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SCREENING BANANA (*Musa* sp.) VARIETIES FOR LEAF PRODUCTION

SELVAKUMAR,K.

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Department of Pomology and Floriculture
COLLEGE OF AGRICULTURE
VELLAYANI, THIRUVANANTHAPURAM- 695 522

DECLARATION

I hereby declare that this thesis entitled **"Screening banana (*Musa* sp.) varieties for leaf production"** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other university or society.

Vellayani,
23 -09- 2004

SELVAKUMAR.K.
(2001-12-19)

CERTIFICATE

Certified that this thesis entitled **"Screening banana (*Musa* sp.) varieties for leaf production"** is a record of research work done independently by Mr. Selvakumar.K. (2001-12-19) under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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16 - 3 - 2004

16/3/2004

Dr. C.S. JAYACHANDRAN NAIR
(Chairman, Advisory Committee)
Associate Professor,
Department of Pomology and Floriculture
College of Agriculture, Vellayani
Thiruvananthapuram.

APPROVED BY

CHAIRMAN

Dr. C.S.JAYACHANDRAN NAIR
Associate Professor,
Department of Pomology and Floriculture,
College of Agriculture, Vellayani,
Thiruvananthapuram-695 522

20.9.2004

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Dr. K.RAJMOHAN
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Plant Molecular Biology and Biotechnology Centre
College of Agriculture, Vellayani,
Thiruvananthapuram-695 522

20/9/04

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Department of Pomology and Floriculture,
College of Agriculture, Vellayani
Thiruvananthapuram- 695 522

20.9.04

Dr. VIJAYARAGHAVAKUMAR
Associate Professor,
Department of Agricultural Statistics,
College of Agriculture, Vellayani,
Thiruvananthapuram- 695 522

20/9/04

EXTERNAL EXAMINER

DEDICATED TO

BELOVED PARENTS

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LIST OF ABBREVIATIONS

AFLP	–	Amplified Fragment Length Polymorphism
bp	–	base pair
BRS	–	Banana Research Station
CATIC	–	Agronomic Centre for Research and Training
CC	–	cubic centimeter
CORBANA	–	National Banana Corporation of Costa Rica
DNA	–	deoxy ribonucleic acid
dNTPs	–	deoxy nucleotides
EDTA	–	Ethylene diaminotetra acetic acid disodium salt
IIHR	–	Indian Institute of Horticultural Research
IITA	–	International Institute of Tropical Agriculture
ISSR	–	Simple Sequence Repeats
KAU	–	Kerala Agricultural University
KCl	–	Potassium chloride
Kg	–	kilogram
M	–	molar
M	–	meter
Mg Cl_2	–	Magnesium chloride
ml	–	milliliter
Mm	–	millimeter
NaCl	–	Sodium chloride
ng	–	nanogram
OD	–	Optical Density
PCR	–	Polymorphic Chain Reaction
pM	–	picomolar
PMBBC	–	Plant Molecular Biology and Biotechnology Centre
PVP	–	Polyvinyl pyrrollidone
RAPD	–	Random Amplified Polymorphic DNA
RFLP	–	Restriction Fragment Length Polymorphism
SCAR	–	Sequence Characterized Amplified Region
SDS	–	Sodium dedecyl sulphate
SSR	–	Simple Sequence Repeats
SSRLP	–	Single Sequence Repeat Length Polymorphism
STMS	–	Sequence Tagged Microsatellite Sites
STSs	–	Short Randomly Repeated Sequences
TAE	–	Tris acetic acid EDTA
TE	–	Tris HCL-EDTA
Tris-HCL	–	Tris (hydroxy methyl) aminomethane hydrochloride
TSS	–	Total Soluble Solids
UPGMA	–	Unweighted Pair Group Method arithmetic Average
VNTRs	–	Variable Number of Tandom Repeats
µ l	–	microlitre
µ m	–	micromolar

INTRODUCTION

1. INTRODUCTION

Banana (*Musa* sp.) is one of the most important commercial tropical fruit crops of India, next only to mango. It is cultivated in tropical and subtropical regions of the world in 130 countries in an area of 88.43 lakh ha, producing 97.15 million tonnes of banana and plantain. India is the largest producer of banana contributing 17.30 per cent to the global production. Banana is grown in an area of 4, 90, 000 ha in our country with an annual production of 16.81 million tonnes. In Kerala it is the leading fruit crop, being cultivated in an area of 1, 06, 054 ha with an annual production of 7, 69, 085 tonnes (FIB, 2004).

The plant is called Kalpataru (plant of all virtues) owing to the versatile uses of all its plant parts. Although all the parts of banana are used for different purposes, and are in demand, the banana leaves which are chiefly used as dining plates in South Indian houses are in great demand and enjoy a ready market. Leaves of soft texture with thin midribs are generally preferred for this purpose. Cultivars like Poovan, Rasthali and Elavazhai are generally used for this purpose. Young leaves are cut when they are pale green, soft, pliable and undamaged by wind (Pillai, 1975).

The banana leaf industry is one of the banana based business in the southern states of Tamil Nadu, Karnataka, Kerala and Andhra Pradesh. The annual turnover of the leaf industry is estimated to be Rupees 128 million, approximately equivalent to $1/7^{th}$ of the annual turnover of the banana industry (Singh, 1996).

Use of banana leaves as biodegradable-dining plates have cultural and ecological significance. Compared with other banana based industries, this has become a source of livelihood for several marginal farming communities. This industry has proved advantageous due to sustainable demand for leaf throughout the year, a year round sustained source of income, the ability to balance the price fluctuation faced by the

farmer in the fruit industry to a greater extent and its applicability to different banana production systems including garden land cultivation, wet land cultivation and high land gardens (Uma *et al.*, 2003).

The leaves are the chief sites of photosynthesis of a crop and the total leaf area is usually assumed to be the size attribute that best measures its inherent photosynthetic potential. The partitioning of biomass between vegetative tissue and fruit gives an indication of plant efficiency towards productivity. Earlier research works on controlled partial defoliation in banana have shown that in AB and AAB group dessert bananas, the proportion of the economic part is comparatively lower and limiting the vegetative growth will enable the bunch to be the sink for the nutrients. Thus through leaf pruning, it may be possible to direct more energy towards bunch development than to support supra optimum vegetative growth. The leaves thus removed can fetch additional returns by way of sale in the local markets for use as leaf plates (Bindu, 1995).

The present study was therefore undertaken with the following objectives.

1. Evaluation of banana varieties exclusively for commercial leaf production
2. Evaluation of the changes in leaf production pattern of banana varieties due to leaf pruning
3. Studies on the efficacy of large scale banana cultivation exclusively for leaf production and
4. Molecular characterization using RAPD markers to analyse the genetic diversity and to provide preliminary information on the genetic make up of the varieties included in the study.

2. REVIEW OF LITERATURE

Banana growth is largely a function of the number of leaves (Simmonds, 1966). A banana plant produces more leaves than that is required for normal fruit development since this enables the plant to build up a strong pseudostem frame work capable of supporting the bunch (Stover and Simmonds, 1987). The banana plant may need to develop a large leaf area during the pre-floral phase to increase the potential to set a large bunch (Turner, 1980; Krishnan and Shanmugavelu, 1983 and Stover and Simmonds, 1987). However the role of post-floral leaf area in determining the final yield potential of banana is less clear (Robinson *et al.*, 1992).

Defoliation studies have been conducted in banana by a number of research workers in order to find out the optimum leaf area for optimum growth and development of the crop. The results of such studies in banana are summarized below.

2.1 EFFECT OF LEAF PRUNING ON GROWTH CHARACTERS

2.1.1 Effect of leaf pruning on plant height

Basu (1901) reported that intensive leaf pruning from the hardy 'Athia' banana variety of Assam reduces the growth of the plants. According to Pillai (1975) retaining either 6, 9, 12, 15, 18 or all the leaves in 'Poovan' banana until flowering affected plant growth. Plant with all the leaves significantly produced maximum height followed by plants with 15 and 18 leaves. The lowest height was recorded in plants with 6 and 9 leaves.

Pillai and Shanmugavelu (1978) observed that pseudostem height at shooting was highest in plants with all leaves in 'Poovan' cultivar. In 'Basrai' banana plants, the height increased as the number of functional leaves per plant increased (Kothavade *et al.*, 1985). Satyanarayana (1986) reported that plant height at shooting was highest in plants retained with

all the leaves in cv. "Dwarf Cavendish". On the other hand Hartman and Bailey (1929) observed that increased plant height due to defoliation in some instances in banana.

Martinez (1984) could observe no effect of defoliation on plant height of banana var. Dominica Harton.

According to Satyanarayana (1985) in 'Basrai' banana, different levels of functional leaves did not influence plant height significantly.

Bindu (1995) observed that the plant height was not significantly affected by the combined effect of leaf area removed by way of pruning and the time of pruning in 'Palayankodan' and 'Njalipoovan' cultivars of banana. It was observed that removal of 25 to 50 per cent of the leaf area after 15-30 days of unfurling had less deleterious effect on the plant height. She also observed that 'Njalipoovan' was comparatively less affected by this leaf pruning strategy compared to Palayankodan.

Increased leaf pruning in banana cultivars Valery and Olbino I' Ewai resulted in a significant reduction in most plant growth parameters. (Blomme *et al.*, 2001).

2.1.2 Effect of leaf pruning on plant girth

Satyanarayana (1985) observed that retention of all functional leaves recorded the maximum plant girth in 'Basrai' banana.

Pillai and Shanmugavelu (1977) reported that the mean girth of the corm decreased with the increase in the number of functional leaves.

Satyanarayana (1986) reported that plant girth was highest in plants retained with all the leaves in cv. "Dwarf Cavendish".

In 'Poovan' banana the girth of the plant was the highest with 12 or 18 functional leaves (Pillai and Shanmugavelu, 1978).

The highest plant girth was recorded in plants with fifteen leaves, while the lowest was recorded in plants with six leaves in banana cv. Poovan (Pillai, 1975).

Martinez (1984) reported no effect of defoliation on plant girth of banana var. Dominica Harton.

The girth of Njalipoovan and Palayankodan cultivars of banana was not severely affected by leaf pruning treatments (Bindu, 1995).

2.1.3 Effect of leaf pruning on leaf characters

According to Simmonds (1966) in banana, growth is a function of the number of leaves produced. A fixed number of leaves emerge prior to flowering in banana (Summerville, 1944; Champion, 1963; Wardlaw, 1972; Ticho, 1960; Barker and Steward, 1962). Simmonds (1966) estimated that 60 to 70 leaves are produced prior to flowering in banana. Turner (1970b) suggested that approximately 11 unemerged leaves are present in banana irrespective of the stage of development. According to Uma *et al.* (2003) the maximum total number of leaves was recorded by the cv. Elavazhai (51.00).

Naik (1963) reported that the total number of leaves per plant before bunching has been worked out to an average of 25 in 'Chakrakeli (white) and 'Mauritius', 27 in 'Poovan' and 29 in Bontha.

The reports by Turner (1970a) and Nambisan and Rao (1980) indicated that leaf production is distinct for each group of clones.

Pillai and Shanmugavelu (1976) observed that the total number of leaves produced was not influenced by leaf pruning in Poovan banana. Pillai (1975) reported that the total leaf production remained almost unaltered irrespective of pruning levels in 'Poovan' cultivar.

Turner and Hunt (1987) reported that in Williams banana, complete defoliation at 15 and 25 leaf stages resulted in the production of an extra 3-4 leaves before emergence. It suggested the existence of an internal mechanism to compensate the depletion of lamina through the production of a few extra leaves. Complete defoliation at 35 leaf stage reduced the number of live leaves at harvest from 5.2 to 4.1.

Bindu (1995) observed that leaf pruning treatments did not adversely affect the number of leaves produced in banana varieties 'Palayankodan and 'Njalipoovan', but an extra three leaves were produced in the most severe form of pruning in 'Palayankodan' and it may be due to varietal characters rather than the pruning strategies adopted.

Summerville (1944) reported that phylachron in banana was seven days under tropical conditions.

According to Anslow (1966) the phylachron depends upon temperature and the assimilation of expanded leaves.

According to Pillai and Shanmugavelu (1976), under leaf removal, phylachron decreased with increase in the number of functional leaves and the level of functional leaves remained had probably a control over phylachron. Highest total leaf area was recorded in plants maintaining all the leaves in 'Poovan' banana (Pillai, 1975).

Kelley (1932), Kramer (1969) and Devlin (1973) have suggested that removal of some leaves may result in water loss and loss of turgidity in the remaining leaves due to exposure to solar radiation and this may result in delay in unfolding of leaves.

Phylachron decreased with increase in plant age (Champion, 1963).

Bindu (1995) observed that the phylachron was not significantly influenced by the leaf pruning strategies adopted in Njalipoovan and Palayankodan.

According to Bindu (1995) leaf pruning in general increased the longevity of the intact portion of leaf on the plant. The severest pruning treatment resulted in the longest life and vice versa. Removal of more than 50 per cent of lamina increased the leaf longevity. Leaf pruning influence the longevity of the existing leaves and this may be one of the adaptations to compensate for the loss of lamina. Uma *et al.* (2003) observed that Elavazhai registered the highest shelf life of leaves (13.333 days). Poor shelf life of leaves was noticed in the cultivar Poovan (8.667 days). The better shelf life of leaves in Elavazhai is due to the thinner

leaves which are least likely to tear during wind. Thicker leaves (usually produced by tetraploids) tend to break easily thus losing shelf life.

Pillai and Shanmugavelu (1976) observed that in Poovan, the highest leaf area was recorded from the plants which retained all the leaves.

The functional leaf area decreased significantly with increase in severity of leaf pruning in Njalipoovan and Palayankodan cultivars. Similarly leaf area index also reduced by increasing in severity of pruning (Bindu, 1995).

Uma *et al.* (2003) observed that there was no significant variation among the different accessions of banana with respective leaf area, maximum leaf area was registered for the cultivar Saba (1.420 m^2) followed by Elavazhai (1.20 m^2).

There are pronounced differences in the photosynthetic efficiency of banana leaves due to leaf age (Groenendijk, 1970), Leaf water potential (Ke, 1980), cultivars (Stover and Simmonds, 1987) and light intensity (Robinson and Nel, 1989).

Hartman and Bailey (1929) reported complete recovery of the leaf surface after defoliation in some instances in banana.

Elavazhai had the midrib thickness of 2.533 cm, which was lesser than Poovan (2.720 cm) and other cultivars. Leaves with the slender midrib are preferred over those with conspicuous midribs (Uma *et al.*, 2003).

2.1.4 Effect of leaf pruning on duration of leaf harvest

Hartman and Bailey (1929) reported that defoliation in banana delayed shooting in some instances. Pillai (1975) reported that total cropping period was considerably less in plants, which maintained all leaves or a minimum of eighteen leaves, while it was more in plants which maintained nine leaves in Poovan banana. Flower bud initiation was

delayed in Poovan banana with only 6 or 9 functional leaves (Pillai and Shanmugavelu, 1977).

The total cropping period was longest on plants with 6 or 9 leaves in Poovan cultivar (Pillai and Shanmugavelu, 1978).

Basrai plants with all leaves retained took less days to flowering (Sathyanarayana, 1985). Satyanarayana (1986) reported that plants with all the leaves recorded considerably less cropping period in banana cv. Dwarf Cavendish.

WardLow (1972) stated that any circumstance which decreased the functional leaves is liable to have an adverse effect on duration of the crop to flowering, bunch formation and its development to maturity.

Ticho (1960) described a technique used in Israel to control the timing of harvest. It involved setting the sucker during the summer months and regulating its growth to avoid the inflorescence differentiation during the winter. The suckers were defoliated before the winter if they were too large. This delayed differentiation of the inflorescence and hence harvest.

Complete defoliation of the plant crop at the five leaf stage, delayed the flowering and harvest in ratoon by two months (Turner and Hunt, 1987).

In Njalipoovan and Palayankodan cultivars, the leaf pruning treatment significantly increased the duration (Bindu, 1995).

On the contrary, Kothavade *et al.* (1985) observed that retention of leaves in Basrai banana delayed flowering and harvesting.

Summerville (1944) formulated an arithmetical model for determining bunch initiation. From the data examination on hours of daylight and the mean temperature during the functional life of each leaf, bunch initiation occurs at TS of 5.6×10^{11}. The highest TS value was observed in plants, which retained the highest number of functional leaves and the lowest value was observed in plants, which retained the minimum number of functional leaves.

Ram Mohan *et al.* (1962) stated that in banana plant, lower number of functional leaves delayed flower bud differentiation.

According to Champion (1963), while in the development of any one plant, a certain leaf area must be produced before bunch initiation occurs in a population the vegetatively largest is not necessarily the first one to throw a bunch.

In 'Williams' banana, removal of more than 75 per cent leaves induced stress in the plant crop. (CSFRI, 1988)

According to Singh and Bhattacharaya (1992) reduction in phylachron exerted considerable influence in reducing overall crop duration in banana.

2.1.5 Incidence of pests and diseases

Among the different accessions studied, Elavazhai recorded zero per cent leaf spot disease severity and YLS (youngest leaf spotted) 13.0 followed by NRCB selection (24.01 %) and YLS (18.0). The highest disease severity was registered by Kunnan (46.4 %) with YLS (7.0) (Uma *et al.*, 2003).

Viswanath (1981) evaluated the resistance of some banana varieties to attack by *Cosmopolites sordidus* (Rhizome Weevil). The study revealed that lacatan was the least susceptible while maduranga was the most susceptible. Nendran ranked third with respect to tolerance among the varieties evaluated.

Babylatha *et al.* (1990) reported that there was wide variability in the reaction to rhizome weevil by various cultivars of banana. Pisang lilin, Sanna chenkadali and Tongat showed fairly high tolerance to rhizome weevil along with tolerance to leaf spot diseases.

Senechal and Gohet (1988) reported that rubber trees artificially defoliated to escape anthracnose disease, thus defoliation reduces the disease incidence by increased level of K and decreased ca^{2+} in tissues.

Brun (1962) stated that the level of resistance to sigatoka displayed by a given cultivar may vary within relatively wide limits according to local conditions and the amount of infective inoculum.

Simmonds (1966) reported that the resistance to sigatoka increases as the proportion of B genome increases.

The mortality due to bunchy top disease was from 0 to 33 per cent among the 'Palayankodan' accessions (Rajeevan, 1985).

Among 18 AAA clones, Manoranjitham showed high field resistance to sigatoka leaf spot (KAU, 1990).

The sigatoka infection index of Palayankodan varied from 2.48 to 6.93 for various accessions (Rajeevan, 1985).

Most of the native varieties of Kerala are tolerant to leaf spot diseases when compared to the exotic Grosmichel and Robusta (Gopimany, 1977).

2.1.6 Effect of leaf pruning on the benefit/cost ratio

Leaf pruning is not recommended as a commercial practice due to bunch mass reduction and the labour cost of pruning. For improved bunch mass and yield per annum, management of the plantation should be good enough to ensure the maximum possible functional leaves on the plant of flowering stage (CSFRI, 1988).

Robinson *et al.* (1992) reported that no yield benefit was achieved by leaf pruning as a possible management technique in 'Williams' banana. However, in the event of frost or hail damage before flower emergence, the results have shown that if an additional eight healthy leaves could emerge before flowering, yield should not be reduced significantly. Whereas only four new leaves could result in significant reduction of marketable yield.

From the economic point of view, leaf pruning is not beneficial in both Njalipoovan and Palayankodan under Kerala conditions. Considering the yield of both leaf and bunch it was observed that the yield was higher

in control where no leaf pruning was practiced. If at all leaf pruning is to be done, the intensity of pruning should be removal of only upto 50 per cent lamina after 30 days of unfurling (Bindu, 1995).

An experiment conducted by Irulappan (2002) showed that plants grown for dual purpose (fruits and leaves) showed B:C ratio of 1:3.5 against plants grown only for leaves which showed a B:C ratio of 1:4.0 under Tamil Nadu conditions.

In coriander cv. PS 360, leaf plucking significantly decreased seed yield but increased the gross returns because of the additional leaf yield (Bhati, 1988).

In west coast tall coconut, Sudhakara *et al.* (1989) reported that the highest income from the sale of leaves was obtained when two leaves were taken every month. Leaf removal had no adverse effect on female flower production, setting percentage or nut yield.

2.2 MOLECULAR MARKERS

Molecular markers are genotypic markers (Bretting and Widrlechner, 1995) which constitute biochemical constituents (secondary metabolites in plants) and macromolecules (protein, DNA). Biochemical markers have been used since long for the characterization of variation in a plant, now considered to be inappropriate as universal markers (Cooke, 1994). Molecular markers are direct manifestation of genetic content (Weising *et al.*, 1995). They serve as reliable indices of genetic variation. In the past decade, molecular markers have very rapidly complemented the classical strategies. The genetic markers are used for clonal identification, linkage mapping, population diversity, taxonomy, evolutionary studies, determining the genetic fidelity during micropropogation, germplasm conservation etc (Waugh and Powell, 1992; Bretting and Widrlechner, 1995).

2.2.1 Isozymes

Numerous attempts have been made to use isozyme polymorphism as genetic markers in *Musa* (Bhat *et al.*, 1992). Esterase has been found

specific for distinguishing French Plantain (AAB) from Bluggoe (ABB) (Horry, 1985). No difference was observed among the different AAA triploid clones using different isozymes (Novak, 1992). The enzyme coding loci do not constitute a random sample of genes and they are not randomly dispersed throughout the genome. Electophoresis will detect only portion of the actual variability present in amino acid sequences (Hills and Moritz, 1990). Some isozyme variants are not selectively neutral. Moreover, isozymes, are unstable markers during plant development and standardization of sampling procedures is sometimes difficult. Therefore, the isozymes have been replaced by DNA based molecular markers (Anolles and Trigiano, 1997).

2.2.2 DNA Markers

The term DNA fingerprinting was introduced for the first time by Jeffrey *et al.* (1985). Presently the term DNA fingerprinting / profiling is used to describe the combined use of several single locus detection systems and are being used as versatile tools for investigating various aspects of plant genomes. These included characterization of genetic variability, genome fingerprinting, genome mapping, gene localization, analysis of genome evolution, population genetics, taxonomy, plant breeding and diagnostics.

With the advent of molecular biology techniques, DNA based marker have replaced enzyme markers in germplasm identification and characterization as well as in gene tagging. Because of its plasticity, ubiquity and stability, DNA is the ideal molecule for such analysis (Caetano – Anolles *et al.*, 1991). Various types of molecular markers are utilized to evaluate DNA polymorphism and are generally classified as hybridization based markers and polymerase chain reaction (PCR) based markers (Joshi *et al.*, 1999).

2.2.2.1 Hybridisation Based DNA Markers

The hybridization based DNA marker techniques utilize labelled nucleic acid molecules as hybridization probes (Anolles *et al.*, 1991). Probe molecules range from synthetic oligonucleotides to cloned DNA. Some of the important hybridization based DNA techniques are Restriction Fragment Length Polymorphism (RFLP), Hypervariable Sequences and Variable Number of Tandem Repeats (VNTRs).

2.2.2.1.1 Restriction Fragment Length Polymorphism (RFLP)

Restriction Fragment Length Polymorphism analysis involves digesting the genome with restriction enzymes, separating the fragments electrophoretically and then preferentially visualizing the fragments containing particular homologous sequences by hybridizing them to a specific DNA probe (Deverna and Alpert, 1990).

Genetic diversity in *Musa* was documented using RFLPs to study the taxonomy and phylogeny of *Musa* species (Jarret *et al.*, 1992; Gawel *et al.*, 1992; Jenny *et al.*, 1997). Examination of 20 *Musa* species and subspecies using total DNA was done via RFLP. The results revealed that there are two clear grouping among these species, one containing species from sections *Musa* and Rhidoclamys and the other containing species from sections Autralimusa and Callimusa (Gawel *et al.*, 1992).

Chloroplast DNA RFLPs were used to study cytoplasmic genetic diversity in various *Musa* species and subspecies (Gawel and Jarret, 1991). Bhat *et al.* (1994) examined nuclear and chloroplast DNA RFLP variability within fifty seven *Musa* germplasm collections in order to evaluate the ability of RFLPs to identify and classify the Indian bananas.

2.2.2.1.2 Hypervariable sequences and variable number of tandom repeats (VNTRs)

Kaemmer *et al.* (1993) used oligonucleotide probes to differentiate *Musa* cultivars in various genomic groups. Bhat *et al.* (1995) found that DNA fingerprinting using oligonucleotide probes was useful for cultivar

identification and for overall genome analysis to establish relatedness among the various accessions of *Musa* germplasm. The presence of hybervariable sequence was confirmed in plants and animals by Gupta *et al.* (1996). Studies by Crouch *et al.* (1999) to compare different PCR based marker system (Random Amplified Polymorphic DNA (RAPD), Variable Number of Tandom Repeats (VNTRs) and Amplified Fragment Length Polymorphism (AFLP)) for the analysis of breeding population of *Musa* showed that VNTRs analysis detected the highest levels of polymorphism.

2.2.2.2 Polymerase chain reaction (PCR) based DNA marker techniques

These are fingerprinting techniques that use an *in vitro* enzymatic reaction to specifically amplify a multiplicity of target sites in one or more nucleic acid molecules (Anolles and Trigiano, 1997). Among the PCR based marker techniques, the important ones are Amplified Fragment Length Polymorphism, Microsatellite, Sequence Characterized Amplified Region and Random Amplified Polymorphic DNA.

2.2.2.2.1 Amplified fragment length polymorphism (AFLP)

Amplified Fragment Length Polymorphism is based on PCR amplification of restriction fragment generated by specific restriction enzymes and oligonucleotide adapters of few nucleotide bases (Vos *et al.*, 1995). Random Amplified Polymorphic DNA (RAPD), Inter Simple Sequence Repeats (ISSR) and Amplified Fragment Length Polymorphism (AFLP) markers were used to fingerprint and to examine genetic diversity among twelve genotypes of the gooseberry (*Ribes grossularia*). AFLP generated unique profiles for each genotype. Studies conducted for identification of some accessions of Musaceae at the *Musa* germplasm bank established at El-Agardo, Columbo using AFLP showed highest Similarity Index within the Cavendish group of banana (Sanchez *et al.*, 1998). AFLP has been used to detect genetic differences and somaclonal variants in *Musa spp.* (Engelborgh *et al.*, 1998). Nine accessions of *Musa*

were evaluated by AFLP. Screening of *Currare enano* and its medium sized off type somaclone for polymorphism correlated with the dwarf genotype revealed twelve differences among 104 generated fragments. Differences were also found between very closely related accessions. AFLP techniques were found to be very useful in saturation mapping and for determination between varieties in oil palm (Singh *et al.*, 1998). AFLP analysis of *Musa* breeding population suggests that this technique may be a most powerful tool in the molecular breeding of plantain and banana (Crouch *et al.*, 1998).

2.2.2.2.2 Microsatellite

The term microsatellite was coined by Litt and Luty (1989). DNA sequences with short repeated motifs (2 – 6 bp) are called Simple Sequence Repeats (SSRs), microsatellite (Epplen *et al.*, 1991; Todokoro *et al.*, 1995) or secondary generation markers (Davies, 1993) because microsatellites are highly polymorphic, randomly distributed in the genome and easily analysed as a general and novel source of genetic markers (Thottappilly *et al.*, 2000).

Microsatellite consist of randomly arranged di-tri-tetra nucleotide repeats, which are hypervariable and ubiquitously distributed throughout eukaryotic genomes. Microsatellite DNA markers, which can be directly amplified by PCR, have been developed using the unique sequences that flank microsatellite (Weber and May, 1989).

Jarret *et al.* (1994) presented information on the isolation of a number of Short Tandomly Repeated Sequences (STSs) or SSRs also known as Variable Number of Tandem Repeats (VNTRs) or microsatellites in *Musa*. Crouch *et al.* (1997) stressed the use of Simple Sequence Repeats Length Polymorphism (SSRLP) assays for fingerprinting of *Musa* hybrids. Data on segregation at microsatellite loci in haploid and diploid gametes of *Musa* indicated the suitability of microsatellite markers for marker assisted selection system in *Musa*.

Candidate markers for such complex and important characters as parthenocarpy, earliness and regulated suckering are also being tested (Vuylsteke *et al.*, 1998).

Two size selected genome libraries from banana were screened for the presence of Simple Sequence Repeats (SSRs) by Kaemmer *et al.* (1997). They demonstrated that SSR are readily applicable to the study of *Musa* genetics. Comprehensive analysis of a significant number of banana Sequence Tagged Microsatellite Sites (STMS) could add to the knowledge on the structure and phylogeny of genome of the *Musa* species and suggest the use of microsatellite as anchor markers for a banana genetic core map. Microsatellite markers have been used in plants for fingerprinting, mapping and genetic analysis. SSRLP analysis has been shown to detect a high level of polymorphism between individuals of *Musa* breeding populations (Crouch *et al.*, 1998). However, isolation of microsatellite is time consuming and expensive. Nevertheless, several hundred SSRLP markers have been generated in *Musa* (Crouch *et al.*, 1998).

2.2.2.2.3 Sequence characterized amplified region (SCAR)

Sequence Characterized Amplified Region analysis was developed to produce reliable PCR based results. Parent and Page (1998) used this technique to identify raspberry cultivars. Damasco *et al.* (1998) used marker based on SCAR to detect dwarf off type of *in vitro* grown Cavendish bananas.

2.2.2.2.4 Random Amplified Polymorphic DNA (RAPD)

Polymerase chain reaction in conjunction with random primers, was used for fingerprinting genomes (Welsh and Mc Clelland, 1990), for population biology studies (Astley, 1992), identification of genome specific markers and other uses (Williams *et al.*, 1990; Erlich *et al.*, 1991). Several authors have applied the RAPD technique to investigate genetic variability and found the technique very efficient and reliable (Brown *et al.*, 1993; Munthali *et al.*, 1996). Analysis of RAPDs offers several

advantages compared to RFLP. The most important advantage is that RAPD is not a labour intensive procedure. It is not necessary to construct or maintain a genomic library. RAPD requires smaller quantities of genomic DNA than RFLP analysis. Also it is less costly compared to RFLP. Generation of RAPD is quicker than RFLP and can be used to detect even single gene mutation (Williams *et al.*, 1990).

2.2.2.2.4.1 RAPD and linkage maps

RAPD assay has been used by several groups as an efficient tool for identification of markers linked to agronomically important traits which are introgressed during the development of mere isogenic lines. Traits of interests studied include jointless pedicel in tomato (Wing *et al.*, 1994), disease resistance (*Pseudomonas* resistance) (Martin *et al.*, 1991) and spotted wilt virus resistance (Chaque *et al.*, 1996) in tomato, anthracnose resistance in mango (Subramanian *et al.*, 1996), scab resistance in apple (Hong *et al.*, 1997; Tartarini, 1996), lettuce infectious yellow virus resistance in melon (*Cucumis melo*) (Mc Creight, 2000) and leaf minor resistance (Moriera *et al.*, 1999).

The trait associated with the seed oil content in Indian mustard was identified with three RAPD markers *viz.* OPH-11, OPJ-06 and OPL-15 (Sharma *et al.*, 1999). It was revealed that there was significant association of oil content with these markers.

Genetic linkage maps have been created in banana (Faure *et al.*, 1993), sweet cherry (Stockinger *et al.*, 1996), citrus (Christophani *et al.*, 1999), rose (Debener and Mattiesch, 1999) and oil palm (Moretzsohn *et al.*, 2000) using RAPD.

In an effort to map the loci affecting the cooking quality traits in basmati rice a double haploid population from the basmati indica (*Hasan Serai*) x non-basmati japonica (Xiang Nuo4) hybrid generated earlier was genotyped using 121 RAPD markers and a linkage map was constructed (IARI, 1999).

2.2.2.2.4.2 RAPD and Taxonomic Studies

RAPD markers have been widely used for taxonomic and related studies. Demeke *et al.* (1992) investigated the potential use of RAPDs for taxonomic studies using *Brassica, Sinapsis* and *Raphanus* taxa. Analysis of the RAPD bands revealed the relationship between diploid and amphidiploid *Brassica* taxa. Results showed that the *Raphanus sativus* and *Sinapsis alba* were distinct from the *Brassica* taxa.

Duneman *et al.* (1994) investigated the use of RAPD markers for taxonomic studies in *Malus*. Eighteen accessions of wild species and twenty-seven apple cultivars were tested with 29 pre-selected primers. The analysis of the bands using Unweighted Pair Group Method Arithmatic Average (UPGMA) showed the relationship among the cultivars which was in agreement with the known lineage. A dendrogram generated for wild species gave relationship that were in accordance with the known phylogenetic information.

The technical simplicity of the RAPD technique has facilitated its use in the analysis of phylogenetic relationship in several plants like roses (Debener *et al.*, 1996), blue berry (Levi and Rowland, 1997), barley (Noli *et al.*, 1997) and cymbidium (Obara-Okeyo and Kako, 1998).

The genetic closseness of various species of Vanda was determined using RAPD markers. Strap-leaved *Vanda* sp. (including *Vanda sanderiana*) and *Ascocentrum miniatum* were more closely related to each other than to the terete leaved Vanda species studied. RAPD analysis supported the suggestion that terete leaved *Vanda teres* and *V. hookeriana* be classified in the separate genus *Papilionanthe* and that *V. sanderiana* should remain in the genus Vanda (Lim *et al.*, 1999).

2.2.2.2.4.3 RAPD and somaclones

RAPD analysis was used to detect genetic variation in micropropagated Cavendish banana (Damasco *et al.*, 1996). A RAPD marker specific to the dwarf off-type from micropropagation of Cavendish

group cultivars was identified following an analysis of 57 normal and 59 dwarf plants generated from several different micropropagation events. Of the 66 random decamer primers used in the initial screening, 28.8 per cent revealed polymorphisms between normal and dwarf plants. Use of this marker could facilitate early detection and elimination of dwarfs from batches of micropropagated bananas. Results of studies by Hammerschlag *et al.* (1996) showed the feasibility of using tissue culture methods to generate fruit trees with increased level of disease resistance. RAPD was used to study genetic variation at the DNA level among somaclonal variants in banana plants (*Musa* AAA cv. 'Grand Naine'). Four different types of somaclonal variants were identified and characterized in banana plants generated by meristem culture (Walther *et al.*, 1997). Tissue cultured off types did not display any visual differences during *in vitro* culture. But after six weeks of hardening in a commercial nursery, the field established plants showed significant phenotypic differences. RAPD analysis of somaclonal variants revealed the presence of polymorphic bands with at least one set of primers. This enabled early detection of somaclonal variants and allowed the elimination of off types before planting of micropropagated plants in the field. RAPD markers were found to be useful for confirmation of genetic fidelity in micropropagated plants (Gupta *et al.*, 1999).

According to Lu *et al.* (1996), RAPDs are useful for establishing a genetic basis for somaclonal variation in rice. The results of RAPD analysis in cultured rice showed that somaclonal variation might have occurred in transfer RNA, ribosomal protein and other genes during cell culture. Also somaclonal variation was found to increase with culture age (Yang *et al.*, 1999).

Random amplified polymorphic DNA technology was applied to monitor the genetic fidelity of micropropagated meadow fescue *viz.*, *Festuca pratensis* (Valles *et al.*, 1993), Norway spruce (Heinze and Schemidt, 1995) and strawberries (Kumar *et al.*, 1995).

Somaclonal variants were reported in *Triticum aestivum* (Brown *et al*, 1993), populus (Rani *et al.*, 1995), beet (Munthali *et al.*, 1996) peach (Hashmi *et al.*, 1997), tomato (Hong *et al.*, 1999), grapes (Vendisson *et al.*, 1999) and pigeon pea (Prasannalatha *et al.*, 1999) using RAPDs.

Plants regenerated by somatic embryogenesis from long term callus culture derived five garlic cultivars were subjected to RAPD analysis (Al-Zahim *et al.*, 1999). Certain changes were observed in the RAPD profiles of the regenerants of different cultivars, suggesting the existence of somaclonal variants.

RAPD analysis was done by Babu (2000) to assess the genetic stability in tissue culture derived black pepper plants. Monomorphic banding pattern was observed for the tissue culture regenerants, compared with their respective source plants. Uniformity was confirmed at both stages of development studies. Thus genetic stability and clonal fidelity were ensured for the tissue culture regenerants and the viability of the protocol was confirmed.

2.2.2.2.4.4 RAPD and hybrids

RAPD technique has been used for the identification of hybrids and their parent determination as well. Wang *et al.* (1994) proposed RAPD fingerprinting as a convenient tool for the identification, protection and parentage determination of plant hybrids. In their study, DNA from three families of rice plants selected in Northern China (each comprising the male sterile, the restorer, the hybrid F_1 and the maintainer lines) was extracted and amplified by RAPD technique. The results obtained were useful for identification of each single plant line.

Truksa and Prochazka (1996) reported different banding pattern based on the DNA polymerase used for testing three lines of cucumber used for the production of hybrid seeds. Low level of polymorphism was obtained which indicated that RAPD was not suitable for verifying the

hybridity of seeds. RAPD markers have been successfully used to test the paternity of Japanese pear hybrid (Banno *et al.*, 2000).

2.2.2.2.4.5 RAPD for identification of somatic hybrids

One of the limiting factors for the efficient exploitation of protoplast fusion is the difficulty of unequivocally identifying nuclear hybrids. RAPDs have been used to characterize both interspecific and intraspecific somatic hybrids. Baird *et al.* (1992) proposed RAPDs for the identification of hybrids at an early stage following fusion in potato. Inter and intraspecific somatic hybrids of potato were characterized by using RAPD along with sexual hybrids.

Xu *et al.* (1993) used RAPD assay for the identification of somatic hybrids between *Solanum tuberosum* and *S. brevidens*. Somatic hybrids showed a combination of the parental banding pattern with four of the five primers screened whereas regenerants from one of the parents had a similar banding pattern as that of the parent.

2.2.2.2.4.6 RAPD in sex determination

Early identification of sex in dioecious plants like papaya (Somri, 1998) and nutmeg (Shibu *et al.*, 2000) was possible with the help of RAPD markers.

Genotypic and morphogenetic differences among three female varieties of *Piper longum*, one variety each from Assam and two variety released from Kerala, were investigated using RAPD analysis and it was revealed that these varieties were genetically different. In *P. longum*, RAPD technique was used to investigate the molecular basis of genotypic differentiation between the male and female parents (Banerjee *et al.*, 1999). As a result male sex associated RAPD markers were identified for the first time in *Piper longum*.

2.2.2.2.4.7 RAPD and detection of genetic variability

RAPD markers have been used to characterize cocoa clones representing the three main cultivated sub populations *viz.* Criollo, Forastero and Trinitario (Wilde *et al.*, 1992). The use of single primers of arbitrary nucleotide sequence resulted in the selective amplification of DNA fragments, which were unique to the individual cocoa clones studied.

