Research Finding into the peculiar features and the complex Biodiversity in the Tamarind grove (Heritage Site) at Nallur Village.

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Foreword

In Nallur, a small village near Mallepura on the way to Hoskote from Devanahalli there is a very old sacred groove spanning of about 30 acres. It is said that the tamarind grooves is existing since the rule of Cholas.

The Tamarind trees are producing prop roots here. We know that the prop roots are common only to the Ficus (banyan) species. The insides of these trees have turned hollow due to constant withering. They have developed prop roots that originate within the stem which then strike the ground and prevent the tree from falling over. In some other trees, the side branches that have grown nearer to the ground have produced a stout prop root.

These trees symbolize prolonged strength against vagaries of nature. They stand tall, yet they seem to undulate with the wind. This fascinating developments is observed in its prop roots produced from its trunk and root suckers from lateral roots. The tree looks like a dinosaur that has lived for million of years. It is believed to have been planted in the 12^{th} century during Rajendra Chola's regime.

Though the main mother trunk in all trees is almost dead, the lateral roots that have a series of root suckers are most unusual and unknown in tamarind trees. This peculiar phenomenon is found only in old trees here. In the process of survival, prop roots have arisen from within the stem and struck ground and established support to the main stem. It is strange to see, even now, small roots arising from the callus-like tissue developed from cambium and piercing through the dead wood. Another interesting feature is that these old trees still bear fruits. The wonder of the massive tree lies in its broad girth.

Research project was sponsored by the Karnataka Biodiversity Board to the University of Agricultural Sciences, Bangalore to study the peculiarity presented by these tamarind trees and to get the age of the trees determined using carbon dating processes. Research is made report is made available by the University of Agricultural Sciences. It is hoped that this report will generate curiosity in the scientific community as well as others for undertaking further advanced research on the nature's way of presenting itself.

(Dr.R.C.Prajapathi, IFS)
Additional Principal Chief Conservator
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Ageless wonders

Of

Nallur Tamarind Biodiversity Heritage Site

(Study sponsored by Karnataka Biodiversity Board)

Tamarind Biodiversity Heritage Site at Nallur in Devanahalli Taluk, Bangalore Rural District, popularly believed to be a relic of the Chola Dynasty that ruled nearly 800 years ago, is spectacle of awesome wonder and a freakish site. Spread over 54 acres comprising a population of nearly 300 trees is a picture of dynamic pattern of plant diversity. The significant component of this popular structure is a group of old plants standing like ageless sentinels, firmly rooted in the ground with their gigantic trunks together with large picturesque crowns spread very high and aloft like open wings of the flying vultures. The age of the trees, which so far remained only in the domain of speculation, is no longer as so now as it has been established through carbon dating process that some of them are more than 400 years old. This firmly establishes the ancient nature of the site besides allaying the nagging doubt, if any, about the heritage value of the site.

Age has certainly reigned supreme and dealt a severe blow on the life and the formation of shape and structure of these trees. Majority of these trees have their trunks hollow of varying dimensions resulting from the collapse of the steeler tissues due to age – related problems. But such hollows are covered fully or partly by a thick layer of cortex, which, though livid, is living with active cells and conduct normal physiological functions. On the other hand, some tree trunks have surprisingly remained solid, but their outer surface (bark) has become rough and rugged and some times freckled out. And in certain cases, they assumed variously shaped curious formations.

The living cells in the cortex, particularly the cambium, become active and produce peg-like stem/root primordial protrusions out of the hollow, their number may vary from one to many per tree. These protrusions continue their growth downwards and produce roots mid-way which remain dangling for want of stimulus for further growth. Whereas some others reach the ground and creep parallaly and give rise to one or more offspring called clones which eventually grow into normal young plants. The number of clones also varies from 1 to 9 per tree and not all the trees exhibit this phenomenon nor is it a common feature with the middle aged groups either, except with one tree. Cloning property indeed is a peculiar phenomenon found only with few trees in this site and they are not found outside elsewhere, nor these have been any reports in the literature relating to tamarind species.

Conversely, in some trees, the stem/root primordial instead or descending downwards, try to grow upwards, perhaps with an intention of developing into a stem or a branch. But invariably halted at certain stage and produce calli of various shapes, some times like sculpted figurines of onlookers curiosity. Indeed, like cloning, this is also a rarer phenomenon which needs to be studied to establish the scientific basis.

