PERFORMANCE EVALUATION OF ECOTYPES OF BANANA (*Musa* AAB PLANTAIN SUBGROUP)

by

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THESIS

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DECLARATION

I, hereby declare that this thesis entitled **"PERFORMANCE EVALUATION OF ECOTYPES OF BANANA (*Musa* AAB PLANTAIN SUBGROUP)"** is a bonafide record of research work done by me during the course of research and 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.

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LIST OF ABBREVIATIONS AND SYMBOLS USED

@	At the rate of
^{0}C	Degree Celsius
%	Per cent
&	and
µg	Microgram
AOAC	Association of Official Agricultural Chemists
BE	Bunch emergence
BRS	Banana Research Station
CD	Critical difference
cm	Centimetre
et al.	And others
Fig.	Figure
GCV	Genotypic Coefficient of Variation
ha	Hectare
ha^{-1}	Per hectare
KAU	Kerala Agricultural University
kg	Kilogram
kg ha^{-1}	Kilogram per hectare
LAD	Leaf area duration
LAI	Leaf area index
m	Metre
MAP	Month after planting
mm	Millimetre
MT	Metric Tons
NS	Non – significant
No.	Number
PCV	Phenotypic coefficient of variation
PSI	Pedicel strength index
RBD	Randomized block design
Sl.	Serial
sp. or spp.	Species (Singular and Plural)
t	Tons
TSS	Total soluble solids
viz.	Namely

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Introduction

1. INTRODUCTION

Banana and plantain are widely cultivated in India with great socio-economic significance, interwoven with cultural heritage of the country. It is referred to as 'Kalpatharu' which means plant of virtues due to its multifaceted uses (Chadha, 2003). In India banana is grown in an area of 8.8 lakh ha with a production of 300 lakh t/annum with a productivity of 34.1t/ha (NHB, 2017). Kerala has a productivity of 8.8 t/ha with a production of 5.45 lakh t/annum from an area of 61936 ha (FIB, 2017).

Banana rank as the fourth most important global food commodity after rice, wheat and milk in terms of the gross value of production. Banana is the cheapest sources of nutrients for millions of people in the developing countries. However, banana production is under threat from different climatic factors and pathogenic agents.Genetic diversity can provide the ability to adapt to changing environments, including new pests and diseases and new climatic conditions.

All banana and plantain landraces are farmers' selections from intra and inter specific hybrids of two diploid species, *Musa acuminata* Colla and *Musa balbisiana* Colla. A number of banana cultivars exist ranging from the delicate diploid *acuminata* (AA) types to hardy hybrid triploid (AAB) types. Kerala has a rich genetic resource of different banana cultivars and many of them are maintained under domestic cultivation. These cultivars have varied adaptation to different agro-climatic conditions and have variations in their biochemical and physical characteristics. Some of the important varieties of banana grown in Kerala include Nendran, Red banana, Palayankodan, Njalipoovan, Monthan etc. Plantain subgroup is one of the most important subgroups in the highly variable genomic group AAB. Plantains are cooking bananas containing more starch and less sugars than dessert bananas. Plantain subgroup includes French plantain represented by Nendran, Horn plantain represented by Zanzibar, False Horn plantain represented by Big Ebanga. Kervegant

(1935) cited by De Langhe *et al.* (2005) states that 'Horn' Plantains are characterized by absence of male flowers at maturity and the presence of very large horn like fruits, while the French plantains have both male and female flowers and smaller fruit size. The concept of 'False Horn' plantains was used to identify 'Horn' type cultivars with a restricted number of neutral flowers, but without any male bud at maturity. One of the popular and leading cultivar of commercial importance in Kerala is *Musa acuminata* cv. Nendran (AAB) belonging to the French plantain group. Nendran is a multipurpose variety used as fresh fruit, for cooking purpose and for making products like chips, banana flour etc.

Nayar (1962) reported several ecotypes of 'Nendran' in different parts of Kerala. Different ecotypes of 'Nendran' such as Changalikodan (Thrissur), Manjeri Nendran (Malappuram), Kaliethan (Thiruvananthapuram), and Changanasseri Nendran (Kottayam) are grown commercially on different parts of Kerala.

Based on yield potential farmers have selected and adopted certain types which perform best in a given locality. Since a number of local names may exist for the same cultivar, many cultivars cannot be easily distinguished on the basis of their morphology, especially if they are closely related. Identification of clones in early days was done based on morphological criteria but in a different environment morphological characters vary. Also due to close genetic relationship among cultivars and changes due to environmental modification, there exist clonal and ecotype variation with respect to growth, yield and reaction to biotic and abiotic stress. Genetic divergence analysis of ecotypes of Nendran using RAPD and ISSR markers have also been attempted.

But, so far information available about the typical clonal characteristics of these types is insufficient. According to Stover and Simmonds (1987), clonal variations are more expressed with respect to characters such as fullness index, pedicel strength index, fruit curvature, bunch shape, leaf area ratio, plant pigmentation etc. Therefore evaluation of these types based on clonal characters

would be helpful in their proper identification. Under this circumstance, the present investigations were undertaken with the objective to characterize the various ecotypes of plantain with respect to clonal characteristics, biometric characters, yield potential and fruit quality.This study will be helpful to identify the clonal, biometric and physiological traits associated with higher yield. Moreover the performance of these ecotypes in south Kerala can be studied. It will also be possible to understand the traits having high heritability. This would be helpful for utilization of these ecotypes in crop improvement programmes.

Review of Literature

2. REVIEW OF LITERATURE

Banana is one of the oldest fruits of the world. It is one of the major fruit crops of India and cultivated extensively in Kerala. In India banana is grown in an area of 8.8 lakh ha with a production of 300 lakh t/annum with a productivity of 34.1tonne/ha (NHB, 2017). Kerala has a productivity of 8.8 t/ha with a production of 5.45 lakh tonne/annum from an area of 61936 ha (FIB, 2017). Bananas and plantains belong to the family *Musaceae*. The *Musa* genus is of great importance in the world due to the commercial and nutritional values of bananas and plantains. The edible *Musa* spp. have their origin in two wild species, *Musa accuminata* Colla with the AA genotype and *Musa balbisiana* Colla with the BB genotype, and their hybrids and polyploids (Simmonds, 1966).

Plantains are cooking bananas containing more starch and less sugars than dessert bananas. Plantain subgroup includes French plantain represented by Nendran, Horn plantain represented by Zanzibar and False Horn plantain represented by Big Ebanga. Kervegant (1935) cited by De Langhe *et al.* (2005) states that 'Horn' Plantains are characterized by absence of male flowers at maturity and the presence of very large horn like fruits, while the French plantains have both male and female flowers and smaller fruit size. The concept of 'False Horn' plantains was used to identify 'Horn' type cultivars with a restricted number of neutral flowers, but without any male bud at maturity.

Among the various varieties of banana in AAB plantain subgroup, Nendran is a well known cultivar in Kerala, due to its high demand and its multifarious use, both for dessert and culinary purposes. Nendran cultivation is mainly done in southern states of India. In Kerala Nendran is grown in wide ecological and climatic conditions exploiting the wide varietal variability that exists in the crop. Variations exist with respect to growth, yield and reaction to biotic and abiotic stress among the various clones and ecotypes of 'Nendran'. So it is a need for crop improvement programmes

to know which clone is best for a particular region and to study the performance of various ecotypes.

Nayar (1962) reported several ecotypes of 'Nendran' in different parts of Kerala. Different ecotypes of 'Nendran' such as Changalikodan (Thrissur), Manjeri Nendran (Malappuram), Kaliethan (Thiruvananthapuram), and Changanasseri Nendran (Kottayam) are grown commercially in different parts of Kerala. According to a study conducted by Rajamanickam (2003) to identify diversity in ecotypes of banana at molecular level, among the 25 ecotypes studied, Changalikodan, Kaliethan, and Attunendran was found in same cluster and two genotypes Myndoli and Zanzibar formed another Cluster. Simmonds (1966) has stated about the existence of different types of 'Nendran'. He designated Kaliethan, Eleri and Changalikodan as clones of Nendran. Isolation of intra clonal variants for better productivity was suggested by Iyer (1987). The results of clonal variation studies in Nendran conducted at Banana Research Station, Kannara showed that Nendran ecotypes or clones collected from various parts of Kerala showed difference in growth and yield when grown in a location other than the place of collection (KAU, 1991; 1993; 2015).

So, a study to determine the performance of various ecotypes would be useful. Effect of ecotype variation on various biometric characters, physiological, yield, quality and clonal attributes of banana are given below:

2.1 EFFECT OF ECOTYPE VARIATION ON BIOMETRIC CHARACTERS

Efforts were taken by Sunilkumar (1997) to select superior types of Kaliethan. High heritability estimates were obtained for most of the characters like plant height, plant girth, number of leaves at flowering, time taken for flowering, time taken for bunch maturity and total crop duration.

2.1.1 Effect of ecotype variation on plant height

Difference in plant stature due to clonal and ecotype variation has been reported by many research workers. Malik *et al.* (1966) reported significant variations in morphological characters of twenty locally selected banana varieties under

Lyllapur conditions. Nair and Nair (1969) studied the performance of nine varieties of banana, eight exotic and one indigenous type at Regional Agricultural Research Station, Ambalavayal. The height of these varieties varied from 150.00 to 165.00 cm in 'Giant Governor' of Cavendish group to 347.00 cm in 'Bodles Altafort'. According to Kothavade *et al.* (1985) in 'Basrai' banana plants, the height increased as the number of functional leaves per plant increased. Sato (1988) in his research work with nineteen banana cultivars grown in Hawaii found that the plant height varied significantly with cultivars. Ram *et al.* (1994) worked on different culinary varieties at Faizabad and observed that pseudostem height varied among the different cultivars. Plant height was the highest for 'Kasthuri' (323.24cm) followed by 'Kanchikela' (321.88cm) and lowest for 'Bankel' (263.66 cm). Valsalakumari and Nair (1990) reported that the cultivars within each genomic group were highly variable with respect to vegetative characters. George *et al.* (1991) in his study at Regional Agricultural Research Station, Ambalavayal with eight cultivars of banana viz. Rasthali/Poovan(AAB), Karpooravally (ABB), Chenkadali (AAA), Njalipoovan (AB), Gros Michel (AAA), Bodles Altafort (AAAA), Mysore/ Palayankodan (AAB) and Kunnan (AB), has shown that in high ranges of Kerala 'Bodles Altafort' attained the maximum height of 2.88m which was on par with 'Gros Michel' and 'Njalipoovan' while 'Karpooravally had the minimum height of 2.3m. Uthaiah *et al.* (1992) observed variation in plant height of 244.00 cm (Robusta) to 397.80 cm (Boodibale). The cultivars Boodibale (ABB), Karibale (ABB) and Rasthali (AAB) were found to be taller and more vigorous, whereas the cultivar Robusta (AAA) was the shortest.

An experiment conducted by Ram *et al.* (1994) recorded a minimum height of 169.44 cm for 'Harichal' (AAA) and a maximum height of 323.33 cm for 'Alpan' (AAB).

Variation in vegetative characters like plant height, girth at later stages, number of leaves per plant, phyllacron at early stages, leaf longevity, leaf area

duration and leaf area index at later stages among different ecotypes of Nendran was reported by Devi (1996). Kaliethen was suggested as the most suitable ecotype for Thiruvananthapuram. On a comparative study of tissue culture plants and plants from suckers of Nendran, it was found that at shooting, the tissue culture plants and suckers recorded an average height of 295.5 cm and 278.42 cm, respectively (Sheela, 1995).

2.1.2 Effect of ecotype variation on girth

George *et al.* (1991) stated that among the eight cultivars of banana grown at the high ranges of Kerala, Gros Michel and Chenkadali recorded the maximum girth of 64.14 cm and Njalipoovan recorded the minimum girth of 51.32 cm. In an experiment to evaluate performance of eight banana cultivars by Uthaiah *et al.* (1992) under Western coastal India, it was found that plant girth varied from 59.2 cm (Karibale) to 85.3 cm (Boodibale). Among the table varieties of banana, Kabuli (AAA), Poovan (AAB), Alpan (AAB), Nepalichinia (AAB), Basrai dwarf (AAA), Harichal (AAA) and Malbhog (AAB), a minimum girth of 35.22 cm was observed for 'Kabuli' and a maximum girth of 50.22 cm for Malbhog indicating genomic differences in plant growth (Ram *et al.*,1994). On a comparative study of tissue culture plants and plants from suckers of Nendran, it was found that at shooting, the tissue culture plants and suckers recorded an average girth of 66.75 cm and 59.67 cm, respectively (Sheela, 1995). In an experiment conducted by Devi (1996) to evaluate ecotypes of Nendran, it was found that at adult pre-floral vegetative stage, the ecotypes did not show significant difference in pseudostem girth. Among the ecotypes studied, Changalikodan, Poovanchira and Kothala recorded the highest plant girth, compared to other ecotypes at flowering time. Girth of pseudostem varied significantly among the ten accessions of Nendran during different stages of growth (Sunilkumar, 1997). In a study conducted at low altitude of Arunachal Pradesh, Pakte (local) had the highest pseudostem girth of 77.5 cm, followed by Vannan, Bharat Mani, Agni Malbhog and Kait Kullang (De *et al.*, 2002).

2.1.3 Effect of ecotype variation on number of functional leaves

Simmonds (1966) reported that in banana, growth is a function of number of leaves produced. According to Turner (1970b) approximately 11 unemerged leaves are present in banana irrespective of the stage of development. Turner (1970a) and Nambisan and Rao (1980) indicated that leaf production is distinct for each group of clones. Turner (1971) stated that rate of leaf emergence is influenced by temperature, wind velocity and relative humidity. According to Flore *et al.* (1985) leaf number varied between clones and decreased during the dry season in a study with cultivars Gros Michel, Dwarf Cavendish, Robusta and Lacatan. Photosynthetic efficiency of banana leaves varied widely among the cultivars (Stover and Simmonds, 1987). Efforts were taken by Sunilkumar (1997) to select superior types of Kaliethan. Genetic analysis in various accessions indicated high PCV and GCV for number of leaves. On comparative study of FHIA hybrids with locally grown Musa clones (FHIA-01 AAAB Hybrid, FHIA-03 AABB Hybrid, Inguiri AAB French Plantain, Bellaco AAB Horn Plantain, Isla del Alto Huallaga AAB), at Peru, 'Isla' had the highest leaf production (Krauss *et al.*, 2001). In a study conducted at Nagaland conditions, to evaluate the performance of fourteen genotypes of banana, RCN-21, had the highest growth parameters like pseudostem girth, height, shooting period and maturity period whereas Borjahajee recorded the highest number of leaves (Babu, 2001).

2.1.4 Effect of ecotype variation on number of suckers

Sucker production was more in genomes of *M. balbisiana* derivatives and less in derivatives of *M. acuminata* (Venkatarmani, 1946). Shanmugavelu and Balakrishnan (1980) found that sucker production was less in tetraploid banana. According to Balakrishnan (1980) there is a decrease in mean number of suckers per plant with the increase in ploidy level. His observation was based on the sucker production efficiency of different cultivars, *viz.*, Anaikomban (AA) (6.4), Robusta (AAA) (5.0), Monthan (ABB) (4.2), Poovan (AAB) (4.6), Klue Taparod (ABBB)

(2.3) and Hybrid Sawai (ABBB) (2.4). Sunilkumar (1997) reported that number of suckers varied from 4.0 to 7.7 among Kaliethan accessions.

2.1.5 Effect of ecotype variation on duration of vegetative phase and shoot-to-harvest duration

According to Rammohan *et al.* (1962) in banana plant, lower number of functional leaves delayed flower bud differentiation. In a study conducted by Devi (1996) time taken for flowering was less for Pandaloor, Muttathukonam, Kaliethan and Poovanchira compared to other types like Puthur, Changalikodan and Kothala. Sunilkumar (1997) in a study to find superior types of Kaliethan, observed that Venniyoor, took the shortest time for flowering followed by Venjaramoodu and Keezhoor. Longest duration for flowering was observed in Neyyatinkara, followed by Karakonam and Anad. Among the AAA genomes studied, it was found that early shooting was observed in Dwarf Cavendish (276 days) followed by Hanuman (255 days) and late shooting was observed in Red banana (384 days) (Kanamadi *et al.*, 2002).

Gonzalez *et al.* (1990) reported that all the seven plantain clones viz. Plantano, Enano, Dominician Dwarf, Harton and Maricongo of Horn type and Congo Enano, Congo Zoo and Lacknan of French type, were harvested on an average of 107 days after flowering. Out of 31 genotypes maintained at Indian Institute of Horticultural Research (IIHR), Bangalore, the longest duration (211.1 days) from flowering to harvest was observed in *Musa balbisiana* and shortest for Monthan (92 days) (Rekha *et al.*, 2001).

2.1.6 Effect of ecotype variation on total crop duration

Crop duration varied from 332 to 359 days in 1982, 207 to 309 days in 1983 and 291 to 328 days in 1985 for the same 'Nendran' clones in a study conducted at Banana research Station, Kannara to evaluate clonal variation. Agro ecological conditions in an area influences the crop duration in banana (KAU, 1987). Crop

duration was 501 days for 'Mysore Ethan', 504 days for 'Bodles Altafort', 494 days for 'Rasthali' and 512 days for 'Karpooravally' under Ambalavayal conditions (George *et al.,* 1991), while under Thrissur conditions, it was 264, 305, 359 and 342 days, respectively (Valsalakumari, 1984). Uthaiah *et al.* (1992) reported that the crop duration was more in tall varieties (433 days for Boodibale) and lesser in medium tall varieties like Robusta (339.3 days) and Nendran (342.9 days). Among the 21 banana clones of AAB group, studied, crop duration was 327.10 days for 'Malaikali' and 437.71 days for 'Myndoli' (Rajamony *et al.*, 1994). On comparative study of FHIA hybrids with locally grown Musa clones at Peru, (FHIA-01 AAAB Hybrid, FHIA-03 AABB Hybrid, Inguiri AAB French Plantain, Bellaco AAB Horn Plantain and Isla del Alto Huallaga AAB), it was found that Isla had the shortest production cycle with significantly fewer days from planting to flowering and harvest than the other varieties (Krauss *et al.*, 2001). Variation exists in the crop duration of different ecotypes of plantain subgroup. According to Menon *et al.* (2002) Myndoli recorded the longest crop cycle of 409 days under Kerala conditions.

2.2 EFFECT OF ECOTYPE VARIATION ON PHYSIOLOGICAL ATTRIBUTES

2.2.1 Effect of ecotype variation on phyllacron

Summervile (1944) suggested that under tropical conditions phyllacron in banana was seven days. Anslow (1966) reported that phyllacron depends upon temperature and assimilation of expanded leaves. In a healthy banana plant a new leaf is emerging from the heart by the time the previous one has fully opened, so one leaf per week may be taken as a rough general figure for the rate of leaf production. Time interval between successive leaves varies considerably. It decreases with increasing plant age (Champion, 1963). Simmonds (1966) reported that on an average it takes about seven days for the emergence of one banana leaf. The growing interval between successive leaves is profoundly influenced by temperature, wind speed and relative humidity (Turner, 1971). Increase in the level of functional leaves decreased the interval of successive leaves (Pillai and Shanmugavelu, 1976). They reported that phyllacron in 'Poovan' varied from 8.0 to 8.6 days. Rajeevan (1985) found that the phyllacron of

'Palayankodan' accessions varied significantly. Singh and Bhattacharaya (1992) reported that reduction in phyllacron exerted considerable influence in reducing overall crop duration.

2.2.2 Effect of ecotype variation on leaf area, leaf area index and leaf area duration

Balakrishnan (1980) studied variation in LAI of eight banana clones and found that LAI was the highest for 'Monthan' (ABB) and the lowest for 'Poovan' (AAB). Higher values of LAI coincide with the stages when the plant produced highest leaf area and number. Significant variation in LAI of 'Dwarf', 'Horn', 'Ordinary' and 'Dominique' was reported by Rao and Edmunds (1985). LAI of 'Dwarf' was 11per cent, 17per cent and 13per cent lower than that of 'Horn', 'Ordinary' and 'Dominique' respectively. Efforts were taken by Sunilkumar (1997) to select superior types of Kaliethan. Genetic analysis in various accessions indicated high PCV and GCV for leaf area, LAI and LAD. Uma *et al.* (2003) found that there was no significant variation among the different accessions of banana with respect to leaf area. Maximum leaf area was registered for the cultivar Saba (1.420 m^2) followed by Elavazhai (1.20 m^2).