Lashermes *et al.* (1996) have successfully employed RAPD markers to analyse genetic diversity among cultivated and sub spontaneous accessions of *Coffea arabica*. The narrow genetic bases of commercial cultivars were confirmed by their study. On the other hand, relatively large genetic diversity was observed within the germplasm collection. Results suggested an East-West differentiation in Ethiopia, the primary centre of diversification of *Coffea arabica*.

Duran *et al.* (1997) analysed 48 coconut types belonging to East African Tall types by different DNA marker techniques including RAPDs, Microsatellite primed PCR and Inter Specific Tandem Repeats (ISTR) analysis. All the three approaches detected large number of DNA polymorphism among the set of genotypes and allowed the identification of single genotypes by individual specific fingerprints. The cluster and principal coordinate analyses were done and the observed clustering and association of individuals corroborated the expectations based on the known geographical origin and parental relationships.

Varghese *et al.* (1997) evaluated the applicability of RAPD markers in the cultivated rubber tree, using forty three primers in a set of twenty four clones selected from different South-East Asian Countries. Out of the total 220 fragments amplified, eleven were polymorphic. The statistical analysis indicated the absence of a distinct geographical grouping because of the breeding history of *Hevea*.

The genetic diversity of twenty seven superior tea accessions (*Camellia sinensis* var. *sinensis*) from Korea, Japan and Taiwan was

evaluated by Kaundun *et al.* (2000) using RAPD-PCR markers. Out of the fifty primers screened, seventeen primers generated fifty eight polymorphic and reproducible bands. A minimum of three primers was sufficient to distinguish all the twenty seven accessions studied

An experiment was carried out on five new strawberry cultivars and one cultivated variety for the study of genetic variability based on RAPD markers and protein (PAGE) pattern using eleven different RAPD primers. Two hundred and four polymorphic DNA fragments with a high potential to differentiate strawberry genotypes could be produced. A dendrogram displaying the relative genetic similarities among the genotypes showed the existence of genetic diversity among the six varieties. From this study, the fingerprints at protein level or DNA-RAPD was found to be very important to distinguish between new strawberry cultivars (El-Tarras *et al.*, 2001b).

An analysis of a Brazilian oil palm (*Elaeis oleifera*) germplasm collection was carried out using RAPD markers. A sample of hundred and seventy five accessions obtained along the Amazon River Basin was analysed and compared to seventeen accessions of oil palm from Africa. Ninety six RAPD markers were used in this analysis, of which fourteen were shown to be specific to oil palm, while twelve were specific to Brazilian oil palm. Results showed that the Brazilian oil palm accessions studied have moderate level of genetic diversity as compared to the other accessions (Moretzsohn *et al.*, 2002).

DNA fingerprints generated by RAPD and Inter Simple Sequence Repeat Polymerase Chain Reaction (ISSR-PCR) analysis were used to compare the four most widely planted *Vitis vinifera* cultivars in Chile. Both the techniques were able to distinguish between the cultivars, although the resolving power of ISSR profiles was higher than that of RAPDs. The results indicated that no variation was found within the Chilean Merlot clone using either ISSR or RAPD analysis (Herrera *et al.*, 2002).

Random Amplified Polymorphic DNA markers were extensively used for the molecular characterization of various crop species. RAPD markers have been used to characterize germplasm in several important crop species including *Carica papaya* (Stiles *et al.*, 1993) and apple (Koller *et al.*, 1993). Mulcalhy *et al.* (1993) characterized twenty five accessions of apple, representing eight cultivars (Golden delicious, Delicious, Gala, Jonathan, Jonagold, Florida, Fior di Cassia and Imperate Dallago) with RAPD. Using separate ten base pair primers, it was possible to obtain a distinctive fingerprint for each of the cultivars. Thus RAPD provided a simple and reliable method for cultivar identification in apple. Goulao *et al.* (2001) screened forty one apple cultivars by RAPD and AFLP markers. RAPD analysis was performed with thirty five arbitrary 10-mer primers selected from sixty primers tested. Of a total of 362 bands observed, 208 (57.5 %) were polymorphic. The cultivars differentiated through mutation were included in this study. The estimated genetic relationships were correlated between the analysis with the two different markers. UPGMA analysis was performed and dendrograms were constructed using either the data apart from each (RAPD and AFLP) method or combined in a single joint matrix. The relationship among the forty one cultivars studied were basically consistent with the known lineage and geographical origins of the cultivars.

Shimada *et al.* (1999) investigated the genetic diversity of forty two plum varieties by RAPD analysis. Twenty primers discriminated all plum varieties. Genetic diversity among the examined strains was duly characterized. The results showed that North American plums were genetically distant to the other strains, and the Taiwanese plums differed from Japanese cultivated plums.

El-Tarras *et al.* (2001a) used RAPD-PCR reactions in four olive cultivars. Thirteen different 10-mer primers which had been pre selected for their performance with olive DNA were used. The amplification products obtained were highly polymorphic between the analysed olive

cultivars. On the average, 6.5 bands were produced per primer and a total of 130 polymorphic fragments were obtained.

RAPD amplification products were obtained in genomic DNA extracted from four dwarf cashew clones (Neto *et al.*, 1995). Six 10-mer arbitrary primers were used for amplification. The profiles obtained for each seedling were compared with each other for identification of clones for specific amplified products. The number of bands in the profiles varied from 0 to 4 depending on the primer and seedling tested. A total of twenty seven amplification products suitable for DNA fingerprinting were disclosed. Mneney *et al.* (1997) evaluated the applicability of RAPD markers in cashew using random 10-mer primers. The optimized PCR-reaction conditions were then used to analyse difference in RAPD profiles among a small selection of cashew varieties obtained from different parts of the world. The relatively uniform RAPD profiles of the Tanzanian lines which were revealed by the small number of random 10-mer primers tested suggested a high degree of DNA level similarity between these accessions. The same results were obtained by Mnency *et al.* (2001).

Machado *et al.* (1996) carried out a study at Brazil to evaluate polymorphism and genetic similarity between 39 Mediterranean mandarin genotypes, using RAPD analysis. One hundred and eleven amplification products were identified using 21 random primers. Cluster analysis revealed a low level of genetic variation between accessions of Mediterranean mandarin whereas their hybrids showed greater genetic dissimilarity with other citrus species. Polymorphism was investigated by the RAPD technique in thirteen citrus species. Inter specific differences were observed (Sawazaki *et al.*, 1997). The sweet orange cluster was distinct from the tangerine group and sour oranges fell between the two. RAPD markers were used to evaluate genetic similarity among thirty five mandarin accessions, including ten species and seven hybrids (Coletta-Filho *et al.*, 1998). One octamer and twenty two decamer primers produced 109 RAPD bands, forty five of which were polymorphic.

Jaccard's Coefficient was used to calculate genetic similarity and UPGMA to generate the phenogram. Bastianel *et al.* (2001) observed that RAPD markers were used to analyse fifteen citrus genotypes. Genetic similarities of the fifteen citrus genotypes, obtained with twelve random primers, indicated a minimum similarity degree of 0.81 among the mandarins. Lower similarity degree were obtained among the less related *Citrus* spp. The four genotypes of sweet orange could not be differentiated using RAPD markers, indicating maximum similarity.

Phylogenetic relationships among nine *Mangifera* species were studied using RAPDs (Schnell *et al.*, 1993). Analysis was conducted using average taxonomic distance, UPGMA and principal component analysis. Ten selected primers produced 109 usable bands. Halos and Ferreon (1998) used RAPD markers to study the genetic variability of Carabao mangoes. Fifty one random primers were screened. However, only eight exhibited polymorphism, making them suitable for study on the genetic variation among carabao mangoes. Lopez-Valenzuela *et al.* (1999) observed that, some fifteen mango cultivars were examined using RAPD markers with decamer primers of arbitrary sequence. Thirteen of the forty primers screened were informative and 109 amplified DNA bands were selected as RAPD markers. Specific RAPD markers for some mango cultivars were identified. Cluster analysis based on the RAPD markers produced a dendrogram of the genetic relatedness of the fifteen mango cultivars. These markers may facilitate the management of mango germplasm for breeding purposes. Sheng *et al.* (1999) revealed that DNA from three mango cultivars was used for RAPD analysis. Primers S 273, S 282 and S 286 were the most suitable for RAPD amplification of the genomic DNA. Some differences were noted in the DNA sequences of the three genotypes. Eighteen commercial mango cultivars were selected to assess genetic relatedness using RAPD markers. Thirty arbitrary 10-mer primers used. Of these, twenty seven primers amplified mango genomic DNA. None of these primers produced unique band pattern for each cultivars. RAPD data were

used to calculate a Squared Euclidean Distance Matrix, and based on this cluster analysis was done using a minimum variance algorithm (Ravishankar *et al.*, 2000). Fifty mango cultivars were screened using RAPD markers with decamer primers of arbitrary sequences (Kumar *et al.*, 2001). Out of the eighty primers screened, ten were selected which gave 139 clear and bright fragments. A dendrogram based on Jaccards Coefficient of Similarity implied a moderate degree of genetic diversity among the cultivars.

Using the technique of RAPD, Howell *et al.* (1994) identified 116 amplification products in *Musa* germplasm using nine primers. This enabled them to identify RAPD markers that are specific to each of the nine genotypes of *Musa* representing AA, AAA, AAB, ABB and BB genotypes. Using RAPD marker techniques to assist with early detection of dwarfism in banana. 'Normal' and dwarf *in vitro* plants of cultivar New Guinea Cavendish was screened with 66 random decamer primers, of which 19 revealed polymorphisms. OPJ-04 consistently amplified a band of approximately 1.5 kb in normal plants which was absent in all dwarfs tested. This primer was then shown to consistently amplify a band of similar size in normal chloroplast DNA, which was always absent in dwarf chloroplast DNA (Damasco *et al.*, 1996). Fifty-seven accessions of *Musa* including cultivated clones of six genomic groups (AA, AB, AAA, AAB, ABB, ABBB), *Musa balbisiana* Colla (BB), *Musa acuminata* Colla spp. *banksii* F Muell (AA), *Musa acuminata* Colla spp. *malaccensis* Ridl. (AA) and *Musa velutina* Wendl and Drude were examined by Bhat and Jarret (1995) using RAPD genetic markers and PCR with sixty 10 mer random primers, which generated 605 polymorphic amplification products. RAPD analysis was performed on several clones of the variety 'Williams' by Iqbal *et al.* (1995). RAPD using Operon primers was used to evaluate genetic variability of sixty six *Musa* spp. accessions in the germplasm collection of the National Banana Corporation of Costa Rica (CORBANA) and the Agronomic Centre for Research and Training (CATIE) also in Costa Rica.

The data obtained were used to generate a Similarity Matrix according to Jaccard's criteria and a phenogram was built. High variability among the AA clones and a low variability, among the AAA, AAB, ABB triploids were observed (Cabrera *et al.*, 1998). Crouch *et al.* (1999) compared different PCR based marker systems *viz.*, RAPD, VNTRs, AFLP in the analysis of breeding populations generated from two diverse *Musa* breeding schemes. All three assays detected a high level of polymorphism between parental genotypes and within progeny populations. AFLP assays had the highest multiplex ratio while VNTR analysis detected the highest level of polymorphism. RAPD analysis of a full sib triploid hybrid population suggested a high frequency of homologous recombination during n (2x) gamete formation by tetraploid hybrids. Genetic diversity among seventy six plantain land races has been studied by Crouch *et al.* (2000) using RAPD analysis at two levels of intensity and compared with groupings based on phenotypic indices and morphotypes. There was also a poor correlation between RAPD analysis and the grouping and the morphotypes do not provide a true reflection of overall genetic divergence. RAPD analysis of fifteen African plantain land races by Newbury *et al.* (2000) revealed a very low proportion of polymorphic bands (13 of 276). However, further examination of these thirteen marker bands demonstrated that they varied within land races and could not be used to distinguish between land races. With the aim of identifying RAPD markers for the A and B genome, Pillay *et al.* (2000) used eight 10-mer Operon primers to amplify DNA from *Musa acuminata* sub sp. *burmanicoides* clone Calcutta 4 (AA genomes) and *Musa balbisiana* clone Honduras (BB genomes). Three primers (OPA-17, OPA-18 and OPD-16) that produced unique genome specific fragments in the two species were identified. The results showed that RAPD analysis can provide a quick and reliable system for genome identification in *Musa* that could facilitate genome characterization and multiplications in breeding lines. Pillay *et al.* (2001) studied the genetic diversity and phylogenetic relationship of twenty nine East African high land banana cultivars using

RAPDs. A genetic Similarity Matrix was established based on the presence or absence of polymorphic amplified fragments. UPGMA and cluster analysis were used to determine phylogenetic relationships. RAPD showed that the highland bananas were closely related with a narrow genetic base. Simi (2001) characterized the eleven ecotypes of Nendran banana using RAPD technology. A total of 106 RAPDs were generated. Of these 100 bands were polymorphic which accounted to an average of 2.5 polymorphic bands per primer. Eight primers (OPA-01, OPA-03, OPA-13, OPB-01, OPB-06, OPB-10, OPB-12 and OPB-18) produced reproducible banding pattern on atleast two runs. These primers yielded 42 scorable bands with an average of 5.25 bands per primer. The Similarity Coefficient values ranged from 0.333 to 0.935 and the genetic distance varied from 0.042 to 0.349. From the dendrogram, it was grouped into five clustered groups. Kahangi *et al.* (2002) examined seventeen *Musa* cultivars for RAPD markers using PCR with ten 10-mer primers. The study included five reference cultivars of genomic groups AA, AB, AAA, AAB and ABB. The ten primers generated 69 genetic markers that were used for estimation of genomic groups and for cultivar identification. The Pair-wise RAPD distance analysis of the data and subsequent generation of the dendrogram using the "Neighbour" "Joining Tree" program grouped the cultivars into two clusters depending on their genomic similarities.

MATERIALS AND METHODS

3. MATERIALS AND METHODS

The present investigation on 'Screening banana (*Musa* sp.) varieties for leaf production' was undertaken at the Department of Horticulture, College of Agriculture, Vellayani, Thiruvananthapuram during 2002-2003. The location is situated at $8^0 5'$ North latitude, $77^0 1'$ East longitude and at an altitude of 29 m above the mean sea level. Soil of the experimental site is red loam belonging to Vellayani series.

Sword suckers of uniform size and age were selected and planted in September 2002. The suckers were planted at a spacing of 1 x 1 m. The plants were maintained with uniform cultural operations during the cropping period as per the package of practice recommended by Kerala Agricultural University (KAU, 1996).

The experimental design adopted was Randomized Block Design with three replications and four numbers of plants per treatment (Plate 1). The treatments included six varieties of banana and leaf pruning as described below.

Pruning levels

T_1 – Pruning all the leaves seven days after unfurling

T_2 – Pruning alternate leaves seven days after unfurling

T_3 – No leaf pruning (control) (Plate 2).

Varieties

V_1 – Elavazhai (BB)

V_2 – Monthan (ABB)

V_3 – Njalipoovan (AB)

V_4 – Palayankodan (AAB)

V_5 – Vayalvazhai (ABB)

V_6 – Karpooravalli (ABB)

Plate 1. General view of the experimental field

A. Pruning all the leaves

B. Pruning alternate leaves

C. Control

Plate 2. Leaf pruning treatments

Table 1. Treatment combinations

Sl. No	Treatment No.	Levels of pruning
1	V_1T_1	Pruning all the leaves seven days after unfurling in var. Elavazhai
2	V_1T_2	Pruning alternate leaves seven days after unfurling in var. Elavazhai
3	V_1T_3	No leaf pruning in var. Elavazhai
4	V_2T_1	Pruning all the leaves seven days after unfurling in var. Monthan
5	V_2T_2	Pruning alternate leaves seven days after unfurling in var. Monthan
6	V_2T_3	No leaf pruning in var. Monthan
7	V_3T_1	Pruning all the leaves seven days after unfurling in var. Njalipoovan
8	V_3T_2	Pruning alternative leaves seven days after unfurling in var. Njalipoovan
9	V_3T_3	No leaf pruning in var. Njalipoovan
10	V_4T_1	Pruning all the leaves seven days after unfurling in var. Palayankodan
11	V_4T_2	Pruning alternate leaves seven days after unfurling in Palayankodan
12	V_4T_3	No leaf pruning in var. Palayankodan
13	V_5T_2	Pruning all the leaves seven days after unfurling in var. Vayalvazhai
14	V_5T_2	Pruning alternative leaves seven days after unfurling in var. Vayalvazhai.
15	V_5T_3	No leaf pruning in var. Vayalvazhai
16	V_6T_1	Pruning all the leaves seven days after unfurling in var. Karpooravalli
17	V_6T_2	Pruning alternative leaves seven days after unfurling in var. Karpooravalli
18	V_6T_3	No leaf pruning in var. Karpooravalli

The treatments were imposed one month after planting during which period the plant had produced leaves for its initial growth.

Observations on the effect of pruning treatments on the biometric characters in the different varieties were recorded. Molecular characterization of the varieties were also carried out.

3.1 BIOMETRIC CHARACTERS

Observations were recorded from all the plants of each replication and average values were worked out.

3.1.1 Plant Height

Plant height (cm) was recorded from the soil level to the base of the unopened leaf. Observations were recorded at monthly intervals till flowering. From the data, plant height during specific stages of growth were computed.

3.1.2 Plant Girth

Plant girth (cm) at monthly intervals was recorded at 10 cm above the ground level till flowering. From the data plant girth during specific stages of growth were computed.

3.1.3. Leaf emission rate

The number of leaves emerged was recorded at monthly intervals till flowering.

3.1.4 Number of leaves produced

The total number of leaves produced by the banana plant in the entire ontogeny, from the emergence of the first commercially acceptable leaf to the flag leaf emerging before the on set of inflorescence, was recorded at monthly intervals.

3.1.5 Number of leaves harvested

Number of leaves harvested per plant at monthly intervals was recorded till flowering

3.1.6 Number of marketable leaves

Number of marketable leaves, which are commercially acceptable were counted per plant and recorded at monthly intervals till flowering.

3.1.7 Length, breadth and thickness of leaves

Length of the leaf was measured from the base of the lamina to the tip and recorded in centimeters.

Breadth of the leaf was measured at the broadest point in the middle region and recorded in centimeters.

Thickness of the leaf was measured at the middle region using screw gauge and recorded in millimeters.

3.1.8. Leaf area and Leaf area index (LAI)

The leaf area index was calculated using the following formula suggested by Watson (1952).

$$LAI = \frac{\text{Leaf area per plant}}{\text{Area occupied by the plant}}$$

The leaf area was calculated using the equation developed by Murray (1960).

$LA = L \times W \times 0.8$

LA – Leaf area per leaf

L – Length of leaf

W – width of leaf

3.1.9 Duration of leaf harvest

The duration of leaf harvest was recorded from the date of first pruning to visual bunch emergence and expressed in days.

3.1.10 Incidence of pests and diseases

The various disease and pests observed in the plant were recorded as and when they appeared. Disease scoring was carried out as per the method suggested by Suharban (1977).

3.1.11 Economics of cultivation

Benefit/cost ratio of various treatments were worked out, considering all aspects of cost of cultivation and the income derived from the plants. Cost of cultivation was calculated based on the norms and rates fixed by the Instructional Farm, College of Agriculture, Vellayani.

3.2 MOLECULAR CHARACTERIZATION

3.2.1 Materials

Six clones of banana were used in the study for molecular characterization. The tissues from the emerging leaves of all the clones of banana, before they fully unfurled, were used.

3.2.2 Methods

3.2.2.1 Isolation of Genomic DNA

The genomic DNA was isolated following modified Walbot (1988) method. About 1 g of emerging leaves of banana clones before they fully unfurled was used for DNA extraction. The leaves were collected in the morning hours and were first washed in running tap water and later in distilled water two to three times after chopping the leaves coarsely. After wiping off the water using tissue paper, the chopped leaves were placed in a cool dry porcelain mortar and were ground well to a fine powder in liquid nitrogen. The powder was transferred to the extraction buffer (168 g Urea, 28 ml 5M NaCl, 20 ml 1M tris HCL, pH 8, 16 ml 0.5 M EDTA, 20 ml phenol, made upto 400 ml with sterile water) placed in the water bath at a temperature of 55^0C. A volume of 2.5ml of 20 per cent SDS (5 g SDS, 25 ml sterile distilled water) and a pinch of polyvinyl pyrollidone (PVP) were added and mixed gently. The temperature of the water bath was set at 50^0C and the lysis buffer was allowed to equilibrate at this temperature. The solution was kept at 50^0C for ten minutes. The lysate was then squeezed through four layers of sterile muslin cloth. Then 25 ml of phenol:chloroform:isoamyl alcohol (25:24:1) solution was added, mixed gently and kept at room temperature for 15 minutes. The same was then

centrifuged at 10000 rpm for ten minutes at 4.0^0C. After collecting the upper phase, the phenol:chloroform:isoamyl alcohol extraction was repeated until the interphase disappeared. After that, the aqueous phase was collected, equal volume of chloroform:isoamyl alcohol (24:1) solution was added and the two phases were mixed gently. Centrifugation was done at 10000 rpm for ten minutes at 4.0^0C. To the upper phase collected $1/10^{th}$ volume of 3.0 M sodium acetate and double the volume of cold absolute ethanol were added. It was mixed gently and DNA strings were spooled out with a glass rod. The DNA was washed with 70 per cent cold ethanol. The pellet was allowed to dry and dissolved in 100 :l to 200 :l of TE buffer (10 mM Tris HCl, pH 8.0, 1 mM EDTA, pH 8.0) and stored at 4.0^0C.

All the materials used in the preparation and storage of reagents including reagent bottles, conical flasks, centrifuge tubes, spatula, glass rods, funnels and tips of micro pipettes were washed with Labolin solution, rinsed with distilled water and autoclaved for 45 minutes before use. Phenol used was saturated and equilibrated using Tris buffer and pH adjusted to 8.0.

3.2.2.2 Quantification of DNA

DNA quantification was carried out with the help of UV-Vis Spectrophotometer (Spectronic Genesis 5). The spectrophotometer was calibrated at 260 nm and 280 nm wave length using TE buffer, in which DNA was dissolved. The optical density (OD) of the DNA sample dissolved in the buffer was recorded at both 260 nm and 280 nm. Since an OD of 1.0 at 260 nm represent 50 $\mu g\ ml^{-1}$ of DNA, the quantity of DNA in the sample was estimated by employing the following formula.

Amount of DNA ($\mu g\ ml^{-1}$) = A_{260} x 50 x dilution factor

(where, A_{260} = absorbance at 260 nm)

The quantity of DNA could be judged from the ratio of the OD values recorded at 260 nm and 280 nm. A ratio between, 1.6 and 1.8 ml indicated good quality of DNA.

3.2.2.3 Agarose Gel Electrophoresis

Agarose gel electrophoresis was carried out in a horizontal gel electrophoresis unit. The required amount of agarose was weighed out (0.9 % for visualizing the genomic DNA and 1.4 % for visualizing the amplified product) and added to 1 x TAE buffer. Agarose was dissolved by boiling. After cooling to about 50^0C, ethidium bromide was added to a final concentration of 0.5 :gml^{-1}. The mixture was poured immediately to a gel tray with appropriate comb. After solidification the comb and the sealing tapes were removed and the gel was mounted in an electrophoresis tank filled with 1x TAE running buffer. The gel was completely covered on the surface by the buffer. The DNA samples were mixed with required volume of gel loading buffer (6.0 x loading dye *viz.*, 40 % sucrose, 0.25 % bromophenol blue). Each well was loaded with 20 :l of the sample. One of the wells was loaded with 5.0 :l of 100 bp ladder molecular weight marker along with required volume of gel loading buffer (1 :l of molecular weight marker, 2 :l of dye, 3 :l of gel loading 1 x TAE buffer).

Electrophoresis was performed at 75 volts until the loading dye reached $3/4^{th}$ length of the gel. The gel was visualized using an ultra-visible (UV-Vis) transilluminator (Appligene Oncor, France).

3.2.2.4 Random Amplified Polymorphic DNA (RAPD) Analysis

Random Amplified Polymorphic DNA analysis was performed following the method recommended by Bhat and Jarret (1995) with required modification. Forty arbitrarily designed decamer primers supplied by Operon Inc., CA, USA were used.

Genomic DNA (20 ng) was amplified *in vitro* in a 25 :l reaction mixture containing 2.5 :l 1x buffer (10 mM Tris HCl, pH 8.0, 1.5 mM $MgCl_2$, 50 mM KCl and 0.01 % gelatin), 5 pM primer, 200 :M each of

deoxy nucleotides (dNTPs) and 0.6 units of Taq DNA polymerase (Bangalore Genei Pvt. Ltd., Bangalore). Amplifications were carried out in a Programmable Thermal Controller (MJ Research Inc.,USA) set for the following programme: An initial denaturation at 95^0C for 3.0 minutes, followed by 45 cycles of denaturation at 95^0C for 1.0 minute, annealing at 36^0C for 1.0 minute 30 seconds and extended at 72^0C for 2.0 minutes. The synthesis step of the final cycle was extended further by 6.0 minutes. Finally, the products of amplification were cooled to 4.0^0C until attended. A negative control containing water, instead of template DNA was included in each reaction set.

Amplified products along with DNA molecular weight marker supplied by US Biochemicals were separated by electrophoresis using 1.4 per cent agarose gel stained with ethidium bromide and visualized on a UV transilluminator.

The number of monomorphic bands, number of polymorphic bands and intensity of bands were recorded. Those primers which when used for amplification produced the maximum number of bands were used to amplify the DNA isolated from all the banana clones. The number of RAPD bands, represented as '+' (for presence) and '-' (for absence) were recorded. The PCR was repeated at least twice in order to check the reproducibility. The amplification products of those primers alone, which could produce amplification for most of the clones were used for further analysis.

3.2.2.5 Data Analysis

The reproducible bands were scored for their presence (+) or absence (-) for all the banana clones studied. A genetic Similarity Matrix was constructed using the Jaccard's Co-efficient Method (Jaccard, 1908),

$$S_{ij} = a / (a + b + c)$$

where,

a- Number of bands present in both the clones in a pair

b- Number of bands present in the first clone but not in the second one

c- Number of bands in the second clone but not in the first

Based on the similarity coefficient, the distance between the clones was computed and a dendogram was constructed by following the nearest neighbour (Single link) method (Krzanowski, 1988). Association between the various clones was found out from the dendrogram.

RESULTS

4. RESULTS

The present investigations on "Screening banana (*Musa* sp.) varieties for leaf production" was conducted at the Department of Horticulture, College of Agriculture, Vellayani, Thiruvananthapuram during 2002 – 2003. The objective of the study was to evaluate the changes in leaf production pattern of banana varieties due to leaf pruning and to select banana varieties for commercial leaf production. Molecular characterization of banana varieties included in the study was also carried out to obtain preliminary information on their genetic makeup. During the course of the experiment, plant growth under different leaf pruning conditions were critically observed. The results of the study are presented in this chapter.

4.1 EFFECT OF LEAF PRUNING ON GROWTH CHARACTERS

4.1.1 Effect of leaf pruning on plant height

The results of the studies on the effect of leaf pruning on plant height of six banana clones are presented in Table 2 and Fig. 1.

The data on the interaction effect of leaf pruning levels and the cultivars indicated that, there was significant difference in plant height between treatments during the third, fifth and seventh month after planting as well as at bunch emergence stage. At third month, the plants were the tallest in V_1T_3 (98.50cm), which was statistically on par with V_6T_3 (96.33), V_1T_2 (94.71 cm) and V_6T_2 (94.25 cm). The lowest plant height was observed in V_1T_1 (68.71 cm), which was statistically on par with V_2T_1 (68.75 cm), V_5T_1 (68.88 cm) and V_3T_1 (70.88 cm). The treatments V_2T_3 (87.09 cm) V_4T_3 (86.99 cm), V_4T_2 (82.21 cm), V_3T_3 (80.71 cm) and V_5T_3 (80.67 cm) were statistically on par and following V_6T_2. Treatment V_5T_3 was followed by V_4T_1 (79.67 cm), V_3T_2 (79.25 cm), V_6T_1 (75.84 cm) V_2T_2 (75.34 cm) and V_5T_2 (74.67 cm); these treatments being statistically on par.

Table 2. Effect of leaf pruning and varieties on height of banana

Treatment	Height of plant, cm			
	Stages after planting			
	3 months	5 months	7 months	At bunch emergence
V_1T_1	68.71	126.25	170.67	245.42
V_1T_2	94.71	173.54	229.71	328.84
V_1T_3	98.50	184.25	258.25	356.75
V_2T_1	68.75	124.13	167.17	250.21
V_2T_2	75.34	152.67	213.75	316.58
V_2T_3	87.09	173.09	247.96	343.29
V_3T_1	70.88	124.17	164.74	240.21
V_3T_2	79.25	152.64	206.21	284.91
V_3T_3	80.71	157.67	221.08	325.96
V_4T_1	79.67	145.92	194.84	282.46
V_4T_2	82.21	164.29	230.25	344.63
V_4T_3	86.99	175.32	255.46	378.31
V_5T_1	68.88	120.34	152.42	217.25
V_5T_2	74.67	151.14	203.99	286.85
V_5T_3	80.67	150.34	219.38	295.49
V_6T_1	75.84	124.67	160.18	228.25
V_6T_2	94.25	169.67	221.92	300.83
V_6T_3	96.33	179.04	246.33	338.04
SE	2.37	2.57	3.84	4.62
CD (0.05)	6.84	7.37	11.02	13.27
V_1	87.31	161.35	219.54	310.34
V_2	77.06	149.96	209.63	303.36
V_3	76.95	144.83	197.34	283.69
V_4	82.96	161.84	226.85	335.13
V_5	74.74	140.60	191.93	266.53
V_6	88.81	157.79	209.48	289.04
SE	1.37	1.48	2.22	2.67
CD (0.05)	3.93	4.25	6.37	7.66
T_1	72.12	127.58	168.34	243.97
T_2	83.41	160.66	217.64	310.44
T_3	88.38	169.95	241.41	339.64
SE	0.97	1.05	1.57	1.89
CD (0.05)	2.78	3.01	4.50	5.42

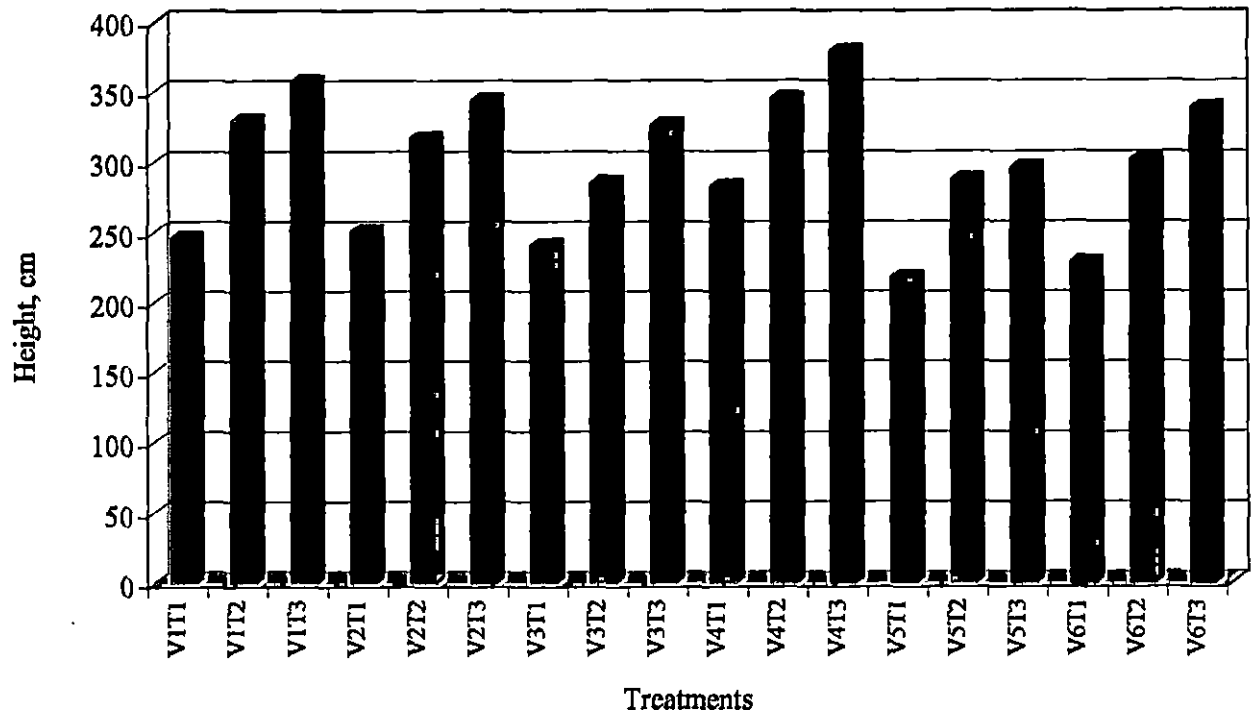


Fig. 1. Combined effect of leaf pruning and varieties on height of banana

At fifth month after planting, the highest value for plant height was recorded in V_1T_3 (184.25cm), which was statistically on par with V_6T_3 (179.04 cm). The lowest height of plants was recorded in V_5T_1 (120.34 cm), which was on par with V_2T_1 (124.13 cm), V_3T_1 (124.17cm), V_6T_1 (124.67 cm) and V_1T_1 (126.25 cm). The treatments V_4T_3 (175.32 cm), V_1T_2 (173.54 cm), V_2T_3 (173.09 cm) and V_6T_2 (169.67 cm) were statistically on par and were next to V_6T_3. These treatments were followed by V_4T_2 (164.29 cm) and V_3T_3 (157.67 cm), which were on par. Treatment V_3T_3 was followed by V_2T_2 (152.67 cm), V_3T_2 (152.64 cm), V_5T_2 (151.14 cm), V5T3 (150.34 cm) and V_4T_1 (145.92 cm), which inturn were on par.

At seventh month after planting the highest values for plant height were recorded in V_1T_3 (258.25 cm), which was on par with V_4T_3 (255.46 cm) and V_2T_3 (247.96 cm). The next best treatment was V_6T_3 (246.33 cm). Treatment V_6T_3 was followed by V_4T_2 (230.25 cm), V_1T_2 (229.71 cm), V_6T_2 (221.92 cm), V_3T_3 (221.08 cm) and V_5T_3 (219.38 cm), which were statistically on par. This was followed by V_2T_2 (213.75 cm), V_3T_2 (206.21 cm) and V_5T_2 (203.99 cm) and they were statistically on par followed by V_4T_1 (194.84 cm). The lowest height was in V_5T_1 (152.42 cm) followed by V_6T_1 (160.18 cm), which was on par with V_3T_1 (164.74 cm), V_2T_1 (167.17 cm) and V_1T_1 (170.67 cm).

At bunch emergence stage, the highest values were recorded in V_4T_3 (378.31 cm) which differed significantly from all other treatments. This treatment was followed by V_1T_3 (356.75 cm), which was statistically on par with V_4T_2 (344.63 cm). Treatment V_4T_2 was followed by V_2T_3 (343. 29 cm) and V6T3 (338.04 cm), which were statistically on par. The treatments V_1T_2 (328.84 cm), V_3T_3 (325.96 cm) and V_2T_2 (316.58 cm) that followed V_6T_3 were on par. These treatments were followed by V_6T_2 (300.83 cm) and V_5T_3 (295.49 cm), which did not differ from one another statistically. The treatments V_5T_2 (286.85 cm), V_3T_2 (284.91 cm) and V_4T_1 (282.46 cm), which followed the former were on par. The lowest plant

height was recorded in V_5T_1 (217.25 cm), which was on par with V_6T_1 (228.25 cm) followed by V_3T_1 (240.21 cm), V_1T_1 (245.42 cm) and V_2T_1 (250.21 cm) and these treatments were not significantly differed from others.

Effect of cultivars significantly influenced the height of plants in all the stages. At third month after planting the plants were the highest in Karpooravalli (V_6-88.81 cm), which was on par with Elavazhai (V_1-87.31 cm). This was followed by Palayankodan (V_4-82.96 cm), which significantly differed from all other treatments. The lowest value was recorded in Vayalvazhai (V_5-74.74 cm), which was on par with Njalipoovan (V_3-76.95 cm) and Monthan (V_2-77.06 cm).

At fifth month after planting, plants were the tallest in Palayankodan (V_4-161.84 cm), which was on par with Elavazhai (V_1-161.35 cm) and Karpooravalli (V_6-157.79 cm). These were followed by Monthan (V_2-149.96 cm). The lowest plant height was recorded in Vayalvazhai (V_5-140.60 cm) and was on par with Njalipoovan (V_3-144.83 cm).

At seventh month after planting the tallest plants were observed in Palayankodan (V_4-226.85 cm) followed by Elavazhai (V_1-219.54 cm); the treatments statistically differed from one another. The lowest plant height was recorded in Vayalvazhai (V_5-191.93 cm), which was on par with Njalipoovan (V_3-197.34 cm). Monthan (V_2-209.63 cm) and Karpooravalli (V_6-209.48 cm) were intermediate in plant height and were not significantly differed from each other.

At bunch emergence stage, the highest values for plant height was recorded in Palayankodan (V_4-335.13 cm) followed by Elavazhai (V_1-310.34 cm) and Monthan (V_2-303.36 cm), the latter two being statistically on par. The lowest values were recorded in Vayalvazhai (V_5-266.53 cm) followed by Njalipoovan (V_3-283.69 cm), which was on par with Karpooravalli (V_6-289.04cm).

Effect of pruning levels significantly influenced the height of plants. In all stages, the treatment T_3 (No leaf pruning) recorded the

highest values for plant height and it differed significantly from all other treatments. The treatment T2 (pruning alternate leaves seven days after unfurling) followed T3 and differed significantly from T1 (pruning all the leaves seven days after unfurling), which was the lowest.

In general the interaction effect of varieties and leaf pruning indicated that, treatment T_1 (pruning all the leaves seven days after unfurling) had the most deleterious effect on plant height attained by the varieties. The control plots (No leaf pruning) had recorded the tallest plants.

The varieties Elavazhai, Palayankodan and Karpooravalli had less adverse effects on plant height when alternate leaves were pruned seven days after unfurling.

Effect of treatments on varieties indicated that Palayankodan followed by Elavazhai, and Karpooravalli were less affected by leaf pruning.

Among the pruning strategies, pruning alternate leaves seven days after unfurling had less harmful effect on plant height.

4.1.2 Effect of leaf pruning on girth of banana

The results of the studies on the effect of leaf pruning on plant girth of six banana cultivars are presented in Table 3.

The data on the interaction effect of leaf pruning levels and the cultivars indicated that, there was significant difference in plant girth between treatments during seventh month after planting as well as at the bunch emergence stage.

