STUDIES ON GENETIC DIVERSITY OF BANANA (*Musa* Spp.) LANDRACES IN NAGALAND

Thesis

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Doctor of Philosophy

in

HORTICULTURE (FRUIT SCIENCE)

by

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"True learning often stems from embracing failure rather than mere words…

Success's true essence is often born from the crucible of failure…

Embrace each stumble as a step towards growth; regrets only linger where efforts were never ventured…"

- Ramit Konjengbam

DECLARATION

I, Konjengbam Ramit Singh, hereby declare that the subject matter of this thesis is the record of work done by me, that the contents of this thesis did not form the basis of the award of any previous degree to me or to the best of my knowledge to anybody else, and that the thesis had not been submitted by me for any research degree in any other University/Institute.

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CERTIFICATE – I

This is to certify that the thesis entitled **"Studies on genetic diversity of banana (*Musa* spp.) landraces in Nagaland"** submitted to Nagaland University in partial fulfillment of the requirements for the award of degree of Doctor of Philosophy in Horticulture (Fruit Science) is the record of research work carried out by Mr. Konjengbam Ramit Singh, Registration No. Ph.D./HOR/00123 under my personal supervision and guidance.

The result of the investigation reported in the thesis have not been submitted for any other degree or diploma. The assistance of all kinds received by the student has been duly acknowledged.

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VIVA VOCE ON THESIS OF DOCTOR OF PHILOSOPHY IN HORTICULTURE (FRUIT SCIENCE)

This is to certify that the thesis entitled **"Studies on genetic diversity of banana (*Musa* spp.) landraces in Nagaland"** submitted by Mr. Konjengbam Ramit Singh, Registration No. Ph.D./HOR/00123 to the NAGALAND UNIVERSITY in partial fulfilment of the requirements for the award of degree of Doctor of Philosophy in Horticulture (Fruit Science) has been examined by the Advisory Board and External examiner on ……………….............

The performance of the student has been found **Satisfactory/Unsatisfactory.**

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ABSTARCT

A study entitled "Studies on Genetic Diversity of Banana (*Musa* spp.) Land Races in Nagaland" was conducted during the year 2019 – 2021 to trace out a wide spectrum of genetic diversity and variability of various characters with potentiality of genotypes of different germplasm of (*Musa* spp.). A survey work was conducted based on NBPGR (National Bureau of Plant Genetic Resources) descriptors for banana (*Musa* spp.) in their natural habitat and the fruit samples were collected *in-situ* from various location of Nagaland. The collected genotypes were conserved *ex-situ* at instructional cum research farm as repositories gene banks, Department of Horticulture, School of Agricultural Science, Nagaland University, Medziphema Campus.

The study was carried out in the state of Nagaland under the district of Chümoukedima, Dimapur, Kohima, Mokokchung, Peren, Wokha and Tuensang covering 46 villages and blocks altogether. Twenty-seven *Musa* spp. were collected during exploration. The genomic groups were determined using the nomenclature scheme based on ploidy level and morphological characters devised by Simmonds and Shepherd.

The findings provided the basic knowledge about the morphological characters and biochemical analysis of different Musa germplasm growing under the natural habitat in Nagaland. Among the genotypes in plant general appearance *Musa balbisiana -1* (Bhimkol) has the highest leaf blade length (351 cm), pseudostem height (5.22 m), number of suckers (5.33). Unidentified-3 has the highest girth size of (92.67 cm) and highest leaf blade width was recorded in *Musa sikkimensis* var. *simondsii* (83.67 cm), petiole length was recorded highest in *Musa balbisiana*-2 (Pfekrei) (84.33 cm). In fruits character, African Rhino Horn Plantain was recorded highest in terms of fruit length (27 cm), fruit width (4.70 cm), fruit peel thickness (5.33 mm), fruit weight (319.06 gm) and pulp weight (217.34 gm). The highest trait character was recorded as

bunch weight in Grand Naine (18.13 kg), number of hands/bunch in Bhootmanohar (11.67), number of fingers/hand in *Musa flaviflora* and chinichampa (18.67). Among the treatments Monthan (Sabjikol) showed the highest TSS (24.02%) and total sugar (16.17 %). The highest acidity was found in *Musa balbisiana* - 2 (1.71%). The highest reducing sugar was found in Meitei Hei (8.07 %).

The highest GCV was observed for fruit weight (g) (74.99) followed by pulp weight (g) (75.66). For PCV, fruit weight (g) (75.78) showed the highest value followed by pulp weight (g) (75.06). It was also observed that all the recorded PCV showed higher values that their corresponding GCV values for each trait which indicated the influence of environment on the expression of the phenotype.

Number of hands/bunch showed significant positive genotypic correlation with the trait of fingers/hand (0.7939**) and bunch weight (0.5851**) suggesting that selection made on the basis of these characters will assist in enhancing the no. of hands/bunch. The traits fruit size width (cm) (-0.4173*) and fruit peel thickness (mm) (-0.3853*) showed significant negative genotypic correlation to number of hands/bunch. Similarly for phenotypic correlation, number of fingers/hand (0.7828**) and bunch weight (g) (0.5776**) showed positive phenotypic correlation to number of hands/bunch. The trait, fruit width (cm) (-0.4030*) showed significant negative phenotypic correlation to number of hands/bunch.

Path analysis was carried out to determine the direct-indirect effects of independent traits on the dependent trait. The traits pseudostem height, titratable acidity (%), fruit weight (g), girth size (cm), bunch weight (g), reducing sugar (%), total soluble sugar (%), petiole length (cm), no of fingers/hand, fruit peel thickness (mm), no of suckers and total sugar (%) showed positive direct effect. The traits pulp weight (g), fruit size width (cm),

fruit size length (cm), leaf blade length (cm), leaf blade width (cm) and shelf life showed negative direct effect.

The heritability for all the traits under the experiment was observed to be very high and the genetic advance as percent of mean was also high in the calculated result indicating the action of additive gene action suggesting the selection for the traits as fit for crop improvement. The systematic exploration and documentation of *Musa* spp. may contain useful alleles and different ploidy level that may be valuable tools for further crop improvement in future.

Key words: Banana, Genetic diversity, Heritability, Physico-chemical, Variability

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LIST OF ABBREVIATIONS

APEDA	: Agricultural and Processed Food Products Export Development Authority
ANOVA	: Analysis of Variance
^{0}B	: Degree Brix
BC	: Before Christ
℃	: Degree Celsius
CE	: Common Era
cm	: Centimeter
DEBDOM	: Database Exploring Banana Diversity of Manipur
E	: East
et al.	: Et alibi and others
etc.	: Et cetera
GCV	: Genotypic Coefficient of Variation
g	: Gram
Ha	: Hectare
NBPGR	: National Bureau of Plant Genetic Resources
kg	: Kilogram
m	: Meter
max.	: Maximum
mg	: Milligram
min.	: Minimum
mm	: Millimeter
MSS	: Mean Sum of Square
msl	: Mean Sea level
MT	: Metric tones
/	: Per
>	: Greater than
%	: Percent

PCA	: Principal component analysis
PCV	: Phenotypic Coefficient of Variation
SAS	: School of Agricultural Sciences
spp.	: Several species
t	: tones
TSS	: Total Soluble Solids
UPOV	: The International Union for the Protection of New Varieties of Plants
US$	: United States Dollar
viz.	: Namely
N	: North
SD	: Standard deviation

CHAPTER 1

INTRODUCTION

INTRODUCTION

Banana (*Musa* spp.), botanically a berry fruit, monocotyledonous, monocarpic, herbaceous, perennial succulent plant and is highly energetic and most important edible food crops worldwide. Banana is one of the most important major fruit crops grown in Indian civilization. Banana is the cheapest among all other fruits in the country. In some of the African countries like Uganda, Bukaba and Tanzania, it has established as a staple food and one of the most important traded tropical fruits in the world (Radha and Matthew, 2007). Banana belongs to the family *Musaceae* of order Zingiberales. Earlier it was included under the order Scitamineae. The true stem of banana is referred as rhizome with roots and vegetative buds. Simmonds (1962) called it as corm as it gives a clear-cut idea being an erect underground stem with restricted horizontal growth and possesses roots and vegetative buds. The centrally located apical meristem gives rise to successions of leaf primordia which eventually develop into leaf sheath, a strong midrib and an enlarged lamina. The central stem is a pseudostem formed out of closely packed leaf sheaths embedding the growing tip.

Earliest documentary mention is in the Vedic period (approx. 1700 BC) where the use of fruits like mangoes, goose berries and bananas has been mentioned in *Rig- Veda*, one of the four volumes of Veda written by the Indian sages (Kulkarni, 1973). Next evidences are from Indian epics, ‘Mahabharata’ and ‘Ramayana’ which date to approx. 1400 BC. Early epics of the Pali Buddhist monks also mentioned about bananas ‘as big as an elephant’s tusk’ in 500-600 BCE and Kautilya’s Arthashastra (300-400 BC). This probably referred to plantains (Horn plantain) from southern peninsula of Greater India (including Sri Lanka), where plantain cultivation is in vogue today. Although it is an undisputed fact that banana and plantain originated in Southeast Asia and the Pacific and it has been proved from chronology of their spread and distribution, recent linguistics, anthropological and archaeological studies have given indications on the possible migratory theory (Nayar, 2010).

Bananas and plantains are cultivated throughout the humid tropics and sub-tropics. This crop is perennial with a faster relative growth rate compared to other fruit crops, while producing fruit all year round. This crop also represents an important source of income for many rural families that work directly or indirectly in this industry. The edible *Musa* spp. originated from two wild species, *Musa acuminata* Colla and *M. balbisiana* Colla, contributing with A and B genomes, respectively, as well as their hybrids and polyploids. Because of their nutritional value, bananas and plantains are considered the fourth most important crop worldwide after rice, wheat and corn. Banana is a nature's gift to the mankind with four times protein, twice carbohydrates, three times phosphorus, five times vitamin A and iron, many times potassium and twice other vitamins and minerals compared to apple (Uma *et al*., 2019). In India, banana is rightly referred as '*Kalpatharu*', a plant of all virtues or popularly called as *Apple of Paradise*. Besides its use as dessert fruit and culinary banana, it has multifaceted uses. Banana leaves are the most popular hygienic dining plate in Southern India. In Africa it is used as dinner plates and wrapping material, male flower is a much-preferred vegetable and inner core of the pseudostem is also a vegetable in demand with lots of therapeutic uses. Plant sap is used as indelible ink in industry. Underground rhizome is mostly exploited as animal feed as a composite mixture with others. Banana flour is rich in starch particularly resistant starch, and this biopolymer constitutes an excellent raw material for baby weaning foods, puddings, soups, gravies etc. for the preparation of low glycemic products (Nelson *et al.,* 2006). Banana wine can be made either from unclarified or clarified juice of beer banana with a characteristic fruit flavour. The banana fruit can be eaten raw or cooked, processed into flour and fermented for the production of beverages such as banana juice, beer, vinegar and wine (Thompson, 1995; Pillay *et al.*, 2002; Nelson *et al*., 2006; Edmeades *et al*., 2006; Pillay and Tripathi, 2007).

In India, total area under banana cultivation in 2020-2021 was (923 ‘000 Hectares) and production was (33379 ‘000 MT) (Anonymous, 2021). The state that has maximum accounts in production of banana are Andhra Pradesh (5838.88 ‘000 MT) followed by Maharashtra (4628.04 ‘000 MT) and Gujarat (3907.21 ‘000 MT). The major banana growing states are Andhra Pradesh, Maharashtra, Gujarat, Tamil Nadu, Karnataka, Uttar Pradesh, Bihar, West Bengal, Assam, and Chhattisgarh (NHB, 2021-22, 1st Adv. Estimate). Variation in productivity ranges from 13.5 to 63.6 tons/ha, which is attributed to cultivars, production system and management strategies. In North East Region of India, the production of banana is 1492 ‘000 MT from an area of 1.0071 lakh with a productivity of 11.32 MT/ha, out of which production in Nagaland is around 117.04 ‘000 MT from an area of 0.0834 lakh with a productivity of 14.03 tonnes / ha. Assam leads in both area (0.53308 lakh) and production (913.27 000’ MT) followed by Mizoram with an area of 0.1101 lakh and production of 117.04 000’ MT in North East region. Lowest production has been found to be in the state of Sikkim (3.71 000’ MT) (Anonymous, 2018).