2.3 EFFECT OF ECOTYPE VARIATION ON YIELD CHARACTERS

Studies on genetic variability and character association in banana indicated the importance of bunch and finger weight as selection criteria for improvement in banana (Rekha and Prasad, 1993). High heritability estimates were obtained for most of the characters like bunch weight, bunch length, number of hands per bunch, number of fingers per bunch and weight of finger in Kaliethan accessions (Sunilkumar, 1997).

Seventy five plantain and eighteen banana cultivars were characterized by Ortiz and Vuylsteke (1998) for sixteen quantitative characteristics. The highest yield

potential was exhibited by Cavendish bananas and the Giant French Plantain cultivars.

2.3.1 Effect of ecotype variation on bunch weight and yield of banana

Variation in bunch weight within a clone may probably be contributed to environmental and other factors (Prasanna and Aravindakshan, 1990). According to Shanmughavelu *et al.* (1992) Attunendran, Nananendran, Myndoli, Moongil and Nendrapadathi yielded 12, 8, 25, 8 and 10 kg bunch per plant respectively. Significant variation in the bunch yield of 24 accessions of the clone 'Palayankodan' was reported by Rajeevan and Mohanakumaran (1993). The accession 21 (Kalavoor) produced the heaviest bunches (14.872 kg) followed by accession 18 (Anchal) (14.378 kg). Accession 14 (Moolamattom) recorded the minimum bunch weight of 9.73 kg.

Under Kannara conditions, Menon (2000) found that, the bunch weight was the highest in Nyombe (32.00 kg) and the lowest in Nendran (10.30 kg). Under Arunachal Pradesh condition, Robusta had the highest bunch weight (17.25 kg) and RCN-22 (9.44 kg) had the lowest bunch weight (Babu, 2001). In a study to evaluate performance of banana cultivars under Orissa conditions, it was found that Chinichampa recorded the highest bunch weight of 25-30 kg bunch^{-1} (Lenka *et al.*, 2002a). Menon *et al.* (2002) observed that among the ten morphotypes of Nendran maintained at BRS, Kannara, Myndoli recorded the highest bunch weight (25 kg bunch^{-1}). A comparative study of 'Popoulu' a potential dessert and cooking exotic cultivar belonging to the Maia Maoli/Popoulu group of the AAB genomic group and Nendran under Kerala growing conditions revealed that bunch weight of Popoulu was superior to 'Nendran'. Thus, fruit yield of 'Popoulu' was significantly higher as compared to 'Nendran' (Menon *et al.*, 2014).

2.3.2 Effect of ecotype variation on number of hands and fingers per bunch

Shanmughavelu *et al.* (1992) reported that finger weight, number of hands and number of fingers per bunch differ between clones of Nendran. In a study in

Peru, it was found that average number of fingers per bunch varied significantly (Krauss *et al.*, 2001). Highest number of hands bunch^{-1} (18) was recorded in Batisa Bantal followed by Mendhi Bantal (10 hands bunch^{-1}) (Lenka *et al.*, 2002b). Ten genotypes consisting of seven plantain, one dessert banana, and one cooking banana hybrid and the landrace 'Agbagba' as a local check were evaluated in a sub-humid agro-ecology of Nigeria (Baiyeri and Tenkouano, 2008). The number of fruits per bunch was the highest for 'PITA 25' and 'FHIA17' and the lowest for the local check 'Agbagba', but the local check had bigger fruits than the other genotypes. Bunch weight per plant and number of fruits per bunch showed a positive association between them.

According to Menon (2000) the highest number of fruits per bunch was observed in Nyombe (150.3) and the lowest in Big Ebanga (44.2). *Musa balbisiana* had the highest number of fruits per bunch (186.00) and lowest was found in Nendran (33.70) (Rekha *et al.*, 2001). Lenka *et al.* (2002b) reported that Bastia Bantal (450), had the highest number of fingers, followed by Mendhi Bantal (190) and Gaja Bantal (190) under agroclimatic conditions of Orissa.

2.3.3 Effect of ecotype variation on length, girth and weight of fingers

Shanmughavelu *et al.* (1992) reported that finger weight differ between clones of Nendran. He also found that finger length varied from 15-20 to 33 cm and finger girth varied between 12.5 and 15-16 cm. The weight of fingers among 'Palayankodan' clones varied from 48.33 to 99.00 g (Rajeevan and Mohanakumaran, 1993). In a study to find superior types of Kaliethan by Sunilkumar (1997), accession 6 (Balaramapurm) had the highest fruit weight, while accession 5 (Palode) observed the lowest fruit weight. According to Uma *et al.* (1999), highest finger weight was observed in Jaheji (100.56 g) and lowest in Ney Poovan (38.92 g). Among the ten cultivars of plantain studied in Orissa, it was found that Paunsia had the highest fruit weight (280.00 g). In a comparative study of Nendran with exotic variety 'Popoulu',

it was found that 'Popoulu' fruits were shorter than 'Nendran', but fruit girth and weight were significantly more when compared to Nendran (Menon *et al.*, 2014).

2.3.4 Effect of ecotype variation on Peel weight and Pulp/ peel ratio

According to Devi (1996), peel weight was the highest in Kaliethan (74.10 g) and lowest in Muttathukonam (43.25 g). The highest pulp/peel ratio was recorded in Poovanchira (2.78) and the lowest in Kaliethan (2.34). Sunilkumar (1997) reported that highest pulp/peel ratio was observed in Karakkonam (4.59) and lowest in Keezhoor (4.17). In a comparative study of Nendran with exotic variety 'Popoulu', it was found that 'Popoulu' had higher pulp to peel ratio (Menon *et al.*, 2014).

2.4 EFFECT OF ECOTYPE VARIATION ON QUALITY ATTRIBUTES

The quality attributes of ripe fruits are mainly influenced by the genotype and nutritional status of the soil (Roy and Chakraborty, 1993). About 1-2 per cent sugar is present in pulp of green fruit, which increases to 15-20 per cent in ripe fruit. In some varieties like 'Red banana' , less than 20 per cent of the sugar is in reducing form but in other varieties 40-60 per cent sugar is in reducing form (Potty, 2005). 'Palayankodan' accessions showed significant differences in TSS, total sugars and reducing sugars (Rajeevan, 1985). According to Rajeevan and Mohanakumaran (1993) quality variations were found among 24 accessions of the clone 'Palayankodan'. TSS: 22-26.17 per cent, acidity: 0.30-0.48 per cent, total sugar: 16.41-17.40 per cent, reducing sugar: 15.5-17.18 per cent and non-reducing sugar: 0.14-0.27 per cent. Rajamony *et al.* (1994) observed a TSS variation of 22 per cent (Mottapoovan) to 30 per cent (Kodapanilla Kunnan) in an experiment with 27 banana clones of AAB group. According to Ram *et al.* (1994) quality variation of banana was reported to be 15.1 to 16.15 per cent, 0.22 to 0.37 per cent and 14.1 to 14.3 per cent for TSS, acidity and total sugars respectively. According to Forsyth (1980) 80 per cent solids in ripe banana contains glucose, fructose and sucrose. Due to heavy concentration of sugars, it is considered as a convenient source of energy (Kotecha and Desai, 1995). According to Shivashankar (1999) the highest TSS was observed

in Malbhog (accession 66) and acidity in Sakkai (accession 416). In an experiment, Babu (2001) revealed that Malbhog was the best with higher TSS and ascorbic acid content. The total sugars, acidity and sugar/acid ratio were significantly higher in Chenichampa. Rekha *et al.* (2001) reported that TSS was the highest in Nendran and Velathan and the lowest in *Musa balbisiana.*

According to Thajudeen (2000) Nendran banana contain starch (12.09 g) and fibre (0.18 g per 100 g). Soluble and insoluble fibre are present in bananas. Insoluble fibre helps in maintaining a healthy digestive system, since it is not broken down during digestion (Eastwood and Kritchevsky, 2009). A medium sized ripe banana provides 12 per cent of daily dietary fibre requirement of an adult (Ching *et al.*, 2001). On dry weight basis unripe banana pulp contains up to 70–80 per cent starch (Zhang *et al.*, 2005).

2.5 EFFECT OF ECOTYPE VARIATION ON CLONAL ATTRIBUTES

Clonal characters are useful in distinguishing different clones, but literature on intraclonal variation in Nendran is few as these characters are less studied. According to Stover and Simmonds (1987), clonal variations are more expressed with respect to characters such as fullness index, pedicel strength index, fruit curvature, bunch shape, leaf area ratio, plant pigmentation etc.

2.6 EFFECT OF ECOTYPE VARIATION ON THE INCIDENCE OF DISEASES AND PESTS

Brun (1962) found that the level of resistance to sigatoka displayed by a given cultivar may vary within relatively wide limits depending on local conditions and the amount of infective inoculums. Simmonds (1966) stated that the resistance to Sigatoka increases as the proportion of B genome increases. Among the varieties studied for disease susceptibility, it was observed that Pisang lilin, Sanna chenkadali and Tongat were highly tolerant; Elavazhai, Karpooravally, Njalipoovan, Dudh sagar, Mottapoovan, Dakshin sagar, Bodles Altafort and Mysore Ethan were tolerant; Matti, Nendran, Myndoli and Zanzibar were highly susceptible to sigatoka leaf spot

(Babylatha *et al.*, 1990). Viswanath (1981) studied the resistance of some banana varieties against the attack by Rhizome weevil (*Cosmopolites sordidus*). He found 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) stated that there was a 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. Among the 18 AAA clones, Manoranjitham showed high field resistance to sigatoka leaf spot (KAU, 1990). Many of the banana and plantain varieties are susceptible to a number of biotic factors, including black Sigatoka (*Mycosphaerella fijiensis* Morelet) and banana weevil (*Cosmopolites sordidus* Germar) (Vuylsteke *et al.*, 1997). The black sigatoka affected crops have yield losses ranging from 30per cent to complete crop failure in Africa and tropical America (Mobambo *et al.*, 1993). Plantain-derived tetraploid hybrids have been bred successfully with genetic resistance to black Sigatoka which was discovered in some diploid accessions in Southeast Asia (Swennen and Vuylsteke, 1993). In a study in Peru, it was found that FHIA hybrids, especially FHIA-03, were least susceptible to both yellow Sigatoka and *Cordana* leafspot. The cultivars, Inguiri and Isla were the most affected by yellow Sigatoka. Bellaco was most susceptible to *Cordana* leafspot, closely followed by Inguiri and Isla (Krauss *et al.*, 2001).

2.7 CORRELATION IN NENDRAN ECOTYPES

Correlation studies are important as they provide estimates of the degree of association of a character with its components and also among the various components. Information on interrelationship between yield and yield attributing characters play an important role in banana improvement programmes. Correlation studies done in banana are given below:

According to Rosamma and Namboodiri (1990), out of the seventeen characters studied, thirteen showed strong correlation with bunch weight of banana.

Genetic gain was the highest for weight of individual finger which recorded maximum direct effect on bunch weight. Significant positive phenotypic correlations between finger weight and bunch weight and between other yield components were found by Rekha and Prasad (1993). But number of hands per bunch and fingers per bunch had either non-significant positive correlations or highly negative correlations with most of the yield components. In a study conducted by Baiyeri and Mbah (1994) in False horn plantain cv. Agbagba, bunch weight was strongly correlated with finger weight, length and circumference. Plant girth recorded the highest correlation with bunch yield. Devi (1996) reported that LAD, girth of fingers, time taken for flowering, number of fingers per bunch, plant height at post floral initiation stage and girth of plant at floral initiation time had a positive correlation with bunch weight in Nendran banana. Bunch yield had highly significant positive correlation with characters like bunch length, number of hands, number of fingers, finger length, finger girth, finger weight, plant height, plant girth and LAD in a study conducted by Sunilkumar (1997) among 10 accessions of Kaliethan (*Musa* AAB) Nendran.

2.8 MOLECULAR CHARACTERIZATION

However, the above studies have given major emphasis on morphological and yield characters only. Valsalakumari *et al.* (1985) studied variability and genetic divergence among Indian bananas. Molecular techniques were found more powerful in understanding genetic relationships and molecular studies in banana cultivars have been reported by Rekha *et al.* (2001), Kahangi *et al.* (2002) and Soni *et al.* (2010). Molecular characterization of plantain clones using RAPD (Crouch *et al.*, 2000; Simi, 2001; Rajamanickam, 2003) and ISSR (Choudhary, 2011; Choudhary *et al.*, 2014) markers have been done. Genetic divergence analysis of ecotypes of Nendran using RAPD marker and morphological traits was also attempted (Rajamanickam and Rajmohan, 2005).

Materials and Methods

3. MATERIALS AND METHODS

The present study on "Performance evaluation of ecotypes of banana (*Musa* AAB Plantain subgroup)" was conducted at the Instructional Farm of the College of Agriculture, Vellayani, Thiruvanathapuram, during April 2016 - May 2017. The details of experiment site and the materials and methods adopted are discussed in this chapter.

3.1 EXPERIMENTAL SITE

The location of the experiment is situated at 8°5' North latitude and 77°1' East longitude at an altitude of 29 m above mean sea level. Predominant soil type is red loam belonging to Vellayani series, texturally classified as sandy clay loam.

3.2 MATERIALS

Ten ecotypes of plantain (*Musa* AAB Nendran) collected from Banana Research Station, Kannara and farmers' fields were used for the study.

3.3 METHODS

3.3.1 Experimental Design and Layout

Design	: RBD
Treatments	: 10
Replication	: 3
Number of plants /replication	: 4
Spacing	: 2m×2m
Plot Size	: 16m^2

Field experiment with the following ecotypes as treatments was conducted under uniform conditions as per the package of practices recommendations (KAU, 2011) for irrigated 'Nendran'.

T1. Attunendran

T2. Big Ebanga

T3. Changalikodan

T4. Kaliethan

T5. Chenkal Local

T6. Nedunendran

T7. Myndoli (Quintal banana)

T8. Zanzibar

T9. Perumatti Nendran

T10. Mettupalayam Nendran

3.4 MAIN ITEMS OF OBSERVATIONS

Observations were recorded from all the plants in each replication and averages were worked out for analysis.

3.4.1 Biometric characters

Observations on biometric characters like plant height, girth and number of leaves were taken three months after planting and at bunch emergence.

3.4.1.1 Plant height

Height of the plant was recorded from soil level to the base of the unopened leaf and expressed in metres.

3.4.1.2 Girth

The girth of the plant was measured from the base at 20 cm height above ground level and expressed in centimetres.

3.4.1.3 Number of functional leaves

The total number of fully opened functional leaves retained by the plant was recorded.

3.4.1.4 Plant spread

Plant spread was recorded in east-west and north-south direction and expressed in metres.

3.4.1.5 Number of sword and water suckers

Numbers of sword and water suckers were counted at harvest.

3.4.1.6 Total number of suckers

Total number of suckers at the time of harvest was noted.

3.4.1.7 Duration of vegetative phase

Time taken for flowering was recorded from the date of planting to visual bunch emergence and expressed in days.

3.4.1.8 Shoot - to - harvest duration

Time taken for harvest was recorded from the date of visual bunch emergence to date of harvest and expressed in days.

3.4.1.9 Total crop duration

Total crop duration was calculated from the date of planting to harvest and expressed in days.

3.4.2 Physiological attributes

Physiological attributes were recorded at three months after planting and at harvest.

3.4.2.1 Phyllacron

Phyllacron was recorded by observing the time interval between the opening of two successive leaves and expressed in days.

3.4.2.2 Leaf area

Leaf area was calculated by using the formula developed by Murray (1960) and expressed in m^2.

LA= Lx Wx 0.8

Where, LA - leaf area per leaf

L - length of leaf

W - width of leaf

3.4.2.3 Leaf area index

Leaf area index was calculated using the formula suggested by Watson (1952).

LAI= Leaf area per plant/ area occupied by the plant

3.4.2.4 Leaf area duration

Leaf area duration was determined using the formula,

LAD = area of last three leaves x time taken from bunch emergence to harvest (Turner, 1980).

3.4.3 Yield characters

The `bunches were harvested at full maturity when fingers showed disappearance of angles (Stover and Simmonds, 1987) and yield characters and clonal attributes were recorded.

3.4.3.1 Length of bunch

Length of bunch was measured from the point of attachment of first hand to that of last hand and expressed in centimetres (Indira, 2003).

3.4.3.2 Bunch weight

Weight of the bunch including the portion of the peduncle up to the first scar was recorded and expressed in kilogram.

3.4.3.3 Number of hands and fingers per bunch

The number of hands and fingers in a bunch was counted and recorded after harvest.

For the finger characters, the middle finger in the top row of the second hand (from the base of the bunch) was selected as representative finger or the index finger (Gottriech *et al.*, 1964)

3.4.3.4 Length, girth and weight of fingers

Length of the finger

Length of the index finger was measured through the convex side and expressed in centimetres.

Girth of the finger

Girth of the index finger was measured at the thickest portion of finger and expressed in centimetres.

Weight of the finger

Weight of the index finger was measured and recorded in gram.

3.4.3.5 Peel weight

Weight of peel of index finger was taken and expressed in gram.

3.4.3.6 Pulp/ peel ratio

The ratio between the weight of pulp and peel was worked out to find the pulp to peel ratio.

3.4.4. Quality of fruits

Raw fruit was used to estimate the starch content and ripe fruits were subjected to quality analysis.

3.4.4.1 Total Soluble Solids (TSS)

Total Soluble Solids was recorded using a hand refractometer and expressed in degree brix (Ranganna, 1977).

3.4.4.2 Acidity

Acidity was determined by the procedure proposed by Ranganna (1977) and the mean values were expressed as percent anhydrous citric acid.

3.4.4.3 TSS/Acid ratio

The values of TSS were divided by values of acidity to compute TSS / Acid ratio.

3.4.4.4 Total sugars

The total sugar content of the samples was determined by using the method described by AOAC (1975) and expressed as percentage on fresh weight basis.

3.4.4.5 Reducing sugar

The content of reducing sugars in the samples was estimated by using the method prescribed by AOAC (1975) and expressed as percentage on fresh weight basis.

3.4.4.6 Non reducing sugar

The non – reducing sugar content was estimated by deducting the values of reducing sugars from the values of total sugars and the mean values were expressed in percentage (Ranganna, 1977).

3.4.4.7 Total carotenoids

Carotenoids were estimated using the procedure suggested by Saini *et al.* (2001) and expressed as microgram/100g.

3.4.4.8 Fibre

Percentage of fiber in ripe banana was calculated using the formula (Sadasivam and Manickam, 1992):

% fibre = $(W_2 - W_3$ / weight of the sample) × 100

Where,

W_2 - weight in g of the crucible with oven dried residue

W_3 - weight in g of crucible with ash

3.4.4.9 Starch content

Starch content of the raw banana was estimated by using potassium ferricyanide method (Ward and Pigman, 1970) and the values were expressed as per cent on fresh weight basis.

3.4.4.10 Peel thickness

Peel thickness of ripe fruits were measured using a screw gauge and expressed in millimeters.

3.4.4.11 Shelf life of fruits at ambient conditions

Number of days from ripening to the stage when fruit skin turns black and become unsuitable for consumption was recorded.

3.4.4.12 Organoleptic quality

Organoleptic evaluation of fruits was done by a 10 member panel of judges selected from M.Sc students of College of Agriculture, Vellayani. Peeled fruit was sliced and uniform slices were evaluated for taste, flavour, texture and appearance.

Score for over all acceptability was obtained using the combined score of all the attributes. The scores were given using a five point hedonic scale as per procedure given by Srivastava and Kumar (2002) (Appendix II).