At seventh month, the highest plant girth was observed in V_4T_3 (55.21 cm), which was on par with V_1T_2 (52.34 cm). The treatments V_6T_3 (51.96 cm), V_1T_3 (50.63 cm), V_4T_2 (50.13cm), V_3T_3 (50.00 cm), V_1T_1 (50.00 cm) and V_6T_2 (48.92 cm) were statistically on par and following V_1T_2. Treatment V_6T_2 was followed by V_2T_3 (48.54 cm), V_6T_1 (47.81 cm), V_2T_2 (46.21 cm), V_4T_1 (45.88 cm), V_5T_3 (45.52 cm) and V_3T_2 (45.52

Table 3. Effect of leaf pruning and varieties on girth of banana

Treatment	Girth of plant, cm			
	Stages after planting			
	3 months	5 months	7 months	At bunch emergence
V_1T_1	32.09	41.96	50.00	63.67
V_1T_2	31.54	43.38	52.34	70.71
V_1T_3	31.42	41.92	50.63	65.92
V_2T_1	28.38	37.59	42.63	54.29
V_2T_2	29.13	39.29	46.21	56.88
V_2T_3	29.92	39.58	48.54	65.00
V_3T_1	29.09	37.57	40.40	52.54
V_3T_2	30.59	39.77	45.52	57.53
V_3T_3	31.25	41.92	50.00	65.25
V_4T_1	29.63	38.59	45.88	60.13
V_4T_2	31.67	41.71	50.13	64.63
V_4T_3	33.40	45.52	55.21	70.42
V_5T_1	29.04	35.63	40.79	49.46
V_5T_2	28.82	36.57	42.93	53.75
V_5T_3	29.56	37.99	45.52	58.67
V_6T_1	30.43	39.97	47.81	63.21
V_6T_2	30.63	41.00	48.92	64.33
V_6T_3	31.79	42.88	51.96	66.33
SE	0.765	0.953	1.10	1.35
CD (0.05)	NS	NS	3.15	3.88
V_1	31.68	42.42	50.99	66.77
V_2	29.14	38.82	45.79	58.73
V_3	30.31	39.75	45.31	58.44
V_4	31.57	41.94	50.40	65.06
V_5	29.14	36.73	43.08	53.96
V_6	30.95	41.28	49.56	64.63
SE	0.442	0.550	0.634	0.780
CD (0.05)	1.27	1.58	1.82	2.24
T_1	29378	38.55	44.59	52.22
T_2	30.40	40.29	47.67	61.31
T_3	31.22	41.63	50.31	65.27
SE	0.312	0.389	0.448	0.552
CD (0.05)	0.897	1.12	1.29	1.59

cm); these treatments being statistically on par. While the lowest was observed in V_3T_1 (40.40 cm), which was on par with V_5T_1 (40.79 cm), V_2T_1 (42.63 cm) and V_5T_2 (42.93 cm).

At bunch emergence stage, the highest plant girth was recorded in V_1T_2 (70.71 cm) and V_4T_3 (70.42 cm), which were not differed significantly. The treatments V_6T_3 (66.33 cm), V_1T_3 (65.92 cm), V_3T_3 (65.25 cm), V_2T_3 (65.00 cm), V_4T_2 (64.63 cm), V_6T_2 (64.33 cm), V_1T_1 (63.67 cm) and V_6T_1 (63.21cm) were statistically on par and were next to V_4T_3. These treatments were followed by V_4T_1 (60.13 cm), V_5T_3 (58.67 cm), V_3T_2 (57.53 cm), and V_2T_2 (56.88 cm), which were on par. The lowest plant girth was recorded in V_5T_1 (49.46 cm) followed by V_3T_1 (52.54 cm), which was on par with V_5T_2 (53.75 cm) and V_2T_1 (54.29 cm).

Effect of cultivars significantly influenced the girth of plants in all the stages. At third month after planting, the highest plant girth was observed in Elavazhai (V_1-31.68 cm) which was on par with Palayankodan (V_4-31.57 cm) and Karpooravalli (V_6-30.95 cm). The lowest plant girth was observed in Vayalvazhai (V_5-29.14 cm), which was on par with Monthan (V_2-29.14 cm) and Njalipoovan (V_3-30.31 cm).

At fifth month after planting, the highest plant girth was observed in Elavazhai (V_1-42.42 cm), which was on par with Palayankodan (V_4-41.94 cm) and Karpooravalli (V_6-41.28 cm). The lowest plant girth was recorded in Vayalvazhai (V_5-36.73 cm), which differed significantly from other treatments, followed by Monthan (V_2-38.82 cm) and Njalipoovan (V_3-39.75 cm), which were not differed significantly from one another.

At seventh month after planting, Elavazhai (V_1-50.99 cm) recorded the highest plant girth, which was on par with Palayankodan (V_4-50.40 cm) and Karpooravalli (V_6-49.56 cm). The varieties Monthan (V_2-45.79 cm) and Njalipoovan (V_3-45.31 cm) were statistically on par and were next to Karpooravalli. The lowest plant girth was recorded in Vayalvazhai (V_5-43.08 cm).

At bunch emergence stage, Elavazhai (V_1-66.77 cm) recorded the highest plant girth, which was on par with Palayankodan (V_4-65.06 cm) and Karpooravalli (V_6-64.63cm). These cultivars were followed by Monthan (V_2-58.73 cm) and Njalipoovan (V_3-58.44 cm), which were statistically on par. The lowest plant girth was observed in Vayalvazhai (V_5-53.96 cm).

Effect of pruning levels significantly influenced the girth of plants. In all the stages, the treatment T_3 (no leaf pruning) recorded the highest values for plant girth and differed significantly from the other treatments, except at third month of planting where T_3 was on par with T_2 (pruning alternate leaves seven days after unfurling). The treatment T_2 followed T_3 and differed significantly from T_1 (pruning all the leaves seven days after unfurling), which was the lowest.

In general, effect of varieties and leaf pruning indicated that treatment T_1 (pruning all the leaves seven days after unfurling) had the most deleterious effect on the varieties followed by T_2 (prior alternate leaves seven days after unfurling). The plants in the control plots (no leaf pruning) had recorded the highest plant girth. The varieties Elavazhai, Palayankodan and Karpooravalli had less adverse effects on plant girth when alternate leaves were pruned seven days after unfurling.

Effect of treatments on varieties indicated that Elavazhai followed by Palayankodan, Karpooravalli were comparatively less affected by leaf pruning.

Among the pruning strategies, pruning alternate leaves seven days after unfurling had moderate harmful effect on plant girth.

4.1.3 Effect of leaf pruning on leaf emission rate of banana

The results of the studies on the effect of leaf pruning on leaf emission rate of six banana cultivars are presented in Table 4; Fig 2 and 3.

The data on the interaction effect of leaf pruning levels and the cultivars indicated that, there was significant difference in leaf emission

Table 4 . Effect of leaf pruning and varieties on leaf emission rate of banana

Treatment	Leaf emission rate, cm											Mean
	Months after planting											
	1	2	3	4	5	6	7	8	9	10	11	
V_1T_1	3.77	3.96	3.92	4.06	5.96	4.75	4.94	4.27	3.75	3.60	2.94	4.17
V_1T_2	3.75	3.58	3.58	3.83	3.75	4.25	4.00	3.42	3.42	3.00	0.00	3.66
V_1T_3	3.67	3.67	3.75	4.00	3.83	4.75	4.75	3.42	3.08	3.17	0.00	3.81
V_2T_1	2.90	2.98	2.92	2.94	3.00	3.12	3.31	3.19	3.04	3.00	3.04	3.04
V_2T_2	3.10	3.10	3.23	3.19	3.17	3.09	3.13	3.15	3.08	3.17	3.17	3.14
V_2T_3	3.19	3.38	3.31	3.15	3.17	3.02	3.23	3.19	3.11	3.06	0.00	3.18
V_3T_1	3.14	3.18	3.44	3.23	3.68	4.00	3.80	3.56	3.38	3.37	3.33	3.46
V_3T_2	3.37	3.15	3.17	3.04	3.09	3.12	3.29	3.14	3.07	3.15	3.04	3.15
V_3T_3	3.02	3.25	3.10	3.19	3.19	3.29	3.31	3.33	3.42	3.11	3.04	3.20
V_4T_1	3.44	3.67	3.71	3.50	3.52	3.90	3.98	3.81	3.71	3.61	3.44	3.66
V_4T_2	3.17	3.38	3.25	3.27	3.17	3.15	3.17	3.27	3.19	3.13	3.12	3.21
V_4T_3	3.36	3.29	3.21	3.14	3.36	3.27	3.09	3.29	3.20	3.23	3.14	3.23
V_5T_1	3.27	3.13	3.06	3.02	3.15	2.96	3.17	2.98	2.92	2.98	3.06	3.06
V_5T_2	3.17	3.19	3.14	3.22	3.22	2.99	3.22	3.41	3.14	3.06	3.13	3.17
V_5T_3	3.32	3.54	3.42	3.42	3.45	3.48	3.38	3.32	3.32	3.31	3.21	3.38
V_6T_1	2.90	3.00	3.29	2.97	3.07	2.92	3.08	3.00	2.94	2.99	2.97	3.01
V_6T_2	3.04	3.04	3.06	3.02	3.23	3.11	3.02	3.08	2.98	3.00	2.98	3.05
V_6T_3	3.07	3.15	3.04	2.96	3.02	3.02	3.00	3.23	3.15	3.05	3.11	3.07
SE	0.115	0.150	0.162	0.136	0.141	0.107	0.122	0.154	0.133	0.127	0.124	0.155
CD (0.05)	NS	NS	NS	NS	NS	0.307	0.351	0.442	0.382	0.364	0.355	0.445

Table 4. continued...

V_1	3.73	3.74	3.75	3.97	3.85	4.58	4.56	3.70	3.42	3.26	0.98	3.59
V_2	3.06	3.15	3.15	3.09	3.11	3.08	3.22	3.18	3.08	3.08	2.07	3.02
V_3	3.18	3.19	3.24	3.15	3.32	3.47	3.47	3.35	3.29	3.21	3.14	3.27
V_4	3.32	3.45	3.39	3.31	3.35	3.44	3.41	3.46	3.37	3.32	3.23	3.37
V_5	3.25	3.29	3.21	3.22	3.27	3.14	3.25	3.24	3.13	3.11	3.14	3.20
V_6	3.00	3.06	3.13	2.98	3.11	3.01	3.04	3.11	3.02	3.01	3.02	3.04
SE	0.06	0.09	0.09	0.08	0.08	0.06	0.07	0.09	0.08	0.07	0.07	0.08
CD (0.05)	0.19	0.25	0.27	0.23	0.23	0.18	0.20	0.26	0.22	NS	0.21	0.22
T_1	3.24	3.32	3.39	3.29	3.40	3.61	3.71	3.47	3.29	3.26	3.13	3.37
T_2	3.27	3.24	3.24	3.27	3.27	3.28	3.30	3.25	3.15	3.08	2.57	3.17
T_3	3.27	3.38	3.31	3.31	3.34	3.47	3.46	3.30	3.21	0.15	2.08	3.21
SE	0.05	0.06	0.07	0.06	0.06	0.04	0.05	0.06	0.05	0.05	0.05	0.05
CD (0.05)	NS	NS	NS	NS	NS	0.13	0.14	0.18	NS	NS	0.14	0.15

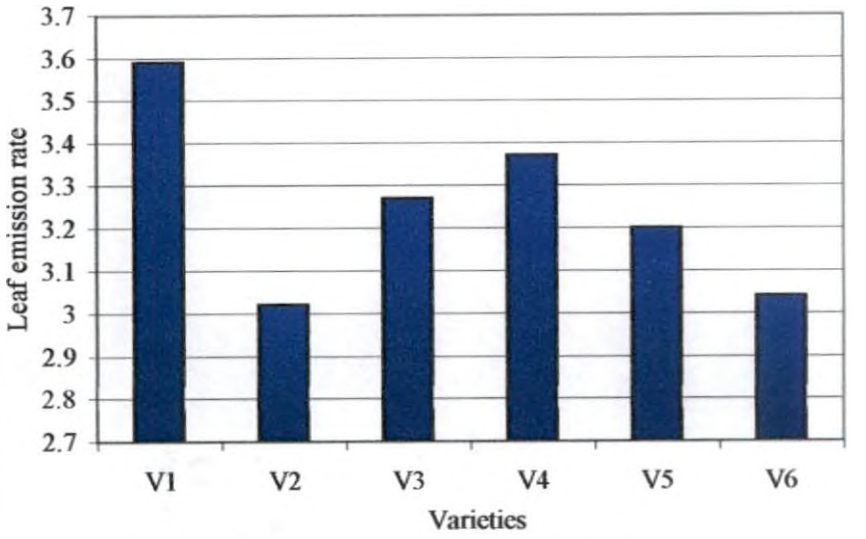


Fig. 2. Effect of varieties on leaf emission rate of banana

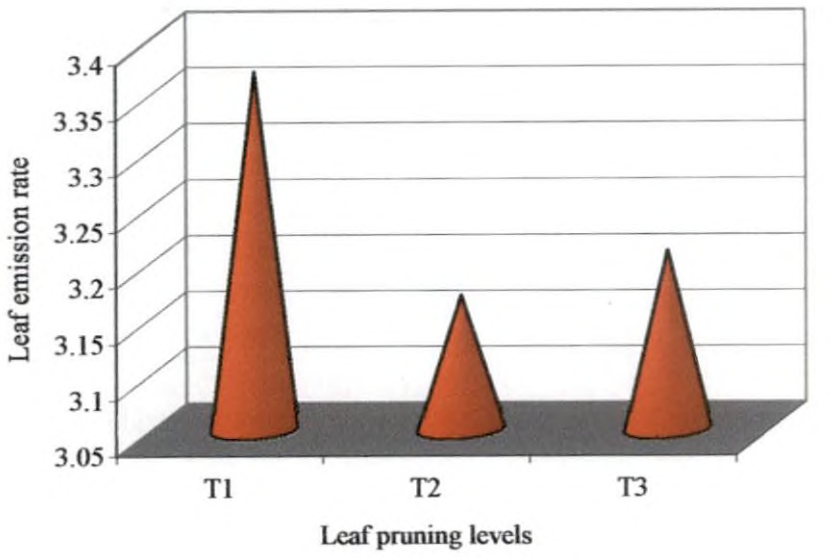


Fig. 3. Effect of leaf pruning on leaf emission rate of banana

rate between treatments during sixth, seventh, eighth, nineth, tenth and eleventh month after planting. At six months after planting, the highest leaf emission rate was recorded in V_1T_1 (4.75), which was on par with V_1T_3 (4.75). The treatments V_1T_2 (4.25) and V_3T_1 (4.00) were statistically on par and following V_1T_3. These treatments were followed by V_4T_1 (3.90), which significantly differed from others. The treatments V_5T_3 (3.48), V_3T_3 (3.29) and V_4T_3 (3.27) were statistically on par and were next to V_4T_1. The lowest leaf emission rate was observed in V_6T_1 (2.92), V_5T_1 (2.96), V_5T_2 (2.99), V_6T_3 (3.02), V_2T_3 (3.02), V_2T_2 (3.09), V_6T_2 (3.12), V_3T_2 (3.12), V_2T_1 (3.12) and V_4T_2 (3.15), which in turn were on par.

At seventh month after planting, the highest leaf emission rate was observed in V_1T_1 (4.94), which was on par with V_1T_3 (4.75). The treatments V_1T_2 (4.00), V_4T_1 (3.98) and V_3T_1 (3.80) were statistically on par and following V_1T_3. These treatments were followed by V_5T_3 (3.38), V_3T_3 (3.31), V_2T_1 (3.31), V_3T_2 (3.29), V_2T_3 (3.23), V_5T_2 (3.22), V_5T_1 (3.17), V_4T_2 (3.17), V_2T_2 (3.13), V_4T_3 (3.09) and V_6T_1 (3.08), which were on par. The lowest leaf emission rate was observed in V_6T_3 (3.00), which was on par with V_6T_2 (3.02).

At eighth month after planting, the highest leaf emission rate was observed in V_1T_1 (4.27). The treatments V_4T_1 (3.81), V_3T_1 (3.56), V_1T_3 (3.42), V_1T_2 (3.42) and V_5T_2 (3.41) were statistically on par and following V_1T_1. The lowest leaf emission rate was observed in V_5T_1 (2.98), V_6T_1 (3.00), V_6T_2 (3.08), V_3T_2 (3.14), V_2T_2 (3.15), V_2T_3 (3.19), V_2T_1 (3.19), V_6T_3 (3.23), V_4T_2 (3.27), V_4T_3 (3.29), V_5T_3 (3.32) and V_3T_3 (3.33), which inturn were on par with one another.

At nineth month after planting, the highest leaf emission rate was recorded in V_1T_1 (3.75) which was on par with V_4T_1 (3.71), V_3T_3 (3.42), V_1T_2 (3.42) and V_3T_1 (3.38). These treatments were followed by V_5T_3 (3.32), V_4T_3 (3.20), V_4T_2 (3.19), V_6T_3 (3.15), V_5T_2 (3.14), V_2T_3 (3.11), V_2T_2 (3.08), V_1T_3 (3.08), V_3T_2 (3.07), V_2T_1 (3.04), V_6T_2 (2.98) and V_6T_1 (2.94). The lowest leaf emission rate was recorded in V_5T_1 (2.92).

At tenth month after planting the highest leaf emission rate was recorded in V_4T_1 (3.61), which was on par with V_1T_1 (3.60), V_3T_1 (3.37) and V_5T_3 (3.31). The lowest leaf emission rate was recorded in V_5T_1 (2.98), V_6T_1 (2.99), V_6T_2 (3.00), V_2T_1 (3.00), V_1T_2 (3.00), V_6T_3 (3.05), V_5T_2 (3.06), V_2T_3 (3.06), V_3T_3 (3.11), V_4T_2 (3.13). V_3T_2 (3.15), V_2T_2 (3.17), V_1T_3 (3.17) and V_4T_3 (3.23), which inturn were statistically on par with one another.

At eleventh month after planting, the highest leaf emission rate was recorded in V_4T_1 (3.44), which was on par with V_3T_1 (3.33), V_5T_3 (3.21), V_2T_2 (3.17), V_4T_3 (3.14), V_5T_2 (3.13), V_4T_2 (3.11) and V_6T_3 (3.11). These treatments were followed by V_5T_1 (3.06), V_2T_1 (3.04), V_3T_3 (3.04), V_3T_2 (3.04), V_6T_2 (2.98), V_6T_1 (2.97) and V_1T_1 (2.94), which were on par. The treatments V_1T_3, V_1T_2 and V_2T_3 had produced no leaves.

The overall mean leaf emission rate indicated that, the highest leaf emission rate was recorded in V_1T_1 (4.17), which was on par with V_1T_3 (3.81). These treatments were followed by V_1T_2 (3.66), V_4T_1 (3.66), V_3T_1 (3.46), V_5T_3 (3.38) and V_4T_3 (3.23), which were statistically on par. The lowest leaf emission rate was recorded in V_6T_1 (3.01), V_2T_1 (3.04), V_6T_2 (3.05), V_5T_1 (3.06), V_6T_3 (3.07), V_2T_2 (3.14), V_3T_2 (3.15), V_5T_2 (3.17), V_2T_3 (3.18), V_3T_3 (3.20) and V_4T_2 (3.21), which did not differ from one another significantly.

Effect of cultivars significantly influenced the leaf emission rate at all the stages except at tenth month after planting.

At first month after planting, Elavazhai (V_1-3.73) recorded high leaf emission rate followed by Palayankodan (V_4-3.32), which was on par with Vayalvazhai (V_5-3.25) and Njalipoovan (V_3-3.18). The lowest leaf emission rate was recorded in Karpooravalli (V_6-3.00), which was on par with Monthan (V_2-3.06).

At second month after planting, Elavazhai (V_1-3.74) recorded the highest leaf emission rate followed by Palayankodan (V_4-3.45), which was on par with Vayalvazhai (V_5-3.29) and Njalipoovan (V_3-3.19). The lowest

leaf emission rate was recorded in Karpooravalli (V_6-3.06), which was on par with Monthan (V_2-3.15).

At third month after planting, the highest leaf emission rate was recorded in Elavazhai (V_1-3.75). The lowest leaf emission rate was recorded in Karpooravalli (V_6-3.13), which was on par with Monthan (V_2-3.15), Vayalvazhai (V_5-3.21), Njalipoovan (V_3-3.24) and Palayankodan (V_4-3.39).

At forth month after planting, the highest leaf emission rate was recorded in Elavazhai (V_1-3.97) followed by Palayankodan (V_4-3.31) which was on par with Vayalvazhai (V_5-3.22), Njalipoovan (V_3-3.15) and Monthan (V_2-3.09). The lowest leaf emission rate was recorded in Karpooravalli (V_6-2.98).

At fifth month after planting, the highest leaf emission rate was recorded in Elavazhai (V_1-3.85). The varieties Palayankodan (V_4-3.35), Njalipoovan (V_3-3.32) and Vayalvazhai (V_5-3.27) were statistically on par and were next to Elavazhai. The lowest leaf emission rate was recorded in Karpooravalli (V_6-3.11) and Monthan (V_2-3.11).

At sixth month after planting, the highest leaf emission rate was recorded in Elavazhai (V_1-4.58). The varieties Njalipoovan (V_3-3.47) and Palayankodan (V_4-3.44) were statistically on par and following Elavazhai. The lowest leaf emission rate was recorded in Karpooravalli (V_6-3.01), Monthan (V_2-3.08) and Vayalvazhai (V_5-3.14), which did not differ from one another significantly.

At seventh month after planting, the highest leaf emission rate was recorded in Elavazhai (V_1-4.56). The varieties Njalipoovan (V_3-3.47) and Palayankodan (V_4-3.41) were statistically on par and following Elavazhai. These varieties were followed by Vayalvazhai (V_5-3.25) and Monthan (V_2-3.22) and were statistically on par with one another. The lowest leaf emission rate was recorded in Karpooravalli (V_6-3.04).

At eighth month after planting the highest leaf emission rate was recorded in Elavazhai (V_1-3.70), which was on par with Palayankodan

(V_4-3.46). The lowest leaf emission rate was recorded in Karpooravalli (V_6-3.11), Monthan (V_2-3.18), Vayalvazhai (V_5-3.24) and Njalipoovan (V_3-3.35), which did not differ from one another statistically.

At nineth month after planting, the highest leaf emission rate was recorded in Elavazhai (V_1-3.42), which was on par with Palayankodan (V_4-3.37) and Njalipoovan (V_3-3.29). The lowest leaf emission rate was recorded in Karpooravalli (V_6-3.02), Monthan (V_2-3.08) and Vayalvazhai (V_5-3.13), which in turn were on par.

At eleventh month after planting, the highest leaf emission rate was recorded in Palayankodan (V_4-3.23), which was on par with Njalipoovan (V_3-3.14), Vayalvazhai (V_5-3.14) and Karpooravalli (V_6-3.02). The lowest leaf emission rate was recorded in Elavazhai (V_1-0.98) followed by Monthan (V_2-2.07).

The overall mean leaf emission rate indicated that, the highest leaf emission rate was recorded in Elavazhai (V_1-3.59), which was on par with Palayankodan (V_4-3.37). These varieties were followed by Njalipoovan (V_3-3.27) and Vayalvazhai (V_5-3.20), which were on par. The lowest leaf emission rate was recorded in Monthan (V_2-3.02), which was on par with Karpooravalli (V_6-3.04).

Effect of pruning significantly influenced the leaf emission rate at sixth, seventh, eighth and eleventh month after planting.

At sixth month after planting, the highest leaf emission rate was recorded in T_1 (pruning all the leaves seven days after unfurling) (3.61) followed by T_3 (no leaf pruning) (3.47) and T_2 (3.28) (pruning alternate leaves seven days after unfurling).

At seventh month after planting, the highest leaf emission rate was recorded in T_1 (pruning all the leaves seven days after unfurling) (3.71) followed by T_3 (3.46) (no leaf pruning) and T_2 (3.30) (pruning alternate leaves seven days after unfurling).

At eighth month after planting, the highest leaf emission rate was recorded in T_1 (pruning all the leaves seven days after unfurling) (3.47)

which was on par with T_3 (3.30) (no leaf pruning). The lowest leaf emission rate was recorded in T_2 (3.25) (pruning alternate leaves seven days after unfurling.

At eleventh month after planting, the highest leaf emission rate was recorded in T_1 (pruning all the leaves seven days after unfurling) (3.13) followed by T_2 (2.57) (pruning alternate leaves seven days after unfurling. The lowest leaf emission rate was recorded in T_3 (2.08) (no leaf pruning).

The overall mean leaf emission rate indicated that the highest leaf emission rate was recorded in T_1 (pruning all the leaves seven days after unfurling) (3.37). The lowest leaf emission rate was recorded in T_2 (3.17) (pruning alternate leaves seven days after unfurling), which was on par with T_3 (3.21) (no leaf pruning).

In general, the data indicated that, in the initial stages of growth, the pruning leaves did not significantly influence the leaf emission rate.

Among the different pruning strategies, the most severe pruning treatment T_1 (pruning all the leaves seven days after unfurling) resulted in higher leaf emission rate compared to lower levels of pruning. Among the varieties, Elavazhai and Palayankodan had the highest leaf emission rate. These varieties were followed by Njalipoovan and Vayalvazhai. The lowest leaf emission rate was observed in Karpooravalli and Monthan.

4.1.4 Effect of leaf pruning on total leaf production

The results of the studies, on the effect of leaf pruning on total leaf production of six banana clones are presented in Table 5; Fig.4 and 5.

The data on the interaction effect of leaf pruning levels and the cultivars indicated that there was no significant difference in total leaf production between treatments during the third, fifth and seventh month after planting, but significant difference was observed only at bunch emergence stage.

At bunch emergence stage, the total leaf production was highest in V_1T_1 (43.92). The treatments V_4T_1 (40.25), V_1T_3 (38.08) and V_3T_1 (38.04)

Table 5. Effect of leaf pruning and varieties on total leaf production

Treatment	Total number of leaves			
	Stages after planting			
	3 months	5 months	7 months	At bunch emergence
V_1T_1	11.65	19.67	27.69	43.92
V_1T_2	10.92	18.50	27.00	36.83
V_1T_3	11.08	18.92	28.42	38.08
V_2T_1	8.67	14.61	20.85	33.13
V_2T_2	9.48	15.82	22.02	34.59
V_2T_3	9.88	16.17	22.42	31.77
V_3T_1	9.76	16.67	24.44	38.04
V_3T_2	10.51	15.81	22.22	34.58
V_3T_3	9.37	15.74	22.33	35.23
V_4T_1	10.79	17.81	25.69	40.25
V_4T_2	9.80	16.23	22.54	35.23
V_4T_3	9.86	16.31	22.62	35.47
V_5T_1	9.46	15.63	21.88	33.82
V_5T_2	9.45	15.94	22.14	34.87
V_5T_3	10.12	16.99	23.84	36.83
V_6T_1	8.96	14.99	20.99	32.94
V_6T_2	9.15	15.40	21.52	33.48
V_6T_3	9.31	15.40	21.42	34.15
SE	0.42	0.57	0.88	1.01
CD (0.05)	NS	NS	NS	2.91
V_1	11.22	19.03	27.70	39.61
V_2	9.34	15.53	21.76	33.16
V_3	9.88	16.08	22.99	35.95
V_4	10.15	16.79	23.62	36.98
V_5	9.68	16.18	22.62	35.17
V_6	9.14	15.26	21.31	33.52
SE	0.24	0.33	0.51	0.59
CD (0.05)	0.69	0.95	1.46	1.68
T_1	9.88	16.56	23.59	37.02
T_2	9.89	16.28	22.91	34.93
T_3	9.94	16.59	23.51	35.26
SE	0.17	0.23	0.36	0.41
CD (0.05)	NS	NS	NS	1.19

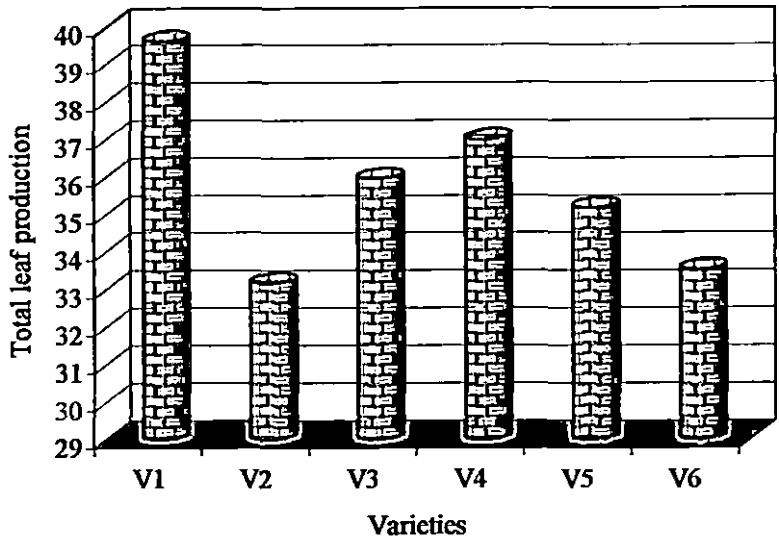


Fig. 4. Effect of varieties on total leaf production

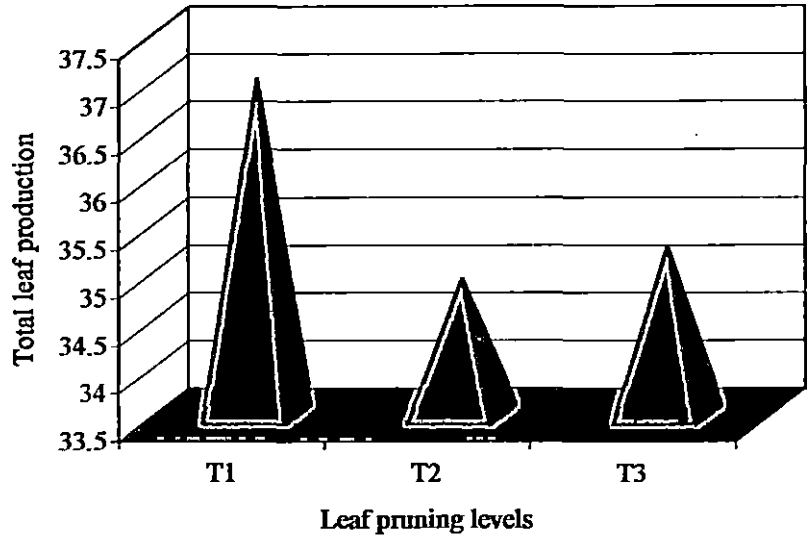


Fig. 5. Effect of leaf pruning on total leaf production

were statistically on par and following V_1T_1. Treatment V_3T_1 was followed by V_1T_2 (36.83), V_5T_3 (36.83), V_4T_3 (35.47), V_3T_3 (35.23), V_4T_2 (35.23), V_5T_2 (34.87), V_2T_2 (34.59). V_3T_2 (34.58) and V_6T_3 (34.15) and these treatments being statistically on par. The lowest leaf production was observed in V_2T_3 (31.77), which was on par with V_6T_1 (32.94), V_2T_1 (33.13), V_6T_2 (33.48) and V_5T_1 (33.82).

Effect of cultivars significantly influenced the total leaf production in all the stages. At third month after planting, the highest leaf production was recorded in Elavazhai (V_1-11.22) followed by Palayankodan (V_4-10.15), which was on par with Njalipoovan (V_3-9.88) and Vayalvazhai (V_5-9.68). The lowest leaf production was recorded in Karpooravalli (V_6-9.14), which was on par with Monthan (V_2-9.34).

At fifth month after planting, the highest leaf production was recorded in Elavazhai (V_1-19.03) followed by Palayankodan (V_4-16.79), which was on par with Vayalvazhai (V_5-16.18) and Njalipoovan (V_3-16.08). The lowest leaf production was recorded in Karpooravalli (V_6-15.26), which was on par with Monthan (V_2-15.53).

At seventh month after planting, the highest leaf production was recorded in Elavazhai (V_1-27.70) followed by Palayankodan (V_4-23.62), which was on par with Njalipoovan (V_3-22.99) and Vayalvazhai (V_5-22.62). The lowest leaf production was recorded in Karpooravalli (V_6-21.31), which was on par with Monthan (V_2-21.76).

At bunch emergence stage, the highest leaf production was recorded in Elavazhai (V_1-39.61) followed by Palayankodan (V_4-36.98), which was on par with Njalipoovan (V_3-35.95). The lowest leaf production was recorded in Monthan (V_2-33.16) followed by Karpooravalli (V_6-33.52), which was on par with Vayalvazhai (V_5-35.17).

Effect of pruning levels on the total leaf production was not significant at third, fifth and seventh month after planting, but significant only at bunch emergence stage. At this stage, the highest leaf production was observed in plants with pruning all the leaves seven days after

unfurling (T_1-37.02). The lowest leaf production was observed in plants with pruning alternate leaves seven days after unfurling (T_2-34.93), which was on par with plants with no leaf pruning (T_3-35.26).

In general the interaction effect of varieties and leaf pruning indicated that treatment T_1 (pruning all the leaves seven days after unfurling) had the higher number of leaves. While the plants in the control plots (No leaf pruning) produced lower number of leaves. The varieties Elavazhai, Palayankodan and Njalipoovan had less adverse effects on total leaf production when all the leaves were pruned seven days after unfurling.

Effect of treatments on varieties indicated that Elavazhai, followed by Palayankodan, Njalipoovan and Vayalvazhai produced more number of leaves than other varieties under the influence of the leaf pruning treatments.

The plants, which were subjected to more severe leaf pruning, had higher leaf production compared to no pruning or less severe pruning.

4.1.5 Effect of leaf pruning on total number of harvested leaves

The results of the studies on the effect of leaf pruning on total number of harvested leaves are presented in Table 6.

The data on the interaction effect of leaf pruning levels and the cultivars indicated that, there was significant difference in total number of harvested leaves between treatments in all the stages.

At third month, the highest number of harvested leaves was recorded in V_1T_1 (11.65) and V_4T_1 (10.79); these treatments being statistically on par. The treatments V_3T_1 (9.76), V_5T_1 (9.46) and V_6T_1 (8.96) were statistically on par and were next to V_4T_1. These treatments were followed by V_2T_1 (8.67), which differed from other treatments significantly. The treatments V_1T_2 (5.50), V_3T_2 (4.67) and V_6T_2 (4.58) were statistically on par and following V_2T_1. The lowest number of

Table 6. Effect of leaf pruning and varieties on total number of harvested leaves

Treatment	Number of leaves harvested			
	Stages after planting			
	3 months	5 months	7 months	At bunch emergence
V_1T_1	11.65	19.67	29.35	43.92
V_1T_2	5.50	8.67	13.42	18.67
V_1T_3	-	-	-	-
V_2T_1	8.67	14.61	20.85	33.13
V_2T_2	4.42	7.50	10.75	17.50
V_2T_3	-	-	-	-
V_3T_1	9.76	16.67	24.44	38.04
V_3T_2	4.67	7.58	10.89	17.44
V_3T_3	-	-	-	-
V_4T_1	10.79	17.68	25.69	40.25
V_4T_2	4.33	7.75	10.83	18.08
V_4T_3	-	-	-	-
V_5T_1	9.46	15.63	21.87	33.82
V_5T_2	4.36	7.55	10.94	17.61
V_5T_3	-	-	-	-
V_6T_1	8.96	14.66	20.99	32.94
V_6T_2	4.58	7.58	10.83	17.17
V_6T_3	-	-	-	-
SE	0.34	0.51	0.69	0.83
CD (0.05)	1.01	1.51	2.02	2.43
V_1	8.57	14.17	21.39	31.29
V_2	6.54	11.05	15.80	25.31
V_3	7.21	12.13	17.66	27.74
V_4	7.56	12.72	18.26	29.17
V_5	6.91	11.59	16.41	25.71
V_6	6.77	11.12	15.92	25.05
SE	0.24	0.37	0.49	0.59
CD (0.05)	0.71	1.07	1.43	1.72
T_1	9.88	16.49	23.87	37.02
T_2	4.64	7.77	11.28	17.75
T_3	-	-	-	-
SE	0.14	0.21	0.28	0.34
CD (0.05)	0.41	0.62	0.82	0.99

harvested leaves was recorded in V_4T_2 (4.33), which was on par with V_5T_2 (4.36) and V_2T_2 (4.42).

At fifth month after planting, the highest number of harvested leaves was recorded in V_1T_1 (19.67). The treatments V_4T_1 (17.68) and V_3T_1 (16.67) were statistically on par and were next to V_1T_1. These treatments were followed by V_5T_1 (15.63), V_6T_1 (14.66) and V_2T_1 (14.61), which were on par. The lowest number of harvested leaves was recorded in V_2T_2 (7.50), which was on par with V_5T_2 (7.55), V_6T_2 (7.58), V_4T_2 (7.75) and V_1T_2 (8.67).

At seventh month after planting, the highest number of harvested leaves was recorded in V_1T_1 (29.35). The treatments V_4T_1 (25.69) and V_3T_1 (24.44) were statistically on par and were next to V_1T_1. These treatments were followed by V_5T_1 (21.87), V_6T_1 (20.99) and V_2T_1 (20.85), which were on par. These treatments were followed by V_1T_2 (13.42), which differed from others statistically. The lowest number of harvested leaves was recorded in V_2T_2 (10.75), which was on par with V_6T_2 (10.83), V_4T_2 (10.83), V_3T_2 (10.89) and V_5T_2 (10.94).

At bunch emergence stage, the highest values were recorded in V_1T_1 (43.92). The treatments V_4T_1 (40.25) and V_3T_1 (38.04) were statistically on par and following V_1T_1. These treatments were followed by V_5T_1 (33.82), V_2T_1 (33.13) and V_6T_1 (32.94), which were on par. The lowest values were recorded in V_6T_2 (17.17), which was on par with V_3T_2 (17.44), V_2T_2 (17.50), V_5T_2 (17.61), V_4T_2 (18.08) and V_1T_2 (18.67).

Effect of cultivars significantly influenced the total number of harvested leaves in all the stages. At third month after planting, the highest number of harvested leaves was recorded in Elavazhai (V_1-8.57) followed by Palayankodan (V_4-7.56), which was on par with Njalipoovan (V_3-7.21) and Vayalvazhai (V_5-6.91). The lowest number of harvested leaves was recorded in Monthan (V_2-6.54), which was on par with Karpooravalli (V_6-6.77).

At fifth month after planting the highest number of harvested leaves was recorded in Elavazhai (V_1-14.17) followed by Palayankodan (V_4-12.72), which was on par with Njalipoovan (V_3-12.13). The lowest number of harvested leaves was recorded in Monthan (V_2-11.05), which was on par with Karpooravalli (V_6-11.12) and Vayalvazhai (V_5-11.59).

At seventh month after planting, the highest number of harvested leaves was recorded in Elavazhai (V_1-21.39) followed by Palayankodan (V_4-18.26), which was on par with Njalipoovan (V_3-17.66). The lowest number of harvested leaves was recorded in Monthan (V_2-15.80), which was on par with Karpooravalli (V_6-15.92) and Vayalvazhai (V_5-16.41).