India is also one of the major exporters of banana among the Asian countries. India takes the credit of being the highest producers of banana contributing to 27 % share in the world (Anonymous, 2018). Since the fruit was available 365 days of the year, it could be exported quickly to its export destinations, because it takes 7-12 days to reach any export destination. Affinity to the West Asian and Middle East markets has offered a huge opportunity for Indian exporters to boost their banana consignments to the region. During the year 2011-2012, India exported 45573.24 MT of banana valuing at Rs. 9154.22 lakh but in 2018-2019, India bananas export has risen to 135.20 000’ MT which was valued at Rs. 415.06 crore. The major destinations of India's banana were UAE, Saudi Arabia, Iran, Kuwait and Bahrain respectively. These countries have imported more than 50 percent of India's banana during the period. The export value of global banana has been increased by 6.1% from 2019 to 2020 (NHB, 2021-22, 1st Adv. Estimate)

Musa species was first reported in India by Hooker as early as 1892. The number of species within *Musa* lies between 30 and 40 (Simmonds and Shephard, 1955). According to Cheesman (1947: 108), genus *Musa* was divided into four sections: *Australimusa* (2n=20), *Callimusa* (2n=20), *Musa* (as *Eumusa*) (2n=22) and *Rhodochlamys* (2n=22), based on chromosome number and morphological characters. This classification of Musa by Cheesman provides general information of the taxonomy and has been used for nearly 50 years without any significant changes (De Langhe, 2000). In the course of time, Wong et al. (2002) made various changes and some major and minor regroupings of the classification of Musa. The present-day banana is said to have originated in Southeast Asia, including the Indian subcontinent (Uma *et al*., 2005) and subsequently distributed to other parts of the world (Simmonds and Shephard, 1955). According to Nwakanma *et al.* (2003), the Eumusa species of banana, which include modern-day cultivars, appear to be very diverse. Banana and plantains (*Musa* spp.) evolved from intra and inter specific crosses of two wild diploid species of Eumusa, *M. acuminata* and *M. balbisiana*, which respectively contributed the A and B genomes (Simmonds and Shephard, 1955). *Musa* spp. is further evolved through polyploidization and somatic mutation accumulations (Stover and Simmonds, 1987). Therefore, depending on the contribution of *M. acuminata* (AA) and *M. balbisiana* (BB), most of the present-day commercial banana possess different genomic combination such as AA, AB, AAA, AAB, ABB, AAAA, AAAB, AABB and ABBB.

It is a known fact that the basic chromosome number of bananas and plantains is x = 11, with 22 (diploid), 33 (triploid) and 44 (tetraploid) chromosomes (Stover and Simmonds, 1987). Furthermore, there is a wide range of B-rich genomes (AB, AAB, ABB and ABBB) and a great diversity of the B genome (BB) in India (Uma *et al*., 2005). *M. acuminata* is found mainly on tropical rainforests and in a region where the incidence of natural hybridization has been reported often among the sub-specific taxa resulting in a high degree of morphological variability (Simmonds, 1962; Simmonds and Shephard, 1955). Southeast Asia being the primary centre of origin of this wild progenitor (Simmonds and Shephard, 1955; Ude *et al.,* 2002; Racharak and Eiadthong, 2007), particularly Malaysia (Daniells *et al.,* 2001; Wong *et al.,* 2001) and reached Indian subcontinent, the secondary centre of diversity, mainly through human interventions and movement like domestication where it introgressed with the hardy wild *M. balbisiana* endemic to North-eastern India (Simmonds, 1962). On account of morphological characters, nine *M. acuminata* spp. were reported from Asia (Hakkinen and De Langhe, 2001), *viz*. *M. acuminata* ssp. *banskii*, ssp. *burminaca*, ssp. *burmannicoides*, ssp. *malaccensis*, ssp. *microcarpa*, ssp. *truncata*, ssp. *siamea*, ssp. *errans* and ssp. *zebrina*, of which only *M. acuminata* ssp. *banskii*, ssp. *burminaca*, and ssp. *burmannicoides* represents 37 % of the total diversity seen in India (Uma *et al*., 2005).

India is well known for its genetic diversity of members of Musaceae including wild species with seeds and seedless cultivars with various levels of ploidy (Prasad *et al.*, 2013). More than 11 species have been reported including *M. acuminata* ssp. *burmannica*, *M. acuminata* ssp. *burmaniccoides*, *M. sikkimensis*, *M. balbisiana*, *M. nagensium*, *M. thomsonii*, *M. itinerans*, *M. ochracea*, *M. flaviflora*, etc., which are widely distributed in the Northeastern India (Uma *et al.*, 2001). *M. balbisiana* is the other wild Eumusa species which had fairly broad distribution across South and SE Asia. It is fairly a stable species without much variability within unlike *M. acuminata.* But recent explorations and molecular characterization have revealed sufficient variability in stature of the plant, pseudostem colour, leaf orientation, male flower bud shape, etc. which may result in few subspecies (Uma *et al.* 2005; Ge *et al.* 2005; Sotto and Rabara 2000).

The north-eastern region of India including Nagaland is home to many indigenous *Musa* cultivars and wild/semi wild species. Many of the *Musa* species are extensively found in different agro-climatic condition and are widely distributed in northeast region of India, (Uma *et al*., 2006) which has been primarily considered as the richest sources of natural banana diversity (Hore *et al*., 1992). Occurrence of *Eumusa* species such as *Musa nagalandiana, M. balbisiana, M. cheesmani, M. flaviflora, M. itinerans, M. nagensium* and *M. puspanjaliae* and species of the section *Rhodochlamys* commonly known as ornamental species were reported from Nagaland, Arunachal Pradesh, Tripura and other parts of Northeast India (Gurumayum *et al*., 2018; Sabu *et al*., 2013; Dey *et al*., 2014; Majumdar *et al.*, 2013). However, the correct identification and classification of banana cultivars in the region is hampered by the presence of different tribes and ethnic communities with different dialects and languages.

Identification and classification of edible bananas and their wild relatives' genome are mainly based on morphological characters and their similarity among two progenitor species, *M. acuminata* and *M. balbisiana*. Since time immemorial, the morphological characters were utilized by farmers for determining of genetic diversity of crops. Vast majority of the present-day knowledge on bananas has been contributed significantly by morphological characterization. The process involves the measurement of various morphological traits of germplasm collections. In 1955, Simmonds and Shepherd formulated a new genome-based nomenclature system for edible fruit bearing bananas based on their genotype. They listed out various features that were characteristic of *M. acuminata* and *M. balbisiana* and gave them arbitrary numerical values. They scored plants based on the visual assessment of these characters and assigned them with various genome groups. *Musa acuminata* was designated as genotype AA and *Musa balbisiana* as BB; both are diploid species. The vast majority of the edible banana is triploid but some bananas were found to have an AA or BB genotype. This classification method has become a primarily preferred system for banana genotyping (Atom *et al*., 2015). Nonetheless, the placing of edible bananas into different genome groups purely based on visual assessment requires a high degree of skill but has been practice to the satisfaction for most of the banana cultivars. Modern genetic technology has largely supported genome assessment made by Simmonds and Shepherd (1955) but significant changes have sometimes been made.

For crop improvement programs, germplasm collection and characterization are of fundamental importance because they provide plant breeders with a source of useful traits (Simmonds and Shepherd, 1955; Ortiz, 1997) and increase the knowledge on the genetic background of the crop (Cordeiro *et al.,* 2003). For proper identification and classification of *Musa* species several qualitative and quantitative morphological characters including vegetative part, inflorescence, male flowers and fruit characters are very useful (Simmonds and Shepherd, 1955; Amorim *et al*., 2012). Multivariate statistical approaches are often used to analyse collections with many accessions for determining relationships among the accessions (Bhargava *et al*., 2007). Principal components and cluster analysis are among the appropriate procedures for analysing genetic variability of the germplasm collections with many accessions and which would help in the identification of patterns and structures in a data set. Moreover, multivariate analyses could effectively be employed as useful tools in understanding studies with complex traits (Iezzoni and Pritts, 1991).

Bananas provide a vital food source for growing populations in many countries that used as a staple food and played an important role in poverty alleviation in many of the underdeveloped countries. To increase the productivity of cultivated banana against growing pest and disease pressure under changing environmental conditions, wild banana needs to explore for their disease resistance and climate resilience gene pool.

In India wild *Musa* spp. are mostly distributed in the north-eastern States, the Western and Eastern Ghats and the Andaman and Nicobar Islands (Joe *et al.*, 2014). However, many regions within its centre of diversification in north-eastern India have not been explored systematically due to various factors such as their occurrence in dense evergreen forests, civil unrest in the region, etc.; hence many taxa remain to be described. These plants are reported to be originated from South East Asia and then introduces in other continents (Daniells *et al.*, 2001: Simmonds, 1966). Besides Eumusa, Rhodochlamys are also abundantly distributed in the states of North eastern region and Western and Eastern Ghats as well in India. *M. ornata* is distributed in Western Ghats and Eastern Ghats, whereas the species like *M. velutina, M. aurantiaca and M. rosacea* are commonly growing in the undisturbed forest areas of Northeastern India. *M. laterita*, a unique species which is very short with rhizomatous roots, is found in Western Ghats (Abraham 1976). Regarding Callimusa and Australimusa, no records are available for the presence of members belonging to these two sections in India. Recently some more new species have been reported in India: *M. swarnaphalya* (Uma *et al.,* 2005), *M. saddlensis* and *M. kuppiana* (Anon. 2005), *M. velutina* subsp. *markkuana* (Sabu *et al.,* 2013), *M. velutina* var. *variegata* (Joe *et al.*, 2013) *and M. sabuana* (Prasad *et al.*, 2013), *M. nagalandiana* (Dey *et al.,* 2014), *Musa balbisiana* var. *andamanica* (Singh *et al.* 1998) and *M. arunachalensis* (Sreejith *et al.*, 2013).

India is one of the countries with different agroclimatic conditions which have encouraged the development of different and large number of varieties catering to local needs. Even though India is having vast diversity for banana and plantains, only few are cultivated commercially in many states of India, and banana trade is dominated by only one or two cultivars especially

Cavendish type (Grand Naine). It is known that 15–20 cultivars are grown based upon the local needs and consumer preferences. Apart from the common commercial cultivars, some other cultivars are also available, but their utilization is meagre. Those less exploited banana landraces were identified and documented (Uma *et al.*, 2014). A lot of variety is known by different names based on the dialects and the communities in different regions of the northeast India. The rugged terrain and topography of the region also made it difficult for extensive exploration. Moreover, majority of the wild varieties are exposed to large scale exploitation and destruction as a result of shifting cultivation by the local tribes, thereby wiping out *Musa* natural habitats (Molina and Kudagamage, 2002). This accentuates the need to collect, characterize and document germplasm before its extinction from these areas. Reliable identification and genetic information on the existing banana genetic resources will be useful for the effective breeding and conservation strategies. Only limited information is available regarding the types and number of variations of *Musa* species in this region. Thus, to make collections of germplasm, determine the variation within the collections; searching of desirable traits and conserving biodiversity would substantiate the ever-increasing constraints on the narrow genetic bases and diversity of the *Musa* species.

Keeping in view the above facts, the present investigation entitled **"**Studies on Genetic Diversity of Banana (*Musa* spp.) Land Races in Nagaland**"** was carried out with the following objectives:

1. To carry out an extensive survey to identify the divergent clone based on survey schedule developed.
2. To study the plant morphological and physico-chemical attributes of fruits in different genotypes.
3. Assessment of genetic diversity and variability based on biometrical analysis of collected banana genotypes.

4. *Ex-situ* conservation of selected clones in university farm as field repositories gene banks.

CHAPTER 2

REVIEW AND LITERATURE

REVIEW OF LITERATURE

An effort has been made to collect and review the relevant literatures available on various aspects of work done so far on morphological traits, genetic variability, character association and quality attributes in banana for diversity mapping and database development among different cultivated and wild genotypes found in Nagaland. Literature on above aspect of the present study was reviewed in this chapter related to research work under the following heads:

2.1 Extensive survey to identify the divergent clone of *Musa* spp.

Häkkinen *et al.* (2008a) made the initial description on *Musa aurantiaca*. The aim of the study was to settle its true identity and to update the description. He surveyed in the regions of Upper Assam and Arunachal Pradesh, India, Northern Myanmar and Tibet, China where it occurred commonly but it was not mentioned in Chinese literature at all. In this paper, the authors also reviewed the description and the literature history of *M. aurantiaca* from 1893 to the present. *Musa aurantiaca* Baker was typified here.

Häkkinen *et al.* (2008b) conducted a study on *M. itinerans* morphologically circumscribed based on field studies in southern China. Four varieties were described as new: *M. itinerans var. chinensis* Häkkinen, *M. itinerans var. guangdongensis* Häkkinen, *M. itinerans var. lechangensis* Häkkinen, and *M. itinerans var. xishuangbannaensis* Häkkinen. We propose a new rank for *M. itinerans subsp. annamica* R. V. Valmayor, L. D. Danh & Häkkinen as *M. itinerans* var. *annamica* (R. V. Valmayor, L. D. Danh & Häkkinen) Häkkinen. A table for the distinguishing characteristics was provided for these varieties and for *M. itinerans* var. *itinerans* Cheesman. All of these studies were based on morphological characteristics observed in the field in China during 2005 and 2006, in various herbaria on Musaceae.

Häkkinen and Vare (2008c) carried out an experiment on taxonomic history and identification of *Musa dasycarpa*, *M. velutina* and *M. assamica* (Musaceae) in Southeast Asia. Since the initial description, the name *Musa dasycarpa* Kurz (1867) has been unclear to most botanists. It has usually been synonymized with *M. velutina* H. Wendl. & Drude (1875). However, although the original diagnosis was very short, "fruits hairy", it is adequate. Thus, according to Vienna Codes, *M. dasycarpa* Kurz has priority over *M. velutina* H. Wendl. & Drude. For that purpose, the names *M. dasycarpa* and *M. velutina* were typified. In addition, critical notes regarding *M. assamica* Bull. were given and was neo typified and considered as conspecific with *M. sanguinea* Hook.

