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Morphological Characterization and Nutritional Analysis (Leaf and Pseudostem) of Selected Banana Varieties in Kerala: An Overview

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Abstract

Banana is an important fruit grown and consumed in tropics and sub tropic regions. It is the edible fruit usually seedless which can be grown in any climatic condition. It is rich in carbohydrates, fat, proteins, vitamins, minerals and water. A comparative study between 10 different Musa sp. in Kerala was conducted to study the various morphological characteristics. Each of the banana plant differ from each other on the basics of its height, length, colour, pseudostem, leaf, flower bud and fruit. The nutritional components such as moisture, crude protein, crude fibre, ether extract and total ash of pseudostem and leaf of selected varieties of Musa were analysed. For this pseudostem and leaf of 4 different varieties were selected and tested. The test was based on the AOAC method. The result shows that the crude fibre content of pseudostem and leaf is high with certain nutritive value.

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Keywords

Banana, Pseudostem, Crude protein, Crude ash, Morphological characterization.

Introduction

Banana belongs to Musaceae family. It is an edible fruit usually seedless (Wirakarnain *et al.,* 2008), is believed to have originated in Indo-Malaysian region. It is the national fruit of Central African Republic. Banana is known to be the fourth largest fruit in the world (INIBAP, 2000; Sathiamoorthy *et al.,* 2000). It is also grown as ornamental or for fibre. Banana is rich in carbohydrate, fat, protein, vitamins, minerals, water. It is not only a part of human diet but it is also used as a feed for domestic animals too (Morton, 1987) which can also grow in a wide variety of soil at any particular climatic condition. Babatunde (1992) states that all the parts are used to feed livestock.

Musa is distributed among the regions in the north from Nepal, southern China and in the south of Southern islands of Indonesia and New Guinea, Western limits in India etc. (Simmonds, 1956; De Langhe *et al.,* 2009; De Langhe and Maret, 1999). Banana is although considered as the one of the most important commercial crops in the world. To maintain high yields, nitrogen and potassium are required in large amounts, also it is referred as gross feeder (Mia *et al.,* 2010; Robinson, 1996; Abdullah *et al.,* 1999; Mahmood *et al.,* 2010; Singh, *et al.,* 2017).

The genomes of *Musa acuminata* and *Musa bulbiciana* contributes two different traits. These are the largest and widely distributed Musa sp. According to Simmonds &

shepherd (1955), *Musa acuminata* (AAA) are parthenocarpy and sterility whereas *Musa bulbiciana* (BBB) are hardiness, drought tolerance, disease resistance and starchiness. In Malaysia the most favoured banana type is AA diploid i.e. Mas banana, it also has a high demand for commercial planting (Wirakarnain *et al.,* 2008).

Banana fruit can be eaten as raw or can be cooked or processed into floor or can be fermented for the production of beverages (Morton, 1987; Nelson *et al.,* 2006; Edmeades, 2006; Pillay and Tripathi, 2007). Except from these, other parts like flower, core of pseudostem, leaf buds, corm etc. are cooked (Espino *et al.,* 1992; Nelson *et al.,* 2006). The leaves are used for many purposes like wrapping food, plates for serving food, thatching etc (Espino *et al.,* 1992; Nelson *et al.,* 2006). For making cloth string or rope fibres from pseudostem or leaves are used.

According to Espino *et al.,* (1992), temperature plays an important role in the successful production of commercial banana i.e. about approx. 27°C and if the temperature is below 15°C it produces poor fruit.

For the planting and harvesting of banana there are mainly seven different growth stages used by the growers to implement farm management practices it includes fertilization and the irrigation requirements. The seven stage are; 15 leaf stage, 25 leaf stage, bunch emergence, bract falls, half maturity, mature bunch, and post-harvest. The above-mentioned stages are known to be Banana Growth Cycle (Broadely *et al.,* 2004).

Objectives

The morphological characterisation and the nutritional analysis of different varieties are yet to be discovered. Based on this background the main objective of the study includes the identification of difference in terms of morphological character and nutritional constituents of selected varieties.

Scope of the study

The study would enlighten morphological and nutritional characters common banana varieties in Kerala which could be further explored.

Banana belongs to the family Musaceae; the term banana is derived from an Arabic word banana which means finger. It is the major food crop, which is grown and consumed in about 100 countries in the tropics and sub tropic region (INIBAP, 2000). According to Simmonds and Shepherd (1955), the most commonly cultivated sweet banana and its plantations belong to Musa, these are the triploid varieties of two wild diploid species.

The genomes of *M. acuminate* is denoted by AA and *M. balbisiana* is denoted by BB. Musa. The genomes of *Musa acuminata* and Musa balbisiana contributes two different traits. These are the largest and widely distributed Musa sp. According to Simmonds and Shepherd (1955), *M. acuminata* (AAA) are parthenocarpy and sterility whereas *M. balbisiana* (BBB) are hardiness, drought tolerance, disease resistance and starchiness. Paradisiaca is the hybrid formed from *M. acuminata* and *M. balbisiana* (Espino *et al.,* 1992). Both *M. acuminata* and *M. balbisiana* hybrids forms edible banana which is a mix of wild and cultivated species. According to Daniells *et al.,* (2087), *M. acuminata* is the most widely spread species of Musa.

The main part of the banana plant is its fruit. According to INIABP (2000), banana is the fourth largest fruit in the world. Banana fruit can be eaten as raw or can be cooked or processed into floor or can be fermented for the production of beverages (Morton, 1987; Nelson *et al.,* 2006; Edmeades *et al.,* 2006; Pillay and Tripathi, 2007).

Except from these, other parts like flower, core of pseudostem, leaf buds, corm etc. are cooked (Espino *et al.,* 1992; Nelson *et al.,* 2006; De Langhe *et al.,* 2009). The leaves are used for many purposes like wrapping food, plates for serving food, thatching etc. (Espino *et al.,* 1992; Nelson *et al.,* 2006). For making cloth string or rope fibres from pseudostem or leaves are used. Babatunde (1992) states that all parts of banana are used to feed stock. Some of the banana plant that produce reddish violet sap are used as due or ink (Nelson *et al.,* 2006; Pillay and Tripthi, 2007).

Various varieties of banana or other different parts of banana possess medicinal properties. The mouth trash in children and skin warts can be treated with root sap and the banana peel which has an antibiotic property is used to treat various diseases (Nelson *et al.,* 2006).

According to Daniells and O'Farrel (2004), the banana can be planted either in a single row or in a double row. For the planting and harvesting of banana there are mainly seven different growth stages used by the

growers to implement farm management practices it includes fertilization and the irrigation requirements.

To produce high yields of good fruits banana plants, require high amounts of potassium and nitrogen (Broadely *et al.,* 2004), these nutrients are applied individually i.e. nitrogen can be supplied in every month except during winter season; potassium can be supplied during June, march, September and phosphorous supplied during the month June. The effective way of applying nutrients to crop is fertigation method (Broadely *et al.,* 2004).

Musa (Banana)

The bispecific origin of edible banana first mentioned by Kurz (1867) and experimentally proved by Simmonds and Shepherd (1955) by cross the two parent varieties; *Musa acuminate* and *Musa balbisiana*. Supported by morphological and cytological evidences, it was assumed that the edible bananas were evolved from the two ancestors in five main stages. The triploids were formed by the fertilization of diploid egg cell with haploid pollen leads to the formation of triploids as a main step in the banana evolution process. The triploids were popular among farmers and breeders due to many beneficial traits especially sturdiness, robustness and pulpiness. Parthenocarpy, sterility, polyploidy and vegetative propagation for perpetuation of useful traits has played a major role in the evolution of current banana varieties (Uma *et al.,* 2005a; Uma *et al.,* 2005b).

The generic name Musa is rooted in Sanskrit word Moca or may have derived from Arabic world Mauz, Mouz or Mauwz, which is used for banana (De Candolle, 1886; Nayar, 2010; Hakkinen *et al.,* 2009). The Arabic name for banana 'Mauz' is also mentioned in Rheede's 'Hortus Malabaricus'.

The earliest scientific classification of banana was made by the famous taxonomist Linnaeus in 1783. According to his classification, all dessert banana were known as *Musa sapientium*; which is sweet during ripening and consumed fresh. The name *Musa paradisiaca* was assigned to the plantain group which are cooked and consumed while starchy. These two apparent species are not species at all, but considered to be closely related interspecific triploids hybrids of the AAB group. The modern method of classifying edible bananas was devised by Simmonds and Shepherd (1955), most modern edible bananas originally come from two wild species, *Musa acuminate* Colla (A genome) and *Musa balbisiana* Colla (B genome). The classification proposed by Simmonds and Shepherd (1955) based on the relative contribution of the parent character to the constitution of the cultivar and to the ploidy or chromosome number of the cultivar. The original characters used by Simmonds and Shepherd (1955) were amended and updated by many taxonomists (Purseglove, 1972; Stover and Simmonds, 1987; Valmayor *et al.,* 2000).

By using 15 separate characters, with strong diagnostic differences between the two ancestors, the contribution of the two species could be clearly distinguished. For each character in which a cultivar agreed completely with wild acuminate, a score of 1 was given, and for each character in which the cultivar agreed with balbisiana, a score of 5 was given. The intermediate expression of the character were assigned as score of 2, 3 or 4, according to intensity.

Concerning ploidy, edible bananas belonging to the section Eumusa have 22, 33 or 44 chromosomes. The basic haploid number is 11, thus cultivars can only be diploid, triploid or tetraploid. Of the 200-300 clones which are thought to exist, more than half are triploids, with the remaining being mostly diploids. Tetraploid clones are very rare. The planted area of triploid bananas is more than 100 times greater than that of diploids. Triploids are hardier, more vigorous and easier to grow. Morphologically, triploids and tetraploids are larger and more robust than diploids. Also leaf thickness and cell size increases with increasing ploidy.

The scoring technique based on 15 plant characters allows for a range of total score from 15 (pure *Musa acuminate*) to 75 (pure *Musa balbisiana*). Scores in between would be based on the relative contribution of the two species plus the level of ploidy in the interspecific hybrid. Simmonds and Shepherd (1955) and Stover and Simmonds (1987) used the groups and scores to classify a range of edible bananas. Silayoi and Chomchalow (1987) classified 137 accessions in the Thai banana gene bank on the same basis. Recognizing some deficiencies, they later modified the classification.

The main difference between these two classification is the introduction of almost pure balbisiana clones in the Thai grouping, which did not appear in the original classification. Espino and Pimentel (1990) used isozyme technology to differentiate clones of pure acuminate, pure balbisiana and their hybrids from one another. They found broad bands of malate dehydrogenease activity

which were unique to pure balbisiana, and other bands which indicated an acuminate genome. They concluded that BB and BBB cultivars were unique and distinct from hybrid ABB clones. The cooking plantain Saba (BBB) is very close to pure balbisiana (73 to 75 points).

Taxonomical classification (*Musa acuminata*; banana)

Kingdom: Plantae-- planta, plantes, plants, vegetal

Subkingdom: Tracheobionta

Superdivision: Spermatophyta

Division: Magnolioophyta

Class: Liliopsida

Order: Zingiberidae

Family: Musaceae

Genus: Musa L

Species: *Musa acuminata*

Plant morphology

In the publications of Simmonds (1962); Barker and Steward (1962); Purseglove (1972); Morton (1987); Simmonds and Weatherup (1990); Espino *et al.,* (1992); Karamura and Karamura (1995); Rieger (2006); Pillay and Tripathi (2007); detailed morphological description of banana plant is provided.

Banana plant is a perennial monocotyledon with an approximate height of about 2-9 m. The part above the ground is called pseudostem (false stem), which is composed of concentric layers of leaf sheath and the part below the ground is called corm (also known as true stem).

The meristem of apical bud initially gives rise to leave before it elongates to the pseudostem. Each pseudostem produces inflorescence only once. According to Barker and Steward (1962), leaves around the Musa gets tightly rolled from the centre of the pseudostem in a clockwise manner. The petiole is formed as the leaf sheath taper on the both sides. The can be erect, intermediate or dropping on the basics of the Musa sp.

According to Méndez *et al.,* (2003), the biochemical composition of the fruit depends on its cultivator, abiotic factors, like climate, method of cultivation and the nature of soil. The fruit contains high level of potassium whereas the level of vitamin A is low. Banana doesn't exist any toxic properties but it contains high levels of biogenic amines. The intake of high amount of banana can cause endomyocardial fibrosis (Foy and Parratt, 1960).

Scope of the study

The study would enlighten the nutritional content of various cultivated banana varieties (leaves and pesudostem) in Kerala and value addition which could be further explored.

Hypothesis

The current research work is based on the following hypothesis

1) The commonly cultivated banana varieties in Kerala shows a clear morphological difference among them.
2) The nutritional quality of the pseudostem and leaf of different commonly cultivated varieties also vary widely.
3) The nutritional parameters of the pseudostem is higher than the leaf among the selected cultivated varieties.

Materials and Methods

Study area

Kerala state covers an area of 38,863 km^2 with a population density of 859 per km^2 and spread across 14 districts. The climate is characterized by tropical wet and dry with average annual rainfall amounts to 2,817 ± 406 mm and mean annual temperature is 26.8°C (averages from 1871-2005; Krishnakumar *et al.,* 2009). Maximum rainfall occurs from June to September mainly due to South West Monsoon and temperatures are highest in May and November.

Sample Collection

Ten various cultivated banana varieties were identified based on a baseline survey and selected for morphological characterization and nutritional analysis from various districts across Kerala State, India. Mature pseudostem and leaves were collected from different varieties and were thoroughly cleaned using double distilled water. The samples were cut into small pieces and dried in hot air oven at 60ºC for 48 hrs, powdered using a kitchen blender (Prestige Nakshatra plus,

Prestige industries Mumbai) and later stored in air tight polyethylene zipper bag for analysis.

Morphological characterization

To study the morphological characteristics, samples of different varieties of Musa sp. were collected and were analysed. About approx. 30 different varieties of banana sp. were found in Kerala; among them the commonly seen varieties were selected from the nearby locality. 10 different Musa sp. were selected for its morphological study.

