlation

$$rg\ 1.2 = \frac{\text{Genotypic covariance between 1 and 2}}{(\text{Genotypic variance of 1 and genotypic variance of 2})^{1/2}}$$

Estimation of genetic diversity

Genetic divergence among the seed sources was studied using biometric techniques.

Genetic divergence

In order to find out the genetic divergence, Mahalanobis (1928) D^2 statistics and subsequently clustering was adopted. It was also necessary to find out the contribution of independent traits towards the divergence so that, while selection, the same can be taken into consideration. The entire analysis was carried out using 'GENRES' computer based statistical package developed by Tamil Nadu Agricultural University, Coimbatore.

D^2 statistics

The mean squares and mean products were estimated between groups and within components by one-way analysis of variance, covariance and the significance tested at clonal level. A variance – covariance was formed from the above and subjected to pivotal condensation to obtain the linear function for transformation of character mean values (x) to a set of independent variables (uncorrected mean) value (y).

The difference between any two mean values for each pair of clones were squared and added to give the D^2 values. Cumulative D^2 values in all possible combination of clones were estimated separately for each y characteristics.

$y_1 = x_1$

$y_2 = x_2 - a_2 x_1$

$y_3 = x_3 - a_{32} y_2 - a_{31} y_1$

$yp = xp - a_{pp-1} y_{p-1} \ldots ap_1 y_1$

where,

x_1 = normalized variables

$a_{ij} = b_{ij} / v(y_j)\ S < -1$

$v(yj) = \lambda \sum a(ji)\ bij - bij = \lambda ij\text{-}1 / atbt$

λij = covariance of i and $j^t = ji$

All possible [n(n-1)/2), D^2 values were calculated by taking sum of different between pair of corresponding 'y' values taking two clones at a time.

Determination of clusters or grouping

The clones were grouped into different clusters on the basis of D^2 values according to Tocher's method as suggested by Rao (1952).

Tocher's method

n (n-1)

------- D^2

In this method, the first step in grouping the clones into distinct clusters was to arrange them in order of their relative distances from each other based on D^2 values. Then the two seed sources having smallest average D^2 value from the clones were added. Similarly, the nearest fourth clone was chosen and the process was continued up to a stage where there was abrupt increase in the average D^2 after adding a particular clone. Similarly, other clusters were formed the clone, which had already been included. The process was continued till the entire seed sources were included into one or other cluster.

Average *intra* and *inter* cluster distances

On completion of clustering, the *intra* and *inter* cluster relationships were studied and the mutual relationship between clusters and their distances were represented. The average *intra* cluster distances was measured using the formula

$$D^2 = Di^2 / n,$$

Where D^2 was the sum of distances between all possible combinations of the clones included in a cluster whereas, the average *inter* cluster divergences were arrived at by taking into consideration of all the component D^2 values possible among the numbers of the two clusters. Then the genetic distance 'D' between the clusters were obtained from square root of the average D^2 values.

RESULTS

Observations on biometrical traits viz., height, basal diameter and ecophysiological traits viz., transpiration rate, stomatal conductance, Inter Cellular CO_2 Concentration (CINT) and photosynthesis rate were measured for all the 35 clones of Eucalypts and one Australian seed source of *E. saligna* which were raised at Tamil Nadu Rice Research Institute, Aduthurai and Agricultural Engineering College and Research Institute, Kumulur. Volume was calculated using the primary data on height and basal diameter. The data were analyzed and results are described in following order.

1. Evaluation of clones for biodrainage efficiency

    1.1 Clonal performance under waterlogged condition

    1.2 Biometric traits

    1.3 Eco-physiological traits

2. Estimation of genetic parameters of clones for biodrainage traits

3. Genetic divergence estimation

4. Ecophysiological characterization of clones

Evaluation of clones for biodrainage efficiency

Clonal performance under waterlogged condition

The individual mean performance of 35 clones of Eucalypts and one Australian seed source of *E. saligna* for biometric traits viz., height, basal diameter and volume are presented from Table 15 to Table 20. Also the *per se* performance of the clones for ecophysiological traits are presented in Table 21 to Table 26.

Biometric traits

Height

The character height exhibited significant variation among the clones in all the months of observation (Table 15; Fig. 1). Among 35 clones and one seed source studied at Aduthurai, fourteen clones viz., MTP-1, MTP-2, MTP-3, MTP-4, MTP-5, MTP-6, MTP-7, TCR-1, TCR-3,ITC-3, ITC-286, KK-1,KK-2 and *E. saligna* recorded significantly higher height than grand mean (7.45). The maximum value for average height was recorded by MTP-6 (10.45 m) followed by MTP-5 (10.21 m) and the minimum average height value was recorded by the clone EU-2 (4.93m).

The same trend of height variation was also observed among the all the clones except KK-1 in experimental plot established at Kumulur (Table 16; Fig. 2).However the grand mean of height recorded at Kumulur (7.45 m) was significantly higher than Aduthurai research plot (8.20 m).

Basal diameter

The clonal variation for basal diameter shown significant variation in all the month among the clones at Aduthurai (Table 17). During 48 MAP about eighteen clones viz., MTP-1, MTP-2, MTP-3, MTP-4, MTP-5, MTP-6, MTP-7, MTP-8, NGL-2, TCR-1, ITC-3, ITC-284, ITC-286, SG-1,SG-2, KK-1, KK-2 and *E. saligna* were recorded significantly maximum value for basal diameter than grand mean. The maximum value of 26.34 m was recorded by MTP-5 followed by 25.58 m in MTP-1. The minimum value (8,77 m) for basal diameter was recorded by PD-10.

At Kumulur research plot the studied revealed that seventeen clones viz., MTP-1, MTP-2, MTP-3, MTP-4, MTP-5, MTP-6, MTP-7, MTP-8, NGL-2, TCR-1, ITC-3,ITC-284, SG-1,SG-2, KK-1, KK-2 and *E. saligna* were recorded significantly higher value for basal diameter over grand mean(19.70 m)(Table.18). Among all the clones, the clone MTP-1 accounted basal diameter of 27.63 m followed by MTP-6 and MTP-5 respectively of 27.43 m and 27.27 m. Eu-2 recorded the lowest basal diameter of 10.30 m.

Table 15.Clonal variation of height (m) (August 2006 to July 2009)- Aduthurai trail

S.No	Clone 1	6 MAP	12 MAP	18 MAP	24 MAP	30 MAP	36 MAP	42 MAP	48 MAP	Mean
1	MTP-1	1.34	3.29	3.85	7.03	10.06	15.71	18.12	20.50	9.99
2	MTP-2	1.11	2.78	3.78	6.72	9.82	14.12	16.23	18.23	9.10
3	MTP-3	0.99	1.99	2.75	6.54	9.53	14.28	16.35	18.84	8.91
4	MTP-4	1.37	2.71	3.14	6.47	9.47	14.35	16.82	18.61	9.12
5	MTP-5	1.26	3.05	4.20	7.41	10.71	16.42	18.21	20.42	10.21
6	MTP-6	1.41	3.55	4.06	7.82	11.03	16.31	18.56	20.82	10.45
7	MTP-7	1.02	1.84	3.48	5.27	8.67	13.86	15.43	17.62	8.40
8	MTP-8	0.86	1.94	2.87	5.24	9.39	13.91	15.51	17.46	8.40
9	NGL-2	0.47	2.85	3.24	5.39	8.32	13.47	15.86	17.56	8.40
10	NGL-3	0.44	1.25	1.57	3.38	6.35	10.56	13.81	16.33	6.71
11	NGL-4	0.51	1.33	1.85	3.01	5.42	9.32	12.65	15.70	6.22
12	RMD-2	0.39	1.01	1.44	2.10	3.92	7.48	10.02	12.15	4.81
13	RMD-3	0.39	0.95	1.35	2.05	3.86	7.32	10.15	11.52	4.70
14	TCR-1	0.98	1.85	3.37	5.18	8.37	13.51	15.15	17.26	8.21
15	TCR-2	0.59	1.22	2.62	3.46	6.32	10.12	13.54	16.83	6.84
16	TCR-3	0.99	1.65	3.12	5.26	8.65	13.79	15.87	17.81	8.39
17	TCR-4	0.41	1.01	1.47	2.48	3.63	7.71	11.52	13.11	5.17
18	ITC-3	0.75	1.37	2.56	6.27	9.54	14.08	16.42	18.63	8.70
19	ITC-284	0.72	1.42	2.51	6.33	9.47	14.13	16.37	18.48	8.68
20	ITC-286	0.55	1.58	2.87	3.01	5.42	9.32	12.65	15.76	6.40
21	SG-1	0.91	3.21	3.82	7.23	10.85	16.32	18.32	20.37	10.13
22	SG-2	0.58	1.18	1.72	6.71	9.54	14.82	16.57	18.05	8.65
23	SG-3	0.68	1.88	2.37	3.23	6.82	10.32	13.32	16.18	6.85
24	SG-4	0.64	2.30	2.95	3.18	5.31	9.48	12.67	15.83	6.54
25	PD-6	0.56	1.37	1.56	2.38	3.76	7.37	10.31	12.61	4.99
26	PD-9	0.43	1.09	1.90	3.68	6.71	10.56	13.54	16.56	6.81
27	PD-10	0.41	1.43	1.94	2.41	3.95	7.58	10.50	12.52	5.09
28	ALR-1	0.44	1.07	1.46	2.31	3.98	7.51	10.12	12.11	4.87
29	ALR-2	0.45	0.88	1.26	3.27	6.34	10.37	13.61	16.48	6.58
30	ALR-5	0.70	1.28	1.61	3.26	6.25	10.45	13.32	16.43	6.66
31	KK-1	0.80	1.97	2.85	5.42	8.12	13.28	15.41	17.62	8.18
32	KK-2	0.79	1.48	2.57	6.34	9.42	14.06	16.32	18.54	8.69
33	E.sal	1.03	1.58	1.99	6.03	9.53	14.01	16.67	18.71	8.69
34	EU-1	0.51	1.25	1.53	2.44	3.52	7.55	11.75	13.85	5.30
35	EU-2	0.48	1.01	1.52	2.41	3.85	7.41	10.22	12.51	4.93

Fig 1.Clonal variation of height at different MAP in Aduthurai

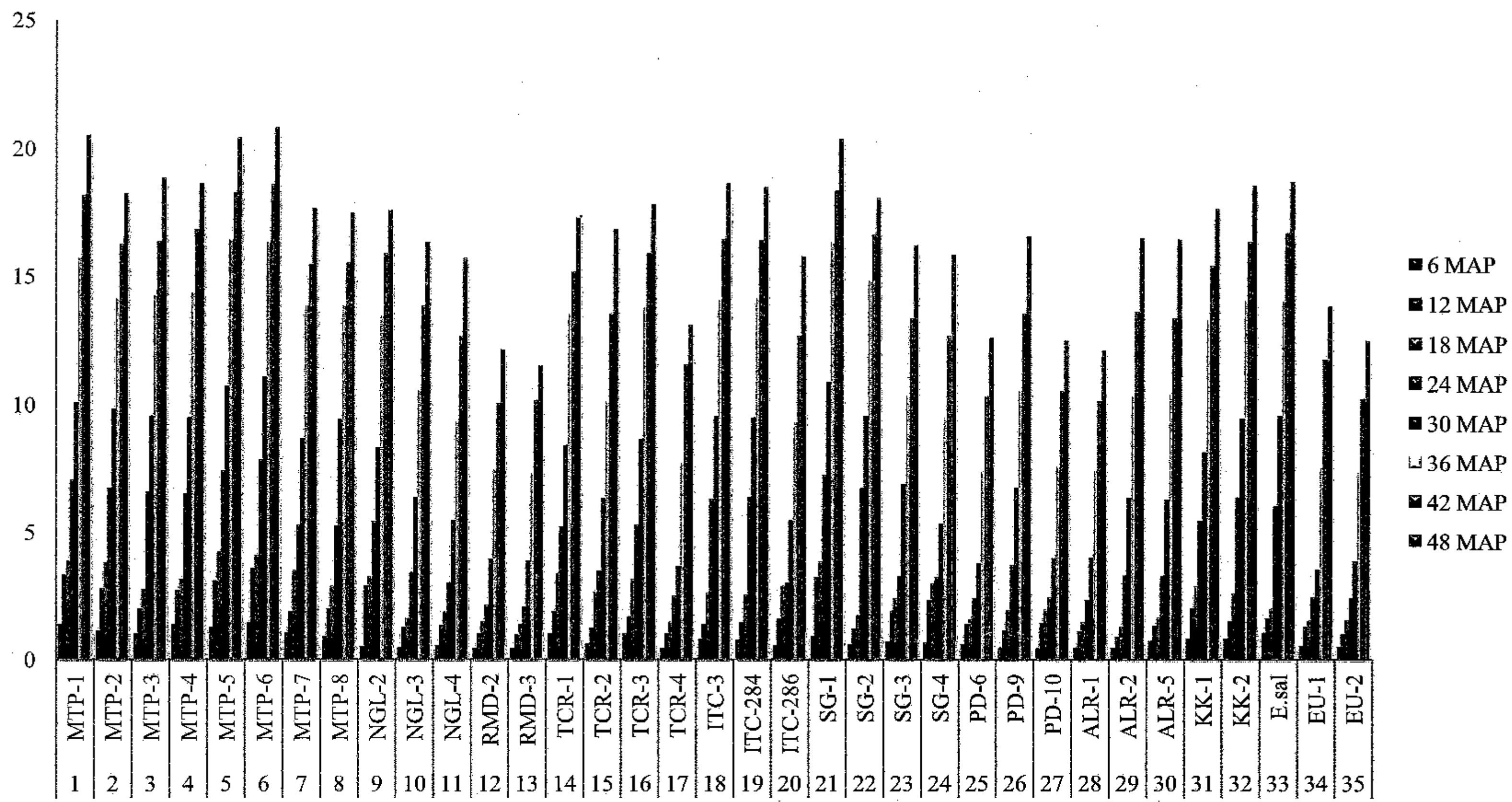


Table 16. Clonal variation of height (m) (August 2006 to July 2009)- Kumulur trail

S.No	Cone 1	6 MAP	12 MAP	18 MAP	24 MAP	30 MAP	36 MAP	42 MAP	48 MAP	Mean
1	MTP-1	2.61	3.30	4.35	8.46	11.46	16.32	20.51	22.01	11.13
2	MTP-2	3.48	4.06	4.11	7.23	9.24	15.40	7.40	20.50	8.93
3	MTP-3	2.14	2.85	4.22	7.43	9.33	15.12	17.15	20.60	9.86
4	MTP-4	2.52	3.28	4.01	7.01	9.32	15.41	17.35	20.44	9.92
5	MTP-5	3.12	4.13	4.85	8.57	11.87	16.91	20.61	22.24	11.54
6	MTP-6	2.63	3.71	4.67	8.44	11.35	16.80	20.61	23.30	12.56
7	MTP-7	2.11	2.85	3.46	6.73	11.54	14.63	16.32	18.45	9.51
8	MTP-8	0.85	1.34	3.41	6.56	9.43	14.50	16.82	18.27	8.90
9	NGL-2	0.55	2.95	3.34	6.49	9.42	14.37	1.76	18.11	7.12
10	NGL-3	1.07	1.99	2.72	4.75	8.34	11.59	14.16	17.09	7.71
11	NGL-4	0.93	1.50	2.23	4.12	9.43	10.23	13.06	16.09	7.20
12	RMD-2	0.70	0.95	2.11	2.87	4.12	7.42	10.16	13.67	5.25
13	RMD-3	0.75	0.98	2.08	2.93	4.03	7.32	10.56	13.68	5.29
14	TCR-1	0.86	1.66	3.64	6.51	9.07	14.14	16.32	13.21	8.18
15	TCR-2	1.01	1.53	2.52	4.54	8.53	11.52	14.56	17.59	7.73
16	TCR-3	2.01	2.75	3.54	6.43	9.73	14.23	16.41	18.39	9.19
17	TCR-4	0.92	1.12	2.73	3.25	4.37	9.57	13.91	15.12	6.37
18	ITC-3	1.65	2.40	4.08	7.12	9.53	15.38	17.47	20.68	9.79
19	ITC-284	2.01	2.01	4.12	7.43	9.50	15.41	17.67	20.54	9.84
20	ITC-286	1.15	1.55	3.62	4.12	7.15	10.23	13.26	16.22	7.16
21	SG-1	2.86	3.87	4.53	8.35	11.43	16.88	20.80	22.11	11.35
22	SG-2	2.07	2.41	4.31	7.45	9.12	15.41	17.50	20.71	9.87
23	SG-3	1.17	1.93	2.37	4.37	8.55	11.83	14.61	17.23	7.76
24	SG-4	1.01	1.56	2.32	4.22	7.45	10.53	13.20	16.12	7.05
25	PD-6	0.96	1.22	2.64	3.67	0.51	9.47	13.10	15.53	5.89
26	PD-9	0.61	1.78	2.11	2.35	3.95	7.51	10.35	13.56	5.28
27	PD-10	1.08	1.87	2.27	4.57	8.43	11.95	14.61	17.08	7.73
28	ALR-1	0.64	1.80	2.07	2.80	4.37	7.37	10.25	13.66	5.37
29	ALR-2	1.05	1.95	2.15	4.31	8.35	11.45	14.51	17.41	7.65
30	ALR-5	0.95	1.67	2.28	4.25	8.69	11.78	14.23	17.61	7.68
31	KK-1	1.64	2.18	3.22	6.55	9.33	14.41	1.81	18.43	7.20
32	KK-2	1.09	2.33	4.12	7.23	9.30	15.63	17.50	20.10	9.66
33	E.sal	2.29	2.10	4.53	7.43	9.51	15.11	17.60	20.12	9.84
34	EU-1	0.90	1.01	2.63	3.14	4.25	9.45	13.57	15.11	6.26
35	EU-2	0.65	1.00	2.01	2.95	4.01	7.35	10.15	13.23	5.17

Fig 2.Clonal variation of height at different MAP in Kumulur

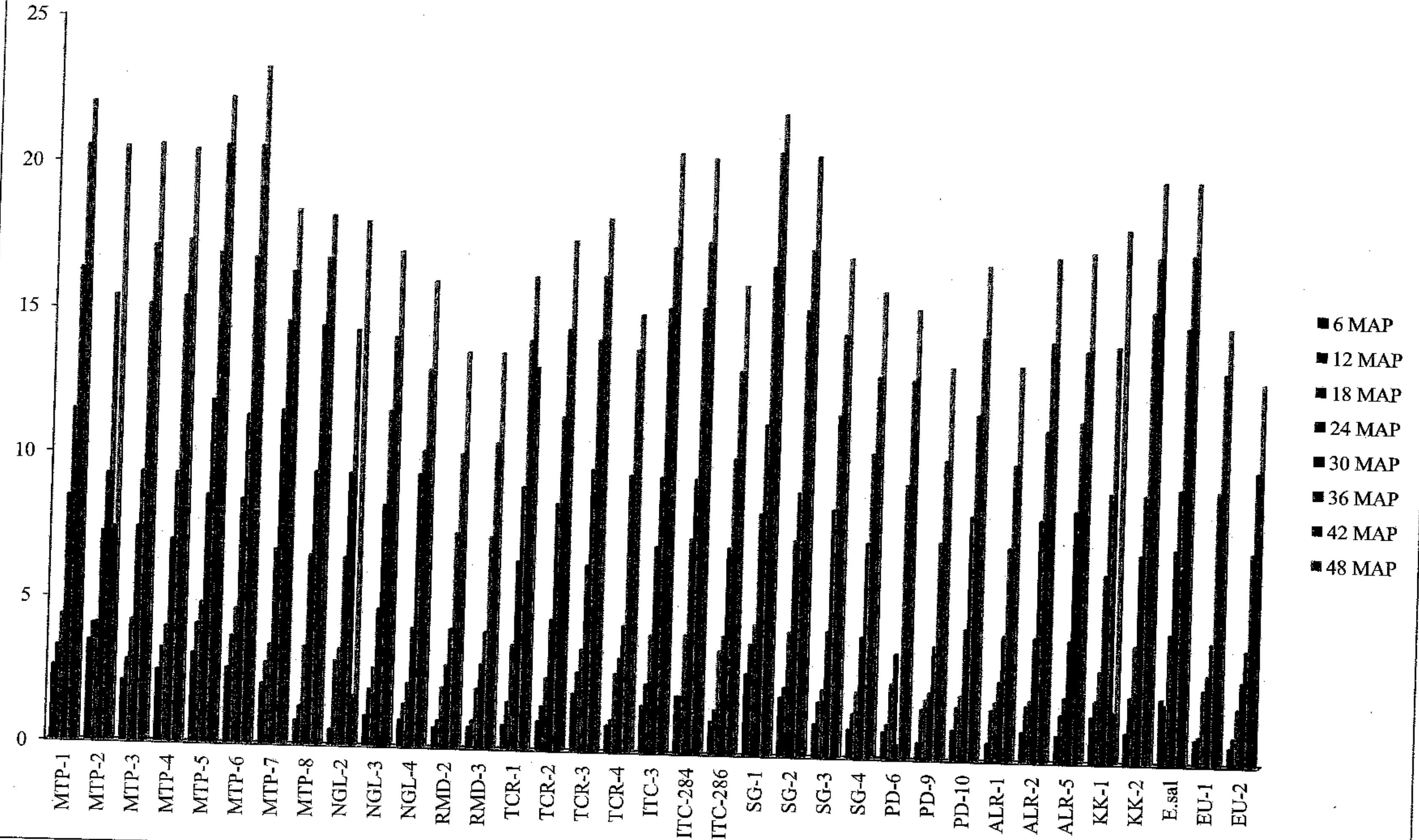


Table 17.Clonal variation of basal diameter (m) - Aduthurai trail

S.No	Clone 1	6 MAP	12 MAP	18 MAP	24 MAP	30 MAP	36 MAP	42 MAP	48 MAP	Mean
1	MTP-1	1.55	3.10	4.09	12.23	25.73	36.23	49.50	72.20	25.58
2	MTP-2	1.55	2.92	4.08	10.35	22.34	30.15	45.16	64.32	22.61
3	MTP-3	1.37	2.10	2.83	10.80	21.52	30.56	45.47	65.42	22.51
4	MTP-4	1.60	2.37	3.91	9.86	21.64	30.42	45.00	64.39	22.40
5	MTP-5	1.45	3.12	4.67	13.54	25.54	38.14	52.25	72.00	26.34
6	MTP-6	1.56	3.16	4.99	13.83	26.14	38.51	2.15	74.25	20.57
7	MTP-7	1.19	1.63	3.97	8.44	20.35	25.95	38.35	56.87	19.59
8	MTP-8	1.15	1.02	3.96	8.56	20.14	24.94	38.15	56.38	19.29
9	NGL-2	1.14	1.66	3.88	8.48	20.38	24.97	38.28	56.72	19.44
10	NGL-3	0.95	1.07	2.15	0.12	14.90	20.11	34.15	52.14	15.70
11	NGL-4	0.80	0.95	2.00	5.12	12.31	15.11	25.31	44.33	13.24
12	RMD-2	0.50	1.37	2.00	2.54	4.95	8.00	19.11	31.00	8.68
13	RMD-3	0.64	1.73	1.50	2.48	4.85	7.99	18.85	31.54	8.70
14	TCR-1	1.12	1.61	3.78	8.52	0.15	24.15	38.15	56.37	16.73
15	TCR-2	0.95	1.53	2.87	6.89	14.35	19.51	34.12	52.86	16.64
16	TCR-3	1.15	1.30	3.65	4.41	20.52	24.56	38.54	56.42	18.82
17	TCR-4	0.81	1.58	2.52	3.47	0.37	15.54	32.11	36.12	11.57
18	ITC-3	1.32	2.07	3.82	9.17	22.15	30.15	44.35	65.32	22.29
19	ITC-284	1.43	2.15	3.80	9.47	22.10	30.58	4.64	64.00	17.27
20	ITC-286	0.82	1.23	2.22	5.15	12.51	15.53	26.41	45.23	13.64
21	SG-1	1.17	3.22	4.36	12.25	26.54	37.51	50.14	70.32	25.69
22	SG-2	0.86	2.13	4.70	9.54	20.44	30.58	44.52	64.56	22.17
23	SG-3	0.93	1.63	2.28	6.31	14.78	20.16	34.20	52.46	16.59
24	SG-4	0.80	1.34	2.03	5.23	12.47	15.32	25.33	45.34	13.48
25	PD-6	0.88	1.58	2.72	3.21	6.51	10.35	22.51	37.56	10.67
26	PD-9	0.79	1.42	2.04	6.56	13.89	20.11	33.85	51.12	16.22
27	PD-10	0.67	1.24	1.78	2.52	5.33	8.12	18.33	32.15	8.77
28	ALR-1	0.62	1.75	1.92	2.63	6.00	8.22	18.51	32.00	8.96
29	ALR-2	0.72	0.88	1.21	6.25	15.00	20.15	33.89	51.56	16.21
30	ALR-5	0.79	1.19	1.48	6.31	15.01	20.14	34.15	51.24	16.29
31	KK-1	1.10	1.65	3.65	8.48	20.38	24.48	38.23	56.12	19.26
32	KK-2	0.96	2.45	4.15	9.86	20.87	30.78	44.79	64.77	22.33
33	E.sal	1.48	2.47	4.91	9.65	21.31	30.56	44.56	64.31	22.41
34	EU-1	0.74	1.47	2.81	3.52	6.78	11.31	21.52	35.22	10.42
35	EU-2	0.65	1.32	2.11	2.65	5.00	8.31	19.00	32.14	8.90