Chiu *et al.* (2011) conducted a study on *Musa itinerans* (Musaceae) in Taiwan. *Musa itinerans* Cheesman var. *formosana* (Warb.) Häkkinen and C. L. Yeh was one of the three wild bananas in Taiwan and represents the taxon previously recognized as *M. formosana* (Warb. Ex Schum.) Hayata [= *M. basjoo* Siebold & Zucc. Ex Iinuma var. *formosana* (Warb. ex-Schum.) S. S. Ying]. The gross morphology of *M. itinerans* var. *formosana* was stable. Some populations without variegation on the pericarps and the bracts of male buds were mainly found in a restricted area of northeast Taiwan. The morphological characteristics of the non-variegated populations were otherwise similar to those of *M. itinerans* var. *formosana*. Their principal distinction was based on the absence of the purplish red streaking on both the pericarps and the male, fertile bracts. This character of non-variegation was stable across the taxon's habitat and as cultivated through a 9-year period of observation. From molecular evidence, the DNA sequence for the ITS region of ribosomal DNA (rDNA) was highly similar in both populations. The non-variegated population segregated as the new variety, *M. itinerans* var. *kavalanensis* H. L. Chiu, C. T. Shii & T. Y. A. Yang. Photos for the three varietal taxa, M. itinerans var. chinensis, variety *formosana* and variety *kavalanensis* and a key to Taiwanese wild bananas were also provided.

Hasan *et al.* (2011) characterised thirty-four types of seeded banana with B genome collected from different agro climatic zones of West Bengal, India. The proximity matrix, both by squared Euclidean and cophenetic correlation, between types indicated high closeness/similarity among Attiakala, Bichkela-1, Bichkela-2 and Hill Banana. The highest proximity value of 20.62 with Kalyani Local-3 showed maximum dissimilarity with Maricha and Jhama Diara. A dendrogram using the single linkage clustering technique on squared Euclidean distance matrix and cophenetic correlation matrix showed 13 and 14 clusters, respectively. PCA was used by considering 13 factors on the basis of variance explained, i.e., more than 3%, and total explained variation was confined to 68%. Thus, considering the dominant characters with positive loading under bract scar on rachis, pollen sacs colour, leaf corrugation, general fruit shape, fruits and compound tepal, the positively loaded types were Bichkela-1, Hill Banana, Attiakala, 'Bichkela-2, Kalyani Local-1 and Jhama Daira. Factor 1 thus explained 14.21% of the total variance. In general, PCA results agreed with the results obtained by cluster analysis. PCA gave a better picture of the relationship between seeded banana types than cluster analysis and was useful in confirming group(s) obtained through cluster analysis. MDS group plots also clearly indicated the clustering of homogeneous types. Among the 34 seeded banana types, 32 were assessed as parthenocarpic. The two non-parthenocarpic types identified were 'Baruipur' and Seed Banana-15.

Joe *et al.* (2013) conducted a study on *Musa velutina* H. Wendl. & Drude (Musaceae) from Assam, North-East India. *Musa velutina* var. *variegata*, a new variety from Assam, North-East. This extremely rare variety was found only in Makum Area of Tinsukia District in Assam. A detailed description, distribution, ecology, phenology, illustration, colour plates and relevant notes were provided. A key to the section Rhodochlamys in North-East India was provided.

Majumdar *et al.* (2013) recently recorded *Ensete glaucum* in Tripura during floristic investigations, which was an additional banana species for the flora. We observed very limited population in the wild and recorded necessary information on its distribution, habitat association and pollen structure. The information was useful for future population assessment, regeneration and other ecological studies to manage its wild stock and to protect this primitive banana from regional extinction.

Sabu *et al.* (2013) identified a new subspecies of *Musa velutina* belonging to section *Rhodochlamys* from north-eastern India and it was described and illustrated as *Musa velutina* subsp. *markkuana*.

Singh *et al.* (2013) had developed a database named DEBDOM to describe the diversity of banana resources of Manipur and it comprised twenty-eight genotypes of Musaceae. The database DEBDOM provided a sophisticated web base access to the details of the taxonomy, morphological characteristics, utility as well as sites of collection of *Musa* genotypes, and it would have contributed as a potential gene pool sources for the conservation, sustainability as well as for crop improvement in the future breeding programmes.

Gogoi (2014a) studied on *Musa aurantiaca* Baker (Musaceae) distributing from northeast India, Tibet to northern Myanmar. In the present study its intraspecific taxa were thoroughly investigated. Two new varieties were described and illustrated based on live plants in the field: *M. aurantiaca* Baker var. *homenborgohainiana* Gogoi and *M. aurantiaca* Baker var.

jengingensis Gogoi. A key to the varieties of *Musa aurantiaca* Baker and closely related taxa was also provided.

Gogoi *et al.* (2014b) studied about the taxonomic identity of *Musa cheesmanii* N. W. Simmonds (1956a) in northeast India and has been uncertain to most botanists and the species has commonly been wrongly identified as *M. nagensium* Prain. The aim of the study was to settle the true identity of the species and provided a revised description and coloured photo illustrations. Coloured photo illustrations of two varieties of *M. nagensium* were also included to avoid misidentifications with *M. cheesmanii*. The study was based on morphological characters observed in the field in northeast India, in various herbaria and supported by relevant literature.

Häkkinen *et al.* (2014) studied about the taxonomic identity of *Musa flaviflora* Simmonds (1956a) and *Musa thomsonii* (King ex Baker) A. M. Cowan & Cowan (1929) have been uncertain to most botanists and have fallen towards oblivion. These two species have also been erroneously synonymized by many botanists but were distinct species with different distributions, viz. *M. flaviflora* from the north-eastern parts of India and *M. thomsonii* from Bhutan, Sikkim, the Himalayan hills of India and Yunnan, China. The aim of this study is to settle the true identity of those 'lost species' and to update their descriptions. These studies were based on morphological characteristics observed in the field in northeast India, and Yunnan, China, in various herbaria as well as in the literature on Musaceae.

Joe et al. (2014) conducted a banana exploration and rediscovered Musa cheesmanii after 57 years. A note on its extended distribution is also discussed. Detailed description and photographs are provided for easy identification.

Hapsari *et al.* (2015) conducted a banana exploration in Madura Island covering areas of Bangkalan, Sampang, Pamekasan and Sumenep Districts.

This paper presents the results of survey, inventory and diversity of bananas in Madura Island including its habitat aspects, agronomic practices and diseases problems. Results showed that banana plants were widely distributed in Madura Island, it grows wild in coastal line, road sides and river banks, or cultivated mostly by small scale farmers in backyards, dry lands, intercropped with annual and/or perennial crops. It is mostly cultivated subsistently with less consideration to cultivation practices for home consumption or for local markets. Major diseases such as bunchy top and wilts have largely spread to the areas, with highest occurrences and intensities in Bangkalan and Pamekasan Districts. Spreads of leaf late blight disease were found sporadically in all areas; with Pamekasan District has the lowest disease intensity. About 37 recognizable banana cultivars with local Madurese names were known with any possible synonymies within the cultivars. It comprises of 15 dessert bananas, 17 cooking bananas and 5 dual purposes bananas. From this exploration, about 21 living banana specimens consist of 83 suckers were collected from the sites to be ex-situ conserved in Purwodadi Botanic Garden, Pasuruan.

Borborah *et al.* (2016a) studied on taxonomy, traditional knowledge and economic potentialities of *Musa balbisiana* Colla in Assam, India. A brief summary of the taxonomy, traditional and medicinal uses of the plant, plant parts and products, based on extensive field observation from different parts of Assam has been documented.

Borborah *et al.* (2016b) carried out a study on a new variety of *Musa balbisiana* colla from Assam, India. During the field work conducted on taxonomic study on the genus *Musa* L., the authors collected certain specimens of seed propagated plants occurring wild and in semi-domesticated state in Assam which were known as "*Sepa-athiya*". It differed from *M. balbisiana* in a number of attributes. The plants were propagated both through seeds and by suckers. Further, unlike the cultivated clones of *M. balbisiana,* the fruits of the collected plants were not edible because of the presence of numerous compactly arranged seeds with scanty flesh. However, the other parts like pseudostem, leaves and inflorescence were used as that of *M. balbisiana*. Considering the above differences of the collected specimens with that of *M. balbisiana*, a new variety *viz., Musa balbisiana* var. *sepa-athiya* is proposed and described.

Joe *et al*. (2016a) made a note on *Musa rubra* Kurz (Musaceae) and reduction of *M. laterita* Cheesman as conspecific. Taxonomic identity and history of *M. rubra* were provided and lectotype was designated here. Detailed description, photographs and illustration were provided for easy identification. *M. laterita* is treated as conspecific to *M. rubra*.

Joe *et al*. (2016b) carried out a study on a new variety of *Musa sikkimensis* Kurz and notes on the taxonomic identity and history of *Musa sikkimensis* (Musaceae) from North-East India. A new variety of *Musa sikkimensis* was described here as *M. sikkimensis* var. *simmondsii*. Notes on taxonomic identity and history of *M. sikkimensis* were provided. Isoneotype for *M. sikkimensis* and lectotype for *Musa hookerii* were designated.

Sabu *et al.* (2016) reported that maximum diversity and distribution of *Musaceae* was located in the north-eastern states, with 30 taxa of which 19 were endemic to the region. This represented about 81% of the total wild *Musaceae* diversity in India. This also indicated that the region bordering with Bangladesh, China and Myanmar was a biodiversity-rich area for *Musaceae* and strengthen the view that this region was considered as one of the major centers of origin of the family *Musaceae*. The second largest *Musaceae* diversity in India was found in Andaman and Nicobar Islands, where three taxa were present all of which were endemic. In the Western Ghats, three taxa were present, including one endemic taxon, and the same was the case in Eastern

Ghats. During this work, two species were found to be extinct from the wild and 19 taxa were categorized as threatened.

Sulistyaningsih (2016) conducted a study on the diversity of wild banana species (Genus *Musa*) in Java. The present taxonomic study was based on morphological characteristics observed in the herbarium specimens deposited at the Herbarium Bogoriense (BO), living collections in the Bogor Botanical Garden, the Cibodas Botanical Garden, and during the explorations done at Mt. Salak, West Java. Eight species of *Musa* (*Musa acuminata*, *M. balbisiana*, *M. coccinea*, *M. ornata*, *M. salaccensis*, *M. sanguinea*, *M. textilis* and *M. velutina*) and seven infraspecific taxa of *M. acuminata* were recognized in Java, of which two infraspecific taxa were endemic. West Java was the center of distribution for the wild banana species in Java. Taxonomic descriptions including an identification key were presented.

Hapsari *et al.* (2017) conducted a survey on ethno botanical survey of bananas (*Musaceae*) in six districts of East Java, Indonesia. During the survey, they discovered seventy-nine local cultivar names were recorded in the six districts, including local Javanese names and some possible synonyms among the cultivars. Four genomic groups were represented: AA (13), AAA (16), AAB (24) and ABB (16); 10 specimens were uncertain AA/AAA/AAB. Banana cultivar names given by local communities mostly reflect distinct morphological or perceptual characteristics, as well as uses, although some of the names do not refer to appearance or anything at all. Some cultivars were restricted to particular regions. Bananas play important roles in East Javanese socio-economic and cultural life. All parts of the plant were used: for food, fodder, domestic materials, fibers, shelters, ornamentals, medicines, in rituals and ceremonial events and other miscellaneous uses. Banana plants have deep philosophical meaning; their characteristics were associated with the process of life and provide lessons on life ethics. Conservation of local banana cultivars was needed in the face of negative impacts of commercialism. In-situ/on-farm conservation of bananas was a suitable strategy. Conserving the diverse species and varieties of bananas was necessary to maintain their adaptability and resilience to resist biotic and abiotic stresses.

Gurumayum *et al.* (2018) conducted a study on diversity of wild *Musa* species (Musaceae) under the sections, *Eumusa* and *Rhodochlamys*. A total of 20 *Musa* specimens consisting of six species under section *Eumusa* and 14 specimens (7 species, 4 unidentified species and 3 hybrids) of *Rhodochlamys* were recorded. *M. cheesmani* among *Eumusa* while *M. velutina* and *M. aurantiaca* among *Rhodochlamys* were most abundant species. All the species and hybrids of *Rhodochlamys* were found growing in disturbed habitats such as degraded foot hills, drying swamps, landslide prone areas and along sides of expanding highway roads. *M. rubinea* was at high risk of loss from the natural habitats if proper conservation measures were taken up immediately. In this study, it was observed that collection and identification of the *Musa* specimens were easier based on the traditional sectional classification. It was suggested that that molecular taxonomy using ITS sequences and chloroplast gene loci may improve correct identification of *Musa*, particularly unidentified species and hybrids in the section *Rhodochlamys*.

Rai *et al.* (2018) studied the diversity of banana cultivars or sub-species in Bali and its usefulness to determine preferable cultivars. They characterized 43 banana cultivars in 10 villages that represented the 8 regencies and 1 city of Bali province. Out of the 43 cultivars, 7 were highly used and at least one cultivar was discovered in each of the studied village. Among the highly ranked cultivars or species, only biu kayu was unique to Bali as it was not found in the closest provinces of East Java and Madura. Hence, the results suggested that to improve the cultivation and production of these 7 highly used cultivars could be an appropriate solution to meet Bali demand of bananas.

Furthermore, cultivating biu kayu would also help conservation effort since this cultivar was also currently listed as a rare genetic resource.

Rajappa *et al.* (2018) collected endemic wild banana genetic resources from Assam and Arunachal Pradesh. Two exploration missions were organised to collect the endemic diversity which resulted in the collection of 23 accessions (Assam-14 accessions & Arunachal Pradesh-9 accessions). Random sampling method was followed for the collection of wild banana accessions from populations located in forests and partially disturbed areas. Suckers were collected and conserved in field gene bank. Considering its importance of wild Musa diversity in the region and for planning proper conservation strategies, an ecological niche modelling using Maximum entropy species distribution method had been conducted to assess potential pockets for the distribution and conservation of wild banana genetic resources in other parts of the country. DIVA-GIS version 7.5 used for converting the ASCII file generated using maximum entropy method. Grid maps were generated for both Current and Future climates. Bioclimatic variables were used for modelling. Under the current climatic regime potential pockets for its in-situ conservation cultivation exists in parts of Assam, Arunachal Pradesh Sikkim, Tripura, Manipur and Meghalaya. The grid map generated for future climate (year 2050) indicated the potential pockets from the states would come down.