Morphological characterizations of banana were studied on the basics of Descriptors of Banana. The instruments used to collect data were, measuring scale, tape, weighing machine, camera, field book, etc were used. Parameters like colour, height, length, width, appearance, shape, curling, apex, orientation of bunch formation, size of pseudostem, leaves, inflorescence, fruit were noted and collected.

Botanical description

To Banana is an herbaceous plant which belong to Musaceae family, it is believed to be originated in the tropical region. It is a perennial herb with leaf sheaths that forms a trunk like pseudostem. About 8-12 number of leaves with an average length of 7 ft. after a 9-12 months of planting the true stem produces the inflorescence. Around the main axis flowers are formed spirally. After the appearance of flowers the fruit get matured for about 60-90 days. These bunch can harvest when the fingers change it colour to light green.

About 20-30 °C is the optimum temperature is required for the ripening of banana, as the frit ripens the sugar content increases based on the species whereas its starch content decreases.

Diseases like Panama wilt-fungus, Black leaf streak-fungus, Cigar-end diseases-fungi, and Nematodes-burrowing are commonly seen in banana whereas it is also affected by the pests like Oriental fruit fly, Spiralling whitefly, Banana skipper and Mealybug.

Varieties selected

Kindle Vazha (N1) Musax paradisiaca(AAB)

This variety attains an average height of about approximately 3m with slender pseudostem aspect. The average number of fruits in its mid hand is about 15 and the fruit colour changes from green to light green at the time of maturity. The fruits are long with thick peel. These fruits are mostly used by cooking.

Nendran (N2) Musa x paradisiaca (AAB)

It is the one of the most commonly cultivated and largely grown variety, also known as Ethavazha. These fruits are mostly eaten as ripe, raw or used as vegetable in the mature unripen condition. Pseudostem of this specific variety possess a colouration. Each bunch may weigh up to 12-15 kg. The fruits are usually large, long, thick, peels are thick and leathery. These fruits remain starchy even on ripening. It is highly susceptible to Banana Bract Mosaic Virus (BBMV), nematodes, and borers

Poovan (N3) Musa x paradisiaca (AAB)

It is a leading cultivar which is grown throughout the country. Produced year round in large quantities. Usually this is tall and vigorous. Fruits are medium in size with pronounced nipple, which weigh up to 25 kg, it turns to attractive golden yellow on ripening. It is highly susceptible to Banana Bract Mosaic Virus (BBMV) and Banana Streak Virus (BSV). It also possess some medicinal properties.

Njali Poovan (N4) Musa acuminate Colla (AB)

Due to its fruit quality it has a high demand among consumers. Fruits of this specific variety which is small are used more than the raw ones, it is very sweet and soft within the peel. It has the poor keeping quality and it falls off bunches. Usually it is cultivated as intercrops between coconut gardens. Soft leaves of this variety are commonly used as plates. It is less susceptible to most of the pests and diseases.

Robusta (N5) Musa acuminate Colla (AAA)

It is an important commercial variety of banana cultivated for fruit. It is a semi tall variety also known as Morris. It have slightly thicker and more rigid bunch stalk and produces heavy yield. The fruit turns to bright yellow from dark green, it is very sweet with a good aroma. These fruits are usually eaten raw. Each bunch weighs about 25-30 kg. Fruit has a poor keeping quality leading to a quick breakdown of pulp after ripening, hence not suited for long distance transportation. It is highly susceptible to Sigatoka Leaf Spot disease.

Chemkadali (N6) Musa acuminate Colla (AAA)

Red banana is the most relished and highly prized variety of Kerala. It is also known as red banana is a great source of fibre. The colour of the pseudostem, petiole, midrib and fruit rind are purplish red. These are soft and sweeter than as compared to the other. It is a robust plant with bunches weighing 20-30 kg. The average number of fruits in its mid hand is about 10. Fruits are sweet, orange yellow coloured and with a pleasant aroma. It is highly susceptible to bunchy top, fusarium wilt and nematodes. Although, most of the varieties in Kerala has yellow skin Chempoovan (red banana) has a reddish maroon colour which tastes entirely different from small banana types. It has many hybrid varieties and its skin colour varies from light maroon to dark maroon or reddish.

Palayamkodan (N7) Musa x paradisiaca (AAB)

It is the most widely cultivated banana variety in Kerala, and can be grown at any particular climatic condition, which is cultivated for both fruit and vegetable purpose. This variety is adjusted as the suitable cultivar of banana for intercropping in coconut gardens. The fruit is usually small or medium with yellow skinned. It has a good shelf quality. It is a sweet variety of banana and the cheapest of all forms of banana. This variety is also known as Mysore Poovan. The average height of the plant is about 2-6m and the number of the fruits in its mid hand is about10-12. It is a small, blunt tipped, round fruit. The peel colour varies from green to yellow and is susceptible to bunchy top and is resistant to panama wilt.

Attukannan (N8) Musa x paradisiaca (ABB)

This is also known as Charapoovan or Charakannan. The plant is tall with a strong pseudostem. The fruit peel possess a greyish green colour at the time of maturity and a greyish yellow colour at time ripening. The fruit seeds are visible with an average size of 0.02mmandcan be grown as an intercrop.

Sundari (N9) Musa acuminate Colla (AA)

It is a type that look likes fingers in shape; the fruit colour changes from green to light yellow at the of maturity. This fruit is not so sweet as compared to the other varieties. The height of the plant is about 2.8 m with slender pseudostem aspect. The average number of fruits in its mid hand is about 15. The fruit shape is curved in S shape.

Kali (N10) Musa x paradisiaca (AAB)

This variety attains an average height of 3.8m, with normal pseudostem aspect. The number of fruits on its mid hand is 13. The fruit colour changes from dark green to green at the maturity period.

Proximate analysis

The powdered banana samples were subjected various proximate analysis using standard protocols. The analysis includes estimation of dry matter and moisture content, estimation of crude protein, estimation of crude ash and insoluble ash, crude fat and determination of dietary fibre.

Estimation of dry matter and moisture

The dry matter (DM) is calculated using oven dry methods where fresh samples were kept hot air oven at 85°C for 48 hrs. The values are calculated based on the initial and final weight of the samples using the equation given below

$$\% \text{ DM} = \frac{DM_1 X DM_2}{100}$$

Estimation of crude ash and insoluble ash

The weight of clean dry empty silica crucible is determined as 'W' gms approximately 3 gms of the dried powdered sample is weighed noting the exact weight of crucible + sample as W1. Ignite it in the muffle furnace at 600°C for 3 hrs, allow to cool overnight. Take the weight of silica crucible + crude ash as W2.

Digest the ash in the crucible with 25 ml of 5N HCl, boiling it for 10 minutes, cool, filter through Whatman no 42 ashless filter paper and make paper and crucible acid free.

Transfer the paper with residue to respective crucible. Dry in hot air oven and ignite in the muffle furnace at 600°C for 3 hrs. Cool overnight and take the weight of the crucible 'W3' gms, and acid insoluble ash is calculated as

$$\% \text{ crude ash (\% CA)} = \frac{W_2 - W}{W_1 - W} \text{ X } 100; \left[\frac{\text{Weight of ash}}{\text{Weight of sample}} \text{ X } 100\right]$$

$$\% \text{ acid insoluble ash} = \frac{\text{Weight of AIA}}{\text{Weight of sample}} \text{ X } 100$$

$$= \frac{W_3 - W}{W_1 - W} \text{ X } 100$$

Estimation of crude fat

The crude fat is done using solvent extraction with petroleum ether. The extraction is done on soxtec fat analyser. Clean dry aluminium cups marked appropriately are weighed W1.Dry powdered sample are weighed approximately 3 gms of sample, noting exact sample weight, W in marked thimbles. The thimbles are attached in correct order on the adaptors of soxtec extractor. 60 ml of petroleum ether is taken in the aluminium cups and assembled seeing that markings of thimble, cup and sample numbers tally. Condenser water supply is switched on. The heating bench is turned on using the 'power on' button on control unit of soxtec unit and when the temperature reaches 100°C, the thimbles are dipped into boiling ether and boiling cycle is done for 15 minutes. The thimbles are raised and rinsed with condensed ether in the rinsing cycle for 30 minutes. This is followed by 10 minutes of recovery cycle where pure unsaturated ether is collected back and recovered. The fat containing cups with residual ether is then dried in hot air at 100°C for 1hr, cooled in desiccators and weighed, W2 gms. The crude fat is calculated as

$$\text{Crude fat} = \frac{\text{Weight of fat}}{\text{Weight of sample}} \text{ X } 100$$

$$= \frac{W2 - W1}{W} \text{ X } 100$$

Estimation of crude fibre

The thimbles containing fat free extract from the forgoing estimation are dried in hot air oven at 50°C for overnight. Approximately 0.8 gms of fat free sample is weighed exactly 'W' gms into gooch crucibles provided with fibretec extraction assembly. They are set on the assembly and two digestions, acid & alkali digestions in 1.25% H2SO4 and 1.25% NaOH are done one after the other for 30 minutes. With draining of acid and alkali and flushing of hot distilled water done in between each digestion. The residue containing crucibles are removed, over dried at 60°C for overnight, weighed 'W1'gms.They are ashed at 600°C for 3 hours in muffle furnace overnight, cooled and weighed 'W2' gms.

Then % crude fibre = $\frac{\text{Weight of crude fibre}}{\text{Weight of fat free extract}}$ X 100

$$= \frac{(W_1 - W_2)}{W} \text{ X } 100$$

Estimation of crude protein

Estimation of crude protein consists of two parts: digestion and distillation. Weigh approximately 0.25 gm of dried powdered sample noting the exact weight, 'W' gms, into clean dry digestion tubes. Add approximately 1 gm of digestion mixture (potassium sulphate and copper sulphate, 9:1 by weight) into each tube. Add 12 ml of con. H_2SO_4 into each tube, place on the digester (Kjeltec) assembly and digest at 400°C for 11 to 12 hrs. Cool down to room temperature.

Place on distillation unit (Kjeltec) and set the program (water-70 ml, alkali-70 ml, receiver-30 ml, tube drain) and distil it with steam in the unit. The instrument estimates the crude protein on entering the weight of sample W as

$$\% \text{ crude protein} = \frac{\text{volume of 0.1N HCl x 0.0014 x 6.25 x 100}}{W}$$

Estimation of nitrogen free extract

NFE or soluble carbohydrate is calculated based on difference

NFE = Dry matter-(crude protein + crude fat+ crude ash + crude fibre)

NFE =100–(moisture + crude protein + crude fat + crude ash + crude fibre)

Statistical analysis

The results were analyzed and descriptive statistics were done using SPSS 12.0 (SPSS Inc., an IBM Company, Chicago, USA) and graphs were generated using Sigma Plot 7 (Systat Software Inc., Chicago, USA).

Results and Discussion

The present study was an attempt to know about the morphological characteristics and nutritional analysis (leaf and pseudostem) of selected banana varieties in Kerala. The morphological studies allows a better knowledge about the common varieties. Ten banana

varieties were studied which differ each other on the basics of height, length, colour of pseudostem, leaf, flower bud and fruit.

The varieties like Kindlevazha, Nendran, Poovan, Njalipoovan, Robusta, Chenkadali, Palayamkodan, Attukannan, Sundari, and Kaali were selected for the morphological study. The habitat of the pseudostem are of mainly 4 types like normal, slender, robust, tall and stout. The height of the plant shows a wide difference in which Chemkadali is the tallest and Poovan is the shortest among these varieties. The pseudostem colour varies from one another based on the varieties of Musa sp. that is mostly they are heavily marked with brown or black blotches whereas in other, it is predominantly green or yellowish green, often with black blotches in the upper part. The sap colour is watery in each variety except in the case of Chemkadali and Kaali it is milky. The leaf habitat can be of drooping, intermediate or erect with an asymmetric symmetry.

The length of the petiole differs from one another where the Chemkadali is the lengthiest and robust is the stout and the base of the petiole can be winged or not winged, clasping or not clasping. The margin colour of the petiole ranges from purple, pink or maroon etc.

The orientation of the inflorescence can be pendulous or sub horizontal with a peduncle with hairy or slightly hairy in appearance with the variation of colour from each variety. The bud shape can be lanceolate, intermediate, linear-lanceolate etc. with imbricate or slightly imbricate in nature.

The female bract shape is lanceolate except in Palayamkodan and kali and it is just opened in Robusta and Attukannan where the other variety behaves as reflexed and revolute. The female flower length ranges from 10-19 where it is too long in the case of Nendran.

The compound tepal of female flower posses' cream or creamy white with lobe colour yellow and the free tepal colour is white, creamy white or cream with purple tinge. The pale green, yellowish green, are the different ranges of the ovary colour with two number of rows of ovule per locule. The position of the rachis is falling vertically, at an angle, or in horizontal position. The bract scars are prominent in all varieties except in the case of Sundari which is scarcely prominent. In pseudostem, moisture content ranges from 7.32-15.44 in different varieties with high value of 15.44 in Poovan along with the highest ether extract (2), but contained the least crude protein content whereas as in all the other varieties the content remain the same. Crude fibre ranges from 18.25-37.09 with high value of 37.09 in Njalipoovan. The total ash content varies from the range of 10.83-29.42, with majority be in Kindle.

As that of pseudostem, in leaf the moisture content is high in Kindle with the value of about 10.16 that ranges from 4.43-10.16. In Njalipoovan the crude protein is high with the value of 10.05 and of the crude fibre value of 28.54. The ether extract content ranges from 3.86-6.37 with the high value of 6.37. The total ash content is high in Njalipoovan with 7.64 that ranges from 5.91-7.64.

Table.1 Different vernacular names of Musa paradisiacal around the globe and India.

Language	Names
Scientific names	*Musa paradisiaca*
Name in various global languages	
French	Bananier
German	Banane
English	Banana
Name in various Indian languages	
Sanskrit	Kadali
Hindi	Kela
Urdu	Bonana
Marathi	Kela
Kannada	Baale
Gujarati	Kelphool
Malayalam	Vazha
Tamil	Vazhai

Table.2 Classification of edible bananas.