Excellent - 5

Very good - 4

Good - 3

Average - 2

Poor - 1

3.4.5 Clonal attributes

3.4.5.1 Bunch shape

Bunch shape index was calculated by the equation proposed by Champion (1967).

$$\frac{D_1-D_2}{L}$$

Where, D_1 – Diameter of bunch at basal hand level (cm)

D_2 – Diameter of bunch at apical hand level (cm)

L – Length of bunch

3.4.5.2 Openness of bunch

Openness of bunch is determined by the distance between nodes on the peduncle.

3.4.5.3 Fullness index

Fullness index was calculated by dividing the fruit weight by convex side length of fruit (Stover and Simmonds, 1987).

3.4.5.4 Fruit curvature

Fruit curvature was calculated using the formula proposed by Stover and Simmonds (1987).

$$\frac{Le}{Li}$$ Where,

Le – length of fruit measured from fruit tip to end of pedicel on convex side (cm).

Li – length of fruit measured from fruit tip to end of pedicel on concave side (cm).

3.4.5.5 Pedicel strength index

Pedicel strength index was calculated as the ratio of length of pedicel to diameter of pedicel in centimeters (Stover and Simmonds, 1987).

3.4.5.6 Proportion of wild fingers

A finger showing unusual shape and orientation is termed as wild finger. Numbers of wild fingers were counted if present.

3.4.5.7 Fruit shape

Fruit shape was determined according to the descriptor of banana by IPGRI (1996).

3.4.5.8 Fruit apex

Fruit apex was determined as per the descriptor of banana by IPGRI (1996).

3.4.5.9 Pigmentation of pseudostem and fruit skin if any

Pigmentation of pseudostem and fruit skin was noted if present.

3.4.5.10 Length/weight ratio of fruits

Length to weight ratio of fruit was calculated by dividing convex length of fruit by weight of fruit.

3.4.5.11 Skin ridging pattern of fruits

Number of ridges in fruit at harvest was counted to get the skin ridging pattern.

3.4.5.12 Any other striking differences

Observations of any other striking features if present were recorded.

3.4.6) Reaction to major pests and diseases

Incidence of major pests and diseases was monitored throughout the crop period. The severity of incidence was scored using an index scale (Mayee and Datar, 1986).

$$\text{Disease incidence (\%)} = \frac{\text{Number of plants affected}}{\text{Total number of plants}} \times 100$$

0 - no incidence

Below 50% - mild incidence

Above 50% - severe incidence

3.4.7) Statistical analysis

Variance and co-variance analysis with respect to biometrical and yield characters were conducted. Correlation studies were also done. Observations were analysed statistically in Randomized Block Design and significance was tested using analysis of variance technique (Panse and Sukhatme, 1967).

For organoleptic analysis, the different scores given by 10 judges in the sensory panel were analysed using the Kruskall – Wallis test to get the mean rank values for all the treatments (Sidney, 1988).

3.4.7.1 Estimation of genetic parameters

a. Coefficient of variation

Genotypic, phenotypic and environment co efficient of variation were worked out using the estimates of V_G, V_P and V_E and expressed in percentage for each trait.

i. Genotypic coefficient of variation, GCV = $\sqrt{\frac{V_G}{\overline{X}}} \times 100$

ii. Phenotypic coefficient of variation, PCV = $\sqrt{\frac{V_P}{\overline{X}}} \times 100$

Iii. Environmental coefficient of variation, ECV = $\sqrt{\frac{V_E}{\overline{X}}} \times 100$

Where, $\overline{X}$ = grand mean

Categorization of the range of variation was followed as reported by Sivasubramanian and Menon (1973).

Low	:	< 10%
Moderate	:	10-20%
High	:	> 20%

b. Heritability

Proportion of genotypic variance to the total observed variance in the total population is referred as heritability in the broad sense. It was calculated and expressed in percentage (Allard, 1999).

$$\text{Heritability, } H^2 = \frac{V_G}{V_P} \times 100$$

As suggested by Johnson *et al.* (1955) the range of heritability estimates were categorized as:

Low	:	< 30%
Medium	:	30- 60%
High	:	> 60%

c. Genetic advance

Genetic advance refers to the expected genetic gain or improvement in the next generation by selecting superior individuals under certain amount of selection pressure. From the heritability estimates the genetic advance was estimated by the following formula given by Burton (1952).

$$GA = k.H^2\sqrt{V_P}$$

Where k= Standardized selection differential (2.06 at 5 % selection intensity).

For visualizing the relative utility of genetic advance among the characters, genetic advance as percent of mean was also estimated.

$$\text{GA as percent of mean} = \frac{GA}{\overline{X}} \times 100$$

The range of genetic advance as percent of mean was classified according to Johnson *et al.* (1955).

Low	:	0-10 %
Moderate	:	10-20 %
High	:	>20 %

3.4.7.2 Correlation analysis

Character association refers to the association of characters which estimates the magnitude and direction of change of one character with respect to the change in another character.

Genotypic and phenotypic correlation coefficients were calculated using the formulae suggested by Falconer (1981).

$$\text{Genotypic coefficient of correlation } (r_G) = \frac{COV_G(X,Y)}{\sqrt{V_P(X).V_P(Y)}}$$

$$\text{Phenotypic coefficient of correlation } (r_P) = \frac{COVp(X,Y)}{\sqrt{V_G(X).V_G(Y)}}$$

Where, COV_P (X,Y) and COV_G (X,Y) respectively denotes the phenotypic and genotypic co-variances between the two traits X and Y. $V_P(X)$ and $V_G(X)$ denotes the phenotypic and genotypic variance for X and $V_P(Y)$ and $V_G(Y)$ indicate the phenotypic and genotypic variance for Y respectively.

For organoleptic analysis, the different scores given by 10 judges in the sensory panel were analysed using the Kruskall – Wallis test to get the mean rank values for all the treatments (Sidney, 1988).

Results

4. EXPERIMENTAL RESULTS

The present study was carried out to evaluate the effect of ecotype variation on biometric characters, physiological attributes, qualitative characters, yield characters and clonal attributes of Nendran ecotypes. The experiment was conducted at Instructional Farm, College of Agriculture, Vellayani, Thiruvanathapuram during the period April 2016 - May 2017. General view of experimental field is given in plate 1. The results of the study are given below;

4.1 EFFECT OF ECOTYPE VARIATION ON BIOMETRIC CHARACTERS

The results of the study on the effect of different ecotypes of Nendran on biometric characters are presented in tables 1, 2 and 3.

4.1.1 Height

The results indicated significant variation in height among the different treatments both at three month after planting and at bunch emergence. At three month after planting (MAP), the treatment T4 and T7 showed highest mean value for plant height (0.99 m) followed by T10 (0.95 m), T5 (0.95 m) and T9 (0.87 m); all the three treatments being statistically on par. This was followed by T3 (0.80 m), which was on par with T8 (0.72 m). The lowest value for plant height was found for T1 (0.56 m), followed by T6 (0.57 m) and T2 (0.58 m); all three treatments being statistically on par.

At bunch emergence, T10 showed highest mean value of 3.60 m, followed by T2 (3.48 m) and T7 (3.41 m); all three were statistically on par. The lowest height was recorded in T1 (3 m), followed by T4 (3.12 m), T3 (3.08 m), T6 (3.07 m) and T9 (3.05 m); all the four treatments being statistically on par.

4.1.2 Girth

Girth of Nendran ecotypes at 3 MAP did not vary significantly, but girth of the plant varied between different treatments during bunch emergence. Mean girth was higher in T10 (73.33 cm), followed by T2 (68.00 cm) which was on par with T8 (67.33 cm) and T7 (65.44 cm). The treatment T5 (58.83 cm) which recorded the

Table 1. Effect of ecotype variation on biometric characters of Nendran clones

Treatments	Plant height (m)		Number of leaves		Girth (cm)	
	3 MAP	BE	3 MAP	BE	3 MAP	BE
T_1	0.56	3.00	8.83	12.58	22.16	60.62
T_2	0.58	3.48	9.00	11.56	25.48	68.00
T_3	0.80	3.08	9.00	12.61	21.36	61.03
T_4	0.99	3.12	9.17	11.25	24.62	58.92
T_5	0.95	3.35	8.75	11.25	25.33	58.83
T_6	0.57	3.07	8.83	11.36	23.23	59.35
T_7	0.99	3.41	9.00	10.31	27.77	65.44
T_8	0.72	3.49	8.83	12.08	22.04	67.33
T_9	0.87	3.05	8.83	11.56	24.41	61.24
T_{10}	0.95	3.60	8.50	12.00	25.00	73.33
CD (0.05)	0.14	0.24	NS	1.07	NS	3.96

T_1: Attunendran
T_2: Big Ebanga
T_3: Changalikodan
T_4: Kaliethan
T_5: Chenkal Local
T_6: Nedunendran
T_7: Myndoli/Quintal banana
T_8: Zanzibar
T_9: Perumatti Nendran
T_{10}: Mettupalayam Nendran

Table 2. Effect of ecotype variation on plant spread of Nendran clones

Treatments	Plant spread E.W (m)		Plant spread N.S (m)	
	3 MAP	BE	3MAP	BE
T_1	0.91	3.52	0.95	3.78
T_2	1.04	3.96	1.06	3.99
T_3	1.03	3.75	1.10	3.80
T_4	1.08	3.80	1.07	3.45
T_5	1.03	3.65	1.09	3.41
T_6	1.10	3.75	1.18	3.35
T_7	1.08	3.92	1.10	4.04
T_8	1.03	3.81	1.05	3.68
T_9	1.06	3.62	1.05	3.65
T_{10}	1.07	3.72	1.10	4.02
CD (0.05)	NS	NS	NS	NS

T_1: Attunendran
T_2: Big Ebanga
T_3: Changalikodan
T_4: Kaliethan
T_5: Chenkal Local
T_6: Nedunendran
T_7: Myndoli/Quintal banana
T_8: Zanzibar
T_9: Perumatti Nendran
T_{10}: Mettupalayam Nendran

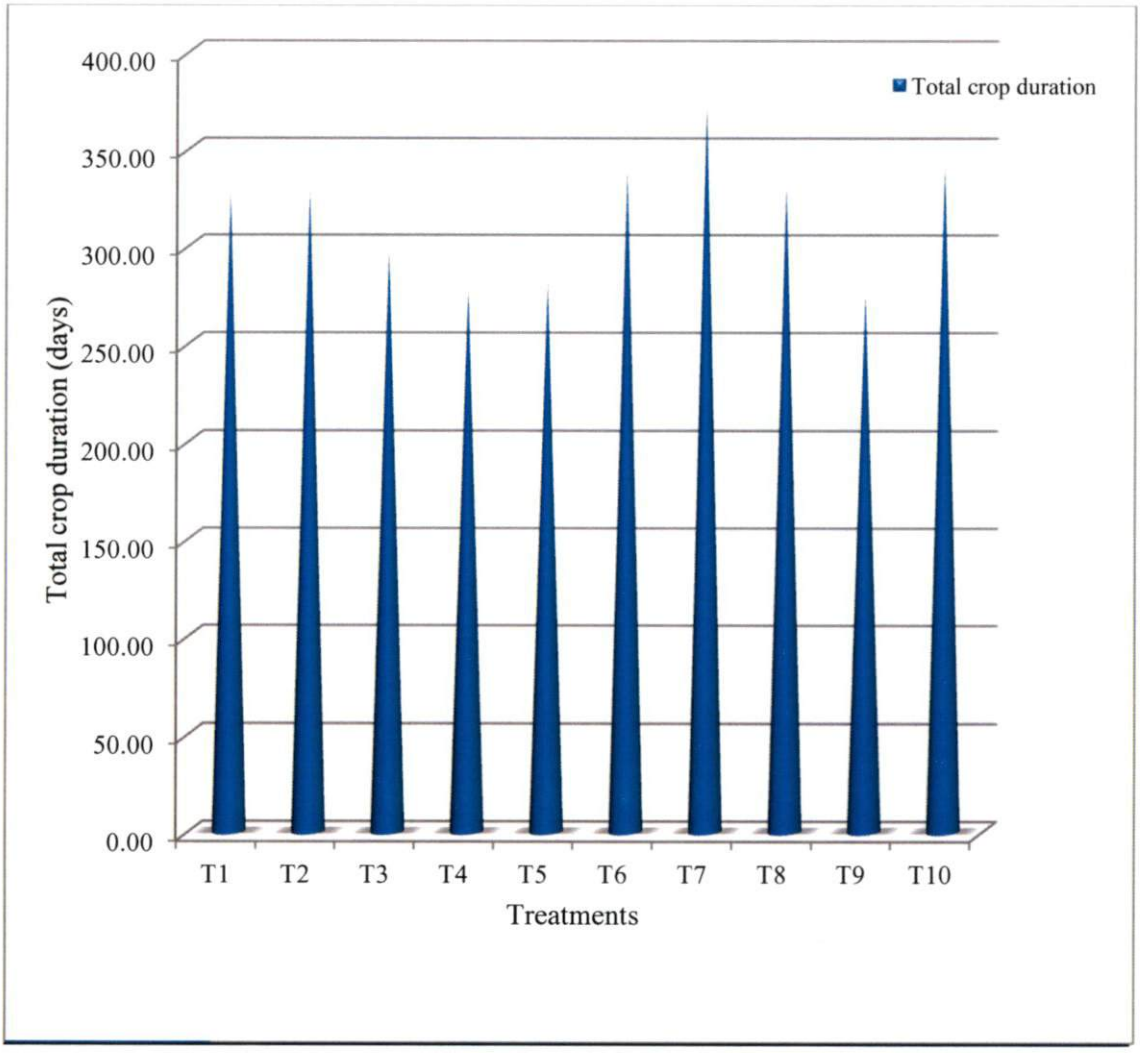
Table 3. Effect of ecotype variation on number of suckers and vegetative, shoot to harvest and total crop duration

Treatments	Number of suckers	Duration of vegetative phase (days)	Shoot to harvest duration (days)	Total crop duration (days)
T_1	10.58	250.69	75.92	326.61
T_2	11.00	255.67	72.58	328.25
T_3	8.92	223.50	73.33	296.83
T_4	9.50	198.25	79.33	277.58
T_5	8.58	201.58	79.08	280.67
T_6	7.50	259.89	78.75	338.64
T_7	7.92	273.17	98.67	371.83
T_8	12.17	261.25	70.00	331.25
T_9	8.17	196.67	78.00	274.67
T_{10}	10.50	253.92	87.25	341.17
CD (0.05)	1.93	12.53	5.79	13.11

T_1: Attunendran
T_2: Big Ebanga
T_3: Changalikodan
T_4: Kaliethan
T_5: Chenkal Local
T_6: Nedunendran
T_7: Myndoli/Quintal banana
T_8: Zanzibar
T_9: Perumatti Nendran
T_{10}: Mettupalayam Nendran

Plate 1. General view of the experimental field

Fig. 1. Effect of ecotype variation on total crop duration



lowest girth of plants, was on par with T4 (58.92 cm), T6 (59.35 cm), T1 (60.62 cm), T3 (61.03 cm) and T9 (61.24 cm).

4.1.3 Number of functional leaves

Number of functional leaves of Nendran ecotypes at 3 MAP did not vary significantly, but number of leaves at bunch emergence varied significantly. The highest number of functiona leaves was found in T3 (12.61) followed by T1 (12.58), T8 (12.08), T10 (12.00), T9 (11.56) and T2 (11.56) which were all on par with T3. The lowest number of functional leaves was found in T7 (10.31), which was on par with T6 (11.36), T4 (11.25) and T5 (11.25).

4.1.4 Plant spread

Results of the data on plant spread at 3 MAP and at bunch emergence are presented in Table 2. There was no significant difference in the plant spread of various treatments. Plant spread at 3MAP varied from 0.91 m in T1 to 1.10 m in T6 in the East-West direction and 0.95 m in T1 to 1.18 m in T6 in North-South direction. Plant spread at bunch emergence varied from 3.52 m in T1 to 3.96 m in T2 in East-West direction and 3.35 m in T6 to 4.04 m in T7 in North-South direction.

4.1.5 Number of suckers

The statistical analysis revealed significant difference among various treatments. The highest number of suckers were found in T8 (12.17), which was on par with T2 (11.00), T1 (10.58) and T10 (10.50) (Table 3). The least number of suckers was found in T6 (7.50), which was on par with T7 (7.92), T9 (8.17), T5 (8.58) and T3 (8.92).

4.1.6 Duration of vegetative phase, shoot-to-harvest and total crop duration

Results of the statistical analysis of duration of vegetative phase, shoot-to-harvest and total crop duration showed significant difference among various treatments (Table 3). The shortest vegetative phase was observed in T9 (196.67 days) and it was on par with T4 (198.25 days) and T5 (201.58 days). It was followed by T3 (223.50 days) which varied significantly from all other treatments. T3 was followed by T1 (250.69 days) which was on par with T10 (253.92 days), T2 (255.67) and T6

(259.89 days). The vegetative phase was longer in T7 (273.17 days) and T8 (261.25 days) which were statistically on par.

The shoot-to-harvest duration was the shortest in T8 (70.00 days) followed by T2 (72.58 days) and T3 (73.33 days) which were statistically on par. The treatment T3 was in turn on par with T1 (75.92 days), T9 (78.00 days), T6 (78.75 days) and T5 (79.08 days). Treatment T5 was on par with T4 (79.33 days). It was followed by T10 (87.25 days) which varied significantly from all other treatments. Among the different treatments T7 (98.67 days) took the maximum time for harvest.

Among the various treatments T9 (274.67 days) recorded the shortest crop duration which was on par with T4 (277.58 days) and T5 (280.67 days) (Fig. 1). It was followed by T3 (296.83 days) which varied significantly from all other treatments. Treatment T3 was followed by T1 (326.61 days) which was on par with T2 (328.25 days), T8 (331.25 days) and T6 (338.64 days). The longest crop duration was observed in T7 (371.83 days), followed by T10 (341.17 days) which varied significantly from all other treatments.

4.2 EFFECT OF ECOTYPE VARIATION ON PHYSIOLOGICAL ATTRIBUTES

The results of the study on the effect of different ecotypes of Nendran on physiological attributes are presented in Table 4.

4.2.1 Phyllacron

Data on the phyllacron of various treatments showed significant difference among the treatments. The highest phyllacron was observed in T1, T2 and T10 (each with 6.67 days) which was on par with four treatments viz. T4 (6.33 days), T7 (6.33 days), T3 (6.00 days) and T9 (6.00 days). The shortest phyllacron was found in T6 (5.00 days), which was in turn on par with T5 (5.33 days) and T8 (5.67 days).

4.2.2 Leaf area

Results of analysis of leaf area of various treatments at 3 MAP and at harvest showed significant difference among the treatments. At 3 MAP leaf area was the maximum in T4 (0.28 m), which was on par with T10 (0.27 m) and T5 (0.26 m). The

Table 4. Effect of ecotype variation on physiological attributes of Nendran clones at 3 MAP and at harvest

Treatments	Phyllacron (days)	Leaf area (m^2)		Leaf Area Index		Leaf Area Duration (days)
		3 MAP	harvest	3 MAP	harvest	
T_1	6.67	0.18	1.07	0.41	0.96	245.51
T_2	6.67	0.19	1.48	0.43	1.12	322.48
T_3	6.00	0.17	0.93	0.36	1.01	221.78
T_4	6.33	0.28	0.87	0.65	0.72	209.04
T_5	5.33	0.26	0.95	0.56	0.86	222.56
T_6	5.00	0.16	0.99	0.36	1.05	243.08
T_7	6.33	0.23	1.10	0.53	1.07	326.03
T_8	5.67	0.21	1.23	0.44	1.12	264.35
T_9	6.00	0.14	0.80	0.31	0.78	193.54
T_{10}	6.67	0.27	1.30	0.57	1.19	338.50
CD (0.05)	0.87	0.04	0.11	0.09	0.20	11.55

T_1: Attunendran
T_2: Big Ebanga
T_3: Changalikodan
T_4: Kaliethan
T_5: Chenkal Local
T_6: Nedunendran
T_7: Myndoli/Quintal banana
T_8: Zanzibar
T_9: Perumatti Nendran
T_{10}: Mettupalayam Nendran

leaf area was the minimum in T9 (0.14 m), which was on par with T6 (0.16 m), T3 (0.17 m) and T1 (0.18 m).