Table 18.Clonal variation of basal diameter (m) - Kumulur trail

S.No	Clone 1	6 MAP	12 MAP	18 MAP	24 MAP	30 MAP	36 MAP	42 MAP	48 MAP	Mean
1	MTP-1	1.75	3.97	6.09	15.32	27.37	39.32	53.21	74.00	27.63
2	MTP-2	1.51	3.68	5.31	12.15	24.85	34.12	48.15	67.15	24.62
3	MTP-3	1.56	3.64	5.47	12.23	24.84	34.12	47.16	67.65	24.58
4	MTP-4	1.48	3.15	5.65	12.45	24.37	34.88	47.47	66.74	24.52
5	MTP-5	1.64	3.66	6.12	15.15	27.35	39.12	52.12	73.00	27.27
6	MTP-6	1.72	3.68	6.22	14.85	26.32	40.15	53.40	73.12	27.43
7	MTP-7	1.31	3.15	4.15	11.59	21.71	30.12	43.71	62.15	22.24
8	MTP-8	1.29	3.39	4.28	11.25	21.68	30.11	43.24	62.76	22.25
9	NGL-2	1.23	3.15	4.12	11.54	21.00	29.54	43.00	61.54	21.89
10	NGL-3	1.15	2.65	3.22	8.15	17.71	25.18	37.00	55.12	18.77
11	NGL-4	0.85	2.55	3.05	7.23	15.25	19.13	28.50	48.23	15.60
12	RMD-2	0.72	1.45	2.27	4.23	7.25	11.38	21.31	34.80	10.43
13	RMD-3	0.78	1.43	2.17	4.58	7.78	11.54	21.58	34.89	10.59
14	TCR-1	1.35	3.57	4.27	11.47	22.56	30.16	44.16	62.47	22.50
15	TCR-2	1.12	2.76	3.05	8.15	17.85	26.50	36.72	57.15	19.16
16	TCR-3	1.41	3.41	4.51	11.38	21.44	31.56	43.56	61.56	22.35
17	TCR-4	0.80	1.65	2.91	5.56	8.59	14.15	24.18	38.44	12.04
18	ITC-3	1.51	3.11	5.71	12.31	23.28	35.25	47.12	67.85	24.52
19	ITC-284	1.48	3.16	5.65	12.48	23.24	34.61	48.15	66.12	24.36
20	ITC-286	0.95	2.54	3.15	7.22	15.55	19.46	28.15	48.70	15.72
21	SG-1	1.75	3.64	6.52	15.85	25.27	39.41	52.14	73.15	27.22
22	SG-2	1.55	3.07	5.12	12.56	24.73	35.08	47.09	66.01	24.40
23	SG-3	1.05	2.64	3.85	8.23	17.15	26.15	36.28	56.00	18.92
24	SG-4	0.95	2.82	3.15	7.12	15.25	19.55	28.15	48.12	15.64
25	PD-6	0.80	1.62	2.91	5.71	8.33	14.15	24.73	38.15	12.05
26	PD-9	1.12	2.55	3.87	8.55	17.23	26.52	36.58	56.05	19.06
27	PD-10	0.75	1.35	2.15	4.11	7.33	11.31	21.51	34.11	10.33
28	ALR-1	0.72	1.32	2.23	4.01	7.25	11.52	21.56	34.23	10.36
29	ALR-2	1.15	3.05	4.15	9.54	18.15	27.00	37.15	56.50	19.59
30	ALR-5	1.16	3.10	4.18	9.67	18.76	27.56	37.16	55.15	19.59
31	KK-1	1.27	3.30	4.28	11.58	22.65	30.32	44.32	62.61	22.54
32	KK-2	1.47	3.62	5.75	12.66	24.68	35.88	47.11	67.09	24.78
33	E.sal	1.58	2.80	4.85	11.95	24.01	35.08	46.15	66.95	24.17
34	EU-1	0.80	1.65	2.92	5.31	8.23	14.08	24.22	38.44	11.96
35	EU-2	0.72	1.31	2.10	4.09	7.26	11.28	21.59	34.04	10.30

Table 19.Clonal variation of volume (m3) - Aduthurai trail

S.No	Clone 1	6 MAP	12 MAP	18 MAP	24 MAP	30 MAP	36 MAP	42 MAP	48 MAP	Mean
1	MTP-1	0.07	0.32	0.49	2.70	8.13	17.87	28.16	46.48	8.02
2	MTP-2	0.05	0.25	0.48	2.18	6.89	13.37	23.01	36.82	6.46
3	MTP-3	0.04	0.13	0.24	2.22	6.44	13.70	23.34	38.70	6.30
4	MTP-4	0.07	0.20	0.39	2.00	6.43	13.71	23.77	37.63	6.41
5	MTP-5	0.06	0.30	0.62	3.15	8.59	19.66	29.88	46.17	8.44
6	MTP-6	0.07	0.35	0.64	3.40	9.05	19.72	1.25	48.54	6.75
7	MTP-7	0.04	0.09	0.43	1.40	5.54	11.29	18.58	31.46	5.17
8	MTP-8	0.03	0.06	0.36	1.41	5.94	10.89	18.58	30.91	5.09
9	NGL-2	0.02	0.15	0.39	1.44	5.32	10.56	19.06	31.27	5.12
10	NGL-3	0.01	0.04	0.11	0.01	2.97	6.67	14.81	26.74	3.31
11	NGL-4	0.01	0.04	0.12	0.48	2.10	4.42	10.05	21.85	2.59
12	RMD-2	0.01	0.04	0.09	0.17	0.61	1.88	6.01	11.83	1.31
13	RMD-3	0.01	0.05	0.06	0.16	0.59	1.84	6.01	11.41	1.28
14	TCR-1	0.03	0.09	0.40	1.39	0.04	10.24	18.15	30.55	4.31
15	TCR-2	0.02	0.06	0.24	0.75	2.85	6.20	14.51	27.93	3.57
16	TCR-3	0.04	0.07	0.36	0.73	5.57	10.63	19.21	31.55	4.96
17	TCR-4	0.01	0.05	0.12	0.27	0.04	3.76	11.62	14.87	1.88
18	ITC-3	0.03	0.09	0.31	1.81	6.64	13.33	22.87	38.21	6.09
19	ITC-284	0.03	0.10	0.30	1.88	6.57	13.57	2.39	37.14	4.71
20	ITC-286	0.01	0.06	0.20	0.49	2.13	4.54	10.49	22.38	2.74
21	SG-1	0.03	0.32	0.52	2.78	9.04	19.22	28.84	44.98	8.17
22	SG-2	0.02	0.08	0.25	2.01	6.12	14.23	23.16	36.59	6.02
23	SG-3	0.02	0.10	0.17	0.64	3.17	6.53	14.30	26.65	3.57
24	SG-4	0.02	0.10	0.19	0.52	2.08	4.56	10.08	22.54	2.77
25	PD-6	0.02	0.07	0.13	0.24	0.77	2.40	7.29	14.87	1.67
26	PD-9	0.01	0.05	0.12	0.76	2.93	6.67	14.39	26.58	3.47
27	PD-10	0.01	0.06	0.11	0.19	0.66	1.93	6.04	12.64	1.40
28	ALR-1	0.01	0.06	0.09	0.19	0.75	1.94	5.88	12.17	1.37
29	ALR-2	0.01	0.02	0.05	0.64	2.99	6.56	14.48	26.68	3.35
30	ALR-5	0.02	0.05	0.07	0.65	2.95	6.61	14.28	26.43	3.41
31	KK-1	0.03	0.10	0.33	1.44	5.20	10.21	18.50	31.05	4.95
32	KK-2	0.02	0.11	0.33	1.96	6.17	13.59	22.95	37.71	6.09
33	E.sal	0.05	0.12	0.31	1.83	6.38	13.44	23.32	37.78	6.12
34	EU-1	0.01	0.06	0.13	0.27	0.75	2.68	7.94	15.32	1.73
35	EU-2	0.01	0.04	0.10	0.20	0.60	1.93	6.10	12.63	1.38

Table 20. Clonal variation of volume (m) - Kumulur trail

S.No	Clone 1	6 MAP	12 MAP	18 MAP	24 MAP	30 MAP	36 MAP	42 MAP	48 MAP	Mean
1	MTP-1	0.14	0.41	0.83	4.07	9.85	20.15	34.27	51.14	9.65
2	MTP-2	0.17	0.47	0.69	2.76	7.21	16.50	11.19	43.22	6.90
3	MTP-3	0.10	0.33	0.72	2.85	7.28	16.20	25.40	43.76	7.61
4	MTP-4	0.12	0.32	0.71	2.74	7.13	16.88	25.86	42.83	7.64
5	MTP-5	0.16	0.47	0.93	4.08	10.19	20.77	33.73	50.98	9.88
6	MTP-6	0.14	0.43	0.91	3.94	9.38	21.18	34.56	74.16	10.82
7	MTP-7	0.09	0.28	0.45	2.45	7.87	13.84	22.40	36.01	6.64
8	MTP-8	0.03	0.14	0.46	2.32	6.42	13.71	22.84	36.00	6.22
9	NGL-2	0.02	0.29	0.43	2.35	6.21	13.33	2.38	34.99	4.90
10	NGL-3	0.04	0.17	0.28	1.22	4.64	9.16	16.45	29.58	4.55
11	NGL-4	0.02	0.12	0.21	0.94	4.52	6.14	11.69	24.37	3.53
12	RMD-2	0.02	0.04	0.15	0.38	0.94	2.65	6.80	14.94	1.72
13	RMD-3	0.02	0.04	0.14	0.42	0.98	2.65	7.16	14.99	1.76
14	TCR-1	0.04	0.19	0.49	2.34	6.43	13.39	22.63	25.91	5.78
15	TCR-2	0.04	0.13	0.24	1.16	4.78	9.59	16.79	31.57	4.65
16	TCR-3	0.09	0.29	0.50	2.30	6.55	14.10	22.45	35.55	6.45
17	TCR-4	0.02	0.06	0.25	0.57	1.18	4.25	10.56	18.25	2.41
18	ITC-3	0.08	0.23	0.73	2.75	6.97	17.02	25.85	44.06	7.54
19	ITC-284	0.09	0.20	0.73	2.91	6.93	16.75	26.72	42.64	7.52
20	ITC-286	0.03	0.12	0.36	0.93	3.49	6.25	11.72	24.80	3.53
21	SG-1	0.16	0.44	0.93	4.16	9.07	20.89	34.05	50.78	9.70
22	SG-2	0.10	0.23	0.69	2.94	7.08	16.97	25.88	42.93	7.56
23	SG-3	0.04	0.16	0.29	1.13	4.60	9.71	16.64	30.30	4.61
24	SG-4	0.03	0.14	0.23	0.94	3.57	6.46	11.67	24.36	3.46
25	PD-6	0.02	0.06	0.24	0.66	0.13	4.21	10.17	18.60	2.23
26	PD-9	0.02	0.14	0.26	0.63	2.14	6.25	11.89	23.87	3.16
27	PD-10	0.03	0.08	0.15	0.59	1.94	4.24	9.87	18.29	2.51
28	ALR-1	0.01	0.07	0.14	0.35	0.99	2.67	6.94	14.68	1.75
29	ALR-2	0.04	0.19	0.28	1.29	4.76	9.71	16.93	30.89	4.70
30	ALR-5	0.03	0.16	0.30	1.29	5.12	10.19	16.60	30.50	4.73
31	KK-1	0.07	0.23	0.43	2.38	6.64	13.72	2.52	36.23	5.09
32	KK-2	0.05	0.26	0.74	2.87	7.21	17.61	25.89	42.34	7.52
33	E.sal	0.11	0.18	0.69	2.79	7.17	16.64	25.50	42.30	7.47
34	EU-1	0.02	0.05	0.24	0.52	1.10	4.18	10.32	18.24	2.35
35	EU-2	0.01	0.04	0.13	0.38	0.91	2.60	6.88	14.14	1.67

Volume

This volume exhibited significant variation at various stages of observations in all the clones at Aduthurai (Table 19). During 48 MAP the maximum volume of 8.44 m^3 was recorded by MTP-4 followed by SG-1 (8.17 m^3). The clone RMD-3 accounted significantly lowest value of 1.28 m^3.

At 48 MAP among 35 clones and one seed source studied, totally sixteen clones viz., MTP-1, MTP-2, MTP-3, MTP-4, MTP-5, MTP-6, MTP-7, MTP-8, NGL-2, TCR-1, ITC-3, ITC-284, SG-1,SG-2, KK-1, KK-2 and *E. saligna* recorded significantly higher value than grand mean. The same trend of volume variation was observed at Kumulur research plot(Table 20). The maximum volume of 10.82 m^3 was recorded by MTP-6 and minimum value of 1.67 m^3 was recorded in clone EU-2.

Ecophysiological traits

The clonal efficiency to fit for biodrainage suitability was evaluated by measuring the biodrainage related ecophysiological traits viz., transpiration rate, stomatal conductance, Inter Cellular CO_2 Concentration (CINT) and photosynthesis rate. The observations in the study result are described here under.

Transpiration

The clonal variation for transpiration rate showed a significant variation among the clones at Aduthurai was described in the Table 21; Fig.3. The mean transpiration rate ranged from 1.94 m mol m^{-2} s^{-1} (MTP-1) to 1.08 m mol m^{-2} s^{-1} (RMD-2 and RMD-3). Totally sixteen clones viz., MTP-1, MTP-2, MTP-3, MTP-4, MTP-5, MTP-6, MTP-7, MTP-8, NGL-2, TCR-1, ITC-3, ITC-284, SG-1,SG-2, KK-1, KK-2 and *E. saligna* recorded significantly higher transpiration rate than grand mean. Among the clones, MTP-1 registered maximum value of 1.94 m mol m^{-2} s^{-1} followed by MTP-6 and SG-1 respectively of 1.91 and 1.86 m mol m^{-2} s^{-1}. The lowest transpiration rate 1.08 m mol m^{-2} $s^{-1}$was registered by two clones namely RMD-2 and RMD-3.

At Kumulur seventeen clones viz., MTP-1, MTP-2, MTP-3, MTP-4, MTP-5, MTP-6, MTP-7, MTP-8, NGL-2, TCR-1, TCR-3, ITC-284, SG-1,SG-2, KK-1, KK-2 and *E. saligna*

Table 21.Clonal variation for ecophysiological traits on transpiration (m mol m-2 s -1)-Aduthurai trail

S.No	Clone No.	6 MAP	12 MAP	18 MAP	24 MAP	30 MAP	36 MAP	42 MAP	42 MAP	MEAN
1	MTP-1	0.75	2.6	3.19	0.77	2.11	3.18	0.86	2.04	1.94
2	MTP-2	0.66	2.25	2.9	0.71	1.81	3.01	0.80	1.91	1.76
3	MTP-3	0.78	2.10	2.96	0.69	1.76	3.04	0.78	1.92	1.75
4	MTP-4	0.64	2.11	2.86	0.68	1.80	3.05	0.77	1.91	1.73
5	MTP-5	0.71	2.56	3.18	0.76	2.01	3.19	0.85	2.07	1.92
6	MTP-6	0.69	2.54	3.14	0.75	2.12	3.17	0.84	2.03	1.91
7	MTP-7	0.46	2.09	2.68	0.52	1.75	2.85	0.61	1.73	1.59
8	MTP-8	0.36	2.11	2.65	0.51	1.76	2.89	0.60	1.72	1.58
9	NGL-2	0.41	2.57	3.06	0.51	1.76	2.86	0.60	1.75	1.69
10	NGL-3	0.52	1.67	2.20	0.47	1.62	2.56	0.56	1.42	1.38
11	NGL-4	0.41	1.51	2.15	0.40	1.45	2.38	0.50	1.26	1.26
12	RMD-2	0.28	1.61	2.03	0.30	0.95	2.05	0.41	0.98	1.08
13	RMD-3	0.29	1.6	2.01	0.35	0.96	2.06	0.44	0.95	1.08
14	TCR-1	0.57	2.10	2.65	0.54	1.78	2.86	0.53	1.75	1.60
15	TCR-2	0.52	1.76	2.05	0.47	1.61	2.51	0.56	1.40	1.36
16	TCR-3	0.56	0.53	2.61	0.53	1.78	2.87	0.54	1.65	1.38
17	TCR-4	0.30	2.13	2.14	0.36	1.23	2.27	0.45	1.15	1.25
18	ITC-3	0.65	2.35	2.75	0.66	1.78	2.39	0.75	1.23	1.57
19	ITC-284	0.64	2.27	2.82	0.65	1.80	3.04	0.74	1.93	1.74
20	ITC-286	0.36	1.78	2.07	0.42	1.51	3.03	0.51	1.94	1.45
21	SG-1	0.37	2.52	3.09	0.75	2.13	3.15	0.84	2.03	1.86
22	SG-2	0.43	2.09	2.25	0.65	1.77	3.04	0.74	2.05	1.63
23	SG-3	0.39	1.79	2.07	0.46	1.72	2.61	0.55	1.50	1.39
24	SG-4	0.46	1.82	2.10	0.42	1.47	2.40	0.51	1.31	1.31
25	PD-6	0.35	1.69	2.11	0.37	1.32	2.22	0.46	1.12	1.21
26	PD-9	0.28	1.67	2.04	0.46	1.71	2.59	0.55	1.48	1.35
27	PD-10	0.27	1.62	2.04	0.31	0.98	2.06	0.41	1.05	1.09
28	ALR-1	0.28	1.86	2.06	0.34	0.95	2.01	0.44	1.02	1.12
29	ALR-2	0.50	1.67	2.20	0.45	1.65	2.57	0.54	1.45	1.38
30	ALR-5	0.51	1.68	2.03	0.47	1.71	2.60	0.58	1.52	1.39
31	KK-1	0.42	2.08	2.09	0.52	2.01	2.88	0.61	1.74	1.54
32	KK-2	0.45	2.04	2.18	0.68	1.79	3.04	0.77	2.02	1.62
33	E.sal	0.63	1.89	2.13	0.64	1.78	3.05	0.73	2.01	1.61
34	EU-1	0.30	1.73	2.15	0.37	1.25	2.21	0.48	1.01	1.19
35	EU-2	0.27	1.67	2.00	0.32	0.98	2.03	0.41	1.04	1.09

Fig 3.Clonal variation for ecophysiological traits on transpiration (m mol m^{-2} s^{-1}) - Aduthurai trail

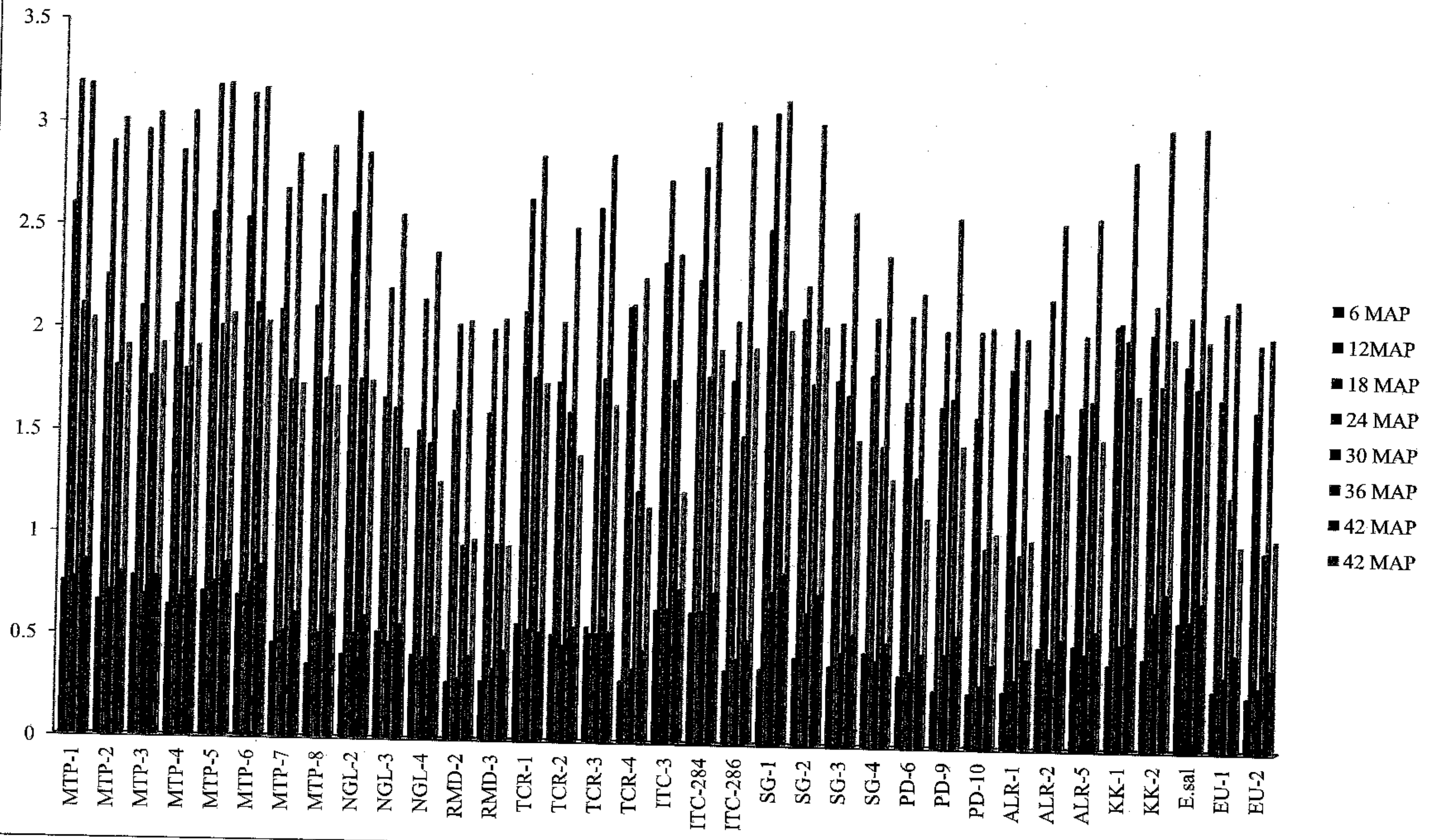
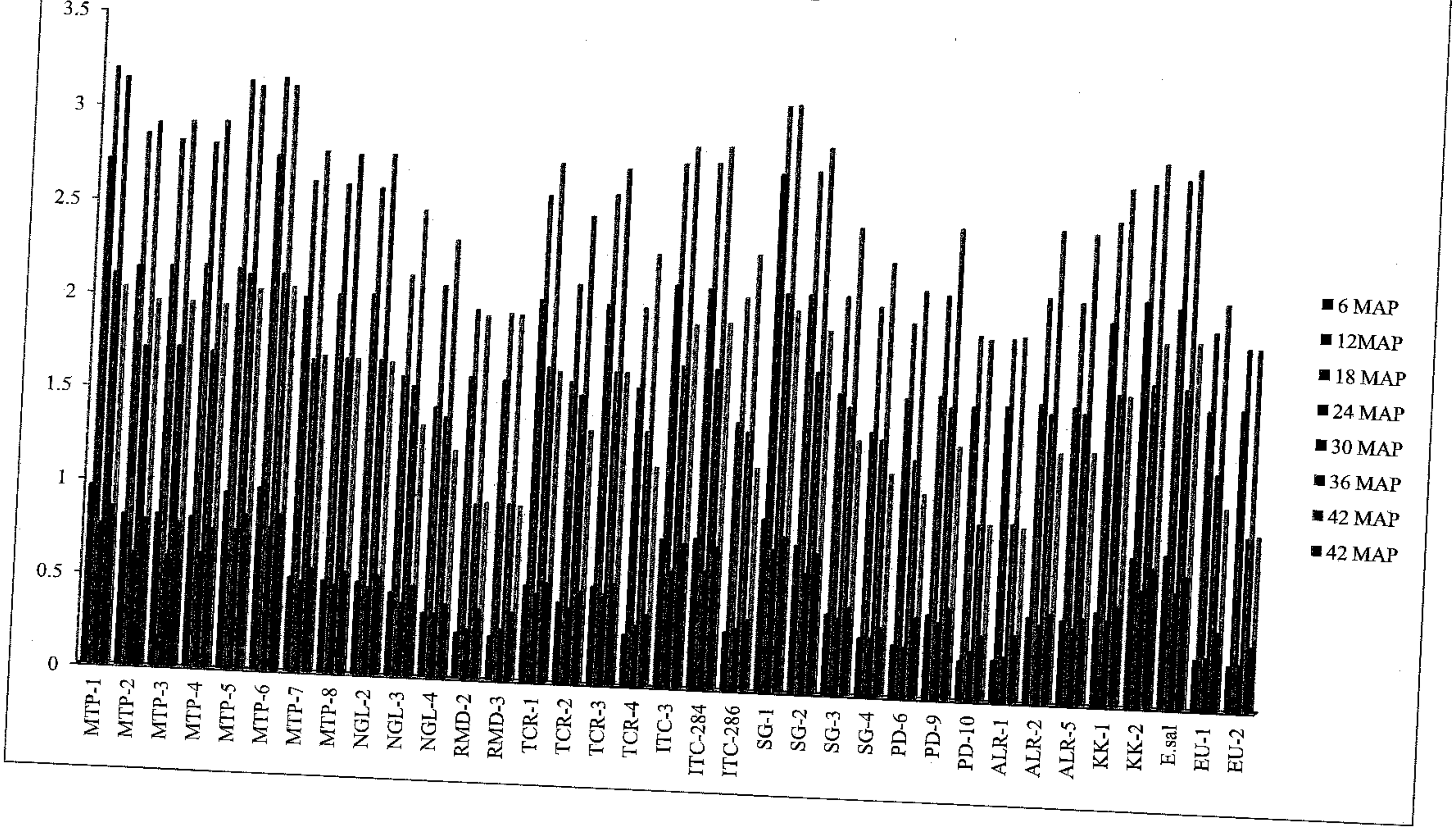