Genomic group	Score	References
AA diploid	15-23	Simmonds and Shepherd (1955); Stover and Simmonds (1987)
AAA triploid	15-23	
AAB triploid	24-46	
AB diploid	49	
ABB triploid	59-63	
ABBB tetraploid	67	
AA/AAA	15-25	Silayoi and Chomchalow (1987)
AAB	26-46	
ABB	59-63	
ABBB	67-69	
BB/BBB	70-75	

Table.3 Important banana varieties cultivated in different states of India.

State	Varieties grown
Andhra Pradesh	Dwarf Cavendish, Robusta, Rasthali, Amritpant, Thellachakrakeli, KarpooraPoovan, Chakrakeli, Monthan and YenaguBontha
Assam	Jahaji (Dwarf Cavendish), ChiniChampa, Malbhog, Borjahaji (Robusta), Honda, Manjahaji, Chinia (Manohar), Kanchkol, Bhimkol, Jatikol, Digjowa, Kulpait, Bharat Moni
Bihar	Dwarf Cavendish, Alpon, Chinia , ChiniChampa, Malbhig, Muthia, Kothia , Gauria
Gujarat	Dwarf Cavendish, Lacatan, Harichal (Lokhandi), Gandevi Selection, Basrai, Robusta, G-9, Harichal, Shrimati
Jharkhand	Basrai, Singapuri
Karnataka	Dwarf Cavendish, Robusta, Rasthali, Poovan, Monthan, Elakkibale
Kerala	Nendran (Plantain), Palayankodan (Poovan), Rasthali, Monthan, Red Banana, Robusta
Madhya Pradesh	Basrai
Maharashtra	Dwarf Cavendish, Basrai, Robusta, Lal Velchi, Safed Velchi, RajeliNendran, Grand Naine, Shreemanti, Red Banana
Orissa	Dwarf Cavendish, Robusta, Champa, Patkapura (Rasthali)
Tamil Nadu	Virupakshi, Robusta, Rad Banana, Poovan, Rasthali, Nendran, Monthan, Karpuravalli, Sakkai, Peyan, Matti
West Bengal	Champa, Mortman , Dwarf Cavendish, Giant Governor, Kanthali, Singapuri

Table.4 Comparison of characters of Musa cultivars (1)

Name	Habitat	Pseudostem					Sap colour
		Height (cm)	Circumference at base (cm)	Colour	Underlying colour	Blotches at the tip	
Kindlevazha	Normal	250-300	43-67	Yellowish green	Green with purple pigmentation	Brown-black	Watery
Nendran	Normal	260-330	45-65	Yellowish green with black patches	Whitish green with purple blotches	Scattered dots (brown)	Watery
Poovan (Rasth)	Normal	170-200	45-63	Green to yellowish green with or without blackish patches	Whitish green with purple blotches	Sparse blotches (brown)	Watery
Njalipoovan	Slender	250-350	50-58	Yellowish green	Whitish green with slight purplish blotches	Scattered (black or blackish brownish)	Milky white
Robusta	Robust	180-240	48-55	Maroon with greyish yellow tinge	Yellowish green with reddish maroon pigmentation	Large & extensive (brown)	Watery
Chemkadali	Tall & stout	290-400	60-75	Brown purple	Purplish maroon	Large & extensive (black)	Milky white
Palayamkodan	Normal	240-320	47-69	Purplish maroon with yellowish green tinge	Yellowish green with purplish tinge	Large & extensive blotches (black)	Watery
Attukannan	Normal	260-320	46-62	Medium Green	Light green	Black blotches	watery
Sundari	Slender	140-280	28-33	Light green with blackish brown pigmentation	Light green with light pinkish pigmentation	Large and extensive (black)	Watery
Kaali(Vannan)	Tall	280-390	51-75	Yellowish green with brown patches	Green with pink tinge	Large and extensive blotches (black)	Milky white

Table.5 Comparison of characters of Musa cultivars (2)

Name	Leaf habitat	Lamina				Petiole			
		Size (cm)	Shape	Base	Symmetry	Length (cm)	Base	Canal	Margin colour
Kindlevazha	Drooping	180-230 x 58-69	Oblong	Both rounded	Asymmetric	30-45	Not winged & clasping	Straight with erect	pink
Nendran	Drooping	190-220 x 65-70	Oblong	One rounded and other pointed	Asymmetric	35-57	Not winged & clasping	Curved inwards	Pinkish purple or red
Poovan	Intermediate to drooping	156-240 x 42-68	Linear-lanceolate	One rounded and other pointed	Asymmetric	45-67	Not winged & clasping	Straight with erect	Light maroon
Njalipoovan	Intermediate	165-215 x 53-64	Oblanceolate	One rounded and other pointed	Asymmetric	60-75	Winged & clasping	Curved inwards	Purple
Robusta	Drooping	182-198 x 66-74	Elliptic	Both pointed	Asymmetric	17-25	Winged & not clasping	Open with spreading	Purple
Chemkadali	Drooping	270-390 x 80-92	Oblanceolate	Both auriculated& round	Asymmetric	65-80	Winged & clasping	Open with spreading	Purple
Palayamkodan	Drooping	176-230 x 68-85	Oblong-lanceolate	Both auriculated& rounded	Asymmetric	45-73	Not winged & clasping	Straight with erect	Purplish maroon
Attukannan	intermediate	285-300 x 58-69	Linear-lanceolate	One rounded & other pointed	Asymmetric	55-70	Winged & not clasping	Open with spreading	purple
Sundari	Erect	120-173 x 45-56	Oblong	One rounded and one pointed	Asymmetric	58-68	Winged & not clasping	Straight with erect	Purplish maroon
Kaali	Erect	180-230 x 55-77	Oblong-lanceolate	One rounded and other pointed	Asymmetric	45-73	Not winged & clasped	Open with spreading	Grey

Table.6 Comparison of characters of Musa cultivars (3)

Name	Inflorescence	Peduncle			Female bud	
		Length	Nature	Colour	Shape	Nature
Kindlevazha	Pendulous	42-55	Slightly hairy	Dull green	intermediate	Slightly imbricate
Nendran	Pendulus	45-60	Glabrous	Dull green	Linear-lanceolate	Slightly imbricate
Poovan	Sub-horizontal	47-58	Slightly pubescence	Dull green	Linear-lanceolate	Imbricate
Njalipoovan	Sub-horizontal	32-46	Slightly pubescence	Light green with maroon pigmentation	Lanceolate	Slightly imbricate
Robusta	Pendulus	45-54	Hairy	Dark green with blackish pigmentation	Linear-lanceolate	Slightly imbricate
Chemkadali	Pendulus	75-86	Hairy	Dark brownish purple	Lanceolate	Slightly imbricate
Palayamkodan	Pendulus	45-55	Slightly pubescence	Dark green with or without maroon pigmentation	Obovate-lanceolate	Imbricate
Attukannan	Sub-horizontal	34-45	hairy	Dark greenish black	lanceolate	imbricate
Sundari	Sub-horizontal	27-42	Slightly pubescence	Green with dark marking	Linear-lanceolate	Convolute
Kaali	Sub-horizontal	43-55	Slightly pubescence	Dark green	Obovate-lanceolate	Imbricate

Table.7 Comparison of characters of Musa cultivars (4).

Name	Female bract						
	Size (cm)	Shape	Colour-abaxial	Colour-adaxial	Colour fading	Apex	Bract behaviour
Kindlevazha	28.35 x 14-17	lanceolate	Dark maroon	Reddish maroon	No sign colour fading	Obtuse & split	Reflexed & revolute
Nendran	28-38 x 13-18	Lanceolate	Dark blackish purple with greenish yellow patches	Reddish maroon with yellowish patches towards margin	No sign of colour fading	Obtuse & split	Reflexed & revolute
Poovan	28-38 x 13-18	Lanceolate	Dark blackish maroon with or without yellowish green patches	Reddish maroon with yellowish patched towards margin	Fade towards base	Obtuse	Reflexed & revolute
Njalipoovan	27-36 x 14-20	Lanceolate	Dark maroon with or without light yellow patches	Reddish maroon	No sign of colour fading	Obtuse & split	Reflexed & revolute
Robusta	32-39 x 12-15	Lanceolate	Greenish yellow with purplish maroon base	Yellowish orange with reddish orange upper part and cream base	Fades towards base	Obtuse & split	Just open, not reflexed
Chemkadali	40-48 x 17-25	Lanceolate	Brownish purple with light yellowish fading towards base and margins	Reddish purple fades towards base	Fades towards base	Obtuse & split	Reflexed & revolute
Palayamkodan	25-36 x 15-24	Obovate-lanceolate	Dark maroon with or without light yellow patches	Brownish maroon with or without light yellow patches	No sigh of colour fadings	Obtuse	Reflexed & revolute
Attukannan	25-34 x 12-16	lanceolate	Dark blackish maroon	Reddish maroon	No sign of colour fading	Obtuse	Just opened
Sundari	22-31 x 11-12.5	Lanceolate	Purplish maroon with or without yellow stripes	Purplish maroon fades to cream towards base and margin	Fades towards base	Slightly pointed to intermediate	Reflexed & revolute
Kaali	27-35 x 19-24	Obovate-lanceolate	Dark marron	Maroon	No sign of colour fading	Intermediate to obtuse	Reflexed & revolute

Table.8 Comparison of characters of Musa cultivars (5)

Name	Female flower length (cm)	Compound tepal			Free tepal				
		Size (cm)	Colour	Lob colour	Size (cm)	Shape	Colour	Apex	Acumen (cm)
Kindlevazha	14-17	4.5-4.8 x 2.0-2.5	cream	yellow	3.4-3.7 x 3.0-3.3	ovate	white	Highly corrugated	0.5-0.6
Nendran	16-19	4.4-4.7 x 2.2-2.5	Cream	Yellowish orange	3.2-3.5 x 2.2-2.4	Ovate	White with yellow patches	Highly corrugated	0.6-0.9
Poovan	7-10	4.8-5.5 x 2.3-2.7	Creamy white with or without slight pink strands	Yellow	3.2-3.6 x 2.1-2.7	Oblong-lanceolate	White or creamy white	Highly corrugated	0.7-0.9
Njalipoovan	11.3-15.0	4.5-5.7 x 1.9-2.9	Creamy white with maroon tinge	Yellow	3.1-3.4 x 1.7-2.2	Lanceolate	White with purplish tinge	Highly corrugated	Not prominent
Robusta	12-13	3.8-4.2 x 1.8-2.2	Cream	Yellow	2.2-2.4 x 1.8-2.0	Ovate-oblong	White or creamy white	Highly corrugated	0.4-0.6
Chemkadali	13-17	5.8-6.6 x 2.3-2.6	Cream white with purplish maroon patched at base	Yellow with black patches	3.7-4.2 x 2.7-3.0	Lanceolate	Cream or white	Highly corrugated	0.4-0.6
Palayamkodan	10-12.5	3.9-4.9 x 1.9-2.5	Cream with maroon fleshy patches	Yellow	2.4-3.0 x 2.0-2.6	Ovate-obovate	Cream	Highly corrugated	0.4-0.6
Attukannan	10-14	4.2-5.5 x 1.5-2.3	cream	yellow	3.0-3.4 x 1.5-2.0	lanceolate	white	Highly corrugated	0.4-0.6
Sundari	8.5-11.5	4.0-4.6 x 1.5-2.1	Cream or creamy white	Yellow	2.0-2.6 x 1.4-2.1	Ovate-obovate	Cream or creamy white	Corrugated	0.2-0.5
Kaali	13-15	4.0-4.9 x 1.9-2.2	Cream with light maroon pigmentation	Yellow	2.4-2.8 x 1.9-2.2	Oblanceolate	White	Highly corrugated	0.3-0.5

Table.9 Comparison of characters of Musa cultivars (6)

Name	Staminode size (cm)	Ovary			Rachis			
		Length (cm)	Colour	Number of rows of ovule per locule	Position	Nature	Length @ fruit maturity (cm)	Bract scars
Kindlevazha	1.5-2.0	7.5-8.2	Pale green	two	Falling vertically	bare	45-62	prominent
Nendran	3.1-3.9	13.5-14.0	Pale green with slight purplish pedicel	Two	Falling vertically	Persistent male flowers and bracts	48-64	Prominent
Poovan	1.3-3.2	7.3-8.3	Light yellowish green	Two	Falling vertically	Bare	75-85	Prominent
Njalipoovan	1.7-3.8	7.3-10.2	Pale green with or without purple patches at base and tip	Two	Falling at an angle	Bare	78-86	Prominent
Robusta	1.7-2.2	7.8-8.8	Pale green	Two	Falling vertically with a curve	Bare	45-56	Prominent
Chemkadali	2.6-3.8	8.5-10.0	Yellowish green with purple tip	Two	Falling vertically	Few hands of persistent neutral flowers near fruit and rest bare	90-110	Prominent
Palayamkodan	1.4-2.2	7.4-9.0	Yellowish green	Two	Falling vertically	Bare	64-76	Prominent
Attukannan	2.0-2.6	6.8-8.6	Yellowish green	two	horizontal	bare	72-85	prominent
Sundari	1.4-2.9	6.2-7.5	Yellowish green	Two	Horizontal	Bare	35-51	Scarcely prominent
Kaali	2.1-2.5	8.0-9.5	Yellowish green	Two	Falling vertically	Bare	61-75	Prominent

Table.10 Comparison of characters of Musa cultivars (7)

Name	Male bud		Male bract				
	Shape	Nature	Size (cm)	Surface nature	Shape	Colour-abaxial	Colour-adaxial
Kindlevazha	Intermediate	Highly imbricate	15-20 x7.5-8.0	grooved	intermediate	Red-purple	Purplish maroon
Nendran	Lanceolate	Highly imbricate	24-29 x 13.0-14.8	Grooved	Lanceolate	Purplish maroon	Reddish maroon
Poovan	Lanceolate	Highly imbricate	18-23 x 11.5-13.5	Grooved	Lanceolate	Blackish maroon with black patches	Reddish maroon
Njalipoovan	Lanceolate	Highly imbricate	14.0-20.3 x 8.3-13.4	Slightly grooved	Lanceolate	Dark purplish maroon	Maroon
Robusta	Lanceolate	Slightly imbricate	20-23 x 9-13	Minutely grooved	Intermediate to lanceolate	Purplish maroon	Orange-red fades to cream towards base & margins and red tip
Chemkadali	Top shaped to intermediate	Convolute	20-25 x 15-17.5	Slightly grooved	Lanceolate to intermediate	Dark purplish maroon with violet tinge	Reddish maroon with cream base
Palayamkodan	Lanceolate to intermediate	Minutely imbricate	15.0-20.5 x 9.0-12.5	Grooved	Lanceolate to intermediate	Dark blackish maroon	Reddish maroon
Attukannan	Lanceolate	Slightly imbricate	20-24 x 7-9	Slightly grooved	lanceolate	Dark maroon	maroon
Sundari	Lanceolate	Convolute	16-19 x 8.5-10.0	Minutely grooved	Lanceolate to intermediate	Dark purplish red to pinkish maroon	Reddish maroon fades to cream towards
Kaali	Top shaped to intermediate	Slightly imbricate	16-20 x 10-13	Grooved	Intermediate to obovate	Dark maroon	Reddish maroon

Table.11 Comparison of characters of Musa cultivars (8).