The data revealed that leaf area at harvest was the highest in T2 (1.48 m) which varied significantly from all other treatments. The lowest leaf area was recorded in T9 (0.80 m) which was followed T4 (0.87 m), which was on par with T9.

4.2.3 Leaf area index

Data on the leaf area index of various treatments at 3 MAP and at harvest showed significant difference among the treatments (Table 4). At 3 MAP, Leaf Area Index (LAI) was the highest in T4 (0.65) which was on par with T10 (0.57) and T5 (0.56). The lowest LAI was observed in T9 (0.31) which varied significantly from all other treatments.

LAI at harvest was the highest for Mettupalayam Nendran (1.19) which was on par with T2 (1.12), T3 (1.01), T6 (1.05), T7 (1.07) and T8 (1.12). The lowest LAI was observed in T4 (0.72) which was on par with T9 (0.78).

4.2.4 Leaf area duration

Data on the leaf area duration (LAD) of various treatments at harvest are presented in table 4 which showed significant difference among the treatments. The results indicated that the highest mean value of LAD was observed in T10 (338.50 days), which varied significantly from all other treatments. It was followed by T7 (326.03 days) which was on par with T2 (322.48 days). The least LAD was found for T9 (193.54 days) which also varied significantly from all other treatments. It was followed by T4 (209.04 days) and T3 (221.78 days) which were on par with T5 (222.56 days).

4.3 EFFECT OF ECOTYPE VARIATION ON YIELD CHARACTERS

The results of the study on the effect of different ecotypes of Nendran on bunch characteristics are presented in table 5 and variability in bunches and D-hand is shown in plates 2 and 3.

4.3.1 Length of bunch

Data on the length of bunch of various treatments are presented in table 5 which showed significant difference among the treatments. The mean bunch length ranged from 25.63 cm in T8 to 41.17 cm in T10. Length of bunch was found to be the highest for T10 (41.17 cm) which was on par with T2 (39.33 cm). T2 in turn was on par with T1 (38.50 cm). Treatments T3 (36.92 cm) and T5 (36.38 cm) which followed T1 were statistically on par. The lowest bunch length was for T8 (25.63 cm) which varied significantly from all other treatments.

4.3.2 Bunch weight

Results of the studies indicated variation of bunch weight among the various ecotypes of Nendran. The bunch weight ranged from 8.13 kg in T4 to 17.94 kg in T10 (Fig. 2). The highest bunch weight was recorded in T10 (17.94 kg). It was followed by T7 (14.42 kg) and T2 (11.38 kg). The treatment T2 was in turn on par with T1 (11.13 kg) and T3 (10.69 kg). The lowest bunch weight was recorded in T4 (8.13 kg) which was on par with T5 (9.29 kg).

4.3.3 Number of hands and fingers per bunch

Analysis of data on number of hands showed significant differences among the ecotypes. The mean number of hands ranged from 2.08 in T8 to 6.83 in T10 (Fig. 3). The treatment T10 had significantly higher number of hands compared to other treatments. Treatments T7 (5.83) and T2 (5.42) which followed T10 were statistically on par. Again T6 (5.33), T3 (5.25) and T1 (5.08) were on par with T2. Lowest hand number was seen in T8 (2.08) which varied significantly from all other treatments.

The number of fingers per bunch showed significant difference among the various treatments. The treatment T10 (92.92) recorded the highest number of fingers per bunch (Fig. 4). This was followed by T7 (66.08) and T3 (55.08). Treatments T6 (54.92) and T1 (53.67) which followed T3 were statistically on par. The lowest number of fingers was recorded in T8 (25.75) which differed significantly from all other treatments.

Table 5. Effect of ecotype variation on bunch characteristics of Nendran clones

Treatments	Length of bunch (cm)	Bunch weight (kg)	No. of hands bunch^{-1}	No. of fingers bunch^{-1}
T_1	38.50	11.13	5.08	53.67
T_2	39.33	11.38	5.42	36.58
T_3	36.92	10.69	5.25	55.08
T_4	36.25	8.13	4.42	39.50
T_5	36.38	9.29	4.92	45.83
T_6	32.08	10.00	5.33	54.92
T_7	35.96	14.42	5.83	66.08
T_8	25.63	9.36	2.08	25.75
T_9	34.88	8.27	4.83	38.50
T_{10}	41.17	17.94	6.83	92.92
CD (0.05)	2.16	1.16	0.43	2.55

T_1: Attunendran
T_2: Big Ebanga
T_3: Changalikodan
T_4: Kaliethan
T_5: Chenkal Local
T_6: Nedunendran
T_7: Myndoli/Quintal banana
T_8: Zanzibar
T_9: Perumatti Nendran
T_{10}: Mettupalayam Nendran

Fig. 2. Effect of ecotype variation on bunch weight

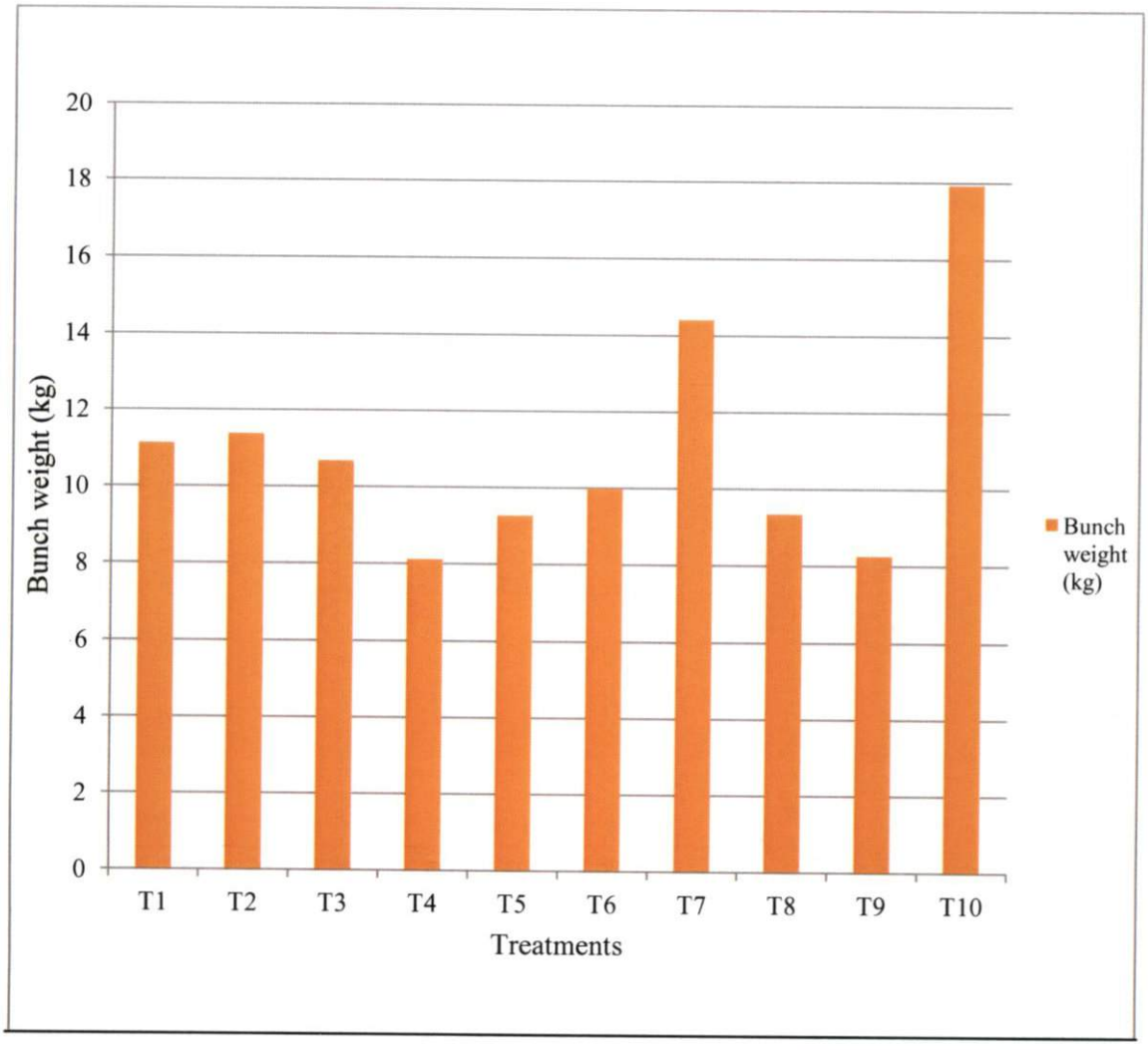


Fig. 3. Effect of ecotypes on number of hands

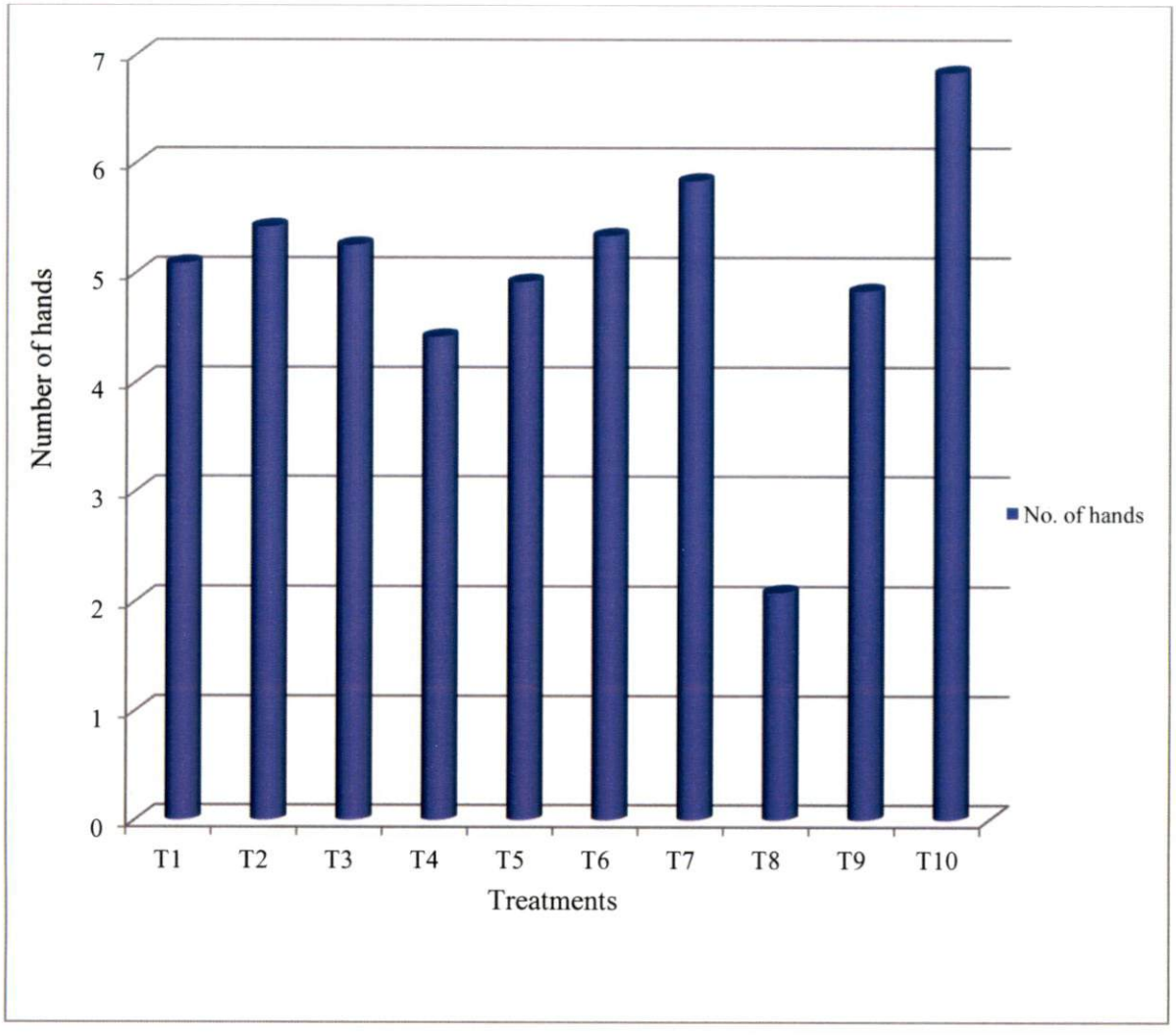
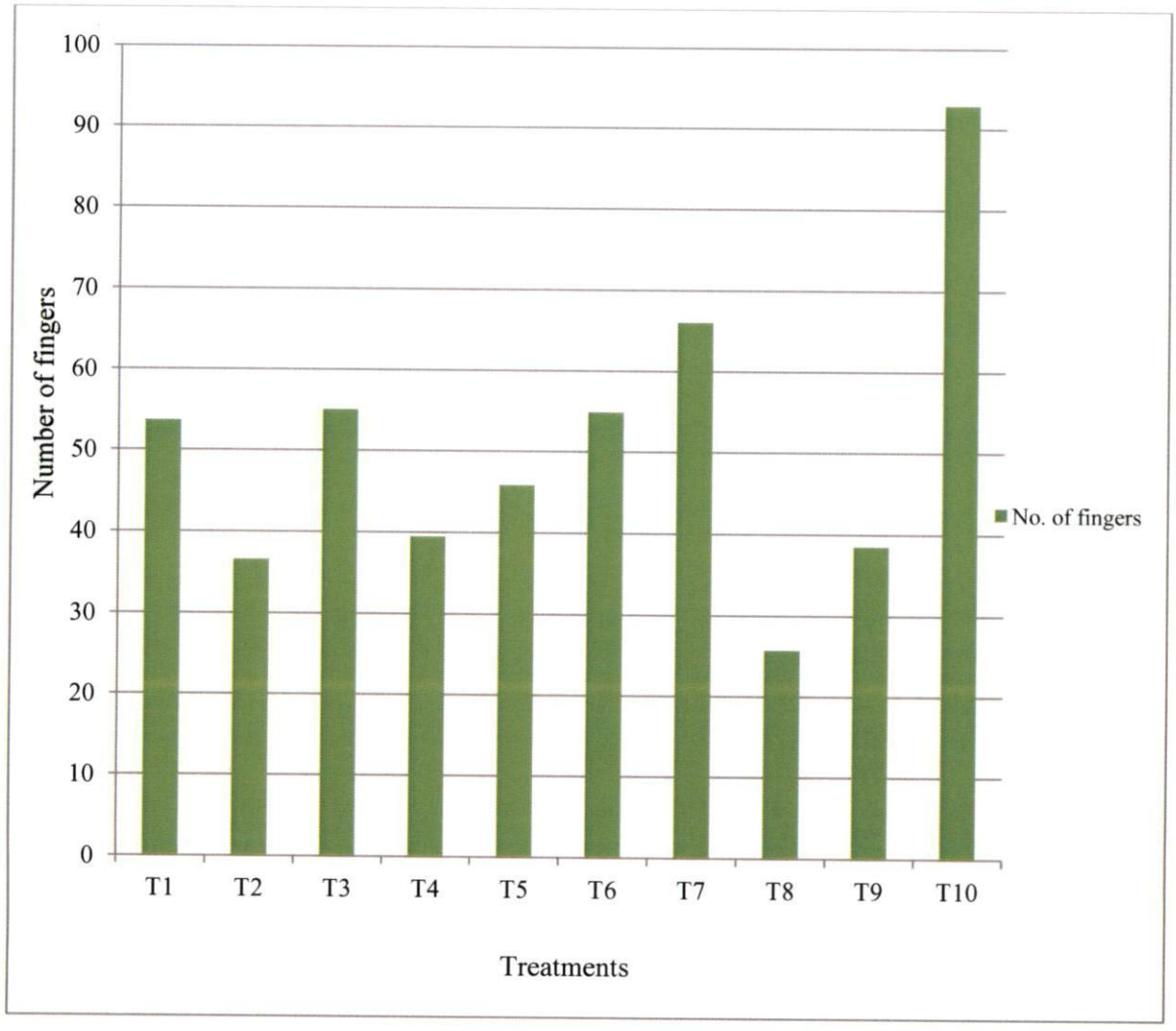


Fig. 4. Effect of ecotypes on number of fingers



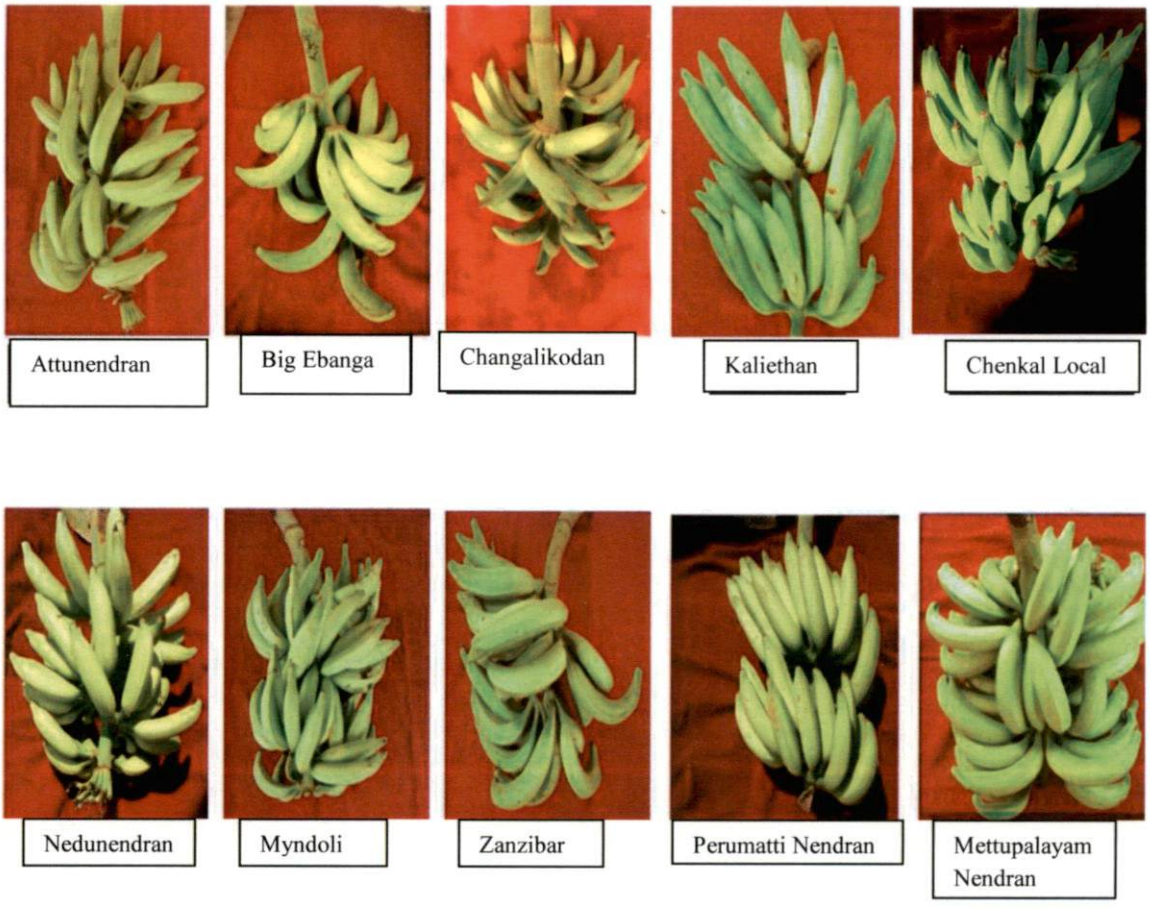


Plate 2. Variability in bunches of Nendran ecotypes

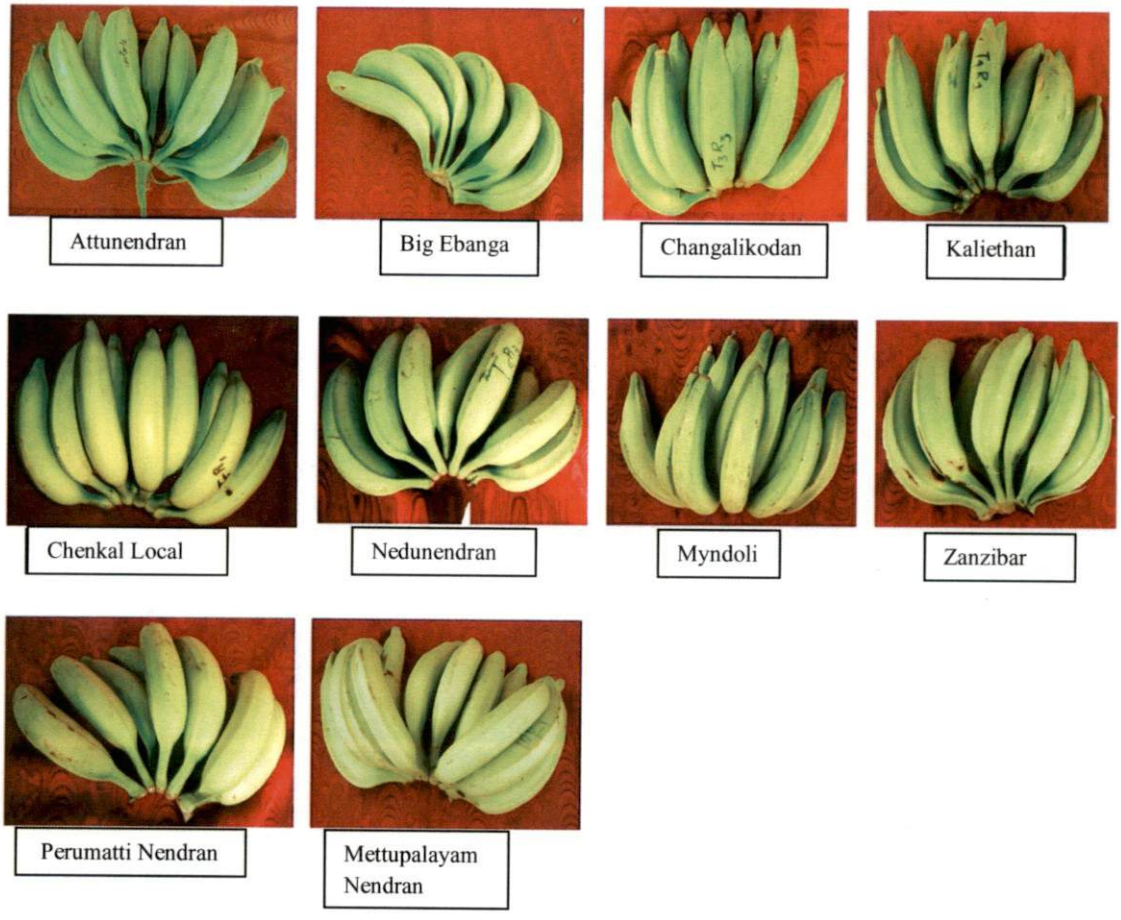


Plate 3. Variability in D-hand of Nendran ecotypes

The results of the study on the effect of different ecotypes of Nendran on finger characteristics are presented in table 6 and variability in D-finger is shown in plate 4.