Crowning glories of the park are the old trees, which, not withstanding their obvious undue longevity, a variety of body deformities and unimaginable body blows to physical and physiological functions wrought on them by innumerable body stresses and strains and climatic vagaries during their lengthy sojourn, they still breath but perform all normal functions like flowering and fruiting. And also meticulously maintain seasonal rhythm, though, understandably, with a reduce vigour and intensity. It is needed, **a wonder of wonders** and unique to these trees.

The other segment of the population-middle and not so aged trees-are laden with rich diversity in the matter of their body parts, which, through a careful analysis and selection may lead to the identification of the elite tree to enrich the tamarind clonal orchards to gain economic advantage from. These plants may also be harboring unique micro-flora for their survival through nutrient cycling for longer period than normal.

This is a natural diversity park rich in living artifacts, which easily draw the attention of the beholders eye. The old trees are living fossils with a long living history and much in store still to reveal to the scientific world besides amusing the visitors and the like. It is the one of its own kind in the entire world and the future world would owe a lot to us if we preserve this heritage and nurture and maintain it in a pristine condition.

Glory to the Nallur Tamarind Heritage Park!!!
Glory to the Living Fossils of the Park!!!

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Research finding into the Peculiar features and the complex biodiversity in the Tamarind grove (Heritage Site) at Nallur Village, Devanahalli Taluk, Bangalore district.

I. INTRODUCTION:

The legendary tamarind grove at Nallur village of Devanahalli Taluk, Bangalore district is believed to have its origin in the Chola dynasty which reigned over this region during early 13th century AD. Apart from its ancient nature it derives its importance from many very old and gigantic trees among nearly 300 Tamarind trees spread over an area of 53 acres .They are said to be nearly as old as the site itself and developed huge irregularly and crookedly branched crowns picturesquely spread out like eagles wings against a backdrop of glowing blue sky. Their trunks are very big, remain either solid or hollowed out due to the disintegration of the steelar region .The cortex remains more or less intact at most places of the hollowed trunk except at the mouths of the hollow. The size and shape of this opening vary from tree to tree. The outer surface of the trunk is either smooth or rugged or variously shaped into freekishly wondrous peculiar features. From inside the hollows in some trees, some cells in the active portion of the cortex become meristematic and grow into peg like fleshy primordia which vary from few to many in each hollow. These primordial structures grow downwards and stop mid way or criss-cross or develop calli which produce huge tumour like features which are a sight to behold. Many others either singly or severally grow down to the ground where they creep like runners of the herbaceous species, strike roots and miniature roots either at one place or at several intervals in a chain which ultimately grow into off shoots and proxy young mother trees.

The obvious geriantricity and peculiar trunk and crown formations not withstanding they amazingly remain active bearing flowers and fruits, though scarcely. Thus they provide wondrous sights and curious objects to onlookers.

Additionally, the bulk of the population comprising middle and young aged trees along with clones (proxy mother trees), which have generally behaved normally have over the years accumulated a sizable intra-population variation of scientific and commercial significance.

Obviously, these unusual combinations (geriantricity and heterogeneity of the tamarind population), which is a unique feature have conferred heritage value and a consequent prerogative of protection and preservation value to the benefit of coming generations.

Realizing the fabulous heritage value of the site, the Govt. of Karnataka declared this as a “Heritage Tamarind Biodiversity Site”. The Karnataka biodiversity Board, Bangalore had sanctioned a project to the University Of Agricultural Sciences, GKVK, Bangalore in 2008 to undertake research on various aspects of this trees.

II. Objectives of the project

a) Age determination of the old trees through radioactive carbon dating techniques
b) Investigating and understanding the nature of the peculiarities developed on the old trees
c) Phenological studies ,both at vegetative and reproductory phases to unravel the pattern of diversity present with the tamarind population as a whole and observing their scientific and economical values
d) Molecular marker (RAPD) analysis to establish the genetic diversity of the genotypes.

An amount of Rs.3,00,000/- was released for one year research work.

III. Investigating team

A a) Dr.R Nandini, Asst Professor (Genetics and Plant Breeding) U.A.S Bangalore
b) Dr T.K.S Gowda, former DI (PGS) and former Head Dept of Biotechnology U.A.S .Bangalore
c) Devendra Muttalmuri, Technical Assistant in the project.