Name	Male bract (cont.)				Male flowers		
	Colour fading	Apex	Bract behaviour	Nature	Numbers/bract	Predominant colour	Nature
Kindlevazha	No sign of colour fading	Obtuse	Reflexed & revolute	persistent	12-17	cream	persistent
Nendran	No sign of colour fading	Obtuse & split	Reflexed & revolute	Persistent	9-12	Cream	Persistent
Poovan	Fades towards base	Slightly pointed	Reflexed & revolute	Deciduous	10-16	Cream	Deciduous
Njalipoovan	No sign of colour fadings	Obtuse	Reflexed & revolute	Deciduous	13-19	Cream with purple fleshy	Deciduous
Robusta	Fades towards base	Obtuse & split	Just open	Deciduous	12-16	Cream	Deciduous
Chemkadali	Fades towards base	Slightly pointed	Reflexed & revolute	Deciduous	13-17	Cream with purple fleshy	Deciduous
Palayamkodan	No sign of colour fading	Intermediate to obtuse	Reflexed & revolute	Deciduous	13-18	Cream	Deciduous
Attukannan	No sign of colour fading	Slightly pointed	Just opened	deciduous	12-19	cream	deciduous
Sundari	Fades towards base	Intermediate to obtuse	Reflexed & revolute	Deciduous	14-20	Cream	Deciduous
Kaali	Fades toward base	Intermediate to obtuse	Reflexed & revolute	Deciduous	15-18	Cream	Deciduous

Table.12 Comparison of characters of Musa cultivars (9).

Name	Compound tepal			Free tepal				
	Size (cm)	Colour	Lobe colour	Size (cm)	Shape	Colour	Apex	Acumen (cm)
Kindlevazha	5.3-5.6 x 1.4 -1.8	Creamy white	yellow	2.5-3.0 x 1.4-1.6	lanceolate	white	Highly corrugated	0.4-0.5
Nendran	5.2-5.8 x 1.5-1.9	Cream	Yellow	3.0-3.3 x 2.6-2.8	Ovate & oblong	Cream	Highly corrugated	0.6-0.9
Poovan	5.2-5.8 x 1.5-2.0	Creamy white with maroon patches	Yellow	2.7-3.2 x 1.9-2.2	Linear-lanceolate	White or creamy white	Highly corrugated	0.3-0.4
Njalipoovan	4.8-5.8 x 1.3-1.9	Cream with purple fleshy	Yellow	2.6-3.0 x 1.3 – 1.9	Lanceolate	Cream with purple tinge	Highly corrugated	o.4-0.6
Robusta	3.4-3.7 x 1.3-1.6	Cream	Yellow	2.2-2.4 x 1.4-1.6	Oblong	Creamy white	Slightly corrugated	0.4-0.6
Chemkadali	5.8-6.5 x 2.0-2.5	Cream with purple fleshly & black pigmentation on the upper part	Yellow	3.8-4.2 x 2.4-2.8	Lanceolate	White or creamy white	Highly corrugated	0.5-0.7
Palayamkodan	4.8-5.2 x 1.1-1.5	Creamy white with or without maroon patches	Yellow	2.1-2.7 x 1.4-1.9	Lanceolate	White or creamy white	Slightly corrugated	0.1-0.3
Attukannan	4.2-5.4 x 1.6-1.8	cream	yellow	2.8-3.0 x 2.0-2.2	ovate	cream	corrugated	0.2-0.3
Sundari	4.4-5.0 x 1.3-1.4	Cream	Yellow	2.0-2.2 x 1.0-1.2	Obovate	White	Smooth	0.2-0.3
Kaali	4.7-5.2 x 1.1-1.5	Cream	Yellow	2.5-3.0 x 1.8-2.1	Ovate	White with light yellow base	Slightly corrugated	0.3-0.4

Table.13 Comparison of characters of Musa cultivars (10).

Name	Stamen						Ovary pigmentation
	Length (cm)	Filament length (cm)	Filament colour	Anther length (cm)	Anther colour	Thecae colour	
Kindlevazha	4.5-5.1	1.5-2.2	Light yellow	2.5-2.8	Creamy yellow	white	absent
Nendran	4.6-5.0	2.4-2.7	Cream	2.4-2.7	Cream	White	Absent
Poovan	4.3-5.0	2.0-2.4	White	2.2-2.5	Creamy white	Brown or black	Absent
Njalipoovan	4.8-5.5	2.5-3.5	Creamy whit	2-3	Cream	Brown or cream	Purple
Robusta	3.4-3.6	1.6-1.7	White	1.9-2.1	Cream	Gray	Absent
Chemkadali	5.5-6.0	3.0-3.3	White	2.5-2.7	White or creamy white	Brown	Reddish maroon
Palayamkodan	3.9-4.6	1.6-2.5	White or creamy white	1.9-2.5	Cream	Yellow or cream	Cream or purple
Attukannan	4.6-5.2	2.0-2.6	white	2.5-3.0	yellow	cream	absent
Sundari	4.0-4.4	1.6-1.8	White with cream base	2.3-2.5	Cream	Whitish gray	Absent
Kaali	4.5-4.9	2.5-2.8	White	2.0-2.3	Creamy white	Yellowish brown	Purple fadings

Table.14 Comparison of characters of Musa cultivars (11).

Name	Style nature	Stigma colour	Fruit bunch			Fruits	
			Appearance	Number of hands	Axis	Number on the mid hand	Pedicel length
Kindlevazha	straight	yellow	lax	6-8	pendulous	10-15	3.5-4.0
Nendran	Straight	Yellow	Lax	5-5	Pendulous	8-10	3.7-4.3
Poovan	Straight	Brownish yellow	Lax	5-8	Sub-horizontal	5-12	1.3-2.0
Njalipoovan	Straight	Pale yellow	Lax	6-10	Sub-horizontal	10-18	1.8-2.5
Robusta	Straight	Yellow	Compact	7-10	Pendulous	12-22	1.5-2.2
Chemkadali	Straight	Yellow	Compact	4-10	Pendulous	10-18	0.8-2.0
Palayamkodan	Curved at base	Yellow	Very compact	7-15	Pendulous	12-19	1.9-2.4
Attukannan	Straight	yellow	compact	6-10	Sub-horizontal	10-12	1.8-2.2
Sundari	Straight	Yellow	Compact	4-8	Sub-horizontal	11-18	0.8-2.0
Kaali	Straight	Yellow	Compact	7-10	Sub-horizontal	8-15	2.3-3.5

Table.15 Comparison of characters of Musa cultivars (12).

Name	Fruits (cont.)									
	Base	Fruit length (cm)	Circumference (cm)	Shape	Nature	C.S	Apex nature	Floral relicts	Mature peel colour	Ripened peel colour
Kindlevazha	No sign of fusion	16-20	13.5-18.0	Straight in distal part	Perpendicular to axis	Pronouncedly ridged	Lengthily pointed	Persistent floral relicts	Dark green	Light green
Nendran	No sign of fusion	20-27	14-18	Straight in the distal part	Perpendicular to the axis	Pronouncedly ridged	Lengthily pointed	Persistent floral relicts	Dark green	Brownish yellow with black markings
Poovan	Fused at base	9-15	9.0-12.5	Straight in the distal part	Slightly curved towards axis	Rounded	Blunt tipped	Absent	Dark green	Bright yellow
Njalipoovan	No sign of fusion	7.0-11.5	8-11	Curved	Curved back to axis	Slightly ridged	Bottle necked	Persistent floral relicts	Dark green	Bright green
Robusta	No sign of fusion	14-22	3-18	Curved	Curved back to axis	Slightly ridged	Pointed	Persistent floral relicts	Dark green	Dark green
Chemkadali	Fused at the base	14-17	14-21	Curved	Curved back to axis	Circular	Blunt tipped	Persistent floral relicts	Greenish purple	Purple
Palayamkodan	Fused at base	9.0-13.5	9-11	Straight	Perpendicular to axis	Slightly rigid	Bottle necked	Absent	Dark green	Bright yellow
Attukannan	No sign of fusion	9-14	8.5-9.2	curved	Slightly curved	Slightly ridged	Blunt tipped	absent	Ash coated green	Ash coated golden yellow
Sundari	No sign of fusion	13-19	8-12	Curved and S shaped	Negatively geotropic	Circular	Bottle necked	Absent	Dark green	Bright yellow
Kaali	Fused at base	12-15	10-14	Straight	Perpendicular to axis	Pronouncedly ridged	Bottle necked	Absent	Dark green	Greenish yellow

Table.16 Proximate analysis leaf and stem of Musa varieties (N1, N3, N4 and N7) in Kerala.

Sample	Moisture (%)	Crude protein (%)	Crude fibre (%)	Ether extract (%)	Total ash (%)	Gross energy (kcal/kg)
Kindleleaf (KL)	10.16 ± 0.34	9.59 ± 0.32	27.87 ± 0.28	3.86 ± 0.11	6.24 ± 0.24	3713 ± 121
Kindle stem (KS)	8.48 ± 0.22	6.55 ± 0.27	21.21 ± 0.21	1.53 ± 0.34	29.42 ± 0.34	2675 ± 58
Poovanleaf (PL)	7.25 ± 0.18	8.72 ± 23	28.53 ± 0.86	6.37 ± 0.22	6.63 ± 0.18	3936 ± 89
Poovanstem (PS)	15.44 ± 0.37	3.06 ± 0.35	18.25 ± 0.29	2.03 ± 0.32	10.83 ± 0.21	3109 ± 54
Najalipoovan leaf (NL)	4.43 ± 0.54	10.05 ± 0.46	28.54 ± 0.81	4.61 ± 0.17	7.64 ± 0.33	3934 ± 59
Najalipoovan stem (NS)	11.55 ± 0.88	6.55 ± 0.26	37.09 ± 0.39	1.99 ± 0.33	16.48 ± 0.11	3095 ± 75
Palayamkodan leaf (PaL)	7.66 ± 0.74	10.02 ± 0.21	27.79 ± 0.21	5.12 ± 0.45	5.91 ± 0.45	3902 ± 88
Palayamkodanstem (PaS)	7.32 ± 0.14	6.55 ± 0.19	23.08 ± 0.43	1.93 ± 0.35	22.03 ± 0.32	3039 ± 80

N1; Kindle, N3; Poovan, N4; Nalipoovan, N7; Palayamkodan
KL; Kindle leaf, KS; Kindle stem, PL; Poovan leaf, PS; Poovan stem; NL; Najalipoovan leaf, NS; Najalipoovan stem, PaL; Palayamkodan leaf, PaS; Palayamkodan stem.
Numbers represent means ± one standard error (SE) of the mean

Table.17 Proximate analysis leaf and stem of Musa varieties (N1, N3, N4 and N7) in Kerala.

Sample	Moisture content (%)	Organic matter* (g)	Organic carbon* (g)	Crude ash* (g)	Acid insoluble ash* (g)	Acid soluble ash* (g)
Kindle leaf (KL)	7.54 ± 0.34	2.25 ± 0.38	1.30 ± 0.28	0.75 ± 0.12	0.24 ± 0.22	0.51 ± 0.08
Kindle stem (KS)	5.55 ± 0.29	1.63 ± 0.21	0.94 ± 0.21	1.37 ± 0.31	0.29 ± 0.11	1.08 ± 0.18
Poovan leaf (PL)	5.19 ± 0.22	2.37 ± 0.27	1.37 ± 0.20	0.63 ± 0.12	0.17 ± 0.04	0.46 ± 0.05
Poovan stem (PS)	8.56 ± 0.12	2.19 ± 0.15	1.27 ± 0.46	0.91 ± 0.11	0.37 ± 0.12	0.54 ± 0.09
Najalipoovan leaf (NL)	7.17 ± 0.31	2.25 ± 0.31	1.30 ± 0.23	0.75 ± 0.31	0.18 ± 0.23	0.57 ± 0.11
Najalipoovan stem (NS)	7.67 ± 0.37	2.06 ± 0.35	1.19 ± 0.25	0.94 ± 0.12	0.35 ± 0.09	0.59 ± 0.08
Palayamkodan leaf (PaL)	7.52 ± 0.51	2.51 ± 0.40	1.45 ± 0.43	0.49 ± 0.13	0.16 ± 0.31	0.33 ± 0.01
Palayamkodan stem (PaS)	4.15 ± 0.18	2.12 ± 0.20	1.23 ± 0.33	0.88 ± 0.31	0.49 ± 0.10	0.39 ± 0.08

* Amount obtained for 3 g of dried plant samples
N1; Kindle, N3; Poovan, N4; Nalipoovan, N7; Palayamkodan
KL;Kindle leaf, KS; Kindle stem, PL; Poovan leaf, PS; Poovan stem; NL; Najalipoovan leaf, NS; Najalipoovan stem, PaL; Palayamkodan leaf, PaS; Palayamkodan stem.
Numbers represent means ± one standard error (SE) of the mean

Figure.1 Map of Kerala showing the sample collection point.