Hastuti *et al.* (2019) carried out a study on diversity wild banana species (*Musa* spp.) in Sulawesi, Indonesia. This study focused on species of wild bananas found in Sulawesi. Observation was carried out in the field as well as using a collection herbarium and living specimens. Identification was done by matching the sample with herbarium and relevant references. The results showed that there were four species of wild bananas found on the island of Sulawesi. These were *Musa balbisiana* Colla, *Musa acuminata* Colla var. *zebrina* (v.Houtte) Nasution, *Musa acuminata* Colla var. *banksii* (F.Muell.)

N.W Simmonds, *Musa acuminata* Colla var. *lutraensis*, *Musa acuminata* Colla var. *sigiensis*, *Musa acuminata* Colla ssp. *microcarpa* Becc., *Musa borneensis* Becc. and *Musa textilis* Nee. Four wild banana accessions had never been reported before. These were *Musa acuminata* var. *zebrina*, *Musa acuminata* var. *lutraensis*, *Musa acuminata* var. *siginenesis* and *Musa borneensis*.

Rajappa *et al.* (2019) conducted a survey in diversity of *Musa* genetic resources explored through rural weekly markets of Meghalaya in Ri-bhoi district and two markets of Garo hills in Meghalaya. Many cultivars like Jahaji, Cheini Champa, Malbhog, and indigenous varieties were found in the markets where the survey was conducted. In the survey, we found that in-situ conservation and planting of wild bananas was limited to a few households.

Das *et al.* (2020) conducted a study on a new seeded diploid accession of *Musa laterita* of section *rhodochlamys* from Gangtok, Sikkim, India with morphology, chromosome number and genome size. *Musa laterita*, a wild species of Gangtok of Indian occurrence was described for the first time morphologically, compared with the existing two accessions of *Musa* Germplasm Information System (MGIS) data and found different in 18 morphological characters against the recorded 117 morphological data as Simmonds (1962) morphological index suggesting its genome of AB. This species has upright inflorescence and very small 7.6–8.9 cm seeded fingers (yellow skinned after ripening with sweet pulp) on 2-3 hands (4 to 5 finger each). The somatic chromosome number recorded was 2n=22 with total chromosome length and volume were 42.6 μm and 18.8 μm3 respectively in the karyotype. The flow cytometric analysis confirmed the 2C DNA content for the first time was 1.302 pg and calculated genome size of 637 Mbp. Detailed genomic characterization of diploid seeded wild banana could be used as a progenitor in the banana breeding program for crop improvement by introgressing the wild disease resistant traits in cultivated banana for their conservation and sustainable utilization.

Shankar *et al.* (2020) studied on genetic diversity of fruits in North East region of India. Bhat Manohar, a natural tetraploid with an ABBB genome, was discovered for the first time in the world in North East India. New natural mutant of *Musa velutina* intersectional hybrid *M. acuminata x M. ornata* have been recorded from Indo-china border of Arunachal Pradesh.

Arne *et al.* (2021) evaluated the genetic diversity and structure of *Musa balbisiana*, important crop wild relatives of plantains, dessert and cooking bananas. They screened the genetic variation and structure present within and between 17 Vietnamese populations and six from China using 18 polymorphic SSR markers. Relatively high variation was found in populations from China and central Vietnam. Populations from northern Vietnam showed varying levels of genetic variation, with low variation in populations near the Red River. Low genetic variation was found in populations of southern Vietnam. Analyses of population structure revealed that populations of northern Vietnam formed a distinct genetic cluster from populations sampled in China. Together with populations of central Vietnam, populations from northern Vietnam could be subdivided into five clusters, likely caused by mountain ranges and connected river systems. We propose that populations sampled in central Vietnam and on the western side of the Hoang Lien Son Mountain range in northern Vietnam belong to the native distribution area and should be prioritised for conservation. Southern range edge populations in central Vietnam had especially high genetic diversity, with a high number of unique alleles and might be connected with core populations in northern Laos and southwest China. Southern Vietnamese populations were considered imported and not native.

2.2 Plant morphological and physico-chemical attributes of *Musa* spp.

Simmonds and Shepard (1955) developed a taxonomic scoring method to classify the edible bananas and to provide evidence on their evolution. Edible diploid forms of *Musa acuminata* were thought to be the primary source of the whole group to which another species, *M. balbisiana*, has contributed by hybridization. Thus, there exist diploid and triploid edible forms of *M. acuminata* and diploid, triploid and tetraploid hybrid types of genetic constitutions that vary according to their histories. There was a faint possibility that a third wild species baa contributed to the origins of a small group of triploid hybrid types. Tri ploidy was probably established under human selection for vigour and fruit size; tetra ploidy was inexplicably rare. The centre of origin of the group was Indo-Malaya and Malaya was probably the primary centre. The two Linnaean species *M. paradisiaca* and *M. sapientum* refer to identifiable edible varieties which were both shown here to be of hybrid origin. The names therefore may be rejected from the nomenclature of the wild bananas.

Valsalakumari and Nair (1993) conducted a study on morphological characters, taxonomic scoring and chromosome numbers of 100 South Indian banana cultivars. The study revealed that many of the cultivar names were synonymous. The cultivars Sanna Chenkadali (AA) and Eraichivazhai (AA) had some characteristics of *Musa balbisiana*. Diploid clones occurred more frequently than has been suggested by Simmonds. The cultivars Krishna vazhai, Vannan, Virupakshi, Sirumalai, Agniswar, Padali Moongil, Kostha Bontha, and Venneettu Mannan were added to the genomic group AB. In the groups AAB and ABB, cultivars exhibited the characteristic traits of *Musa acuminata* and *M. balbisiana* in various degrees. The groups AB, AAB, and ABB were common in the cultivated bananas of India.

Osuji *et al.* (1995) conducted a study on morphological characterisation of *Musa* cultivars. *Musa* cultivars were grown worldwide in the tropics constitute an important source of food. The International Institute of Tropical Agriculture (IITA) *Musa* gene bank contained over 300 accessions including plantains and bananas. Quantitative phenotypic descriptors show that small French plantain cultivars appear to be mutants of giant French plantain cultivars. Quantitative reproductive features such as flowering time and fruit size can be used to distinguish plantain from bananas whereas vegetative features alone could not be used to distinguish between banana cultivars or plantain cultivars. The *Musa* gene bank at IITA is an important source of alleles for the development of new *Musa* cultivars.

Ortiz (1997) evaluated the extent of morphological variation of the *Musa* germplasm maintained in the gene-bank of the International Institute of Tropical Agriculture in southeastern Nigeria. Qualitative and quantitative descriptors were used to evaluate AA, BB, AB, AAA, AAB, AAAA, AAAB and AABB bananas, AAA and ABB cooking bananas, AAA beer bananas and AAB plantains and a few wild species. Univariate and principal component (PCA) analyses were performed to identify the most important descriptors to characterize and classify *Musa* germplasm collections. The quantitative descriptors have a high heritability (>0.8), high repeatability (>2.0) and low coefficient of variation (9–15%) with the exception of the height of the tallest sucker. The paper also proposes a new scientific nomenclature for the triploid *Musa* cultivars.

Muhammad *et al.* (2002) characterized fourteen populations of *Musa acuminata* ranging from populations in the lowlands of northern (*Siamea* ssp.) to central Malaysian region (*Malaccensis* spp.) and highland banana (*Truncate* spp.) based on chromosome number and 46 morphological characters. A large amount of variation was observed within the populations. However, only highland bananas appeared morphologically distinct. Lowland populations both from northern and central Malaysia were found to be overlapping and no distinguishing pattern was observed. The morphological characters found variable within these populations were related to developmental changes and mutations.

Det *et al.* (2004) collected 309 wild bananas from five national parks. All samples were examined through classical taxonomy, then major qualitative characteristics were classified into 7 groups. Meanwhile, Hierarchical and K-mean cluster analysis used numerical taxonomy to report examination with these characteristics. There were 7 characteristics of species identification criterion, while other 13 characteristics were subspecies. All samples were classified into 7 groups at 5 units of re-scaled distance with 80% of similarity by Heirarchical cluster analysis. In addition, the similar classification results which were re-approved by K-means cluster analysis and non-significantly different at P=0.05 from Heirarchical cluster analysis. Discriminant analysis was shown the probability of precise separation and prediction into 7 groups of both cluster techniques at 83-100% with the original and cross validated methods. Both results from numerical morphological classification were synchronized and non-significantly different from the result of classical morphological taxonomy with Pearson Chi-square test (P=0.05). Sample in the group 6 was highly different from *M. acuminata* Colla with its erect rachis position that should be a new wild banana group. It was very interesting to focus on re-identification of this sample through banana taxonomic system. The prominent strong convolute with significant 1/3 bright green tip of male bud of the group 2 which was also interesting and might be a new promising subspecies of *M. acuminata* Colla.

Pillay *et al*. (2006) conducted a study to determine the ploidy levels and genome composition of the *Musa* germplasm collection, constituting over 300 accessions, at the International Institute of Tropical Agriculture in Nigeria and Uganda. Flow cytometric analysis of nuclear DNA content was used to estimate ploidy levels while genome composition was ascertained with RAPD markers that were specific for the A and B genomes of *Musa*. It was determined that at least 8% of the plants in the germplasm collection were miss-classified in terms of ploidy and/or genome composition. The cultivars 'Pisang awak', 'Foulah 4' and 'Nzizi', previously classified as triploids, were found to be tetraploids by flow cytometry and conventional root tip chromosome counts. Similarly, cultivars that were previously classified as diploids including ‘Too’, and ‘Toowoolee’ were found to be triploids in the analysis. Ploidy and genome classification in *Musa* was generally determined from morphological characteristics. While the study showed that such a system was not always reliable, it was interesting to find that none of the plantains in the germplasm collection were miss-classified with regards to both ploidy and genome composition.

Selatsa *et al*. (2009) carried out a study to assess the extent and cause of intra-field morphological diversity in plant communities of plantain farmers in Cameroon. Vegetative propagules ascribed by farmers to the popular varieties Asang-Da, Ebang, Elat and Essong were field established at the research stations of the International Institute of Tropical Agriculture for phenotypic evaluation. None of the varieties appeared to be a community of unique morphotypes with average similarity indices of 46.5% for Asang-Da, 48.3% for Ebang, 49.4% for Elat and 55.8% for Essong confirming the mixture nature of the varieties. Inter-variety phenotypic similarity coefficient ranged from 41.7% (Ebang vs Elat) to 45.0% (Ebang vs Essong) equally showing considerable overlaps, yet sufficient phenotypic differentiation between the varieties. Many migrants, being more distantly related to individuals in their respective assigned groups than to individuals ascribed to other groups, were identified in all variety groups, except Ebang.

Issirep and Mera (2010) evaluated the anatomical character and morphology of fives Indonesian banana cultivars based on their level of ploidy. The samples of roots, rhizome and leaf were collected from five banana cultivars i.e. *Musa acuminata* cv. Penjalin, *M. balbisiana* cv. Kluthuk warangan, *M. acuminata* cv Ambon warangan, *M. paradisiaca* cv Raja nangka and *M. paradisiaca* cv Kluthuk susu. Stem and leaf morphology character of diploid level (AA and BB genome) was different with triploid level (AAA, AAB, and ABB genome). Anatomy and morphology character of root and rhizome of banana in diploid level (AA and BB genome) and triploid level (AAA, AAB, and ABB genome) was quite similar. Distribution of stomata was found in leaf and pseudostem. Stomata were found in adaxial and abaxial epidermis layer. The size of guard cells in triploid cultivars was longer than the diploid cultivars. The root composed of epidermis layer, cortex and cylinder vascular of five cultivar's root show anomalous structure. Anatomically, there were no differences in the rhizome structure among five banana cultivars. The row of vascular bundles acted as demarcation area between peripheric and central zone. In the cultivar with BB genome (diploid) and ABB genome (triploid) the row of vascular bundle was not found.

Onyango *et al.* (2011) conducted a study to identify morphological characters that distinguish the various subgroups of AAB dessert bananas found in East Africa and from other cultivated AA Muraru bananas and to evaluate the relationship among the AAB and among the AA Muraru banana groups of East Africa in relation to other bananas. Forty-three (43) cultivars of AAB, AA groups and out-groups from a large banana collection at the Kenya Agricultural Research Institute, Kisii were characterised in 2007 using morphological traits. Morphological data were collected using 84 characters derived from a modified version of the descriptors for bananas developed by Biodiversity International in conjunction with CIRAD. Techniques of multivariate analysis were employed. Based on unweighted pair group using arithmetic mean (UPGMA), two major clusters of *Musa acuminata* derived cultivars (AAs and AAAs) and hybrids of *Musa balbisiana* and *M. acuminata* (AAB) were produced. Within the major clusters were subclusters conforming to various subgroups. Within the AAB dessert cluster, four distinct subclusters were formed, *i.e.,* Sukari Ndizi, Prata, Mysore and Silk. Muraru also formed a well-defined cluster. Thirty-three (33) characters contributed 71 % of the total variation within the 43 accessions on the first and second principal components, allowing separation of clusters corresponding to genome groups and subgroups.