At bunch emergence stage, the highest number of harvested leaves was recorded in Elavazhai (V_1-31.29) followed by Palayankodan (V_4-29.17), which was on par with Njalipoovan (V_3-27.74). The lowest number of harvested leaves was recorded in Karpooravalli (V_6-25.05), which was on par with Monthan (V_2-25.31) and Vayalvazhai (V_5-25.71)

Effect of pruning levels significantly influenced the total number of harvested leaves in all the stages. In all the stages, the treatment T_1 (pruning all the leaves seven days after unfurling) recorded the highest values for total number of harvested leaves and differed significantly from the other treatments. The treatment T_2 (pruning alternate leaves seven days after unfurling) differed significantly from T_1 and recorded the lowest value. The treatment T_3 (No leaf pruning) being control the leaves were not harvested.

In general, the interaction effect of varieties and leaf pruning indicated that treatment T_1 (pruning all the leaves seven days after unfurling) resulted in more number of harvested leaves from the varieties under test. The plants in the T_2 plots (pruning alternate leaves seven days after unfurling) had less number of harvested leaves. In the varieties, Elavazhai, Palayankodan, Njalipoovan and Vayalvazhai more number of leaves could be harvested when all the leaves were pruned seven days after unfurling.

Effect of treatments on varieties indicated that in varieties Elavazhai followed by Palayankodan, Njalipoovan and Vayalvazhai the number of leaves harvested was more compared to the other varieties tested.

Among the pruning strategies, pruning all the leaves seven days after unfurling resulted in the harvest of more number of leaves compared to other treatments. This treatment enabled harvest of double the number of leaves compared to the intensity of pruning alternate leaves.

4.1.6 Effect of leaf pruning on marketable leaves

The results of the studies on the effect of leaf pruning on total number of marketable leaves of six banana clones are presented in Table 7.

The data on the interaction effect of leaf pruning levels and the cultivars indicated that, there was significant difference in total number of marketable leaves between treatments in all the stages.

At third month after planting, the highest number of marketable leaves was recorded in V_1T_1 (11.65) and V_4T_1 (10.79), these treatments being statistically on par. The treatments V_3T_1 (9.76), V_5T_1 (9.46) and V_6T_1 (8.96) were statistically on par and were next to V_4T_1. These treatments were followed by V_2T_1 (8.67), which differed from other treatments significantly. The treatments V_1T_2 (5.50), V_3T_2 (4.67) and V_6T_2 (4.58) were statistically on par and following V_2T_1. The lowest number of marketable leaves was recorded in V_4T_2 (4.33), which was on par with V_5T_2 (4.36) and V_2T_2 (4.40).

At fifth month after planting, the highest number of marketable leaves was recorded in V_1T_1 (19.67). The treatments V_4T_1 (17.68) and V_3T_1 (16.67) were statistically on par and were next to V_1T_1. These treatments were followed by V_5T_1 (15.63), V_6T_1 (14.66) and V_2T_1 (14.61), which were on par. The lowest number of marketable leaves was recorded in V_2T_2 (7.50), which was on par with V_5T_2 (7.55), V_6T_2 (7.58), V_3T_2 (7.58), V_4T_2 (7.75) and V_1T_2 (8.67).

Table 7. Effect of leaf pruning and varieties on marketable leaves

Treatment	Number of marketable leaves			
	Stages after planting			
	3 months	5 months	7 months	At bunch emergence
V_1T_1	11.65	19.67	29.35	40.00
V_1T_2	5.50	8.67	13.42	18.00
V_1T_3	-	-	-	-
V_2T_1	8.67	14.61	20.85	30.50
V_2T_2	4.40	7.50	10.25	17.25
V_2T_3	-	-	-	-
V_3T_1	9.76	16.67	24.44	34.75
V_3T_2	4.67	7.58	10.89	17.25
V_3T_3	-	-	-	-
V_4T_1	10.79	17.68	25.69	36.83
V_4T_2	4.33	7.75	10.83	18.08
V_4T_3	-	-	-	-
V_5T_1	9.46	15.63	21.67	30.58
V_5T_2	4.36	7.55	10.94	17.61
V_5T_3	-	-	-	-
V_6T_1	8.96	14.66	20.99	30.17
V_6T_2	4.58	7.58	10.83	17.17
V_6T_3	-	-	-	-
SE	0.34	0.51	0.69	0.81
CD (0.05)	1.01	1.51	2.02	2.37
V_1	8.57	14.17	21.39	29.00
V_2	6.54	10.81	15.55	23.88
V_3	7.22	12.13	17.66	26.00
V_4	7.56	12.72	18.26	27.46
V_5	6.91	11.59	16.31	24.10
V_6	6.77	11.12	15.91	23.67
SE	0.24	0.37	0.48	0.54
CD (0.05)	0.71	1.07	1.40	1.54
T_1	9.88	16.47	23.83	33.81
T_2	4.64	7.69	11.19	17.56
T_3	-	-	-	-
SE	0.14	0.21	0.27	0.31
CD (0.05)	0.41	0.62	0.81	0.89

At seventh month after planting, the highest number of marketable leaves was recorded in V_1T_1 (29.35). The treatments V_4T_1 (25.69) and V_3T_1 (24.44), were statistically on par and were next to V_1T_1. These treatments were followed by V_5T_1 (21.67), V_6T_1 (20.99) and V_2T_1 (20.85), which were on par. These treatments were followed by V_1T_2 (13.42), which differed from others statistically. The lowest number of marketable leaves was recorded in V_2T_2 (10.25), which was on par with V_6T_2 (10.83), V_4T_2 (10.83), V_3T_2 (10.89) and V_5T_2 (10.94).

At bunch emergence stage, the highest number of marketable leaves was recorded in V_1T_1 (40.00). The treatments V_4T_1 (36.83) and V_3T_1 (34.75) were statistically on par and following V_1T_1. These treatments were followed by V_5T_1 (30.58), V_2T_1 (30.50) and V_6T_1 (30.17), which were on par. The lowest values were recorded in V_6T_2 (17.17), which was on par with V_3T_2 (17.25), V_2T_2 (17.25), V_5T_2 (17.61), V_1T_2 (18.00) and V_4T_2 (18.08).

Effect of cultivars significantly influenced the total number of marketable leave in all the stages. At third month after planting, the highest number of marketable leaves was recorded in Elavazhai (V_1-8.57) followed by Palayankodan (V_4-7.56), which was on par with Njalipoovan (V_3-7.22) and Vayalvazhai (V_5-6.91). The lowest number of marketable leaves was recorded in Monthan (V_2-6.54), which was on par with Karpooravalli (V_6-6.77).

At fifth month after planting, the highest number of marketable leaves was observed in Elavazhai (V_1-14.17) followed by Palayankodan (V_4-12.72), which was on par with Njalipoovan (V_3-12.13). The lowest number of marketable leaves was recorded in Monthan (V_2-10.81), which was on par with Karpooravalli (V_6-11.12) and Vayalvazhai (V_5-11.59).

At seventh month after planting, the highest number of marketable leaves was recorded in Elavazhai (V_1-21.39) followed by Palayankodan (V_4-18.26), which was on par with Njalipoovan (V_3-17.66). The lowest

number of marketable leaves was recorded in Monthan (V_2-15.55), which was on par with Karpooravalli (V_6-15.91) and Vayalvazhai (V_5-16.31).

At bunch emergence stage, the highest number of marketable leaves was recorded in Elavazhai (V_1-29.00), which was on par with Palayankodan (V_4-27.46). These cultivars were followed by Njalipoovan (V_3-26.00), which differed from others significantly. The lowest number of marketable leaves was recorded in Karpooravalli (V_6-23.67), which was on par with Monthan (V_2-23.88) and Vayalvazhai (V_5-24.10).

Effect of pruning levels significantly influenced the total number of marketable leaves in all the stages. In all the stages, the treatment T_1 (pruning all the leaves seven days after unfurling) recorded the highest values for total number of marketable leaves and differed significantly from other treatments. The treatment T_2 (pruning alternate leaves seven days after unfurling) differed significantly from T_1 and recorded the lowest values. The treatment T_3 (no leaf pruning) being control, the leaves were not harvested.

In general, the interaction effect of varieties and leaf pruning indicated that, treatment T_1 (pruning all the leaves seven days after unfurling) resulted in more number of marketable leaves from the varieties under test. The plants in the T_2 plots (pruning alternate leaves seven days after unfurling) had lesser number of marketable leaves. In the varieties Elavazhai, Palayankodan, Njalipoovan and Vayalvazhai, more number of marketable leaves could be obtained when all the leaves were pruned seven days after unfurling.

Effect of treatments on varieties indicated that in varieties Elavazhai followed by Palayankodan, Njalipoovan and Vayalvazhai, the number of marketable leaves was more compared to the other varieties tested.

Among the pruning strategies, pruning all the leaves seven days after unfurling resulted in the more number of marketable leaves

compared to other treatments. This treatment enabled double the number of marketable leaves compared to the intensity of pruning alternate leaves.

4.1.7 Effect of leaf pruning on leaf length

The results of the study on the effect of leaf pruning on leaf length of six banana clones are presented in Table 8.

The data on the interaction effect of cultivars and the pruning levels indicated that there was no significant difference among the treatments in all the stages.

Effect of cultivars on leaf length was significant in all the months except at forth month of planting.

At first month of planting the highest leaf length was recorded in Karpooravalli (V_6-33.57 cm), which was on par with Njalipoovan (V_3-30.68 cm), Vayalvazhai (V_5-29.72 cm) and Palayankodan (V_4-29.56 cm). The lowest leaf length was recorded in Elavazhai (V_1-23.98 cm), which was on par with Monthan (V_2-27.93 cm).

At second month of planting, the highest leaf length was recorded in Karpooravalli (V_6-50.71cm), which was on par with Njalipoovan (V_3-45.83 cm) and Vayalvazhai (V_5-45.80 cm). The lowest leaf length was recorded in Elavazhai (V_1-39.40 cm), which was on par with Monthan (V_2-42.29 cm) and Palayankodan (V_4-44.87 cm).

At third month of planting, the highest leaf length was recorded in Karpooravalli (V_6-68.97 cm), which was on par with Njalipoovan (V_3-65.85 cm). The lowest leaf length was recorded in Elavazhai (V_1-59.43 cm, which was on par with Palayankodan (V_4-60.89 cm), Monthan (V_2-61.75 cm) and Vayalvazhai (V_5-62.21 cm).

At fifth month of planting, the highest leaf length was recorded in Karpooravalli (V_6-106.25 cm). The lowest leaf length was recorded in Palayankodan (V_4-96.11cm), which was on par with Vayalvazhai (V_5-96.34 cm), Elavazhai (V_1-97.31 cm), Monthan (V_2-98.96 cm) and Njalipoovan (V_3-100.19 cm).

Table 8. Effect of leaf pruning and varieties on leaf length

Treatment	Leaf length, cm/ Months after planting										
	1	2	3	4	5	6	7	8	9	10	11
V_1T_1	22.67	37.96	57.92	78.00	97.21	116.42	141.25	166.17	189.21	211.42	211.42
V_1T_2	25.63	41.75	61.58	81.54	99.25	116.38	137.92	162.67	185.75	209.17	209.17
V_1T_3	23.64	38.50	58.79	79.00	95.46	112.21	133.46	158.54	181.25	204.42	204.42
V_2T_1	24.17	37.92	58.79	78.71	97.25	113.42	136.09	160.09	182.59	205.50	205.50
V_2T_2	28.96	43.79	63.75	82.71	97.92	113.04	135.67	158.46	182.92	204.92	204.92
V_2T_3	30.67	45.17	62.71	81.63	101.71	118.17	139.83	163.54	184.79	207.00	207.00
V_3T_1	30.19	45.38	67.26	86.06	101.13	116.60	135.13	156.86	179.42	199.92	199.92
V_3T_2	29.53	45.07	65.49	84.78	99.68	114.10	131.60	155.15	175.78	197.64	197.64
V_3T_3	32.33	47.04	64.79	83.21	99.75	116.25	136.04	157.79	178.21	199.58	200.00
V_4T_1	29.00	44.21	60.21	76.85	94.71	113.30	132.34	151.38	171.00	190.88	190.88
V_4T_2	31.59	45.63	62.04	79.63	97.99	116.75	135.63	155.09	175.25	195.79	195.79
V_4T_3	28.10	44.77	60.41	78.06	95.64	113.56	132.39	151.43	171.18	191.53	191.53
V_5T_1	28.71	45.34	62.92	80.42	97.75	115.79	134.24	153.29	173.21	193.17	193.17
V_5T_2	30.57	46.02	62.72	79.74	97.53	115.46	134.02	153.07	172.46	192.44	192.44
V_5T_3	29.89	46.06	61.00	76.86	93.75	111.49	129.71	148.82	167.77	187.27	187.27
V_6T_1	34.38	51.40	68.00	85.06	102.99	121.04	139.31	158.84	178.67	199.17	199.17
V_6T_2	33.54	50.29	69.23	88.79	107.75	127.00	146.75	167.38	187.92	209.08	209.08
V_6T_3	32.79	50.42	69.67	88.29	108.00	128.25	148.58	167.59	190.71	212.25	212.25
SE	2.90	3.45	3.58	3.79	3.62	4.01	4.16	4.40	4.66	4.96	4.96
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 8. continued...

V_1	23.98	39.40	59.43	79.52	97.31	115.00	137.54	162.46	185.41	208.33	208.33
V_2	27.93	42.29	61.75	81.02	98.96	114.88	137.20	160.70	183.43	205.81	205.81
V_3	30.68	45.83	65.85	84.68	100.19	115.65	134.26	156.60	177.80	199.05	199.05
V_4	29.56	44.87	60.89	78.18	96.11	114.54	133.45	152.63	172.48	192.73	192.73
V_5	29.72	45.80	62.21	79.01	96.34	114.25	132.66	151.73	171.15	190.96	190.96
V_6	33.57	50.71	68.97	87.38	106.25	125.43	144.88	164.60	185.77	206.83	206.83
SE	1.68	1.99	2.07	2.19	2.09	2.32	2.40	2.54	2.69	2.86	2.86
CD (0.05)	4.81	5.71	5.94	NS	6.00	6.65	6.89	7.30	7.72	8.22	8.22
T_1	28.19	43.70	65.52	80.85	98.51	116.09	136.39	157.77	179.02	200.01	200.01
T_2	29.97	45.43	64.14	82.87	100.02	117.12	136.93	158.64	180.01	201.51	201.51
T_3	29.57	45.33	62.90	81.18	99.05	116.65	136.67	157.95	178.99	200.34	200.34
SE	1.19	1.41	1.46	1.55	1.48	1.64	1.70	1.80	1.90	2.02	2.02
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

At sixth month of planting, the highest leaf length was recorded in Karpooravalli (V_6-125.43 cm). The lowest leaf length was recorded in Vayalvazhai (V_5-114.25 cm), which was on par with Palayankodan (V_4-114.54 cm), Monthan (V_2-114.88 cm), Elavazhai (V_1-115.00 cm) and Njalipoovan (V_3-115.65 cm).

At seventh month of planting the highest leaf length was recorded in Karpooravalli (V_6-144.88 cm) and the lowest leaf length was recorded in Vayalvazhai (V_5-132.66 cm), which was on par with Palayankodan (V_4-133.45 cm), Njalipoovan (V_3-134.26 cm), Monthan (V_2-137.20 cm) and Elavazhai (V_1-137.54 cm).

At eight month of planting the highest leaf length was recorded in Karpooravalli (V_6-164.60 cm), which was on par with Elavazhai (V_1-162.46 cm) and Monthan (V_2-160.70 cm). The lowest leaf length was recorded in Vayalvazhai (V_5-151.73 cm), which was on par with Palayankodan (V_4-152.63 cm) and Njalipoovan (V_3-156.60 cm).

At ninth month of planting the highest leaf length was recorded in Karpooravalli (V_6-185.77 cm), which was on par with Elavazhai (V_1-185.41) and Monthan (V_2-183.43 cm). The lowest leaf length was recorded in Vayalvazhai (V_5-171.15 cm), which was on par with Palayankodan (V_4-172.48 cm) and Njalipoovan (V_3-177.80 cm).

At tenth month of planting the highest leaf length was recorded in Elavazhai (V_1-208.33 cm) which was on par with Karpooravalli (V_6-206.83 cm) and Monthan (V_2-205.81 cm) and the lowest leaf length was recorded in Vayalvazhai (V_5-190.96 cm), which was on par with Palayankodan (V_4-192.73 cm) and Njalipoovan (V_3-199.05 cm).

Effect of pruning levels on leaf length was not significant in all the stages.

In general, the interaction effect of varieties and leaf pruning indicated that the treatments did not significantly influenced the length of leaves.

The different levels of pruning did not adversely affect the length of leaves.

Effect of treatments on varieties indicated that the varieties Karpooravalli followed by Elavazhai, Monthan, Njalipoovan and Palayankodan produced the lengthiest leaves.

4.1.8 Effect of leaf pruning on leaf breadth

The results of the studies on the effect of leaf pruning on leaf breadth of six banana cultivars are presented in Table 9.

The data on the interaction effect of leaf pruning levels and the cultivars indicated that there was no significant difference among the treatments in all the stages of growth.

Effect of cultivars on leaf breadth was significant at second, forth, sixth, seventh, eighth and tenth month after planting.

At second month after planting, the highest leaf breadth was recorded in Karpooravalli (V_6-22.87 cm), Njalipoovan (V_3-20.74 cm), Palayankodan (V_4-20.70 cm) and Vayalvazhai (V_5-20.36 cm), which did not differ from one another statistically. The lowest leaf breadth was recorded in Elavazhai (V_1-18.40 cm), which was on par with Monthan (V_2-18.45 cm).

At forth month after planting, the highest leaf breadth was recorded in Karpooravalli (V_6-37.78 cm), which was on par with Vayalvazhai (V_5-34.63 cm). The lowest leaf breadth was recorded in Monthan (V_2-31.38 cm), Palayankodan (V_4-32.61 cm), Njalipoovan (V_3-32.73 cm) and Elavazhai (V_1-33.52 cm), which did not differ from one another statistically.

At sixth month after planting, the highest leaf breadth was recorded in Karpooravalli (V_6-45.00 cm), which was on par with Elavazhai (V_1-42.65 cm) and Vayalvazhai (V_5-41.66 cm). The lowest leaf breadth was recorded in Njalipoovan (V_3-37.33 cm), which was on par with Palayankodan (V_4-38.04 cm) and Monthan (V_2-38.61 cm).

At seventh month after planting, the highest leaf breadth was recorded in Elavazhai (V_1-49.04 cm), Karpooravalli (V_6-48.57 cm),

Table 9. Effect of leaf pruning and individual varieties on leaf breadth

Treatment	Leaf breadth, cm										
	Months after planting										
	1	2	3	4	5	6	7	8	9	10	11
V_1T_1	11.13	18.21	26.88	34.04	40.88	44.63	52.04	57.46	63.17	70.75	70.75
V_1T_2	12.21	20.04	27.96	34.55	38.79	42.33	48.46	54.71	60.00	68.80	68.69
V_1T_3	10.59	16.96	24.42	31.96	37.63	41.00	46.63	53.17	59.00	67.63	67.63
V_2T_1	10.71	17.42	24.75	31.67	36.33	40.00	44.96	51.00	57.96	66.40	66.40
V_2T_2	12.21	18.33	26.88	31.30	35.38	38.42	43.92	49.46	56.00	62.25	62.00
V_2T_3	13.21	19.59	26.04	31.17	34.54	37.42	43.79	50.04	58.00	64.63	64.63
V_3T_1	13.33	20.33	29.48	33.56	35.81	37.61	41.83	49.22	55.92	62.46	62.46
V_3T_2	12.59	20.56	28.00	33.64	36.15	38.13	42.42	47.75	54.03	59.63	59.63
V_3T_3	14.58	21.33	26.99	31.00	33.83	36.25	40.09	46.21	52.09	59.96	59.96
V_4T_1	12.21	20.00	27.58	32.09	35.54	38.54	42.71	49.50	56.17	63.17	63.17
V_4T_2	14.21	21.08	27.00	30.83	33.38	35.46	39.34	45.38	51.50	58.25	58.25
V_4T_3	12.68	21.03	28.69	34.90	37.63	40.11	45.46	51.78	56.94	62.78	62.78
V_5T_1	12.92	20.83	28.54	33.17	37.67	41.33	47.71	53.71	58.79	66.75	66.75
V_5T_2	13.42	20.25	27.93	35.92	39.06	41.38	46.08	51.88	57.54	64.82	64.82
V_5T_3	13.02	19.99	26.48	34.82	38.60	42.27	46.46	51.65	56.93	63.18	63.18
V_6T_1	14.33	22.61	30.61	35.58	39.69	43.67	47.40	53.44	59.83	66.13	66.13
V_6T_2	14.38	23.34	29.48	38.88	40.58	44.67	48.21	52.92	57.29	61.92	61.92
V_6T_3	13.50	22.67	31.21	38.88	42.59	46.67	50.08	54.34	59.00	63.71	63.71
SE	1.45	1.58	1.83	2.14	2.62	2.91	2.91	2.52	2.67	2.56	2.56
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 9. continued...

V_1	11.31	18.40	26.42	33.52	39.09	42.65	49.04	55.11	60.72	69.06	69.06
V_2	12.04	18.45	25.89	31.38	35.42	38.61	44.22	50.17	57.32	64.43	64.43
V_3	13.50	20.74	28.16	32.73	35.26	37.33	41.45	47.73	54.01	60.68	60.68
V_4	13.03	20.70	27.76	32.61	35.52	38.04	42.50	48.89	54.87	61.40	61.40
V_5	13.12	20.36	27.65	34.63	38.44	41.66	46.75	52.41	57.76	64.92	64.92
V_6	14.07	22.87	30.43	37.78	40.95	45.00	48.57	53.57	58.71	63.92	63.92
SE	0.84	0.91	1.06	1.24	1.51	1.68	1.68	1.46	1.54	1.48	1.48
CD (0.05)	NS	2.63	NS	3.55	NS	4.83	4.82	4.18	NS	4.24	4.24
T_1	12.44	19.90	27.97	33.35	37.65	40.93	46.11	52.39	58.64	65.94	65.94
T_2	13.17	20.60	27.88	34.19	37.22	40.06	44.74	50.35	56.06	62.61	62.61
T_3	12.93	20.26	27.31	33.79	37.47	40.62	45.42	51.20	56.99	63.65	63.65
SE	0.59	0.65	0.75	0.87	1.07	1.19	1.19	1.03	1.09	1.04	1.04
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Vayalvazhai (V_5-46.75 cm) and Monthan (V_2-44.22 cm), which did not differ from one another statistically. The lowest leaf breadth was recorded in Njalipoovan (V_3-41.45 cm), which was on par with Palayankodan (V_4-42.50 cm).

At eight month after planting, the highest leaf breadth was recorded in Elavazhai (V_1-55.11cm), which was on par with Karpooravalli (V_6-53.57 cm) and Vayalvazhai (V_5-52.41 cm). The lowest leaf breadth was recorded in Njalipoovan (V_3-47.73 cm) which was on par with Palayankodan (V_4-48.89 cm) and Monthan (V_2-50.17 cm).

At tenth month after planting, the highest leaf breadth was recorded in Elavazhai (V_1-69.06 cm). The lowest leaf breadth was recorded in Njalipoovan (V_3-60.68 cm), Palayankodan (V_4-61.40 cm), Karpooravalli (V_6-63.92 cm) and Monthan (V_2-64.43 cm), which did not differ from one another significantly.

At eleventh month after planting the data showed the same trend as in tenth month after planting.

In general, the combined effect of varieties and leaf pruning levels indicated that the treatments were not significantly influenced the leaf breadth. The different levels of leaf pruning also did not affect the leaf breadth significantly.

Effect of varieties indicated that Elavazhai followed by Vayalvazhai, Monthan and Karpooravalli were recorded the highest leaf breadth.

4.1.9 Effect of leaf pruning on leaf thickness

The results of the studies on the effect of leaf pruning on leaf thickness of six banana clones are presented in Table 10.

The data on the interaction effect of leaf pruning levels and the cultivars indicated that, there was significant difference among the treatments in forth, fifth, seventh, tenth and eleventh month after planting.

Table 10. Effect of leaf pruning and varieties on leaf thickness

Treatment	Leaf thickness, mm										
	Months after planting										
	1	2	3	4	5	6	7	8	9	10	11
V_1T_1	0.17	0.17	0.16	0.16	0.17	0.16	0.17	0.17	0.16	0.17	0.17
V_1T_2	0.17	0.17	0.16	0.17	0.18	0.16	0.16	0.17	0.17	0.18	0.17
V_1T_3	0.18	0.18	0.17	0.17	0.18	0.17	0.18	0.18	0.17	0.17	0.17
V_2T_1	0.20	0.19	0.20	0.19	0.19	0.20	0.20	0.20	0.19	0.19	0.19
V_2T_2	0.20	0.19	0.20	0.20	0.19	0.19	0.19	0.21	0.20	0.20	0.21
V_2T_3	0.20	0.20	0.19	0.19	0.20	0.20	0.19	0.20	0.19	0.19	0.20
V_3T_1	0.16	0.17	0.17	0.17	0.18	0.18	0.18	0.18	0.19	0.20	0.19
V_3T_2	0.19	0.17	0.18	0.19	0.18	0.19	0.17	0.18	0.19	0.18	0.20
V_3T_3	0.18	0.18	0.18	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
V_4T_1	0.18	0.19	0.18	0.20	0.19	0.19	0.18	0.19	0.19	0.19	0.20
V_4T_2	0.19	0.20	0.19	0.19	0.18	0.18	0.18	0.19	0.19	0.19	0.19
V_4T_3	0.19	0.20	0.19	0.20	0.18	0.18	0.19	0.20	0.17	0.19	0.19
V_5T_1	0.21	0.20	0.22	0.22	0.22	0.22	0.23	0.21	0.22	0.21	0.21
V_5T_2	0.20	0.20	0.20	0.19	0.20	0.19	0.18	0.21	0.22	0.20	0.21
V_5T_3	0.20	0.22	0.22	0.24	0.20	0.22	0.21	0.21	0.21	0.20	0.20
V_6T_1	0.21	0.21	0.20	0.21	0.19	0.20	0.19	0.20	0.19	0.20	0.23
V_6T_2	0.21	0.22	0.20	0.20	0.20	0.20	0.19	0.20	0.22	0.19	0.23
V_6T_3	0.21	0.22	0.21	0.20	0.19	0.19	0.22	0.19	0.22	0.21	0.22
SE	0.005	0.006	0.005	0.005	0.006	0.005	0.005	0.005	0.006	0.004	0.004
CD (0.05)	NS	NS	NS	0.01	0.02	0.01	0.01	NS	NS	0.01	0.01

Table 10. continued...

V_1	0.17	0.17	0.16	0.17	0.17	0.17	0.17	0.17	0.16	0.17	0.17
V_2	0.20	0.19	0.20	0.19	0.19	0.20	0.19	0.20	0.20	0.19	0.20
V_3	0.18	0.17	0.17	0.18	0.18	0.19	0.18	0.18	0.19	0.19	0.19
V_4	0.19	0.20	0.19	0.20	0.18	0.18	0.18	0.19	0.18	0.19	0.19
V_5	0.20	0.21	0.21	0.22	0.21	0.21	0.21	0.21	0.22	0.20	0.21
V_6	0.21	0.22	0.20	0.20	0.20	0.20	0.20	0.20	0.21	0.20	0.23
SE	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.002	0.003
CD (0.05)	0.009	0.009	0.008	0.008	0.01	0.01	0.008	0.008	0.01	0.007	0.006
T_1	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.20
T_2	0.19	0.19	0.19	0.19	0.19	0.19	0.18	0.19	0.20	0.19	0.20
T_3	0.19	0.20	0.19	0.20	0.19	0.19	0.20	0.20	0.19	0.19	0.20
SE	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.001
CD (0.05)	NS	NS	NS	NS	NS	NS	0.006	NS	NS	NS	NS

At forth month after planting, the highest leaf thickness was recorded in V_5T_3 (0.24 mm) followed by V_5T_1 (0.22 mm), which was on par with V_6T_1 (0.21 mm). The treatments V_2T_2 (0.20 mm), V_4T_1 (0.20 mm), V_4T_3 (0.20 mm), V_6T_2 (0.20 mm), V_6T_3 (0.20 mm), V_3T_3 (0.19 mm), V_4T_2 (0.19 mm), V_2T_3 (0.19 mm), V_2T_1 (0.19 mm), V_5T_2 (0.19 mm) and V_3T_2 (0.19 mm) were statistically on par and were next to V_6T_1. The lowest leaf thickness was recorded in V_1T_1 (0.16 mm), which was on par with V_1T_3 (0.17 mm), V_1T_2 (0.17 mm) and V_3T_1 (0.17 mm).

At fifth month after planting, the highest leaf thickness was recorded in V_5T_1 (0.22 mm), which was on par with V_6T_2 (0.20 mm) V_2T_3 (0.20 mm), V_5T_3 (0.20 mm) and V_5T_2 (0.20 mm). The lowest leaf thickness was recorded in V_1T_1 (0.17 mm), which was on par with V_3T_1 (0.18 mm), V_1T_2 (0.18 mm), V_1T_3 (0.18 mm), V_4T_2 (0.18 mm), V_3T_2 (0.18 mm), V_4T_3 (0.18 mm), V_2T_1 (0.19 mm), V_4T_1 (0.19 mm), V_2T_2 (0.19 mm), V_3T_3 (0.19 mm), V_6T_3 (0.19 mm), and V_6T_1 (0.19 mm).

At sixth month after planting, the highest leaf thickness was recorded in V_5T_3 (0.22 mm) which was on par with V_5T_1 (0.22 mm). The treatments V_6T_2 (0.20 mm), V_2T_1 (0.20 mm), V_2T_3 (0.20 mm), V_6T_1 (0.20 mm), V_3T_3 (0.19 mm), V_6T_3 (0.19 mm), V_5T_2 (0.19 mm), V_2T_2 (0.19 mm) V_3T_2 (0.19 mm) and V_4T_1 (0.19 mm) were statistically on par and following V_5T_1. These treatments were followed by V_4T_3 (0.18 mm), V_3T_1 (0.18 mm), V_4T_2 (0.18 mm) and V_1T_3 (0.17 mm), which were on par. The lowest leaf thickness was recorded in V_1T_2 (0.16 mm), which was on par with V_1T_1 (0.16 mm).

At seventh month after planting, the highest leaf thickness was recorded in V_5T_1 (0.23 mm), which was on par with V_6T_3 (0.22 mm). The treatments V_5T_3 (0.21 mm) and V_2T_1 (0.20 mm) were statistically on par and were next to V_6T_3. These treatments were followed by V_2T_3 (0.19 mm), V_6T_2 (0.19 mm), V_3T_3 (0.19 mm), V_6T_1 (0.19 mm), V_4T_3 (0.19 mm), V_2T_2 (0.19 mm), V_4T_2 (0.18 mm), V_5T_2 (0.18 mm), V_4T_1 (0.18 mm), V_3T_1 (0.18 mm) and V_1T_3 (0.18 mm), which were on par. The lowest leaf

thickness was recorded in V_1T_2 (0.16 mm), which was on par with V_1T_1 (0.17 mm) and V_3T_2 (0.17 mm).

At tenth month after planting, the highest leaf thickness was recorded in V_6T_3 (0.21 mm), which was on par with V_5T_1 (0.21 mm), V_2T_2 (0.20 mm), V_5T_2 (0.20 mm), V_6T_1 (0.20 mm), V_3T_1 (0.20 mm) and V_5T_3 (0.20 mm). These treatments were followed by V_4T_1 (0.19 mm), V_4T_2 (0.19 mm), V_2T_3 (0.19 mm), V_6T_2 (0.19 mm, V_4T_3 (0.19 mm), V_2T_1 (0.19 mm), V_3T_3 (0.19 mm), V_3T_2 (0.18 mm) and V_1T_2 (0.18 mm), which in turn were on par. The lowest leaf thickness was recorded in V_1T_1 (0.17 mm), which was on par with V_1T_3 (0.17 mm).

At eleventh month after planting, the highest leaf thickness was recorded in V_6T_1 (0.23 mm), which was on par with V_6T_2 (0.23 mm) and V_6T_3 (0.22 mm). The treatments V_5T_1 (0.21 mm), V_5T_2 (0.21 mm), V_2T_2 (0.21 mm), V_2T_3 (0.20 mm), V_5T_3 (0.20 mm), V_4T_1 (0.20 mm) and V_3T_2 (0.20 mm) were statistically on par and were next to V_6T_3. These treatments were followed by V_4T_3 (0.19 mm), V_4T_2 (0.19 mm), V_2T_1 (0.19 mm), V_3T_1 (0.19 mm) and V_3T_3 (0.19 mm), which were on par. The lowest leaf thickness was recorded in V_1T_1 (0.17 mm), which was on par with V_1T_3 (0.17 mm) and V_1T_2 (0.17mm).

Effect of cultivars significantly influenced the leaf thickness in all the stages. At one month after planting, the highest leaf thickness was recorded in Karpooravalli (V_6-0.21 mm), which was on par with Vayalvazhai (V5-0.20 mm) and Monthan (V_2-0.20 mm). The lowest leaf thickness was recorded in Elavazhai (V_1-0.17 mm) followed by Njalipoovan (V_3-0.18 mm), which was on par with Palayankodan (0.19 mm).

At second month after planting, the highest leaf thickness was recorded in Karpooravalli (V_6-0.22 mm), which was on par with Vayalvazhai (V_5-0.21 mm) followed by Palayankodan (V_4-0.20 mm), which was on par with Monthan (V_2-0.19 mm). The lowest leaf thickness was recorded in Elavazhai (V_1-0.17 mm) and Njalipoovan (V_3-0.17 mm).

At third month after planting, the highest leaf thickness was recorded in Vayalvazhai (V_5-0.21 mm), which was on par with Karpooravalli (V_6-0.20 mm) and Monthan (V_2-0.20 mm). The lowest leaf thickness was recorded in Elavazhai (V_1-0.16 mm), which was on par with Njalipoovan (V_3-0.17 mm) followed by Palayankodan (V_4-0.19 mm).

At forth month after planting, the highest leaf thickness was recorded in Vayalvazhai (V_5-0.22 mm) followed by Karpooravalli (V_6 - 0.20 mm) and Palayankodan (V_4-0.20 mm), which was on par with Monthan (V_2-0.19 mm). The lowest leaf thickness was recorded in Elavazhai (V_1-0.17 mm), which was on par with Njalipoovan (V_3-0.18 mm).

At fifth month after planting, the highest leaf thickness was recorded in Vayalvazhai (V_5-0.21 mm), which was on par with Karpooravalli (V_6-0.20 mm) followed by Monthan (V_2-0.19 mm), which was on par with Njalipoovan (V_3-0.18 mm) and Palayankodan (V_4-0.18 mm). The lowest leaf thickness was recorded in Elavazhai (V_1-0.17 mm).

At sixth month after planting, the highest leaf thickness was recorded in Vayalvazhai (V_5-0.21 mm), which was on par with Karpooravalli (V_6-0.20 mm) and Monthan (V_2-0.20 mm) followed by Njalipoovan (V_3-0.19 mm), which was on par with Palayankodan (V_4-0.18 mm). The lowest leaf thickness was recorded in Elavazhai (V_1-0.17 mm).

At seventh month after planting, the highest leaf thickness was recorded in Vayalvazhai (V_5-0.21 mm), which was on par with Karpooravalli (V_6-0.20 mm) followed by Monthan (V_2-0.19 mm), Njalipoovan (V_3-0.19 mm), and Palayankodan (V_4-0.18 mm) which did not differ from one another. The lowest leaf thickness was recorded in Elavazhai (V_1-0.17 mm).

At eighth month after planting, the highest leaf thickness was recorded in Vayalvazhai (V_5-0.21 mm), which was on par with Karpooravalli (V_6-0.20 mm) and Monthan (V_2-0.20 mm). These varieties were followed by Palayankodan (V_4-0.19 mm) and Njalipoovan (V_3-0.18

mm), which were on par. The lowest leaf thickness was recorded in Elavazhai (V_1-0.17 mm)

At ninth month after planting, the highest leaf thickness was recorded in Vayalvazhai (V_5-0.22 mm), which was on par with Karpooravalli (V_6-0.21 mm). The varieties Monthan (V_2-0.20 mm) and Njalipoovan (V_3-0.19 mm) were statistically on par and were next to Karpooravalli. The lowest leaf thickness was recorded in Elavazhai (V_1-0.16 mm) followed by Palayankodan (V_4-0.18 mm).

At tenth month after planting, the highest leaf thickness was recorded in Vayalvazhai (V_5-0.20 mm), Karpooravalli (V_6-0.20 mm), Monthan (V_2-0.19 mm), Njalipoovan (V_3-0.19 mm), and Palayankodan (V_4-0.19mm), which did not differ from one another statistically.

At eleventh month after planting, the highest leaf thickness was recorded in Karpooravalli (V_6-0.23 mm). The varieties Vayalvazhai (V_5-0.21 mm) and Monthan (V_2-0.20 mm) were statistically on par and were next to Karpooravalli. These varieties were followed by Njalipoovan (V_3-0.19 mm) and Palayankodan (V_4-0.19 mm), which were on par. The lowest leaf thickness was recorded in Elavazhai (V_1-0.17 mm).

Effect of pruning levels significantly influenced the leaf thickness at second, third, sixth and seventh month after planting.

At seventh month after planting, the highest leaf thickness was recorded in T_3 (no leaf pruning) (0.20 mm), which was on par with T_1 (pruning all the leaves seven days after unfurling) (0.19 mm). The lowest leaf thickness was recorded in T_2 (pruning alternate leaves seven days after unfurling (0.18 mm).

In general, it was observed that the thickness of leaves differed significantly under the interaction effect of leaf pruning and varietal characters. However, the effect of pruning levels indicated that leaf thickness was not influenced by the pruning treatments.

The relation of leaf thickness with varietal difference was more pronounced. The varieties Elavazhai, Palayankodan and Njalipoovan had

comparatively lower leaf thickness while Karpooravalli, Vayalvazhai and Monthan had more leaf thickness.

4.1.10 Effect of leaf pruning on Leaf Area Index (LAI)

The results of the study on the effect of leaf pruning on Leaf Area Index of six banana clones are presented in Table 11.

The data on the interaction effect of cultivars and pruning levels indicated that there was significant difference among the treatments at bunch emergence stage.

At bunch emergence stage, the highest leaf area index was recorded by V_1T_1 (1.29) followed by V_1T_2 (1.15), V_2T_1 (1.14), V_6T_3 (1.13), V_6T_1 (1.13), V_5T_1 (1.11), V_1T_3 (1.11), V_6T_2 (1.10), V_2T_2 (1.09), V_5T_2 (1.08), V_2T_3 (1.08), V_3T_1 (1.07), V_3T_3 (1.06), V_4T_1 (1.05), V_5T_3 (1.05), V_3T_2 (1.03) and V_4T_3 (1.03) which did not differ from one another significantly. The lowest leaf area index was recorded in V_4T_2 (0.99).