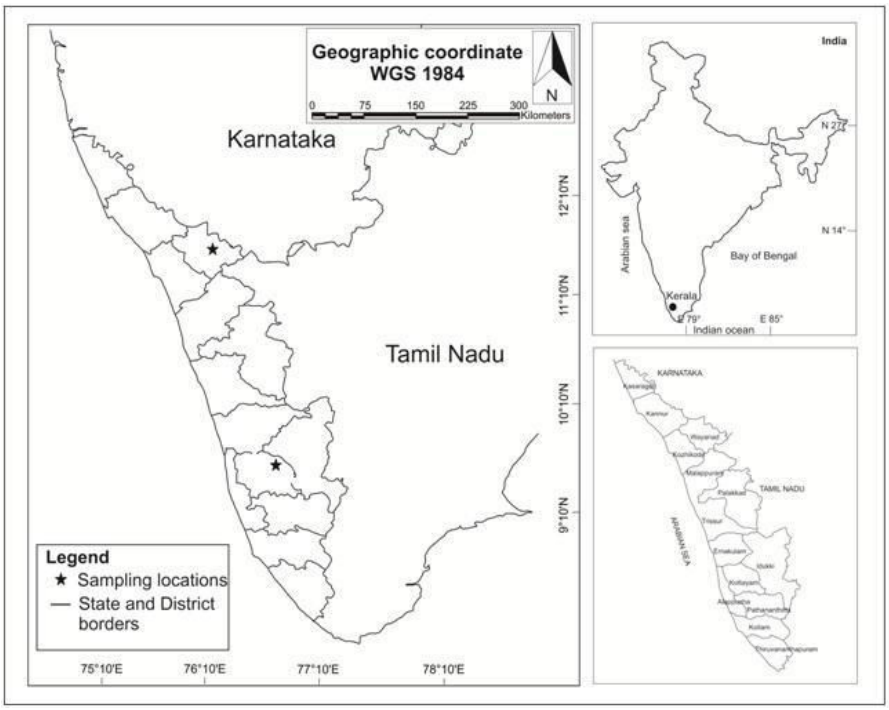


Figure.2 The evolution of the banana complex: A, *M. acuminata*; B, *M. balbisiana*. Genotypes known to occur naturally are encircled, those known only from experiment are not encircled (adopted from Simmonds and Shepherd, 1955).

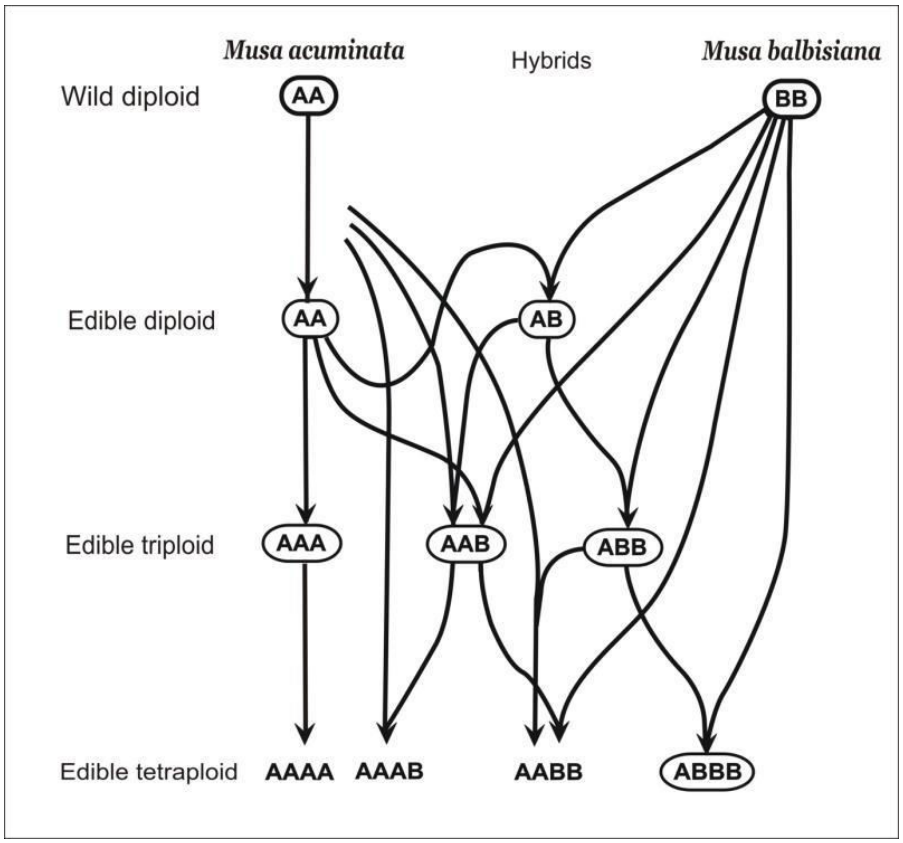


Figure.3 Description of pseudostem/suckers of banana. Modified after: IPGRI, 1984.

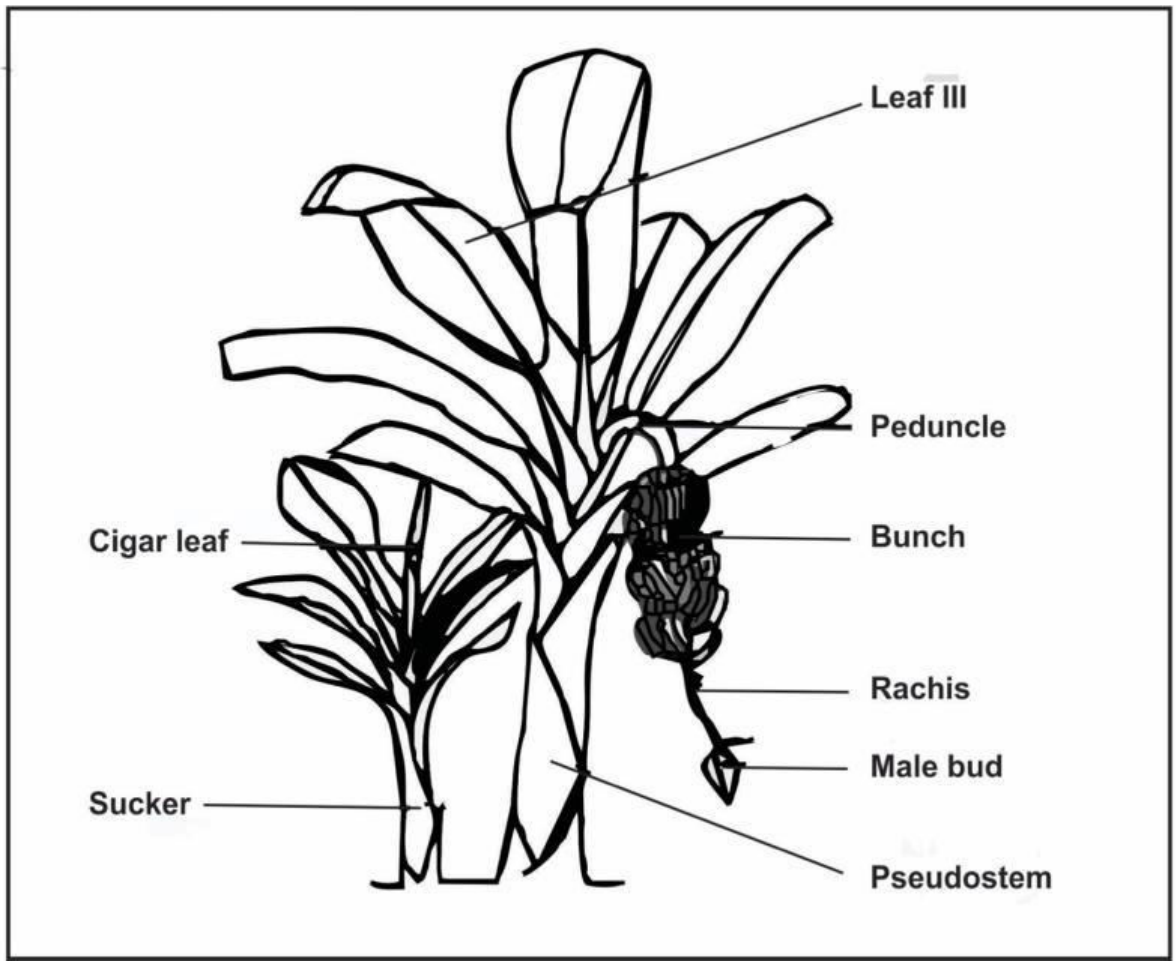


Figure.4 General morphology A) habitat (A1, suckers; A2, pseudostem; A3, petiole base; A4, inflorescence; A5, petiole; A6, leaf base; A7, 3rd leaf), B) inflorescence at early stages (B1, peduncle; B2, sterile bract; B3, female bud; B4, female flowers; B5, female bract), C) female flower (C1, ovary; C2, free tepal; C3, compound tepal; C4, stigma), D) compound tepal, E) free tepal, F) pistil with staminodes (F1, ovary; F2, staminodes; F3, style; F4, stigma), G) c.s of ovary, H) infructescence (H1, peduncle; H2, fruits; H3, rachis; H4, male bract; H5, male bud), I) male flower, J) rudimentary pistil with stamens (J1, rudimentary pistil; J2, stamens), K) fruit hand (K1, pedicel; K2, fruit; K3, fruit apex).

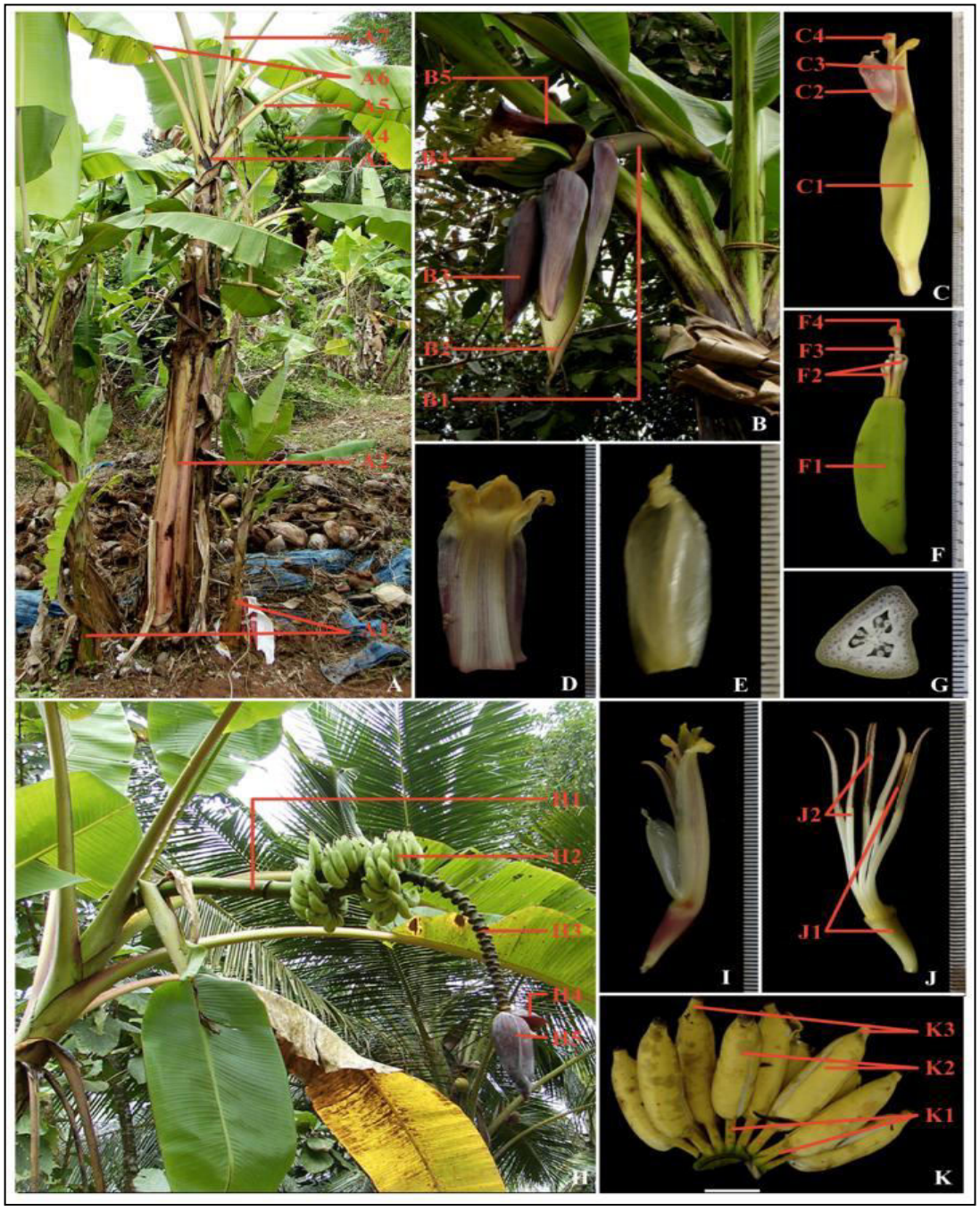


Figure.5 *Musa acuminate* Colla A) habitat, B) pseudostem coloration, C) inflorescence at early stage, D) leaf base, E) leaf apex, F) female flower, G) compound tepal, H) free tepal, I) pistil with staminodes, J) c.s of ovary, K) male bract abaxial surface, L) male flower, M) compound tepal, N) rudimentary pistil with stamens, O) ripened fruit hand, P) seeds.