Lalrinfela and Thangjam (2012) reported that various wild and edible banana and plantains were found in the state of Mizoram. Fourteen varieties of banana were collected and characterized using morphological parameters. Ten varieties were identified under *Musa paradisiaca*, one under *M. acuminata* and one under *M. balbisiana*. In addition, two other varieties were identified as *Ensete glaucum* and *M. ornata* respectively. Based on the morphological scores, the genome groups of twelve varieties belonging to *Eumusa* section were established under AB, AAB, ABB, AAA, BB and ABBB groups.

Tapre and Jain (2012) analysed three advanced stages of maturity of banana cv. Robusta *i.e*., stage 5, 6 and 7 for their physico-chemical and mechanical properties. Fruits were treated with 500 ppm ethrel solution and kept for ripening under controlled conditions at 20±1°C and maturity stages were selected on the basis of the standard colour chart. As the ripening progressed, various physical changes observed in fruit such as increased in pulp to peel ratio, decreased in the intensity of greenness of peel and also polyphenol oxidase activity decreased. Mechanical properties decreased significantly from stage 5 to stage 7. A similar trend was observed for other mechanical properties such as cohesiveness, chewiness, fracture force and stiffness during the different stages of ripening. Moisture content, titratable acidity, pectin content, total sugar and TSS of pulp showed an increasing trend from stage 5 to stage 7 whereas starch content progressively decreased during ripening.

Karuna and Rao (2013) observed the growth and yield of different cultivars of banana at three different places of Visakhapatnam district, Andhra Pradesh. Six banana cultivars were taken viz., Karpura Chakkarakeli, Dwarf Cavendish, Robusta, Rashtali, Thella Chakkarakeli and Yenugubontha. Maximum plant (pseudostem) height, pseudostem girth, number of suckers at harvest and petiole length was recorded in Yenugubontha. The highest leaf length, width and total leaves per plant were recorded in Robusta. Similarly, more leaf area, LAI was registered in Robusta. The highest bunch weight and per ha yield was recorded in Robusta whereas, finger length, girth, weight and finger volume were maximum in Yenugubontha.

Fahrasmane *et al.* (2014) analysed the importance of banana on health preservation potentialities. The medicinal properties of banana were part of the folk medicine of all tropical countries. Bananas were used in special diets where ease of digestibility, low fat, minerals and vitamins were required. These special diets were used for babies, the elderly and patients with stomach problems, gout and arthritis.

Hapsari *et al.* (2014) conducted an inventory of wild *Musa* species in Purwodadi Botanic Garden. Total 17 wild *Musa* accessions has been recorded planted in Purwodadi Botanic Garden since 1990 until 2012; comprised of eight *Musa acuminata* sub species, two *Musa balbisiana* forms, one *Musa ornata*, one *Musa troglodytarum*, one *Musa borneensis* and four unidentified species. Morpho-taxonomic review of those eight wild *Musa* accessions remained will be discussed in this paper including their geographical distributions. According to its differentiated morphological characteristics observations, it is known that there were three accessions were resembled cultivars and one unidentified species have been determined its species level, so that their registration identity needs to be revised. It is important next to prioritize ex-situ conservation of wild *Musa* species not yet collected in Purwodadi Botanic Garden especially from Eastern Indonesia.

Sagar *et al.* (2014) evaluated twenty-three genotypes for growth and yield. The highest leaf length (166.67 cm) and leaf area (0.82 m^2) were observed in Robusta genotype. Whereas, the lowest leaf length (123.63cm) and leaf area (0.45m^2) were recorded in the genotype Mitli. Among the genotypes evaluated, the genotype Mitli performed very poor with the lowest yield (3.84 t/ha). From the investigation, it concluded that the genotype Hanuman was suitable to maximize the yield under Northern Dry Zone of Karnataka.

Wahengbam *et al*. (2014) conducted an analysis on banana genome groups of wild and cultivated species of Manipur using score card. It was found there were many indigenous banana varieties in Manipur as wild and cultivated forms, some banana Pseudo stem and male buds were used as medicinal plants for women, some groups were very costly because of their rarity of cultivation and used only in holistic purpose. Some wild species of bananas like *Ensete glaucum, Musa cheesmanii, M. magnesium, M. balbisiana, Musa laterita,* etc. have been recorded from the state. Many domesticated bananas have proved to be triploid, (2n=3x=33) with genome constitution of AAA, AAB or ABB. There were also seedless cultivated AA and AB diploid, and tetraploids (2n=4x=44) with genome constitution of AAAA, AAAB, AABB and ABBB.

Atom *et al.* (2015) studied the taxonomic identification and genomic classification of banana in Manipur. A total of 27 cultivars were collected in the present study. Of all the cultivars, *Musa balbisiana* clone was represented by 3 cultivars; 8 cultivars were identified under *M. acuminata* clones. Majority of the cultivars (16) were identified as *Musa species*, hybrid of *M. balbisiana* and *M. acuminata*. Among these cultivars, 3 cultivars were classified under BB genome while 3 cultivars were classified under the AA genome group. The ABB genome group was represented by 13 cultivars. 5 non-seeded cultivars were classified under AAA genome group and the AAB group was also represented by 3 sweet smelling cultivars.

Phanideepthi (2016) studied the scoring technique in *Musa balbisiana* which ranges from 15-75 depending upon the genomic group. Evolution of modern banana was chain reaction of *Musa acuminata* and *Musa balbisiana*.

Sunandar and Kahar (2017) studied on the morphological and anatomical character of Pisang Awak in West Kalimantan, Indonesia. In this study, Pisang Awak were collected from Padang Tikar I village, Batu Ampar Sub-district, Kubu Raya district, West Kalimantan. Morphological characterizations were conducted by following the instruction on Descriptors for Banana (*Musa* spp.) from IPGRI. In the future, morphological and anatomical character in Pisang Awak could be applied as the basis of information for breeding programs of banana cultivars and classification.

Chang *et al.* (2018) conducted a study and classified 19 *Musa* species and cultivars based on morphological characters. Fifteen morphological characters for *Musa acuminata* and *M. balbisiana* and 50 morphological characters adapted from International Union for the Protection of New Varieties of Plant (UPOV) codes were employed to elucidate the phylogenetic relationship between both banana species. Analyses of genetic similarity based on all of these morphological characters suggested that bananas with A-genomes were in the same cluster. Moreover, a genetic similarity coefficient of 0.36 was obtained between *M. acuminata* and *M. balbisiana* in the analysis with the 15 morphological characters for both species and 0.47 in the analysis with 50 UPOV–based morphological characters. Moreover, principal component analysis (PCA) of the 15 morphological characters suggested that

PC-1 and PC-2 together explained 78.6% of the total variance. A PCA with 50 UPOV–based morphological characters indicated that PC-1 explained 80.6% of the total variance, for which the main variables were pseudostem length, leaf blade length, and peduncle length. PCA of the 15 morphological characters showed that ‘Pei Chiao’, ‘Giant Cavendish’, and ‘Dwarf Cavendish’ were proximal in the PCA scatterplot. Notably, the PCA of 50 UPOV–based morphological characters indicated that ‘Pei Chiao’ and ‘Giant Cavendish’ were near each other in the PCA scatterplot, suggesting that they were phylogenetically related. The PCA of *M. itinerans* var. *formosana* with 15 morphological descriptors showed that this variant was phylogenetically distant from *M. acuminata* and *M. balbisiana* accessions.

Dhimal *et al.* (2018) evaluated the morphological and compositional characters of six commonly grown varieties of banana in Hilley and Shompangkhag under Sarpang. Using quantitative characters, through cluster analysis, they were grouped into four. Significant difference was observed in pseudo-stem height, pseudo-stem diameter, leaf blade length, leaf blade width, peduncle width, number of fingers per hand, finger length and finger weight. No significant difference was observed in bunch weight among six varieties. Peduncle length was similar among the varieties. Bunch weight was correlated with peduncle width and number of fingers per hand. Qualitative characters related to leaf, growth habit, bunch, rachis, male bud, bracts, male flower and fingers were observed. Dhusrey had generally different characters compared to other varieties. Through cluster analysis on compositional characters, they were grouped into two. Significant difference was observed in pulp pH and dry matter content while no difference was found in TSS, ash and protein content among six varieties. Compositionally Jhaji had comparatively different characters while others were similar.

Joseph and Simi (2018) conducted a study to characterize the various ecotypes of plantain with respect to clonal characteristics and yield potential. The study revealed that considerable variability existed between the different ecotypes of plantain. The ecotypes varied significantly with respect to all the clonal characters studied, except the number of ridges. Mettupalayam Nendran produced the highest yield but it had long duration. Zanzibar and Big Ebanga were superior in terms of finger characteristics. PSI (Pedicel Strength Index) was recorded highest in Mettupalayam Nendran (3.17) which was significantly higher than all other clones.

Anu *et al*. (2019) characterized a commonly used varieties of banana morphologically and genotypically based on International Plant Genetic Resources Institute, 1984 (Descriptors for banana *Musa* spp.) and RAPD analysis. Five varieties were morphologically similar in parameters such as leaf habit, pseudo stem appearance and peel colour. RAPD analysis proved that these varieties of banana were closely related which coincides with the morphological characterization.

Vilhena *et al.* (2019) conducted a study on morpho-anatomy of the inflorescence of *Musa* × *paradisiaca*. This work was aimed at studying the morphological and anatomical characteristics of the inflorescences of *Musa* × *paradisiaca* L., which could contribute to the characterization of these species cultivated in Brazil. Plant materials were collected and prepared in accordance with standard optical microscopy techniques. Morphological characterizations were conducted using morphological descriptors for inflorescences, including some descriptors from International Plant Genetic Resources Institute for Musa spp. Microscope slides were prepared using glycol-methacrylate and were stained in toluidine blue. Main features observed for *M.* × *paradisiaca* inflorescence were amphistomatic bracts with tetracytic stomata, fiber caps next to the phloem, adaxial and abaxial uniseriate epidermis, and papillose on the abaxial face. Outer tepals have multilayer epidermis and vascular bundles aligned next to the abaxial face. Free tepal has unilayered epidermis. Anthers were tetrasporangiate and the locules were separated by the septum. Ovary was inferior and trilocular with external unilayered and internal epidermis. The main morpho-anatomical characteristics of inflorescence of Musa × paradisiaca were highlighted in this study, contributing to provide more information about the characterization of this species cultivated in Brazil.

Ernawiati *et al.* (2020) conducted an experiment to determine the differences in the morphological structure of flowers among the Pisang Kepok cultivars with each other. The research was carried out in two stages. First, field sampling in residential area of Bandar Lampung City, Pesawaran Regency and South Lampung Regency. Second, morphological characterization based on the parameters determined. The results revealed that the cultivar Pisang Kepok had been observed to have almost the same morphological structure except in Kepok Batu. The specific character of Pisang Kepok batu can be seen in the character of the colour of pollen sacs, compound tepal pigmentation, free tepal colour, free tepal apex shape and pistil shape.

Ismail *et al.* (2021) conducted an experiment on genetic relationship analysis on five species of Banana (*Musa Paradisiaca*) based on morphological characteristics in Majalengka Regency, Indonesia. This study aimed to determine the relationship between 5 local genotypes of banana in Majalengka Regency, Indonesia. They are Apuy, Roid, Latundan, Raja Bulu and Raja Dengkel bananas. The research methodology used was direct method in the form of field survey method that was descriptive and morphological characterization. The characters observed were all characters included in the banana descriptor. Observational data analysis was tested based on kinship test. The kinship test was carried out to determine the closeness of the kinship relationship between Apuy, Roid, Latundan, Raja Bulu and Raja Dengkel bananas. Data analysis was done using Mega6 software. The findings show that Apuy, Latundan and Raja Dengkel bananas has a closer relationship than other bananas.

Thatayaone *et al.* (2022) conducted an experiment on morphological and horticultural characteristics of six cultivars of banana fruits (*Musa spp.*) that were commercially grown in Kerala, belonging to different genomic groups *viz.* Nendran (AAB), Pisang Lilin (AA), Karpooravalli (ABB), Njalipoovan (AB), Grand Naine (ABB) and Yangambi (KM-5) (AAA) were evaluated. The morphological traits were characterized using Banana Descriptors established by IPGRI (1996), from which 9 characters were selected for quantitative analysis. Horticultural characters on variables such as number of fruits per bunch, fruit length (cm), fruit pedicel length (mm), fruit pedicel width (mm), peel thickness (mm), pulp weight (g), fruit to peel ratio, fruit flesh firmness (cm^2kg^{-1}) was analysed and subjected to one way ANO-VA to determine the significance (*p*=.05). The cultivar Nendran (AAB) exhibited large morphological and horticultural traits, particularly for the fruit length (22.07cm), pulp weight (89.20g) and peel weight (49.30g). The cultivar Karpooravalli (ABB) was smaller in terms of the fruit length (10.67 cm) and peel weight (9.65g), but had a large (4.81) fruit: pulp ratio compared to other cultivars studied. The present work reveals substantial morphological and horticultural variation among banana cultivars of different genomic groups, with an overlap of similarities and differences even in banana cultivars having the same genomic group.