Table.22.Clonal variation for ecophysiological traits on transpiration (m mol m-2 s -1) Kumulur trail

S.No	Clone No.	6 MAP	12 MAP	18 MAP	24 MAP	30 MAP	36 MAP	42 MAP	42 MAP	MEAN
1	MTP-1	0.96	2.71	3.19	0.76	2.10	3.14	0.85	2.03	1.97
2	MTP-2	0.81	2.14	2.85	0.61	1.71	2.91	0.79	1.96	1.72
3	MTP-3	0.82	2.15	2.82	0.60	1.72	2.92	0.78	1.96	1.72
4	MTP-4	0.81	2.16	2.81	0.62	1.70	2.93	0.75	1.95	1.72
5	MTP-5	0.95	2.15	3.15	0.75	2.12	3.12	0.83	2.04	1.89
6	MTP-6	0.98	2.76	3.17	0.77	2.13	3.13	0.84	2.06	1.98
7	MTP-7	0.51	2.01	2.63	0.49	1.68	2.79	0.56	1.70	1.55
8	MTP-8	0.50	2.03	2.62	0.48	1.69	2.78	0.55	1.69	1.54
9	NGL-2	0.50	2.04	2.61	0.47	1.69	2.79	0.54	1.68	1.54
10	NGL-3	0.45	1.61	2.15	0.40	1.56	2.50	0.49	1.35	1.31
11	NGL-4	0.35	1.45	2.10	0.35	1.40	2.35	0.40	1.22	1.20
12	RMD-2	0.25	1.62	1.98	0.27	0.94	1.95	0.38	0.95	1.04
13	RMD-3	0.24	1.61	1.97	0.28	0.95	1.96	0.37	0.94	1.04
14	TCR-1	0.52	2.05	2.61	0.48	1.69	2.78	0.54	1.67	1.54
15	TCR-2	0.44	1.62	2.14	0.41	1.55	2.51	0.50	1.36	1.32
16	TCR-3	0.53	2.04	2.63	0.49	1.68	2.77	0.55	1.68	1.55
17	TCR-4	0.28	1.60	2.03	0.33	1.37	2.32	0.39	1.18	1.19
18	ITC-3	0.80	2.16	2.81	0.63	1.73	2.90	0.78	1.95	1.72
19	ITC-284	0.81	2.15	2.82	0.64	1.72	2.91	0.77	1.97	1.72
20	ITC-286	0.32	1.44	2.11	0.34	1.39	2.34	0.39	1.20	1.19
21	SG-1	0.93	2.78	3.14	0.77	2.14	3.15	0.84	2.05	1.98
22	SG-2	0.80	2.14	2.80	0.65	1.73	2.93	0.76	1.95	1.72
23	SG-3	0.44	1.62	2.14	0.42	1.55	2.51	0.48	1.37	1.32
24	SG-4	0.32	1.42	2.09	0.32	1.38	2.33	0.38	1.20	1.18
25	PD-6	0.29	1.61	2.01	0.28	1.28	2.19	0.44	1.10	1.15
26	PD-9	0.46	1.63	2.17	0.42	1.57	2.53	0.50	1.36	1.33
27	PD-10	0.22	1.58	1.96	0.27	0.95	1.94	0.36	0.95	1.03
28	ALR-1	0.23	1.59	1.95	0.25	0.96	1.96	0.37	0.94	1.03
29	ALR-2	0.47	1.61	2.18	0.43	1.56	2.54	0.49	1.35	1.33
30	ALR-5	0.46	1.60	2.16	0.42	1.57	2.53	0.48	1.36	1.32
31	KK-1	0.51	2.06	2.60	0.47	1.68	2.78	0.55	1.67	1.54
32	KK-2	0.81	2.18	2.81	0.64	1.74	2.92	0.76	1.96	1.73
33	E.sal	0.83	2.15	2.84	0.63	1.72	2.90	0.72	1.97	1.72
34	EU-1	0.28	1.61	2.03	0.29	1.27	2.18	0.43	1.09	1.15
35	EU-2	0.25	1.62	1.95	0.26	0.94	1.95	0.36	0.95	1.04

Fig 4.Clonal variation for ecophysiological traits on transpiration (m mol m^{-2} s^{-1}) - kumular trail



recorded significantly higher transpiration rate and it was described in Table 22 ;Fig.4. The highest transpiration rate (1.98 m mol m^{-2} s^{-1}) was recorded by two clones (MTP-6 and SG-1). PD-10 and ALR-1 recorded significantly lowest value of 1.03 m mol m^{-2} s^{-1} respectively than grand mean.

Stomatal conductance

Stomatal conductance an examiner of biodrainage is also measured in all the clones at Aduthurai and Kumulur. The research result at Aduthurai revealed that stomatal conductance also exhibited significant variations among the clones (Table 23). Significantly higher stomatal conductance was observed in fifteen clones viz MTP-1, MTP-2, MTP-3, MTP-4, MTP-5, MTP-6, NGL-2, TCR-1, ITC-1, ITC-284, SG-1,SG-2, SG-3, KK-1, KK-2 and *E. saligna* with the value of 124.73, 117.09, 113.26, 114.34, 124.62, 107.91,109.19, 113.21, 113.66, 118.73, 113.37, 206.63,109.21 and 114.10 m mol m^{-2} s^{-1} respectively. The clone MTP-1 registered the maximum for stomatal conductance of 124.73 m mol m^{-2} s^{-1} followed by MTP-5 and MTP-6 respectively of 124.70 and 124.62 m mol m^{-2} s^{-1}. Also most of the clones showed significantly parity with grand mean. The minimal and significantly low stomatal conductance was exhibited by the clone RMD-3 (78.65 m mol m^{-2} s^{-1}).

The research result at Kumulur revealed that significantly higher stomatal conductance was observed in eighteen clones viz MTP-1, MTP-2, MTP-3, MTP-4, MTP-5, MTP-6, MTP-7, MTP-8, NGL-2, TCR-1, TCR-3, ITC-3, ITC-284, SG-1,SG-2, KK-1, KK-2 and *E. saligna* than grand mean. The clone MTP-6 registered the maximum for stomatal conductance of 140.50 m mol m^{-2} s^{-1} followed by MTP-1 and SG-1 respectively of 140.12 and 138.90 m mol m^{-2} s^{-1} (Table 24). The minimal and significantly low stomatal conductance was exhibited by the clone RMD-2 (77.20 m mol m^{-2} s^{-1}).

Inter Cellular CO_2 Concentration (CINT)

Inter Cellular CO_2 Concentration which is also a measure of high productivity and biodrainage efficiency of clones is measured and the result is described in the Table 25. At Aduthurai all the clones showed significant variation among them in terms of Inter Cellular CO_2 Concentration. Among all the 35 clones and one seed source studied, the clonal members MTP-1, MTP-2, MTP-3, MTP-4, MTP-5, MTP-6, MTP-7, MTP-8, NGL-2, TCR-1, TCR-3, ITC-3, Table.23. Stomatal Conductance (m mol $m^{-2} S^{-1}$) - Aduthurai Trial

S.No	Clone 1	6 MAP (m)	12 MAP	18 MAP	24 MAP	30 MAP	36 MAP	42 MAP	48 MAP	Mean
1	MTP-1	48.22	163.92	163.37	75.32	125.30	150.65	105.35	165.67	124.73
2	MTP-2	50.18	153.81	163.43	67.31	116.25	141.23	92.03	152.50	117.09
3	MTP-3	41.20	145.84	149.79	65.48	117.86	140.25	92.08	153.60	113.26
4	MTP-4	45.54	146.17	151.90	66.54	116.37	140.83	92.85	154.50	114.34
5	MTP-5	51.88	171.07	161.47	76.15	124.56	151.37	106.56	154.50	124.70
6	MTP-6	48.25	171.57	155.46	75.37	125.68	150.93	105.85	163.87	124.62
7	MTP-7	38.76	152.69	142.74	55.30	90.38	121.59	85.30	164.56	99.80
8	MTP-8	38.19	143.46	153.16	55.40	90.54	122.40	83.40	138.48	103.13
9	NGL-2	36.49	171.04	165.10	54.38	92.73	121.59	82.43	139.50	107.91
10	NGL-3	33.56	132.50	140.58	48.35	85.32	115.31	75.50	139.72	96.36
11	NGL-4	30.14	130.50	136.58	41.15	79.30	109.30	68.50	132.40	90.98
12	RMD-2	24.35	128.50	133.40	30.15	64.87	83.48	55.65	125.30	80.71
13	RMD-3	25.62	127.40	132.41	29.46	65.78	84.56	54.73	109.23	78.65
14	TCR-1	34.23	155.20	145.60	54.80	93.54	122.30	83.50	109.42	109.19
15	TCR-2	34.70	141.24	149.11	48.30	86.32	115.32	74.32	138.30	98.45
16	TCR-3	45.30	147.20	155.20	56.38	93.50	120.38	8.35	133.32	94.95
17	TCR-4	33.50	131.56	144.67	35.38	72.34	95.30	60.35	135.40	88.56
18	ITC-3	42.52	146.32	151.32	97.31	115.00	142.70	92.38	118.15	113.21
19	ITC-284	42.20	146.57	150.20	66.42	116.20	142.38	91.50	153.80	113.66
20	ITC-286	35.83	138.77	155.32	40.32	79.86	110.40	69.30	154.30	98.01
21	SG-1	34.25	169.63	162.61	76.56	124.58	151.85	105.88	124.50	118.73
22	SG-2	34.30	144.44	149.55	65.30	115.47	142.95	91.08	163.85	113.37
23	SG-3	31.43	137.63	147.20	47.48	84.32	114.13	74.12	154.87	98.90
24	SG-4	39.58	169.14	163.64*	40.50	80.89	110.40	96.88	131.37	95.54
25	PD-6	34.73	136.02	143.48	35.46	73.50	96.42	61.56	124.50	88.21
26	PD-9	32.25	133.19	143.54	47.12	85.12	113.33	75.81	112.50	92.86
27	PD-10	39.25	129.91	148.43	30.67	63.72	85.47	54.38	130.37	85.28
28	ALR-1	33.10	136.82	147.76	60.15	63.54	85.65	54.32	109.50	86.36
29	ALR-2	34.12	132.28	139.72	47.13	85.86	114.33	74.32	108.50	92.03
30	ALR-5	31.30	131.87	140.92	46.32	84.33	112.41	75.67	129.36	94.02
31	KK-1	39.94	148.69	151.85	55.30	92.30	121.40	80.42	130.14	106.63
32	KK-2	32.84	141.95	148.16	65.87	116.80	143.80	91.78	132.50	109.21
33	E.sal	48.26	139.76	151.96	66.72	116.37	143.58	91.33	154.80	114.10
34	EU-1	32.31	129.50	145.30	35.48	72.50	94.48	62.51	119.54	86.45
35	EU-2	35.54	125.30	132.50	30.15	65.34	84.32	55.62	109.50	79.78

Table.24. Stomatal Conductance (m mol m^{-2} S^{-1}) -Kumulur Trial

S.No	Clone 1	6 MAP (m)	12 MAP	18 MAP	24 MAP	30 MAP	36 MAP	42 MAP	48 MAP	Mean
1	MTP-1	156.16	152.98	165.34	76.77	130.55	156.32	110.47	172.35	140.12
2	MTP-2	155.34	149.28	150.22	71.52	122.46	147.38	98.26	157.20	131.46
3	MTP-3	134.86	147.82	151.56	71.08	121.30	148.51	97.50	156.20	128.60
4	MTP-4	136.04	142.78	152.08	71.09	123.40	147.36	98.20	155.32	128.28
5	MTP-5	157.33	161.98	153.47	77.48	121.48	145.40	95.55	156.42	133.64
6	MTP-6	154.61	151.14	165.48	78.51	132.51	156.78	112.65	172.32	140.50
7	MTP-7	120.20	148.52	145.30	62.50	98.20	135.25	90.15	141.50	117.70
8	MTP-8	107.60	126.01	142.20	65.30	105.30	132.82	91.20	142.80	114.15
9	NGL-2	117.28	132.51	145.32	64.32	102.51	133.28	92.58	143.90	116.46
10	NGL-3	100.28	115.02	138.50	52.58	95.00	125.50	81.00	137.00	105.61
11	NGL-4	91.52	98.33	135.20	45.38	82.51	115.20	72.50	129.30	96.24
12	RMD-2	75.36	74.48	111.56	31.42	65.35	90.57	54.31	114.51	77.20
13	RMD-3	74.67	74.56	112.56	32.56	66.48	89.48	54.56	115.81	77.59
14	TCR-1	123.65	131.15	145.20	60.50	99.20	135.20	91.20	142.80	116.11
15	TCR-2	101.56	116.47	138.42	53.54	96.76	126.00	82.75	138.48	106.75
16	TCR-3	126.29	140.35	142.56	62.58	100.28	134.58	92.80	143.80	117.91
17	TCR-4	85.35	82.30	125.20	40.20	72.00	100.51	65.30	121.50	86.55
18	ITC-3	155.36	150.34	151.32	72.32	122.31	146.20	97.38	156.20	131.43
19	ITC-284	154.48	152.41	150.51	71.56	120.51	142.31	99.20	156.56	130.94
20	ITC-286	95.26	99.52	134.56	44.20	82.56	115.28	73.56	128.59	96.69
21	SG-1	153.84*	158.88	164.48	75.60	128.50	157.48	113.85	173.50	138.90
22	SG-2	150.23	148.22	149.20	70.21	121.58	142.30	98.48	156.21	129.55
23	SG-3	101.56	116.35	139.48	51.54	96.38	126.48	82.56	138.47	106.60
24	SG-4	96.30	98.28	135.48	44.76	84.85	116.25	74.23	128.54	97.34
25	PD-6	84.30	81.30	135.26	41.36	73.50	101.46	64.70	122.54	88.05
26	PD-9	102.56	117.48	124.50	52.61	96.71	124.61	82.56	135.48	104.56
27	PD-10	75.31	76.77	139.48	30.26	64.56	91.35	55.64	115.36	81.09
28	ALR-1	75.47	77.48	112.56	28.34	62.34	92.48	55.20	115.47	77.42
29	ALR-2	101.52	116.25	138.35	51.28	95.87	123.43	81.68	134.87	105.41
30	ALR-5	102.51	117.37	136.38	52.76	94.23	124.58	82.70	135.20	105.72
31	KK-1	135.20	144.36	143.20	61.58	99.20	134.28	91.50	142.80	119.02
32	KK-2	117.73	136.00	148.51	71.52	119.28	145.33	99.50	158.30	124.52
33	E.sal	120.32	136.97	150.21	72.56	120.20	143.28	98.50	157.28	124.92
34	EU-1	84.36	80.36	132.56	39.40	71.50	101.47	64.37	120.56	86.82
35	EU-2	75.36	76.38	111.56	30.54	65.76	90.31	54.11	115.30	77.42

Table.25. Clonal variation for ecophysiological traits on intercellular CO_2 concentration (CINT) (ppm)- Aduthurai trail

S.No	Clone No.	6 MAP	12 MAP	18 MAP	24 MAP	30 MAP	36 MAP	42 MAP	48 MAP	Mean
1	MTP-1	245.67	235.66	225.13	233.46	237.16	254.33	240.61	265.68	242.21
2	MTP-2	235.68	195.36	185.62	185.65	205.66	204.67	200.87	222.36	204.48
3	MTP-3	205.36	196.63	185.36	182.23	201.23	200.11	205.11	223.01	199.88
4	MTP-4	205.66	200.26	195.85	184.36	206.63	203.13	206.33	224.11	203.29
5	MTP-5	245.65	235.47	225.68	233.61	237.68	254.50	239.40	264.50	242.06
6	MTP-6	244.37	235.61	225.56	232.81	237.60	253.60	238.40	265.89	241.73
7	MTP-7	195.43	182.15	175.33	183.23	200.31	195.61	177.61	195.06	188.09
8	MTP-8	192.34	181.16	173.20	185.67	201.41	195.65	178.71	195.16	187.91
9	NGL-2	195.33	180.51	175.66	180.32	200.11	196.65	176.16	194.86	187.45
10	NGL-3	170.46	155.46	151.47	159.65	175.47	185.41	165.31	183.41	168.33
11	NGL-4	151.66	142.55	139.44	141.55	160.22	165.08	150.31	170.22	152.63
12	RMD-2	115.67	106.45	109.35	110.44	122.68	132.66	120.33	141.55	119.89
13	RMD-3	114.87	105.55	109.66	110.56	122.69	131.76	121.66	142.66	119.93
14	TCR-1	196.41	182.61	176.76	182.43	201.21	198.11	179.36	197.20	189.26
15	TCR-2	171.15	156.37	152.16	163.17	185.36	190.30	170.35	185.36	171.78
16	TCR-3	197.14	186.23	167.67	189.30	212.31	195.30	180.63	195.40	190.50
17	TCR-4	126.15	115.67	116.37	112.56	135.01	144.33	127.35	145.36	127.85
18	ITC-3	203.12	201.56	192.55	182.55	202.50	195.66	108.51	223.10	188.69
19	ITC284	203.67	202.67	192.67	181.89	203.61	194.67	109.61	225.67	189.31
20	ITC-286	151.61	142.60	138.45	140.65	160.37	165.77	151.63	171.38	152.81
21	SG-1	244.33	233.47	225.67	132.63	237.46	153.66	240.39	266.37	216.75
22	SG-2	201.78	206.15	191.36	185.95	206.96	193.39	210.11	224.16	202.48
23	SG-3	172.67	156.47	155.65	161.66	180.55	190.33	170.41	186.23	171.75
24	SG-4	151.67	142.76	138.76	142.67	161.56	165.81	150.31	171.88	153.18
25	PD-6	126.65	114.37	115.16	112.65	135.70	143.33	126.35	144.63	127.36
26	PD-9	175.33	160.33	161.36	162.35	182.11	195.33	171.43	158.41	170.83
27	PD-10	115.36	106.30	109.23	110.35	122.33	130.67	120.80	140.30	119.42
28	ALR-1	115.67	105.23	109.31	110.65	122.41	130.68	120.81	140.67	119.43
29	ALR-2	175.32	162.55	165.33	163.87	183.21	195.21	172.77	183.41	175.21
30	ALR-5	175.66	162.66	165.44	164.78	183.40	194.20	173.73	182.81	175.34
31	KK-1	190.32	181.15	175.35	183.32	200.11	196.23	175.66	195.16	187.16
32	KK-2	202.30	208.16	195.30	190.21	206.11	196.32	208.60	222.69	203.71
33	E.sal	205.11	207.16	192.50	189.50	205.60	195.30	209.50	225.60	203.78
34	EU-1	126.26	114.36	116.35	113.47	135.08	195.48	180.11	195.40	147.06
35	EU-2	115.37	106.37	109.06	110.32	122.11	130.40	120.16	140.55	119.29

Table.26. Clonal variation for ecophysiological traits on intercellular CO_2 concentration (CINT) (ppm)- Kumulur trail

S.No	Clone No.	6 MAP	12 MAP	18 MAP	24 MAP	30 MAP	36 MAP	42 MAP	48 MAP	Mean
1	MTP-1	255.34	247.37	231.10	237.05	240.37	256.37	235.30	260.56	245.43
2	MTP-2	208.26	195.32	190.32	191.31	210.15	209.56	195.33	215.10	201.92
3	MTP-3	205.43	196.88	191.33	190.05	211.25	208.23	194.20	214.19	201.45
4	MTP-4	202.14	192.53	192.44	190.61	211.35	208.11	193.40	215.30	200.74
5	MTP-5	209.32	244.40	232.11	237.06	240.12	256.37	234.40	260.46	239.28
6	MTP-6	251.65	246.92	233.06	235.36	240.24	235.11	233.30	260.34	242.00
7	MTP-7	185.48	173.26	170.14	178.20	195.31	191.01	173.46	191.26	182.27
8	MTP-8	185.58	173.57	170.16	178.20	195.47	190.03	173.41	192.46	182.36
9	NGL-2	283.53	175.47	171.26	177.15	192.05	192.04	172.43	193.67	194.70
10	NGL-3	165.35	154.23	150.23	158.54	174.82	183.25	162.54	182.51	166.43
11	NGL-4	144.14	134.56	133.56	138.57	155.23	162.55	145.35	160.15	146.76
12	RMD-2	112.12	102.15	105.11	108.20	125.30	130.22	115.20	140.55	117.36
13	RMD-3	112.20	102.35	105.20	108.10	125.56	130.56	115.36	170.86	121.27
14	TCR-1	184.09	174.68	170.15	175.35	192.65	190.23	172.15	192.36	181.46
15	TCR-2	163.33	153.24	150.33	157.53	175.23	185.23	163.66	155.66	163.03
16	TCR-3	185.08	173.65	172.06	175.64	192.01	190.23	172.16	192.06	181.61
17	TCR-4	123.61	112.65	112.50	110.41	132.51	140.36	125.64	144.70	125.30
18	ITC-3	206.35	195.37	190.06	192.31	212.66	208.40	193.44	215.20	201.72
19	ITC284	206.47	197.48	189.12	193.42	211.66	208.44	193.47	215.25	201.91
20	ITC-286	144.15	133.36	132.56	136.33	154.25	165.31	143.23	159.54	146.09
21	SG-1	251.75	245.23	231.06	237.15	240.33	256.11	235.12	260.76	244.69
22	SG-2	207.23	192.33	192.10	189.32	192.50	208.31	195.68	214.16	198.95
23	SG-3	163.27	153.33	151.33	157.23	173.55	183.11	163.51	181.23	165.82
24	SG-4	145.35	135.15	154.23	135.11	155.01	164.31	142.33	158.04	148.69
25	PD-6	123.51	152.44	152.40	156.40	172.66	185.11	164.66	182.33	161.19
26	PD-9	163.33	113.54	112.47	110.30	132.32	141.20	125.35	143.20	130.21
27	PD-10	113.15	102.56	106.37	108.27	155.37	129.31	115.30	137.28	120.95
28	ALR-1	114.27	103.57	106.27	109.51	124.41	132.41	114.30	138.00	117.84
29	ALR-2	162.45	151.46	151.77	157.67	173.46	180.23	163.77	181.66	165.31
30	ALR-5	163.65	151.66	151.88	157.68	173.66	183.23	163.77	181.77	165.91
31	KK-1	183.66	173.15	169.36	174.56	194.66	192.50	174.63	192.31	181.85
32	KK-2	206.01	190.51	190.25	159.50	193.51	207.31	196.73	213.15	194.62
33	E.sal	208.15	190.27	191.28	159.11	194.20	206.50	196.37	214.15	195.00
34	EU-1	123.41	113.45	111.30	110.20	131.62	140.33	126.20	142.50	124.88
35	EU-2	113.25	104.38	107.27	109.27	121.51	130.23	116.20	138.20	117.54

ITC-284, SG-1,SG-2, KK-1, KK-2 and *E. saligna* than grand mean. The clone MTP-1 registered the maximum Inter Cellular CO_2 Concentration of 242.21 ppm and the clone EU-2 accounted the minimal Inter Cellular CO_2 Concentration value of 119.29 ppm.