B Advisor

Dr C Kempanna, Former Deputy Director General and Chief of Crop Sciences
Division of the Indian Council of Agricultural Research and presently Visiting Scientist, UAS Bangalore

IV. Historical Background of the *Tamarindus indica*

Nomenclature

Tamarindus indica is known in Arabic language as "Tamarus-u'l Hind" meaning "Indian date". Linnaeus who described this species in species plantarum"in 1753 named it *Tamarindus indicus* deriving Tamarindus from the word "Tamar" and indicus from the epithet "Hind". Finally it has come to be known as *Tamarindus indica L.*

a) Origin

Origin and evolution of this species has yet remained obscured however from the consideraration of the species epithet Indicus, it was speculated up on possible Indian orgin.But the final acceptance remained in the limbo because of its ubiquitous nature of its distribution and the intra specific and intra population variations as evaluated through RAPD procedure by Diallo et al(2007) of 10 intra populations originating from different parts of the world all the 10 population showed considerable variation with in themselves how ever this group on the consideration of paleantological and Anthropological evidences tentatively suggested the possibility of African orgin more especially of central Africa thus the question is still open.

b) The Indian position

The "Brahma Samhita" an ancient Indian Scripture Tamarindus indica was mentioned. This provides the clue for speculating upon its presence in India between 1200-200 BC .Today it is found growing in all warmer (hot, humid) parts of India more particularly in south India

V. The report details

1) Enumeration of the population at site

A total of 278 plants were enumerated and labeled and accordingly the trees were classified into 3 categories:

a) Old Trees	18
b) Middle aged/young trees	234
c) Clones	26
Total	**278**

(All the 18 old trees labeled are as in fig.1(a))

Among the old trees, one tree (Tree no. 37) has been uprooted in the recent heavy gales and rains. It is now survived by one clone (proxy mother)

Tree no. 118 was cut at the ground level some time ago leaving only tissues now. However, it is survived by 7 clones

Tree no. 152 also had lost its main trunk. But the callus formed, perhaps from the trunk has developed into a peculiar (curious) structure and is now represented by a clone passing through the callus.

2. **Age determination**

Wood samples from the core of the steelar region of the trunk of all the 18 marked trees were collected (Fig. 1(b) and sent to two universities for analysis and determination of age:

i) Birbal Sahany Institute of Paleo Botany, Luck now to determine the age through "Liquid Scintillating counting" (LSC) technique and
ii) Accellerator Mass Spectrometry Lab, Institute of Physics, Bhubaneswar for testing through, AMS techniques.

3. **Phonological studies at Vegetative phase**

A.Old trees

a). Growth habit

Generally tamarind is a slow growing, long lived, hefty, ever-green tree with huge trunk and widely spread out irregular branched crown. Many of the old trees fall in line with this general description, not withstanding minor differences with individual trees.

b). Trunk Characteristics

In nature the trunk is large and thick from 1.5 to 2.5 meters across and up to 8-9 meters in circumferences. They are either mono trunked (Tree nos. 73, 161,178) or double trunked (Tree nos. 72, 155, 159, 169) or multiple trunked (tree nos. 162, 153). Some trees have trunks split in the middle and lean opposite each other while retaining the base intact (tree no. 79). In some trees, the base is forked out and moved out slightly away from the main trunk in such a way that the space between two trunks permits the passage of a bullock cart or a jeep (tree no. 78)

c) Trunk peculiarities

No doubt that the trunks are very big and in some cases, gigantic with either smooth or rugged or freckled surfaces with dirty brown to grey colours. There are two types of trunks – solid and hollow trunks. Surface of the solid trunks had become rough and rugged, form a picturesque furrows and ridges or turned out twisted into knots of various shapes and sizes (Tree nos.159, 161, etc.) and other inexplicable shapes.

Majority of the old trees have hollowed trunks (Tree No.s 1, 73, 178 etc). Trunks had become hollow because of the disintegration of the steelar region due to old age and which is further hastened by the infection of *Cryptococcus neoformans*, a saprophytic fungus. These hollows varied in size and shape and are protected by the other cortex except at the mouths of the hollows (picture)

Peculiar structures observed in the hollows of the trunks were that some living cells, though livid, became meristematic and produced fleshy peg-like structures to stem/root primordia. They were one to many number either short or longer in length (Tree no. 178), twisted or intertwined between themselves (Picture) or produced calli which later developed into variable curious structures. Some primordial produced roots (Pictures) which remained midway in the hollow or some of them continued to grow down to the ground and creep, either underground or above the ground, some distance, slightly away from the main trunk (Tree nos. 118,1) and struck roots and produced shoots and later developed into mini tamarind trees. Such mini trees are either single or many in number per tree (1-7) (Tree nos. 1, 118, 73) This phenomenon could be compared to plant rejuvenation through stolons or runners characterized by many creeping herbs like asparagus, pepper betel vines, etc. but not found in tree species, more especially in tamarindus species.