2.3 Variability based on biometrical analysis of collected *Musa* spp.

Lorenna *et al.* (2010) characterized 26 banana accessions of the active gene bank of Embraga Cassava and Tropical Fruits (Brazil) for agronomic, physical and physicochemical characteristics. The plant height of the diploid

028003-01 and triploid Walha was short. Regarding the number of fruits and bunch weight, triploids Caipra, Thap Maeo and the tetraploids Ambrosia and Calipso performed particularly well. Total carotenoid contents were highest in the diploids Jaran and Malbut. The total contents of flavonoid and polyphenol, two natural antioxidants, were highest in tetraploid Terapod. Wide genetic variability was detected for most agronomic, physical and chemical characteristics of the fruits of the banana accessions.

Rajamanickam and Rajmohan (2010) evaluated six palayankodan ecotypes of banana belonging to AAB genomic group for genetic variability among quantitative traits. Genotypic and phenotypic coefficient of variation, heritability and genetic advance were estimated for eighteen traits that included plant height, pseudostem girth, number of leaves per plant, leaf width, number of suckers per plant, days taken from planting to shooting, total crop duration; length, girth, weight and volume of finger; hand weight, bunch weight, number of fingers per bunch, number of fingers per hand, ripe-fruit weight, sugar/acid ratio and pulp weight. Remarkable variability was observed among the collections for these characters. Bunch weight, number of fingers per bunch and number of suckers per plant with very high value of PCV, GCV, heritability and genetic advance makes it prime traits for direct selection. Plant height, pseudostem girth, total crop duration, sugar: acid ratio, finger length and days taken from planting to shooting recorded high value of heritability and moderate value of genetic advance. PCV were other important traits which need to be considered for selection. The volume of finger with low values for GCV, PCV, heritability and genetic advance as percent of mean implies that it was highly influenced by environment and should not be taken as a criterion for selection. Plant height, total crop duration, sugar: acid ratio, finger length, pseudostem girth, number of fingers per bunch and days taken from planting to shooting showed high genetic advance and heritability and important characters to be considered for selection of ecotypes.

Mohammed *et al*. (2014) evaluated the genetic variation among 4 local and 11 introduced desert banana (*Musa* spp.) genotypes. Genetic variability components analyses were conducted considering 20 morpho-physicochemical traits. Phenotypic and genotypic coefficient of variations ranged from 8.95 to 52.63% and 7.2 to 48.16%, respectively, with low magnitude of differences and moderate to high for most of the traits. Heritability (H^2) and genetic gain (GA) values were ranged from 14.69 to 98 and 7.4 to 81.45%, respectively, and both H^2 and GA values were high and moderate for 16 traits. Fruit yield showed strong genotypic and phenotypic correlations with all growth traits and yield components with higher magnitude of genotypic correlation coefficients. Euclidean distance ranged from 2.36 to 7.6 which distinctly grouped genotypes into two clusters and five sub-groups. Moreover, the local clones were more distant each other and with introduced genotypes and performed better than introduced genotypes for most of the traits including fruit yield. The study revealed the presence of genetic variation among local and introduced genotypes and most of the traits were controlled more of by genetic factors.

Sawant *et al.* (2016) carried out an investigation to assess growth, yield performance and the extent of genetic variation in thirty banana genotypes in West Coastal Zone of India for fourteen characters. The genotypes showed substantial variation and the PCV were found greater than GCV for all the characters studied. High heritability in broad sense (h2b) coupled with high genetic advance (GAM) was noticed for ‘number of living leaves at harvest’ and ‘fruit peel thickness’ indicating the role of additive gene action. The important yield characters *viz*., bunch and fruit weight with high PCV, GCV, heritability and moderate to high GAM were proved as the primary selection criteria. The genomic group AAA was found better than others in both yield and quality characters at a time. The genotypes ‘Pache Bontha Bathesa’ (ABB) and ‘Udhayam’ (ABB) were found high yielding but considering quality characters, ‘Grand Naine’ (AAA) was found as the best in ecological conditions of the West Coastal Zone of India.

Smrutirekha and Das (2018) conducted an experiment to study thirteen cooking banana genotypes laid out in a Randomize Block Design with 5 replications at All India Coordinated Research Project (Banana), Horticultural Research Station, Bhubaneswar, Odisha. On the basis of mean performance, plant morphology and quantitative yield parameters were recorded. Maximum pseudostem girth, total number of leaves, average number of hands, fingers and bunch weight was recorded in Bantala Sambalpuri (Patiapalli). Least pseudostem height, girth, bunch weight was recorded in Dakhinisagar. Analysis of variance among 13 genotypes showed significant difference for all characters studied. Highest genotypic coefficient of variation (GCV) and phenotypic coefficient variation (PCV) was observed for number of fingers per bunch, number of hands per bunch and bunch weight indicating selection for such characters would be more reliable to be used as selection for crop improvement. High degree of heritability estimates was obtained in case of length and breadth of leaf, number of fingers per bunch. High genetic advance was observed for number of fingers per bunch and pseudostem height indicating predominance of additive gene effects and possibilities of effective selection for the improvement of these characters.

Thirugnanavel *et al*. (2018) conducted a study on evaluation of genetic variability in the wild Musa spp suitable for ornamental value. The studies were carried out to evaluate five wild banana (*Musa* spp.) and three hybrids for morphological characters and their suitability of ornamental value based on 12 quantitative and 6 qualitative traits at NRC for Banana, Tiruchirappalli. The results showed that all the eight species varied significantly for all the traits. The wild were dwarf (<1.0 m height) and slender (<20 cm stem girth) and recorded an average of 7-9 leaves/plant. The hybrids were larger (>1.0 m height) and little sturdy (>30.0 cm stem girth). The wild bananas recorded an average of 4 hands/bunch and 4 fruits/hand while hybrids recorded more than 4 hands/bunch and 10 fruits/hand. The inflorescence was erect and bract colour ranged from lilac, brick-red, red, yellow and pink. Based on the study, the wild bananas were highly suitable for potted plants, cut flowers, male inflorescence and landscape plants while hybrids were suitable only for landscape purposes.

Joga *et al.* (2020) carried out phytochemical investigations on the therapeutic properties of *Ensete glaucum* (Roxb.) Cheesman. The traditional Khasi tribal community of North-East India cite the use of pseudostem sap for diarrhoea cure. They screened pseudostem sap for the presence of amino acids, cardiac glycosides, flavonoids, polyphenols, alkaloids, reducing sugars, starch, saponins, tannins, terpenoids and oils and fats. Standard tests confirmed the presence of flavonoids, reducing sugars, terpenoids, saponins, cardiac glycosides and alkaloids, which together contribute to the curative property of the sap. Polyphenol content was found to be 10.59 mg GAE mL^{-1} and total antioxidant capacity estimated was 54.538 mg AAE mL^{-1}, whereas, total flavonoids were measured at 2.52 mg QE mL^{-1} of fresh sap

Rajamanickam (2020) evaluated the genotypic and phenotypic coefficient of variation, heritability, genetic advance and correlation coefficient of Nendran ecotypes of banana for seventeen traits which included plant height, number of suckers per plant, number of leaves per plant, leaf width, days taken from planting to shooting, bunch weight, bunch length, hand weight, number of fingers per bunch, number of fingers per hand, length, girth, weight and volume of finger, ripe fruit weight, sugar: acid ratio and pulp weight. A remarkable variability was observed among the collections for these characters. All the characters showed the highest estimates of broad sense heritability whereas genetic advance as percentage of mean recorded higher in traits such as volume of finger, finger weight, ripe fruit weight, pulp weight and number of fingers per bunch. The value of high PCV, GCV, heritability and genetic advance makes it a prime character for the direct selection. Weight of finger, bunch weight, volume of finger and number of fingers per bunch showed high genetic advance and high heritability were the other important characters which have to be considered for selection of the ecotypes.

Rajamanickam and Rajmohan (2020) conducted a study to determine the variability, heritability, genetic advance and correlation for their eighteen morphological and quality traits. The genotypic and phenotypic coefficient of variance, heritability and genetic advance were estimated for eighteen traits. The high magnitude of PCV and GCV were recorded for number of fingers per bunch, ripe fruit weight, pulp weight, sugar: acid ratio, finger weight and number of suckers per plant. All the characters showed higher estimates of broad sense of heritability whereas genetic advance was recorded very high in bunch weight, followed by finger weight, ripe fruit weight, pulp weight and number of fingers per bunch. Regarding correlation studies, bunch weight had significantly positively correlated with plant height, pseudostem girth, number of leaves per plant, leaf width, days taken for planting to flowering, number of fruits per bunch, number of fruits per hand and hand weight.

2.4 *Ex-situ* conservation of selected clones.

Harrison and Schwarzacher (2007) reviewed on domestication and genomics for banana. They wrote over a thousand domesticated *Musa* cultivars and their genetic diversity indicating multiple origins from different wild hybrids between two principle ancestral species. They described a challenge to banana production from virulent diseases, abiotic stresses and new demands for sustainability, quality, transport and yield. Within the gene pool of cultivars and wild species there were genetic resistances to many stresses. Genomic approaches were rapidly advancing in *Musa* and had the prospect of helping enable banana to maintain and increase its importance as a staple food and cash crop through integration of genetically, evolutionary and structural data, allowing targeted breeding, transformation and efficient use of *Musa* biodiversity in the future.

Jesus *et al.* (2013) conducted an experiment on genetic diversity and population structure of *Musa* accessions in ex-situ conservation in which he found that banana cultivars were mostly derived from hybridization between wild diploid subspecies of *Musa acuminata* (A) and *Musa balbisiana* (B) and they exhibited various levels of ploidy and genomic constitution. The Embrapa ex situ *Musa* collection contains over 220 accessions, of which only a few have been genetically characterized. Knowledge regarding the genetic relationships and diversity between modern cultivars and wild relatives would assist in conservation and breeding strategies. The objectives were to determine the genomic constitution based on Internal Transcribed Spacer (ITS) regions polymorphism and the ploidy of all accessions by flow cytometry and to investigate the population structure of the collection using Simple Sequence Repeat (SSR) loci as co-dominant markers based on Structure software, not previously performed in *Musa*. From the 221 accessions analysed by flow cytometry, the correct ploidy was confirmed or established for 212 (95.9%), whereas digestion of the ITS region confirmed the genomic constitution of 209 (94.6%). Neighbour joining clustering analysis derived from SSR binary data allowed the detection of two major groups, essentially distinguished by the presence or absence of the B genome, while subgroups were formed according to the genomic composition and commercial classification. The co-dominant nature of SSR was explored to analyse the structure of the population based on a Bayesian approach, detecting 21 subpopulations. Most of the subpopulations were in agreement with the clustering analysis. The data generated by flow cytometry, ITS and SSR supported the hypothesis about the occurrence of homologue recombination between A and B genomes, leading to discrepancies in the number of sets or portions from each parental genome. These phenomenon have been largely disregarded in the evolution of banana, as the “single-step domestication” hypothesis had long predominated. These findings will have an impact in future breeding approaches. Structure analysis enabled the efficient detection of ancestry of recently developed tetraploid hybrids by breeding programs, and for some triploids. However, for the main commercial subgroups, Structure appeared to be less efficient to detect the ancestry in diploid groups, possibly due to sampling restrictions. The possibility of inferring the membership among accessions to correct the effects of genetic structure opens possibilities for its use in marker-assisted selection by association mapping.

Dayarani *et al.* (2014) conducted an experiment on conservation of wild bananas (*Musa* Spp.) through seeds and improved regeneration through seed treatments. The influence of maturity and hormonal factors affected germination and regeneration of *Musa ornata* seeds through embryo culture and embryo rescue. Embryos extracted from seeds harvested at various maturity stages were cultured in MS media with different concentrations of plant growth regulators. Good embryo recovery was seen in seeds from 80% and 100% mature fruits. Maturity status of embryos played a key role in direct and indirect regeneration. Medium rich in auxins led to callus (M8) formation at all maturity levels, leading to indirect regeneration. Good direct regeneration was observed from 100% mature embryos, in media supplemented with 6-benzylaminopurine (M4). Study revealed that zygotic embryos of *M. ornata* could be rescued and regenerated through callus when harvested at 80% maturity and media augmented with Kinetin (M6) gave the best regeneration. In general, medium rich in auxins led to callus formation at all maturity levels. Therefore, *in vitro* embryo culture and embryo rescue provide a potential tool for recovery and perpetuation of wild *Musa* species.

Hernández *et al.* (2014) evaluated the effect of different treatments on seed germination *in vitro*. Fresh seeds and seeds were stored for two or four months. Treatments comprised of exposure of endosperm, mechanical scarification, immersion in gibberellic acid, excised zygotic embryos and chemical scarification with sulphuric acid (H2SO4) for different immersion periods. Germination occurred only with excised zygotic embryos or following chemical scarification. In the case of excised zygotic embryos, germination was _ 90% after 21 days, with significant seedling development in both fresh and stored seeds. Seed immersion in H2SO4 for five minutes resulted in 16% germination after 90 days. Plants obtained *in vitro* were cultivated *ex vitro* in a greenhouse. There was 100% survival. Factors affecting seed germination included fungal contamination, hardness and resistance of testa and storage.