At Kumulur all the clones showed significant variation among them in terms of Inter Cellular CO_2 Concentration. Among all the 35 clones and one seed source studied, the clonal members MTP-1, MTP-2, MTP-3, MTP-4, MTP-5, MTP-6, MTP-7, MTP-8, NGL-2, TCR-1, TCR-3, ITC-3, ITC-284, SG-1,SG-2, KK-1, KK-2 and *E. saligna* than grand mean. The clone MTP-1 registered the maximum Inter Cellular CO_2 Concentration of 245.43 ppm and the clone RMD-2 accounted the minimal Inter Cellular CO_2 Concentration value of 117.36 ppm(Table 26).

Photosynthesis

Photosynthetic rate also showed significant variation among the clones and the result described in Table 27. At Aduthurai the clonal members viz., MTP-1, MTP-2, MTP-3, MTP-4, MTP-5, MTP-6, MTP-7, MTP-8, NGL-2,TCR-1, ITC-3, ITC-284, SG-1,SG-2, ALR-2, KK-2 and *E. saligna* accounted higher photosynthetic rate than grand mean with the value of 2.68,2.23,2.12,2.17,2.66,2.63,1.94,1.91,2.02,1.86,2.16,2.09,2.59,2.39,2.16,2.05 and 2.33 μ mol m^{-2} s^{-1} respectively. The lowest significant level of photosynthetic rate was registered by the clonal members of RMD-2 and RMD-3 (0.91 μ mol m^{-2} s^{-1}) followed by ALR-1 (0.93 μ mol m^{-2} s^{-1}) and EU-2 (0.96 μ mol m^{-2} s^{-1}).

At Kumulur all the clones showed significant variation among them in terms of Inter Cellular CO_2 Concentration. Among all the 35 clones and one seed source studied, the clonal members MTP-1, MTP-2, MTP-3, MTP-4, MTP-5, MTP-6, ITC-3, ITC-284, SG-1, SG-2, SG-4 and *E. saligna* than grand mean(Table 28). The clone SG-2 registered the maximum Inter Cellular CO_2 Concentration of 16.78 μ mol m^{-2} s^{-1} and the clone EU-2 and ALR-1 accounted the minimal Inter Cellular CO_2 Concentration value of 3.00 μ mol m^{-2} s^{-1}.

Table.27. Clonal variation for ecophysiological traits on photosynthetic rate (µ mol m^{-2} s^{-1}) Aduthurai trail

S.No	Clone No.	6 MAP	12 MAP	18 MAP	24 MAP	30 MAP	36 MAP	42 MAP	48 MAP	Mean
1	MTP-1	0.55	3.34	5.95	0.59	5.58	4.35	0.44	0.64	2.68
2	MTP-2	0.51	2.89	5.23	0.55	4.31	3.29	0.40	0.62	2.23
3	MTP-3	0.52	2.81	4.40	0.57	4.43	3.22	0.41	0.63	2.12
4	MTP-4	0.50	2.81	4.68	0.55	4.57	3.24	0.39	0.62	2.17
5	MTP-5	0.58	3.32	5.88	0.63	5.53	4.15	0.47	0.69	2.66
6	MTP-6	0.57	3.29	5.63	0.62	5.52	4.24	0.46	0.70	2.63
7	MTP-7	0.49	2.74	4.84	0.54	3.56	2.36	0.38	0.60	1.94
8	MTP-8	0.49	2.74	4.74	0.53	3.43	2.41	0.38	0.59	1.91
9	NGL-2	0.48	2.38	5.76	0.53	3.72	2.32	0.37	0.58	2.02
10	NGL-3	0.41	2.01	3.75	0.46	2.65	1.52	0.30	0.52	1.45
11	NGL-4	0.37	2.15	3.61	0.42	2.16	1.32	0.26	0.48	1.35
12	RMD-2	0.29	1.13	2.17	0.34	1.93	0.85	0.18	0.39	0.91
13	RMD-3	0.28	1.15	2.22	0.33	1.90	0.84	0.17	0.40	0.91
14	TCR-1	0.47	2.41	4.72	0.52	3.48	2.32	0.36	0.58	1.86
15	TCR-2	0.42	2.08	3.81	0.47	2.59	1.49	0.31	0.53	1.46
16	TCR-3	0.46	2.44	3.65	0.51	3.45	2.32	0.35	0.56	1.72
17	TCR-4	0.33	1.88	2.17	0.37	2.08	1.00	0.22	0.43	1.06
18	ITC-3	0.51	2.85	4.85	0.56	4.38	3.15	0.40	0.61	2.16
19	ITC-284	0.38	2.83	4.65	0.44	4.38	3.28	0.27	0.49	2.09
20	ITC-286	0.52	2.22	3.80	0.58	2.16	1.06	0.41	0.50	1.41
21	SG-1	0.53	3.01	5.53	0.60	5.56	4.47	0.42	0.63	2.59
22	SG-2	0.53	2.89	4.24	0.59	5.48	4.35	0.42	0.63	2.39
23	SG-3	0.43	2.16	4.00	0.47	2.46	1.35	0.24	0.54	1.46
24	SG-4	0.36	2.14	3.69	0.41	2.15	1.05	0.26	0.45	1.31
25	PD-6	0.35	1.95	2.75	0.40	2.01	1.00	0.25	0.46	1.15
26	PD-9	0.38	2.05	3.80	0.43	2.47	1.34	0.28	0.48	1.40
27	PD-10	0.27	1.75	2.23	0.32	1.93	0.85	0.16	0.39	0.99
28	ALR-1	0.27	1.33	2.16	0.33	1.92	0.87	0.16	0.38	0.93
29	ALR-2	0.38	2.04	3.74	0.43	2.53	1.43	6.27	0.48	2.16
30	ALR-5	0.37	2.02	3.79	0.42	2.67	1.50	0.26	0.47	1.44
31	KK-1	0.48	2.45	4.01	0.54	3.27	2.17	0.37	0.56	1.73
32	kk-2	0.52	2.84	3.99	0.56	4.26	3.15	0.41	0.63	2.05
33	E.Sal	0.54	2.82	3.95	0.58	5.38	4.28	0.43	0.62	2.33
34	EU-1	0.34	1.85	2.73	0.38	2.05	1.01	0.13	0.45	1.12
35	EU-2	0.28	1.55	2.15	0.33	1.95	0.85	0.16	0.37	0.96

Table.28. Clonal variation for ecophysiological traits on photosynthetic rate (µ mol m-2 s -1) Kumulur trail

S.No	Clone No.	6 MAP	12 MAP	18 MAP	24 MAP	30 MAP	36 MAP	42 MAP	48 MAP	Mean
1	MTP-1	8.81	8.54	6.51	8.62	0.54	5.51	8.95	8.70	7.02
2	MTP-2	8.09	8.12	5.32	7.43	0.50	4.35	8.70	8.56	6.38
3	MTP-3	8.02	6.28	5.43	7.54	0.51	4.42	8.73	8.51	6.18
4	MTP-4	8.34	6.65	5.54	7.65	0.49	4.57	8.71	8.50	6.31
5	MTP-5	8.75	8.87	6.52	7.63	0.57	5.52	8.93	8.71	6.94
6	MTP-6	8.84	8.52	6.50	7.61	0.55	5.53	8.92	8.72	6.90
7	MTP-7	7.51	7.01	4.52	5.63	0.48	3.36	7.61	7.11	5.40
8	MTP-8	7.80	7.02	4.51	5.62	0.46	3.42	7.83	7.21	5.48
9	NGL-2	7.72	7.06	4.74	5.85	0.40	3.75	7.86	7.15	5.57
10	NGL-3	6.51	6.05	3.61	4.72	0.38	2.64	7.01	6.56	4.69
11	NGL-4	6.11	5.98	3.15	4.26	0.28	2.15	6.10	5.32	4.17
12	RMD-2	4.35	4.23	2.95	4.04	0.27	1.94	4.24	3.05	3.13
13	RMD-3	4.36	4.15	2.92	4.05	0.48	1.45	4.15	3.16	3.09
14	TCR-1	5.69	5.27	4.41	5.62	0.41	3.42	7.82	7.16	4.98
15	TCR-2	7.02	6.42	3.57	4.68	0.45	2.57	7.12	6.52	4.79
16	TCR-3	7.70	7.08	4.46	5.57	0.34	3.45	7.80	7.17	5.45
17	TCR-4	5.06	4.56	3.09	4.11	0.52	2.09	5.16	4.76	3.67
18	ITC-3	6.73	6.94	5.35	6.46	0.37	4.39	8.73	8.51	5.94
19	ITC-284	8.71	8.43	5.35	6.48	0.51	4.37	8.71	8.54	6.39
20	ITC-286	8.73	8.53	3.17	4.29	0.52	2.14	6.15	5.43	4.87
21	SG-1	8.70	8.39	6.58	7.69	0.54	5.55	8.96	8.72	6.89
22	SG-2	8.80	8.42	6.45	7.56	0.52	5.23	8.73	8.51	16.78
23	SG-3	7.18	6.83	3.47	4.58	0.45	2.23	7.15	6.63	4.82
24	SG-4	8.80	8.42	3.16	4.27	0.38	2.08	5.12	5.37	14.70
25	PD-6	5.23	4.75	3.05	4.16	0.38	2.01	6.14	4.85	3.82
26	PD-9	7.18	6.67	3.48	4.59	0.32	2.37	7.16	6.73	4.81
27	PD-10	4.37	3.09	2.92	4.05	0.28	1.87	4.33	3.15	3.01
28	ALR-1	4.27	3.06	2.95	4.04	0.29	1.85	4.38	3.16	3.00
29	ALR-2	7.15	6.37	3.55	4.65	0.35	2.85	7.14	6.59	4.83
30	ALR-5	7.15	6.54	3.28	4.76	0.35	2.71	7.16	6.66	4.83
31	KK-1	6.25	6.56	3.28	4.39	0.45	3.32	7.83	7.13	4.90
32	KK-2	5.73	5.54	5.28	6.35	0.53	4.28	8.77	8.53	5.63
33	E.sal	6.26	5.82	6.18	7.29	0.52	5.39	8.71	8.56	6.09
34	EU-1	5.12	4.54	3.04	4.15	0.33	2.06	5.22	4.75	3.65
35	EU-2	4.12	3.26	2.91	4.04	0.27	1.93	4.30	3.14	3.00

Genetic parameters of clones for biodrainage traits

Variability of clones for biodrainage traits

The biodrainage related traits of clones like transpiration rate, stomatal conductance, height and volume were used to identify their contribution in biodrainage efficiency of clones. Also, effects of each character on others and their variations viz., phenotypic variations, genotypic variations and environmental variations were estimated in experimental plots located at Aduthurai and Kumulur and tabulated in the Table 29 and 30;fig 5 and 6.

Phenotypic variations

At Aduthurai among the traits viz., transpiration rate, stomatal conductance, height and volume studied, the volume (18905.62) accounted maximum phenotypic variation followed by height (1136.04). Stomatal conductance registered lower level of phenotypic variations 57.15 and transpiration rate accounted least phenotypic variations of 0.029.

At Kumulur among the traits viz., transpiration rate, stomatal conductance, height and volume studied, the volume (19105.77) accounted maximum phenotypic variation followed by height (1106.24). Stomatal conductance registered lower level of phenotypic variations 49.89 and transpiration rate accounted least phenotypic variations of 0.030.

Genotypic variations

Genotypic variations was highest for volume (16204.35) followed by height (989.25). The traits stomatal conductance and transpiration rate accounted the genotypic variation of 29.53 and 0.019 respectively in experimental plot located at Aduthurai.

At Kumulur Genotypic variations was highest for volume (17204.26) followed by height (890.45). The traits stomatal conductance and transpiration rate accounted the genotypic variation of 31.49 and 0.014 respectively.

Environmental variations

At Aduthurai the variation due to environment was less in all the traits compare to phenotypic and genotypic variations. Among the four traits studies, volume had high

Table 29. Contribution of variation for biodrainage attributes at Aduthurai

Character	GV	PV	EV
Height	989.25	1136.04	146.79
Stomatal conductance	29.53	57.15	27.62
Transpiration rate	0.019	0.029	0.010
Volume	16204.35	18905.62	2701.27

Table 30. Contribution of variation for biodrainage attributes at Kumulur

Character	GV	PV	EV
Height	890.45	1106.24	136.89
Stomatal conductance	31.53	49.89	23.73
Transpiration rate	0.014	0.030	0.011
Volume	17204.26	19105.77	2701.49

Fig 5. Contribution of variation for biodrainage attributes at Aduthurai

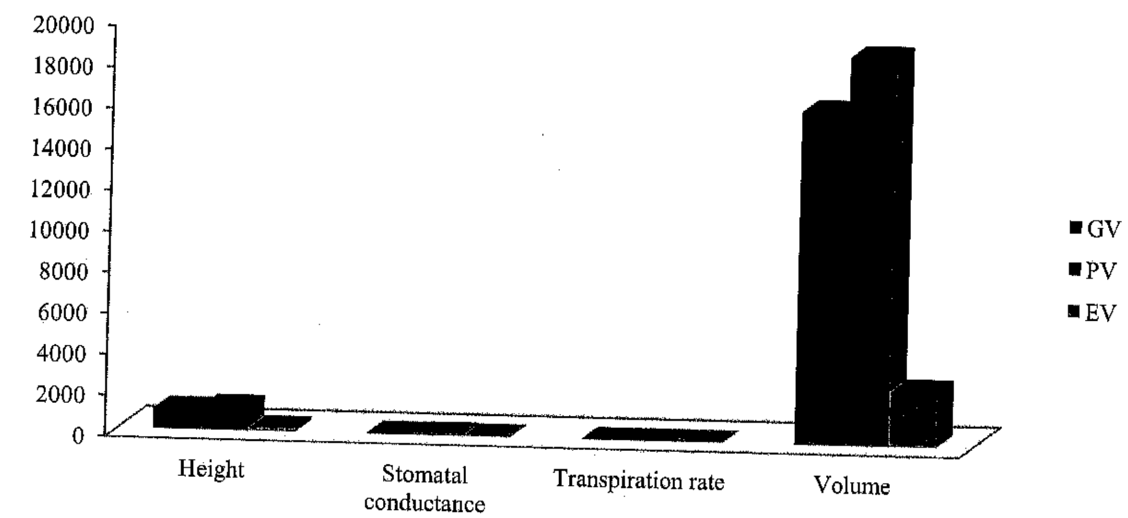
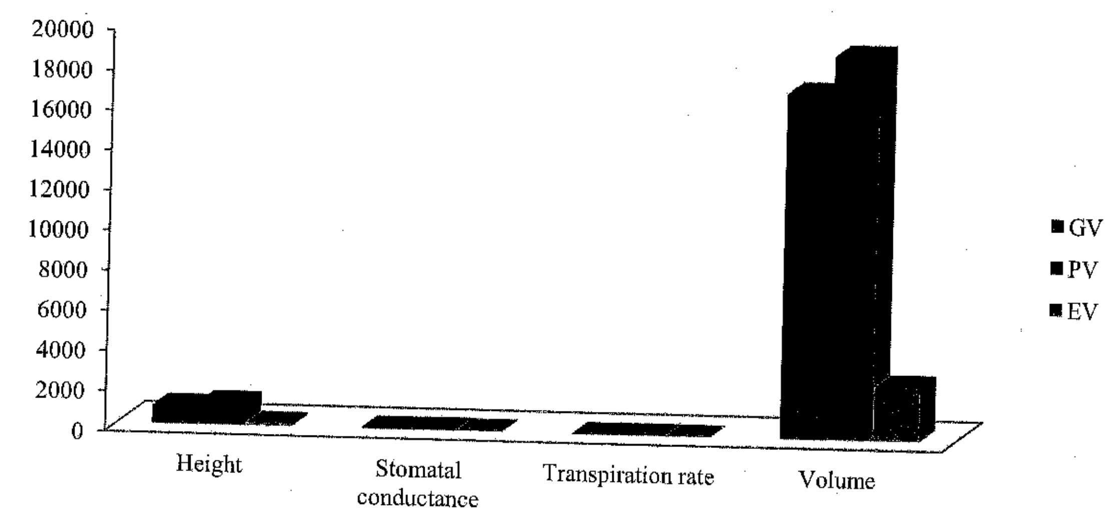


Fig 6.. Contribution of variation for biodrainage attributes at Kumulur



environmental variation of 2701.27 followed by height, stomatal conductance and transpiration rate with the variation of 146.79, 27.62 and 0.010 respectively.

The variation due to environment was less in all the traits compare to phenotypic and genotypic variations. Among the four traits studies, volume had high environmental variation of 2903.49 followed by height, stomatal conductance and transpiration rate with the variation of 136.89, 23.73 and 0.011 respectively at Kumulur.

These results help to conclude that environmental influence on the traits were less. However, all the traits were largely dictated by phenotypic and genotypic influence.

Estimation of genetic parameters

The contribution of variation in terms of genotypic, phenotypic and environmental coefficient of variations of the clones in terms of various biodrainage related traits were explained in the Table 31; Fig. 7. In addition, the heritability and genetic advance of the clones for various biodrainage traits were also explained in the same Table 32; Fig. 8. The results were presented using the estimation of traits at 6 MAP.

Genotypic coefficient of variation

The success of the selection depends on the control of characters by the genetic factors. The results of present study at Aduthurai revealed that among the four traits volume had highest genotypic coefficient of variation 89.06, whereas, height and transpiration rate accounted the genotypic coefficient of variation of 37.84 and 30.73 respectively. Among the four traits, stomatal conductance accounted very low genotypic coefficient of variation of 14.11.

The results of present study revealed that among the four traits volume had highest genotypic coefficient of variation 88.96, whereas, height and transpiration rate accounted the genotypic coefficient of variation of 34.86 and 31.82 respectively. Among the four traits, stomatal conductance accounted very low genotypic coefficient of variation of 13.18 in Kumulur.

Table 31. Genetic parameter for biodrainage attributes at Aduthurai

Character	GCV	PCV	ECV	Heritability (%)	GA (%) of mean
Height	37.84	40.55	14.57	87.08	72.73
Stomatal conductance	14.11	19.63	13.65	51.67	20.90
Transpiration rate	30.73	37.83	22.07	65.98	51.42
Volume	89.06	96.19	36.36	85. 71	169.84

Table 32.Genetic parameter for biodrainage attributes at Kumulur

Character	GCV	PCV	ECV	Heritability (%)	GA (%) of mean
Height	34.86	39.61	13.54	83.10	71.78
Stomatal conductance	14.18	19.59	13.62	51.71	21.78
Transpiration rate	30.83	37.80	21.99	65.91	56.39
Volume	88.96	99.19	38.36	79. 71	167.84

Fig 7. Genetic parameter for biodrainage attributes at Aduthurai

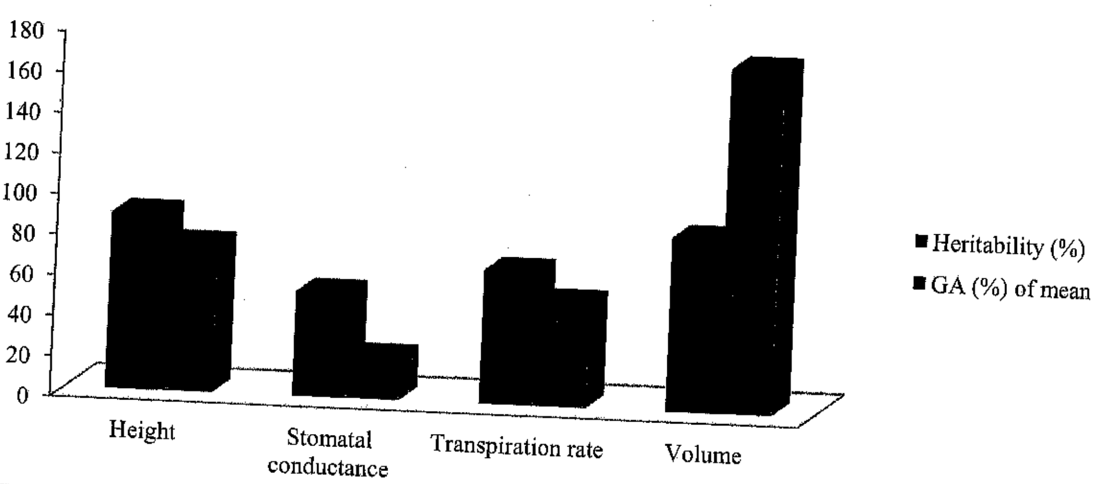


Fig 8.Genetic parameter for biodrainage attributes at Kumulur

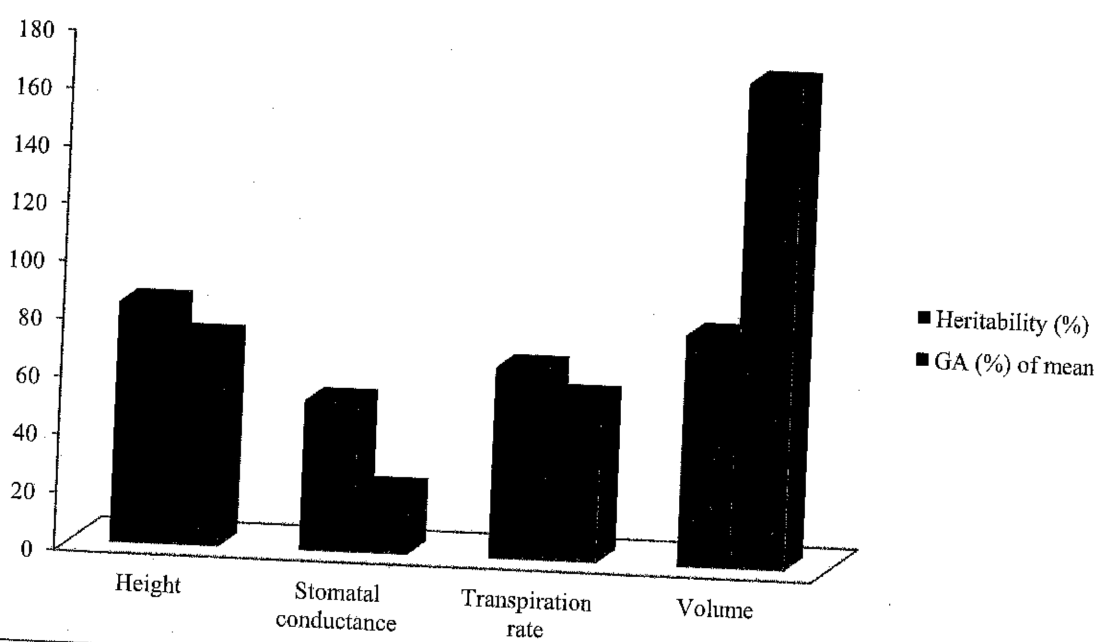


Table 33. Genotypic correlation co-efficient for biodrainage attributes at Aduthurai

Character	Height	Stomatal conductance	Transpiration rate	Volume
Height	1.000	0.980*	0.993*	0.977*
Stomatal conductance		1.000	0.861*	0.902*
Transpiration rate			1.000	0.948*
Volume				1.000

* Significant @ 5% level

Table 34.Genotypic correlation co-efficient for biodrainage attributes at Kumulur

Character	Height	Stomatal conductance	Transpiration rate	Volume
Height	1.000	0.989*	0.997*	0.987*
Stomatal conductance		1.000	0.881*	0.906*
Transpiration rate			1.000	0.942*
Volume				1.000

* Significant @ 5% level

Phenotypic coefficient of variation

Phenotypic desirability of the clones helps to identify the best performing Candidate Plus Trees (CPTs) by breeders. In Aduthurai the result revealed that similar to genotypic coefficient of variation, maximum phenotypic coefficient of variation of 96.19 was accounted by volume followed by height (40.55) and transpiration rate (37.83). The least phenotypic coefficient of variation of 19.63 was accounted by stomatal conductance.

In Kumulur maximum phenotypic coefficient of variation of 99.19 was accounted by volume followed by height (39.61) and transpiration rate (37.83). The least phenotypic coefficient of variation of 19.59 was accounted by stomatal conductance.