Since these offshoots resemble the mother trees in most of the characters, they may be termed as clones (proxy mothers). Whether these clones are genetically the same as the mother tree or not is a matter to be known through molecular marker studies.

Earlier workers termed these clone like structures as props or root suckers (Bhaskar, 2002-03, 2008, Narayanaswamy 2008,) which are meant to support the falling branches as in banyan trees and other species of the genus Ficus or to supplement/substitute the degenerating dying trunk of an old tree in order to perpetuate the life of the tree which would otherwise get lost due to old age. However, there is a clear evidence from this study that they in any case, could not be compared

or equated to trop roots since these clones are quite independent of mother trees having no physical contact with the falling or bending or weaker branches of the trees.

On the other hand, to presume them to act as life times to the old and tattered mother trees to give them perpetuity untenable since many clones served their connections with the mother trees, although some still do maintain such connections. Further, the cloning phenomenon has confined only to few old trees and not all. Additionally, this phenomenon also seemed to be alien to the middle aged and younger lot with, of course an exception of just one middle aged tree (Tree no 12). This creates confusion confounded about the purpose of the clones. Thus it has remained to be a wonder of wonders debying any plausible scientific explanation. However, molecular studies may perhaps throw some light.

But what is clear from the study of the older population is that there is a considerable amount of variation between the trees, which may perhaps lend support to the improvement of the species.

4. Phenological studies of the middle aged and younger populations.

a) Trunk characters

The tree populations in this category are still in the process of developing hence it is difficult to generate the trunk characters in terms of shape, size etc. however, more of them had exhibited any of the peculiarities presented by the older generation. However there are some differences in the nature of trunks such as:

i) Mono trunk , ii) Double Trunk iii) Triple Trunk and iv) Multiple Trunk (Figure2). Another interesting or peculiar thing encountered was a kind of "wedged trunk" which is unusual and only unique and only one tree was found with this character in the whole of the plantation when the main trunk developed well, another branch of the trunk in an otherwise multi trunked tree, penetrated through the main trunk. It is a kind by itself and unique. It is difficult to find scientific explanation.

b) Crown characters.

In normal tamarind populations, more common crown shapes are dome, oval, semi circle and spreading. But here there were 6 different crown shapes and frequency of them was as follows:

	Shape	No. Of trees
i.	Dome	56
ii.	Oval	20
iii.	Circle	2
iv.	Semi circle	18
v.	Cone	53
vi.	Irregular and spreading	103

(figure3)

Most dominant crow shapes were irregularly branched and spreading, dome and cone shapes. The irregular and spreading types seemed to look like those of the older trees. This raises a question whether this trait could have been inherited from the older populations, in which the crown shape is dominant. The answer may perhaps be expected from the molecular marker studies.

C) **Branching habit**

Normally, tamarind tree starts branching from the trunk about a meter high from the ground level. But this population exhibits variation in respect of growing habit, which fall into a categories.

Picture 1- depicts normal branching type
Picture 2- Shows multiple branches originating from the ground level.
Picture 3- Branching from the ground level as well as subsequently from higher levels too. It is a clear case of multiple branching but with a difference.
Picture 4- Two branches from almost the ground level and subsequent branches from a fairly higher level
Picture 5- Multiple branching, but irregularly
Picture 6- Multiple branching originates at a fairly higher height from the ground level
Picture 7- Another type of irregular branching
Picture 8- Multiple branching from a point on the trunk at a fairly higher level on the trunk
Picture 9- Multiple branching. But two bottom branches both from the ground level and also from slightly higher level grow longer and slender and bend almost to the ground level and then turn upwards and grow longer.

However, from the middle of this branch arose two to three branches again the second branch opposite to the first one produced crooked growth, almost touched the ground and then turned upwards and produced two branches at some distance away.

The ideal branching in tamarind tree is supposed to be multiple branching originating from a meter high above the ground level. There are many such trees among the younger generation.

d) **Foliage Characteristics**
Normally, it is dense and dark – green at the population level. But here, it was possible to find four types:

i) Dense and dark green
ii) Sparse and dark green
iii) Dense and light green and
iv) Sparkle and light green

e) Leaf Character

Leaves are generally pinnately compound and leaflets opposite each other. But leaflets keep open during the day and close as the day light fades out. But in this case two types of trees could be found, one fall in line with the general and known pattern. Where as in some trees, the leaflets remain closed throughout during the day and night irrespective of the light or no light. Could this latter phenomenon be a case of some disturbance in the mechanism of a normal phototropism, if so, how this change had come off-genetic or physiological, is a gain a matter to be further examined.