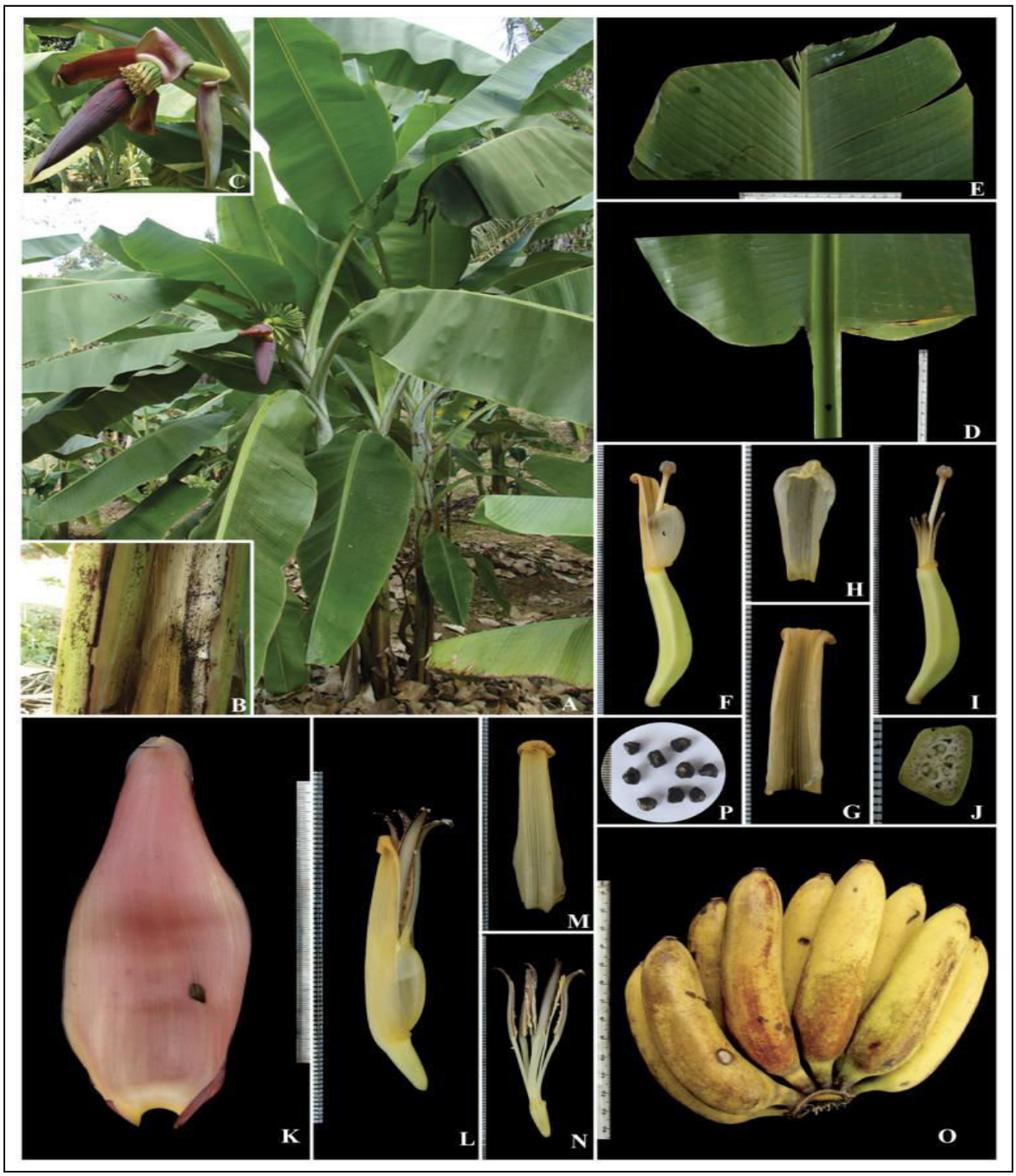


Figure.6 *Musa balbisiana* CollaA) habitat, B) infructescences with advanced stage of male bud, C) leaf base, D) leaf apex, E) female flower, F) compound tepal (female), G) free tepal (female), H) pistil with staminodes, I) c.s of ovary, J) male bract, K) female flower, L) compound tepal (male), M) free tepal (male), N) rudimentary pistil with stamen, O) ripened fruit hand, P) single fruit, Q) seeds.

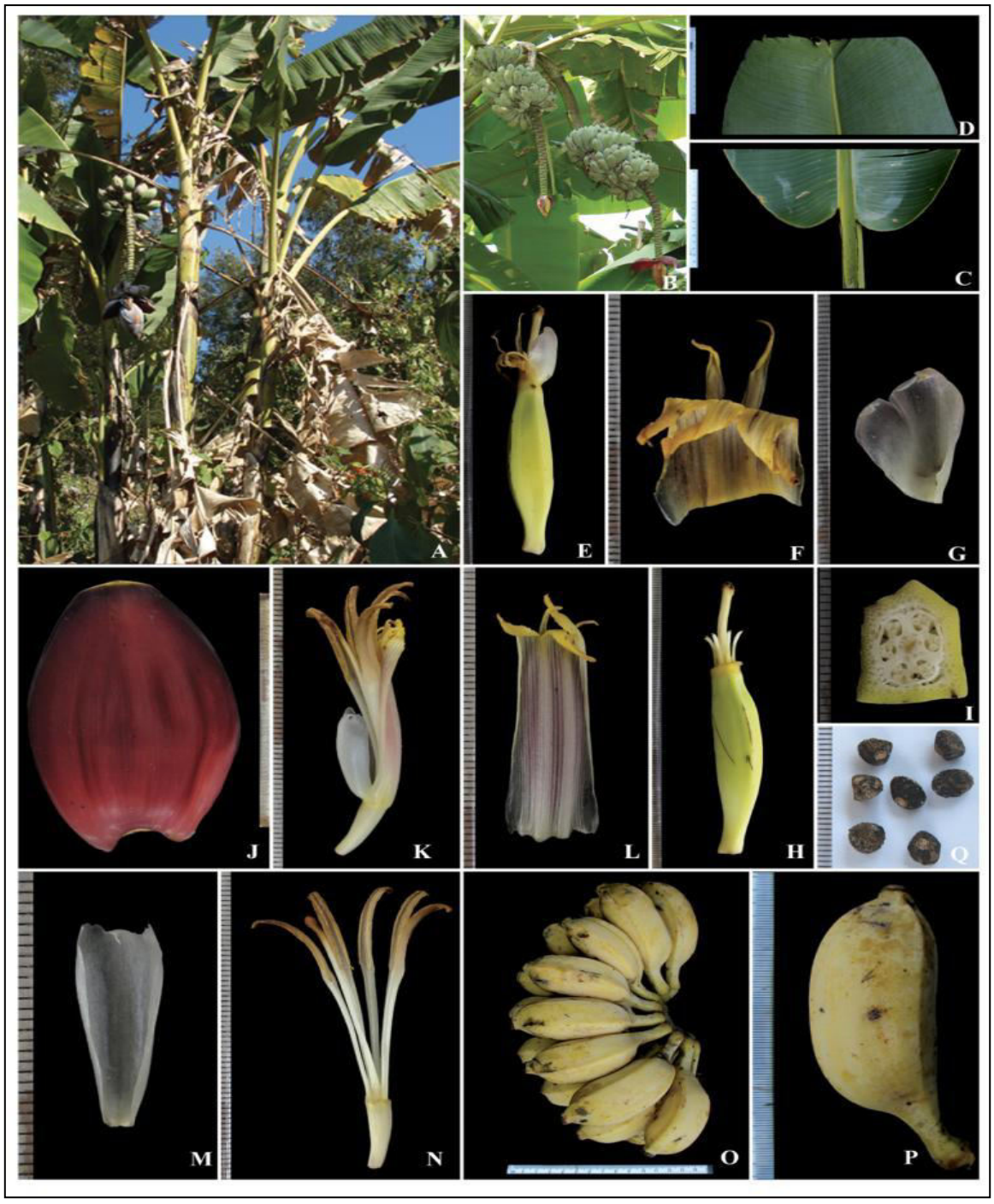


Figure.7 Important characters used in species and genome groups of edible banana. Modified after: IBPGR, 1984.

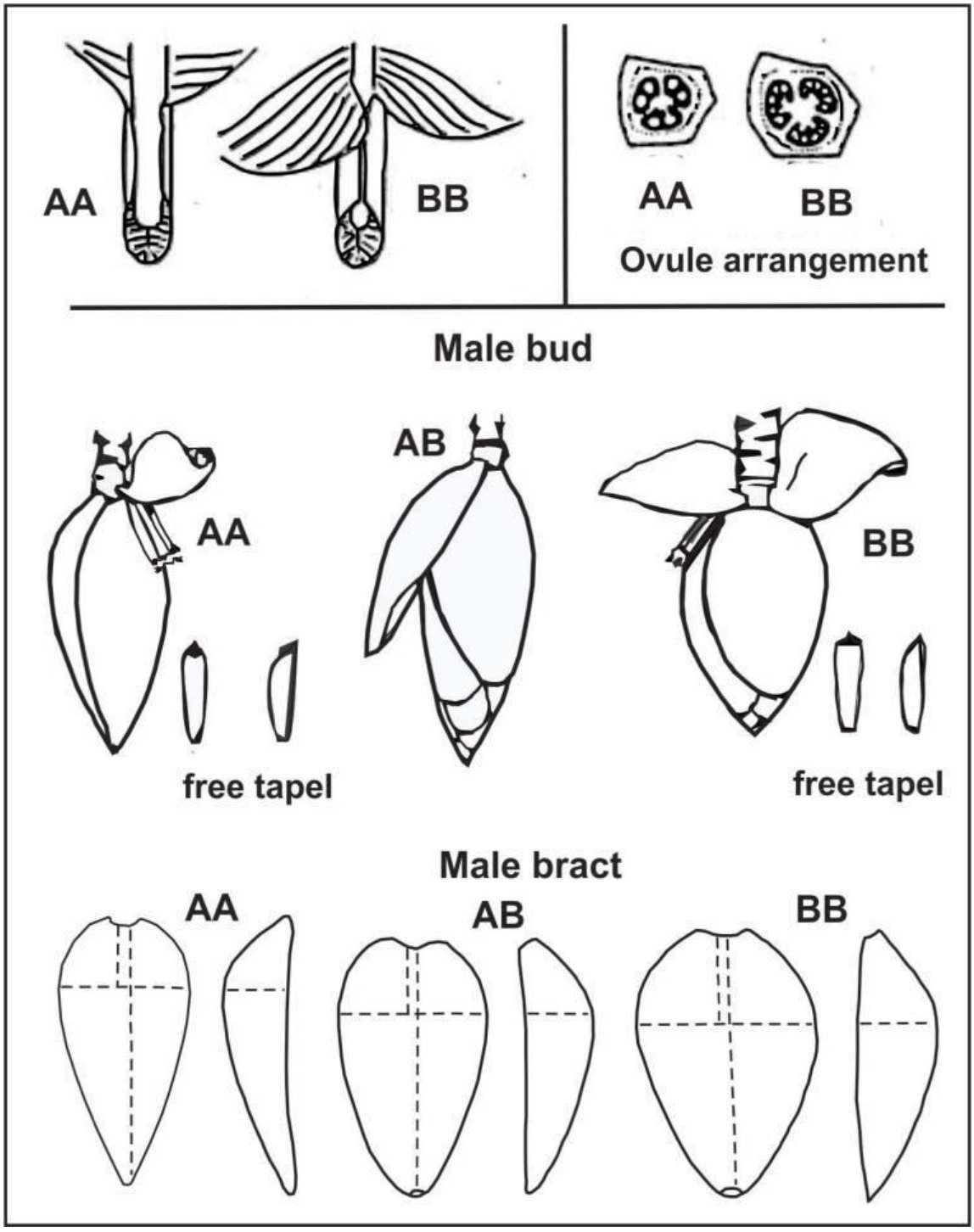


Figure.8 Different leaf habit of banana1)Erect, 2) Intermediate, 3) Drooping. Modified after: IPGRI, 1984.

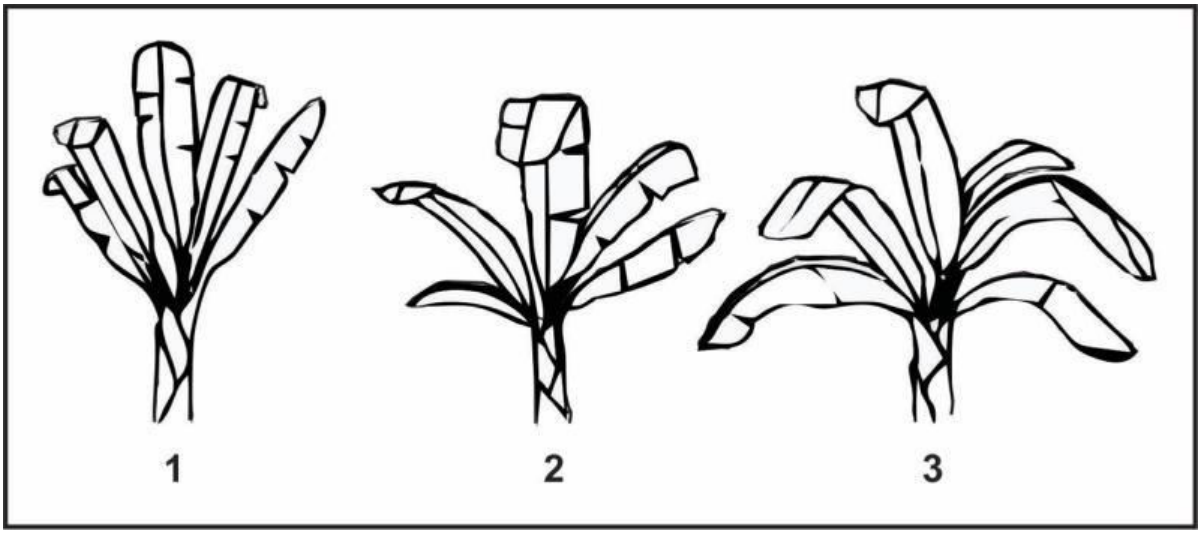


Figure.9 Petiole/midrib/leaf of banana. Modified after: IPGRI, 1984.