Environmental coefficient of variation

The study revealed that environmental coefficient of variation also showed similar trend like GCV and PCV at Aduthurai. Higher environmental coefficient of variation (36.36) was accounted by volume followed by transpiration rate (22.07) and height (14.57). The least environmental coefficient of variation of 13.65 was registered by stomatal conductance.

At Kumulur higher environmental coefficient of variation (38.16) was accounted by volume followed by transpiration rate (21.99) and height (13.54). The least environmental coefficient of variation of 13.62 was registered by stomatal conductance.

The above result explained the characters viz., volume, height, transpiration rate and stomatal conductance used for biodrainage studied were largely dictated by genotypic and phenotypic variation. It is also important to note that environment played a little role on the characters studied.

Heritability

The maximum genetic gain can be achieved through high heritability. It is also important that, the characters considered for selection must have high heritability to capture maximum benefit. Among the four characters studied at Aduthurai, height accounted highest heritability of 87.08 per cent, volume, transpiration rate and stomatal conductance have the heritability of 85. 71 per cent, 65.98 per cent and 51.67 per cent respectively.

Table 35. **Phenotypic correlation co-efficient for biodrainage attributes at Aduthurai**

Character	Height	Stomatal conductance	Transpiration rate	Volume
Height	1.000	0.685*	0.720*	0.942*
Stomatal conductance		1.000	0.655*	0.691*
Transpiration rate			1.000	0.732*
Volume				1.000

* Significant @ 5% level

Table 36.**Phenotypic correlation co-efficient for biodrainage attributes at Kumulur**

Character	Height	Stomatal conductance	Transpiration rate	Volume
Height	1.000	0.679*	0.721*	0.944*
Stomatal conductance		1.000	0.659*	0.692*
Transpiration rate			1.000	0.734*
Volume				1.000

* Significant @ 5% level

Table 37. Environmental correlation co-efficient for biodrainage attributes at Aduthurai

Character	Height	Stomatal conductance	Transpiration rate	Volume
Height	1.000	0.112	-0.153	0.724
Stomatal conductance		1.000	0.091	0.001
Transpiration rate			1.000	-0.176
Volume				1.000

Table 38. Environmental correlation co-efficient for biodrainage attributes at Kumulur

Character	Height	Stomatal conductance	Transpiration rate	Volume
Height	1.000	0.115	-0.163	0.728
Stomatal conductance		1.000	0.091	0.001
Transpiration rate			1.000	-0.169
Volume				1.000

At Kumulur height accounted highest heritability of 83.10 per cent, volume, transpiration rate and stomatal conductance have the heritability of 79.71 per cent, 65.91 per cent and 51.71 per cent respectively.

Genetic advance

The experimental result at Aduthurai revealed that maximum genetic gain in terms of genetic advance was obtained by volume (169.84%) followed by height (72.73%), transpiration rate (51.42%) and stomatal conductance (20.90%).

The experimental result at Kumulur revealed that maximum genetic gain in terms of genetic advance was obtained by volume (167.16%) followed by height (71.73%), transpiration rate (56.39%) and stomatal conductance (21.78%).

Association of biodrainage traits

Correlation studies

The correlation among the traits will help to harvest additional genetic gain if one character is highly correlated with another character. The estimation of correlation in terms of genetic correlation, phenotypic correlation, environmental correlation and simple correlation were explained in the Table 33 to Table 40 respectively.

Genotypic correlation

All the four characters viz., height, volume, transpiration rate and stomatal conductance were highly correlated with each other genotypically. In Aduthurai among the four attributes, height showed very strong genotypic correlation (0.993) with transpiration rate followed by height vs stomatal conductance (0.980) and height vs. volume (0.977). Transpiration rate also had strong correlation with volume by registering genotypic correlation value of 0.948. Stomatal conductance showed moderate genotypic correlation with volume (0.902), whereas, slightly lesser genotypic correlation was observed for stomatal conductance vs. transpiration (0.861) (Table 33).

In Kumulur among the four attributes, height showed very strong genotypic correlation (0.997) with transpiration rate followed by height vs stomatal conductance (0.989) and height vs.

volume (0.987). Transpiration rate also had strong correlation with volume by registering genotypic correlation value of 0.942. Stomatal conductance showed moderate genotypic correlation with volume (0.906), whereas, slightly lesser genotypic correlation was observed for stomatal conductance vs. transpiration (0.881) (Table 34).

Phenotypic correlation

Compared to genotypic correlation, phenotypic correlation showed only moderate relationship among the clones. At Aduthurai the phenotypic correlation was found to be high for height vs. volume (0.942), followed by transpiration rate vs volume (0.732). Stomatal conductance vs. transpiration rate showed a low phenotypic correlation of 0.655 (Table 35). The correlations between all these four traits were significant at five per cent level.

At Kumulur the phenotypic correlation was found to be high for height vs. volume (0.944), followed by transpiration rate vs. volume (0.734). Stomatal conductance vs. transpiration rate showed a low phenotypic correlation of 0.659 (Table 36).

Environmental correlation

At Aduthurai the height showed positive correlation (0.724) with volume, whereas height with transpiration rate (-0.153) and transpiration rate with volume (-0.176) were negatively correlated environmentally. Stomatal conductance showed moderate environmental correlation with transpiration rate (0.091) and very low environmental correlation with volume (0.001) (Table 37).

At Kumulur the height showed positive correlation (0.728) with volume, whereas height with transpiration rate (-0.163) was negatively correlated environmentally. Stomatal conductance showed moderate environmental correlation with transpiration rate (0.091) (Table 38)

The above result showed that all the characters considered for the selection are dictated by genotypic and phenotypic factors and are less influenced by environmental factor. Hence, the characters considered for the selection for biodrainage can be used.

Simple correlation

The association of characters were analyzed and furnished in Table 39 and 40.The research result at Aduthurai indicated that height exerted a strong correlation with volume (0.964) followed by transpiration rate with volume (0.906). Stomatal conductance had correlation with volume and transpiration rate with the correlation coefficient being 0.883 and 0.870 respectively. Height showed the least simple correlation with stomatal conductance (0.847) (Table 39).

The research result at Kumulur indicated that height exerted a strong correlation with volume (0.968) followed by transpiration rate with volume (0.906). Stomatal conductance had correlation with volume and transpiration rate with the correlation coefficient being 0.878 and 0.870 respectively. Height showed the least simple correlation with stomatal conductance (0.851) (Table 40).

Path coefficient analysis for biodrainage traits

The estimates of direct and indirect effects of biodrainage traits viz., transpiration rate, stomatal conductance, height and volume are presented in the Table 41and Table 42. The residual effect for the evaluation trail on volume was 0.18893.

Direct effect

In Aduthurai among all the biodrainage traits studied, the height exhibited negative effect on volume (-0.241), while stomatal conductance and transpiration rate showed direct positive effect on volume with path value of 0.525 and 0.709 respectively (Table 41).

In Kumulur among all the biodrainage traits studied, the height exhibited negative effect on volume (-0.231), while stomatal conductance and transpiration rate showed direct positive effect on volume with path value of 0.531 and 0.701 respectively (Table 42).

Table 39. Simple correlation co-efficient for biodrainage attributes at Aduthurai

Character	Height	Stomatal conductance	Transpiration rate	Volume
Height	1.000	0.847	0.882	0.964
Stomatal conductance		1.000	0.870	0.883
Transpiration rate			1.000	0.906
Volume				1.000

Table 40.Simple correlation co-efficient for biodrainage attributes at Kumulur

Character	Height	Stomatal conductance	Transpiration rate	Volume index
Height	1.000	0.851	0.879	0.968
Stomatal conductance		1.000	0.870	0.878
Transpiration rate			1.000	0.906
Volume				1.000

Table 41. Path coefficients of biodrainage traits showing direct and indirect effects on volume index at Aduthurai

Characters	Height	Stomatal conductance	Transpiration rate	Correlation(r) with volume index
Height	-0.241	0.514	0.703	0.977
Stomatal conductance	-0.236	0.525	0.750	1.038
Transpiration rate	-0.239	0.555	0.709	1.025

Residual effect= 0.18893 (Diagonal values are direct effect)

Table 42.Path coefficients of biodrainage traits showing direct and indirect effects on volume index at Kumulur

Characters	Height	Stomatal conductance	Transpiration rate	Correlation(r) with volume index
Height	-0.231	0.504	0.802	0.865
Stomatal conductance	-0.229	0.531	0.760	1.028
Transpiration rate	-0.235	0.556	0.701	1.019

Residual effect= 0.18893 (Diagonal values are direct effect)

Indirect effect

Height

At Aduthurai height exhibited maximum positive indirect effect on volume through transpiration rate (0.703) and also expressed lesser positive indirect effect through stomatal conductance (0.514) (Table 41).

At Kumulur height exhibited maximum positive indirect effect on volume through transpiration rate (0.802) and also expressed lesser positive indirect effect through stomatal conductance (0.504) (Table 42).

Stomatal conductance

At Aduthurai stomatal conductance also exhibited positive indirect effect on volume through transpiration rate (0.750) and exerted its maximum negative indirect effect through height (-0.236) on volume (Table 41).

At Kumulur, stomatal conductance also exhibited positive indirect effect on volume through transpiration rate (0.753) and exerted its maximum negative indirect effect through height (-0.229) on volume (Table 42).

Transpiration

At Aduthurai transpiration rate registered negative indirect effect on volume through height (-0.235) and also exhibited positive indirect effect through stomatal conductance (0.556) (Table 41).

Genetic divergence estimation

The genetic divergence estimation of clones helps to understand the genetic distance among the clones. In the present study, based on the result collected on transpiration rate, stomatal conductance, Inter Cellular CO_2 Concentration, photosynthetic rate, height and volume of all the clones were subjected for multivariate analysis using "GENRES" statistical package. The D^2 estimation of 35 clones and one seed source grouped into seven genetically distinct clusters.

Cluster components

The multivariate analysis of the 35 clones and one seed source and their genetic grouping along with the cluster components are furnished in the Table 43. The D^2 analysis grouped 35 clones and one seed source into seven genetically distinct clusters. Among the seven clusters, maximum clones (8 clones) were accounted in the cluster VI followed by cluster V and VII which was constituted with six clones each. The cluster II and III have three clones each and the cluster I has five clones. The cluster IV has four clones. The highest number of clones viz., MTP-2, MTP-3, MTP-4, ITC-3, ITC-284, SG-2, *E. saligna* and KK-2, where grouped in cluster VI whereas the clusters V and VII have six clones viz., MTP-7, MTP-8, NGL-2, TCR-1, TCR-3 and KK-1 and NGL-3, TCR-2, SG-3,PD-9,ALR-2 and ALR-5 respectively. The cluster II and III was constituted with three clones each viz., NGL-4, ITC-286 and SG-4 and TCR-4,PD-6 and EU-1 respectively. Similarly, four clones viz., MTP-1, MTP-5, MTP-6 and SG-1 constituted in cluster IV. The five clones viz., RMD-2, RMD-3, PD-10,ALR-1 and EU-2 were accommodated in the cluster I.

Inter and intra cluster average distance

The average intra and inter cluster distances among the seven clusters are presented in Table 44 and Table 45; Fig. 9 and Fig 10. At Aduthurai the clones within the cluster VI had high intra genetic distance of 5.329 followed by cluster IV (3.384), while the least genetic distance of 0.992 among the clones was observed in the cluster II(Table 44) . The highest inter cluster distance was recorded between the cluster I and cluster IV (9.425) followed by cluster III and cluster IV (9.348). The cluster I and cluster III showed very minimal inter cluster distance of 1.809 representing their genetic relatedness.

At Kumulur the clones within the cluster VI had high intra genetic distance of 5.297 followed by cluster IV (4.272), while the least genetic distance of 0.892 among the clones was observed in the cluster II. The highest inter cluster distance was recorded between the cluster I and cluster IV (9.392) followed by cluster III and cluster IV (9.337) (Table 45). The cluster I and cluster III showed very minimal inter cluster distance of 1.006 representing their genetic relatedness.

Table 43. Clustering pattern of Eucalyptus for biodrainage traits

Cluster number	Number of clones	Members
1	5	RMD 2 RMD 3 PD 10 ALR 1 EU 2
2	3	NGL 4 ITC 286 SG 4
3	3	TCR 4 PD 6 EU 1
4	4	MTP 1 MTP 5 SG 1 MTP 6
5	6	MTP 7 MTP 8 NGL 2 TCR 1 TCR 3 KK 1
6	8	MTP 2 MTP 3 MTP 4 ITC 3 ITC 284 SG2 E.Sal KK 2
7	6	NGL 3 TCR 2 SG 3 PD 9 ALR 2 ALR 5

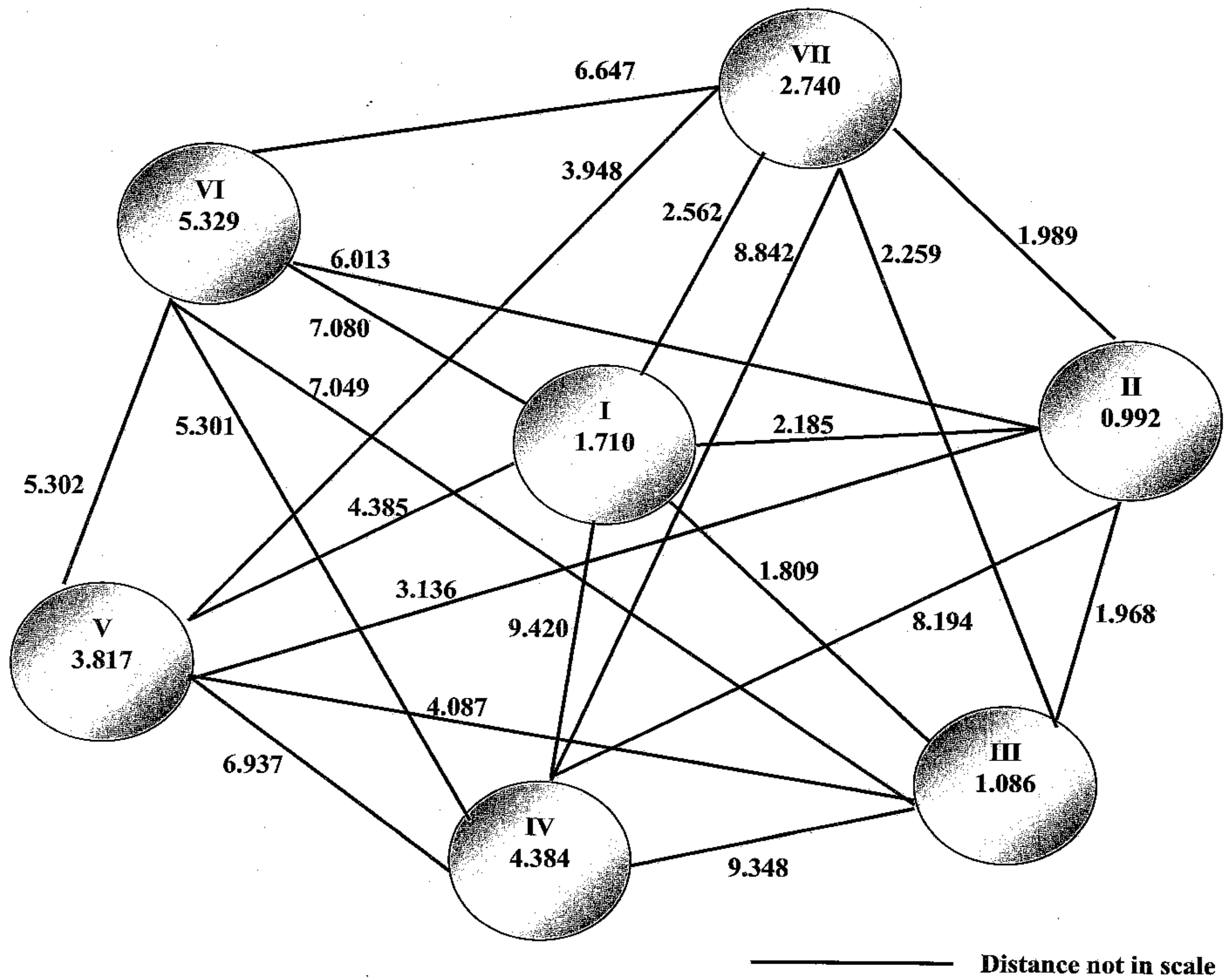
Cluster mean performance

The cluster means for the traits were estimated and are furnished in the Table 46 for Aduthurai. The maximum cluster mean of 1.91 m mol m^{-2} s^{-1} was observed for transpiration rate in cluster I. whereas, the least cluster mean transpiration rate (1.54 m mol m^{-2} s^{-1}) was exhibited by the cluster VII. The cluster members in cluster I showed highest performance for height and volume with the cluster mean of 10.19 and 7.85 m^3 respectively. On the contrary, the minimum cluster mean of 4.88 cm and 1.35 m^3 respectively for height and volume was observed in cluster VII. In the case of stomatal conductance, the cluster mean was highest for cluster I (123.19 m mol m^{-2} s^{-1}) and the lowest cluster mean was exhibited by the cluster VII (82.16 m mol m^{-2} s^{-1}). Among the seven clusters, cluster I exhibited the maximum cluster mean values of 2.64 μ mol m^{-2} s^{-1} and 235.69 ppm respectively for photosynthetic rate and Inter Cellular CO_2 Concentration. The lowest cluster mean value for photosynthetic rate and Inter Cellular CO_2 Concentration was registered by cluster VII (0.94 μ mol m^{-2} s^{-1}) and (119.59 ppm) respectively.

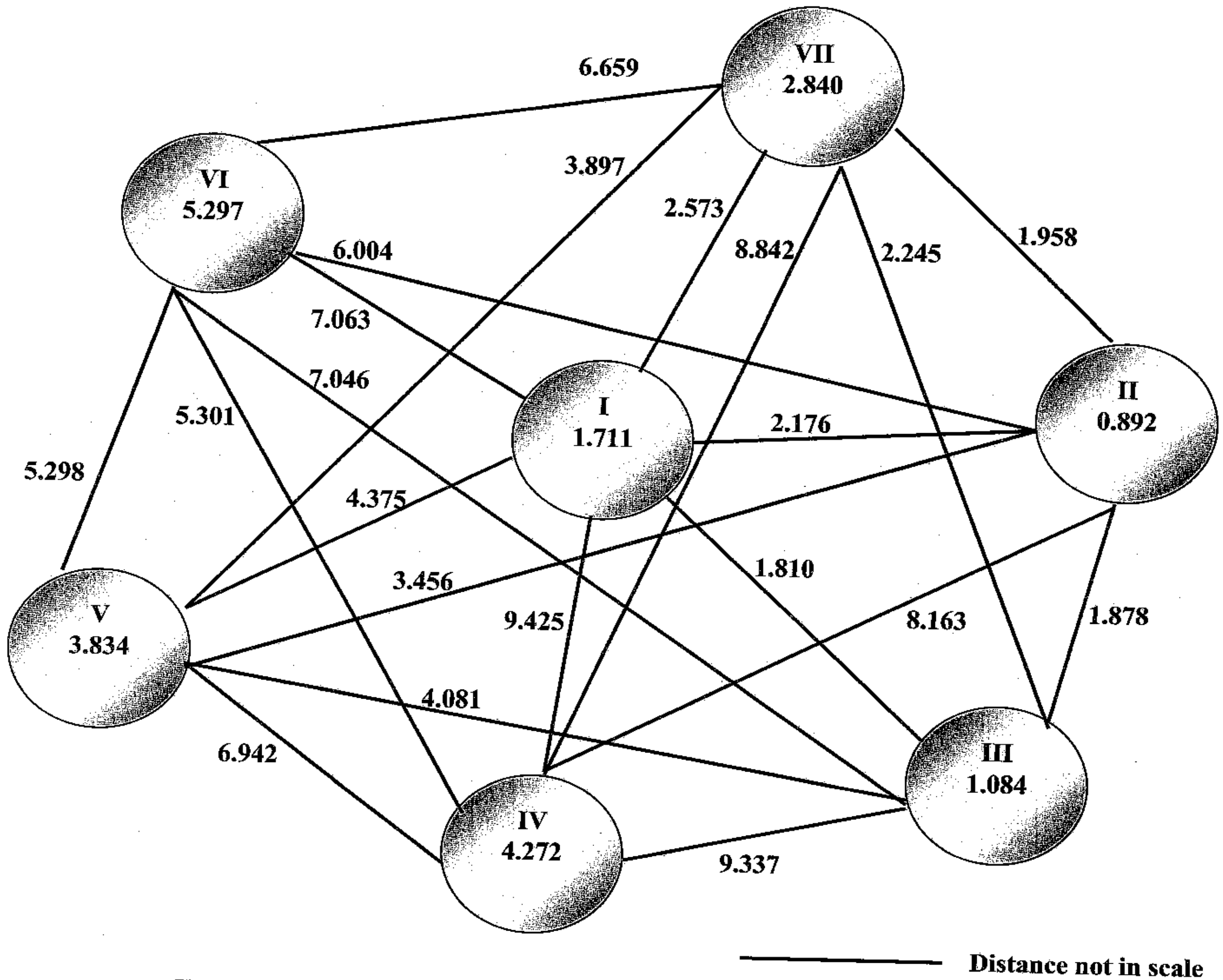
The cluster means for the traits were estimated and are furnished in the Table 47 for Kumulur. The maximum cluster mean of 1.95 m mol m^{-2} s^{-1} was observed for transpiration rate in cluster I. Whereas, the least cluster mean transpiration rate (1.04 m mol m^{-2} s^{-1}) was exhibited by the cluster VII. The cluster members in cluster I showed highest performance for height and volume with the cluster mean of 11.65 and 10.01 m^3 respectively. On the contrary, the minimum cluster mean of 5.76 cm and 1.88 m^3 respectively for height and volume was observed in cluster VII. In the case of stomatal conductance, the cluster mean was highest for cluster I (138.29 m mol m^{-2} s^{-1}) and the lowest cluster mean was exhibited by the cluster VII (78.14 m mol m^{-2} s^{-1}). Among the seven clusters, cluster I exhibited the maximum cluster mean values of 6.94 μ mol m^{-2} s^{-1} and 242.85 ppm respectively for photosynthetic rate and Inter Cellular CO_2 Concentration. The lowest cluster mean value for photosynthetic rate and Inter Cellular CO_2 Concentration was registered by cluster VII (3.05 μ mol m^{-2} s^{-1}) and (118.99 ppm) respectively.