Phenological studies at the vegetative phase have clearly provided evidence that there was variation within the populations for many characters irrespective of the size of the population. But it needs to be quantified through further studies.

5. Phenological studies at Reproductory phase

a) Inflorescence:

It is a raceme with a cluster of flowers at the end of the branches while the majority of the trees both with old and younger group, have flowered 11 trees did not flower at all.

The normal flowering period in tamarind is April-May. While the majority of the trees flowered during this period there was one tree which produced flowers during September. Whether it is a case of an off season flowering and fruiting type as in the case of Mango or a freak needs to be confirmed by further studies.

Also the case of 11 non flowering plants belonged to a group of permanently non flowering types which are found with tamarind populations or it could be a case of alternate flowering and bearing type, as again in the case of mango. It also requires further study.

b) Flower :

It is bisexual, protogynous, self-incompatible extroneophylus and nectarferous.

c) Floral parts

i. Bud Character- the bud is either round or boot shaped. It has three colours, Pale green, yellow and pink (figure4)
ii. Bracts- Two in number, the cover the buds lives partially or fully may vary in colour viz., pale green, yellow, pale yellow, pale pink, pink and deep pink (figure5)
iii. Corolla- there were 5 petals of which 5 turned into bristles and remained at the base of the flower. Two laterals and posterior were conspicuous and variously coloured: pale yellow with streaks, yellow with streaks, orange yellow with streaks, gold colour with streaks and orange red with streaks (figure6)
iv. Anthers- there were 3 anthers transverse and coloured: dark orange, deep pink, reddish, brown and deep red (figure7). Filaments united below to form a sheath.
v. Pollen yellow and highly fertile (80-90%). Anther delisceuse at 8.30 am and pollen remain viable for nearly 48 hours.
vi. Ovary- superior with 10-18 ovules. Stigma remains viable for fairly long time.
vii. Pollination: High percentage of cross pollination (90-95%) and mostly by honey bees. Sometimes 3-5% self pollination also occurs, but rarely

d. Phenological studies at Reproductory phase

Fruits are still developing and the observations would start later.

E. Molecular Marker Studies

DNA has been extracted from 12 old trees (Pictur) and the same has yet to be done with the remaining 6 old trees. Further analysis of the DNA would have to be started later.

F. Pattern of Intra-Population variability

Tamarindus Indica is a highly cross pollinated species and consequently, a high percentage of variability (heterogenity) could be expected with the tamarind populations. This assumption is strengthened by the observations of Diallo et al (2007) that tamarind species showed a higher level of genetic diversity (H=0.30) than the tropical rain forest tree species which showed genetic variability of H=0.11.

Even with in this limited phonological study of vegetative phase only, one could find considerable amount of variations. But it is only a part and full picture will emerge when the phonological studies at reproductory phase are completed.

Yet the data available on only two principal components, crown and inflorescence, were analysed and a preliminary categorization of the population was attempted and a "Dendrogram" was drawn up (fig 8). According to this analysis the population divided themselves into 6 clusters. This is only a trend of variability at this stage. The real pattern would emerge after the remaining studies are completed.

INTEGRATED DENDROGRAM BASED ON INFLORESCENCE AND CROWN AS TWO PRINCIPAL COMPONENTS. According to this the population distinguishes into 7 Broad clusters.