Effect of cultivars on leaf area index was significant in all the stages.

The third month of planting, the highest leaf area index was recorded in Karpooravalli (V_6-0.17), which was on par with Njalipoovan (V_3-0.16). The lowest leaf area index was recorded in Elavazhai (V_1-0.13) and Monthan (V_2-0.13), which was on par with Vayalvazhai (V_5-0.14) and Palayankodan (V_4-0.14).

At fifth month of planting, the highest leaf area index was recorded in Karpooravalli (V_6-0.35), which was on par with Elavazhai (V_1-0.31). The lowest leaf area index was recorded in Palayankodan (V_4-0.28), which was on par with Njalipoovan (V_3-0.29), Monthan (V_2-0.29) and Vayalvazhai (V_5-0.30).

At seventh month of planting, the highest leaf area index was recorded in Karpooravalli (V_6-0.57), which was on par with Elavazhai (V_1-0.55). The lowest leaf area index was recorded in Palayankodan (V_4-0.46) and Njalipoovan (V_3-0.46), which was on par with Monthan (V_2-0.49) and Vayalvazhai (V_5-0.50).

Table 11. Effect of leaf pruning and varieties on Leaf Area Index

Treatment	Leaf area index			
	Stages after planting			
	3 months	5 months	7 months	At bunch emergence
V_1T_1	0.13	0.32	0.59	1.29
V_1T_2	0.14	0.31	0.54	1.15
V_1T_3	0.12	0.29	0.50	1.11
V_2T_1	0.12	0.29	0.50	1.14
V_2T_2	0.14	0.28	0.49	1.09
V_2T_3	0.14	0.29	0.50	1.08
V_3T_1	0.16	0.29	0.46	1.07
V_3T_2	0.15	0.30	0.46	1.03
V_3T_3	0.15	0.28	0.45	1.06
V_4T_1	0.14	0.28	0.46	1.05
V_4T_2	0.14	0.27	0.43	0.99
V_4T_3	0.15	0.29	0.48	1.03
V_5T_1	0.15	0.30	0.51	1.11
V_5T_2	0.14	0.30	0.50	1.08
V_5T_3	0.13	0.29	0.48	1.05
V_6T_1	0.18	0.33	0.53	1.13
V_6T_2	0.17	0.35	0.57	1.10
V_6T_3	0.17	0.37	0.60	1.13
SE	0.01	0.02	0.04	0.05
CD (0.05)	NS	NS	NS	0.13
V_1	0.13	0.31	0.55	1.19
V_2	0.13	0.29	0.49	1.10
V_3	0.16	0.29	0.46	1.05
V_4	0.14	0.28	0.46	1.02
V_5	1.14	0.30	0.50	1.08
V_6	0.17	0.35	0.57	1.12
SE	0.008	0.01	0.02	0.03
CD (0.05)	0.02	0.04	0.06	0.08
T_1	0.15	0.30	0.51	1.13
T_2	0.15	0.30	0.50	1.08
T_3	0.14	0.30	0.50	1.08
SE	0.006	0.009	0.01	0.02
CD (0.05)	NS	NS	NS	NS

The bunch emergence stage, the highest leaf area index was recorded in Elavazhai (V_1-1.19), which was on par with Karpooravalli (V_6-1.12). The lowest leaf area index was recorded in Palayankodan (V_4-1.02), which was on par with Njalipoovan (V_3-1.05), Vayalvazhai (V_5-1.08) and Monthan (V_2-1.10).

Effect of pruning levels had no influence on leaf area index in all the stages.

In general, the interaction effect of varieties and leaf pruning indicated that the treatments were significant.

Among the pruning strategies, also there was no significant difference among the treatments.

Effect of treatments, on varieties indicated that Elavazhai followed by Karpooravalli had the highest leaf area index when the total value at bunch emergence stage was considered. This was followed by Monthan, Vayalvazhai, Njalipoovan and Palayankodan in the order of higher values of leaf area index. These treatments were statistically on par.

4.1.11 Effect of leaf pruning on duration of banana

The results of the studies on the effect of leaf pruning on total duration of leaf harvest of six banana clones are presented in Table 12; Fig. 6 and 7.

The data on the interaction effect of leaf pruning levels and the cultivars indicated that, there was significant difference in total duration between the treatments.

The longest duration was recorded in V_6T_1 (337.83 days). The treatments V_6T_2 (322.42 days) and V_4T_1 (314.83 days) were statistically on par and following V_6T_1. Treatment V_4T_1 was followed by V_3T_1 (314.25 days), V_1T_1 (313.25 days). V_6T_3 (310.58 days) and V_2T_1 (308.17 days) and these treatments being statistically on par. The treatments V_3T_2 (303.19 days) and V_4T_2 (300.58 days) were statistically on par and were next to V_2T_1. These treatments were followed by V_2T_2 (292.75 days), V_1T_2

Table 12. Effect of leaf pruning on duration of banana varieties

Treatment	Duration, days
V_1T_1	313.25
V_1T_2	292.17
V_1T_3	287.42
V_2T_1	308.17
V_2T_2	292.75
V_2T_3	278.25
V_3T_1	314.25
V_3T_2	303.19
V_3T_3	285.50
V_4T_1	314.83
V_4T_2	300.58
V_4T_3	289.56
V_5T_1	287.00
V_5T_2	278.61
V_5T_3	276.11
V_6T_1	337.83
V_6T_2	322.42
V_6T_3	310.58
SE	2.67
CD (0.05)	7.65
V_1	297.61
V_2	293.06
V_3	300.98
V_4	301.66
V_5	280.57
V_6	323.61
SE	1.54
CD (0.05)	4.42
T_1	312.56
T_2	298.29
T_3	287.90
SE	1.09
CD (0.05)	3.12

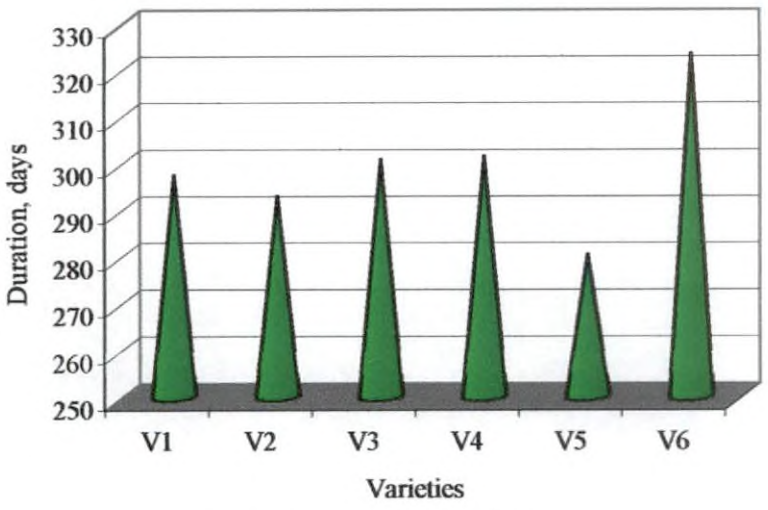


Fig. 6. Effect of varieties on duration of banana

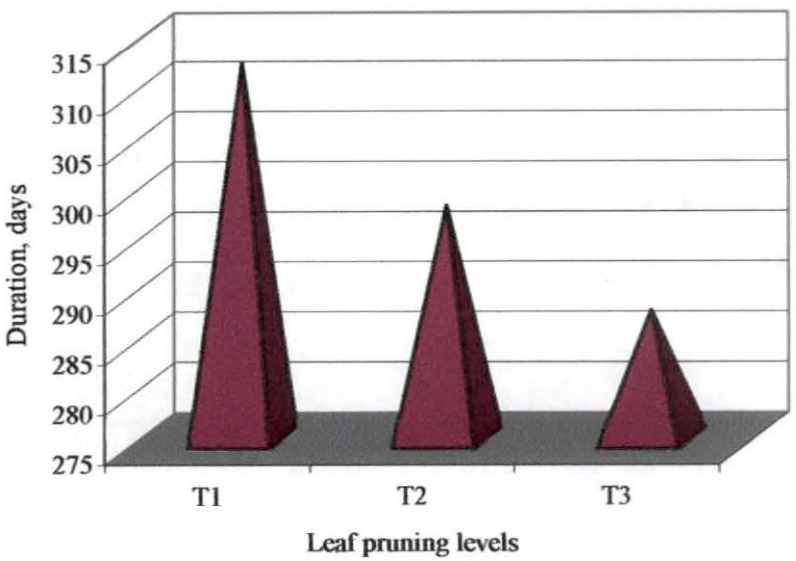


Fig. 7. Effect of leaf pruning on duration of banana

(292.17 days), V_4T_3 (289.56 days), V_1T_3 (287.42 days), V_5T_1 (287.00 days) and V_3T_3 (285.50 days), which were statistically on par. The shortest duration was recorded in V_5T_3 (276.11 days), V_2T_3 (278.25 days) and V_5T_2 (278.61 days), which did not differ from one another statistically.

Effect of cultivars significantly influenced the total duration of leaf harvest. The longest duration was recorded in Karpooravalli (V_6-323.61 days). This was followed by Palayankodan (V_4 -301.66 days), which was on par with Njalipoovan (V_3-300.98 days) and Elavazhai (V_1-297.61 days). The shortest duration was recorded in Vayalvazhai (V_5-280.57 days) followed by Monthan (V_2 – 293.06 days).

Effect of pruning levels also significantly influenced the total duration of leaf harvest. The longest duration was observed in T_1 (pruning all the leaves seven days after unfurling) (312.56 days) followed by T_2 (pruning alternate leaves seven days after unfurling) (298.29 days), and T_3 (No leaf pruning) (287.90 days).

The results thus indicated that pruning all the leaves seven days after unfurling (T_1) resulted in longer duration in the varieties tested, followed by pruning alternate leaves seven days after unfurling (T_2). The variety Karpooravalli had the longest duration. This was followed by Palayankodan, Njalipoovan and Elavazhai. The shortest duration was in Vayalvazhai followed by Monthan.

4.1.12 Effect of leaf pruning on the incidence of pests and diseases

The data on the incidence of pests are presented in Table 13.

The data revealed that the incidence of rhizome weevil was not significant among the treatments. However, the effect of cultivars and pruning levels showed significant difference. Within the cultivars, Njalipoovan recorded the incidence of rhizome weevil (V_3-1.0) while the other cultivars were not affected by this pest. Effect of pruning levels

Table 13. Effect of leaf pruning on the incidence of rhizome weevil

Treatment	Number of rhizome weevil / plant
V_1T_1	0.00
V_1T_2	0.00
V_1T_3	0.00
V_2T_1	0.00
V_2T_2	0.00
V_2T_3	0.00
V_3T_1	0.00
V_3T_2	3.00
V_3T_3	0.00
V_4T_1	0.00
V_4T_2	0.00
V_4T_3	0.00
V_5T_1	0.00
V_5T_2	0.00
V_5T_3	0.00
V_6T_1	0.00
V_6T_2	0.00
V_6T_3	0.00
SE	0.001
CD (0.05)	NS
V_1	0.00
V_2	0.00
V_3	1.00
V_4	0.00
V_5	0.00
V_6	0.00
SE	0.004
CD (0.05)	0.01
T_1	0.00
T_2	0.50
T_3	0.00
SE	0.008
CD (0.05)	0.03

also showed significant difference among themselves. T_2 (0.5) recorded the incidence of the pest. But others were free from the pest.

The overall assessment shows that Njalipoovan with the leaf pruning treatments of T_1 (pruning all the leaves seven days after unfurling) and T_2 (pruning alternate leaves seven days after unfurling) had more incidence of disease. Elavazhai, Monthan and Palayankodan were not affected by diseases with irrespective of leaf pruning treatments.

Effect of leaf pruning levels and varietal response on rhizome weevil showed that, the treatments were not significantly influenced. Effect of leaf pruning alone indicated that T_2 (pruning alternate leaves seven days after unfurling) was affected by rhizome weevil while the effect of varieties showed that, Njalipoovan was mostly affected.

The data on the incidence of sigatoka leaf spot disease and bunchy top are presented in Table 14.

The data revealed that the incidence of leaf spot disease was not significant in the treatments at all the stages of development. Effect of cultivars and pruning levels also were not significant irrespective of the development of the plant. However, the disease was higher in adult pre-floral vegetative stage than in post floral stage. Least occurrence of leaf spot disease was recorded at floral initiation stage. The combined effect of leaf pruning levels and varietal response on leaf spot disease showed that, the treatments were not significant. The individual effect of leaf pruning and varieties on leaf spot disease also showed that, the treatments were not significant.

It was noted that incidence of bunchy top disease was not significant within the treatments. However 5.6 per cent plants were affected in V_3T_2 followed by V_3T_1 (2.8 %) and V_6T_1 (2.8 %). The individual effect of cultivars showed significant difference among themselves. The highest incidence was recorded in Njalipoovan (V_3-2.8%) followed by Karpooravalli (V_6-0.93%). The other cultivars were not affected. The individual effect of pruning levels also showed significant

Table 14. Effect of leaf pruning on the incidence of diseases

Treatment	Sigatoka leaf spot disease index				
	Juvenile stage	Adult prefloral vegetative stage	Floral initiation stage	Post floral stage	Bunchy top (percentage)
V_1T_1	N	1.0	1.2	1.0	0.0
V_1T_2	N	1.0	1.0	1.2	0.0
V_1T_3	N	1.5	1.0	1.0	0.0
V_2T_1	N	1.6	1.0	1.3	0.0
V_2T_2	N	1.0	1.3	1.3	0.0
V_2T_3	N	2.0	1.2	1.2	0.0
V_3T_1	N	1.2	1.3	1.4	2.8
V_3T_2	N	1.2	1.4	1.0	5.6
V_3T_3	N	1.0	1.0	1.2	0.0
V_4T_1	N	2.4	1.0	1.3	0.0
V_4T_2	N	2.0	1.2	1.2	0.0
V_4T_3	N	2.0	1.0	1.3	0.0
V_5T_1	N	1.0	1.0	1.2	0.0
V_5T_2	N	1.2	1.2	1.3	0.0
V_5T_3	N	1.0	1.0	1.4	0.0
V_6T_1	N	1.1	1.0	1.0	2.8
V_6T_2	N	1.2	1.2	1.2	0.0
V_6T_3	N	1.0	1.2	1.3	0.0
SE	-	0.03	0.02	0.02	0.01
CD (0.05)	-	NS	NS	NS	NS
V_1	N	1.17	1.07	1.07	0.0
V_2	N	1.53	1.17	1.26	0.0
V_3	N	1.13	1.23	1.20	2.8
V_4	N	2.13	1.07	1.26	0.0
V_5	N	1.07	1.07	1.30	0.0
V_6	N	1.10	1.13	1.17	0.93
SE	-	0.08	0.05	0.06	0.02
CD (0.05)	-	NS	NS	NS	NS
T_1	N	1.38	1.08	1.20	0.93
T_2	N	1.27	1.22	1.20	0.93
T_3	N	1.42	1.07	1.30	0.0
SE	-	0.15	0.10	0.12	0.04
CD (0.05)	-	NS	NS	NS	0.17

N-Negligible

Note:

Disease index	Leaf area infected, %
Negligible	0 – 5
1	6 - 10
2	11-25
3	26-30
4	31-40
5	41-50
6	51-75
7	75 and above

difference. The highest incidence of the disease was recorded in T_1 (0.93 %) and T_2 (0.93 %) while T_3 was not affected.

Effect of leaf pruning levels and varietal response on bunchy top disease showed that, the treatments were not significant.

Effect of leaf pruning alone indicated that T_3 was not affected, while T_1 and T_2 were affected by bunchy top.

Effect of varieties showed that Njalipoovan was highly affected by bunchy top while Karpooravalli was least affected and other varieties were not affected.

4.1.13 Effect of leaf pruning on the cost of cultivation, net profit and benefit cost ratio of banana

The detailed cost of cultivation in Appendix II and its abstract presented in Table 15 and 16; Fig. 8 and 9, revealed that the cost of cultivation was higher in all the treatment plants (T_2-Rs.429015.93) compared to the control plants (T_3-Rs.417135.93) and the lowest was recorded in (T_1-Rs.394118.43). The total income per hectare was the highest in (V_1T_1-Rs.817500.00) followed by V_1T_2 (Rs.775500.00), V_4T_1 (Rs.770700.00), V_1T_3 (Rs.727000.00), V_4T_3 (Rs.725800.00) and V_3T_1 (Rs.678900.00). The lowest total income per hectare was observed in V_5T_1 (Rs.373000.00) followed by V_6T_1 (Rs.387000.00) and V_5T_2 (Rs.392000.00).

The income from fruits was the highest in V_1T_3 (Rs.567000.00 ha^{-1}) followed by V_4T_3 (Rs.565800.00 ha^{-1}) and V_3T_3 (Rs.517200.00 ha^{-1}). The lowest income from fruits was recorded in V_5T_1 (Rs.136000.00 ha^{-1}) followed by V_6T_1 (Rs.139500.00 ha^{-1}) and V_2T_1 (Rs.165000.00 ha^{-1}). The income from leaves was the highest in V_1T_1 (Rs.427500.00 ha^{-1}) followed by V_4T_1 (Rs.397500.00 ha^{-1}) and V_3T_1 (Rs.367500.00 ha^{-1}). The lowest income from leaves was recorded in V_5T_2 (Rs.96000.00 ha^{-1}) and V_6T_2 (Rs.96000.00 ha^{-1}) followed by V_2T_2 (Rs.150000.00 ha^{-1}) and V_3T_2 (Rs.160000.00 ha^{-1}).

. Table 15. Effect of leaf pruning and varieties (interaction) on the cost of cultivation, net profit and benefit/cost ratio of banana

Treatment	Cost of cultivation, Rs ha^{-1}	Income, Rs ha^{-1}				Profit (+)/loss (-), Rs ha^{-1}	Benefit/ cost ratio
		Fruits	Suckers	Leaves	Total		
V_1T_1	394118.43	270000.00	120000.00	427500.00	817500.00	+423381.57	2.07
V_1T_2	429015.93	468000.00	120000.00	187500.00	775500.00	+346484.07	1.81
V_1T_3	417135.93	567000.00	160000.00	-	727000.00	+309864.07	1.74
V_2T_1	394118.43	165000.00	80000.00	292500.00	537500.00	+143381.57	1.37
V_2T_2	429015.93	360000.00	80000.00	150000.00	590000.00	+160984.07	1.38
V_2T_3	417135.93	460000.00	120000.00	-	580000.00	+162864.07	1.39
V_3T_1	394118.43	191400.00	120000.00	367500.00	678900.00	+284781.57	1.72
V_3T_2	429015.93	280800.00	120000.00	160000.00	560800.00	+131784.07	1.31
V_3T_3	417135.93	517200.00	160000.00	-	677200.00	+260064.07	1.62
V_4T_1	394118.43	253200.00	120000.00	397500.00	770700.00	+376581.57	1.96
V_4T_2	429015.43	384600.00	120000.00	172500.00	677100.00	+248084.07	1.58
V_4T_3	417135.93	565800.00	160000.00	-	725800.00	+308664.07	1.78
V_5T_1	394118.43	136000.00	60000.00	177000.00	373000.00	-21118.43	0.95
V_5T_2	429015.93	236000.00	60000.00	96000.00	392000.00	-37015.93	0.91
V_5T_3	417135.93	352000.00	90000.00	-	442000.00	+24864.07	1.06
V_6T_1	394115.43	139500.00	60000.00	187500.00	387000.00	-7118.43	0.98
V_6T_2	429015.93	270000.00	60000.00	96000.00	426000.00	-3905.93	0.99
V_6T_3	417135.93	382500.00	90000.00	-	472500.00	+55364.07	1.13

Table16. Effect of leaf pruning and varieties on the cost of cultivation, net profit and benefit/ cost ratio of banana

Treatment	Cost of cultivation, Rs ha^{-1}	Income, Rs.ha^{-1}	Profit, Rs.ha^{-1}	Benefit/cost ratio
Cultivars				
V_1	413423.43	773333.33	359909.90	1.87
V_2	413423.43	569166.67	155743.24	1.38
V_3	413423.43	638966.67	225543.24	1.55
V_4	413423.43	724533.33	311109.90	1.77
V_5	413423.43	402333.33	-11090.10	0.97
V_6	413423.43	428500.00	14779.90	1.03
Pruning treatments				
T_1	394118.43	594100.00	199981.57	1.51
T_2	429015.93	570233.33	141069.07	1.33
T_3	417135.93	604083.33	186947.40	1.45

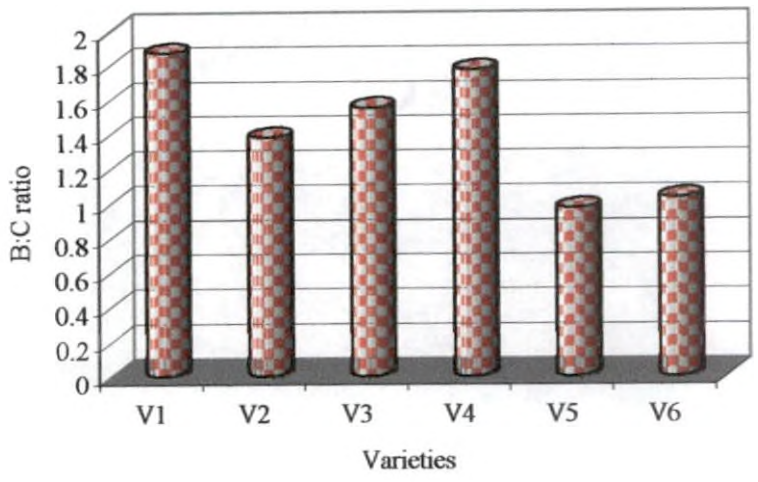


Fig. 8. Effect of varieties on benefit cost ratio

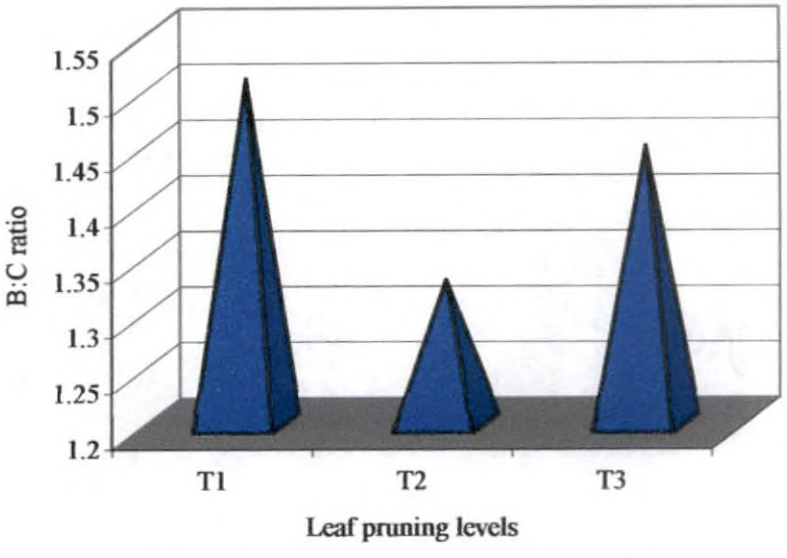


Fig. 9. Effect of leaf pruning on benefit cost ratio

The net profit per hectare was the highest in V_1T_1 (Rs.423381.57 ha^{-1}) followed by V_4T_1 (Rs.376581.57 ha^{-1}) and V_1T_2 (Rs.346484.07 ha^{-1}). The lowest net profit per hectare was recorded in V_5T_3 (Rs.24864.07 ha^{-1}) followed by V_6T_3 (Rs.55364.07 ha^{-1}).

The net loss per hectare was the highest in V_5T_2 (Rs.37015.93 ha^{-1}) followed by V_5T_1 (Rs.21118.43 ha^{-1}) and V_6T_1 (Rs.7118.43 ha^{-1}).

The highest benefit/cost ratio recorded in V_1T_1 (2.07) followed by V_4T_1 (1.96), V_1T_2 (1.81), V_4T_3 (1.78), V_1T_3 (1.74) and V_3T_1 (1.72). The lowest benefit/cost ratio was recorded in V_5T_2 (0.91) followed by V_5T_1 (0.95), V_6T_1 (0.98) and V_6T_2 (0.99).

Effect of cultivars were also shown a wide variation. The highest income was recorded in Elavazhai (V_1-Rs.773333.33 ha^{-1}) followed by Palayankodan (V_4-Rs.724533.33 ha^{-1}) and Njalipoovan (V_3-Rs.638966.67 ha^{-1}). The lowest income was recorded in Vayalvazhai (V_5-Rs.402333.33 ha^{-1}) followed by Karpooravalli (V_6-Rs.428500.00 ha^{-1}) and Monthan (V_2-Rs.569166.67 ha^{-1}). The highest profit was recorded in Elavazhai (V_1-Rs.359909.90 ha^{-1}) followed by Palayankodan (V_4-311109.90 ha^{-1}) and Njalipoovan (V_3-225543.24 ha^{-1}). The highest loss was recorded in Vayalvazhai (V_5-11090.10 ha^{-1}).

The highest benefit/cost ratio was recorded in Elavazhai (V_1-1.87) followed by Palayankodan (V_4-1.77) and Njalipoovan (V_3-1.55). The lowest benefit/cost ratio was recorded in Vayalvazhai (V_5-0.97) followed by Karpooravalli (V_6-1.03) and Monthan (V_2-1.38).

Effect of pruning levels also shown a wide variation. The highest cost of cultivation was recorded in T_2 (Rs.429015.93 ha^{-1}) followed by T_3 (Rs.417135.93 ha^{-1}). The lowest cost of cultivation was recorded in T_1 (Rs.394118.43 ha^{-1}).

The highest income was recorded in T_3 (Rs.604083.33 ha^{-1}) followed by T_1 (Rs.594100.00 ha^{-1}). The lowest income was recorded in T_2 (Rs.570233.33 ha^{-1}). The highest profit was recorded in T_1 (Rs.199981.57 ha-1) followed by T_3 (Rs.186947.40 ha^{-1}). The lowest

profit was recorded in T_2 (Rs.141069.07 ha^{-1}). The highest benefit/cost was recorded in T_1 (1.51) followed by T_3 (1.45). The lowest benefit/cost ratio was recorded in T_2 (1.33).

In general, the interaction effect of varieties and leaf pruning indicated that treatment T_1 (pruning all the leaves seven days after unfurling) was most profitable when the income from both leaf and bunch were considered. The plants in the T_2 plots (pruning alternate leaves seven days after unfurling) was least profitable. Since bunches were bigger in control, this was the second best treatment, though leaves were not available for sale. The varieties Elavazhai followed by Palayankodan and Njalipoovan found suitable for leaf production by pruning all the leaves seven days after unfurling. These were followed by Monthan, Vayalvazhai and Karpooravalli, which were found to be least suitable varieties for leaf production.

The following major conclusions could be drawn from the present studies on effect of leaf pruning on various banana varieties.

The pruning of leaves affected the plant height and girth. The deleterious effect was more pronounced in severe levels of pruning. The varieties Elavazhai, Palayankodan and Karpooravalli were less adversely affected compared to the other varieties.

In general, the length and breadth of leaves were not affected by the levels of leaf pruning. The variation in the length and breadth was mainly due to the varietal characteristics. However, all the varieties had the leaf length and breadth suitable for marketing as leaf plates.

The leaf thickness was not significantly influenced by the pruning levels. The varieties Elavazhai, Palayankodan and Njalipoovan had thin leaves.

Leaf area index was significantly influenced by the pruning treatments. Varieties Elavazhai and Karpooravalli had more leaf area index compared to other varieties.

The economically important consideration in growing the banana for leaf purpose are total leaves produced, number of leaves harvested, number of marketable leaves, leaf emission rate, duration of leaf harvest and the benefit/cost ratio. With respect to the above characters, it was observed that pruning all the leaves seven days after unfurling gave the bet results followed by pruning alternate leaves seven days after unfurling. The varieties Elavazhai, Palayankodan and Njalipoovan were found to be superior for leaf production compared to the other varieties tested.

From the above results, it is observed that banana varieties Elavazhai, Palayankodan and Njalipoovan are suitable for cultivation in Kerala conditions for leaf production. Pruning all the leaves seven days after unfurling was the most profitable practice in these varieties.

4.2 MOLECULAR ANALYSIS

Modified Walbot method standardized for red banana (Nayar, 2001) was followed for DNA isolation. Emerging leaves, before unfurling were used. The DNA yield of six banana clones are given in Table 17.

The DNA yield of six banana clones ranged from 395 µg / ml (Karpooravalli) to 1480 µg / ml (Njalipoovan). The purity of DNA (OD_{260}/OD_{280}) ranged from 1.57 (Vayalvazhai) to 1.97 (Elavazhai).

The electrophoretic assay of DNA samples using agarose gel (1.4%) revealed that the DNA samples isolated were intact in nature without any shearing.

4.2.1 Polymerase Chain Reaction (PCR)

The 25 µl reaction mixture consisted of 2.5 µl 1 x buffer (10 mM Tris-HCl, pH 9.0, 1.50 mM Kcl and 0.01 % gelatin) 200 µM each of dNTPs, 0.6 units of taq DNA polymerase, 5.0 pM primer and 20 ng of DNA gave good amplification. The programme consisted of an initial denaturation at 95^0C for 3.0 minutes followed by 45 cycles of denaturation at 95^0C for one minute, annealing at 36^0C for 1.0 minute 30 seconds and extension at 72^0C for 2.0 minutes. The synthesis step of the final cycle

Table 17. Quality and quantity of DNA isolated from six banana clones using modified Walbot's method

Sl. No.	Clones	A_{260}	A_{280}	A_{260}/A_{280}	DNA yield (µg / ml)
1	Elavazhai	0.183	0.093	1.97	915
2	Monthan	0.291	0.160	1.82	1455
3	Njalipoovan	0.296	0.153	1.93	1480
4	Palayankodan	0.147	0.091	1.62	735
5	Vayalvazhai	0.108	0.069	1.57	540
6	Karpooravalli	0.079	0.042	1.88	395

was extended further by 6.0 minutes. The amplification products were cooled to 4.0^{0}C after the reaction.

Forty decamer primers were screened for their efficiency using the DNA isolated from Elavazhai as the representative sample. Out of 40 decamer primers, 32 yielded amplification products. There was no amplification with the primers OPA-06, OPA-09, OPA-18, OPA-19, OPB-3, OPB-8, OPB-9 and OPB-14. The total number of bands, number of faint bands and the number of intense bands produced by the primers are given in Table 18.

These primers amplified 118 bands (average of 2.95 bands per primer) of which 115 bands (97.46 %) were polymorphic and three bands (2.54 %) were monomorphic. Primers varied in their ability to yield banding patterns with the template DNA (Fig. 10 to 13) Monomorphic bands were produced by the primers OPB-02, OPB-13 and OPB-18.

The highest number of bands (nine) was produced by the primer OPB-11; eight bands were produced by the primer OPB-15. OPA-11, OPB-06 produced seven bands. Five bands were produced by the primers OPA-03, OPA-20, OPB-07 and OPB-10. The least number of bands (two each) were produced by the primers like OPA-05, OPA-08, OPA-15, OPB-05, OPB-16 and OPB-17. OPB-02, OPB-13 and OPB-18 were produced one band each.

For further PCR amplification, only fifteen primers were selected (OPA-03, OPA-04, OPA-07, OPA-11, OPA-12, OPA-16, OPA-20, OPB-01, OPB-06, OPB-07, OPB-10, OPB-11, OPB-15, OPB-19 and OPB-20) which produced good amplification and more number of polymorphic bands. From the fifteen primers, eight primers were selected for DNA amplification of 6 banana clones (OPA-03, OPA-11, OPA-20, OPB-06, OPB-07, OPB-10, OPB-11 and OPB-15). These eight primers produced the highest number of bands as well as the highest number of intense bands. The PCR reactions were repeated at least twice in order to check the reproducibility. Data obtained from eight primers that gave

Table 18. Primer associated banding patterns with the DNA of Elavazhai using 40 primers (belonging to Kit A and Kit B) supplied by the Operon Inc., CA, USA.

Sl. No.	Primers	No.of faint bands	No.of intense bands	Total no. of bands
1	OPA-01	1	2	3
2	OPA-02	3	0	3
3	OPA-03	3	2	5
4	OPA-04	2	2	4
5	OPA-05	0	2	2
6	OPA-06	0	0	0
7	OPA-07	1	3	4
8	OPA-08	2	0	2
9	OPA-09	0	0	0
10	OPA-10	2	1	3
11	OPA-11	5	2	7
12	OPA-12	3	1	4
13	OPA-13	1	2	3
14	OPA-14	1	2	3
15	OPA-15	2	0	2
16	OPA-16	3	1	4
17	OPA-17	0	3	3
18	OPA-18	0	0	0
19	OPA-19	0	0	0
20	OPA-20	2	3	5
21	OPB-01	0	4	4
22	OPB-02	0	1	1
23	OPB-03	0	0	0
24	OPB-04	1	2	3
25	OPB-05	1	1	2
26	OPB-06	4	3	7
27	OPB-07	2	3	5
28	OPB-08	0	0	0
29	OPB-09	0	0	0
30	OPB-10	5	0	5
31	OPB-11	6	3	9
32	OPB-12	1	2	3
33	OPB-13	0	1	1
34	OPB-14	0	0	0
35	OPB-15	4	4	8
36	OPB-16	2	0	2
37	OPB-17	1	1	2
38	OPB-18	0	1	1
39	OPB-19	2	2	4
40	OPB-20	3	1	4

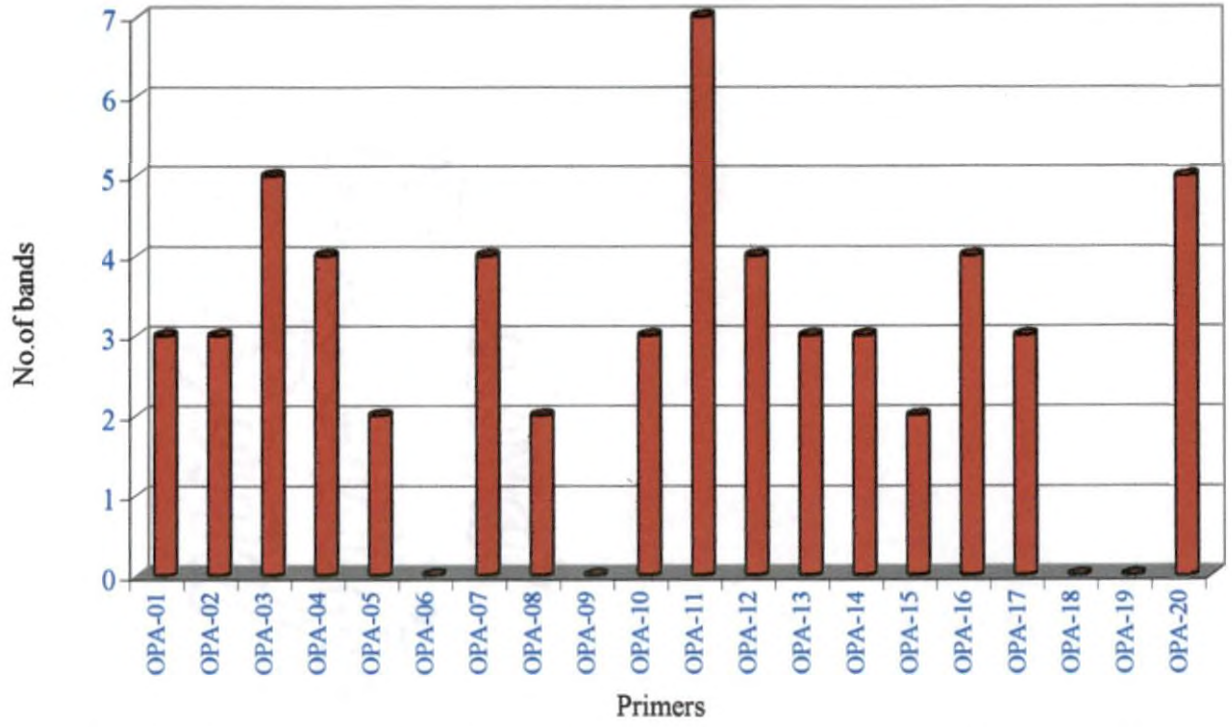


Fig. 10. Amplification profiles (total bands) of the DNA of Elavazhai using 20 primers (belonging to Kit A)

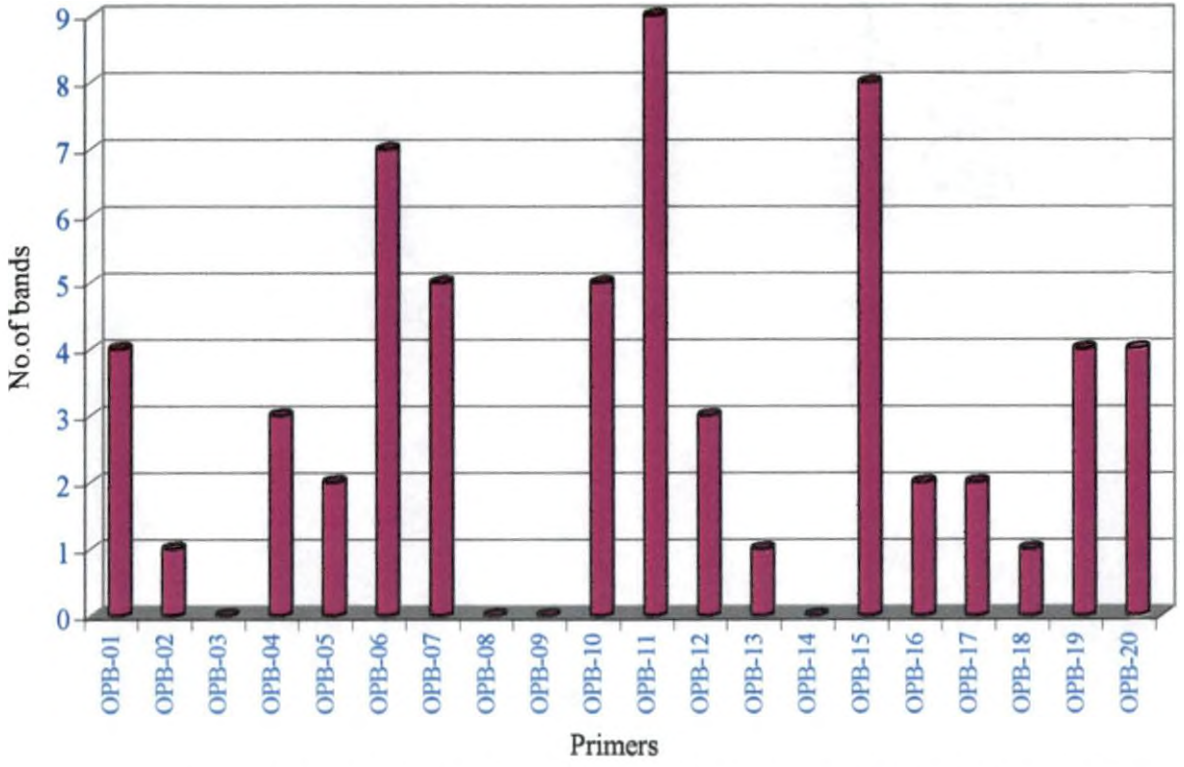


Fig. 11. Amplification profiles (total bands) of the DNA of Elavazhai using 20 primers (belonging to Kit B)