Contribution of characters towards genetic divergence

The number of times each character ranking first was counted and percentage contribution towards genetic divergence was calculated and presented in Table 48 and Table 49; Fig.11 and Fig 12. In Aduthurai among all traits, height contributed maximum (39.32 %) towards



Cluster diagram for biodrainage attributes for Aduthurai



Cluster diagram for biodrainage attributes for Kumulur

Table 44. Inter and intra cluster distances of the clones for biodrainage traits at Kumulur

Clusters	1	2	3	4	5	6	7
1	1.711	2.176	1.810	9.425	4.375	7.063	2.573
2		0.892	1.878	8.163	3.456	6.004	1.958
3			1.084	9.337	4.081	7.046	2.245
4				4.272	6.942	5.301	8.842
5					3.834	5.298	3.897
6						5.297	6.659
7							2.840

Table 45. Inter and intra cluster distances of the clones for biodrainage traits at Aduthurai

Clusters	1	2	3	4	5	6	7
1	1.710	2.185	1.809	9.420	4.385	7.080	2.562
2		0.992	1.968	8.194	3.136	6.013	1.989
3			1.086	9.348	4.087	7.049	2.259
4				4.384	6.937	5.301	8.842
5					3.817	5.302	3.948
6						5.329	6.647
7							2.740

Table 46.Cluster means for the Eucalyptus clones for biodrainage attributes at Kumulur

Cluster no	Cluster ranking	Height	Basal Diameter	Volume index	CINT	Stomatal conductance	Transpiration rate	Photosynthetic rate
4	1	11.65	27.39	10.01	242.85	138.29	1.95	6.94
6	2	9.71	24.49	7.47	199.54	128.71	1.72	6.19
5	3	8.35	22.30	5.85	184.04	116.89	1.54	5.30
7	4	7.30	19.18	4.40	159.45	105.77	1.32	4.01
2	5	7.14	15.65	3.51	147.18	96.76	1.19	4.46
3	6	6.17	12.01	2.33	137.12	87.14	1.16	3.71
1	7	5.76	10.40	1.88	118.99	78.14	1.04	3.05

Table 47. Cluster means for the Eucalyptus clones for biodrainage attributes at Aduthurai

Cluster no	Cluster ranking	Height	Basal diameter	Volume index	CINT	Stomatal conductance	Transpiration rate	Photosynthetic rate
4	1	10.19	24.55	7.85	235.69	123.19	1.91	2.64
6	2	8.82	21.75	6.02	199.45	120.27	1.68	2.19
5	3	8.33	18.86	4.93	188.40	113.53	1.56	1.86
7	4	6.74	16.27	3.45	172.20	95.44	1.37	1.56
2	5	6.39	13.45	2.70	152.87	94.84	1.34	1.36
3	6	5.15	10.88	1.76	134.09	87.74	1.22	1.11
1	7	4.88	8.80	1.35	119.59	82.16	1.54	0.94

Table 48. Contribution of each character to genetic divergence at Kumulur

Character	Number of first rank	% Contribution
Height	134	39.27
CINT	27	6.60
Stomatal conductance	7	1.95
Transpiration rate	45	12.51
Photosynthetic rate	24	7.14
Volume index	114	32.53
Total	**351**	**100**

Table 49. Contribution of each character to genetic divergence at Aduthurai

Character	Number of first rank	% Contribution
Height	138	39.32
CINT	23	6.55
Stomatal conductance	7	1.99
Transpiration rate	44	12.54
Photosynthetic rate	25	7.12
Volume index	114	32.48
Total	**351**	**100**

Fig 11. Contribution of each character to genetic divergence at Kumulur

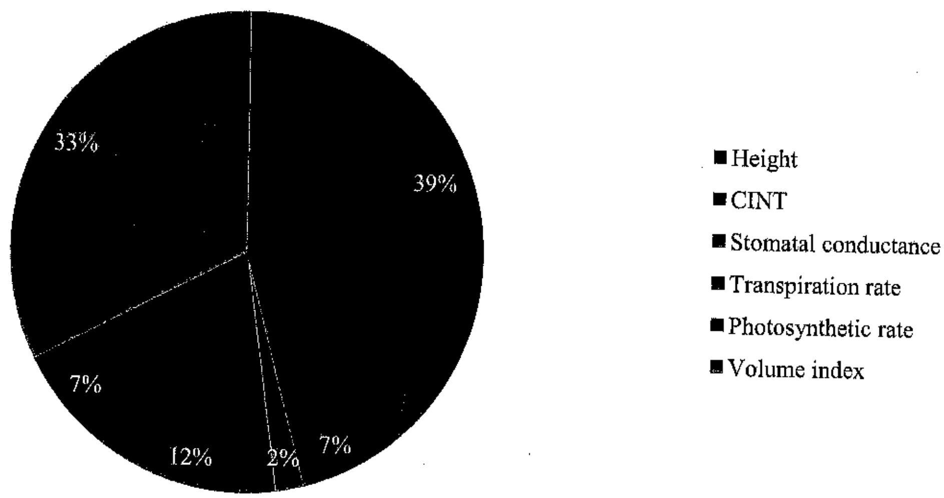
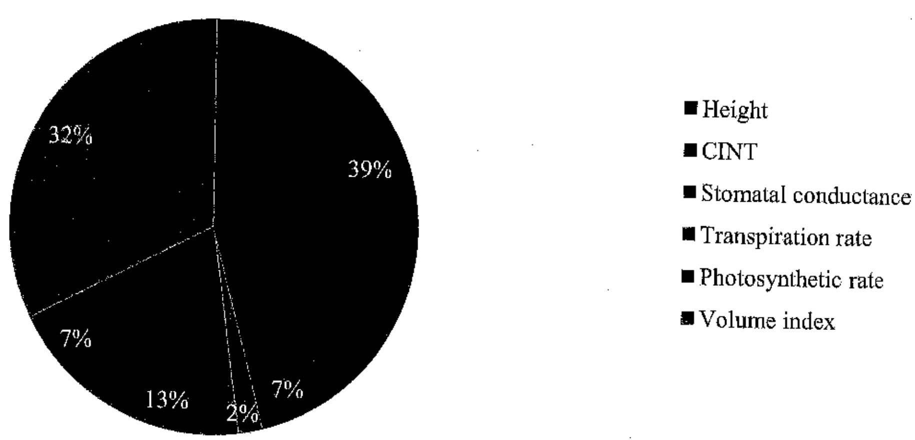


Fig 12. Contribution of each character to genetic divergence at Aduthurai



divergence followed by volume (32.48%). Minimal contribution towards divergence was recorded by stomatal conductance (1.99%). Transpiration rate contributed 12.54 per cent towards divergence of clones and it is described in Table 48; Fig 11.

In Kumulur among all traits, height contributed maximum (39.27 %) towards divergence followed by volume (32.53%). Minimal contribution towards divergence was recorded by stomatal conductance (1.95 %). Transpiration rate contributed 12.51 per cent towards divergence of clones (Table 49; Fig 12).

Ecophysiological characterization of clones

The biodrainage ability of the clones was dictated by the ecophysiological characters viz., transpiration rate, stomatal conductance, photosynthesis and Inter Cellular CO_2 Concentration (CINT). These traits were estimated and presented here under.

Transpiration

Transpiration rate is an important trait which decides the biodrainage efficacy of clones. Based on the divergence studies at Aduthurai, the cluster mean for transpiration rate of the clones is presented in Table 50. Among the clusters, highest transpiration rate was accounted by clonal members in cluster IV (0.62 m mol m^{-2} s^{-1}) followed by clones in cluster VI (0.48 m mol m^{-2} s^{-1}). Among all the 35 clones and one seed source, the clone MTP-1 constituted in the cluster IV recorded the highest transpiration rate of .1.94 m mol m^{-2} s^{-1} (Table 21).The minimum transpiration rate with cluster mean of 0.30 m mol m^{-2} s^{-1} was exerted by cluster VII. In the same cluster, the clones viz., RMD-2 and RMD-3 were rated as low performing clones in terms of their transpirational value as 1.08 m mol m^{-2} s^{-1}. The moderate performance was observed in the cluster V and VI with the transpiration value of 0.411 m mol m^{-2} s^{-1} and 0.48 m mol m^{-2} s^{-1}. Here also, the high performing clones were accounted high transpiration rate. Thus, the clones have shown their potentiality to be fit for alleviating biodrainage problem.

Same trend of diurnal variation in transpiration rate was observed in Kumulur trail. Among the clusters, highest transpiration rate was accounted by clonal members in cluster IV (0.60 m mol m^{-2} s^{-1}) followed by clones in cluster VI (0.48 m mol m^{-2} s^{-1}). The minimum transpiration rate with cluster mean of 0.29 m mol m^{-2} s^{-1} was exerted by cluster VII (Table 51).

Stomatal conductance

Stomatal conductance having positive association with transpiration rate and it is also an important factor which decides the biodrainage efficiency of clones. The cluster mean value for stomatal conductance for Aduthurai trail is described in Table 52. Among the clusters, the maximum stomatal conductance was registered by cluster IV followed by cluster V with the stomatal conductance of 43.91 and 38.49 m mol m^{-2} s^{-1} respectively. Among all the 35 clones and one seed source, the clone MTP-1 constituted in the cluster IV recorded the highest stomatal conductance of 124.73 m mol m^{-2} s^{-1} (Table 23). The minimum stomatal conductance value of 33.00 m mol m^{-2} s^{-1} was recorded in cluster VII and the low performing clone RMD-3 was placed in this cluster with the stomatal conductance value of 78.65 m mol m^{-2} s^{-1} (Table 23). The moderate performance was shown by the clonal members in cluster V with the stomatal conductance of 38.49 m mol m^{-2} s^{-1}.

The cluster mean value for stomatal conductance Kumulur trail showed the same trends as that of Aduthurai trail (Table 53). Among the clusters, the maximum stomatal conductance was registered by cluster IV with the stomatal conductance of 40.97 mol m^{-2} s^{-1} respectively. The minimum stomatal conductance value of 32.39m mol m^{-2} s^{-1} was recorded in cluster VII.

Photosynthesis

The cluster mean for photosynthetic efficiency of different clusters for Aduthurai trail is presented in Table 54. The photosynthetic rate of clusters showed a range of 0.47 to 0.28 μ mol m^{-2} s^{-1}. Among all the clusters, the clones in cluster IV recorded maximum photosynthetic rate followed by cluster VI with the photosynthetic rate of 0.47 μ mol m^{-2} $s^{-1}$and 0.42 μ mol m^{-2} s^{-1} respectively. The better performing clones MTP-6 and SG-1 (2.68 μ mol m^{-2} s^{-1}) in terms of photosynthetic rate were placed in cluster IV (Table 27).

The cluster mean for photosynthetic efficiency of different clusters for Kumulur trail is presented in Table 55. The photosynthetic rate of clusters showed a range of 0.46 to 0.25 μ mol m^{-2} s^{-1}. Among all the clusters, the clones in cluster IV recorded maximum photosynthetic rate followed by cluster VI with the photosynthetic rate of 0.46 μ mol m^{-2} $s^{-1}$and 0.41 μ mol m^{-2} s^{-1} respectively. The better performing clone MTP-1 (7.02μ mol m^{-2} s^{-1}) in terms of photosynthetic rate were placed in cluster IV (Table 28). The minimal photosynthetic rate (0.25 μ mol m^{-2} s^{-1}) was recorded in cluster VII and the low performing clone EU-2 (3.00 μ mol m^{-2} s^{-1}) in terms of photosynthetic rate presents in the same cluster.

Inter Cellular CO_2 Concentration (CINT)

Here also, the higher productivity is highly associated with high Inter Cellular CO_2 Concentration (CINT). The mean performances of clusters for Inter Cellular CO_2 Concentration (CINT) at Aduthurai trail are furnished in Table 56. Among the clusters, highest Inter Cellular CO_2 Concentration was accounted by clonal members in cluster IV (272.91 ppm) followed by clones in cluster II (247.80 ppm). Among all the 35 clones and one seed source, the clone MTP-1 present in the cluster IV recorded the highest Inter Cellular CO_2 Concentration of 242.21 ppm (Table 25). Similarly, the minimal Inter Cellular CO_2 Concentration of 201.90 ppm was accounted by clonal members in cluster III. In the same cluster, the low performing clone (EU-2) with the Inter Cellular CO_2 Concentration value of 119.29 ppm was placed. The average performance of Inter Cellular CO_2 Concentration was accounted by clonal members in cluster II and VI.

The mean performances of clusters for Inter Cellular CO_2 Concentration (CINT) at Kumulur trail are furnished in Table 57. Among the clusters, highest Inter Cellular CO_2 Concentration was accounted by clonal members in cluster IV (261.21ppm) followed by clones in cluster II (248.60 ppm). Similarly, the minimal Inter Cellular CO_2 Concentration of 202.70 ppm was accounted by clonal members in cluster III. The average performance of Inter Cellular CO_2 Concentration was accounted by clonal members in cluster II and VII.

Diurnal variation of ecophysiological characters in clones

The ecophysiological characters viz., transpiration rate, stomatal conductance, photosynthesis and Inter Cellular CO_2 Concentration (CINT) were estimated at an hourly interval to study diurnal behaviour of clones. The diurnal behaviour in terms of various ecophysiological characters was explained in the Table 50 to Table 58.

Diurnal variation in transpiration

At Aduthurai trail the transpirational behaviour of all the 35 clones and one seed source estimated from 8.00 AM to 5.00 PM is described in Table 50; Fig. 13. Among the all clusters, the clones in cluster IV were showed highest transpiration rate through out the day without any midday depression. In the same cluster, the clonal members registered maximum transpiration rate of 0.89 m mol m^{-2} s^{-1} at 10.00 AM. Interestingly, they also showed 0.79 m mol m^{-2} s^{-1} of transpiration even at 12.00 noon proving their potential to fit for biodrainage suitability without midday depression. The clonal members in cluster VII showed lowest transpiration rate, when compared to all other clusters. This cluster also recorded the transpiration rate ranged from 0.15 to 0.45 m mol m^{-2} s^{-1}. This cluster also accounted minimal transpiration rate (0.34 m mol m^{-2} s^{-1}) during 12.00 noon indicating the tendency of strong midday depression.. Similar midday depression was observed at 12.00 noon in the cluster VII with the cluster mean transpiration rate of 0.34 m mol m^{-2} s^{-1}. It is also interesting to note that clonal members in all the clusters had not shown much midday depression at 12.00 noon. A moderate performance of clonal members for diurnal variation in transpiration rate was observed in the cluster III and cluster V. Slightly lesser performance of clonal members in the cluster I and cluster II were also observed. But it is important to note that these clusters have not shown much midday depression. The difference was observed only in terms of transpiration rate.

Same trend of diurnal variation in transpiration rate was also observed in Kumulur trail. Among the all clusters, the clones in cluster IV were showed highest transpiration rate throughout the day without any midday depression. In the same cluster, the clonal members registered maximum transpiration rate of 0.92 m mol m^{-2} s^{-1} at 10.00 AM (Table 51; Fig. 14.). This cluster also recorded the transpiration rate ranged from 0.25 to 0.92 m mol m^{-2} s^{-1}.

Diurnal variation in stomatal conductance

Stomatal conductance is also an important trait for deciding the biodrainage efficiency of clones, which ultimately influence the transpiration rate of the clones. The performance of each clone under waterlogged condition was assessed by measuring stomatal conductance at an hourly interval at Aduthurai and the results are presented in the Table 55; Fig. 15. Measurement of stomatal conductance during the study period revealed that the clonal members in the cluster IV

Table 50. Cluster means for diurnal variation in transpiration rate (m mol m^{-2} s^{-1}) at Aduthurai

Clusters	Time									
	8.00	9.00	10.00	11.00	12.00	1.00	2.00	3.00	4.00	Mean
1	0.20	0.24	0.23	0.44	0.47	0.49	0.31	0.30	0.17	0.32
2	0.22	0.35	0.57	0.43	0.46	0.33	0.45	0.28	0.16	0.36
3	0.17	0.41	0.28	0.50	0.39	0.23	0.34	0.39	0.25	0.33
4	0.39	0.60	0.89	0.83	0.79	0.65	0.50	0.47	0.44	0.62
5	0.27	0.34	0.49	0.51	0.59	0.49	0.38	0.30	0.36	0.41
6	0.30	0.39	0.47	0.86	0.56	0.78	0.41	0.37	0.20	0.48
7	0.15	0.29	0.45	0.42	0.34	0.27	0.27	0.29	0.21	0.30

Table 51. Cluster means for diurnal variation in transpiration rate (m mol m^{-2} s^{-1}) at Kumulur

Clusters	Time									
	8.00	9.00	10.00	11.00	12.00	1.00	2.00	3.00	4.00	Mean
1	0.22	0.25	0.26	0.47	0.49	0.52	0.32	0.31	0.18	0.34
2	0.23	0.36	0.58	0.48	0.35	0.46	0.42	0.3	0.18	0.37
3	0.22	0.28	0.41	0.51	0.42	0.27	0.27	0.25	0.24	0.32
4	0.25	0.49	0.92	0.87	0.82	0.71	0.62	0.4	0.35	0.60
5	0.26	0.33	0.84	0.81	0.76	0.46	0.34	0.37	0.29	0.50
6	0.27	0.37	0.87	0.76	0.66	0.74	0.46	0.34	0.26	0.53
7	0.15	0.29	0.45	0.41	0.34	0.27	0.27	0.2	0.21	0.29

Fig 13. Cluster means for diurnal variation in transpiration rate (m mol m^{-2} s^{-1}) at Aduthurai

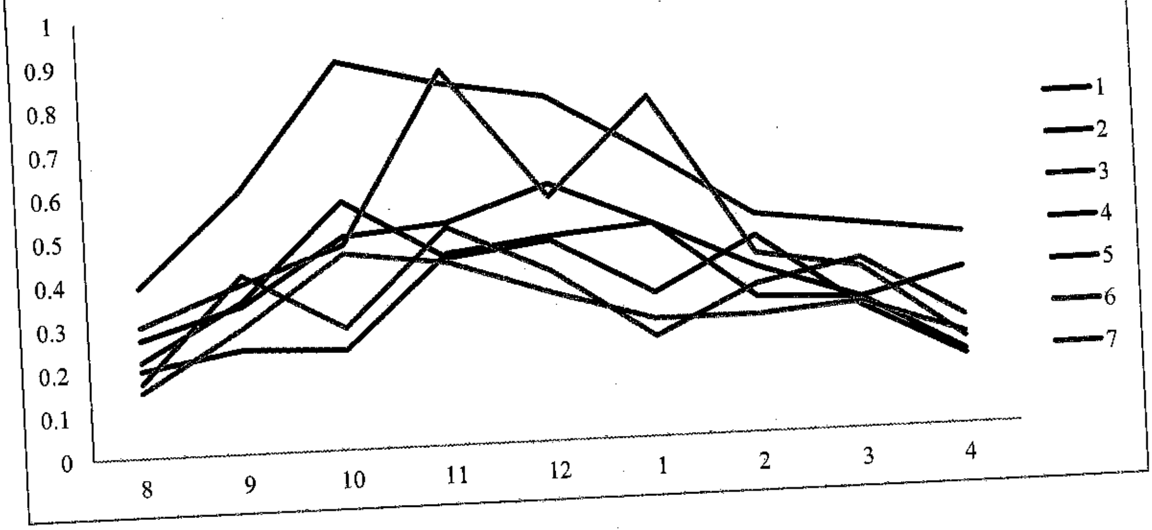


Fig 14. Cluster means for diurnal variation in transpiration rate (m mol m^{-2} s^{-1})at Kumulur

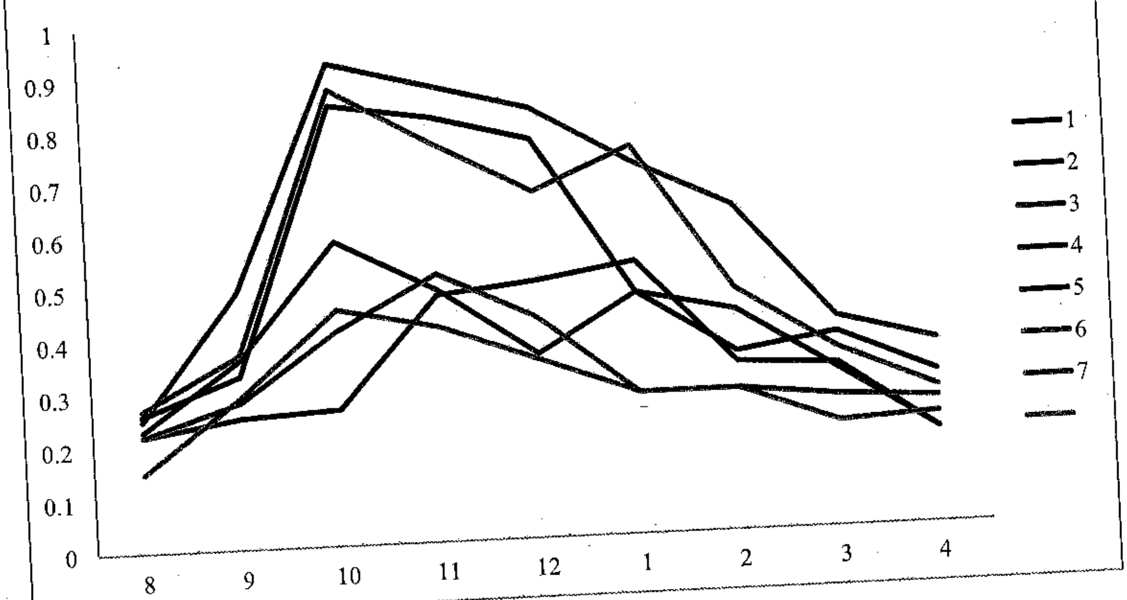


Table 52. Cluster means for diurnal variation in stomatal conductance (m mol m^{-2} s^{-1}) at Aduthurai

Clusters	Time									
	8.00	9.00	10.00	11.00	12.00	1.00	2.00	3.00	4.00	Mean
1	37.9	39.6	38.2	39.0	35.9	38.9	25.7	25.4	28.3	34.32
2	39.0	43.7	42.2	36.8	44.3	27.6	37.7	30.0	24.2	36.17
3	44.0	41.9	43.9	39.0	30.7	28.9	24.0	21.1	28.2	33.52
4	57.9	50.1	61.6	28.5	41.7	46.4	41.1	41.5	26.4	43.91
5	41.0	49.2	42.0	42.2	41.7	35.0	27.8	37.6	29.9	38.49
6	29.4	44.0	38.0	36.8	34.3	31.5	47.4	34.2	26.5	35.79
7	38.8	41.6	32.3	36.7	31.5	28.2	34.5	26.2	27.2	33.00

Table 53. Cluster means for diurnal variation in stomatal conductance (m mol m^{-2} s^{-1}) at Kumulur

Clusters	Time									
	8.00	9.00	10.00	11.00	12.00	1.00	2.00	3.00	4.00	Mean
1	35.9	38.6	39.2	39	36.9	38.5	25.7	24.4	28.3	34.06
2	39.4	42.7	41.2	37.8	43.3	26.6	37.7	30	26.2	36.10
3	43	41.7	44.9	39	30.8	27.9	24.6	21	27.2	33.34
4	42.4	51.1	50.6	24.5	42.7	46.6	41.7	41.7	27.4	40.97
5	40.6	48.1	42.4	42.8	42.7	34	27.8	36.6	30.9	38.43
6	28.4	45	37	34.8	33.3	30.5	46.4	37.2	25.5	35.34
7	35.8	43.6	31.3	35.7	29.5	28.1	33.5	26.1	27.9	32.39

Fig 15. Cluster means for diurnal variation in stomatal conductance (m mol m^{-2} s^{-1}) at Aduthurai

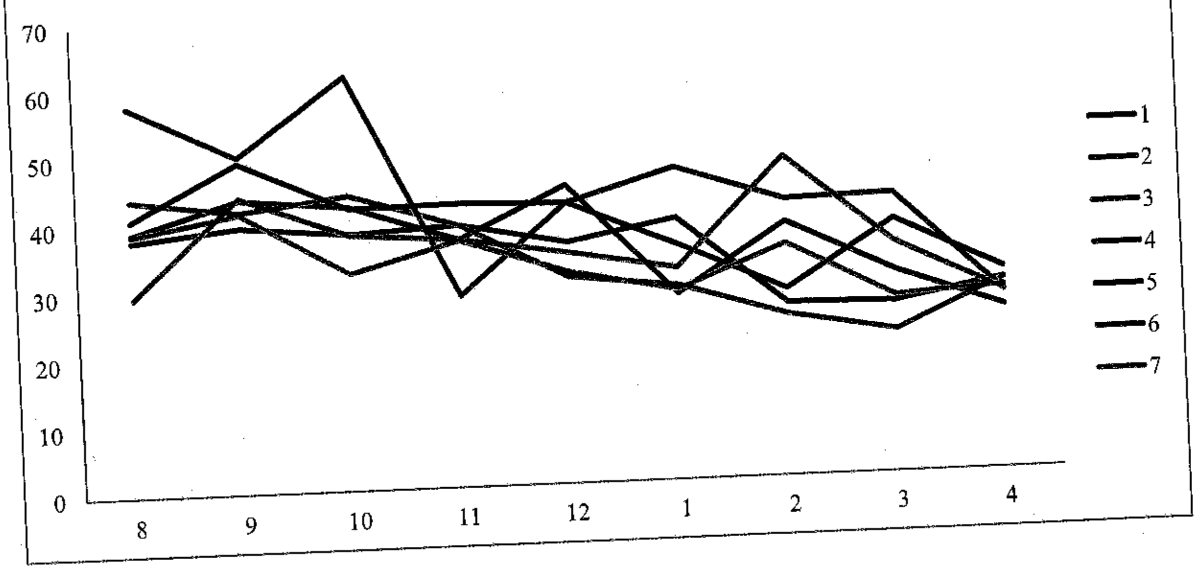
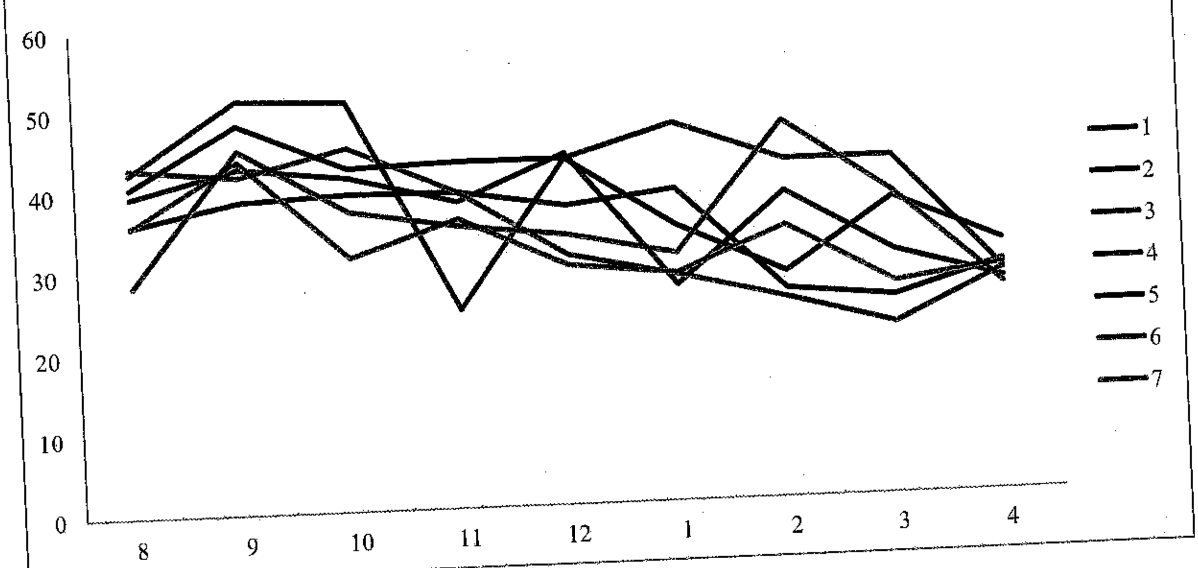


Fig 16.Cluster means for diurnal variation in stomatal conductance (m mol m^{-2} s^{-1}) at Kumulur



and II registered highest stomatal conductance. It is also important to note that the clones in the cluster IV had registered the highest stomatal conductance, when compared to all other clusters. The peak stomatal conductance of 61.6 m mol m^{-2} s^{-1} was registered at 10.00 AM by the clonal members in the cluster IV. The same cluster had also maintained high level of stomatal conductance (41.7 m mol m^{-2} s^{-1}) even at 12.00 noon. When compared to all other clusters, the clonal members in the cluster IV had maintained highest stomatal conductance during the after noon by registering the stomatal conductance of 46.4, 41.1 and 41.5 m mol m^{-2} s^{-1} respectively at 1.00, 2.00 and 3.00 PM. The study also revealed that the clonal members in the cluster II have registered highest stomatal conductance (44.3 m mol m^{-2} s^{-1}) at 12.00 noon. Similar to transpiration rate, moderate level of stomatal conductance was observed in the cluster III and V. The lowest stomatal conductance was observed in the cluster VII compared to all other clusters.