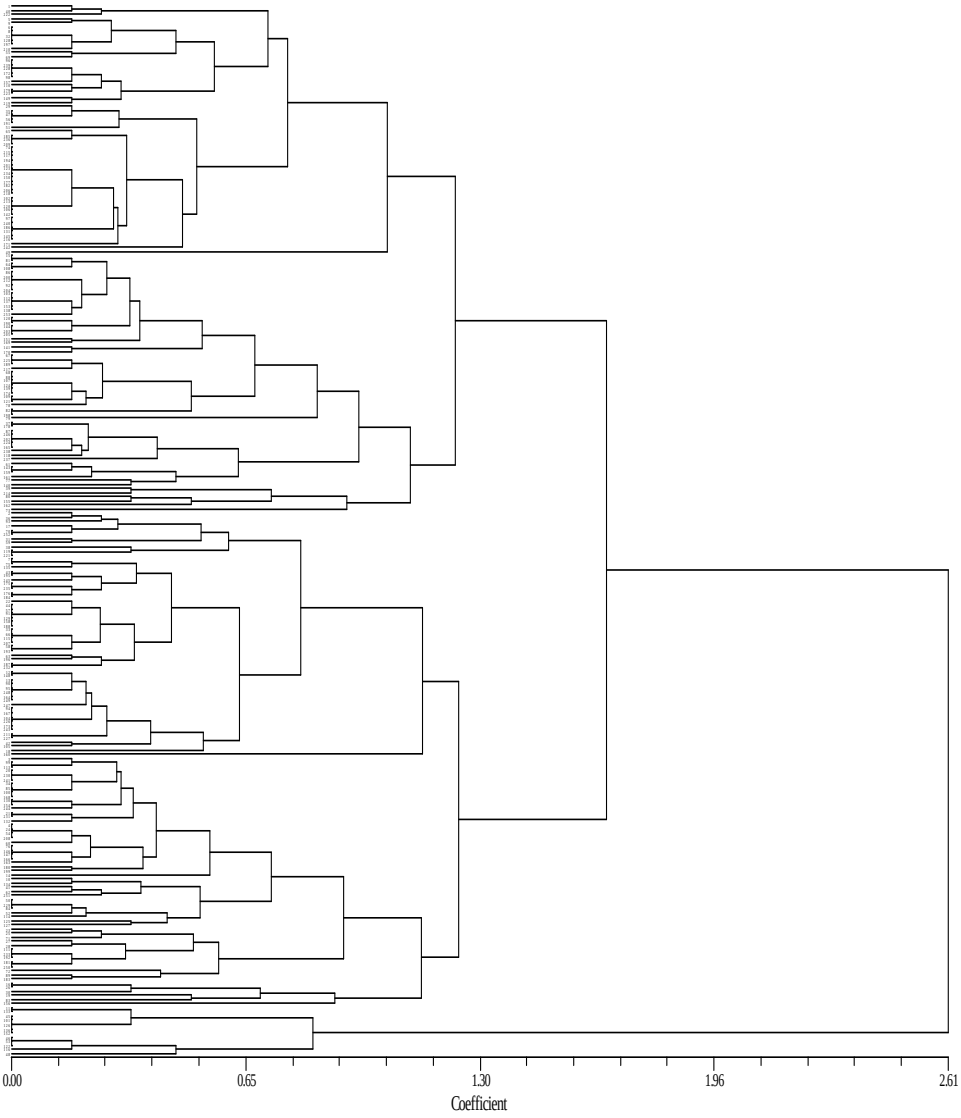


Figure 8

OLD TREES

TREE NO - 1

TREE NO-37

Tree No-72

Tree No-73

Tree No 78

Tree No 79

Tree No-118

Tree no-80

Tree No.163

Tree No.162

Tree no169

Tree no.178

Tree no – 37

Tree No.118

Tree no-152 (Trunk has disappeared callus has formed into a peculiar structure with a clone emerging from the callus)

Wood chips sent for Carbon dating of old trees

Fig:1(b)

Tree No.73

Tree no-161

Tree No.72

Tree No.155

Tree No.159

Tree No. 169

Tree no-162

Tree No. 153

Tree No-78

Tree No-79

Tree No.161

Tree No.1

TREE NO-73

Tree No.178

TREE NO-118 (Main trunk has been cut and the tree is survived by seven clones)

TRUNK CHARACTERISTICS

Mono trunk

Multiple trunk

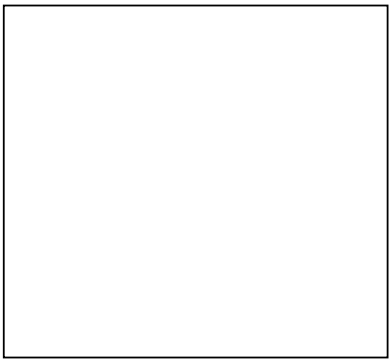
Wedged Trunk

Triple trunk

Double trunk

CROWN SHAPE

Dome Shape



Circle Shape

INFLORESCENCE STUDIES

Bud Character

1-Pale green

2-yellow

3-Pink

Bracts colour

1-Pale Green

2- Pale yellow

3-Yellow

4-Pale pink

5-pink

6-deep pink

Petal colour

1-pale yellow with streaks

2-Yellow with streaks

3-gold with streaks

4-orange yellow with streaks

5-orange red with streaks

Anther colour

1-dark orange

2-deep pink anthers

3-Reddish brown

4-Deep red

MOLECULAR WORK

Figure 9

EXTRACTED NUCLIEC ACID FROM 13 OLD TREES