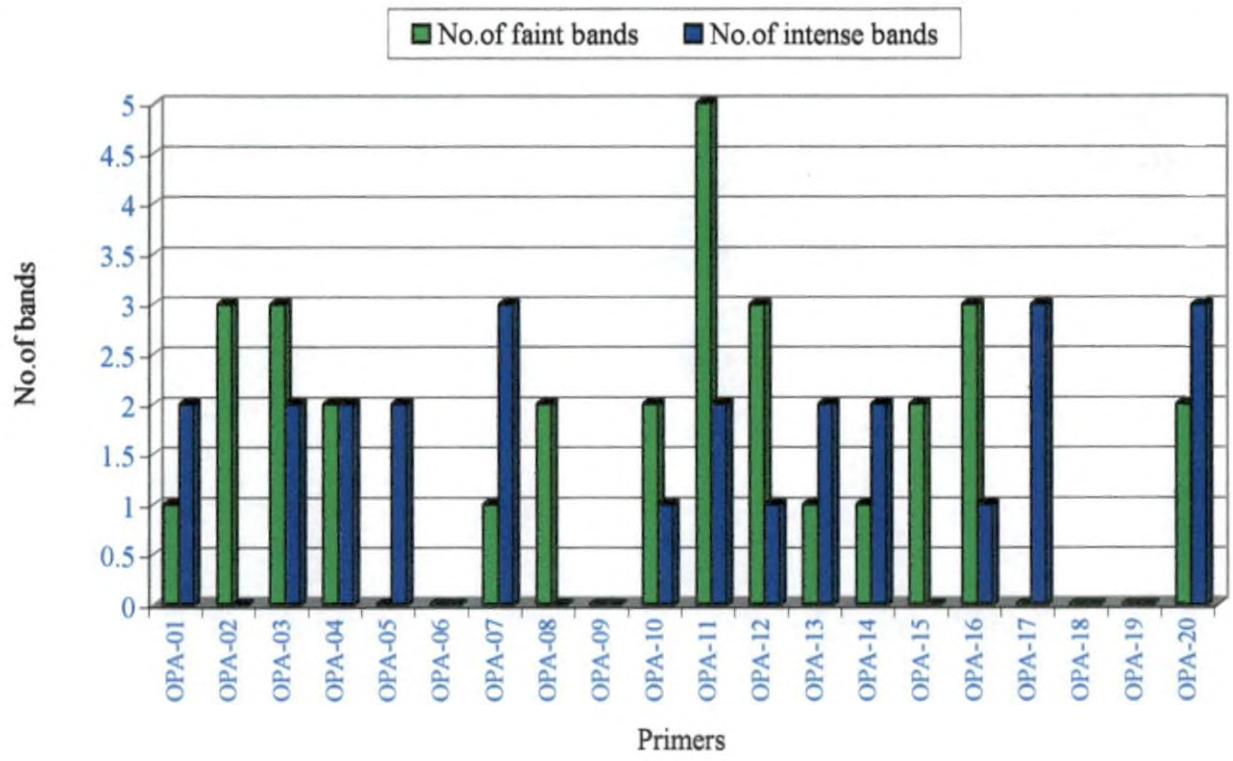


Fig. 12. Amplification profiles (intense and faint bands) of the DNA of Elavazhai using 20 primers (belonging to Kit A)

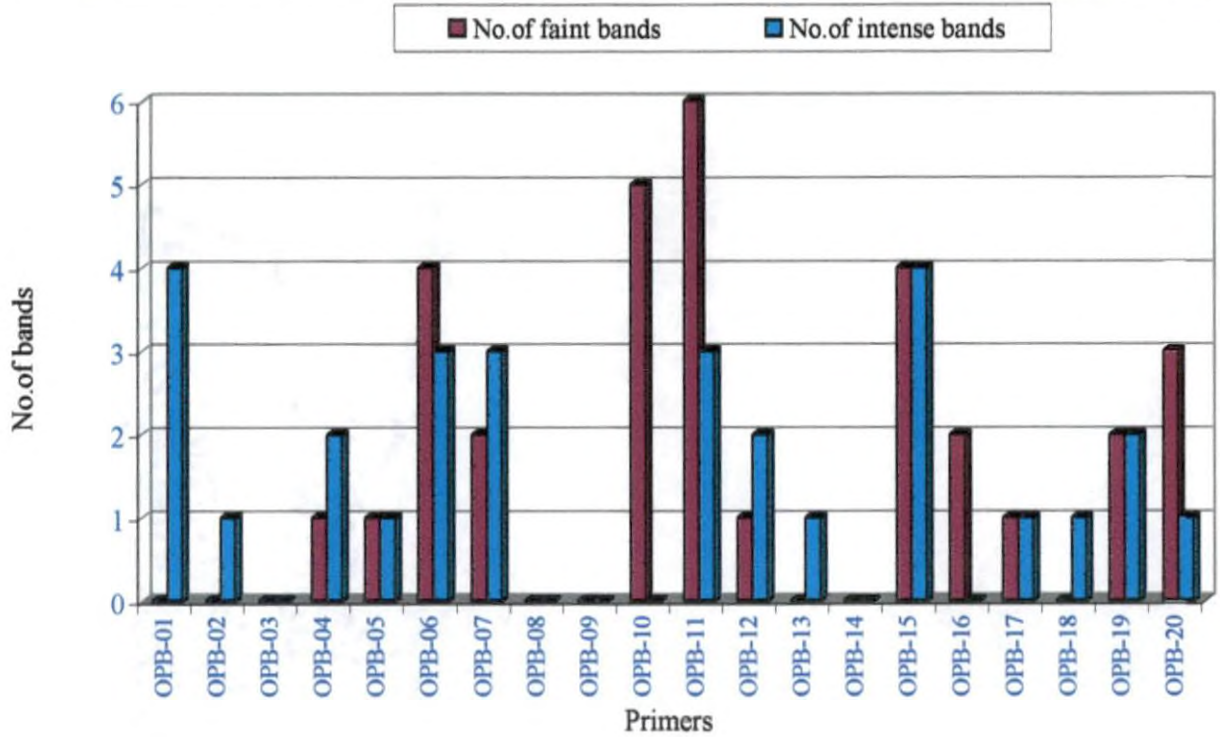


Fig. 13. Amplification profiles (intense and faint bands) of the DNA of Elavazhai using 20 primers (belonging to Kit B)

reproducible bands were used for further analysis. These eight primers amplified 89 scorable bands with an average of 11.13 bands per primer. The nucleotide sequence of these eight primers and number of informative RAPD markers given by each primers are shown in Table 19 and Fig.14. The number of bands resolved per amplification was primer dependent and varied from a minimum of nine and to a maximum of sixteen.

The highest number of scorable bands (sixteen) was obtained by the primer OPA-11. With the primer OPA-11, Monthan gave the highest number of bands (10). The eight bands each were obtained for Njalipoovan and Karpooravalli. The clones like Palayankodan and Vayalvazhai produced five bands each. The seven bands were obtained for Elavazhai. This primer did not produce any monomorphic bands (Plate 3 and Fig. 15).

The primer OPB-10 produced a total of twelve bands. Njalipoovan gave the highest number of bands (11). The seven bands were obtained for Monthan. The clones like Palayankodan, Vayalvazhai and Karpooravalli produced six bands each. The least number of bands (5) were obtained from Elavazhai. This primer did not produce any monomorphic bands (Plate 4 and Fig. 16).

The primers OPA-20 and OPB-06 produced a total of eleven bands each. With the primer OPA-20, Karpoorvalli gave the highest number of bands (9). The eight bands were obtained from Palayankodan. The clones like Elavazhai, Monthan and Vayalvazhai produced seven bands each. The least number of bands (6) were obtained from Njalipoovan. This primer did not produce any monomorphic bands (Plate 5 and Fig. 17).

The primer OPB-06 yielded a total of eleven scorable bands. With this primer, Elavazhai and Karpooravalli produced nine bands each. Vayalvazhai produced only eight bands. The six bands were produced from Palayankodan. Five bands each were obtained from Monthan and Njalipoovan. This primer did not produce any monomorphic bands (Plate 6 and Fig. 18).

Table19. Nucleotide sequences of primers and total number of informative RAPD markers amplified with them in the banana clones used in this study

Primer	Sequence	Number of informative RAPD markers
OPA-03	5`-AGTCAGCCAC-3`	10
OPA-11	5`-CAATCGCCGT-3`	16
OPA-20	5`-GTTGCGATCC-3`	11
OPB-06	5`-TGCTCTGCCC-3`	11
OPB-07	5`-GGTGACGCAG-3`	10
OPB-10	5`-CTGCTGGGAC-3`	12
OPB-11	5`-GTAGACCCGT-3`	9
OPB-15	5`-GGAGGGTGTT-3`	10

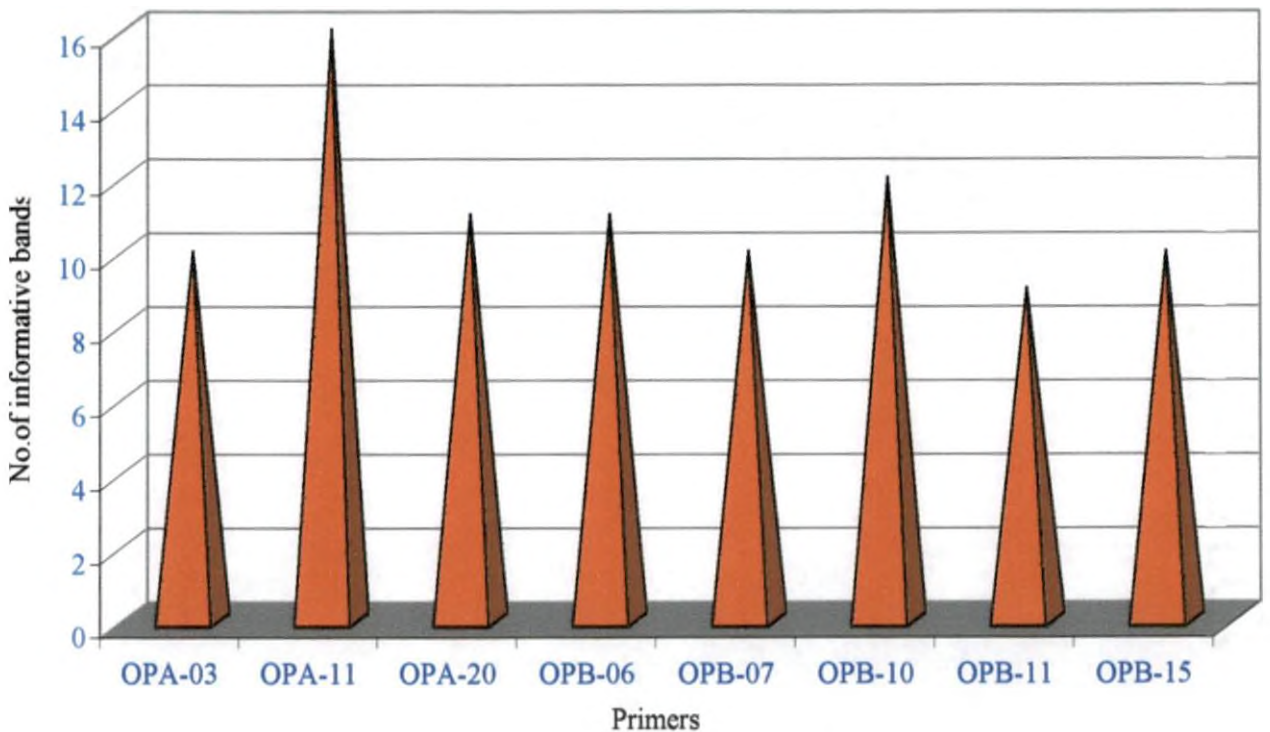
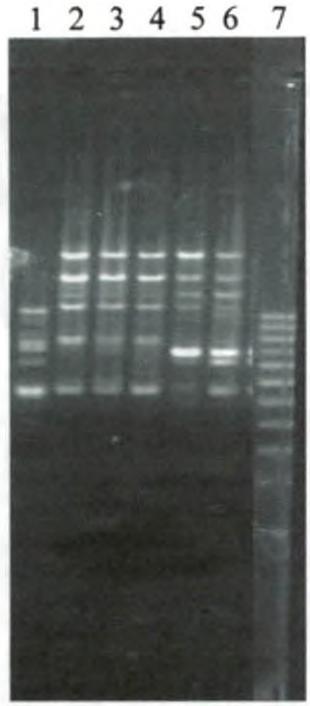
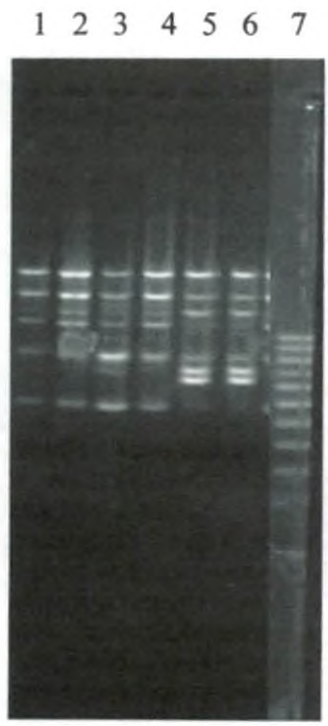


Fig. 14. Total number of informative RAPD markers amplified with the eight primers in six banana clones



1-Ilavazha
2-Monthan
3-Njalipoovan
4-Palayankodan
5-Vayalvalzhai
6-Karpooravalli
7-PCR molecular weight marker
(U.S. Biochemicals)

Plate 3. RAPD profile of six banana clones using the primer OPA 11



1-Ilavazha
2-Monthan
3-Njalipoovan
4-Palayankodan
5-Vayalvalzhai
6-Karpooravalli
7-PCR molecular weight marker
(U.S. Biochemicals)

Plate 4. RAPD profile of six banana clones using the primer OPB 10

Elavazhai	Palayankodan	Njalipoovan	Monthan	Vayalvazhai	Karpooravalli
-	+	-	-	-	-
-	+	-	-	-	-
-	+	-	-	-	-
-	+	+	+	+	+
-	+	+	+	+	+
-	+	+	-	-	-
-	+	+	-	+	+
-	+	+	+	+	+
+	-	-	-	-	+
+	-	-	-	-	-
+	-	-	-	-	-
-	+	+	+	-	-
+	-	-	-	-	-
+	-	+	-	+	+
+	-	-	-	-	+
+	+	+	+	-	+

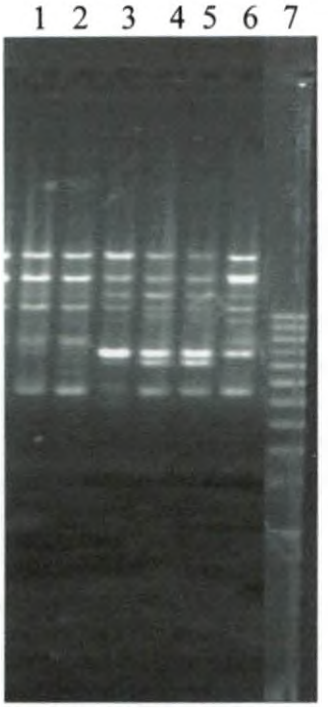
+ → Presence of band - →absence of band

Fig. 15. Representation of the amplification profile of the DNA of six banana clones using the primer OPA-11

Elavazhai	Palayankodan	Njalipoovan	Monthan	Vayalvazhai	Karpooravalli
+	+	+	+	+	+
+	+	+	+	+	+
-	+	+	-	-	-
-	+	+	+	+	+
+	+	+	+	-	-
-	-	+	-	-	-
+	+	+	+	+	+
-	-	+	-	+	+
-	-	-	-	+	+
+	+	+	+	-	-
-	-	+	-	-	-
-	-	+	-	-	-

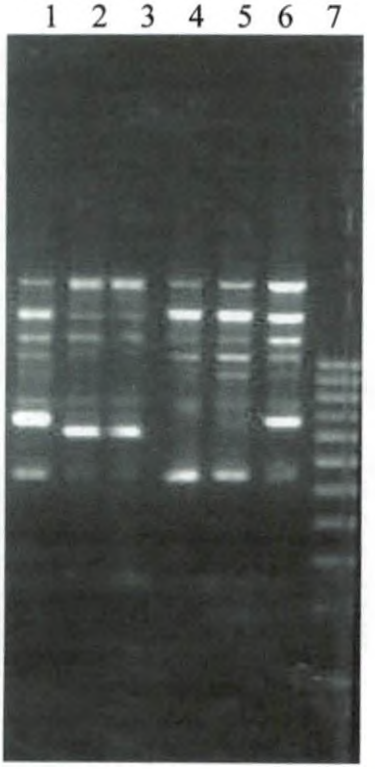
+ → Presence of band - →absence of band

Fig. 16. Representation of the amplification profile of the DNA of six banana clones using the primer OPB-10



1-Ilavazha
2-Monthan
3-Njalipoovan
4-Palayankodan
5-Vayalvalzhai
6-Karpooravalli
7-PCR molecular weight marker
(U.S. Biochemicals)

Plate 5. RAPD profile of six banana clones using the primer OPA 20



1-Ilavazha
2-Monthan
3-Njalipoovan
4-Palayankodan
5-Vayalvalzhai
6-Karpooravalli
7-PCR molecular weight marker
(U.S. Biochemicals)

Plate 6. RAPD profile of six banana clones using the primer OPB 06

Elavazhai	Palayankodan	Njalipoovan	Monthan	Vayalvazhai	Karpooravalli
+	+	+	+	+	+
+	+	+	+	+	+
+	+	+	+	+	+
+	+	+	+	+	+
-	-	-	-	-	+
-	-	-	-	-	+
+	+	-	-	-	+
-	-	+	+	+	+
-	-	+	+	+	-
+	+	-	-	-	-
+	+	-	+	+	+

+ → Presence of band - →absence of band

Fig. 17. Representation of the amplification profile of the DNA of six banana clones using the primer OPA-20

Elavazhai	Palayankodan	Njalipoovan	Monthan	Vayalvazhai	Karpooravalli
+	+	+	+	+	+
+	-	-	-	-	-
+	+	+	+	+	+
+	+	+	+	+	+
+	-	-	+	+	+
+	-	-	-	+	+
-	-	-	-	+	+
+	+	+	+	+	+
+	-	-	-	-	+
-	+	+	-	-	-
+	-	-	+	+	+

+ → Presence of band - →absence of band

Fig. 18. Representation of the amplification profile of the DNA of six banana clones using the primer OPB-06

The primers OPA-03, OPB-07 and OPB-15 produced a total of ten bands each. With the primer OPA-03, Njalipoovan and Vayalvazhai gave the highest number of bands (7). The six bands each were obtained for Monthan and Palayankodan. The five bands were produced for Elavazhai. The least number of bands (4) were produced by Karpooravalli. This primer did not produce any monomorphic bands (Plate 7 and Fig. 19).

Ten scorable bands were obtained on amplification with the primer OPB-07. The highest number of bands (9) were produced by Monthan. Eight bands were produced by Palayankodan. The clones like Njalipoovan and Vayalvazhai produced seven bands each. Six bands were obtained for Karpooravalli. The least number of bands (5) were produced by Elavazhai. This primer did not produce any monomorphic bands (Plate 8 and Fig. 20).

The primer OPB-15 produced a total of ten bands. The highest number of bands (8 bands each) were produced by Monthan and Vayalvazhai. The clones like Elavazhai and Karpooravalli produced seven bands each. Six bands were obtained from Njalipoovan. The least number of bands (5) were produced by Palayankodan. This primer did not produce any monomorphic bands (Plate 9 and Fig. 21).

The primer OPB-11 produced a total of nine bands. Elavazhai gave nine bands. Seven bands each were obtained by Monthan, Palayankodan and Vayalvazhai. Clones like Njalipoovan and Karpooravalli produced only six bands each. This primer did not produce any monomorphic bands (Plate 10 and Fig. 22).

4.2.2 Data analysis

The banding pattern from RAPD analysis for each primer was scored by visual observation. Reproducible bands were scored for their presence (+) or absence (-) for all the banana clones studied. A genetic Dissimilarity Matrix was constructed using the Jaccard's Coefficient Method (Table 20). The pairwise dissimilarity coefficient values varied

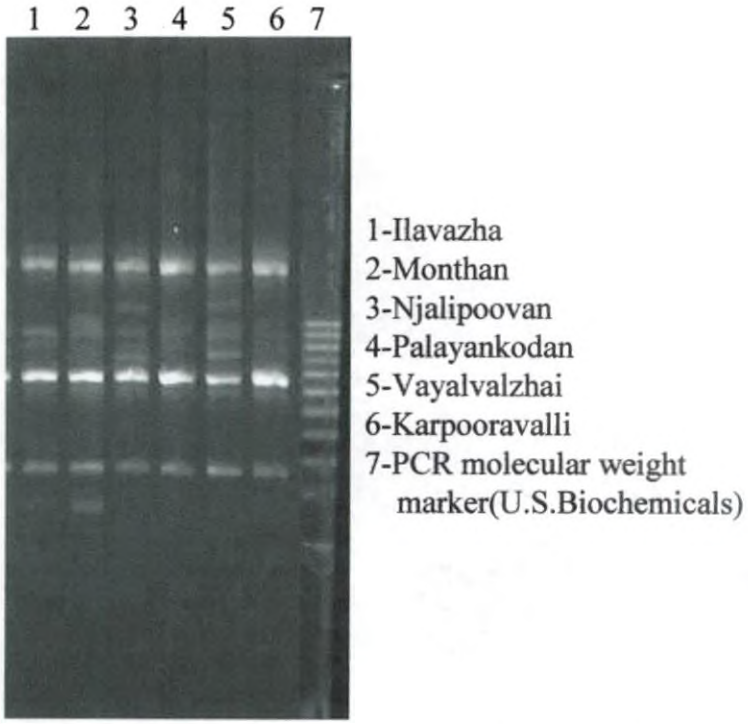


Plate 7. RAPD profile of six banana clones using the primer OPA 03

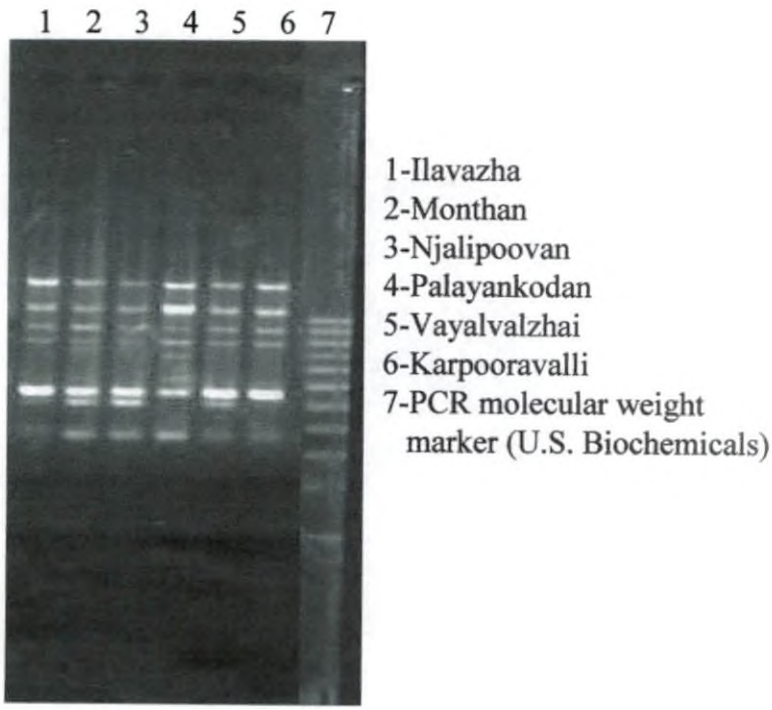


Plate 8. RAPD profile of six banana clones using the primer OPB 07

Elavazhai	Palayankodan	Njalipoovan	Monthan	Vayalvazhai	Karpooravalli
+	+	+	+	+	+
-	-	+	-	+	-
+	+	+	+	+	-
-	-	-	-	+	-
-	-	+	-	-	-
+	+	+	+	+	+
+	+	+	+	+	+
-	+	-	-	-	-
+	+	+	+	+	+
-	-	-	+	-	-

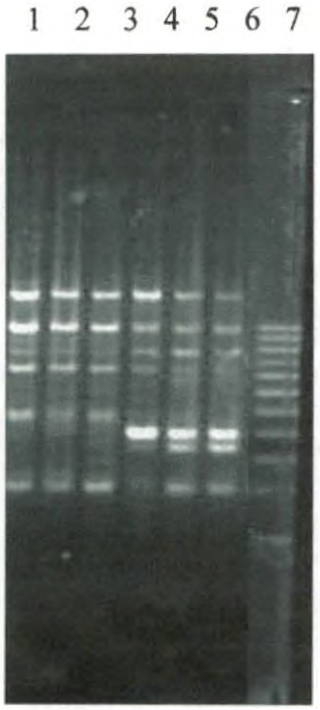
+ → Presence of band - →absence of band

Fig. 19. Representation of the amplification profile of the DNA of six banana clones using the primer OPA-03

Elavazhai	Palayankodan	Njalipoovan	Monthan	Vayalvazhai	Karpooravalli
+	+	+	+	+	+
+	+	+	+	+	+
+	+	+	+	+	+
+	+	+	+	+	+
-	+	-	-	-	-
-	-	-	+	-	-
-	+	-	+	-	-
+	+	+	+	+	+
-	+	+	-	+	-
-	+	+	+	+	+

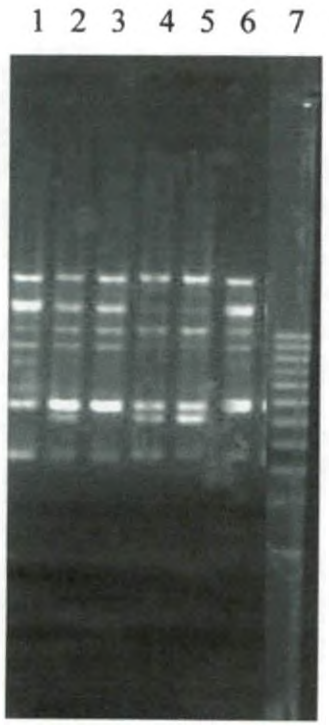
+ → Presence of band - →absence of band

Fig. 20. Representation of the amplification profile of the DNA of six banana clones using the primer OPB-07



1-Ilavazha
2-Monthan
3-Njalipoovan
4-Palayankodan
5-Vayalvalzhai
6-Karpooravalli
7-PCR molecular weight marker (U.S. Biochemicals)

Plate 9. RAPD profile of six banana clones using the primer OPB 15



1-Ilavazha
2-Monthan
3-Njalipoovan
4-Palayankodan
5-Vayalvalzhai
6-Karpooravalli
7-PCR molecular weight marker (U.S. Biochemicals)

Plate 10. RAPD profile of six banana clones using the primer OPB 11

Elavazhai	Palayankodan	Njalipoovan	Monthan	Vayalvazhai	Karpooravalli
+	+	+	+	+	+
+	+	+	+	+	+
+	+	-	-	-	-
+	+	+	+	+	+
+	+	+	+	+	+
-	-	-	-	+	-
+	+	+	-	-	-
-	+	-	+	+	+
-	-	-	-	+	+
+	+	+	-	+	+

+ → Presence of band - →absence of band

Fig. 21. Representation of the amplification profile of the DNA of six banana clones using the primer OPB-15

Elavazhai	Palayankodan	Njalipoovan	Monthan	Vayalvazhai	Karpooravalli
+	+	+	+	+	+
+	+	+	+	+	+
+	+	+	+	+	+
+	+	+	+	+	+
+	-	-	-	-	-
+	-	-	-	-	-
+	+	+	+	+	+
+	+	-	+	+	-
+	+	+	+	+	+

+ → Presence of band - →absence of band

Fig. 22. Representation of the amplification profile of the DNA of six banana clones using the primer OPB-11

Table 20. Dissimilarity Matrix of six banana clones based on the Jaccard's Similarity Index

	Elavazhai	Palayankodan	Njalipoovan	Monthan	Vayalvazhai	Karpooravalli
Elavazhai	0	0.444	0.486	0.448	0.479	0.388
Palayankodan		0	0.309	0.333	0.417	0.438
Njalipoovan			0	0.354	0.343	0.414
Monthan				0	0.317	0.344
Vayalvazhai					0	0.226
Karpooravalli						0

from 0.226 to 0.486. The least Dissimilarity Coefficient value was that of Vayalvazhai with Karpooravalli (0.226) followed by Palayankodan and Njalipoovan (0.309). Monthan with Vayalvazhai (0.317), Palayankodan with Monthan (0.333) and Njalipoovan with Vayalvazhai (0.343).

The highest value for Dissimilarity Index was obtained for Elavazhai with Njalipoovan (0.486) followed by Elavazhai with Vayalvazhai (0.479) and Elavazhai with Monthan (0.448).

Based on Dissimilarity Coefficients, the distance between pairs of clones was computed. The distance between pairs of clones and number of clusters formed corresponding to each distance were tabulated (Table 21). The genetic distance ranged from 0.226 to 0.388. The distance was the least between Vayalvazhai and Karpooravalli (0.226), followed by Palayankodan and Njalipoovan (0.309) and Monthan and Vayalvazhai (0.317).

On drawing a vertical line in the dendrogram (Fig. 23), along the point corresponding to a distance of 0.333, all the six clones got divided into three clusters. Monthan, Vayalvazhai and Karpooravalli together formed the largest cluster. Within this cluster, Vayalvazhai and Karpooravalli were more close to each other. Palayankodan and Njalipoovan formed another cluster. Elavazhai formed a separate cluster which was genetically distinct from all other clones.

Table 21. Genetic distance calculated using the nearest neighbour (single-link) method

Clones	Genetic distance	No. of clones in the clusters
Vayalvazhai, Karpooravalli	0.226	2
Palayankodan, Njalipoovan	0.309	2
Monthan, Vayalvazhai, Karpooravalli	0.317	3
Monthan, Njalipoovan, Palayankodan, Vayalvazhai, Karpooravalli	0.333	5
Elavazhai, Monthan, Njalipoovan, Palayankodan, Vayalvazhai, Karpooravalli	0.388	6

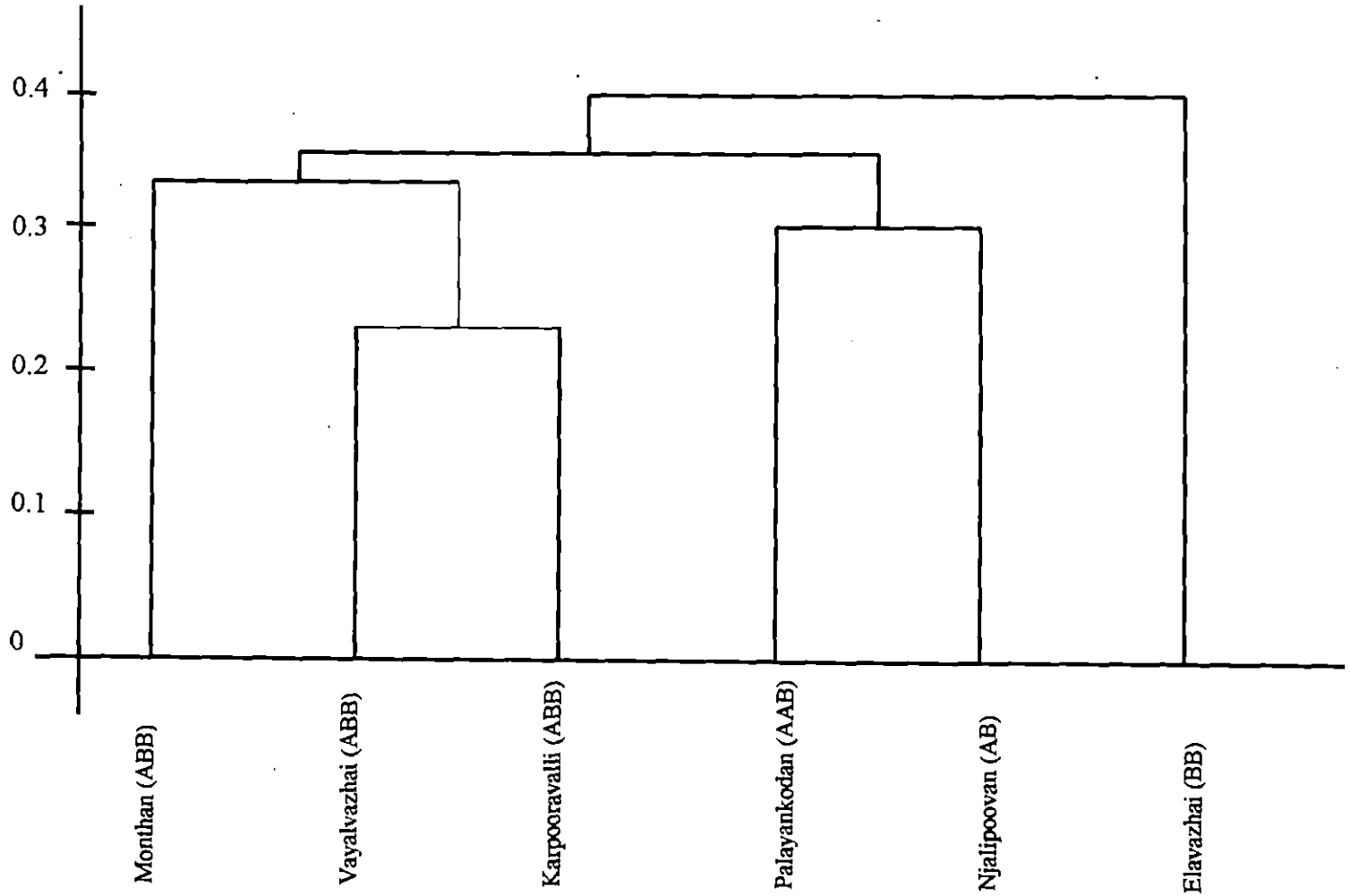


Fig. 23. Dendrogram obtained from RAPD analysis using nearest neighbour (single-link) method

DISCUSSION

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5. DISCUSSION

Banana is one of the important tropical fruit crops of the world. It is commercially grown from the equator to a latitude of 30^0 or more. Banana growth is largely a function of the number of leaves (Simmonds, 1966). A banana plant produces more leaves than that is required for normal fruit development, since this enables the plant to build up a strong pseudostem frame work capable of supporting the bunch (Stover and Simmonds, 1987). Excess leaf area and a thick pseudostem could explain why the harvest index in banana is much lower than most other fruit crops.

Experimental leaf pruning in banana has mostly been applied before flowering either to simulate leaf loss due to insect or disease damage (Ostmark, 1974) or to extend the cycle time for crop timing purposes (Turner and Hunt, 1987). Banana plants were selectively pruned by Pillai and Shanmugavelu (1977) and by Satyanarayana (1985). They found a delay in flowering time and reduction of bunch mass when leaf number was continually maintained at six compared with eighteen. However experiments in Honduras (Stover and Simmonds, 1987) indicated that when defoliation in the mother plant left as few as seven leaves at flowering, ratoon sucker growth was accelerated. This suggests that increased light penetration may be involved. There are pronounced differences in the photosynthetic efficiency of banana leaves due to the leaf age, leaf water potential, cultivar and light intensity. The possibility exists therefore that some compensatory photosynthetic boost may occur in the remaining leaves on pruned plants. In 'Williams' banana, rate of ratoon growth and plant water relations were affected by defoliation (Turner, 1970a). Increased light penetration may be the causative factor for ratoon growth in certain banana cultivars (Stover and Simmonds, 1987).

The present investigations were designed to find out banana varieties, which can be utilized for commercial cultivation exclusively for leaf production. Response of varieties to leaf pruning was also evaluated

in the experiment. Information on the feasibility of banana leaf production as a commercial venture were also expected from the study. Molecular characterization studies were carried out to obtain preliminary information on the genetic makeup of the varieties included in the study. The results obtained are discussed below.

5.1 EFFECT OF LEAF PRUNING ON GROWTH CHARACTERS

5.1.1 Effect of leaf pruning on plant height

The results of the study on the interaction effect of varieties and leaf pruning intensity indicated that pruning all the leaves seven days after unfurling had the most deleterious effect on plant height attained compared to pruning alternate leaves seven days after unfurling or no leaf pruning. Among the varieties tested, Elavazhai, Palayankodan and Karpooravalli had less adverse effects on plant height when pruning was done.

The studies on the growth characters of different banana varieties had led to the general impression that the banana plant produced more leaves than that is required for normal fruit development (Stover and Simmonds, 1987).

Partial defoliation studies in banana were conducted by several research workers. Basu (1901) reported that intensive leaf pruning from the hardy 'Athia' banana variety of Assam reduces the growth of the plants. According to Pillai (1975), plants with all the leaves in 'Poovan' banana produced maximum height. Pillai and Shanmugavelu (1978) observed that pseudostem height at shooting was the highest in plants with all leaves in 'Poovan' cultivar. In 'Basrai' banana plants, the height increased as the number of functional leaves per plant increased (Kothavade *et al.*, 1985). Satyanarayana (1985) in 'Basrai' banana observed that partial defoliation resulted in decreased growth in terms of height. Satyanarayana (1986) reported that plant of cv. Dwarf Cavendish at shooting was the highest when all the leaves were retained in the plants.

Increased leaf pruning in banana cultivars Valery and 'Olbino'I' Ewai resulted in a significant reduction in most plant growth parameters (Blomme *et al.*, 2001). Results of these studies agree with the present findings. Difference in the varietal response to leaf pruning as observed in the present studies, wherein Elavazhai Palayankodan and Karpooravalli were found to be comparatively less affected by the pruning intensities imposed agree with the results obtained by Bindu (1995) also.

5.1.2 Effect of leaf pruning on plant girth

The results of the study on the interaction effect of varieties and leaf pruning indicated that, pruning all the leaves seven days after unfurling had the most deleterious effect on plant girth attained by the varieties. The varieties Elavazhai, Palayankodan and Karpooravalli had less adverse effects on plant girth when alternate leaves were pruned seven days after unfurling. Pruning alternate leaves seven days after unfurling had less harmful effect on plant girth.