Bauri *et al.* (2016) conducted a study on ex-situ conservation and performance of genetic resources of banana to characterize the growth, yield, quality and biotic stresses during 2002-2016 in new alluvial Zone of West Bengal 143 genotypes of different genomic groups as per Simmonds and Shepherd's scoring system (1955) based on 15 characters (Pseudostem colour, Petiole canal, Peduncle, Pedicels, Ovules, Bract shoulder, Bract curling, Bract shape, Bract apex, Bract colour, Colour fading, Bract scars, Free tepal of male flower, Male flower colour & Stigma colour) that were chosen because they were different in *Musa acuminata* and *Musa balbisiana* comprising of elite clones, land races, primitive and reference cultivars viz. 6 of AA genomic group, 3 of AB, 11 of BB, 29 of AAA, 44 of AAB, 20 of ABB (Dessert type), 26 of ABB (Cooking type), 2 of AAAA and 1 each of AAAB and AABB were evaluated as per descriptor developed by Bioversity International for two successive planting as Plant Crop (PC) and first Ratoon Crop (RC-I). In genomic groups of AA and AB plant growth and yield were observed to be minimum compared to all other groups. Among the BB genomic group, maximum plant height (5.8m) in Bhimkol. Maximum crop duration

(721.5days), bunch weight (47.8kg) and TSS content (26.7°Brix) were noted in Bechakala-III (seeded banana). BB genotypes also recorded maximum tolerance to major pest and diseases. Under AAA genomic group, maximum bunch weight (26.7kg) was found in Dwarf Cavendish followed by Barjahaji (23.2kg) and maximum TSS (25.8°Brix) was recorded in Red Banana. In AAB genomic group Dudhsagar-I produced maximum bunch weight of 23.2kg followed by Dudhsagar-II (22.4kg) while minimum bunch weight (7.2kg) was recorded in Hill Banana. The TSS content in the dessert type of ABB group was noted higher ranging from 18.1° Brix (Kothia) to 26.5° Brix (Kanthali). Kanthali Clone –I produced maximum bunch weight (25.4kg) followed by Bagda (25.3kg). ABB (Dessert type) was very famous because of its use in different festivals and rituals in Bengal. Cooking-I under ABB (Cooking type) genomic group showed minimum crop duration (315days) and Baish Chhara recorded maximum bunch weight (23.6kg), yield (47.2t ha-1), hands (15.9) and fingers (224). Baish Chhara was suitable for kitchen garden as the hands can be harvested in staggered manner from top to bottom. Behula recorded maximum finger weight (222 g). FHIA-17 and 23 under AAAA, FHIA-01 (Gold finger) under AAAB and FHIA-03 (Sweet heart) under AABB genomic group were performed well and FHIA-03 (Cooking type) was gaining popularity as the pulp do not develops blackish colour in the curry.

Wu *et al.* (2018) conducted an experiment on high cryptic species diversity revealed by genome-wide polymorphisms in a wild relative of banana, *Musa itinerans*, and implications for its conservation in subtropical China. Morphologically similar species were sometimes difficult to recognize even after examination by experienced taxonomists. With the advent of molecular approaches in species delimitation, this hidden diversity has received much recent attention. *Musa itinerans* was widely distributed in subtropical Asia, and at least six varieties have been documented. However, the number of evolutionarily distinct lineages remains unknown. Using genome resequencing data of five populations (making up four varieties), we examined genome wide variation and found four varieties that were evolutionary significant units. Our results showed that the *M. itinerans* species complex harbours high cryptic species diversity. We recommend that *M. itinerans* var. *itinerans* and *M. itinerans* var. *lechangensis* be elevated to subspecies status, and the extremely rare latter subspecies be given priority for conservation. We also recommend that the very recently diverged *M. itinerans* var. *chinensis* and *M. itinerans* var. *guangdongensis* should be merged under the subspecies *M. itinerans* var. *chinensis*.

Zainy *et al.* (2019) conducted an experiment to study the *Ex-situ* conservation and morpho-biochemical analysis of exotic cultivars of banana at National Agricultural Research Center (NARC), Islamabad, Pakistan during 2015. The impact of various (growth/storage) media (SM1 to SM8) on biochemical and morphological traits of three cultivars of banana has been observed in this current study (Pisange, Brazillian and William). Two different temperature treatments i.e., 26°C and 18°C in order to develop an effective protocol for a short-term ex-situ conservation. Maximum variations were observed for all of the morphological traits at a varied temperature and media concentrations. At 26°C, enhanced growth (plant height) and increased number of shoots had been observed in all cultivars, while the rate of increased number of roots was non-significant at both temperatures. After conserving the cultivars for short term of 5 months, biochemical analysis was performed; it revealed the significant variations at both of the temperatures as well as on media. Brazilian cultivar (cultivar 2) substantially accumulated higher concentration of soluble sugar and proline both of provided temperatures as compared to other genotypes Cultivar 3 showed a significant increase in total chlorophyll content and chlorophyll a, b (William). The overall maximum proline and contents of chlorophyll were recorded in the cultures that were incubated at 26°C and 18°C respectively. So, 18°C temperature in combination with media SM_2 and SM_3 was better recommendation for short-term conservation of banana cultivars ex situ while 26°C was the best recommended temperature for maximum growth.

Kallow *et al.* (2020) conducted an experiment to study the ex-situ seed conservation of banana crop wild relatives (*Musa* spp.). Challenges in collecting seeds from wild populations impact the quality of seed collections. It was, therefore, crucial to evaluate the viability of seeds from such collecting missions in order to improve the value of future seed collections. They evaluated the seed viability of 37 accessions of seven Musa species, collected from wild populations in Papua New Guinea, during two collecting missions. Seeds from one mission had already been stored in conventional storage (dried for four months at 15% relative humidity, 20 °C and stored for two months at 15% relative humidity and at -20 ^{0}C). Seeds from the second mission were assessed freshly extracted and following desiccation. We used embryo rescue techniques to overcome the barrier of germinating in vivo Musa seeds. Seeds from the first mission had low viability (19±27% mean and standard deviation) after storage for two months at 15% relative humidity and -20°C. Musa balbisiana Colla seeds had significantly higher post-storage germination than other species ($p < 0.01$). Desiccation reduced germination of the seeds from the second collecting mission, from 84 ± 22% (at 16.7 ± 2.4% moisture content) to 36 ± 30% (at 2.4 ± 0.8% moisture content).

Arne *et al.* (2021) conducted a study on conservation status assessment of banana crop wild relatives using species distribution modelling with MaxEnt with an aim to construct a dataset on the distribution of wild banana species (*Musa* spp.) and assess their risk and conservation status, which areas were potentially suitable for wild banana species and how much of the wild banana diversity was currently at risk or insufficiently conserved ex and in situ. Extinction risk was evaluated following IUCN criterion B, and the ex and in situ conservation status was assessed using an indicator for biodiversity and sustainable development targets. They found that 11 out of 59 assessed species can be considered as vulnerable and nine as endangered. Highest species richness was found along the border of south China and northern Vietnam, in the north-eastern states of India and on the Malayan peninsula. Our distribution modelling approach indicates that the northern Indo-Burmese region has the highest environmental suitability for most wild banana species and that lowland rain forests in general are highly suitable for bananas. Assessment of in and ex situ conservation status indicates that 56 out of 59 assessed species were currently insufficiently conserved ex situ and that 49 were of high priority for further conservation. Additional in situ conservation was of high priority for six species and of medium priority for 40 species.

Singh *et al.* (2021) conducted a study on seed storage behaviour of *Musa balbisiana* Colla, a wild progenitor of bananas and plantains- Implications for ex situ germplasm conservation. The purpose of this study was to investigate seed storage behaviour of *M. balbisiana* for devising and applying suitable strategies to conserve CWR of banana/plantain germplasm in gene banks, both for short-and long-term. Seeds (from mature fruits) of three accessions of *M. balbisiana* from Field Gene Bank of ICAR-NBPGR, New Delhi (EC653579) and natural populations from ICAR-NBPGR, Thrissur, Kerala (IC630992) and Mizoram University, Mizoram (IC633382) were augmented and desiccated to various moisture contents (MC at 5,10,15, 20 and 25 % on fresh weight basis). Fresh and desiccated seeds were stored at three temperatures (25, -20 and -196 ◦C) to assess freezing sensitivity. Our studies confirm that *M. balbisiana* seeds were 'orthodox' in storage behaviour, and can be easily conserved for short-term at 25 ◦C, medium-term at -20 ◦C and long-term at -196 ◦C with 5–10 % MC. However, unlike other typical orthodox seeds, regeneration of conserved seeds is only feasible through zygotic embryo culture under in vitro conditions, as desiccated whole seeds fail to germinate using standard protocols. For cryobanking, whole seed or excised zygotic embryo cryopreservation was a feasible option for germplasm conservation of *M. balbisiana*.

Kallow *et al.* (2022) conducted an experiment on drying banana seeds for *ex situ* conservation and they found the ability of seeds to withstand drying fundamentally to *ex situ* seed conservation but drying responses were not well known for most wild species including crop wild relatives. They look at drying responses of seeds of *Musa acuminata* and *Musa balbisiana*, the two primary wild relatives of bananas and plantains, using the following four experimental approaches: (i) They equilibrated seeds to a range of relative humidity (RH) levels using non-saturated lithium chloride solutions and subsequently measured moisture content (MC) and viability. At each humidity level we tested viability using embryo rescue (ER), tetrazolium chloride staining and germination in an incubator. They found that seed viability was not reduced when seeds were dried to 4% equilibrium relative humidity (eRH; equating to 2.5% MC). (ii) They assessed viability of mature and less mature seeds using ER and germination in the soil and tested responses to drying. Findings showed that seeds must be fully mature to germinate and immature seeds had negligible viability. (iii) They dried seeds extracted from ripe/unripe fruit to 35–40% eRH at different rates and tested viability with germination tests in the soil. Seeds from unripe fruit lost viability when dried and especially when dried faster; seeds from ripe fruit only lost viability when fast dried. (iv) They dried and re-imbibed mature and less mature seeds and measured embryo shrinkage and volume change using X-ray computer tomography. Embryos of less mature seeds shrank significantly when dried to 15% eRH from 0.468 to 0.262 mm3, but embryos of mature seeds did not. Based on their results, mature seeds from ripe fruit were desiccation tolerant to moisture levels required for seed gene banking but embryos from immature seeds were mechanistically less able to withstand desiccation, especially when water potential gradients were high.

CHAPTER 3

MATERIALS AND METHODS

MATERIALS AND METHODS

The present investigation entitled "Studies on Genetic Diversity of Banana (*Musa* spp.) Land Races in Nagaland" was conducted during the year 2019 – 2022 to trace out a wide spectrum of genetic diversity and variability of various characters with potentiality of genotypes of different germplasm of (*Musa* spp.). A survey work was conducted based on IPGRI (International Plant Genetic Resources Institute) Descriptors for Banana (*Musa* spp.) during the given period in their natural habitat and the fruit samples were collected, *in-situ*, from various locations of Nagaland. The collected genotypes were conserved *ex-situ* at Instructional cum Research Farm, Department of Horticulture, School of Agricultural Science and Rural Development, Nagaland University, Medziphema Campus for further evaluation and documentation.

3.1 GENERAL INFORMATION

3.1.1 Location

The study was carried out in the state of Nagaland under the district of Chümoukedima, Dimapur, Kohima, Mokokchung, Peren, Wokha and Tuensang covering 46 villages altogether. Twenty-seven genotypes of banana (*Musa* spp.) were collected to conduct the experiment. Topographically, Nagaland is much dissected, full of hill ranges, which break into a wide chaos of spurs and ridges. Latitudinal and Longitudinal extend of Nagaland is located at 25.1584^{o}N and 95.1524^{o}E. Sites information including longitude and latitude location of the genotypes was collected using Google Earth.

Table 3.1: Information on different collection site of banana (*Musa* spp.) genotypes

Wild Species

Accession No.	Genotypes	Collection site and District	Latitude	Longitude	Altitude (m MSL)
G-1	***Musa aurantiaca***	Laingchen, Alichen, Mokokchung	94.4855ºE	26.2993ºN	1055
		Old Chungliyimti village, Tuensang	94.8331ºE	26.3457ºN	1315
		Ungma village, Mokokchung	94.2863ºE	26.1595ºN	1160
G-2	***Musa balbisiana* - 1**	Sukhovi village, Chumoukedima	93.7190ºE	25.7631ºN	323
		Chuchuyimpang village, Mokokchung	94.5540ºE	26.3346ºN	1309
		Bade village, Dimapur	93.4432ºE	25.5445ºN	145
G-3	***Musa balbisiana* - 2**	Sirhi Angami village, Chumoukedima	94.1552ºE	26.5123ºN	465
		Old Chungliyimti village, Tuensang	94.8131ºE	26.2357ºN	1305
		Longkum village, Mokokchung	94.2383ºE	26.1632ºN	1383
G-4	***Musa cheesmanii***	Kiro Ait, Alichen, Mokokchung	94.4555ºE	26.2693ºN	1097
		Sector - B, Old Jalukie, Peren	93.4224ºE	25.3462ºN	769
		Chare Town, Tuensang	94.3650ºE	26.1745ºN	963
G-5	***Musa flaviflora***	Tsiepama village, Chumoukedima	93.5714ºE	25.4634ºN	1089
		Seprouliezie colony, Medziphema, Chumoukedima	93.8883ºE	25.7594ºN	356
		Chuchuyimlang village, Mokokchung	99.4599ºE	26.4064ºN	1054
G-6	***Musa itinerans***	Old Chungliyimti village, Tuensang	94.8131ºE	26.2357ºN	1305
		Sector - B, Old Jalukie, Peren	93.4306ºE	25.3415ºN	935
		Longkum village, Mokokchung	94.2383ºE	26.1632ºN	1383
G-7	***Musa rubra***	Medziphema village, Chumoukedima	93.5128ºE	25.4591ºN	442
		Bade village, Dimapur	93.4930ºE	25.6445ºN	198
		Mhainamtsi, Jalukie, Peren	93.7027ºE	25.6327ºN	400