Same trend of diurnal variation in transpiration rate was also observed in Kumulur trail. Among the all clusters, the clones in cluster IV were showed highest transpiration rate (40.97 m mol m^{-2} s^{-1}) throughout the day without any midday depression. In the same cluster, the clonal members registered maximum and minimum transpiration rate of 50.60 m mol m^{-2} s^{-1} and 31.30 m mol m^{-2} s^{-1} respectively (Table 56; Fig 16).

Diurnal variation in photosynthesis

The modulation of photosynthetic efficiency of the clones helps to identify not only the efficient clones for biodrainage but also helps to identify high productive genotypes under waterlogged condition at Aduthurai. The diurnal variation value of photosynthetic rate of all the clones were estimated and computed in the Table 54; Fig.17. Similar to transpiration rate and stomatal conductance, highest photosynthetic efficiency was observed in the cluster IV followed by cluster VI. The highest photosynthetic rate of 0.52 μ mol m^{-2} s^{-1} at 12.00 noon was registered by the clonal members in the cluster IV. The same cluster was also registered the highest photosynthetic rate of 0.60 μ mol m^{-2} s^{-1} at 10.00 A.M., compared to all other clonal members in the other clusters. The same cluster also registered highest photosynthetic rate of 0.43, 0.32, 0.49 and 0.34 μ mol m^{-2} s^{-1} respectively at 1.00, 2.00, 3.00 and 4.00 PM. The lowest photosynthetic rate was observed in the cluster VII and II. The clonal members in the cluster VII registered lowest photosynthetic rate 0.26 μ mol m^{-2} s^{-1} at 12.00 noon. The study also observed that the

Table 54. Cluster means for diurnal variation in photosynthetic rate (μ mol m^{-2} s^{-1}) at Aduthurai

Clusters	Time									
	8.00	9.00	10.00	11.00	12.00	1.00	2.00	3.00	4.00	Mean
1	0.38	0.39	0.37	0.28	0.29	0.38	0.21	0.20	0.26	0.31
2	0.40	0.33	0.25	0.39	0.41	0.28	0.30	0.34	0.22	0.32
3	0.25	0.33	0.34	0.32	0.30	0.30	0.32	0.19	0.26	0.29
4	0.47	0.59	0.60	0.45	0.52	0.43	0.32	0.49	0.34	0.47
5	0.45	0.45	0.40	0.42	0.39	0.38	0.46	0.37	0.32	0.40
6	0.50	0.55	0.44	0.50	0.42	0.47	0.33	0.27	0.26	0.42
7	0.36	0.28	0.35	0.33	0.26	0.26	0.24	0.25	0.21	0.28

Table 55.Cluster means for diurnal variation in photosynthetic rate (μ mol m^{-2} s^{-1}) at Kumulur

Clusters	Time									
	8.00	9.00	10.00	11.00	12.00	1.00	2.00	3.00	4.00	Mean
1	0.36	0.37	0.33	0.24	0.27	0.34	0.17	0.16	0.35	0.29
2	0.36	0.29	0.21	0.35	0.37	0.24	0.26	0.3	0.29	0.30
3	0.21	0.29	0.3	0.28	0.26	0.25	0.28	0.15	0.29	0.26
4	0.43	0.56	0.56	0.42	0.48	0.39	0.28	0.45	0.55	0.46
5	0.41	0.41	0.38	0.38	0.35	0.34	0.42	0.33	0.41	0.38
6	0.46	0.51	0.4	0.46	0.38	0.41	0.29	0.26	0.51	0.41
7	0.32	0.24	0.31	0.29	0.22	0.22	0.2	0.21	0.28	0.25

Fig 17. Cluster means for diurnal variation in photosynthetic rate ($m\ mol\ m^{-2}\ s^{-1}$) at Aduthura

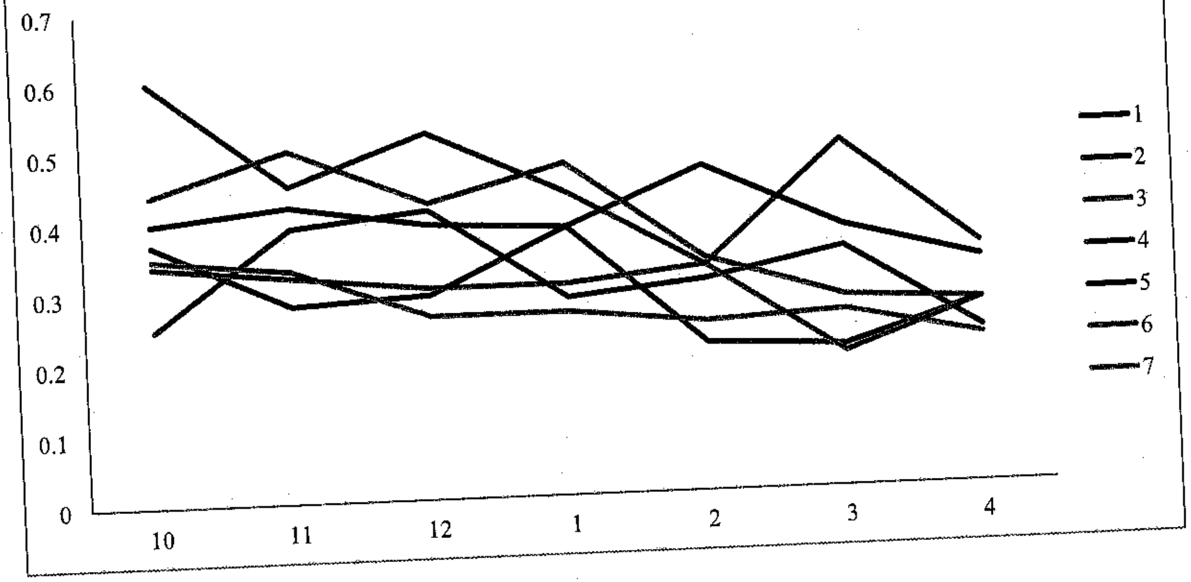


Fig 18.Cluster means for diurnal variation in photosynthetic rate ($m\ mol\ m^{-2}\ s^{-1}$) at Kumulur

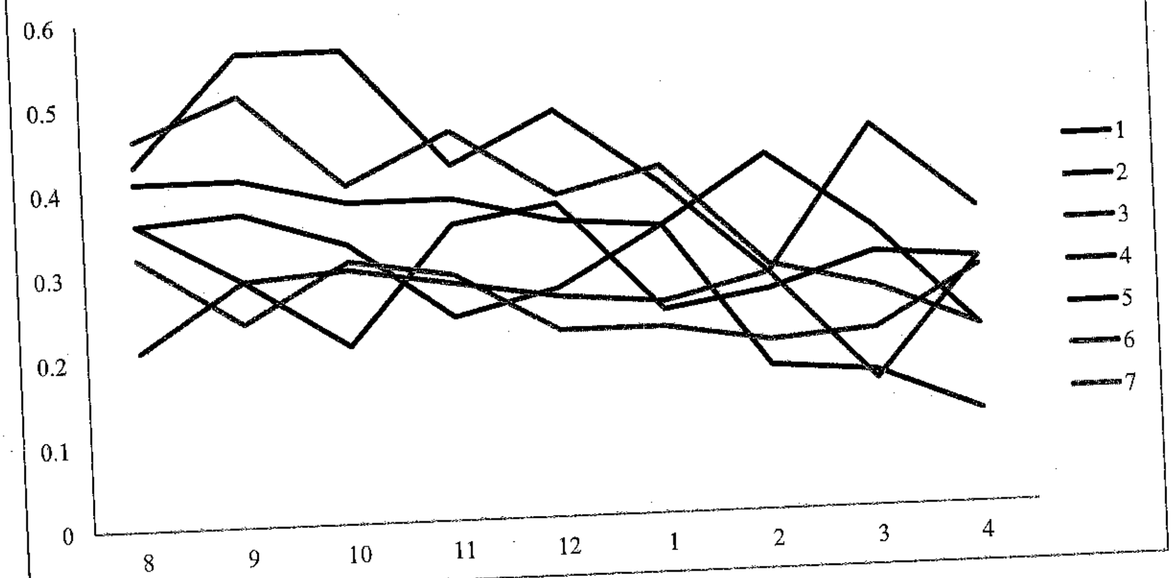


Table 56. Cluster means for diurnal variation in inter cellular CO_2 concentration (CINT) (ppm) at Aduthurai

Clusters	Time									
	8.00	9.00	10.00	11.00	12.00	1.00	2.00	3.00	4.00	Mean
1	277.9	256.5	283.7	243.6	202.5	192.5	229.6	182.1	228.6	233.00
2	296.4	294.1	225.4	276.1	249.6	225.7	232.8	162.9	267.2	247.80
3	215.4	247.2	247.8	181.2	183.5	216.9	165.3	160.0	199.8	201.90
4	286.7	290.7	341.1	228.7	294.3	288.8	245.2	274.2	206.5	272.91
5	255.9	286.7	275.5	241.1	218.9	194.3	257.3	219.7	202.6	239.11
6	277.0	263.2	248.0	327.4	278.7	209.9	219.9	198.7	202.5	247.26
7	249.5	243.2	316.4	190.2	250.1	228.5	183.2	254.9	210.6	236.29

Table 57.Cluster means for diurnal variation in inter cellular CO_2 concentration (CINT) (ppm) at Kumulur

Clusters	Time									
	8.00	9.00	10.00	11.00	12.00	1.00	2.00	3.00	4.00	Mean
1	273.7	252.54	280.94	241.74	193.41	193.3	230.4	182.9	212.4	229.04
2	225.56	294.9	297.9	276.9	250.4	226.5	233.6	163.7	268	248.61
3	216.2	248	248.6	182	184.3	217.7	166.1	160.8	200.6	202.70
4	277.14	235.86	341.9	229.5	280.65	279.24	245.17	254.12	207.3	261.21
5	256.7	287.5	276.3	241.9	219.7	195.1	258.1	220.5	203.4	239.91
6	277.8	264	248.8	328.2	279.5	210.7	220.7	199.5	203.3	248.06
7	225.1	244	275.64	191	217.38	229.3	184	230.74	211.4	223.17

Fig 19. Cluster means for diurnal variation in inter cellular CO_2 concentration (CINT) (ppm) at Aduthurai

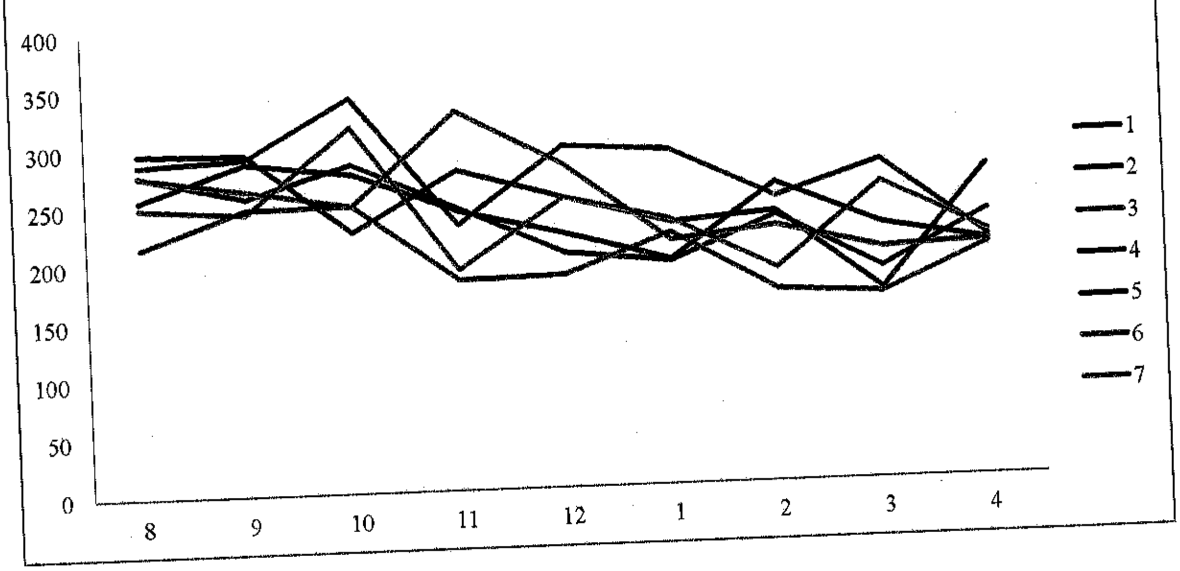
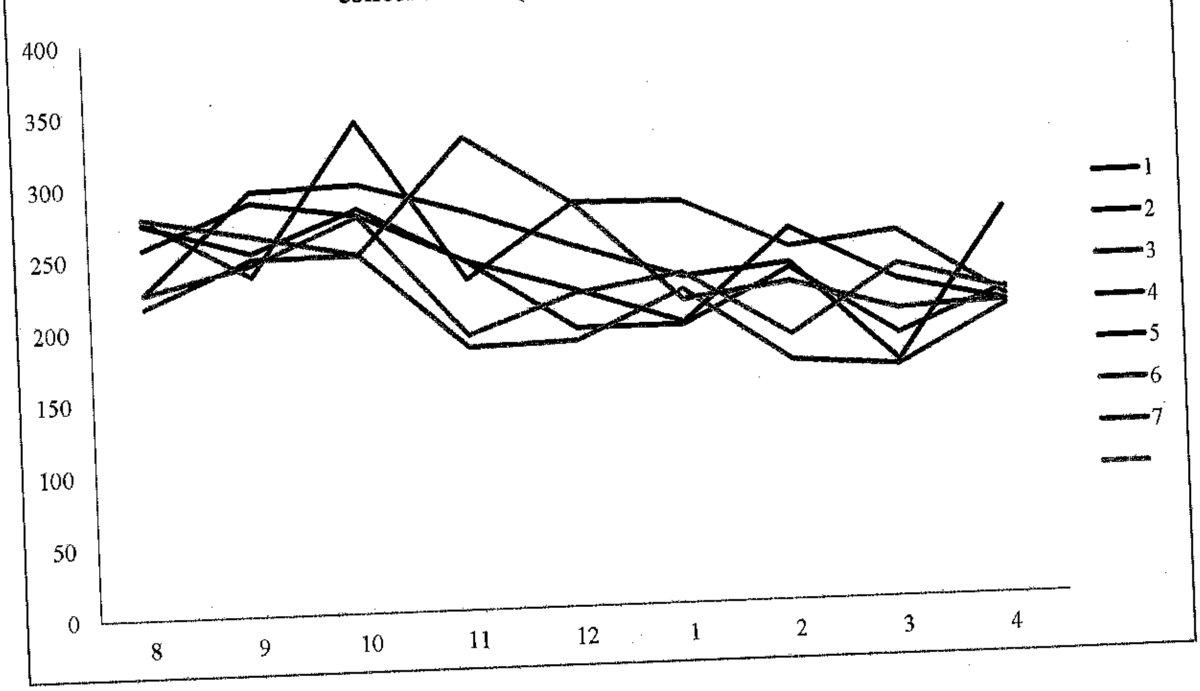


Fig 20.Cluster means for diurnal variation in inter cellular CO_2 concentration (CINT) (ppm) at Kumulur



clonal members in the cluster V showed a moderate performance in terms of photosynthetic efficiency.

The diurnal variation value of photosynthetic rate of all the clones at Kumular were estimated and computed in Table 55; Fig.18.The highest photosynthetic rate of 0.56 μ mol m^{-2} s^{-1} at 10.00 AM was registered by the clonal members in the cluster IV. The same cluster was also registered the highest photosynthetic rate of 0.48 μ mol m^{-2} s^{-1} at 12.00 A.M., compared to all other clonal members in the other clusters. The lowest photosynthetic rate was observed in the cluster VII and III. The clonal members in the cluster VII registered lowest photosynthetic rate 0.20 μ mol m^{-2} s^{-1} at 2.00 P.M. The study also observed that the clonal members in the cluster V showed a moderate performance in terms of photosynthetic efficiency.

Diurnal variation in Inter Cellular CO_2 Concentration (CINT)

The Inter Cellular CO_2 Concentration is also a measure of productivity and biodrainage efficiency of clones, which results in high level of dry matter production. All the clones subjected for water logging were measured for Inter Cellular CO_2 Concentration at an hourly interval in the diurnal variation study at Aduthurai. The performance of the clones of cluster mean is explained in the Table 56; Fig. 19. The highest Inter Cellular CO_2 Concentration (294.3 ppm) was observed at 12.00 noon in the cluster IV. It is observed that the clonal members in the cluster IV maintained very high Inter Cellular CO_2 Concentration value through out the day. Similarly, higher Inter Cellular CO_2 Concentration was observed among the clonal members in the cluster II (327.4 ppm at 11.00 AM). The clonal members in the cluster IV and VI have maintained high Inter Cellular CO_2 Concentration in after noon from 1.00 PM to 4.00 PM. These results clearly help to concluded that the clonal members in the cluster IV were highly efficiency in terms of their biodrainage as well as photosynthetic productivity. The study also concluded that the lowest Inter Cellular CO_2 Concentration value was observed in the cluster III. Among all the clusters, the lowest Inter Cellular CO_2 Concentration value of 160.00 ppm was observed at 3.00 PM in the cluster III.

Similar trend of Diurnal variation in Inter Cellular CO_2 Concentration (CINT) was recorded at Kumulur trial. The highest Inter Cellular CO_2 Concentration (341.9ppm) was observed at 12.00 noon in the cluster IV. It is observed that the clonal members in the cluster IV maintained very high Inter Cellular CO_2 Concentration value throughout the day. Similarly, higher Inter Cellular CO_2 Concentration was observed among the clonal members in the cluster II (297.90 ppm at 10.00 AM). The clonal members in the cluster IV and VI have maintained high Inter Cellular CO_2 Concentration in after noon from 1.00 PM to 4.00 PM.

The diurnal variation study of the clones at Aduthurai and Kumulur by measuring transpiration rate, stomatal conductance, photosynthesis and Inter Cellular CO_2 Concentration (CINT) revealed that the cluster IV showed highest performance, when compare to all other clusters. This helps to conclude that the clonal members in this Cluster viz., MTP-1, MTP-5, MTP-6 and SG-1 were having highest biodrainage efficiency as well as the photosynthetic productivity. Hence, the genetic potential of these clones towards biodrainage efficiency can be exploited to alleviate water logging related problems (Table 57; Fig 20).

ROOT DISTRIBUTION STUDY

The root distribution of 35 clones raised under waterlogged condition was studies at the end of project period by destructive analysis through excavation and uprooting of tress .In all the clones, the root distribution was studied in terms of lateral root length, tap root length and number of roots (Table 58)

The study result explained that SG-1 , MTP -6 ,MTP-5 AND MTP -1 were observed with very high number of roots 49,49,48, and 46 respectively .the very low number were observed in RMD -2 , RMD-3, PD-10 , ALR-1, EU-1 AND EU-2 with their average root number of 5,6,7,8,9 and 8 respectively.

The average lateral root length was highest in SG-1 (8.91), MTP-1 (8.95) followed by MTP -5 (8.78), MTP-6 (8.62). Very low lateral root length (0.42m) was observed in EU- 2 followed by PD-10 (0.43), RMD-2 (0.45) and RMD- 3 (0.46) .The tap root length was highest found in MTP-6 (2.86) followed by MTP -5 (2.79) , MTP-1(2.62) .Very low root length of 0.38 m was observed in eu-2 followed by PD-10 (0.40) and RMD -3 (0.41) . the study result revealed that best performing clones showed lateral root length range of 8.5 m to 9 m and tap root length range of 2 to 3 meters and number of roots range of 45 to 50 the medium performing clones namely MTP-7, MTP-8, NGL-2, TCR-1, TCR-3 and KK-1 showed average lateral root length range of 5 to 6 m, .Tap root length of 2 m and average number of roots ranged from 25 to 30.

Table 58. Root distribution studies under water logged condition

S.No	Clone No	Lateral root length(m)	Root length (m)	No. of. Roots
1	MTP-1	8.95	2.62	46
2	MTP-2	7.56	2.56	36
3	MTP-3	7.21	2.45	39
4	MTP-4	7.69	2.39	37
5	MTP-5	8.78	2.79	48
6	MTP-6	8.62	2.86	49
7	MTP-7	5.66	2.10	26
8	MTP-8	5.98	1.98	28
9	NGL-2	5.46	2.00	25
10	NGL-3	3.42	1.46	19
11	NGL-4	1.59	0.90	11
12	RMD-2	0.45	0.39	5
13	RMD-3	0.46	0.41	6
14	TCR-1	5.48	1.91	27
15	TCR-2	3.86	1.58	15
16	TCR-3	5.32	2.02	26
17	TCR-4	1.45	0.46	10
18	ITC-3	7.49	2.45	35
19	ITC-284	7.28	2.57	36
20	ITC-286	1.78	0.96	12
21	SG-1	8.91	2.83	49
22	SG-2	7.92	2.56	40
23	SG-3	3.86	1.59	18
24	SG-4	1.95	0.95	12
25	PD-6	1.42	0.46	10
26	PD-9	3.76	1.65	16
27	PD-10	0.43	0.40	7
28	ALR-1	0.48	0.38	8
29	ALR-2	3.66	1.49	18
30	ALR-5	3.53	1.63	20
31	KK-1	5.63	2.15	30
32	KK-2	7.85	2.49	38
33	E.sal	7.53	2.58	37
34	EU-1	1.35	0.45	9
35	EU-2	0.42	0.38	8

Data not statistically analysed

Annexure- III

9. Conclusion and recommendation

The biodrainage project funded by the Ministry of Water Resources, Government of India was carried out to evolve the superior clones of eucalyptus for high biodrainage efficiency. Accordingly, about 35 clones which include 32 selection in different parts of Tamilnadu and *Eucalyptus saligna* seed source from CSIRO, Australia and 2 hybrid clones of *E. eurograndis* were utilised for the present study. The clones were mass multiplied and raised under waterlogged conditions in two locations namely Tamil Nadu Rice Research Institute (TRRI), Aduthurai, Agriculture Engineering College and Research Institute, Kumulur for field testing. The clones were assessed for their biodrainage efficiency in terms of biometric traits namely height, diameter, volume and ecophysiological traits such as transpiration rate, stomatal conductance, intercellular co2 concentration (CINT) and photosynthesis rate.