4.3.4 Length, girth and weight of fingers

Length of fingers in various treatments varied significantly and the mean finger length varied from 25.79 cm in T3 to 37.92 cm in T8 (Table 6 and Fig. 5). The highest finger length was recorded in T8 (37.92 cm), followed by T2 (35.50 cm) and T7 (31.40 cm) and T5 (28.01 cm). T5 was on par with T10 (27.88 cm). The lowest length of finger was recorded in T3 (25.79 cm), followed by T9 (26.71 cm), T4 (26.80 cm) and T6 (27.29 cm). Treatment T1 (27.35 cm) was on par with T6.

Statistical analysis of the data on the girth of fingers of various treatments revealed significant variability between treatments (Fig. 5). Girth of fingers was the highest for T8 (16.63 cm) followed by T2 (15.63 cm) which was on par with T5 (15.23 cm). It was followed by T6 (15.17 cm) and T10 (14.72 cm). T10 was on par with T4 (14.71 cm), T1 (14.53 cm), T7 (14.45 cm), T3 (14.31 cm) and T9 (14.27 cm) (Table 6).

Data on the weight of fingers showed significant difference among the various treatments. The mean weight of fingers varied from 141.17 g in T6 to 268.17 g in T8. The treatment T8 which recorded the highest weight of fingers was on par with T2 (265.33 g). The lowest weight of fingers was observed in T6 (141.17 g) followed by T9 (170.60 g). Treatments T3 (175.92 g), T4 (179.85 g), T10 (182.60 g) and T7 (182.75 g) were statistically on par with T9.

4.3.5 Peel weight

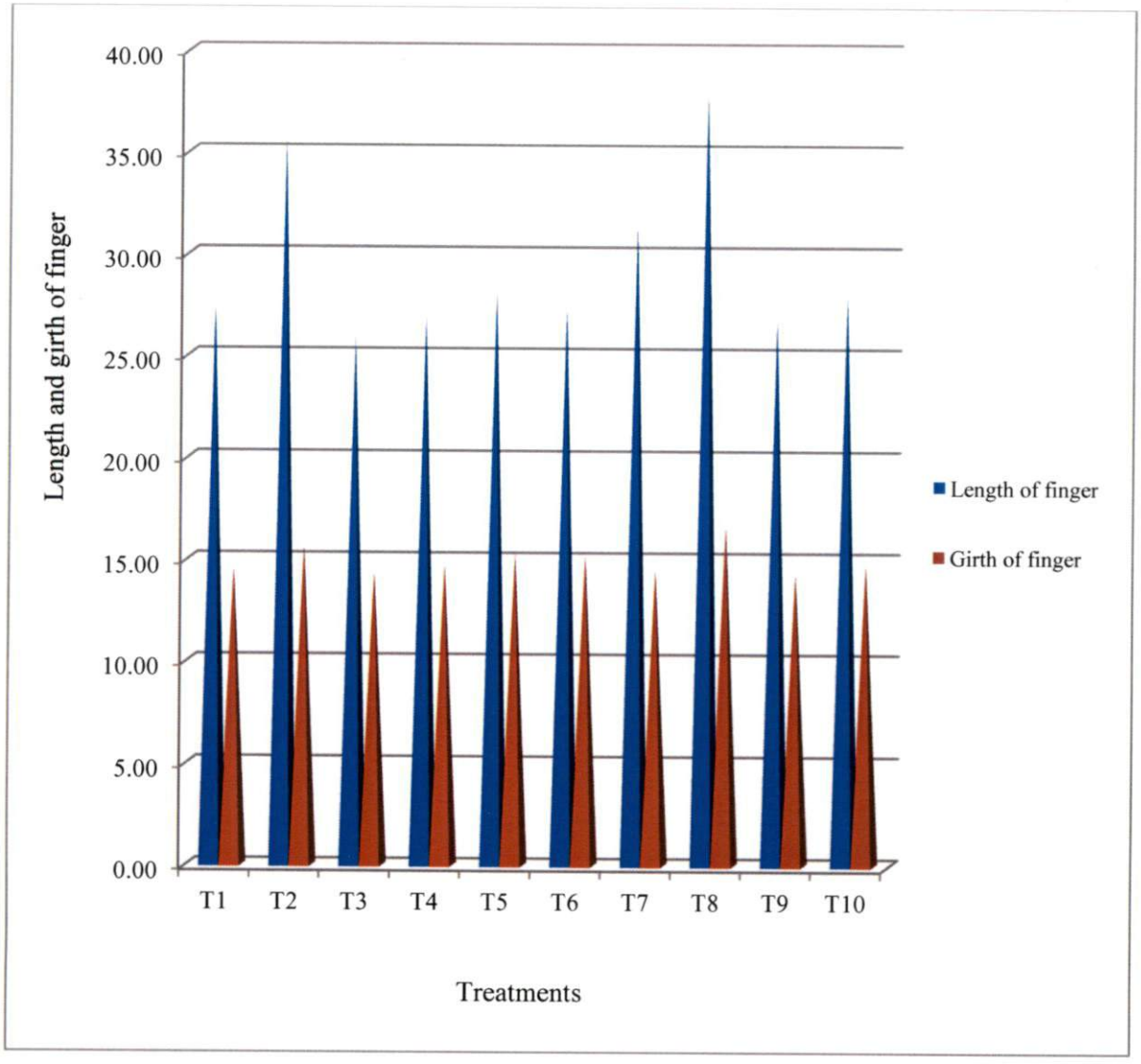
Statistical analysis of peel weight showed significant variation among the ecotypes of Nendran. Peel weight was observed to be the highest in T8 (64.50 g) which was on par with T2 (62.83 g). It was followed by T1 (48.13 g) which was again on par with T5 (47.83 g), T10 (46.58 g) and T7 (44.28 g). The lowest peel weight was recorded in T6 (32.67 g) which was on par with T3 (35.78 g).

Table 6. Effect of ecotype variation on finger characteristics of Nendran clones

Treatments	Length of finger (cm)	Girth of finger (cm)	Weight of finger (g)	Peel weight (g)	Pulp/peel ratio
T_1	27.35	14.53	187.68	48.13	2.90
T_2	35.50	15.63	265.33	62.83	3.24
T_3	25.79	14.31	175.92	35.78	3.85
T_4	26.80	14.71	179.85	41.09	3.22
T_5	28.01	15.23	192.42	47.83	3.02
T_6	27.29	15.17	141.17	32.67	3.24
T_7	31.40	14.45	182.75	44.28	3.16
T_8	37.92	16.63	268.17	64.50	3.32
T_9	26.71	14.27	170.60	39.38	3.30
T_{10}	27.88	14.72	182.60	46.58	2.92
CD (0.05)	0.42	0.44	13.15	6.20	0.38

T_1: Attunendran
T_2: Big Ebanga
T_3: Changalikodan
T_4: Kaliethan
T_5: Chenkal Local
T_6: Nedunendran
T_7: Myndoli/Quintal banana
T_8: Zanzibar
T_9: Perumatti Nendran
T_{10}: Mettupalayam Nendran

Fig. 5. Effect of ecotypes on length and girth of finger



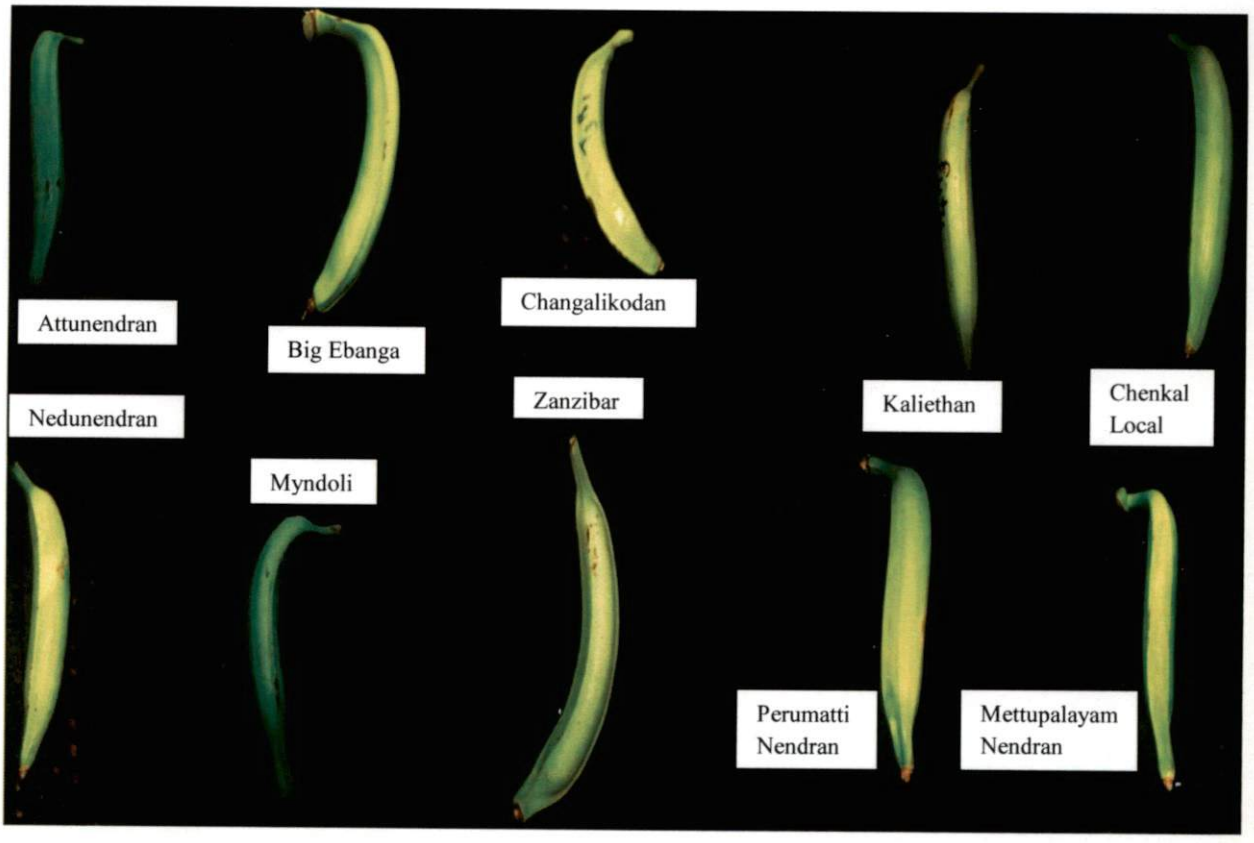


Plate 4. Variability in D-finger of Nendran ecotypes

4.3.6 Pulp/Peel ratio

Pulp/peel ratio varied significantly between the ecotypes. The highest pulp/peel ratio of ripe fruits was observed in T3 (3.85) followed by T8 (3.32). T8 was on par with T9 (3.30), T2 and T6 (each with 3.24), T4 (3.22), T7 (3.16) and T5 (3.02). The lowest pulp/peel ratio was seen in T1 (2.90) which in turn was on par with T10, T1, T5, T7, T4, T2 and T6.

Highest benefit/cost ratio was recorded for T10 (4.42) followed by T7 (3.52) and T2 (Big Ebanga) (3.03) (Appendices III and IV).

4.4 QUALITY OF FRUITS

Data on the quality characters of various treatments are presented in tables 7a and 7b.

The treatments showed significant difference in acidity of fruits. The acidity was the highest in T4 (0.42 per cent). Treatments T9 (0.39 per cent), T5 and T8 (each with 0.37 per cent) and T6 (0.36 per cent) was on par with T4. The lowest value for acidity was observed in T3 (0.30 per cent) which were on par with T1 (0.31 per cent), T2 and T7 (each with 0.33 per cent) and T10 (0.34 per cent).

Statistical analysis of the data revealed that there was significant variation among the different ecotypes of Nendran with regard to Total Soluble Solids (TSS) of ripe fruits. Maximum TSS was recorded in T3 (29.16) which was on par with T8 (28.60), T9 (28.83) and T1 (29.10). The minimum TSS was recorded in T4 (23.57) which were on par with T7 (24.17).

TSS/acid ratio varied significantly among the treatments. The highest TSS/acid ratio was observed in T3 (98.25) which were on par T1 (95.61) and T2 (84.58). The lowest TSS/acid ratio was observed in T4 (56.35) which was on par with T5 (70.30), T7 (73.13) and T6 (73.25).

Significant variation could be observed for non reducing sugar content of fruit samples from various treatments. The maximum non reducing sugar content was recorded in T8 (17.77 per cent) which was on par with T3 (17.71 per cent). The

Table 7a. Effect of ecotype variation on quality of ripe fruits of Nendran clones

Treatments	Acidity (%)	TSS (°Brix)	TSS/Acid ratio	Non-Reducing sugars (%)	Reducing sugars (%)	Total sugars (%)
T_1	0.31	29.10	95.61	14.39	4.68	19.07
T_2	0.33	27.43	84.58	14.65	4.09	18.73
T_3	0.30	29.16	98.25	17.71	6.39	24.10
T_4	0.42	23.57	56.35	13.94	4.39	18.33
T_5	0.37	26.00	70.30	13.25	5.35	18.60
T_6	0.36	26.10	73.25	14.87	4.30	19.17
T_7	0.33	24.17	73.13	12.97	4.33	17.30
T_8	0.37	28.60	76.62	17.77	6.11	23.88
T_9	0.39	28.83	73.71	14.40	4.83	19.23
T_{10}	0.34	25.40	75.98	12.67	4.22	16.89
C.D (0.05)	0.07	1.72	17.16	1.43	1.34	2.00

T_1: Attunendran
T_2: Big Ebanga
T_3: Changalikodan
T_4: Kaliethan
T_5: Chenkal Local
T_6: Nedunendran
T_7: Myndoli/Quintal banana
T_8: Zanzibar
T_9: Perumatti Nendran
T_{10}: Mettupalayam Nendran

Table 7 b. Effect of ecotype variation on quality of ripe fruits of Nendran clones

Treatments	Starch content* (%)	Fibre (%)	Total carotenoids (µ/100g)	Peel thickness (mm)	Shelf life (days)
T_1	12.61	0.87	266.27	2.26	6.00
T_2	17.27	0.92	231.93	4.20	8.33
T_3	20.55	1.03	333.23	2.40	6.67
T_4	22.67	1.03	304.67	2.50	6.67
T_5	16.50	1.17	234.67	2.60	7.00
T_6	22.33	1.03	235.00	2.70	6.67
T_7	21.65	0.93	310.80	2.90	7.33
T_8	24.07	0.91	244.07	4.70	8.00
T_9	21.56	1.01	320.17	2.40	6.33
T_{10}	23.22	0.92	260.13	3.15	7.33
CD (0.05)	2.75	NS	15.58	0.33	0.94

*- raw fruit

T_1: Attunendran
T_2: Big Ebanga
T_3: Changalikodan
T_4: Kaliethan
T_5: Chenkal Local
T_6: Nedunendran
T_7: Myndoli/Quintal banana
T_8: Zanzibar
T_9: Perumatti Nendran
T_{10}: Mettupalayam Nendran

minimum non reducing sugar content was found in T10 (12.67 per cent) which was in turn on par with T7 (12.97 per cent), T5 (13.25 per cent) and T4 (13.94 per cent).

Statistical analysis showed significant variation for reducing sugar content. The mean value ranged from 4.09 per cent in T2 to 6.39 per cent in T3. Treatment T3 (6.39 per cent) which had the maximum reducing sugar content was on par with T8 (6.11 per cent) and T5 (5.35 per cent). The minimum reducing sugar was found in T2 (4.09 per cent) which was on par with T6 (4.30 per cent), T7 (4.33 per cent), T4 (4.39 per cent), T1 (4.68 per cent), T9 (4.83 per cent) and T5 (5.35 per cent).

The total sugars in the fruit samples from different treatments showed significant variation. The highest total sugar content was recorded in T3 (24.10 per cent) which was on par with T8 (23.88 per cent). The lowest total sugar content was recorded in T10 (16.89 per cent) which in turn was on par with the treatments T7 (17.30 per cent), T4 (18.33 per cent), T5 (18.60 per cent) and T2 (18.73 per cent).

Significant variation was observed with regard to starch content of fruits among different treatments. T8 recorded the highest starch content (24.07 per cent) followed by T10 which recorded 23.22 per cent and T4 which recorded 22.67 per cent. T8 was on par with T10, T4, T6 (22.33 per cent), T7 (21.65 per cent) and T9 (21.56 per cent). T1 (12.61 per cent) recorded the lowest starch content which was significantly different from all other treatments.

The fibre content of fruit samples from different treatments did not show significant variation. However the mean value of fibre varied from 0.87 per cent in T1 to 1.17 per cent in T5. The highest mean values of fibre was recorded in T5 (1.17 per cent) followed by T3 and T9 (each with 1.01 per cent) while T1 (0.87 per cent) recorded the lowest fibre content followed by T8 (0.91 per cent), T10 and T2 (each with 0.92 per cent).

The highest carotenoid content in fruit pulp was observed in T3 (333.23 µg/100g) followed by T9 (320.17 µg/100g) and T7 (310.80 µg/100g), T3 was on par with T9. T7 was on par with T4 (304.67 µg/100g). The lowest value for carotenoid content of fruit pulp was observed in T2 with 231.93 µg/100g followed by T5

(234.67 µg/100g), T6 (235.00 µg/100g) and T8 (244.07 µg/100g) which were all on par.