Satyanarayana (1985) observed that retention of all functional leaves produced the maximum plant girth in 'Basrai' banana. The highest plant girth was recorded in plants with higher number of leaves while the lowest was recorded in plants with lower number of leave in banana cv. Poovan (Pillai, 1975). Satyanarayana (1986) reported that plant girth was highest in plants retained with all the leaves in cv. Dwarf Cavendish. In poovan banana the girth of the plant was the highest with 12 or 18 functional leaves (Pillai and shanmugavelu, 1978). Increased leaf pruning in banana cultivars valery and Olbino I Ewai resulted in a significant reduction in most plant growth parmeters. (Blomme *et al*, 2001).

In the present studies Elavazhai, Palayankodan and Karpooravalli were found to be comparatively less adversely affected by the pruning treatments imposed. The above reports are in agreement with the general conclusions made from the present investigation of leaf pruning on plant girth.

5.1.3 Effect of leaf pruning on leaf characters

The present investigation on the effect of leaf pruning on the leaf characters indicated that the varieties Elavazhai, Palayankodan and Njalipoovan had less adverse effects on total number of leaf production when all the leaves were pruned seven days after unfurling. Elavazhai followed by Palayankodan, Njalipoovan and Vayalvazhai produced more number of leaves than other varieties under the influence of the leaf pruning treatments. The plants, which were subjected to more severe leaf pruning produced more leaves compared to no leaf pruning or less severe leaf pruning.

From the varieties, Elavazhai, Palayankodan, Njalipoovan and Vayalvazhai the number of leaves produced as well as number of marketable leaves were higher even when all the leaves were pruned seven days after unfurling. This treatment enabled harvest of double the number of leaves compared to the intensity of pruning alternate leaves.

Leaf emission rate, in general, increased with the severity of pruning. Elavazhai and Palayankodan had more leaf emission rate followed by Njalipoovan and Vayalvazhai.

Banana growth is a function of number of leaves produced (Simmonds, 1966). A fixed number of leaves emerge prior to flowering (Summerville, 1944; Champion, 1963 and Wardlaw, 1972).

The reports by Turner (1970a) and Nambisan and Rao (1980) indicated that leaf production is distinct for each group of clones.

Turner and Hunt (1987) suggested the existence of an internal mechanism to compensate the depletion of lamina through the production of a few extra leaves. Bindu (1995) observed that extra three leaves were produced in the most severe form of pruning in 'Palayankodan'. This may be the reason for the higher leaf production in severe leaf pruning treatments.

The treatments did not significantly influence the length, breadth and thickness of leaves. Karpooravalli followed by Elavazhai, Monthan,

Njalipoovan and Palayankodan produced lengthiest leaves. Elavazhai followed by Vayalvazhai, Monthan and Karpooravalli recorded the highest leaf breadth while Elavazhai, Palayankodan and Njalipoovan had comparatively lower leaf thickness.

The interaction effect of varieties and pruning levels significantly influenced the leaf area index. However, the mean values indicated that Elavazhai and Karpooravalli had more leaf area index followed by Monthan, Vayalvazhai, Njalipoovan and Palayankodan.

According to Simmonds (1966) in banana, growth is a function of the number of leaves produced. A fixed number of leaves emerge prior to flowering in banana (Summerville, 1944; Champion, 1963; Wardlaw, 1972; Ticho, 1960 and Barker and Steward, 1962). The reports by Turner (1970a) and Nambisan and Rao (1980) indicated that leaf production and leaf area are distinct for each group of clones. This may be the reason for the poor response of the leaf pruning treatments on these characters in the present study.

The present studies on the effect of leaf pruning on the total number of leaves produced indicated that Elavazhai, Palayankodan and Njalipoovan had less adverse effects on total number of leaf production when all the leaves were pruned seven days after unfurling. Elavazhai followed by Palayankodan, Njalipoovan and Vayalvazhai produced more number of leaves compared to the other varieties. The plants with more severe leaf pruning produced more number of leaves. This result is in conformity with the above reports indicating that the number of leaves produced being more dependent on the varietal characteristics may be influenced to a lesser extent by other factors. From the studies in similar lines, Uma *et al.* (2003) also observed that the maximum number of leaves was recorded by the Cv. Elavazhai. Findings of Turner and Hunt (1987) suggested the existence of an internal mechanism to compensate the depletion of lamina through the production of a few extra leaves. Bindu (1995) observed that an extra three leaves were produced in the most

severe form of pruning in 'Palayankodan'. In the present studies, production of a notable number of extra leaves (3-4 leaves) was observed in the most severe form of pruning. Thus it seems that pruning strategies had influenced the production of extra leaves rather than the varietal characteristics.

The present studies also indicated that, more number of leaves were produced and more number of marketable leaves were obtained in Elavazhai, Palayankodan, Njalipoovan and Vayalvazhai when all the leaves were pruned seven days after unfurling. This is mainly due to the reason that severe leaf pruning enabled harvest of double the number of leaves compared to the intensity of pruning alternate leaves.

The present studies on the effect of leaf pruning on leaf length, breadth and thickness indicated that the pruning treatment imposed did not significantly influence the leaf length, breadth and thickness. However, varietal differences were observed in the characters. Turner (1970a) and Nambisan and Rao (1980) reported that leaf area is distinct for each group of clones. From the studies on similar lines Uma *et al.* (2003) observed that maximum leaf area was registered for the cultivar Saba (1.420 m^2) followed by Elavazhai (1.20m^2). Elavazhai had the midrib thickness of 2.533 cm which was lesser than other cultivars (Uma *et al.*, 2003). The above reports are in agreement with the conclusions made from the present investigation on leaf length, breadth and thickness.

The present studies on the effect of leaf pruning on leaf emission rate indicated that leaf emission rate increased with the severity of pruning. Turner and Hunt (1987) as well as Robinson *et al.* (1992) have suggested the existence of some internal mechanism to compensate the depletion of lamina in banana plants. According to Pillai and Shanmugavelu (1976), under leaf pruning treatments, phylachron decreased with increase in the number of functional leaves and the level of functional leaves remained had probably a control over phylachron. Based on the above findings, it is possible to assume that the higher leaf

emission rate observed in the present studies maybe one of the adaptation to compensate for the loss of lamina.

The present studies indicated that the leaf area index was significantly influenced by the pruning treatments. However, the plants retained with all the leaves had the highest leaf area index. From studies on similar lines, Pillai and Shanmugavelu (1976) observed that in Poovan the highest leaf area was recorded from the plants which retained all the leaves. Bindu (1995) also observed that leaf area index was significantly affected by the leaf pruning treatments. Turner (1970a) and Nambisan and Rao (1980) indicated that leaf area is distinct for each group of clones. Uma *et al.* (2003) also observed that leaf area is distinct for the clones. The above reports are in agreement with the results of the present investigation on leaf area index. It may be assumed that leaf area index was primarily influenced by the varietal characteristics rather than the external factors.

5.1.4 Effect of leaf pruning on duration of leaf harvest

The present investigation on the effect of leaf pruning on duration of leaf harvest indicated that plants with pruning all the leaves seven days after unfurling had longer duration followed by pruning alternate leaves seven days after unfurling. Among the varieties evaluated the longest duration was recorded by Karpooravalli followed by Palayankodan, Njalipoovan and Elavazhai.

Leaf production in banana is related to flower induction. The number of leaves that emerge and the number of leaves inside the pseudostem have been related with floral initiation based on the production of fixed number of leaves in total (Ticho, 1960; Champion, 1963; Turner, 1970a and Wardlaw, 1972). Hartman and Bailey (1929) reported that defoliation in banana delayed shooting in some instances. Pillai (1975) reported that total cropping period was considerably less in plants, which maintained all leaves while it was more in plants which

maintained lower number of leaves in 'Poovan banana. 'Basrai' plants with all leaves retained took less days to flowering (Satyanarayana, 1985). Wardlaw (1972) stated that any circumstances which decreased the functional leaves is liable to have an adverse effect on duration of the crop to flowering. Satyanarayana (1986) reported that plants with all the leaves recorded considerably less cropping period in banana cv. Dwarf Cavendish. In banana cultivars Njalipoovan and Palayankodan, the leaf pruning treatment significantly increased the duration (Bindu, 1995). The similar results were obtained earlier by Turner and Hunt (1987); Ram Mohan *et al.* (1962) and Champion (1963) also. Thus from the present studies and earlier reports in similar lines, it becomes evident that leaf pruning extends the time for flowering in banana. It was also noted that with the increase in the intensity of leaf pruning there was a corresponding increase in the time taken for flowering.

5.1.5 Incidence of pests and diseases

The results of the studies on the interaction effect of varieties and leaf pruning indicated that the incidence of pests and diseases was not significantly influenced by the pruning treatments imposed. However individual cultivars had shown significant difference in pest and disease incidence. Elavazhai recorded zero percent leaf spot disease severity and youngest leaf spotted. The highest disease severity was registered by Kunnan (Uma *et al.*, 2003). Lacatan was the least susceptible to Rhizome weevil while maduranga was the most susceptible. Nendran ranked third with respect to rhizome weevil among the varieties evaluated (Viswanath, 1981). Babylatha *et al.* (1990) reported that there was wide variability in the reaction to rhizome weevil by various cultivars of banana. Brun (1962) stated that the level of resistance to Sigatoka displayed by a given cultivar might vary within relatively wide limits according to local conditions and the amount of infective inoculum. Thus the present studies and earlier reports indicate that pest and disease incidence may vary

within relatively wide limit of cultivars based on the local conditions and the present load of the inoculum rather than the intensity of leaf pruning.

5.1.6 Effect of leaf pruning on the benefit/cost ratio

The studies indicated that from the economic point of view, pruning all the leaves seven days after unfurling is beneficial in Elavazhai Palayankodan and Njalipoovan cultivars under Kerala conditions. It is observed that the control plants where no leaf pruning was practiced had the second best benefit cost ratio followed by plants with pruning alternate leaves seven days after unfurling. In general benefit/cost ratio ranged between 1:0.91 to 1:2.07.

Irulappan (2002) observed that plants grown for dual purpose (fruits and leaves) showed B:C ratio of 1:3.5 against plants grown only for leaves which showed a B:C ratio of 1:4.0 under Tamil Nadu conditions. Similar additional benefit and gross returns due to additional leaf yield was reported in other crops like Coriander (Bhati, 1988) and Coconut (Sudhakara *et al.*, 1989).

However, leaf pruning was found to be uneconomical by several research workers like Robinson *et al.* (1992), Bindu (1995) and CSFRI (1988). This controversial situation may be due to the consideration of yield of the both leaf and bunch. But the plants exclusively grown for leaves have the advantage of production of higher number leaves with shortest intervals giving additional benefits than the plants grown for dual purpose or for bunch alone.

The results obtained from the current studies thus indicated that pruning all the leaves had adverse effect on plant height and plant girth. In general, the length, girth and leaf thickness were not significantly influenced by the pruning levels. Leaf area index was also not significantly influenced. While considering the economically important characters like total number of leaves produced, number of leaves harvested, number of marketable leaves, leaf emission rate, duration of

leaf harvest and benefit / cost ratio, it was observed that pruning all the leaves seven days after unfurling have the best results followed by pruning alternate leaves seven days after unfurling. The varieties Elavazhai, Palayankodan and Njalipoovan were found to be more suitable for leaf production compared to the other varieties tested.

From the above results it is observed that banana varieties Elavazhai, Palayankodan and Njalipoovan are suitable for cultivation in Kerala condition exclusively for leaf purpose. Pruning all the leaves seven days after unfurling was the most profitable practice in these varieties.

5.2 MOLECULAR CHARACTERIZATION

5.2.1 RAPD Analysis

The PCR amplification was carried out using forty decamer primers (Operon Inc., CA., USA) of kit A and Kit B with the DNA of Elavazhai. The procedure standardized by Nayar (2001) of Red banana and Simi (2001) for Nendran ecotypes were used for amplification. Thirty-two primers out of the 40 used yielded amplification products. The total number of bands ranged from 1.0 to 9.0. The primers OPA-06, OPA-09, OPA-18, OPA-19, OPB-03, OPB-08, OPB-09 and OPB-14 did not yield any bands. This indicated that there is no sequence complementary to the sequence of these primers in the DNA of Elavazhai.

A total of 118 bands (average of 2.95 bands per primer) were generated by the thirty-two primers, of which 97.46 per cent (115 bands) were polymorphic and 3 bands were monomorphic. Twenty-nine primers showed high level of polymorphism. This could be explained by the capability of individual primers to amplify the less conserved and highly repeated regions of the genomic DNA (Prasannalatha *et al.*, 1999). There is a high probability for the amplified fragments to contain repeated sequences.

In the present study, eight promising primers for the RAPD analysis were identified, based on the number of polymorphic bands obtained. They were OPA-03, OPA-11, OPA-20, OPB-06, OPB-07, OPB-10, OPB-11 and OPB-15. These primers were used for amplifying DNA from six banana clones. Howell *et al.* (1994) observed similar results in nine *Musa* genotypes with nine random primers, fifty seven banana varieties with forty nine random primers (Bhat and Jarret, 1995); eleven Nendran ecotypes with eight random primers (Simi, 2001); twenty two *Musa* genotypes with six random primers (Jagannath, 2002). A previous report in *Brassica* L. (Demeke *et al.*, 1992) indicated that a minimum of 17 primers (284 polymorphisms) were necessary to obtain a stable classification of related species. However, Bhat and Jarret (1995) suggested that the number of polymorphisms may be more important than the number of primers for the generation of a stable phenogram. They also suggested that, the number of polymorphisms required to generate a stable phenetic analysis will vary with the plant material under investigation and the sequences that are amplified.

The eight primers used in this analysis yielded 89 scorable bands with an average of 11.13 bands per primer. The number of bands resolved per amplification was primer dependent and varied from 9.0 to 16.0. A similar study (Bhat and Jarret, 1995) was carried out in the assessment of genetic diversity in Indian *Musa* germplasm, genetic diversity in Nendran ecotypes (Simi, 2001) and genetic diversity analysis in AA and AB diploids in *Musa* (Jagannath, 2002).

It is interesting to note that OPA-11 primer has amplified relatively maximum number of scorable bands (sixteen) followed by OPB-10 yielded a twelve scorable bands, OPA-20 and OPB-06 recorded eleven scorable bands, OPA-03, OPB-07 and OPB-15 recorded ten scorable bands and OPB-11 produced nine scorable bands. Similar results were obtained by Bhat and Jarret (1995), twenty four scorable bands amplified with OPC-15, OPA-04 (twenty three), OPD-13 (twenty two), OPA-03 (Twenty);

Nayar (2001) eight scorable bands amplified with OPA-20 primer; Rekha *et al.* (2001) twenty eight *Musa* clones amplified with OPA-10(twelve bands) OPA-18, OPQ-18 (eleven bands), OPA-13 (ten bands), OPA-03 (nine bands) and OPA-04 (seven bands); Simi (2001) eleven Nendran clones amplified with OPB-10 (nine bands), OPA-03 and OPA-13 (seven bands), OPB-12 (five bands), OPB-01 and OPB-18 (four bands), OPA-10 and OPB-06 (three bands); Jagannath (2002) fourteen bands amplified with OPG-03, followed by OPC-03, OPF-04, OPF-12 and OPF-15 which recorded twelve scorable bands.

5.2.2 Data analysis

A genetic dissimilarity matrix was constructed using the Jaccard's coefficient method. The genetic distance between the clones ranged from 0.226 (Vayalvazhai and Karpooravalli) to 0.486 (Elavazhai and Njalipoovan). The pair wise coefficient values varied between 0.226 to 0.388. The least dissimilarity coefficient value was that vayalvazhai with Karpooravalli (0.226). The highest value for dissimilarity index was obtained for Elavazhai with Monthan, Njalipoovan, Palayankodan, Vayalvazhai and Karpooravalli (0.388). This substantiates, the moderately broad distribution of genetic variability, which can be attributed to the genetic base in their origin. Simi (2001) obtained average similarity coefficient value for French plantain clones was 0.6616.

The estimation of dissimilarity coefficients and construction of dendrogram by using the nearest neighbour (single link) method revealed the presence and extent of genetic similarities among the six banana clones evaluated. All the six banana clones got divided into three clusters. Vayalvazhai, Karpooravalli and Monthan (ABB) together formed single cluster. Within this cluster, Vayalvazhai and Karpooravalli were more close to each other. This may be due to similar genome characters and also morphological characters. Morphologically both had robust growth characters like plant height, pseudo stem girth and bunch characters.

Rekha *et al.* (2001) found that all the cultivars of ABB group were found to be in single cluster. Bhat and Jarret (1995) reported that ABB cultivars were grouped together. Palayankodan (AAB)and Njalipoovan (AB) grouped together. The similar results were obtained by Kahangi (2002), where the AAB and AB groups were grouped together. Bhat and Jarret (1995) stated that Njalipoovan and Palayankodan were grouped together. The close relationship of the cultivars in this group had common AB genomic group. The dendrogram illustrates clearly evident that Elavazhai (BB) entirely different from the rest of the clones and it formed a single cluster. It is well known that Elavazhai collected from Tamil Nadu is morphologically different from the other clones. The similar results were obtained by Bhat and Jarret (1995), where BB group was grouped separately from other clones.

Our study indicated that RAPD markers are readily detectable and analysed the variations present among the clones and intraclones of banana. RAPD techniques tends itself to germplasm characterization. Polymorphism obtained in the present study will be useful in finger printing and in determining the genetic diversity among the banana clones. Further studies on analysis of clones with more number of reliable DNA markers may be helpful in confirming the results. Knowledge of the degree of genetic relationship between these clones will be important for the development of new accessions and to establish a core collection as a part of the germplasm collection and management. The molecular marker analysis through RFLP, SSR etc. may probably throw more light on their genetic relatedness of these clones.

SUMMARY

6.SUMMARY

The present investigations on "Screening banana (*Musa* sp.) varieties for leaf production" was conducted at the Department of Horticulture, College of Agriculture, Vellayani, Thiruvananthapuram during 2002 – 2003. The objective of the study was to evaluate the changes in leaf production pattern of banana varieties due to leaf pruning and to select banana varieties for commercial leaf production. The treatments included six varieties of banana with three pruning levels. Molecular characterization of banana varieties included in the study was also carried out to obtain preliminary information on their genetic makeup. During the course of the experiment, plant growth under different leaf pruning conditions were critically observed. The important findings are summarized below.

The plant height was significantly affected by the combined effect of leaf pruning and the varieties. The varieties Elavazhai, Palayankodan and Karpooravalli had less adverse effects on plant height when alternate leaves were pruned seven days after unfurling. The plots with no leaf pruning had recorded the tallest plants. Effect of treatments on varieties indicated that Palayankodan followed by Elavazhai and Karpooravalli were less affected by leaf pruning. Among the pruning strategies, pruning alternate leaves seven days after unfurling had less harmful effect on plant height.

The girth of the plants was significantly affected by the interaction effect of leaf pruning and the varieties. The varieties Elavazhai, Palayankodan and Karpooravalli had less adverse effects on plant girth when alternate leaves were pruned seven days after unfurling. Elavazhai followed by Palayankodan and Karpooravalli were comparatively less affected by the pruning treatments. Pruning alternate leaves seven days after unfurling had less harmful effect on plant girth. The plants with no leaf pruning recorded the highest girth.

The leaf emission rate was significantly affected by the interaction effect of leaf pruning and varieties. In the varieties, tested leaf emission rate was higher when all the leaves were pruned seven days after unfurling. Elavazhai and Palayankodan followed by Njalipoovan and Vayalvazhai had more leaf emission rate, while Karpooravalli and Monthan had low leaf emission rate.

The leaf production was significantly affected by the interaction effect of leaf pruning and the varieties. Leaf pruning in general increased the total leaf production. The varieties Elavazhai, Palayankodan and Njalipoovan showed less adverse effects on total number of leaf production when all the leaves were pruned seven days after unfurling. Effect of treatments on varieties indicated that Elavazhai followed by Palayankodan, Njalipoovan and Vayalvazhai produced more number of leaves. The plants which were subjected to more severe leaf pruning had more leaf production, while the plants in the control plots produced lower number of leaves.

The number of harvested leaves was significantly affected by the interaction effect of leaf pruning and varieties. In the varieties, Elavazhai, Palayankodan, Njalipoovan and Vayalvazhai, more number of leaves could be harvested when all the leaves were pruned seven days after unfurling. In the varieties, Elavazhai followed by Palayankodan, Njalipoovan and Vayalvazhai more number of leaves were harvested compared to the other varieties tested. Pruning all the leaves resulted in harvest of more number of leaves compared to other treatments. This treatment enabled harvest of double the number of leaves compared to the intensity of pruning alternate leaves.

The number of marketable leaves was significantly affected by the interaction effect of leaf pruning and varieties. In the varieties Elavazhai, Palayankodan, Njalipoovan and Vayalvazhai more number of marketable leaves were obtained when all the leaves were pruned seven days after unfurling. In the varieties, Elavazhai, Palayankodan,

Njalipoovan and Vayalvazhai more number of marketable leaves were obtained. Pruning all the leaves resulted in more number of marketable leaves compared to other treatments. This treatment enabled double the number of marketable leaves compared to the intensity of pruning alternate leaves.

The leaf length was not significantly affected by the interaction effect of leaf pruning and the varieties. The varieties Karpooravalli followed by Elavazhai, Monthan, Njalipoovan and Palayankodan produced lengthiest leaves. Effect of pruning did not significantly affect the length of leaves.

The leaf breadth was not significantly affected by the interaction effect of leaf pruning and the varieties. The varieties Elavazhai, followed by Vayalvazhai, Monthan and Karpooravalli recorded the highest leaf breadth. Effect of pruning did not significantly affect the breadth of leaves.

The leaf thickness was not significantly affected by the interaction effect of leaf pruning and the varieties. The relation of leaf thickness, with varietal response was more pronounced. The varieties Elavazhai, Palayankodan and Njalipoovan had comparatively lower leaf thickness, while Karpooravalli, Vayalvazhai and Monthan had more leaf thickness.

The leaf area index was significantly affected by the interaction effect of leaf pruning and the varieties. The varieties, Elavazhai and Karpooravalli recorded highest leaf area index, while Palayankodan, Njalipoovan and Vayalvazhai recorded the lowest leaf area index. Effect of pruning did not significantly affect the leaf area index.

The duration of leaf harvest was significantly affected by the interaction effect of leaf pruning and the varieties. All the varieties tested had higher duration, when all the leaves were pruned seven days after unfurling followed by pruning alternate leaves seven days after unfurling. The varieties Karpooravalli followed by Palayankodan, Njalipoovan had the higher duration while Vayalvazhai and Monthan had

the lowest duration. Pruning all the leaves seven days after unfurling resulted in higher duration while plants with no leaf pruning had lower duration.

The occurrence of bunchy top disease was not significant with the interaction effect of leaf pruning and the varieties. However, Njalipoovan and Palayankodan were affected by the disease while other varieties were not affected by bunchy top.

The occurrence of leaf spot disease was not significant with the interaction effect of leaf pruning and the varieties. Treatments like varieties and pruning levels were not found to be significantly associated with disease incidence.

The occurrence of rhizome weevil was not significantly affected by the interaction effect of leaf pruning and the varieties. However, Njalipoovan was affected by rhizome weevil while others were not affected.

The interaction effect of varieties and leaf pruning indicated that, pruning all the leaves seven days after unfurling was most profitable when income from both leaf and bunch were considered. The plants with pruning alternate leaves seven days after unfurling was least profitable. Since the bunches were bigger in control, this was the second best treatment, though leaves were not available for sale. The varieties, Elavazhai followed by Palayankodan and Njalipoovan found suitable for leaf production by pruning all the leaves seven days after unfurling. These varieties were followed by Monthan, Vayalvazhai and Karpooravalli, which were found to be less suitable varieties for leaf production.

Molecular characterization of six banana clones was carried out using RAPD markers.

The DNA yield of six banana clones ranged from 395 µg / ml (Karpooravalli) to 1480 µg / ml (Njalipoovan). The purity of DNA (OD_{260}/OD_{280}) ranged from 1.57 (Vayalvazhai) to 1.97 (Elavazhai).

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Initially DNA isolated from Elavazhai was screened with 40 decamer primers and these primers amplified 118 bands (average of 2.95 bands per primer) of which 115 bands (97.46 %) were polymorphic and three bands (2.54 %) were monomorphic. Eight primers were selected for DNA amplification of 6 banana clones (OPA – 03, OPA – 11, OPA – 20, OPB – 06, OPB – 07, OPB – 10, OPB – 11 and OPB – 15). These eight primers amplified 89 scorable bands with an average of 11.13 bands per primer.

A genetic dissimilarity matrix was constructed using the Jaccard's coefficient method. The pair wise coefficient values varied from 0.226 to 0.486. Based on dissimilarity coefficients, the distance between pairs of clones and number of clusters were computed. The genetic distance ranged from 0.226 to 0.388. At a distance of 0.333, all the six clones got divided into three clusters. Monthan, Vayalvazhai and Karpooravalli together formed the largest cluster. Within this cluster, Vayalvazhai and Karpooravalli were more close to each other. Palayankodan and Njalipoovan formed another cluster. Elavazhai formed a separate cluster, which was genetically distinct from all other varieties.

REFERENCES

7. REFERENCES

Al-Zahim, M.A., Ford-Lloyd, B.V. and Newbury, H.J. 1999. Detection of somaclonal variation in garlic (*Allium sativum* L.) using RAPD and cytological analysis. *Pl. Cell Rep.* 18: 473-477

Anolles, C. G., Bassam, G.B. and Gresshoff, P.J. 1991. DNA amplification on fingerprinting using very short arbitary oligonucleotide primers. *Biotechnology* 9: 553-557

Anolles, C.G. and Trigiano, R.N. 1997. Nucleic acid markers in agricultural biotechnology. *Agric. Biotech. News Inf.* 9: 235-242

Anslow, R.C. 1966. The rate of appearance of leaves, on the tillers of the Gramineae. *Herb. Abstr.* 36: 149-155

Astley, D. 1992. Preservation of genetic diversity and accession integrity. *Fld. Crops Res.* 219: 205-224

Babu, H.T.P. 2000. RAPD analysis to assess the genetic stability in tissue culture derived black pepper (*Piper nigrum* L.) plants. M.Sc.(Hort.) thesis, Kerala Agricultural University, Thrissur, 89 p.

Babylatha, A.K., Amma, P.S. and Pushkaran, K. 1990. Field tolerance of banana cultivars to leaf spot diseases and rhizome weevil. *S. Indian Hort.* 38:102-107

Baird, F., Cooper, B.S., Waugh, R., De Maine, M. and Powel, W. 1992. Molecular characterization of inter and intraspecific somatic hybrids of potato using random amplified polymorphic DNA (RAPD) markers. *Mol. Gen. Genet.* 233: 469-475

Banerjee, N.S., Manoj, P. and Das, M.R. 1999. Male-sex associated RAPD markers in *Piper longum* L. *Curr. Sci.* 77: 693-695

Banno, K., Yifei, L., Ishikawa, H., Nakano, S. and Nobatake, S. 2000. Isozymes and RAPD markers to identify the parent-hood of Japanese pear 'Kuratsuki'. *J. Jpn. Soc. hort. Sci.* 69: 208-213

Barker, W.G.and Steward, F.C. 1962. Growth and development of the banana plant. *Ann. Bot.* 26:421-425

Bastianel, M., Dornelles, A.L.C., Machado, M.A., Wickert, E., Coletta, H.D.F., Schafer, G. and Maraschin, S.D.F. 2001. Characterization of citrus genotypes (*Citrus* spp.) using RAPD markers. *Ciencia-Rural* 31: 763-768

Basu, B.C. 1901. *The Cultivation of Plantain in the Assam Valley.* Agricultural Department, Assam, 145 p.

Bhat, K.V., Bhat, S.R. and Chandel, K.P.S. 1992. Survey of isozyme polymorphism for clonal identification in *Musa*. *HortScience*. 27: 501-507

Bhat, K.V., Jarret, R.L. and Liu, Z.W. 1994. RFLP characterization of Indian *Musa* germplasm for clonal identification and classification. *Euphytica* 80: 95-103

Bhat, K.V. and Jarret, R.L. 1995. Random amplified polymorphic DNA and genetic diversity in Indian *Musa* germplasm. *Genet. Resour. Crop Eval.* 42: 107-118

Bhat, K.V., Bhat, S.R., Chandel, K.P.S., Lakhanpaul, S. and Ali, S. 1995. DNA fingerprinting of *Musa* cultivars with oligonucleotide probes specific for simple repeats motifs. *Genet. Anal. Tech. Appl.* 45: 51-57

Bhati, D.S. 1988. Effect of leaf plucking on growth, yield and economics of coriander varieties under semi arid conditions. *Indian J. Agron.* 33:242-244

Bindu, C.S. 1995. Regulation of leaf pruning to optimize leaf and bunch harvest in *Musa* (AB group) Njalipoovan and (AAB group) Palayankodan. M.Sc.(Hort.) thesis, Kerala Agricultural University, Thrissur, 191 p.

Blomme, G., Tenkouano, A. and Swennen, R. 2001. Influence of leaf removal on shoot and root growth in banana. *Infomusa* 10(2): 10-13

Bretting, P.K. and Widrlechner, M.P. 1995. Genetic markers and horticultural germplasm management. *HortScience* 30: 1349-1356

Brown, P.T.H., Lang, F.D., Kranz, E. and Lorz, H. 1993. Analysis of single protoplasts and regenerated plants by PCR and RAPD technology. *Mol. Gen. Genet.* 237: 311-317

Brun, J. 1962. Studies preliminaries sut putilisation des varieties de bananiers, resistantes dans la lutte contre la cercosporiose. *Fruits d outré met.* 17:113-119 (Spanish)

Cabrera, O., Macaya, G., Villatobos, H., Diaz, M. and Leon, O. 1998. Study of the genetic variability in *Musa* spp. with random amplified polymorphic DNA technique (RAPD). *Revista Fitotecnia Mexicana* 21: 61-67

Caetano-Anolles, G., Bassam, B.J. and Greshoff, P.M. 1991. DNA amplification fingerprinting: a strategy for genome analysis. *Pl. Mol. Biol. Rep.* 9: 294-307

Champion, J. 1963. *Lebananier*. Maison-neuve et Larose, Paris, 381 p.

Chaque, V., Mercir, J.S., Guinard, M.A., Gaurcel, D. and Vedel, F. 1996. Identification and mapping on chromosome nine of RAPD markers linked to SW-5 in tomato by bulk segregant analysis. *Theor. Appl. Genet.* 92: 1045-1051

Christophani, M., Machado, M.A. and Grattapagha, D. 1999. Genetic linkage mapping of citrus Sunki Hort and *Poncirus trifoliate* (L.) and mapping of citrus tristeza virus resistance gene. *Euphytica* 109: 25-32

Coletta-Filho, H.D., Machado, M.A., Targon, M.L.P.N., Moreira, M. C. P. Q. D. G. and Pompeu-Junior, J. 1998. Analysis of the genetic diversity among mandarins (*Citrus* spp.) using RAPD markers. *Euphytica* 102: 133-139

Cooke, R.J. 1994. The characterization and identification of crop cultivars by electrophoresis. *Electrophoresis* 5: 59-72

Crouch, J.H., Crouch, H.K., Ortiz, R. and Jarret, R.L.1997. Microsatellite markers for molecular breeding of *Musa*. *INFOMUSA* 6: 5-6

Crouch, J.H., Vuylsteke, D. and Ortiz, R. 1998. Perspectives on the application of biotechnology to assist the genetic enhancement of plantain and banana (*Musa* spp.). *Electron. J. Biotech.* 1: 1-18

Crouch, J.H., Crouch, H.K., Constandt, H., Gysel, A.V., Breyne, P., Montagu, M.V., Jarret, R.L. and Ortiz, R. 1999. Comparison of PCR-based molecular marker analysis of *Musa* breeding populations. *Mol. Breed.* 5: 233-244

Crouch, J.H., Crouch, H.K., Madsen, S., Vuylsteke, D.R. and Ortiz, R. 2000. Comparative analysis of phenotypic and genotypic diversity among plantain landraces (*Musa* spp. AAB group). *Theor. Appl. Genet.* 101: 1056-1065

CSFRI. 1988. *Does Leaf Pruning Benefit Banana Yields ?* Information Bulletin. Citrus and Subtropical Fruit Research Institute, Kimberley, 248 p.

Damasco, O.P., Graham, C.G., Henry, J.R., Adkins, S.W., Smith, M.K. and Godwin, I.D. 1996. Random amplified polymorphic DNA (RAPD) detection of dwarf off types in micropropagated Cavendish (*Musa* spp. AAA) bananas. *Pl. Cell Rep.* 16: 118-123

Damasco, O.P., Adkins, S.W., Godwin, I.D. and Smith, M.K. 1998. Use of a SCAR-based marker for early detection of dwarf off-types in micropropagated Cavendish bananas. *Acta Hort.* 461: 157-164

Davies, K. 1993. Of mice and men (and cow and cats). *Nature* 361-478

Debener, T., Bartels, C. and Mattiesch, L. 1996. RAPD analysis of genetic variation between a group of rose cultivars and selected wild rose species. *Mol. Breed.* 2: 321-327

Debener, T. and Mattiesch, L. 1999. Construction of a genetic linkage map for roses using RAPD and AFLP markers. *Theor. Appl. Genet.* 99: 891-899

Demeke, T., Adams, R.P. and Chibbar, R. 1992. Potential taxonomic use of random amplified polymorphic DNA (RAPD): a case study in *Brassica*. *Theor. Appl. Genet.* 84: 990-994

Deverna, J.W. and Alpert, K.B. 1990. RFLP technology. Horticultural Biotechnology: *Royal Horticultural Biotechnology Symposium, November 7-9, 1989.* (eds. Bennett, A.B. and Neil, S.D.O), University of California, Wiley-Liss, New York, pp. 247-250

Devlin, R.M. 1973. *Plant Physiology.* Van Nostrand Reinhold Co. London, 478 p.

Duneman, F., Kahuan, R. and Schmidt, H. 1994. Genetic relationship in *Malus* evaluated by RAPD fingerprinting of cultivars and wild species. *Pl. Breed.* 113: 150-159

Duran, Y., Rohde, W., Kullaya, A., Goikoetxea, P. and Ritter, E. 1997. Molecular analysis of East African tall coconut genotypes by DNA marker technology. *J. Genet. Breed.* 51: 279-288

*El-Tarras, A., Fayek, M., Kilany, O. and Wally, H. 2001a. Biochemical and molecular genetic studies of olive cultivars. *Egypt. J. Hort.* 28: 1-13

*El-Tarras, A., Hossni, Y.A., Elbanna, A.A. and Shehata, S. H. M. 2001b. Identifying strawberry cultivars using protein pattern (PAGE) and random amplified polymorphic DNA (RAPD) markers. *Egypt. J. Hort.* 28: 15-25

Engelborgh, I., Swenner, R. and Campenhout, S. V. 1998. The potential of AFLP to detect genetic differences and somaclonal variants in *Musa* spp. *INFOMUSA* 7: 3-6

Epplen, J.T., Ammer, H. and Epplen, C. 1991. Oligonucleotide fingerprinting using simple repeat motifs: a convenient, ubiquitously applicable method to detect hypervariability for multiple purposes. *DNA finger printing: Approaches and Applications* (eds. Burke, T., Dolf, G., Jeffreys, A.J. and Wolff, R.). Birkhauser, Basel, pp. 50-69

Erlich, H.A., Gelfand, D. and Srinsky, G. 1991. Recent advances in the polymerase chain reaction. *Science* 252: 1643-1651

Faure, S., Noyer, J.L., Horry, J.P., Bakry, F., Lanaud, C. and Gonzalez, D. 1993. A molecular marker based linkage map of diploid bananas. (*Musa acuminata*). *Theor. Appl. Genet.* 87: 517-526

FIB. 2004. *Farm Guide 2004.* Farm Information Bureau. Government of Kerala, Thiruvananthapuram, 96 p.

Gawel, N. J. and Jarret, R.L. 1991. Cytoplasmic genetic diversity in banana and plantain. *Euphytica* 52: 19-23

Gawel, N.J., Jarret, R.L. and Whittemore, A.P. 1992. Restriction fragment length polymorphism (RFLP) based phylogenetic analysis of *Musa*. *Theor. Appl. Genet.* 81: 783-786

Gopimany, R. 1977. A note on clone reaction to leaf spot diseases in banana. *Agric. Res. J. Kerala* 15:73-76

Goulao, L., Cabrita, L., Oliveira, C.M. and Leitao, M.J. 2001. Comparing RAPD and AFLP analysis in discrimination and estimation of genetic similarities among apple cultivars. *Euphytica* 119: 259-270

*Groenendijk, K.E. 1970. *Photosynthesis in Banana.*. Department of Tropical crops, Agricultural University, Wageningen, 74 p.

Gupta, P.K., Balyan, H.S., Sharma, P.C. and Ramesh, B. 1996. Microsatellites in plants-A new class of molecular markers. *Curr. Sci.* 70: 45-53

Gupta, P.K., Rajeev, K. and Varshney. 1999. Molecular markers for genetic fidelity during micropropagation and germplasm conservation. *Curr. Sci.* 76: 1308-1310

Halos, S.C. and Ferreon, A.C.M. 1998. Assessment of genetic variation in Philippine mangoes using RAPD markers. *Philipp. J. Crop Sci.* 23: 73-74

Hammerschlag, F.A., Hashmi, G., Huettel, R., Werner, D. and Ritchie, P. 1996. *In vitro* selection and *in vitro* screening for disease resistance in fruit trees. *HortScience* 31: 695-696

Hartman, A.N. and Bailey, A.L. 1929. *The Effect of Defoliation on Banana Weights.* United Fruit Company, New York, 247 p.

Hashmi, G., Huettel, R., Meyor, R., Krusberg, L. and Hammerschlag, F. 1997. RAPD analysis of somaclonal variants derived from embryo callus cultures of peach. *Pl. Cell Rep.* 16: 624-627

Heinze, B. and Schemidt, J. 1995. Monitoring genetic fidelity Vs Somaclonal variation in Norway spruce (*Picea alies*) somatic embryogenesis by RAPD analysis. *Euphytica* 85: 341-345

Herrera, R., Cares, V., Wilkinson, M.J. and Caligari, P.D.S. 2002. Characterisation of genetic variation between *Vitis vinifera* cultivars from Central Chile using RAPD and inter simple sequence repeats (ISSRs) markers. *Euphytica* 124: 139-145

Hills, D.M. and Moritz, C. 1990. *Molecular Systematics.* Sinaner Association, Sunderland, Mass, 490 p.