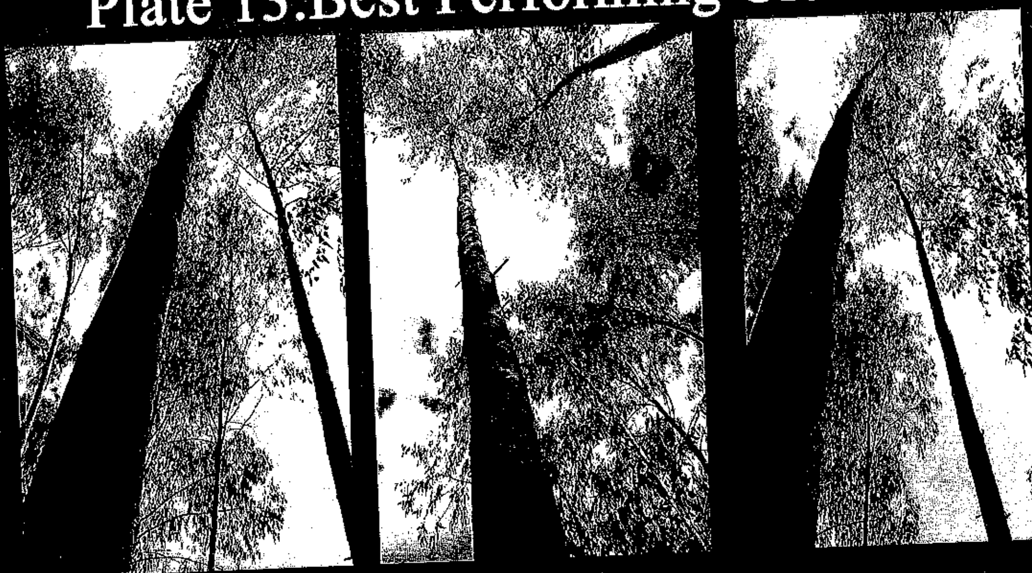
The observation were taken at 6 months intervals and subjected for the D^2 statistical analysis for genetic grouping of clones having similar biodrainage efficiency. D^2 analysis categorized 35 clones into 7 genetically distinct clusters. Among 7 clusters, maximum of 8 clones were accounted in cluster 6 followed by 6 clones each in cluster 5 and 7. Similarly, cluster 2 and 3 were having 3 clones each whereas, the cluster 1 and 4 contains 5 clones and 4 clones respectively. It is interesting to note that clonal member namely MTP -1, MTP-5, SG-1 and MTP-6 performed very well under waterlogged conditions and showed very good transpiration rate with high biomass productivity. Similarly, the clonal member in the 6th cluster showed very good performance and explained their suitability for waterlogged conditions. On the contrary, the clonal member namely RMD -2, RMD -3, PD-10, ALR -1 and EU-2 showed very poor performance under the water logged condition with very low growth and transpiration rate. Thus, these clones are not fit for water logged conditions.

Similarly, the clones TCR -4, PD-6, EU-1 also showed very poor performance in terms of growth and transpiration rate. A moderate transpiration and growth performance was observed among the clones MTP -7, MTP -8, NGL-2, TCR -1, TCR-3 and KK-1 belonging to 5th cluster. Equal moderate performance was observed among the 6 clonal member of the 7th cluster. The moderate performance of these clones revealed that the clones are just managing waterlogged condition but they cannot meet the requirement of high biodrainage efficiency. The root distribution study also explained that clonal member in the 4th cluster showed very good root distribution in terms lateral root length, root depth and number of roots.

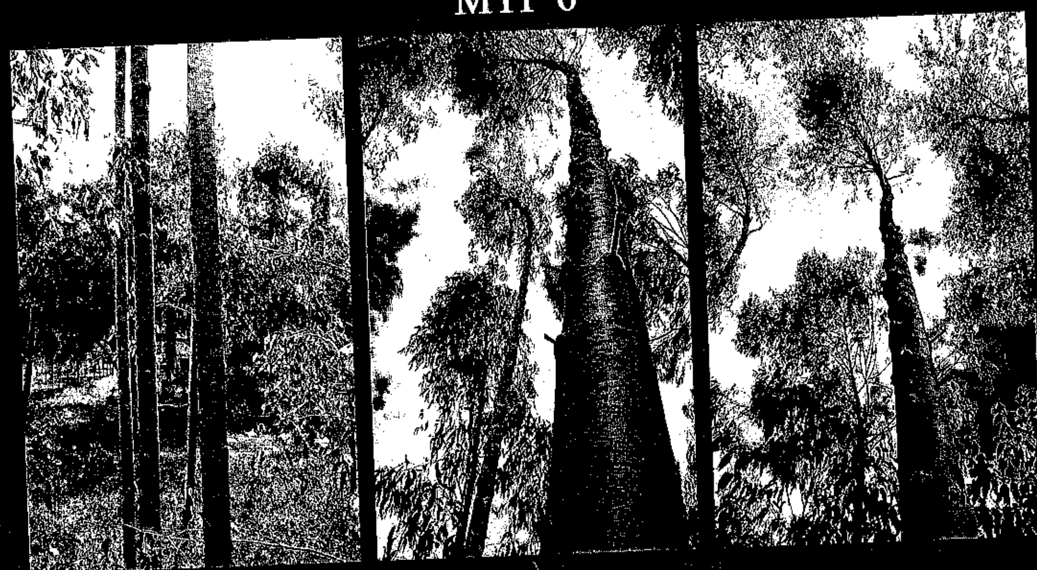
The same study also explains that the poor performing clones could not able to establish good root system under waterlogged condition by showing very minimal root length, root depth and number of roots. *Eucalyptus saligna* obtained from Australia showed good transpiration rate in India under waterlogged condition, but it could not it able to grow well and showed low growth and productivity .Literature evidences of *Eucalyptus saligna* revealed that it could not grow well in India due to variation in latitude between India and Australia. Thus the present study observed that *Eucalyptus saligna* cannot be exploited for biodrainage utility under Indian condition.

It is also interesting to know that eucalyptus hybrid namely *Eucalyptus eurograndis* could not grow well under waterlogged condition and showed low grow and transpiration rate when raised under waterlogged condition. The detailed study result recommends that the clonal members namely MTP -1, MTP-5, SG-1, and MTP-6 were superior in maintaining high biodrainage efficient with good growth performance and can be exploited to alleviate water logging problems in India. In addition, the clonal member MTP-2, MTP -3, MTP -4, ITC-3, SG-2 and KK-2 were also showed good response under waterlogged condition, hence, these clones can also be used for biodrainage utility .

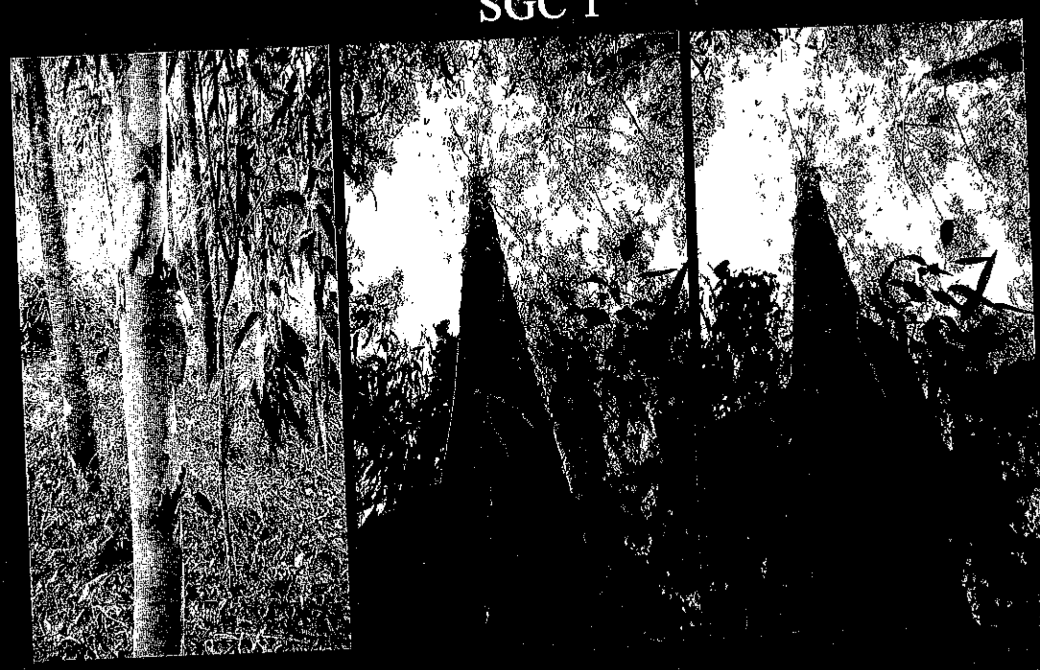
Plate 13.Best Performing Clones



MTP 6



SGC 1



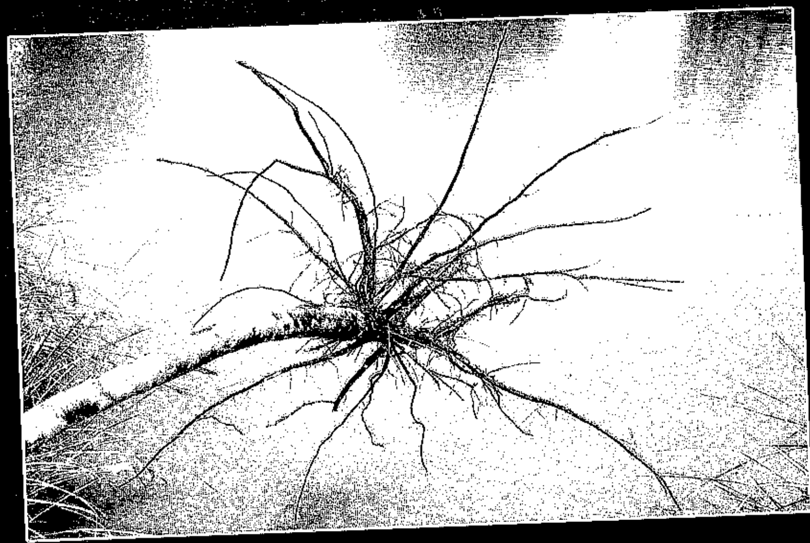
MTP 5

Plate 14.Poor performing clones

Susceptible clones

Poor performing clones

Plate 15. Medium Performing Clones



Annexure- IV

10. Conclusion / recommendations compared with current thinking

Water logging problem in India showed positive shifts for the past 3 decades due to extension of agriculture area and development of new irrigation projects across the country. Eventually, it is estimated that about 7.5 million ha of total geographical area of country is affected by salinity and water logging. For instance, in Tamil Nadu alone about 50,000 ha are being affected by water logging in the Cauvery river command area alone. The water logging problem is also augmented through irregular raining pattern due to influence of climate change. During 2011 alone, about 20 to 30 % increase in rainfall was observed throughout the country and posing more threats of water logging. In addition, to increase in sea level across the coastal area this is accounted to be 7500 kms.

The biodrainage technique offers greater scope to alleviate water logging problems at cheaper costs as against engineering drainage systems. The good performing clones namely MTP- 1, MTP-5 SG-1 and MTP-6 showed superior biodrainage efficiency under waterlogged condition. Hence, afforesting these clones in the waterlogged areas offers great scope for alleviating problems related to water logging. Additionally, growth and productivity of these clones adds economic benefits to the farmers. At this context, the biodrainage efficient clones identified in the present study will help in a grater way to alleviate water logged problem under present scenario of climate change.

Annexure- V

Field test conducted

The present study was undertaken to investigate the evaluation of Eucalypts clones for high biodrainage efficiency. To attain the objectives two field experiments were carried out at the following two locations.

- ✓ Tamil Nadu Rice Research Institute (TRRI), Aduthurai
- ✓ Agricultural Engineering College and Research Institute, Kumulur

Field experiment - I - Tamil Nadu Rice Research Institute, Aduthurai

The ramets of all the clones were planted in field as a biodrainage evaluation trail at Tamil Nadu Rice Research Institute, Aduthurai. The trail was laid out in Completely Randomized Black Design (CRBD) with three replications and spacing adopted 2 m x 3 m. The biometric and ecophysiological observations were recorded to evaluate the clones for biodrainage efficiency. The experimental area Tamil Nadu Rice Research Institute (Aduthurai) lies exactly at 11°N latitude and 79.3°E longitude with an altitude of 19.5 m MSL. This location receives an annual average rainfall of 1254 mm and the mean and minimum temperature is 30.5°C and 20.4°C respectively. The soil type of field trail is alluvial clay with the pH of 8.4.

Field experiment – II Agricultural Engineering College and Research Institute, Kumulur

The ramets of all the clones were planted in the field at Agriculture Engineering College and Research Institute, Kumulur. The experiment was laid out in Completely Randomized Black Design (CRBD) with three replications and a spacing of 3m x 2m. The biometrical and ecophysiological observations were recorded at three monthly intervals to evaluate the clones for biodrainage efficiency. Agriculture Engineering College and Research Institute (Kumulur) lies exactly at 10° 56' 1" N latitude and 78° 49'50" E longitude with an altitude of 19.5 m MSL. This location receives an annual average rainfall from 821 to 947mm and the mean maximum and minimum temperature is 37.7°C and 18.9°C respectively. The soil type of the experimental field is sandy loam (*Typic Ustochrept*) with the pH of 7.9.

Annexure- VI

13. Possibility of any patent / copyright

The study identified 4 high performing clones namely MTP-1, MTP-5, SG-1, AND MTP-6. These clones can be protected through registration by the provision given by the Protection of Plant Varieties and Farmers Rights Act, 2001. The gazette notification for registration guidelines and DUS testing protocols for eucalyptus is in progress by Protection of Plant Varieties and Farmers Rights Authority (PPV & FRA), New Delhi. Once the gazette notification for registration is issued by the authority, the best performing clones for higher biodrainage evolved through the present study will be registered under the above act.

Annexure- VII

14. Suggestion for future work

The present study was funded with the objective of identifying good clones suitable for waterlogged areas hence the best clones namely MTP-1, MTP-5 SG-1 , AND MTP-6 need to be retested at field level besides an extensive trial in a large scale (around 100 acres) need to be taken up to exactly quantify the lowering of stagnated water under waterlogged condition.

In addition, many water polluting industries are dumping out their treated effluents in the open area which are eventually contaminating ground water. Under such circumstances a detailed study to be taken up using high bio drainage efficient clones identified in the present study to test their fitness for pumping effluent water and thus reduce the groundwater contamination.

Annexure VIII

Explanation for Experts Comments

1) **Test results are based on locations. It should also be based on agro-climatic factors like temperature, humidity, sunshine, etc. for its replication in other regions**

The agro-climatic factors like temperature, humidity, sunshine, etc. were recorded at monthly interval in the study locations during 2005-2009 (study period). The agro-climatic parameter recorded during the study period is enclosed in the Annexure A.

2) **Test results do not mention an important factor of spacing and age of trees on Bio-drainage efficiency and age of tree species**

The data were recorded at different growth interval of trees and the results are presented based on the age of the tree. The spacing of the tree planted in the plantation was 2m X 2m has also been indicated in the report.

3) **Some potential trees species other than eucalyptus could also have been identified and tested**

The project was sanctioned in the title on "**Screening superior genotypes of eucalyptus for biodrainage through ecophysiological approaches**" with the objective of testing the biodrainage efficiency of Eucalyptus clones. Other species will not come under the purview of the present proposal. However the biodrainage efficiency in terms of transpiration rate of 11 native species is appended in Annexure B.

Annexure – A

2005	Aduthurai						Kumulur					
	Max Temp (°C)	Min Temp (°C)	RH (%)	Evaporation (mm)	Sun Shine (Hours)	Rainfall (mm)	Max Temp (°C)	Min Temp (°C)	RH (%)	Evaporation (mm)	Sun Shine (Hours)	Rainfall (mm)
January	30.04	20.22	92.65	3.63	6.51	0.00	31.10	19.27	74.52	2.67	6.35	0.00
February	32.33	20.43	91.79	4.29	8.79	13.20	33.73	15.93	71.93	3.71	8.06	0.00
March	34.80	22.22	86.81	4.40	8.49	0.00	35.56	21.92	73.52	4.34	7.41	27.30
April	34.01	24.58	87.80	3.33	6.64	162.00	34.92	23.90	74.47	3.16	6.29	508.90
May	36.88	25.85	85.00	4.34	8.28	43.60	37.24	24.84	70.00	3.92	5.68	224.20
June	36.03	25.86	86.67	4.57	6.54	0.00	36.07	25.67	62.43	5.84	3.22	196.90
July	35.75	25.28	81.87	4.51	6.79	26.80	35.74	31.15	67.16	6.09	3.75	63.40
August	35.06	25.51	78.06	5.04	7.00	131.60	35.89	24.52	72.87	5.69	8.87	62.80
September	33.94	24.67	83.50	4.20	6.38	103.40	35.28	23.83	69.97	4.53	4.36	123.60
October	32.64	24.89	86.81	3.12	5.91	153.80	32.23	22.48	73.29	2.12	4.54	444.40
November	28.70	22.27	90.50	1.91	3.54	497.40	35.92	24.53	73.30	5.76	8.71	62.80
December	29.35	21.80	92.16	2.97	5.21	147.40	29.94	26.32	77.00	1.73	3.52	148.90

Annexure - A

2006	Aduthurai						Kumulur					
	Max Temp (°C)	Min Temp (°C)	RH (%)	Evaporation (mm)	Sun Shine (Hours)	Total Rainfall (mm)	Max Temp (°C)	Min Temp (°C)	RH (%)	Evaporation (mm)	Sun Shine (Hours)	Total Rainfall (mm)
January	29.49	19.75	93.45	3.21	6.59	25.80	30.10	18.58	73.52	3.25	4.87	37.40
February	31.42	19.11	92.50	4.02	8.67	0.00	32.00	17.91	74.93	4.22	7.61	0.00
March	33.84	22.42	89.87	4.55	8.03	48.40	34.63	21.94	73.58	4.94	6.74	45.60
April	36.34	24.16	83.90	6.22	8.91	21.80	37.03	23.70	66.37	5.58	7.57	10.80
May	36.10	25.43	78.97	6.82	7.52	73.00	36.24	24.24	65.16	6.60	6.22	107.40
June	36.01	25.53	75.63	8.30	6.43	20.40	36.05	24.80	65.07	8.17	5.68	34.50
July	35.12	25.76	72.45	8.23	6.20	0.00	35.52	24.99	70.23	9.96	4.00	0.00
August	34.70	24.74	79.26	7.32	7.79	37.00	35.56	23.81	71.45	8.08	6.06	91.00
September	33.62	23.90	87.97	5.69	6.36	111.20	33.49	22.88	72.80	5.10	3.67	190.30
October	31.86	24.04	87.65	3.83	5.46	296.20	32.73	22.37	73.61	3.40	3.98	70.40
November	29.79	23.17	90.40	3.01	5.08	214.20	30.65	21.43	77.43	2.37	4.67	140.50
December	29.59	20.94	90.23	4.17	6.57	109.80	30.23	19.56	69.58	3.60	5.79	39.50

Annexure - A

2007	Aduthurai						Kumulur					
	Max Temp (^oC)	Min Temp (^oC)	RH (%)	Evaporation (mm)	Sun Shine (Hours)	Total Rainfall (mm)	Max Temp (^oC)	Min Temp (^oC)	RH (%)	Evaporation (mm)	Sun Shine (Hours)	Total Rainfall (mm)
January	29.95	19.70	89.90	4.22	6.57	0.60	31.11	18.47	66.48	4.25	6.02	0.00
February	31.34	19.94	89.21	3.59	8.40	114.80	32.95	18.69	64.45	5.71	8.50	0.00
March	34.41	21.44	88.77	4.58	9.72	0.00	35.63	20.47	64.97	6.97	8.30	0.00
April	35.53	24.03	84.73	4.96	9.03	56.80	36.38	23.33	63.03	7.03	7.94	62.40
May	37.89	25.58	77.48	6.14	9.44	41.20	38.42	24.58	55.32	7.23	7.13	28.50
June	35.46	25.69	77.30	5.09	5.94	19.20	36.08	24.40	52.63	6.39	3.57	21.80
July	34.56	25.44	80.16	5.25	6.01	42.20	35.98	24.23	54.68	8.54	2.66	14.90
August	33.74	24.13	83.71	4.38	7.05	149.40	34.87	29.02	61.58	6.23	4.89	181.80
September	33.73	24.58	82.50	4.81	7.07	174.80	35.10	23.50	56.80	6.52	5.83	19.00
October	32.11	23.93	88.29	3.99	5.32	360.40	33.60	24.18	66.74	5.51	4.22	146.10
November	30.31	21.39	88.23	3.33	7.63	106.40	31.67	21.52	66.17	4.12	6.64	9.80
December	28.22	20.57	92.94	2.79	5.45	371.00	29.63	20.82	80.19	3.38	4.11	264.40

Annexure - A

2008	Aduthurai						Kumulur					
	Max Temp (°C)	Min Temp (°C)	RH (%)	Evaporation (mm)	Sun Shine (Hours)	Total Rainfall (mm)	Max Temp (°C)	Min Temp (°C)	RH (%)	Evaporation (mm)	Sun Shine (Hours)	Total Rainfall (mm)
January	29.85	19.19	92.74	3.52	8.88	16.60	37.31	19.44	74.39	3.98	6.37	0.00
February	31.92	20.41	93.14	3.72	8.74	19.00	33.07	21.40	77.72	4.62	7.04	43.20
March	31.98	22.43	91.16	3.17	6.64	159.60	32.45	22.10	78.26	3.69	3.88	125.80
April	35.53	24.44	87.20	5.32	8.60	8.40	36.32	24.68	63.53	5.36	6.68	26.80
May	37.72	25.11	76.81	6.12	9.11	28.80	38.00	25.58	54.81	6.55	7.09	39.40
June	35.78	24.81	76.73	5.16	6.63	40.20	36.93	26.12	50.53	7.66	4.66	16.40
July	34.94	24.93	78.52	6.00	7.27	4.40	35.97	25.30	56.13	7.15	5.84	149.40
August	34.11	24.38	83.10	4.38	6.39	113.40	34.48	24.62	60.68	5.95	6.78	59.70
September	34.11	24.36	82.90	4.98	7.09	36.00	34.85	24.85	52.20	5.91	5.15	28.40
October	32.74	23.92	89.97	3.69	6.74	257.80	33.44	23.44	64.65	3.94	5.37	139.00
November	30.20	22.34	92.23	2.57	5.45	772.40	31.55	21.93	56.20	3.87	4.63	442.40
December	29.02	21.39	93.77	2.94	5.71	118.00	29.58	20.82	62.55	3.24	4.38	66.40

Annexure - A

2009	Aduthurai						Kumulur					
	Max Temp (°C)	Min Temp (°C)	RH (%)	Evaporation (mm)	Sun Shine (Hours)	Total Rainfall (mm)	Max Temp (°C)	Min Temp (°C)	RH (%)	Evaporation (mm)	Sun Shine (Hours)	Total Rainfall (mm)
January	29.63	19.65	94.81	3.44	8.21	34.00	30.37	19.55	66.52	4.05	6.82	3.00
February	32.41	19.10	97.07	4.49	9.09	0.00	32.71	18.04	66.00	4.70	8.68	0.00
March	34.37	21.52	95.81	4.50	10.98	49.60	35.06	21.21	66.32	5.53	7.56	7.80
April	35.66	24.67	89.27	7.08	8.00	41.00	37.38	25.02	58.80	6.82	6.59	17.20
May	37.23	26.05	82.48	6.15	7.12	23.92	38.11	26.45	46.00	7.74	4.29	12.40
June	35.90	25.34	81.17	7.02	8.37	28.60	37.67	26.32	42.53	9.64	7.23	47.60
July	35.23	25.57	79.84	8.48	5.80	0.20	36.73	26.19	44.19	9.82	2.90	11.40
August	34.55	24.90	85.52	6.51	7.13	243.00	35.61	25.40	57.77	7.03	5.75	319.60
September	35.07	25.20	85.00	5.76	7.08	60.60	35.02	25.43	61.07	6.22	5.64	116.20
October	33.21	24.22	86.74	4.95	7.14	67.20	34.45	24.31	63.90	5.31	6.18	28.20
November	29.67	23.40	94.27	2.35	4.39	437.40	30.58	23.00	72.80	2.57	3.61	217.30
December	28.24	21.79	94.90	2.71	4.29	351.80	29.16	21.82	54.06	2.49	3.21	99.80