Analysis of data on peel thickness revealed significant differences among various treatments. The lowest peel thickness was recorded in T1 which had a thickness of 2.26 mm which was on par with the treatments T3 and T9 (each with 2.40 mm) and T4 (2.50 mm). The highest peel thickness was observed in T8 (4.70 mm) followed by T2 (4.20 mm) and T10 (3.15 mm). The treatment T8 varied significantly from all other treatments.

Ecotypes of Nendran significantly influenced the shelf life of fruits. The highest shelf life (8.33 days) was recorded in T2 followed by T8 (8.00 days), T10 and T7 (each with 7.33 days). The treatment T2 was on par with T8. Statistically T10 and T7 were found to be on par with T5 (7.00 days), T3, T4 and T6 (6.67 days each). T1 recorded the lowest shelf life (6.00 days) followed by T9 (6.33 days).

4.5 ORGANOLEPTIC QUALITIES OF FRUITS

Organoleptic scoring for flavor, taste, texture and overall acceptability of fruits (table 8) revealed that the ecotypes differed significantly with each other. Treatment scores for appearance did not vary significantly; mean score ranged from 3.6 in T9 (Perumatti Nendran) to 4.3 in T3 (Changalikodan) and T5 (Chenkal Local). The mean score for flavor (4.1), taste (4.8), texture (4.3) and overall acceptability (4.4) was the highest for Changalikodan. It was followed by Big Ebanga with mean score of 3.9 for flavor, 4.3 for taste, 3.9 for texture and 4.2 for overall acceptability. The lowest mean score for flavor was observed for T9 (2.5), T8 (3) and T4 (3.1). The lowest mean score for taste was observed for T9 (3.2), T1 (3.7) and T6 (3.9). The lowest mean score for texture was observed for T9 (2.6), T6 and T8 (each with 2.9). The lowest mean score for overall acceptability was seen in T9 (3.3), T4, T7 and T8 (each with 3.5).

4.6 CLONAL ATTRIBUTES

The clonal characters studied varied significantly between the treatments (Table 9).

Table 8. Effect of ecoptype variation on organleptic qualities of ripe fruits of Nendran clones

Treatments	Appearance	Flavour	Taste	Texture	Overall acceptability
T_1	4.0	3.3	3.7	3.3	3.8
T_2	4.0	3.9	4.3	3.9	4.2
T_3	4.3	4.1	4.8	4.3	4.4
T_4	3.9	3.1	4.1	3.3	3.5
T_5	4.3	3.4	4.2	3.3	3.9
T_6	3.7	3.7	3.9	2.9	3.6
T_7	3.9	3.6	4.1	3.6	3.5
T_8	3.7	3	3.9	2.9	3.5
T_9	3.6	2.5	3.2	2.6	3.3
T_{10}	3.7	3.3	4.2	3.5	3.9
K W value	9.6	25.8	27.5	33.3	27.5
χ^2 - 16.91					

T_1: Attunendran
T_2: Big Ebanga
T_3: Changalikodan
T_4: Kaliethan
T_5: Chenkal Local
T_6: Nedunendran
T_7: Myndoli/Quintal banana
T_8: Zanzibar
T_9: Perumatti Nendran
T_{10}: Mettupalayam Nendran

Table 9. Effect of ecotype variation on clonal attributes of Nendran clones

Treatments	Bunch shape index	Openness of bunch	Fullness index	Fruit curvature	Pedicel strength index	Length/weight ratio	Number of ridges
T_1	0.36	7.65	7.25	1.18	2.32	0.15	4.00
T_2	0.53	6.81	8.46	1.46	2.49	0.13	3.33
T_3	0.44	6.31	7.14	1.16	2.11	0.15	4.33
T_4	0.55	7.00	7.16	1.21	1.87	0.15	3.66
T_5	0.57	8.10	7.46	1.26	2.68	0.15	4.66
T_6	0.34	6.25	5.47	1.18	2.03	0.19	4.33
T_7	0.40	4.95	6.47	1.32	2.61	0.17	4.66
T_8	0.20	5.67	7.56	1.18	2.46	0.14	4.00
T_9	0.52	6.95	6.77	1.17	2.27	0.16	4.66
T_{10}	0.53	5.99	6.92	1.17	3.17	0.15	4.66
CD (0.05)	0.11	1.06	0.66	0.05	0.23	0.01	NS

T_1: Attunendran
T_2: Big Ebanga
T_3: Changalikodan
T_4: Kaliethan
T_5: Chenkal Local
T_6: Nedunendran
T_7: Myndoli/Quintal banana
T_8: Zanzibar
T_9: Perumatti Nendran
T_{10}: Mettupalayam Nendran

4.6.1 Bunch shape index

Data on the bunch shape index of various treatments are presented in table 9 which showed significant difference among the treatments. The highest bunch shape index was observed in T5 (0.57) followed by T4 (0.55) and T2 and T10 (each with 0.53). Treatment T5 was on par with T2, T10 and T9 (0.52). The lowest bunch shape index was recorded in T8 (0.20) which varied significantly from all other treatments, followed by T6 (0.34) and T1 (0.36).

4.6.2 Openness of bunch

Data on openness of bunch presented in table 9 showed significant difference among the various treatments. The mean openness varied from 4.95 in T7 to 8.10 in T5. The treatment T5 which recorded the highest openness of bunch was statistically on par with T1 (7.65).

4.6.3 Fullness index

Statistical analysis of the data on fullness index (table 9) showed significant differences among the various treatments. Fullness index was the highest in T2 (8.46), followed by T8 (7.56) and T5 (7.46). Treatment T2 was superior to all other treatments. The lowest fullness index was recorded in T6 (5.47) followed by T7 (6.47) and T9 (6.77).

4.6.4 Finger curvature

Data on the finger curvature presented in table 9 showed significant difference among the various treatments. The mean finger curvature varied from 1.16 in T3 to 1.46 in T2. The treatment T2 which recorded the highest finger curvature varied significantly from all other treatments. It was followed by T7 (1.32) and T5 (1.26). The lowest fruit curvature was recorded in T3 (1.16) followed by T9 and T10 (each with 1.17). Treatment T3 was on par with T9, T10, T1, T8 and T4.

4.6.5 Pedicel strength index

Pedicel strength index varied significantly among treatments. T10 (3.17) recorded the highest pedicel strength index followed by T5 (2.68) and T7 (2.61) which differed significantly. PSI was the lowest in T4 (1.87).

4.6.6 Length/weight ratio

The statistical analysis showed that length/weight ratio had significant difference. The length/weight ratio varied from 0.13 in T2 to 0.19 in T6. The treatment T6 which showed highest length/weight ratio was superior to all other treatments. T6 was followed by T7 (0.17) which was in turn on par with T9 (0.16). The lowest pedicel strength index was found in T2 (0.13) which was on par with treatments T8 (0.14), T1, T3, T4, T5 and T10 (each with 0.15).

4.6.7 Number of ridges

Statistical analysis of the number of ridges did not show significant differences. The mean values of number of ridges varied from 3.33 in T2 to 4.66 in T5, T7, T9 and T10 (table 9).

4.6.8 Fruit shape and apex

According IPGRI descriptor for banana, fruit shape (straight in the distal part) and fruit apex (lengthily pointed) for all treatments had a uniform score of 2.

4.7 REACTION TO MAJOR PESTS AND DISEASES

Statistical analysis for incidence of sigotaka leaf spot revealed no significant difference among various treatments. The percentage of sigatoka incidence was highest in T5 (100 per cent) and lowest in T6 (64 per cent) (table 10).

Banana pseudostem weevil was found in two plants of treatment 3. No other serious pest or disease was noticed.

4.8 GENETIC PARAMETERS

4.8.1 Coefficient of variation, heritability and genetic advance

Genetic parameters such as genotypic and phenotypic coefficient of variation, genetic gain and heritability were studied for biometric and yield characters. The results of these genetic parameters are given in table 11.

Range of variation has been categorized into low (less than 10 %), moderate (10-20 %) and high (more than 20 %) as suggested by Sivasubramanian and Menon (1973). Analysis has revealed that the phenotypic coefficient of variation (PCV) was the highest for number of fingers (37.04), followed by bunch weight (27.81) and

Table 10. Effect of ecotype variation on percentage sigatoka incidence of Nendran clones

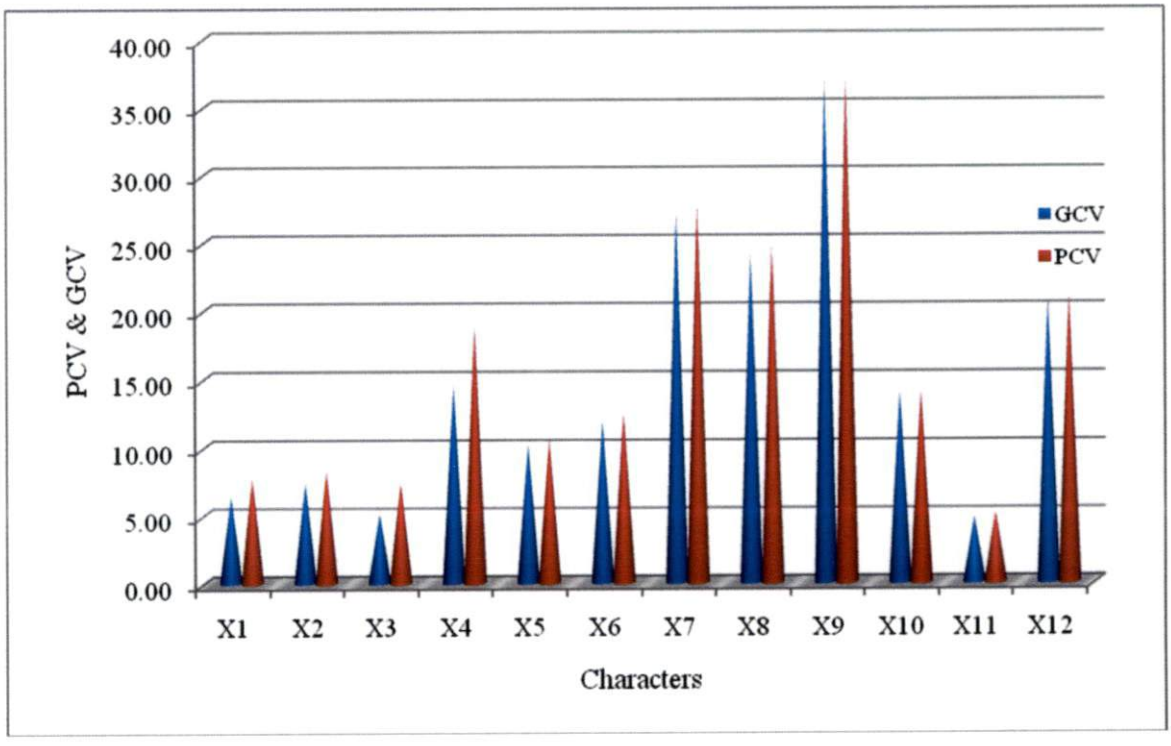
Treatments	Percentage sigatoka incidence
T_1	75
T_2	72
T_3	83
T_4	83
T_5	100
T_6	64
T_7	92
T_8	58
T_9	67
T_{10}	75
CD (0.05)	NS

T_1: Attunendran
T_2: Big Ebanga
T_3: Changalikodan
T_4: Kaliethan
T_5: Chenkal Local
T_6: Nedunendran
T_7: Myndoli/Quintal banana
T_8: Zanzibar
T_9: Perumatti Nendran
T_{10}: Mettupalayam Nendran

Table 11. Genetic parameters of biometric and yield characters of Nendran clones

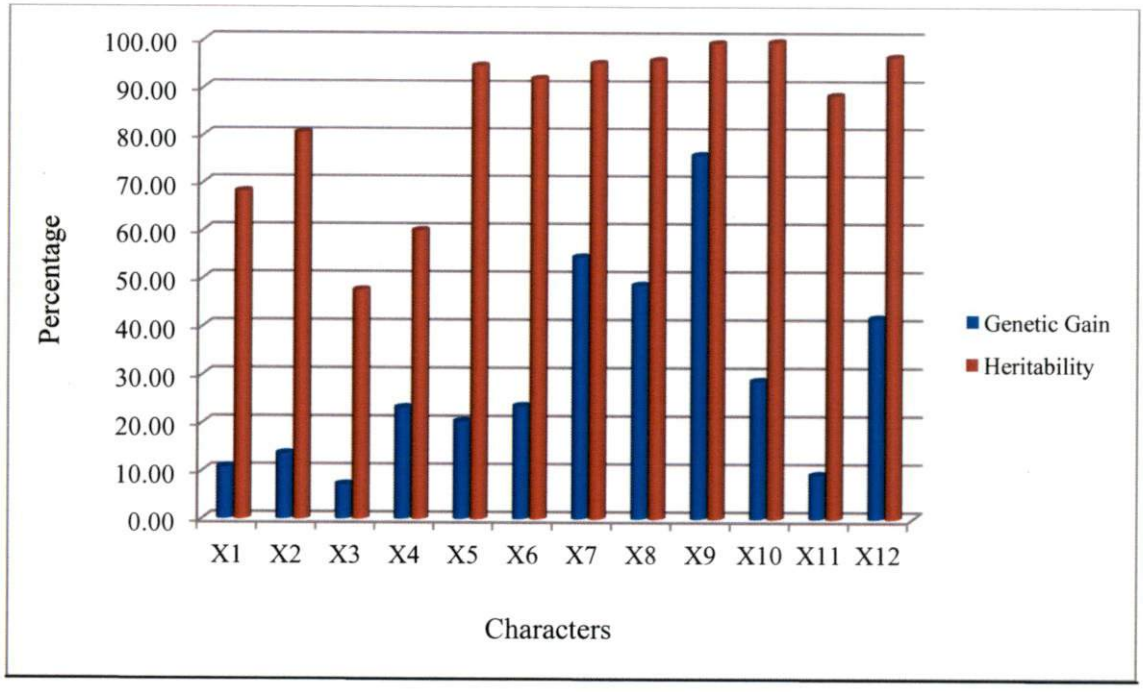
Characters	Coefficient of variation		Heritability	Genetic Advance (as % of mean)
	GCV	PCV		
Plant height (m)	6.37	7.71	68.26	10.84
Girth (cm)	7.41	8.26	80.61	13.71
Number of leaves	5.09	7.38	47.64	7.24
Number of suckers	14.57	18.80	60.06	23.26
Total crop duration (days)	10.19	10.47	94.69	20.43
Length of bunch (cm)	11.95	12.45	91.99	23.60
Bunch weight (kg)	27.13	27.81	95.17	54.51
Number of hands	24.13	24.65	95.84	48.67
Number of fingers	36.93	37.04	99.38	75.83
Length of finger (cm)	14.01	14.04	99.65	28.82
Girth of finger (cm)	4.78	5.08	88.49	9.26

Fig. 6. PCV and GCV of biometric and yield characters



X1	Plant height (m)	X7	Girth of finger (cm)
X2	Girth (cm	X8	Weight of finger (g)
X3	Total crop duration	X9	Fullness index
X4	Bunch weight (kg)	X10	Fruit curvature
X5	Number of hands	X11	Pedicel strength index
X6	Number of fingers	X12	Length/weight ratio

Fig. 7. Genetic gain and heritability of biometric and yield characters



X1 Plant height (m)
X2 Girth (cm)
X3 Total crop duration
X4 Bunch weight (kg)
X5 Number of hands
X6 Number of fingers
X7 Girth of finger (cm)
X8 Weight of finger (g)
X9 Fullness index
X10 Fruit curvature
X11 Pedicel strength index
X12 Length/weight ratio

number of hands (24.65). Moderate PCV values were recorded for number of suckers (18.80), length of finger (14.04) and length of bunch (12.45) and total crop duration (10.47). However, characters like girth (8.26), plant height (7.71) and number of leaves (7.38) showed low PCV values (Fig. 6).

Genotypic coefficient of variation (GCV) also showed the same trend as that of PCV. The highest GCV was observed for number of fingers (36.93), followed by bunch weight (27.13), and number of hands (24.13). Moderate GCV values were observed for number of suckers (14.57), length of finger (14.01), length of bunch (11.95) and total crop duration (10.19). Characters like girth (7.41), plant height (6.37) and number of leaves (5.09) showed very low GCV values (Fig. 6).

Johnson *et al.* (1955) reported the range of genetic advance as percentage of mean and classified it into low (less than 10%), moderate (10-20 %) and high (more than 20%). High genetic gain was observed for characters like number of fingers (75.83), bunch weight (54.51), number of hands (48.67), length of finger (28.82), length of bunch (23.60), number of suckers (23.26) and total crop duration (20.43) (fig. 7). Low genetic gain was observed for number of leaves (7.24) and girth of finger (9.26) and moderate genetic gain for characters like plant height (10.84) and girth of pseudostem (13.71) (Fig. 7).

According to Johnson *et al.* (1955) range of heritability in broad sense are expressed as low (0-30 per cent), medium (30-60 per cent) and high (above 60 per cent). Most of the characters had high heritability (in broad sense) values such as length of finger, number of finger, number of hands, bunch weight, total crop duration, length of bunch, girth of finger and girth of pseudostem, plant height and number of suckers. Medium heritability was recorded for only one character, which is number of leaves (Fig. 7).

4.8.2 Correlation coefficient analysis

The correlation between different characters was computed and genotypic correlation coefficients are presented in table 12 and phenotypic correlation coefficients in table 13.

Table 12. Phenotypic correlation matrix of some characters of banana clones

Traits	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12
X1	1											
X2	0.77**	1										
X3	0.42	0.53*	1									
X4	0.53*	0.71**	.67**	1								
X5	0.06	0.19	0.24	0.65**	1							
X6	0.22	0.40	0.45*	0.86**	0.81**	1						
X7	0.41	0.25	0.17	-0.17	-0.63**	-0.48*	1					
X8	0.53*	0.46*	0.15	-0.04	-0.51	-0.48*	0.71**	1				
X9	0.37	0.24	-0.21	-0.11	-0.24	-0.37	0.31	.77**	1			
X10	0.38	0.23	0.26	0.10	0.17	-0.18	0.21	0.50*	0.44	1		
X11	0.69**	0.64**	0.40	0.74**	0.36	0.55*	0.12	0.25	0.19	0.16	1	
X12	-0.24	-0.21	0.32	0.09	0.30	0.32	-0.22	-0.71**	-0.89**	-0.22	-0.19	1

X1 Plant height (m)
X2 Girth (cm)
X3 Total crop duration
X4 Bunch weight (kg)
X5 Number of hands
X6 Number of fingers
X7 Girth of finger (cm)
X8 Weight of finger (g)
X9 Fullness index
X10 Fruit curvature
X11 Pedicel strength index
X12 Length/weight ratio

* significant at 5% level
** significant at 1% level

Table 13. Genotypic correlation coefficient of some characters of banana clones

Traits	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12
X1	1											
X2	0.88**	1										
X3	0.50*	0.61**	1									
X4	0.64**	0.80**	0.70**	1								
X5	0.07	0.23	0.25	0.69**	1							
X6	0.27	0.44	0.46**	0.89**	0.83**	1						
X7	0.59**	0.32	0.20	-0.21	-0.69**	-0.51*	1					
X8	0.64**	0.52*	0.14	-0.05	-0.51*	-0.50*	0.79**	1				
X9	0.40	0.32	-0.25	-0.08	-0.27	-0.42	0.42	0.85**	1			
X10	0.46*	0.24	0.27	0.11	0.19	-0.19	0.24	0.51*	0.53*	1		
X11	0.87**	0.83**	0.41	0.78**	0.39	0.58**	0.13	0.26	0.24	0.17	1	
X12	-0.30	-0.25	0.40	0.12	0.29	0.36	-0.28	-.70**	-0.99**	-0.23	-0.20	1

X1 Plant height (m)
X2 Girth (cm)
X3 Total crop duration
X4 Bunch weight (kg)
X5 Number of hands
X6 Number of fingers
X7 Girth of finger (cm)
X8 Weight of finger (g)
X9 Fullness index
X10 Fruit curvature
X11 Pedicel strength index
X12 Length/weight ratio

* significant at 5% level
** significant at 1% level

Phenotypic correlation matrix shows highly significant positive correlation of bunch weight with number of fingers (0.86), PSI (0.74), girth of plant (0.71), total crop duration (0.67), number of hands (0.65) and plant height (0.53). Weight of finger had significant and positive correlation with fullness index (0.77), girth of finger (0.71), height (0.53), fruit curvature (0.50) and girth of plant (0.46). Plant height had significant positive correlation with pseudostem girth (0.77) and PSI (0.69). Pseudostem girth was positively and significantly correlated with total crop duration (0.53) and PSI (0.64). Length/weight ratio had significant negative correlation with Fullness index (0.71) and weight of finger (0.89).