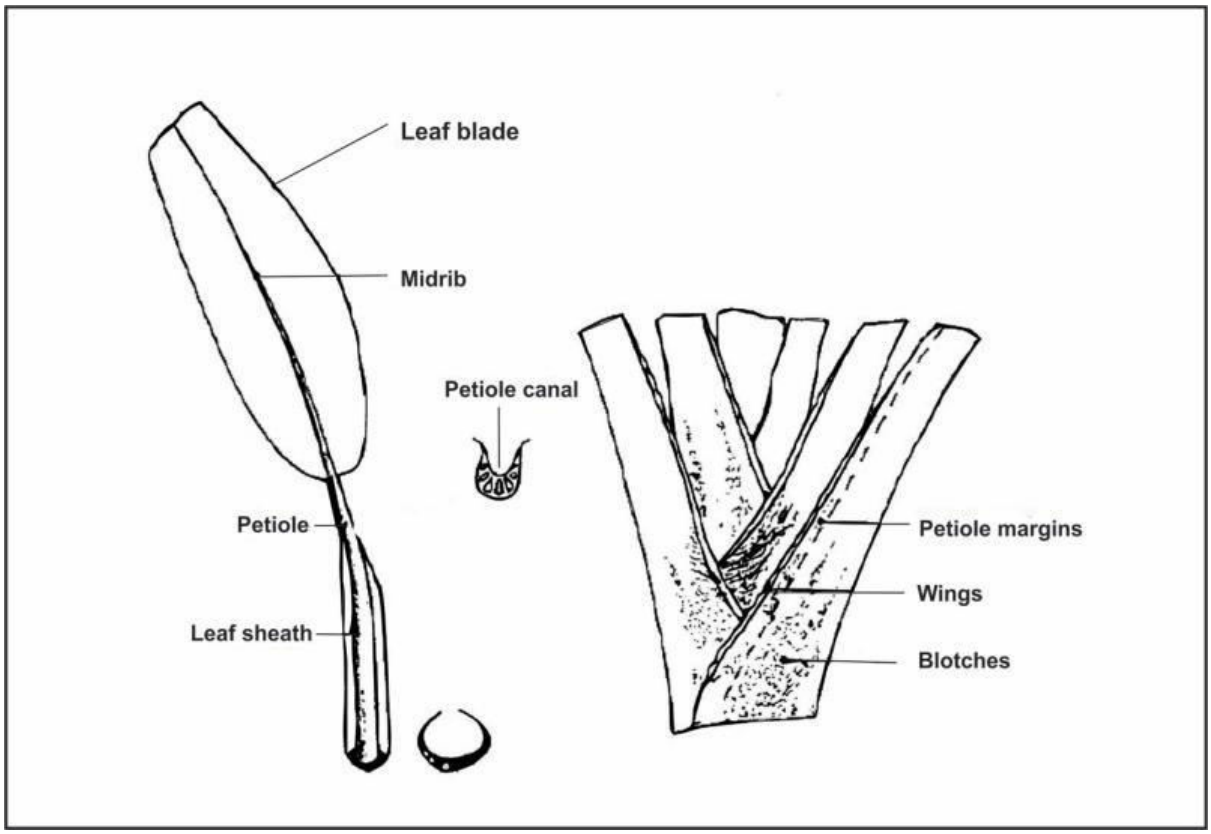


Figure.10 Shape of leaf blade base 1) both side rounded, 2) one side rounded, one pointed, 3) both side pointed. Modified after: IPGRI, 1984.

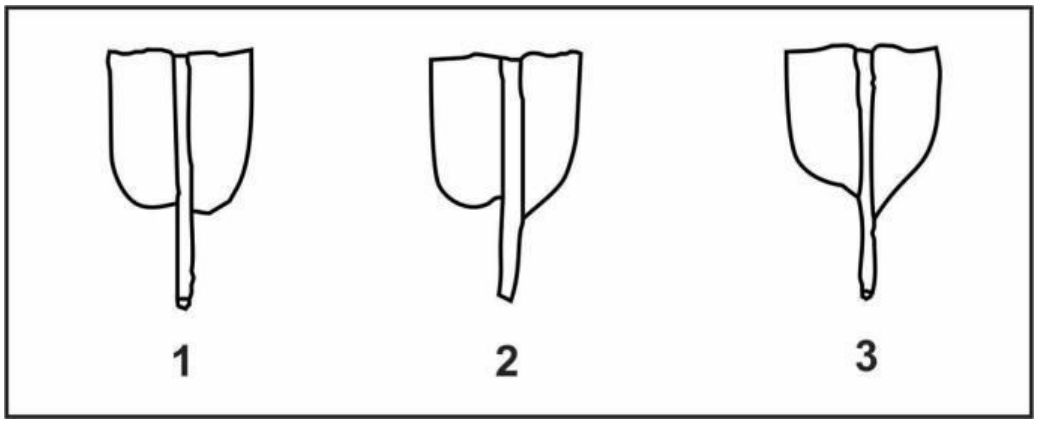


Figure.11 Rachis position 1) falling vertically, 2) at an angle, 3) with a curve, 4) horizontal, 5) erect. Modified after: IPGRI, 1984.

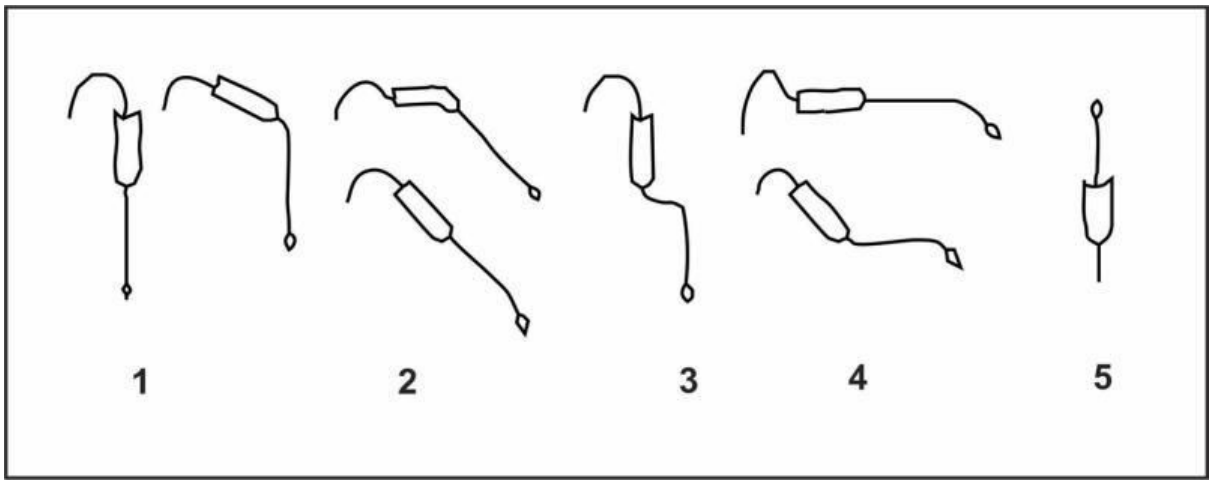


Figure.12 Petiole canal leaf III. Modified after: IPGRI, 1984.

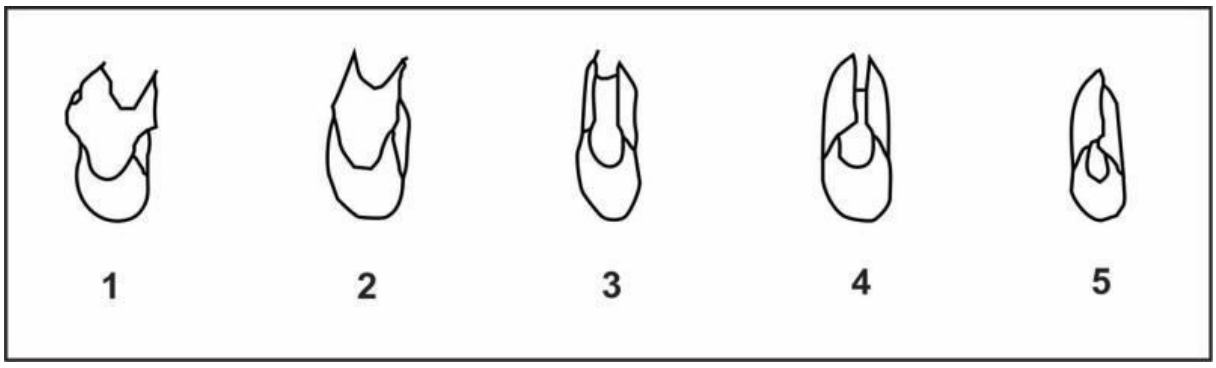


Figure.13 Male bud shape 1) like a top, 2) lanceolate, 3) intermediate, 4) ovoid, 5) rounded. Modified after: IPGRI, 1984.

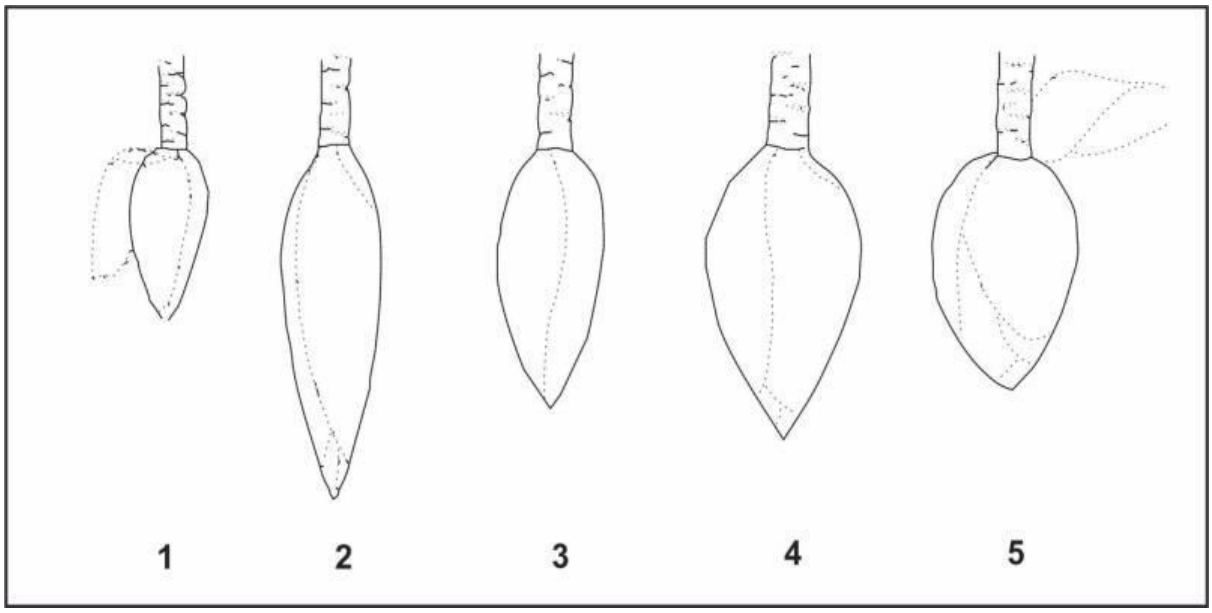


Figure.14 Bract base shape 1) small shoulder, 2) medium, 3) large shoulder. Modified after: IPGRI, 1984.

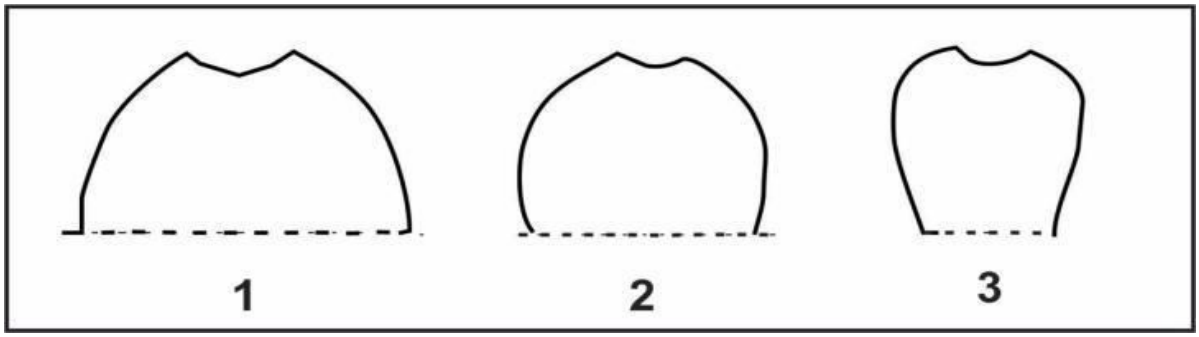


Figure.15 Bract apex shape 1) pointed, 2) slightly pointed, 3) intermediate, 4) obtuse, 5) obtuse and split. Modified after: IPGRI, 1984.

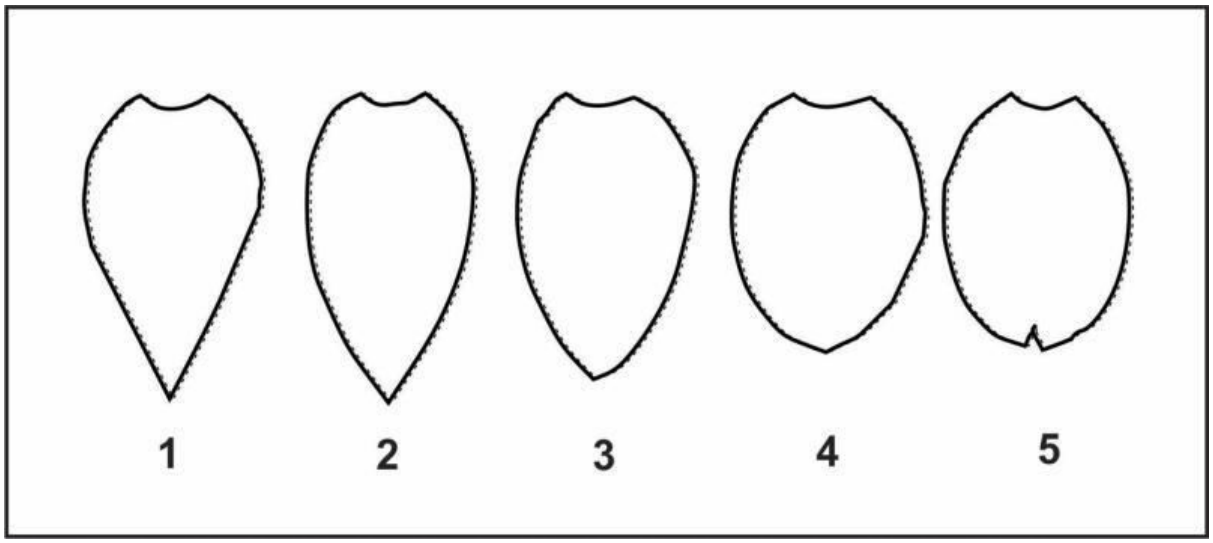


Figure.16 Male bract shape. Modified after: IPGRI, 1984.