Hong, Y.Y., Schuyler, S.K., Jutta, K. and Hanna, S. 1997. A RAPD marker tightly linked to the scab resistance gene Vf in apple. *J. Am. Soc. hort. Sci.* 122: 47-52

Hong, D.J., Shuang, S.H. and Qin, Z.X. 1999. Rapid identification of tomato somaclonal variation with RAPD. *J. trop. Subtrop. Bot.* 7: 308-312

*Horry, J.P. 1985. Mise en point d'une technique characterization de quelques genotypes de bananiers (*Musa* spp.) cultivars *in vitro* par electrophorese des esterases. *Fruits* 40: 785-788 (French)

Howell, E.C., Newbury, H.J., Swennen, R.L., Withers, L.A. and Ford-Lloyd, B.V. 1994. The use of RAPD for identifying and classifying *Musa* germplasm. *Genome* 37: 328-332

IARI. 1999. *Research Report 1998-1999.* Indian Agricultural Research Institute, Indian Council of Agricultural Research, New Delhi, 160 p.

Iqbal, M.J., Asad, S. and Zafar, Y. 1995. DNA polymorphism in banana and sugarcane varieties revealed by RAPD analysis. *International Symposium on the Use of Induced Mutations and Molecular Techniques for Crop Improvement, June 19-23, 1995.* International Atomic Energy Agency, Vienna, Austria, pp. 309-317

Irulappan, I. 2002. Cultivating banana for leaves. *Global Conference on Banana and Plantain –Souvenir, October 28-31, 2002.* (eds. Singh, H.P. and Dadlani, N.K). Association for The Improvement in Production and Utilization of Banana, Bangalore, pp.35-37

Jaccard, P. 1908. Nouvelles rescherchers sur la distribution Florále Bull. Soc. Vaudoise de sciences *Naturelles* 44: 223-270 (French)

Jagannath, P.S.K. 2002. Genetic diversity analysis in AA and AB diploids of *Musa* using Random Amplified Polymorphic DNA (RAPD) markers. M.Sc.(Hort.) thesis, Tamil Nadu Agricultural University, Coimbatore, 65 p.

Jarret, R.L., Gawel, N., Whittemore, A. and Sharrock, S. 1992. RFLP-based phylogeny of *Musa* in Papua New Guinea. *Theor. Appl. Genet.* 84: 579-584

Jarret, R.L., Bhat, K.V., Cregan, P., Ortiz, R. and Vuylsteke, D. 1994. Isolation of microsatellite DNA markers in *Musa*. *INFOMUSA* 3: 3-4

Jeffrey, A.J., Wilson, V. and Thein, S.L. 1985. DNA fingerprinting in plants. *Nature* 314: 67-73

Jenny, C., Carreal, F. and Bakry, F. 1997. Revision of banana taxonomy: Klue Teparod (*Musa* spp.) reclassified as a triploid. *Fruits* 52: 83-91

Joshi, S.P., Prabhakar, K.R. and Vidhya, S.G. 1999. Molecular markers in plant genome analysis. *Curr. Sci.* 77: 230-240

Kaemmer, D., Afza, A., Weising, K., Kahl, G. and Novak, F. J. 1993. Oligonucleotide and amplification fingerprinting of wild species and cultivars of banana (*Musa* spp.). *Biotechnology* 10: 1030-1035

Kaemmer, D., Fescher, D., Jarret, R.L., Baurens, F.C., Grapin, A., Dambier, D., Noyer, J.L., Lanaud, C., Kahl, G. and Lagoda, P.J.L. 1997. Molecular breeding in the genus *Musa*-A strong case for STMS marker technology. *Euphytica* 96: 49-63

Kahangi, E.M., Lawton, M.A. and Kumar, C.A.C.Y. 2002. RAPD profiling of some banana varieties selected by small scale farmers in Kenya. *J. hort. Sci. Biotech.* 77: 393-398

KAU. 1990. *KAU Achievements and Activities*. Banana Research Station (KAU), Kannara, 24 p.

KAU. 1996. *Package of practices recommendations, 'Crops', 1996.* Kerala Agricultural University, Directorate of Extension, Mannuthy, Thrissur, Kerala, 267 p.

Kaundun, S.S., Zyvoloup, A. and Park, Y.G. 2000. Evaluation of the genetic diversity among elite tea (*Camellia sinensis* var. *sinensis*) accessions using RAPD markers. *Euphytica* 115: 7-16

Ke, I.S. 1980. Studies on the physiological characteristics of banana in Taiwan. *J. Chinese. Soc. Hort. Sci.* 26:18-26

Kelley, V.W. 1932. The effect of pruning of excised shoots on the transpiration rates of some deciduous fruit species. *Proceedings of American Society of Horticultural Science, March 25-29, 1932.* (eds.Cadillat, R.M. and Ellis, F.). American Society of Horticultural Sciences, New York, pp.71-73

Koller, B., Lehmann, A., Mc Demott, J.M. and Gessler, C. 1993. Identification of apple cultivars using RAPD markers. *Theor. Appl. Genet.* 85: 900-904

Kothavade, D.V., Mahajan, P.R., Sanghavi, K.U. and Patil, D.R. 1985. Effect of leaf area on growth and yield of Basrai banana. *S. Indian Hort.* 33(2): 7-8

Kramer, P.J. 1969. *Plant and Soil Water Relationship-a Modern Synthesis.* Tata Mc Graw Hill, New Delhi, 309 p.

Krishnan, B.M. and Shanmugavelu, K.G. 1983. Correlation studies in banana cv. Robusta. *S. Indian Hort.* 31:10-11

Krzanowski, W.J. 1988. *Principles of Multivariate Analysis a User's Perspective.* Clarendon Press, Oxford, 123 p.

Kumar, M.B., Barker, R.E. and Reed, B.M. 1995. Genetic stability of micropropagated strawberries. *In vitro* 31: 52

Kumar, N.V.H., Narayanaswamy, P., Prasad, D.T., Mukunda, G.K. and Sondur, S.N. 2001. Estimation of genetic diversity of commercial mango (*Mangifera indica* L.) cultivars using RAPD markers. *J. hort. Sci. Biotech.* 76: 529-533

Lashermes, P., Tronslot, P., Anthony, F., Combes, M.C. and Charrier, A. 1996. Genetic diversity for RAPD markers between cultivated and wild accessions of *Coffea arabica. Euphytica* 87: 59-64

Levi, A. and Rowland, L.J. 1997. Identifying blueberry cultivars and evaluating their genetic relationships using RAPD and SSRs anchored primers. *J. Am. Soc. hort. Sci.* 122: 74-78

Lim, S.H., Teng, P.C.P., Lee, Y.H. and Goh, C.J. 1999. RAPD analysis of some species in the genus *Vanda. Ann. Bot.* 83: 193-196

Litt, M. and Luty, J.A. 1989. A hypervariable microsatellite revealed by *in vitro* amplification of a dinucleotide repeat within cardiac muscle antigen. *Am. J. Human Genet.* 44: 397-401

Lopez-Valenzuela, J.A., Martinez, O. and Paredes-Lopez, O. 1999. Geographic differentiation and embryo type identification in *Mangifera indica* L. cultivars using RAPD markers. *HortScience* 34: 1105-1108

Lu, Z., Reighard, G.I., Baird, W.V., Abbott, A.G. and Rajapakse, S. 1996. Identification of peach rootstock cultivars by RAPD markers. *HortScience* 31: 127-129

Machado, M.A., Coletta-Fieho, H.D., Targon, M.L.P.N. and Pompen, Jr. J. 1996. Genetic relationship of Mediterranean mandarins (*Citrus deliciosa* Tenore) using RAPD markers. *Euphytica* 92: 321-326

Martin, G.B., Williams, J.G.K. and Tanksley, S.D. 1991. Rapid identification of markers linked to a pseudomonas-resistance gene in tomato by using random primers and near isogenic lines. *Proc. nat.. Acad. Sci. USA*. 88: 2336-2340

Martinez, G.A. 1984. Determination of the minimum leaf area for bananas in the humid tropics. *Revista Instituto Columbiano Agro-Pecuario* 19(2): 183-186 (French)

Mc Creight, J.D. 2000. Molecular and phenotypic variation in melon PI 313970. *Acta Hort.* 510: 235-239

Mneney, E.E., Mantell, S.H., Tsoktouridis, G., Amin, S., Bessa, A.M.S. and Thangavelu, M. 1997. RAPD profiling of Tanzanian cashew (*Anacardium occidentale* L.). *Proceedings of the International Cashew and Coconut Conference:Trees for life-the key to development, February 20-22, 1997,* (eds. Topper, C.P., Caligari, P.D.S., Kullaya, A.K. and Shomari, S.H.). Dar Es Salaam Tanzania, pp. 17-35

Mneney, E.E., Mantell, S.H. and Bennett, M. 2001. Use of random amplified polymorphic DNA (RAPD) markers to reveal genetic diversity within and between populations of cashew (*Anacardium occidentale* L.). *J. hort. Sci. Biotech.* 76: 375-383

Moretzsohn, M.C., Nunes, C.D.M., Ferreira, M.E. and Grattapaglia, D. 2000. RAPD linkage mapping of shell thickness locus in oil palm. *Theor. Appl. Genet.* 100: 63-70

*Moretzsohn, M.C., Ferreira, M.A., Amaral, Z.P.S., Coelho, P.J.A., Grattapaglia, D. and Ferreira, M.E. 2002. Genetic diversity of Brazilian oil palm (*Elaeis oleifera* H.B.K.) germplasm collected in the Amazon Forest. *Euphytica* 124: 35-45

Moriera, L.A., Mollema, C. and Heusden, S.V. 1999. Search for molecular markers linked to *Liriomyza trifoli* resistance in tomato. *Euphytica* 109: 149-156

Mulcalhy, D.L., Cresti, M., Sansavini, S., Douglas, G.C., Linskens, H.F., Mulcahy, B.G., Vignani, R. and Pancaldi, M. 1993. The use of random amplified polymorphic DNAs to fingerprint apple genotypes. *Sci. Hort.* 54: 89-96

Munthali, M.T., Newbury, H.J. and Ford-Lloyd, B.V. 1996. The detection of somaclonal variants of beet using RAPD. *Pl. Cell. Rep.* 15: 474-478

Murray, D.B. 1960. Shade and fertilizer relations in the banana. *Trop. Agric. Trinidad* 38:123-132

Naik, K.C. 1963. *South Indians Fruits and their Culture.* Varadachary and Co., Madras, 289 p.

Nambisan, K.M.P. and Rao, V.N.M. 1980. The influence of specific origin on leaf production and associated growth characters in south India banana. *Proceedings of National Seminar on Banana Production Technology, July 10-12, 1980.* (eds. Muthukrishnan, C.R. and Abdulkhader, J.P.M.). Tamil Nadu Agricultural University, Coimbatore, pp.33-40

Nayar, A.S. 2001. Molecular evaluation of genomic stability of banana plants developed by *in vitro* clonal propagation. M.Sc.(Hort.) thesis, Kerala Agricultural University, Thrissur, 68 p.

Neto, S.P.S., Maruta, I., Takaiwa, F., Oono, K., Matsumoto, K. and Gomes, J.A. 1995. Identification of cashew (*Anacardium occidentale* L.) seedlings with RAPD markers. *Acta Hort.* 370: 21-26

Newbury, H.J., Howell, E.C., Crouch, J.H. and Lloyd, F.B.V. 2000. Natural and culture induced genetic variation in plantains (*Musa* spp. AAB group). *Aust. J. Bot.* 48:493-500

Noli, E., Salvi, S. and Tuberosa, R. 1997. Comparative analysis of genetic relationship in barley based on RFLP and RAPD markers. *Genome* 40: 607-616

Novak, F.J. 1992. *Musa (Banana and Plantains).* Biotechnology of perennial fruit crops. (eds. Hammerschlag, F.A. and Litz, R.E.). CAB International, Wallingford, pp.449-488

Obara-Okeyo, P. and Kako, S. 1998. Genetic diversity and identification of Cymbidium cultivars as measured by random amplified polymorphic DNA (RAPD) markers. *Euphytica* 99: 95-101

Ostmark, H.E. 1974. Economic insect pests of bananas. *Ann. Rev. Entomol.* 19:161-176

Parent, J.G. and Page, D. 1998. Identification of raspberry cultivars by sequence characterized amplified region DNA analysis. *HortScience* 33: 140-142

Pillai, O.A.A. 1975. Studies on the effect of functional leaves maintained on the growth and development of Poovan banana. M.Sc.(Ag.) thesis, Tamil Nadu Agricultural University, Coimbatore, 212 p.

Pillai, O.A.A. and Shanmugavelu, K.G. 1976. Studies on the effect of number of functional leaves on the growth and development of poovan banana total leaf production, phylachron, total leaf area and leaf function hypothesis. *S. Indian. Hort.* 24(3): 83-87

Pillai, O.A.A. and Shanmugavelu, K.G. 1977. Studies on the effect of number of functional leaves on flower bud initiation in banana cv. Poovan. *Indian J. Hort.* 34: 358-361

Pillai, O.A.A. and Shanmugavelu, K.G. 1978. Studies on the effect of number of functional leaves on the growth and development of Poovan banana. *Vatika* 1(1): 15-16

Pillay, M., Nwakanma, D.C. and Tenkouano, A. 2000. Identification of RAPD markers lined to A and B genome sequences in *Musa*. *Genome* 43: 763-767

Pillay, M., Ogundiwin, E., Nwakanma, D.C., Ude, G. and Tenkouano, A. 2001. Analysis of genetic diversity and relationship in East African banana germplasm. *Theor. Appl. Genet.* 102: 965-970

Prasannalatha, C.H., Kaur, P. and Bhalla, J.K. 1999. Molecular characterization of somaclonal variants in pigeon pea. *Curr. Sci.* 76: 693-695

Rajeevan, P.K. 1985. Intraclonal variation and nutritional studies in banana cv. Palayankodan. Ph.D thesis, Kerala Agricultural University, Trichur, 148 p.

Rammohan, H., Rammansi, P.R. and Steward, F.C. 1962. Growth and development of banana plant. *Ann. Bot.* 26:657-673

Rani, V., Parida, A. and Raina, S.N. 1995. Random amplified polymorphic DNA markers for genetic analysis in micropropagated plants of *Populus deltoids* Marsh. *Pl. Cell Rep.* 14: 459-462

Ravishankar, K.V., Anand, L. and Dinesh, M.R. 2000. Assessment of genetic relatedness among mango cultivars of India using RAPD markers. *J. hort. Sci. Biotech.* 75: 198-201

Rekha, A., Ravishankar, K.V., Anand, L. and Hiremath, S.C. 2001. Genetic and genomic diversity in banana (*Musa* spp. and cultivars) based on D^2 analysis and RAPD markers. *INFOMUSA* 10: 29-34

Robinson, J.C. and Nel, P.J. 1989. Plant density studies with banana (cv. Williams) in a subtropical climate. *J. hort. Sci.* 64:513-519

Robinson, J.C., Anderson, T. and Eckstein, K. 1992. The influence of functional leaf removal at flower emergence on components of yield and photosynthetic compensation in banana. *J. Hort. Sci.* 67(3): 406-410

Sanchez, I., Gaviria, D., Gallego, G., Fagardo, D., Valencia, J.A., Lobo, M., Thome, J., Roca, W. and Crane, J.H. 1998. Molecular characterization for the management of Columbian collection of *Musaceae*. *Proc. Int. Am. Soc. trop. Hort.* 42: 252-259

Satyanarayana, M. 1985. Effect of number of functional leaves on growth and yield of Basrai banana. *Madras Agri. J.* 72(9): 532-533

Satyanarayana, M. 1986. *Effect of Number of Functional Leaves on Growth and Yield of Dwarf Cavendish Banana (AAA).* Banana Newsletter 9. National Research Centre for Banana, Tiruchirapalli, 127 p.

Sawazaki, H.E., Muller, G.W. and Sodek, L. 1997. Genetic diversity study of citrus plants by means of RAPD. *Revista-Brasileira-de-Biologia.* 57: 337-342

Schnell, R.J., Knight, R.J. and Schaffer, B. 1993. Genetic relationships among *Mangifera* spp. based on RAPD markers. *Acta Hort.* 341: 86-96

*Senechal, Y. and Gohet, E. 1988. Influence of leaf disease (*Colleotrichum gloeosporiodes*) on the foliar mineral composition of *Hevae brasiliensis*. *Comptes Rendus de L' Aa Ademides Sciencees* 307:445-450

Sharma, R., Mohapatra, T., Mukherjee, A.K., Pal, K. and Sharma, O.P. 1999. Molecular markers for seed oil content in Indian mustard. *J. Pl. Biochem. Biotech.* 8: 99-102

Sheng, D.J., Chang, L.Z. and Ying, B.Z. 1999. RAPD analysis of mango cultivars. *J. Fruit Sci.* 16: 156

Shibu, M.P., Ravishankar, K.V., Anand, L., Ganeshaiah, K.N. and Shanker, R.V. 2000. Identification of specific DNA markers in the dioecious tree, nutmeg (*Myristica fragrans* Houtt.). *Pl. Genet. Resour. Newsl.* 12: 59-61

Shimada, T., Hayame, H., Haji, T., Yamaguchi, M. and Yoshida, M. 1999. Genetic diversity of plum characterized by random amplified polymorphic DNA (RAPD) analysis. *Euphytica* 109: 143-147

Simi, S. 2001. Molecular characterization of banana (*Musa* AAB plantain subgroup) clones. M.Sc. (Hort.) thesis, Kerala Agricultural University, Thrissur, 72 p.

Simmonds, N.W. 1966. *Bananas*. Second Edition, Longmans, London, 468 p.

Singh, H.P. 1996. Growing banana for leaf. *INFOMUSA* 5:27-28

Singh, R.K.O. and Bhattacharya, R.K. 1992. *Leaf Area During Growth and Yielding Capacity of Banana.* Banana Newsletter 5. National Research Centre for banana, Tiruchirapalli, 218 p.

Singh, R., Cheah, S. and Abdul, R. 1998. Generation of molecular markers in oil palm *(Elaeis guinensis)* using AFLP markers. *Focus* 20: 26-27

Somri, S. 1998. Improvement of papaya (*Carcia papaya* L.) for south eastern Queens land-Investigation of sex type and fruit quality. Ph.D. thesis, The University of Galton College, Queens land, 125 p.

Stiles, J.I., Lemme, C., Sondur, S., Morshidi, M. and Manshardt, R.M. 1993. Using random amplified polymorphic DNA for evaluating genetic relationships among papaya cultivars. *Theor. Appl. Genet.* 85: 697-701

Stockinger, E.J., Mulinix, C.A., Long, C.M., Brettin, T.S. and Lezzoni, A.I. 1996. A linkage map of sweet cherry based on RAPD analysis of a microspore derived callus culture population. *J. Heredity* 87: 214-218

Stover, R.H. and Simmonds, N.W. 1987. *Bananas*. Third edition, Longmans, London, 470 p.

Subramanian, J., Litz, R.E. and Schnell, R.J. 1996. Selection and characterization of resistance in mango embryogenic cultures to *Colletotrichum gloeosporioides*. *HortScience* 31: 695

Sudhakara, K., Kannan, K. and Nambiar, I.P.S. 1989. Effect of defoliation on productivity of coconut palm (*Cocos nucifera* L.). cv. West coast tall. *J. Pln. Crops* 16:457-461

Suharban, M. 1977. Studies on the leaf spot and post harvest diseases of banana and their control. M.Sc.(Ag.) thesis, Kerala Agricultural University, Thrissur, 73 p.

Summerville, W.A.T. 1944. Studies on nutrition as qualified by development of *Musa cavendish*. L. *Qd. J. Agric. Sci.* 1: 1-12

Tartarini, S. 1996. RAPD markers linked to the Vf gene for scab resistance in apple. *Theor. Appl. Genet.* 92 : 803-810

Thottappilly, G., Mignouna, H.D. and Omitogun, O.G. 2000. The use of DNA markers for rapid improvement of crops in Africa. *Afr. Crop Sci. J.* 8: 99-108

Ticho, R.J. 1960. *The banana industry in Israel.* Report of first FAO/ OCTA International Meeting on Banana Production. Food and Agricultural Organisation(FAO), Abidjan, 295 p.

Todokoro, S., Terauchi, R. and Kawano, S. 1995. Microsatellite polymorphisms in natural populations of *Arabidopsis thaliana* in Japan. *Jpn. J. Genet.* 70: 543-554

Truksa, M. and Prochazka, S. 1996. Potential use of RAPD markers in verification of cucumber hybrids. *Rostlinna Vyroba* 42: 241-244

Turner, D.W. 1970a. Bunch covers, leaf number and yield of bananas. *Aust. J. Exp. Agric. Anim. Husb.* 10:802-805

Turner, D. W. 1970b. The growth of the banana. *J. Aust. Inst. Agric. Sci.* 36: 102-110

Turner, D.W. 1980. Some factors related to yield components of banana in relation to sampling to assess nutrient status. *Fruits* 35: 19-23

Turner, D.W. and Hunt, N. 1987. Planting date and defoliation influence time of harvest of bananas. *Scientia Horticulturae* 32: 233-248

Uma, S., Selvarajan, R., Sathiamoorthy, S., Rameshkumar, A. and Durai, P. 2003. Evaluation of banana germplasm for the leaf industry and for suitability to different growing environments in India. *Pl. Genet. Res. Newsl.*134: 177-178

Valles, M.P., Wang, Z.Y., Montaron, P., Potrykus, I. and Spangenberg, G. 1993. Analysis of genetic stability of plant regenerated from suspension culture and protoplasts of meadow fescue (*Festuca patensis* Huds.). *Pl. Cell. Rep.* 12: 101-106

Varghese, Y.A., Knaak, C., Sethuraj, M.R. and Ecke, W. 1997. Evaluation of random amplified polymorphic DNA (RAPD) markers in *Hevea brassiliensis*. *Pl. Breed.* 116: 47-52

Vendisson, S., Bailliene, F. and Audran, J.C. 1999. Use of RAPD markers to detect chimerism in synthetic grape chimera (*Vitis vinifera* L.). *Vitis* 38: 93-95

Viswanath, B.N. 1981. Development of *Cosmopolites sordidus* on banana varieties in South India. *Colemania* 1:57-58

Vos, P., Hogers, R., Blecker, M., Lee, V.T., Hornes, M., Frijters, A., Pot, J., Pecleman, J., Kliper, M. and Zabean, M. 1995. AFLP-A new technique for DNA fingerprinting. *Nucl. Acids Res.* 23: 4407-4417

Vuylsteke, D.R., Crouch, J.H., Pellegrineschi, A. and Thottapilly, G. 1998. The biotechnology case history for *Musa*. *Acta Hort.* 461: 75-86

Walbot, V. 1988. Preparation of DNA from single rice seedlings. *Rice Genet. Newsl.* 5 : 149-151

Walther, R., Illam, A., Lerser, A., Durdevani, A. and Khayat, E. 1997. Analysis of somaclonal variation in the tissue cultured banana plants (*Musa* AAA cv. Grand Nain). *Proceedings of International Symposium on Importance Varieties for Production of Quality Wine, January 12-15, 1997.*(eds. Altman, A. and Ziv, M.), University of California, Davis, Wiley-Liss, New York, pp. 379-383

Wang, G., Castiglione, S., Zhang, J., Fu, R., Ma, J., Li, W., Sun, Y. and Sala, F. 1994. Hybrid rice (*Oryza sativa* L.) identification and parentage determination by RAPD fingerprinting. *Pl. Cell. Rep.* 14: 112-115

Wardlaw, C.W. 1972. *Banana diseases including plantains and abaca.* Longmans, London, 381 p.

Watson, D.J. 1952. The physiological basis of variation in yield. *Adv. Agron.* 4:101-145

Waugh, R. and Powell, W. 1992. Using RAPD markers for crop improvement. *Trends Biotech.* 10: 186-191

Weber, J.L. and May, P.E. 1989. Abundant class of human polymorphism which can be typed using the polymerase chain reaction. *Am.J. Human Genet.* 44: 388-396

Weising, K., Nybom, H., Wolff, K. and Meyer, W. 1995. *DNA fingerprinting in plants and fungi.* CRC Press, Boca Raton, Florida, 120 p.

Welsh, J. and Mc Clelland. 1990. Fingerprinting genomes using PCR with arbitrary primers. *Nucl. Acids Res.* 18: 7213-7218

Wilde, J., Waugh, R. and Powell, W. 1992. Genetic fingerprinting of Theobrome clones using randomly amplified polymorphic DNA markers. *Theor. Appl. Genet.* 83: 871-877

Williams, J.G.K., Kubelik, A.R., Livak, R.J., Rafalski, J.A. and Tingsey, S.V. 1990. DNA polymorphisms amplified by arbitrary primers are useful as genetic markers. *Nucl. Acids Res.* 18: 6531-6535

Wing, R.A., Zhang, H.B. and Tanksley, S.D. 1994. Map based cloning in crop plants, tomato as a model system. *Mol. Gen. Genet.* 242: 681-688

Xu, Y., Clark, M.S. and Pehu, E. 1993. Use of RAPD markers to screen somatic hybrids between *Solanum tuberosum* and *S. brevidens*. *Pl. Cell Rep.* 12: 107-109

Yang, H., Tabei, Y., Kamada, H., Kayano, T. and Takaiwa, T. 1999. Detection of somaclonal variation in cultured rice cells using digoxygenin based random amplified polymorphic DNA. *Pl. Cell Rep.* 18: 520-526

*Originals not seen

APPENDICES

APPENDIX I

Effect of leaf pruning on the cost of cultivation, net profit and benefit cost ratio

Details	Rate	T_1			T_2			T_3		
		No.of labourers@ Rs.181/day	Quantity	Amount, Rs. Ps	Labour	Quantity	Amount Rs. Ps.	Labour	Quantity	Amount Rs. Ps.
1.Clearing of land	@280 m^2 / lbr	36	-	6480.00	36	-	6480.00	36	-	6480.00
2.Earthing up	@200 m^2 / lbr	50	-	9000.00	50	-	9000.00	50	-	9000.00
3.Making irrigation and drainage channels	@400 m / lbr	6	-	1080.00	6	-	1080.00	6	-	1080.00
4.Taking pits	@150 / lbr	67	-	12060.00	67	-	12060.00	67	-	12060.00
5. Planting materials (considering 5 % mortality rate)	Rs.4 / plant	-	10,500	42000.00	-	10500	42000.00	-	10500	42000.00
6. Planting	250 / lbr	40	-	7200.00	40	-	7200.00	40	-	7200.00
7. Compost / dry cowdung (10 kg / plant)	Rs.300 / t	-	100	30000.00	-	100	30000.00	-	100	30000.00
8. Gap filling	-	1	-	181.00	1	-	181.00	1	-	181.00
9. Compost application	@ 500 / lbr	20	-	3600.00	20	-	3600.00	20	-	3600.00
10. Irrigation after planting (for 1 month) once in 3 days	@ 500 / lbr	200	-	36000.00	200	-	36000.00	200	-	36000.00

APPENDIX I Continued...

11. Cost of fertilizers										
Urea	160 g / plant@ 5.05 /kg	-	3478 kg	17565.21	-	3478 kg	17565.21	-	3478 kg	17565.21
Rock phosphate	160 g / plant@ 4.25 /kg	-	5653 kg	24028.27	-	5653 kg	24028.27	-	5653 kg	24028.27
MOP	320 g / plant@ 4.65/kg	-	5333 kg	24800.00	-	5333 kg	24800.00	-	5333 kg	24800.00
12. Fertilizer application										
a. 1 MAP	@ 250 / lbr	40	-	7200.00	40	-	7200.00	40	-	7200.00
b. 2 MAP	@ 250 / lbr	40	-	7200.00	40	-	7200.00	40	-	7200.00
13. Irrigation after fertilizer application (for 2 application)	@250 / lbr	80	-	14400.00	80	-	14400.00	80	-	14000.00
14. Irrigation during summer months (once in 3 days for 2 months)	@ 500 / lbr	400	-	72000.00	400	-	72000.00	400	-	72000.00
15.Leaf cutting and transporting	-	60	-	10800.00	60	-	10800.00	-	-	-
16. Weeding (hand weeding) 3 times	@ 500 m2 / lbr	60	-	10800.00	60	-	10800.00	60	-	10800.00
17. Phorate (25 g/ plant)	@ Rs.55 / kg	-	250 kg	13750.00	-	250 kg	13750.00	-	250	13750

APPENDIX I Continued...

18. Phorate application	@ 500 / lbr	20	-	3620.00	20	-	3620.00	20	-	3620.00
19. Propping	@ 250 / lbr	-	-	-	40	-	7200.00	40	-	7200.00
20. Cost of propping materials	@ Rs. 2 / plant	-	-	-	-	10000 plants	20000.00	-	10000 plants	20000.00
21. Harvesting and transporting	@ 200 / lbr	25	-	4525.00	50	-	9050.00	50	-	9050.00
22. Interest on working capital	@ 10 % / annuum	-	-	35828.95	-	-	39001.45	-	-	37921.45
Total expenditure incurred		-	-	394118.43	-	-	429015.93	-	-	417135.93
1. Elavazhai	**Rate**	**Yield / plant**	**Yield / ha**	**Amount Rs. Ps.**	**Yield / plant**	**Yield / ha**	**Amount Rs. Ps.**	**Yield / plant**	**Yield / ha**	**Amount Rs. Ps.**
1. Income from bunches	Rs. 6 / kg	4.5 kg/ pt	45000 kg	270000.00	7.8 kg	78000 kg	468000.00	9.45	94500	567000.00
2. Income from suckers	Rs. 4 / sucker	3	30000	120000.00	3	30000	120000.00	4	40000	160000.00
3. Income from leaves	Re. 1 / leaf	42.75	427500.00	427500.00	18.75	187500	187500.00	-	-	-
Total income				817500.00			775500.00			727000.00
Total expenditure				394118.43			429015.93			417135.93
Net profit / loss				423381.57			346484.07			309864.07
Benefit / cost ratio				2.07			1.81			1.74
2. Monthan										
1. Income from bunches	Rs. 5 / kg	3.3 kg / pt	33000 kg	165000.00	7.2 kg	72000 kg	360000.00	7.2 kg	92000.00 kg	460000.00
2. Income from suckers	Rs. 4 / sucker	2	20000	80000.00	2	20000	80000.00	3	30000.00	120000.00

APPENDIX I Continued...

3. Income from leaves	Re. 1 / leaf	29.25	292500	292500.00	15	150000	150000.00	-	-	-
Total income				537500.00			590000.00			580000.00
Total expenditure				394118.43			429015.93			417135.93
Net profit / loss				143381.57			160984.07			162864.07
Benefit / cost ratio				1.37			1.38			1.39
3. Njalipoovan										
1. Income from bunches	Rs. 6 / kg	3.19 kg	31900 kg	191400.00	4.68 kg	46800 kg	280800.00	8.62 kg	86200 kg	517200.00
2. Income from suckers	Rs. 4 / sucker	3	30000	120000.00	3	30000	120000.00	4	40000	160000.00
3. Income from leaves	Re. 1 / leaf	36.75	367500	367500.00	16	160000	160000.00	-	-	-
Total income				678900.00	-		560800.00	-	-	677200.00
Total expenditure				394118.43			429015.93			417135.93
Net profit / loss				284781.57			131784.07			260064.07
Benefit / cost ratio				1.72			1.31			1.62
4. Palayankodan										
1. Income from bunches	Rs. 6 / kg	4.22 kg	42200 kg	253200.00	6.41 kg	64100 kg	384600.00	9.43 kg	94300 kg	565800.00
2. Income from suckers	Rs. 4 / sucker	3	30000	120000.00	3	30000	120000.00	4	4000	160000.00
3. Income from leaves	Re. 1 / leaf	39.75	397500	397500.00	17.25	172500	172500.00	-	-	
Total income				770700.00			677100.00			725800.00
Total expenditure				394118.43			429015.93			417135.93
Net profit / loss				396581.57			248084.07			308664.07
Benefit / cost ratio				1.96			1.58			1.78

APPENDIX I Continued...

5. Vayalvazhai										
1. Income from bunches	Rs. 4 / kg	3.4 kg	34000 kg	136000.00	5.9 kg	59000 kg	236000.00	8.8 kg	88000	352000.00
2. Income from suckers	Rs. 3 / sucker	2	20000	60000.00	2	20000	60000.00	3	30000	90000.00
3. Income from leaves	Re. 1 / leaf	29.5	295000	177000.00	16	160000	96000.00	-	-	-
Total income				373000.00			392000.00			442000.00
Total expenditure				394118.43			429015.93			417135.93
Net profit / loss				2118.43			37015.93			24864.07
Benefit / cost ratio				0.95			0.91			1.06
6. Karpooravalli										
1. Income from bunches	Rs. 4.5 / kg	3.1	31000	139500.00	6.0	60000	270000.00	8.5	85000	382500.00
2. Income from suckers	Rs. 3 / sucker	2	20000	60000.00	2	20000	60000.00	3	30000	90000.00
3. Income from leaves	Re. 0.60 / leaf	31.25	312500	187500.00	16	160000	96000.00	-	-	-
Total income				387000.00			426000.00	-	-	472500.00
Total expenditure				394118.43			429015.93			417135.93
Net profit / loss				7118.43			3905.93			55364.07
Benefit / cost ratio				0.98			0.99			1.13

APPENDIX II

Modified Walbot's Method

Leaves were ground to fine powder

↓

Transferred to extraction buffer kept in water bath at 50^0C

↓

SDS and PVP were also added to the extraction buffer and mixed gently

↓

The solution was kept in water bath at 50^0C for 30 minutes

↓

Lysate was squeezed through 4 layers of muslin cloth

↓

Phenol:Chloroform:isoamyl alcohol (25:24:1) extraction was done

↓

Chloroform: isoamyl alcohol (24:1) extraction was done

↓

To the upper aqueous phase collected 3 volumes of cold absolute ethanol and $1/10^{th}$ volume of 3.0 M sodium acetate were added

↓

DNA was precipitated

↓

75 per cent ethanol wash was given

↓

DNA was stored in Tris-Hcl (TE) (10:1) buffer

APPENDIX III

Yield characters

Treatments	Bunch yield / plant, kg	No.of suckers / plant
V_1T_1	4.50	3
V_1T_2	7.80	3
V_1T_3	9.45	4
V_2T_1	3.30	2
V_2T_2	7.20	2
V_2T_3	9.20	3
V_3T_1	3.19	3
V_3T_2	4.68	3
V_3T_3	8.62	4
V_4T_1	4.22	3
V_4T_2	6.41	3
V_4T_3	9.43	4
V_5T_1	3.40	2
V_5T_2	5.90	2
V_5T_3	8.80	3
V_6T_1	3.10	2
V_6T_2	6.00	2
V_6T_3	8.50	3

SCREENING BANANA (*Musa* sp.) VARIETIES FOR LEAF PRODUCTION

SELVAKUMAR,K.

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Department of Pomology and Floriculture
COLLEGE OF AGRICULTURE
VELLAYANI, THIRUVANANTHAPURAM- 695 522

ABSTRACT

The present investigations on 'Screening banana (*Musa* sp.) varieties for leaf production' was carried out at the Department of Horticulture, College of Agriculture, Vellayani, Thiruvananthapuram during 2002-2003 to evaluate the changes in leaf production pattern of banana varieties due to leaf pruning and to select banana varieties for commercial leaf production. Molecular characterization (RAPD analysis) of banana varieties was also carried out to obtain preliminary information on the genetic makeup of the varieties evaluated.

Studies revealed that the plant height and girth were affected by the interaction effect of leaf pruning and the varieties. Elavazhai, Palayankodan and Karpooravalli were less adversely affected when alternate leaves were pruned seven days after unfurling. Plant height and girth were higher with less severe pruning treatments.

The leaf emission rate was affected by the interaction effect of leaf pruning and varieties. Elavazhai, Palayankodan, Njalipoovan and Vayalvazhai had higher leaf emission rate when all the leaves were pruned seven days after unfurling. In general, pruning all the leaves resulted in higher leaf emission rate.

The total leaf production, number of harvested leaves, and the number of marketable leaves were affected by the interaction effect of leaf pruning and the varieties. Leaf pruning in general increased the total leaf production, number of harvested leaves and number of marketable leaves. Elavazhai, Palyankodan and Njalipoovan attained higher leaf production, number of harvested leaves and marketable leaves when all leaves were pruned seven days after unfurling.

The leaf length was not affected by the interaction effect of leaf pruning and the varieties. Karpooravalli, Elavazhai, Monthan, Njalipoovan and Palayankodan had produced the lengthiest leaves.

The leaf breadth and leaf thickness were not affected by the interaction effect of leaf pruning and the varieties. Elavazhai, Vayalvazhai, Monthan and Karpooravalli had the highest leaf breadth while Elavazhai, Vayalvazhai, Monthan and Karpooravalli had more leaf thickness.

The leaf area index was affected by the interaction effect of leaf pruning and the varieties. Elavazhai, and Karpooravalli had the highest leaf area index.

The duration of leaf harvest was affected by the interaction effect of leaf pruning and the varieties. In general, pruning of leaves resulted in higher duration. Karpooravalli, Palayankodan and Njalipoovan, had the higher duration while Vayalvazhai and Monthan had the lowest duration.

The occurrence of bunchy top disease was not influenced with the interaction effect of leaf pruning and the varieties. Njalipoovan and Palayankodan were affected by the disease.

The occurrence of leaf spot disease was not influenced by the interaction effect of leaf pruning and the varieties.

The occurrence of rhizome weevil was not affected by the interaction effect of leaf pruning and the varieties. However, Njalipoovan was affected by rhizome weevil while other varieties were not affected.

The interaction effect of varieties and leaf pruning indicated that, pruning all the leaves seven days after unfurling was most profitable when income from both leaf and bunch were considered.

The studies indicated that banana varieties Elavazhai, Palayankodan and Njalipoovan were suitable for leaf production in commercial varieties. The practice of pruning all the leaves seven days after unfurling was economically viable under Kerala conditions.

DNA isolated from six varieties were subjected to RAPD analysis. Out of the 40 decamer primers screened for RAPD analysis, 32 could

produce amplification. Totally 118 bands (average of 2.95 bands per primer) by thirty-two primers, of which 97.46 per cent (115 bands) were poly morphic. Three bands (2.54%) were monomorphic. Eight primers showed high level of polymorphism *viz.* OPA-03, OPA-11, OPA-20, OPB-06, OPB-07, OPB-10, OPB-11 and OPB-15 were used for RAPD analysis of six *Musa* sp. varieties. These primers yielded 89 scorable bands with an average of 11.13 bands per primer.

A genetic dissimilarity matrix was constructed using the Jaccard's coefficient method and the values ranged from 0.226 to 0.486. The genetic distance between the varieties ranged from 0.226 to 0.338. Dendrogram expressed three major clusters. Monthan, Vayalvazhai and Karpooravalli together formed the largest cluster. Within this cluster, Vayalvazhai and Karpooravalli were more close to each other. Palayankodan and Njalipoovan formed another cluster. Elavazhai formed a separate cluster, which was generally distinct from all other clones.