Genotypic correlation analysis exhibited the same trend as that of phenotypic correlation studies. Highly significant positive correlation of bunch weight with number of fingers (0.86), girth of plant (0.80), PSI (0.78), total crop duration (0.70), number of hands (0.69) and plant height (0.64) was recorded. Weight of finger had significant and positive correlation with fullness index (0.85), girth of finger (0.79), height (0.64), fruit curvature (0.51) and girth of plant (0.52). Plant height had significant positive correlation with pseudostem girth (0.88) and PSI (0.87). Pseudostem girth was positively and significantly correlated with PSI (0.83) and total crop duration (0.61). Length/weight ratio had significant negative correlation with Fullness index (0.70) and weight of finger (0.99).

Discussion

5. DISCUSSION

Banana and plantain are widely cultivated in India with great socio-economic significance, interwoven with the cultural heritage of the country. It is referred to as 'Kalpatharu' which means plant of virtues due to its multifaceted uses (Chadha, 2003). In India bananas and plantains were grown even before the Vedic times. It is grown under varied soil and climatic conditions due to its wide varietal variability. For the classification of banana cultivars into different genomic groups morphological characterization is important. Variability among African plantains has been studied by Swennen *et al.* (1995). Clonal and ecotype variation with respect to growth and yield has been reported in Nendran which is the popular commercial cultivar of Kerala (KAU, 2015).

The present investigation was done to characterize different ecotypes of plantain with respect to clonal characteristics, biometric characters, yield potential and fruit quality. The different observations recorded and the results obtained are discussed below;

5.1 BIOMETRIC CHARACTERS

5.1.1 Effect of ecotype variation on the height of banana cv. Nendran

The study has shown that the height of plants varied significantly among the different ecotypes evaluated. Among the different treatments, plant height at bunch emergence was the lowest in Attunendran followed by Perumatti Nendran and Nedunendran while the highest plant height was observed in Mettupalayam Nendran followed by Zanzibar and Myndoli. Plant height and crop duration was significantly and positively correlated. Clones Attunendran and Perumatti Nendran which had lower values for plant height had shorter crop duration. Higher crop duration was recorded for Myndoli and Mettupalayam Nendran which were taller compared to other ecotypes. Variation in height among different clones of banana has been reported by Valsalakumari and Nair (1990) and Ram *et al.* (1994) under varied climatic conditions. According to Rajeevan (1985) significant differences exist in

height among the different accessions of Palayankodan. In a comparative study of Manjeri Nendran with Nedunendran conducted at BRS, Kannara, it was found that Manjeri Nendran was taller (3.19 m) compared to Nedunendran (3.00 m) (ICAR, 2017).

5.1.2 Effect of ecotype variation on the girth of banana cv. Nendran

The present study revealed that girth of ecotypes did not vary significantly at 3 month after planting (MAP) but significant difference was observed at bunch emergence. In the present study Mettupalayam Nendran showed the highest pseudostem girth of 73.33 cm and Chenkal Local recorded the lowest girth of 58.83 cm. During initial stages rate of growth was comparable among the different clones, but between early vegetative phase and bunch emergence, significant variation in rate of growth was observed, resulting in a significant difference between clones regarding the girth of plant. It is proven that weight of bunch and girth of plant are positively correlated in banana (Rajamanickam, 2003). The findings of the present study are in conformity with this trait. Mettupalayam Nendran which had highest plant girth had highest bunch weight. Chenkal Local with lowest plant girth recorded the least bunch weight of 9.29 kg. Jacob (1952) reported variation in growth characters such as plant height and girth among different clones of banana. According to Sreerangaswamy *et al.* (1980) Peykunnan (65.00 cm) had the highest pseudostem girth. Rajamanickam (2003) reported that among the triploids, the highest girth (96.00 cm) was found in Vellapalayankodan (AAB) and the lowest in Changalikodan (55.44 cm). He also reported that within clones of Nendran, Quintal banana (78.68 cm) recorded the highest pseudostem girth and the lowest in Chengalikodan (55.44 cm). Variation in pseudostem girth due to intraclonal variation has been reported (KAU, 1990). Among Nendran ecotypes, Changalikodan, Poovanchira and Kothala recorded the highest plant girth compared to other types (Devi, 1996).

5.1.3 Effect of ecotype variation on the plant spread of banana cv. Nendran

The study revealed that plant spread in east-west and north-south direction at 3 MAP and bunch emergence did not vary significantly. At 3 MAP plant spread in

east-west direction varied from 0.91 to 1.10 m and in north-south direction it varied from 0.95 to 1.10 m. At bunch emergence east-west plant spread varied from 3.52 to 3.96 m and north-south plant spread ranged between 3.35 to 4.04 m. No reports on plant spread of banana are available.

5.1.4 Effect of ecotype variation on number of functional leaves of banana cv. Nendran

Of the ten ecotypes studied variability in the number of leaves at 3 MAP was non-significant but at the bunch emergence showed significant difference. The highest number of leaves had been recorded in Changalikodan (12.61) followed by Attunendran (12.58) and the lowest for Myndoli (10.31). Number of emerged leaves before the onset of flowering is subjected to variation, while the number of leaves remaining in the pseudostem is fairly constant (Turner, 1970a). Among the Nendran intraclones maximum number of leaves was recorded in Koonoor Ethan (11.00) and the lowest in Vellayani Nendran and Zanzibar (each with 8.39) (Rajamanickam, 2003). Significant differences in number of leaves have been seen among the accessions of Kaliethan (Sunilkumar, 1997). These earlier findings are in line with reports of the present study.

5.1.5 Effect of ecotype variation on number of suckers of banana cv. Nendran

According to Shanmugavelu and Balakrishnan (1980) sucker production is influenced by genome and ploidy level. However, in this study number of suckers per plant varied significantly among the ten clones of Nendran studied. Eventhough the genome and ploidy level are the same for different ecotypes, wide variability could be observed in the number of suckers produced. The highest number of suckers has been recorded in Zanzibar (12.17) followed by Big Ebanga (11.00) and the lowest has been recorded in Nedunendran (7.50) followed by Myndoli (7.92). *Acuminata* cultivar produced more number of suckers compared to *Balbisiana* (Stover and Simmonds, 1987).

5.1.6 Effect of ecotype variation on vegetative, shoot-to-harvest and total crop duration of banana cv. Nendran

There was significant variation in the duration of vegetative, shoot-to-harvest and total crop duration. The longest vegetative phase (273.17 days), shoot-to-harvest duration (98.67 days) and total crop duration (371.83 days) were observed for Myndoli. The shortest vegetative (196.67 days) and total crop duration (274.67 days) was recorded for Perumatti Nendran. But lowest value for shoot to harvest duration (70 days) was recorded for Zanzibar. This is in conformity with the findings of Rajamanickam (2003). Among the Nendran intraclones maximum crop duration was recorded in Myndoli (411.8 days) and the lowest duration for Vellayani Nendran (265.8 days) (Rajamanickam, 2003). Duration of banana is very much influenced by varietal characters and growing conditions (Simmonds, 1962). Valsalakumari (1984) reported that agroclimatic conditions and seasonal variations affect crop duration of banana. In the present study, the ecotypes, Myndoli and Mettupalayam Nendran with the longest crop duration produced the heaviest bunches.

5.2 PHYSIOLOGICAL CHARACTERS

5.2.1 Effect of ecotypes of Nendran on phyllacron, Leaf area, LAI and LAD

Present study revealed that phyllacron varied significantly with respect to ten ecotypes of Nendran. Interval of leaf production was higher in Attunendran, Big Ebanga and Mettupalayam Nendran (6.67 days). Interval of leaf production was lower in Nedunendran (5 days). According to Turner (1970a) rate of leaf production is dependent on temperature. Rate of leaf production vary with wind speed and relative humidity (Turner, 1971) and genome constitution (Nambisan, 1972). Rajeevan (1985) reported variation in phyllacron among different accessions of 'Palayankodan'. In the present study, phyllacron was found to be higher in ecotypes which ultimately recorded higher crop duration indicating their slow rate of growth compared to other crops.

Leaf area varied significantly among the treatments at 3 MAP and at harvest. At 3 MAP leaf area was the highest in Kaliethan, followed by Mettupalayam Nendran and Chenkal Local and the lowest leaf area was recorded in Perumatti Nendran. However at harvest the leaf area was the highest for Big Ebanga followed by Mettupalayam Nendran and Myndoli. Leaf area is the critical factor determining efficiency of photosynthesis which in turn contributes to higher yield. The ecotypes, Myndoli, Mettupalayam Nendran and Big Ebanga which showed higher leaf area recorded higher yield.

The study indicated that both at 3 MAP and at harvest, leaf area index (LAI) varied significantly. LAI at 3 MAP was the highest for Kaliethan (0.65), followed by Mettupalayam Nendran (0.31) and the lowest for Perumatti Nendran (0.31). LAI at harvest was the highest for Mettupalayam Nendran (1.19), followed by Myndoli (1.12) and the lowest for Kaliethan. Balakrishnan (1980) has reported varietal level variation in LAI in banana. Number of leaves produced at different stages is different and since the land area remains unchanged, the variation may be due to changes in number of leaves at different stages of growth. Devi (1996) reported that among the Nendran clones studied, Changalikodan and Kothala recorded the highest LAI values while Kaliethan, Pandaloor and Puthur types had low LAI.

In the present study, leaf area duration (LAD) varied significantly among the treatments studied. The highest leaf area duration was recorded in Mettupalayam Nendran (338.50 days), followed by Myndoli (326.03 days). The lowest leaf area duration was recorded in Perumatti Nendran (193.54 days), followed by Kaliethan and Changalikodan. Leaf area duration is an indication of the functional longevity of leaves, determining the photosynthetic efficiency. Ecotypes like Mettupalayam Nendran and Myndoli with high leaf area duration recorded higher yield. Genomic constitution and ploidy level of the variety influence the LAD (Nambisan and Rao, 1980). Nendran being a triploid and having a contribution of *Balbisiana* genome may have higher LAD compared to diploid *Acuminata*. According to Sunilkumar (1997) high phenotypic association of LAD on bunch yield can be explained as due to the

high indirect effect through plant height and girth. Thus the variations in the physiological characters observed in the present study are supported by the research findings discussed above.

5.3 YIELD CHARACTERS

5.3.1 Effect of ecotypes of Nendran on length of bunch

Length of bunch showed significant variation among the treatments. The longest bunch was recorded in Mettupalayam Nendran (41.17 cm) followed by Big Ebanga (39.33 cm) and the shortest in Zanzibar (25.63 cm). Bunch length increased with increase in number of fingers and hands. Since Mettupalayam Nendran had higher number of hands and fingers it had higher bunch length. In an attempt to select superior types of Kaliethan, Sunilkumar (1997), recorded significant difference in bunch length between the accessions. Accordingly, the mean bunch length ranged from 40.89 cm in T9 (Karakkonam) to 48.25 cm in T6 (Balaramapuram). The treatment T6 was statistically on par with T4 (Venjaramoodu) (46.70 cm) and T2 (Vellayani) (45.01 cm).

5.3.2 Effect of ecotypes of Nendran on bunch weight

Bunch weight varied significantly among the ten ecotypes of Nendran studied. The highest bunch weight was recorded in Mettupalayam Nendran with 17.94 kg followed by Myndoli (14.42 kg) and the lowest bunch weight was recorded in Kaliethan (8.13 kg). Rajamanickam (2003) has reported that among the triploids studied, maximum bunch weight was recorded in Quintal banana (30.4 kg) while the lowest in Zanzibar (6.50 kg). Variation in bunch weight occurs due to change in location or inherent genetic variations (Babu, 2001). Variation in yield performance of clones has been reported under different agroclimatic conditions (KAU, 1987).

5.3.3 Effect of ecotypes of Nendran on number of hands and fingers/bunch

Number of hands and fingers per bunch showed significant differences among the treatments. The highest number of hands and fingers has been observed in Mettupalayam Nendran (6.83 and 92.92 respectively) followed by Myndoli (5.83 and 66.08 respectively). The lowest number of hands and fingers per bunch was recorded

in Zanzibar. There exists variation in number of hands per bunch among the Nendran clones (Shanmugavelu *et al.*, 1992). According to Simmonds (1960) environmental factors affect hands per bunch. Number of fingers per bunch varied significantly among the ecotypes of Nendran from 36.00 to 50.00 (Devi, 1996). This was in confirmity with the findings of the present study with values ranging from 36.58 to 92.92.

5.3.4 Effect of ecotypes of Nendran on length, girth and weight of fingers

The present investigation showed that there was significant variation in length, girth and weight of fingers. The highest length, girth and weight of finger were observed in Zanzibar with 37.92 cm, 16.63 cm and 268.17 g length, girth and weight respectively. It was followed by Big Ebanga with 35.50 cm length, 15.63 cm girth and 265.33 g weight. This is in line with the findings of the following workers. In a study conducted by Rajamanickam (2003) among the Nendran intraclones highest finger length was observed in Koonoor Ethan (37.26 cm) and the minimum in Changalikodan (17.80 cm). Finger weight in Nendran intraclones was the highest in Koonoor Ethan (507.42 g) and the lowest in Myndoli (180.06 g). Girth of finger varied from 8.84 cm to 14.58 cm in Kaliethan ecotypes (Sunilkumar, 1997). So it is evident that variability exists in finger characters within a clone. Variation in finger characteristics has been described as a varietal character by several workers (Devi, 1996; Lenka *et al.*, 2002a).

5.3.5 Effect of ecotypes of Nendran on peel weight and pulp/peel ratio

Analysis of the data on peel weight and pulp/peel ratio revealed the existence of significant difference among the ecotypes of Nendran. The highest peel weight was seen in Zanzibar (64.50 g) followed by Big Ebanga (62.83 g) and Attunendran (48.13 g). The lowest peel weight was recorded in Nedunendran (32.67 g). High pulp/peel ratio is a desirable character of the fruits. In the present study, pulp/ peel ratio was the highest in Changalikodan (3.85) followed by Zanzibar (3.32) and Perumatti Nendran (3.30). The lowest pulp/peel ratio was recorded in Attunendran and Mettupalayam Nendran. As in the present study, wide variation was reported

regarding pulp/peel ratio of Nendran as evident from the following report. Wide variability in pulp/peel ratio between the different ecotypes of Nendran has been reported by Rajamanickam (2003). Among the Nendran ecotypes the highest peel weight was reported in Quintal banana and the lowest in Changanasseri Nendran. He found that pulp/peel ratio varied from 2.94 in Mysore Ethan to 6.60 in Changanasseri Nendran.

5.4 QUALITY CHARACTERS

5.4.1 Effect of ecotypes of Nendran on TSS, acidity, TSS/acid ratio, reducing, non-reducing and total sugar

Quality characters studied varied significantly among the ecotypes studied. TSS, TSS/acid ratio, reducing sugar and total sugar were the highest in Changalikodan. Non reducing sugar was observed to be the highest in Zanzibar (17.77 per cent) followed by Changalikodan (17.71 per cent) and Nedunendran (14.87 per cent). The least acidity was observed in Changalikodan (0.30 per cent) followed by Attunendran (0.31 per cent), Big Ebanga and Myndoli (0.33 per cent each).

Research works in similar lines have shown the existence of significant variation in quality characters of fruits. Rajeevan (1985) observed that TSS, reducing sugar and total sugar showed significant variation among the Palyankodan accessions. Acidity varied from 0.32 per cent in Koonoor Ethan to 0.74 per cent in Kaliethan (Rajamanickam, 2003). Total sugar and non-reducing sugar has been reported to vary significantly among different clones of Nendran (Ram *et al.*, 1994 and Devi, 1996).

5.4.2 Effect of ecotypes of Nendran on fibre, starch, total caroteniods, peel thickness and shelf life

Except for fibre, all the other quality characters such as starch, total caroteniods, peel thickness and shelf life showed significant variation. Though fibre content did not show significant variation, mean values varied from 0.87 per cent in Attunendran to 1.17 per cent in Chenkal Local. Starch content was the highest in

Zanzibar followed by Mettupalayam Nendran and Kaliethan. The lowest starch content was observed in Attunendran. Total carotenoids were the highest in Changalikodan followed by Perumatti Nendran and Myndoli. Peel thickness which is a contributing factor towards shelf life was the highest for Zanzibar, Big Ebanga and Mettupalayam Nendran. So Big Ebanga had the longest shelf life followed by Zanzibar and Mettupalayam Nendran.

5.5 ORGANOLEPTIC ANALYSIS

Results of organoleptic analysis are discussed below. Analysis has shown that, flavor, taste, texture and overall acceptability varied significantly while appearance did not. The mean score for flavor (4.1), taste (4.8), texture (4.3) and overall acceptability (4.4) was the highest for Changalikodan. It was followed by Big Ebanga with mean score of 3.9 for flavor, 4.3 for taste, 3.9 for texture and 4.2 for overall acceptability. Though organoleptic scores for appearance did not vary significantly, mean score ranged from 3.6 in Perumatti Nendran to 4.3 in Changalikodan and Chenkal Local.

5.6 CLONAL CHARACTERS

5.6.1 Effect of ecotypes of Nendran on clonal characters

The present investigation has revealed that clonal characters varied significantly among the ten ecotypes. Bunch shape index was the highest for Chenkal Local (0.57) followed by Kaliethan (0.55) and Big Ebanga (0.53). These clones with high bunch shape index exhibited overall attractive bunches.

Openness of bunch varied from 4.95 in Myndoli to 8.10 in Chenkal Local. The highest openness of bunch was recorded in Chenkal Local followed by Attunendran and Kaliethan. Different environmental conditions affect the openness or compactness of the bunch by altering finger placement and length of internodes (Stover and Simmonds, 1987).

Fullness index was the highest in Big Ebanga (8.46) followed by Zanzibar (7.56) and Chenkal Local (7.46). Fullness index was high for ecotypes which had good finger characteristics like higher length, girth and weight of finger, which

ultimately contributed to fullness of finger. In Nendran fullness index of individual fruit is critical in deciding the overall acceptability.

Fruit curvature varied significantly and the highest fruit curvature was obtained in Big Ebanga (1.46) followed by Myndoli (1.32) and Chenkal Local (1.26). Changalikodan which is considered as a clone with attractive bunches, among the Nendran clones, had moreover straight fingers as indicated by low fruit curvature of 1.16. Clones like Big Ebanga and Myndoli, however had significantly high fruit length, compensating the high value of fruit curvature.

PSI (Pedicel Strength Index) was the highest in Mettupalayam Nendran (3.17) which was significantly higher than all other clones. It was followed by Chenkal Local (2.68) and Myndoli (2.61). PSI is an important character in deciding the retention of fingers in the bunch.

Length/weight ratio of finger was the highest in Nedunendran (0.19) which was significantly higher from all other ecotypes. Fingers of Nedunendran recorded significantly lower values for weight of finger, due to which length/weight ratio was the highest. Clones like Myndoli (0.17), Perumatti Nendran (0.16), Attunendran, Changalikodan, Kaliethan, Chenkal Local and Mettupalayam Nendran (each with 0.15) were on par.

Clones Big Ebanga and Kaliethan had more round, full and attractive fingers with few ridges compared to other ecotypes. However, difference in number of ridges between the treatments was not statistically significant with mean value ranging from 3.66 to 4.66.