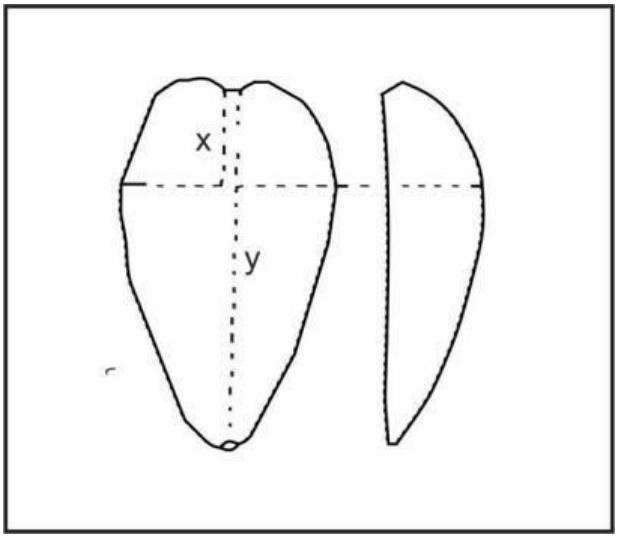


Figure.17 Bract behaviour before falling 1) revolute (rolling), 2) not revolute (not rolling). Modified after: IPGRI, 1984.

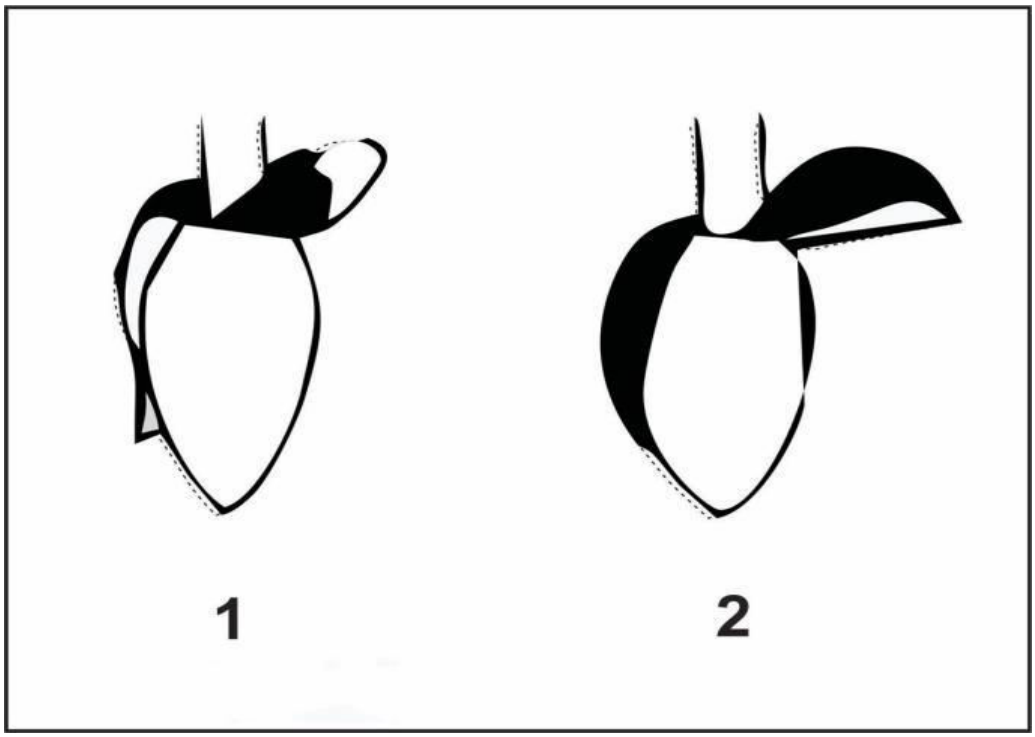


Figure.18 Male bud and flower. Modified after: IPGRI, 1984.

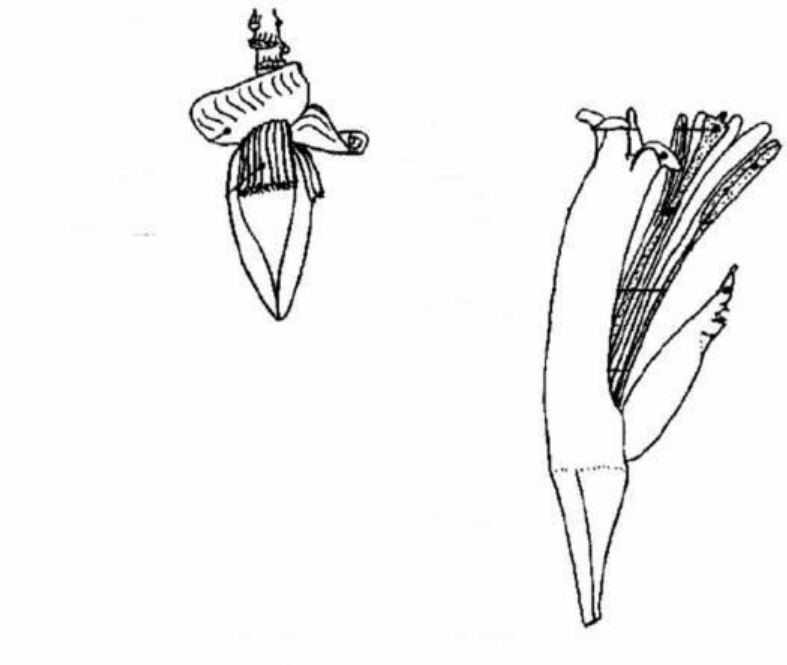
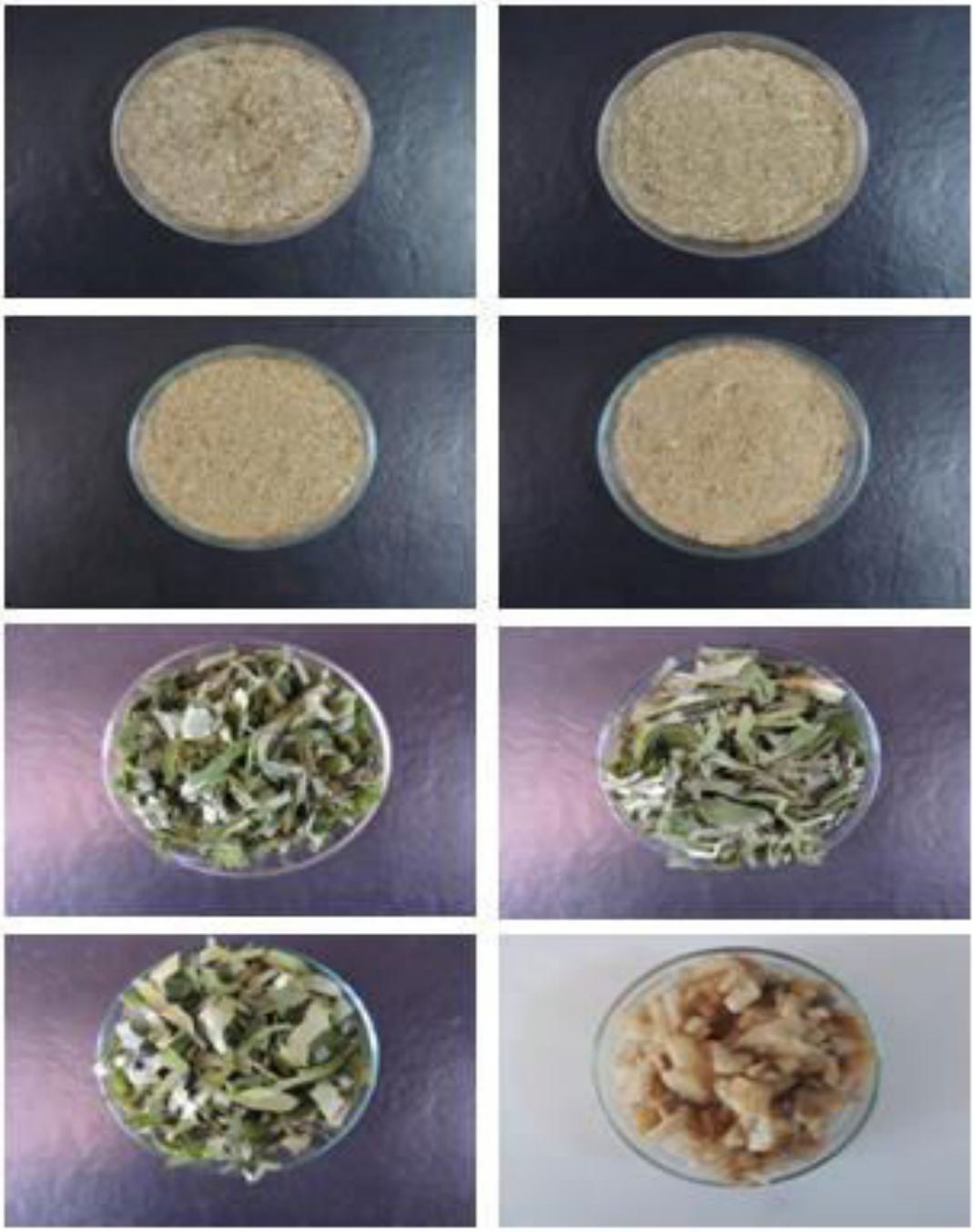


Figure.19 Chopped pseudostem and leafbefore drying a) pseudostem of Kindle, b) pseudostem of Poovan, c) pseudostem of Njalipoovan, d) pseudostem of Palayamkodan, e) leaves of Kindle, f) leaves of Poovan, g) leaves of Njalipoovan, h) leaves of Palayamkodan for proximate analysis.

Figure.20 Powdered and dry a) pseudostem of Kindle, b) pseudostem of Poovan, c) pseudostem of Njalipoovan, d) pseudostem of Palayamkodan, e) chopped leaves of Kindle, f) Chopped leaves of Poovan, g) Chopped leaves of Njalipoovan, h) fresh pseudostem of Palayamkodan for proximate analysis.



The male bud and bract shape are intermediate in Kindle, top shaped to intermediate in Chemkadali, lanceolate to intermediate in Palayamkodan and lanceolate in others. The nature of the bud is convolute in Chemkadali and Sundari; slightly imbricate in Robusta and in Palayamkodan and highly imbricate in others. The surface nature of the male bract can be grooved, slightly or minutely grooved with colour variation in adaxial and abaxial. The bracts are reflexed and revolute except in the case of Robusta and Attukannan. The nature of male flowers is deciduous where it is persistent in the case of Kindle and Nendran; the predominant colour of the male

flower is cream and cream with purple. The colour and size variation also take place in the case of compound and free tepal too. The length of the stamen varies from 3-6 where its filament length varies from 1.5-3.5 and the colour of the filament is cream and creamy yellow. The ovary pigmentation is present in Chemkadali, Palayamkodan and Kaali where it is absent in other variety. Presence of curved base at the style in palayamkodan where it is straight in others. The stigma colour varies from brownish yellow in Poovan and pale yellow in Njalipoovan where it is yellow in others.

The fruit appears in lax (Kindle, Nendran, Poovan, Njalipoovan), compact (Robusta, Chemkadali, Attukannan, Sundari, Kaali) and it is very compact in the case of Palayamkodan. The number of hands in the fruit bunch ranges from 4-10 where the number of fruits on the mid hand is 5-20 and Robusta possess the highest rate.

The cross section of the fruit can be pronouncedly ridged, rounded, and slightly ridged, the difference in its apex nature like lengthily pointed, blunt tipped, bottle necked, pointed and the presence and absence of floral relicts are its functions. The peel colour varies from dark green at its maturity period and the colour varies from light green, bright yellow etc at the time of ripening.

For the nutritional analysis of pseudostem and leaf of 4 different varieties, the samples were collected and tested for various factors such as moisture, crude protein, crude fibre, ether extract, total ash, crude ash, acid insoluble ash. The amount of crude ash obtained in pseudostem and leaf is high in kindle and the least was found to be in Palayamkodan.

Conclusions

Banana is a perennial herbaceous plant that grows from the underground rhizome. Banana has a unique growth characteristic. The pseudostem consists of broad leaves with long petioles, the average height of the plant from the ground surface is about 2-6 m. At the maturity period it produces an inflorescence which passes through the pseudostem, the flower emerges out at the top of the leaf clusters. The inflorescence then develops into a hanging bunch which usually consist of 3- 20 hands with 5-15 fingers approx. each. The banana fruit is composed of soft, easily digestible flesh made up of sugars like fructose and sucrose. The pseudostem and leaf possess several nutrition and health benefits.

There is a clear morphological variation that exists among the banana varieties in Kerala and the morphological studies help in the better knowledge about the common varieties. About 10 varieties were studied and differ each other on the basics of height, length, colour, etc. of pseudostem, leaf, flower bud and fruit. Selected 4 different varieties of banana parts like pseudostem and leaves and were used to detect its nutritional qualities like moisture, crude protein, crude fibre, ether extract, and total ash and the test was based on the AOAC method.

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