5.7 GENETIC PARAMETERS

5.7.1 Coefficient of variation, heritability and genetic advance

Genetic parameters such as genotypic and phenotypic coefficients of variation, genetic gain and heritability were studied for biometric and yield characters. The results of these genetic parameters are discussed below;

Amount of genetic variability present in a population for the desired characters determine the success of conventional genetic improvement programmes.

The range of variability present in a crop is presented by the genotypic coefficient of variation and helps a breeder to compare the amount of variability that exists among different characters. The relative value of these types of coefficients gives an idea about the magnitude of variability present in a genetic population. The result of interaction between genotype and environment is the phenotypic expression of the character.

The present study revealed close association between estimates of PCV and GCV. High GCV and PCV were obtained for number of fingers, bunch weight and number of hands. For most of the characters GCV and PCV were closely corresponding to each other. Moderate PCV and GCV values were recorded for number of suckers, length of finger and length of bunch and total crop duration. However, characters like girth, plant height and number of leaves showed low PCV and GCV values. According to Rajamanickam (2003) highest PCV and GCV was obtained for fingers/bunch and weight of finger. Rajeevan and Geetha (1984) recorded high GCV and PCV values for bunch weight, number of fingers, number of hands and weight of finger in a study with forty banana cultivars. Similar reports were made by Rekha and Prasad (1993) and Uma *et al.* (1999) in banana.

Heritability governs the resemblance between parents and their progeny and suggests the relative role of genetic factors in expression of phenotypes. It also acts as an index of transmissibility of a particular trait to its offspring. Heritability in broad sense refers to the proportion of genotypic variance to the total observed variance in the total population. Traits with high heritability indicate that the characters under study are less influenced by environment. Using simple selection procedures these characters with high heritability could be improved (Johnson *et al.*, 1955). All these information on genetic variation, heritability and genetic advance helps to predict the percentage of genetic gain that could be obtained in later generations. Genetic advance refers to the expected genetic gain or improvement in the next generation by selecting superior individuals under certain amount of selection pressure. Heritability and genetic advance are the important genetic parameters for selecting a genotype

that permit greater effectiveness of selection by separating out environmental influence from total variability.

High heritability (in broad sense) estimates was obtained for most of the characters under study viz., length of finger, number of finger, number of hands, bunch weight, total crop duration, length of bunch, girth of finger, girth of pseudostem, plant height and number of suckers. Medium heritability was recorded for only one character, which is number of leaves. Rajamanickam (2003) observed high heritability for characters like plant height, suckers per plant, fingers/bunch, bunch weight, length of finger, girth of finger, length of bunch and days from flowering to shooting. The results of the present studies are in agreement with the findings of Rosamma and Namboodiri (1990) and Uma *et al.* (1999). High genetic gain was observed for characters like number of fingers, bunch weight, number of hands, length of finger, length of bunch, number of suckers and total crop duration. Low genetic gain was observed for number of leaves and girth of finger and moderate genetic gain for characters like plant height and girth of pseudostem. The high genetic advance obtained for number of fingers in the present study is in agreement with the findings of Rajamanickam (2003).

In the present investigation, influence of environment is negligible as most of the characters had high heritability. The traits with high heritability coupled with high genetic advance indicate that these traits are controlled by additive gene action which makes selection very effective (Sharma *et al.*, 2010). So characters like number of fingers and bunch weight with high heritability coupled with high genetic gain can be used for selection.

5.7.2 Correlation coefficient analysis

Association of plant characters with yield should be understood thoroughly for the success of crop improvement programmes. Correlation estimates provide information on the nature and magnitude of association between yield and its component characters. Thus, correlation analysis helps to design selection strategies to improve yield. In the present study, correlation studies were done for certain yield,

clonal and biometric characters. It was found that genotypic correlations were high as compared to their phenotypic correlations.

Phenotypic correlation coefficients show highly significant positive correlation of bunch weight with number of fingers, PSI, girth of plant, total crop duration, number of hands and plant height. Highly positive and significant association of bunch yield with number of fingers is in conformity with the reports of Rosamma and Namboodiri (1990) and George (1994). Positive and significant phenotypic correlation of plant height with bunch yield as seen in the present study was earlier reported by Sunilkumar (1997).Weight of finger had significant and positive correlation with fullness index, girth of finger, height, fruit curvature and girth of plant. Plant height had significant positive correlation with girth of plant and PSI. Pseudostem girth was positively and significantly correlated with total crop duration and PSI. Genotypic correlation analysis exhibited the same trend as that of phenotypic correlation studies.

From the correlation studies, it can be concluded that yield can be improved by exercising selection for the characters, number of fingers, PSI, girth of plant, total crop duration, number of hands and plant height.

Summary

6. SUMMARY

The study entitled "Performance evaluation of ecotypes of banana (*Musa* AAB Plantain subgroup)" was undertaken in the Department of Pomology and Floriculture, College of Agriculture, Vellayani during April 2016 - May 2017 with the objective to characterize the various ecotypes of plantain with respect to clonal characteristics, biometric characters, yield potential and fruit quality. The performance of ten ecotypes of banana (*Musa* AAB plantain subgroup) was studied in detail and important findings are summarized below.

Evaluation studies revealed that the ecotypes differed significantly in most of the biometric characters except for plant spread. Among the different ecotypes, plant height at bunch emergence was the lowest in Attunendran, Perumatti Nendran and Nedunendran, while highest value for plant height was observed in Mettupalayam Nendran followed by Zanzibar and Big Ebanga. Number of functional leaves varied significantly and the highest number of functional leaves was recorded in Changalikodan followed by Attunendran and Zanzibar. Leaf production was lowest in Myndoli followed by Kaliethan and Chenkal Local. Girth of the plant did not vary significantly at three months after planting (3 MAP), but varied significantly at bunch emergence. The ecotypes Mettupalayam Nendran followed by Big Ebanga and Zanzibar had the highest pseudostem girth. The ecotypes Kaliethan, Chenkal Local and Nedunendran had comparatively lower girth. Number of suckers produced varied significantly among the ecotypes at harvest and more number of suckers was produced by Zanzibar, Big Ebanga, Attunendran and Mettupalayam Nendran. Sucker production was less in ecotypes like Nedunendran, Myndoli and Perumatti Nendran. Duration of vegetative phase, shoot-to-harvest and total crop duration varied significantly. The longest vegetative phase, shoot-to-harvest and total crop duration was observed in Myndoli. Perumatti Nendran had the shortest vegetative phase followed by Kaliethan and Chenkal Local. Shoot-to-harvest duration was the shortest

in Zanzibar followed by Big Ebanga and Changalikodan. The ecotype Perumatti Nendran had the shortest crop duration followed by Kaliethan and Chenkal Local.

All the physiological attributes studied significantly varied among the ecotypes. Phyllacron at 3 month after planting (MAP) was the highest in Attunendran followed by Big Ebanga and Mettupalayam Nendran and lowest in Nedunendran followed by Chenkal Local and Zanzibar. Leaf area varied significantly both at 3 MAP and at harvest. At 3 MAP leaf area was the highest in Changalikodan followed by Mettupalayam Nendran and Chenkal Local and the lowest in Perumatti Nendran. But, at harvest Big Ebanga had the highest leaf area and Perumatti Nendran had the lowest. At harvest, Leaf Area Index (LAI) was the highest in Mettupalayam Nendran followed by Zanzibar and Big Ebanga. The ecotypes Kaliethan followed by Perumatti Nendran and Chenkal Local had the lowest LAI. The highest LAD was observed in Mettupalayam Nendran followed by Myndoli. The lowest Leaf Area Duration (LAD) was observed in Perumatti Nendran followed by Kaliethan and Changalikodan.

Yield characters varied significantly among the ecotypes. The length of bunches was the highest in Mettupalayam Nendran and the lowest in Zanzibar. Mettupalayam Nendran had large bunch (17.94 kg) compared to all other clones. Kaliethan (8.13 kg) and Perumatti Nendran (8.27 kg) had the smallest bunches. Mettupalayam Nendran exhibited the largest (6.83) number of hands per bunch and Zanzibar the lowest (2.08). Number of fingers per bunch also showed the same trend. Mettupalayam Nendran had the largest number of fingers (92.92) and Zanzibar had the lowest (25.75).

Finger characteristics also varied significantly among the ecotypes. Zanzibar had the highest length (37.92 cm), girth (16.63 cm) and weight (268.17 g) of fingers. Shortest finger was observed in Changalikodan (25.79 cm). Girth was the lowest in Perumatti Nendran (14.27 cm) while Nedunendran recorded the lowest finger weight (141.17 g). Peel weight was the highest in Zanzibar (64.50) and the lowest in Nedunendran (32.67 g). Changalikodan recorded the highest pulp/peel ratio (3.85),

followed by Zanzibar (3.32) and Perumatti Nendran (3.30). The lowest pulp/peel ratio was found in Attunendran.

All the clonal characters studied varied significantly among the ecotypes, except for number of ridges. Bunch shape index was the highest in Chenkal Local and the lowest in Zanzibar. Chenkal Local recorded the highest openness of bunch while lowest was recorded in Myndoli. Fullness index was the highest in Big Ebanga and Zanzibar, while it was the lowest in Nedunendran. Maximum fruit curvature was recorded in Big Ebanga and the minimum in Changalikodan. Pedicel strength index was the highest in Mettupalayam Nendran and the lowest in Kaliethan. Nedunendran had the highest length/weight ratio and Big Ebanga the lowest.

Significant variation was observed among different accessions for qualitative parameters except for fibre content. TSS, TSS/acid ratio, reducing sugar, total sugar and total carotenoids were the highest in Changalikodan. TSS and TSS/acid ratio was the lowest in Big Ebanga. Acidity was the lowest in Changalikodan. Non-reducing sugar was the highest in Zanzibar. Zanzibar had the highest starch percentage of 24.07 and the least starch content was observed in Attunendran. Peel thickness and shelf life was the highest in Big Ebanga and lowest in Attunendran.

Organoleptic analysis revealed significant differences among the various ecotypes. The highest score for appearance was obtained for Changalikodan and Chenkal Local. The mean score for flavor, taste, texture and overall acceptability was the highest for Changalikodan.

Genetic parameters such as GCV (Genotypic Coefficients of Variation) and PCV (Phenotypic Coefficients of Variation) were studied for biometric and yield characteristics. The GCV and PCV were close to each other and exhibited the same trend. The highest estimate of phenotypic and genotypic coefficients of variation were recorded for number of fingers/bunch and bunch weight. Except girth of finger, plant height, number of leaves and girth of pseudostem all the other characters studied exhibited moderate to high PCV and GCV.

High to moderate heritability was exhibited by all the characters except number of leaves. All the characters other than number of leaves and girth of finger exhibited high genetic advance.

Correlation analysis indicated that most of the character combinations had higher genotypic correlation coefficients than phenotypic correlation coefficients. High positive and significant correlations were found between bunch weight and number of fingers, Pedicel strength index, girth of plant, number of hands, total crop duration and plant height. Weight of finger had significant positive correlation with height and girth of plant, girth of finger, fullness index and fruit curvature.

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Appendices

APPENDIX I

Weather data for the cropping period 23rd April to 8th May 2016 – Weekly average

Standard week	Temperature (°C)		Relative humidity (%)	Rain fall (mm)
	Maximum	Minimum		
17	35.2	26.9	82.5	0
18	35.7	26.0	82.5	21.3
19	34.8	24.8	87.3	11.9
20	32.5	24.1	88.9	55.5
21	33.1	24.7	83.1	24.3
22	32.7	24.8	83.3	0
23	31.5	25.1	89.9	48.0
24	31.1	23.4	90.4	19.8
25	31.5	24.4	88.8	9.7
26	31.3	24.2	87.5	14.6
27	32.4	25	84.6	14.0
28	31.3	24.3	87.3	11.9
29	31.8	24.7	85.4	0
30	31.1	24.6	87.7	12.9
31	31.2	24.9	84.3	6.0
32	32.3	25.2	82.0	1
33	31.8	24.5	84.8	4.8
34	31.9	25	83.5	10.4
35	31.7	24.5	84.2	2.0
36	31.5	24.4	84.5	0.2
37	31.9	24.5	83.1	0
38	32	24.7	84.5	2.6
39	31.9	24.7	82.7	0
40	31.7	24.3	82.5	0
41	31.6	24.3	83.3	0
42	32.1	24.3	81.0	12.0
43	31.5	24.1	83.6	0
44	31.9	24.4	86.4	15.0
45	32.0	24.2	84.2	0
46	31.7	24.0	84.9	2.0
47	32.2	24.2	88.8	5.1
48	32.0	23.4	85.7	24.0
49	31.5	23.8	86.3	3.9
50	31.6	23.1	83.7	1.0
51	32.5	23.9	84.2	0
52	33.6	23.7	84.3	18.8
1	32.7	22.5	83.3	0
2	32.8	22.8	84.5	0

APPENDIX- II

KERALA AGRICULTURAL UNIVERSITY

COLLEGE OF AGRICULTURE

DEPARTEMENT OF POMOLOGY AND FLORICULTURE

SCORE CARD FOR ORGANOLEPTIC EVALUATION

Name of Student : Annjoe V Joseph (2015-12-012)
Title of thesis : Performance evaluation of ecotypes of banana (*Musa* AAB Plantain subgroup)

PARTICULATES	**TREATMENTS**									
	T1	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**	**T8**	**T9**	**T10**
Taste										
Appearance										
Flavour										
Texture										
Overall acceptability										
Remarks, if any										

***Kindly indicate your rating between 1-5 (1 stands for poor and 5 stands for excellent)**

NAME:

SIGNATURE:

APPENDIX- III

COST OF CULTIVATION

Particulars	Quantity ha^{-1}	Rate	Amount (Rupees)
Land preparation			10,300
Planting material	2500 numbers	Rs. 15/ sucker	3,75,00/-
Cowdung	37500	Rs. 0.50/kg	18750/-
Fertilizers			
Urea	1032.60 kg	Rs. 8.00/ kg	8260/-
Rajphos	1437.50 kg	Rs. 10.00/ kg	14,375/-
MOP	1250.00 kg	Rs. 17.00/ kg	21,250/-
SOP	375.00 kg	Rs. 39.00/kg	14,625/-
Lime	2500 kg	Rs. 15/kg	37,500/-
Labour cost	400 numbers	Rs. 750/ labour	3,00,000/-
Total			462560/-

APPENDIX- IV

Economics of Cultivation

Treatments	Cost of cultivation ($Rs.\ ha^{-1}$)	Income ($Rs.\ ha^{-1}$) (Fruits : Rs. 40/kg Suckers: Rs.10/sucker)	Net profit ($Rs.\ ha^{-1}$)	B:C ratio
T1	465260/-	Fruits : 1113000/- Suckers :264500/- Total : 1377500/-	912240/-	2.96
T2	465260/-	Fruits : 1138000/- Suckers :275000/- Total : 1413000/-	947740/-	3.03
T3	465260/-	Fruits : 1069000/- Suckers : 223000/- Total : 1292000/-	826740/-	2.77
T4	465260/-	Fruits : 813000/- Sucker :237500/- Total : 1050500/-	585240/-	2.25
T5	465260/-	Fruits : 929000/- Sucker : 214500/- Total : 1143500/-	678240/-	2.45
T6	465260/-	Fruits : 1000000/- Suckers :187500/- Total : 1187500/-	722240/-	2.55
T7	465260/-	Fruits : 1442000/- Suckers :198000/- Total : 1640000/-	1174740/-	3.52
T8	465260/-	Fruits : 936000/- Suckers : 304250/- Total : 1240250/-	774990/-	2.66
T9	465260/-	Fruits : 827000/- Suckers : 204250/- Total : 1031250/-	565990/-	2.21
T10	465260/-	Fruits : 1794000/- Suckers : 262500/- Total : 2056500/-	1591240/-	4.42

PERFORMANCE EVALUATION OF ECOTYPES OF BANANA (*Musa* AAB PLANTAIN SUBGROUP)

by

ANNJOE V JOSEPH

(2015-12-012)

Abstract of the thesis

Submitted in partial fulfilment of the

requirements for the degree of

MASTER OF SCIENCE IN HORTICULTURE

Faculty of Agriculture

Kerala Agricultural University

DEPARTMENT OF POMOLOGY AND FLORICULTURE

COLLEGE OF AGRICULTURE

VELLAYANI, THIRUVANANTHAPURAM-695522

KERALA, INDIA

2017

ABSTRACT

The study entitled "Performance evaluation of ecotypes of banana (*Musa* AAB Plantain subgroup)" was undertaken in the Department of Pomology and Floriculture, College of Agriculture, Vellayani during April 2016 - May 2017 with the objective to characterize the various ecotypes of plantain with respect to clonal characteristics, biometric characters, yield potential and fruit quality. Ten ecotypes of plantain collected from BRS, Kannara and farmers' field were maintained at the Instructional Farm, as per POP recommendations for irrigated Nendran in a Randomized Block Design (RBD) with three replications. These were evaluated based on biometric, physiological, yield, quality and clonal attributes.

Biometric characters studied varied significantly among the treatments. At three month after planting, Kaliethan (T_4) showed the maximum height and the lowest was shown by Attunendran (T_1). At bunch emergence, Mettupalayam Nendran (T_{10}) had the maximum height and the lowest for Attunendran (T_1). Girth and number of functional leaves at bunch emergence varied significantly, the highest value was observed in Mettupalayam Nendran (T_{10}) and Changalikodan (T_3) for girth and number of leaves respectively. Number of suckers, duration of vegetative phase, shoot-harvest duration and total crop duration had significant difference among clones. Highest number of suckers was found in Zanzibar (T_8). The vegetative phase (273.17 days), shoot-harvest (98.67 days) and total crop duration (371.83 days) was found to be the highest for Myndoli/Quintal banana (T_7). The shortest crop duration of 274.67 days was observed for Perumatti Nendran (T_9).

Among the physiological attributes, phyllacron, leaf area, leaf area index and leaf area duration varied significantly among clones.

In the yield characters studied, length of bunch (41.17 cm), bunch weight (17.94 kg), number of hands (6.83) and fingers (92.92) per bunch was found maximum for Mettupalayam Nendran (T_{10}). Among other yield characters related to

finger, such as length, girth and weight of finger and peel weight was found to be the highest for Zanzibar (T_8). But pulp/peel ratio was observed to be highest for Changalikodan (T_3). Highest benefit/cost ratio was recorded for Mettupalayam Nendran (T_{10}) (4.42) followed by Myndoli/Quintal banana (T_7) (3.52) and Big Ebanga (T_2) (3.03).

All the clonal attributes studied, varied significantly, except number of ridges. Bunch shape index and openness of bunch was the highest for Chenkal Local (T_5). Fullness index and fruit curvature was the highest for Big Ebanga (T_2).

Among the qualitative characters studied, all the treatments varied significantly for the characters studied, except for fibre content. Maximum TSS, TSS/acid ratio, reducing sugar, total sugar and total carotenoids were found to be the highest for Changalikodan (T_3). Sensory evaluation indicated that Changalikodan (T_3) obtained the highest score for overall acceptability.

Coefficient of variation was computed for some of the biometric and yield characters. Number of fingers exhibited the highest GCV (36.93 %) and PCV (37.04 %). Heritability was high for all the characters except girth of pseudostem. Genetic advance was high for all the characters except plant height, girth, number of leaves and girth of finger. The association analysis revealed that bunch weight was significantly and positively correlated with number of hands and fingers/bunch, pedicel strength index, height, girth and total crop duration both at genotypic and phenotypic levels.

The study revealed that considerable variability existed between the different ecotypes of banana. The ecotypes varied significantly with respect to all the clonal characters studied, except the number of ridges. Ecotype Mettupalayam Nendran (T_{10}) got high yield but it had long duration. It was followed by Myndoli (T_7) and Big Ebanga (T_2). Perumatti Nendran (T_9) had the shortest crop duration, followed by Kaliethan (T_4). Zanzibar (T_8) and Big Ebanga (T_2) were superior in terms of finger characteristics. Based on organoleptic parameters, Changalikodan (T_3) was found to

be the best followed by Big Ebanga (T_2). Characters like number of fingers and bunch weight with high heritability coupled with high genetic gain can be used for selection. The genotypes having high yield like Mettupalayam Nendran, Myndoli etc can be used in further crop improvement programmes to develop high yielding Nendran varieties.