G-8	***Musa sikkimensis* var. *sikkimensis***	Old Chungliyimti village, Tuensang	94.8331ºE	26.3457ºN	1289
		Sector - B, Old Jalukie, Peren	93.4362ºE	25.3154ºN	1119
		Khonoma road, Kohima	94.3455ºE	25.3982ºN	1521
G-9	***Musa sikkimensis* var. *simondsii***	Ward - 2, Forest colony, Wokha	94.2655ºE	26.0830ºN	1313
		Old Chungliyimti village, Tuensang	94.8231ºE	26.3057ºN	1327
		Poilwa village, Peren	93.8793°E	25.5636°N	1922
G-10	***Musa velutina***	House no. - 139, Vungoju Colony, Wokha	94.2651ºE	26.0629ºN	1313
		Longtho village, Mokokchung	94.2107ºE	26.3022ºN	149
		Tsurang Watiyim village, Mokokchung	94.2329ºE	26.3168ºN	145

Local cultivar

Accession No.	Genotypes	Collection site and District	Latitude	Longitude	Altitude (m MSL)
G-11	**Dwarf Cavendish (Jahaji)**	Medziphema, Chumoukedima	93.8671ºE	25.7556ºN	360
		Mhainamtsi, Jalukie, Peren	93.4077ºE	25.4228ºN	361
		Full Nagarjan, Dimapur	93.7408ºE	25.8827ºN	209
G-12	**Cavendish (Grand Naine)**	NU: SAS, Medziphema, Chumoukedima	93.8671ºE	25.7556ºN	360
		Full Nagarjan, Dimapur	93.7422ºE	25.8822ºN	205
		Tuli, Mokokchung	94.6465ºE	26.6569ºN	199
G-13	**Nendran**	SFS School, New Medziphema, Chumoukedima	93.8430ºE	25.7587ºN	373
		Changtongya village, Mokokchung	94.6827ºE	26.5345ºN	689
		Greenland colony, Mhainamtsi, Peren	93.4219ºE	25.4076ºN	382
G-14	**Monthan**	Alichen, Mokokchung	94.4555ºE	26.2693ºN	1097
		Forest colony, Wokha	94.2655ºE	26.0830ºN	1313
		Tseithrongse village, Chumoukedima	93.7068ºE	25.8079ºN	214
	African Rhino Horn Plantain	ICAR Upper Colony, New Medziphema,	93.8430ºE	25.7587ºN	373

G-15		Chumoukedima			
		Litem village, Tuensang	94.4159ºE	26.2152ºN	937
		Doyang Dam, Wokha	94.1816ºE	26.1459ºN	437
G-16	**Bharatmani**	Punglwa village, Peren	93.8418ºE	25.6792ºN	428
		Tuli, Mokokchung	94.6565ºE	26.6669ºN	210
		Kukidolong village, Chumoukedima	93.8345ºE	25.7632ºN	286
G-17	**Bhootmanohar**	Sirhi Angami village, Kohima	93.9976ºE	25.7126ºN	465
		Kukidolong village, Chumoukedima	93.8202ºE	25.7720ºN	295
		Greenland colony, Mhainamtsi, Peren	93.7014ºE	25.6687ºN	304
G-18	**Chinichampa**	NU: SAS, Medziphema, Chumoukedima	93.8530ºE	25.7523ºN	323
		Lhomithi colony, Dimapur	93.7226ºE	25.9015ºN	164
		Greenland colony, Mhainamtsi, Peren	93.7014ºE	25.6687ºN	304
G-19	**Kanthali**	Medziphema Village, Chumoukedima	93.9403ºE	25.7286ºN	176
		Greenland colony, Mhainamtsi, Peren	93.4219ºE	25.4076ºN	382
		Tuli, Mokokchung	94.6565ºE	26.6669ºN	210
G-20	**Red Banana**	Heningkunglwa village, Peren	93.7784ºE	25.6625ºN	358
		Full Nagarjan, Dimapur	93.7407ºE	25.8825ºN	187
		NU: SAS, Medziphema, Chumoukedima	93.8570ºE	25.7533ºN	415
G-21	**Unidentified - 1**	Moava village, Chumoukedima	93.8461ºE	25.7008ºN	158
		Greenland colony, Mhainamtsi, Peren	93.4210ºE	25.4080ºN	289
		Thaheku village, Dimapur	93.7228ºE	25.8617ºN	125
G-22	**Unidentified - 2**	Moava village, Chumoukedima	93.9403ºE	25.7286ºN	156
		Sechu Zubza, Kohima	94.0353ºE	25.7099ºN	1100
		Stadium colony, Jalukie town, Peren	93.6730ºE	25.6460ºN	349
G-23	**Unidentified - 3**	Sochunoma village, Chumoukedima	93.8418ºE	25.6792ºN	428
		Stadium colony, Jalukie town, Peren	93.6730ºE	25.6460ºN	375
		Sechu Zubza, Kohima	94.0353ºE	25.7099ºN	1100

G-24	**Unidentified - 4**	Jalukie, Peren	93.9976ºE	25.7126ºN	400
		Sechu Zubza, Kohima	94.0353ºE	25.7099ºN	1100
		Tseipama village, Chumoukedima	93.9305ºE	25.7832ºN	823
G-25	**Unidentified - 5**	Bade village, Dimapur	93.4430ºE	25.5445ºN	145
		Tseithrongse village, Chumoukedima	93.7068ºE	25.8079ºN	214
		Greenland colony, Mhainamtsi, Peren	93.7014ºE	25.6687ºN	304
G-26	**Unidentified - 6**	Peace Camp, Dimapur	93.4654ºE	25.6625ºN	158
		Kiruphe village, Kohima	94.0248ºE	25.7274ºN	1198
		Pherema village, Chumoukedima	93.9219ºE	25.7755ºN	524
G-27	**Meitei Hei**	Molvom village, Chumoukedima	93.8681ºE	25.7566ºN	360
		Sector - B, Old Jalukie, Peren	93.4306ºE	25.3415ºN	935
		Khonoma village, Kohima	94.0198ºE	25.6531ºN	1535

3.1.2 Climatic condition

The climate of the experimental locations under the selected districts of Nagaland represents sub-humid tropical climate zone with moderate temperature and medium to high rainfall. The relative humidity ranges from 75% to 85%. The mean temperature ranges from 21ºC to 30ºC during summer and rarely goes below 8ºC in winter due to high atmospheric humidity. The average rainfall varies between 2000 - 2500 mm starting from April and ends with the month of September while the period from October to March remains completely dry.

3.1.3 Soil condition

Nagaland receives an annual rainfall average which ranges from 1800 - 2500mm, which is relatively high (1.5 % of the country's total precipitation). Soil of Nagaland is acidic to strongly acidic in nature (pH below 5.5). This is due to leaching of bases under the influence of heavy precipitation. Heavy precipitation accelerates the process of acidity. Soil in this region is rich in organic matter and organic carbon. SOC (soil organic carbon) content decreases as the depth of the soil increases, contains high amount of exchangeable aluminium, deficient in Phosphorus. The steep slopes, undulating topography, higher density of drainage from hills stimulates soil erosion risks, sedimentation loss and ultimately decreases the soil fertility There is formation of new soil at foothills and near rivers and streams which are colluvial and alluvial in origin. Five different soil orders have been identified based on the variability of the parent material, climate, relief and topography, and type of vegetation Alfisols, Entisols, Inseptisols, Mollisols and Ultisols. Major problems are soil acidity, soil degradation with very poor physical, chemical and biological characteristics and soil erosion etc.

3.2 SURVEY SCHEDULE

Crop	: Banana (*Musa* spp.)
Survey area	: Nagaland
No. of genotypes collected	: 27 (twenty-seven)
No. of replication	: 3 (three)

3.2.1 Observations recorded

3.2.1.1. Passport Data Collection

Passport data was collected using National Bureau of Plant Genetic Resources (NBPGR), New Delhi, Passport data collection format as mentioned below.

NATIONAL BUREAU OF PLANT GENETIC RESOURCES,

PASSPORT DATA SHEET

Date.................................... Collector's No…………..………. Accession No........................ Botanical Name...................Common Name (English)…………Crop/Vern. Name….……… Cultivar name..................... Region Explored............................ Village/Block..................... District..............................State...Latitude………………….. Longitude.……………..… Altitude….……… Temp………... Rainfall……………………	
COLLECTION SITE	1. Natural wild 2. Disturbed wild 3. Farmer's field 4.Threshing yard 5. Fallow 6. Farm store 7.Market 8.Garden 9.Institute 10......
BIOLOGICAL STATUS	1.Wild 2.Weed 3.Landrace 4.Primitive cultivar 5.Breeder's line
FREQUENCY	1.Abundant 2.Frequent 3.Occassional 4.Rare
MATERIAL	1.Seeds 2.Fruits 3.Inflorescence 4.Roots 5.Tubers 6. Rhizomes 7.Suckers 8.Live plants 9.Herbarium 10…………..
BREEDING SYSTEM	1.Self-pollinated 2.Cross-pollinated 3.Vegetatively propagated
HABITAT	1.Cultivated 2.Disturbed 3.Partly disturbed 4.Rangeland 5..….
DISEASE SYMPTOMS	1.Susceptible 2.Mildly susceptible 3.Tolerant 4.Resistant 5.Immune
INSECT/ PEST/ NEMATODE INFECTION	1. Mild 2.Moderate 3. High
CULTURAL PRACTICE SEASON	1. Irrigated 2.Rainfed 3.Arid 4.Wet 5..................... 1. Kharif 2.Rabi 3.Spring-summer 4.Perennial type
ASSOCIATED FLORA	1. Sole 2.Mixed with………………………
SOIL COLOUR	1. Black 2.Yellow 3.Red 4.Brown 5……..…………

SOIL TEXTURE	1.Sandy 2.Sandy loam 3.Loam 4.Silt loam 5.Clay 6.Silt
TOPOGRAPHY	1.Swamp 2.Flood plain 3.Level 4.Undulating 5.Hilly dissected 6.Steeply dissected 7.Mountainous 8.Valley
AGRONOMIC SCORE	1.V poor 2.Poor 3.Average 4.Good 5.V good
ETHNOBOTANICAL USES	
PART(S)	1.Stem 2.Leaf 3.Root 4. Fruit 5.Flower 6.Whole plant 7.Seed 8.Others
KIND	1.Food 2.Medicine 3.Fibre 4.Timber 5.Fodder 6.Fuel 7.Insecticide/ Pesticide 8.Others
HOW USED	....
INFORMANT(S)	1.Local Vaidya 2.Housewife 3.Old folk 4.Graziers /Shepherds 5.Others
PHOTOGRAPH	1.Colour/Video
FARMER'S/ DONOR'S NAME................................ ETHNIC GROUP.............................	
ADDRESS	
PLANT CHARACTERISTIC/ USES ADDL. NOTES	

3.3 PLANT MORPHOLOGICAL CHARACTERIZATION

3.3.1. Plant general appearance

Morphological data of the genotypes were taken *in-situ.* The collected genotypes of banana were morphologically analysed for their features based on the NBPGR descriptors for banana.

3.3.1.1 Leaf habit

The genotypes were differentiated from their leaf habits either in the form of erect, intermediate and drooping.

a) Erect
b) Intermediate
c) Drooping

(a) (b) (c)

3.3.1.2 Leaf blade length (cm)

The leaf blade length was measured at its maximum point and was recorded in centimetre.

3.3.1.3 Leaf blade width (cm)

The leaf blade width was measured at its maximum point and was recorded in centimetre.

3.3.1.4 Colour of leaf upper surface

Colour of the leaf upper surface was recorded base on the following parameters:

a) Green – yellow

b) Medium Green

c) Green

d) Dark green

e) Dark green with red purple (Presence of large blotches of red - purple)

f) Blue

3.3.1.5 Dwarfism

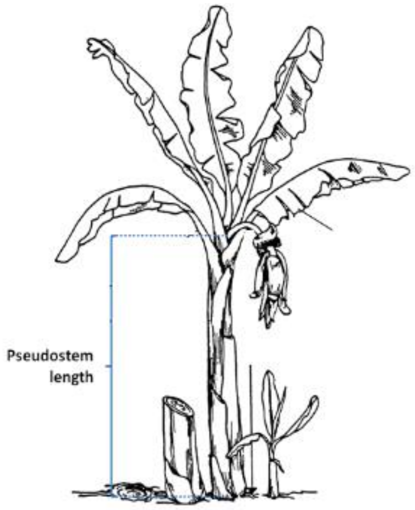
The leaf ratio was measured on the third leaf, counting from the last one that emerged. It was differentiated either -

a) Normal: Leaves not overlapped and leaf ratio inferior to 2.5

b) Dwarf type: Leaves strongly overlapped and leaf ratio superior

3.3.1.6 Pseudostem height (m)

The height of the pseudostem was recorded by measuring the length between the base of the pseudostem and the emerging point of the peduncle.



3.3.1.7 Girth size (cm)

Girth size of the pseudostem was measured 30 cm above the ground level (UPOV, 2010).

3.3.1.8 Pseudostem colour

Colour of the pseudostem was recorded without removing the external sheaths without taking into account the colour of the old dried leaf sheaths was recorded as follows:

a) Green-yellow
b) Medium green
c) Green
d) Dark green
e) Red
f) Red - purple
g) Blue
h) Chimerical
i) Other

3.3.1.9 Number of suckers

Number of suckers emerging from the mother plant were counted and recorded.

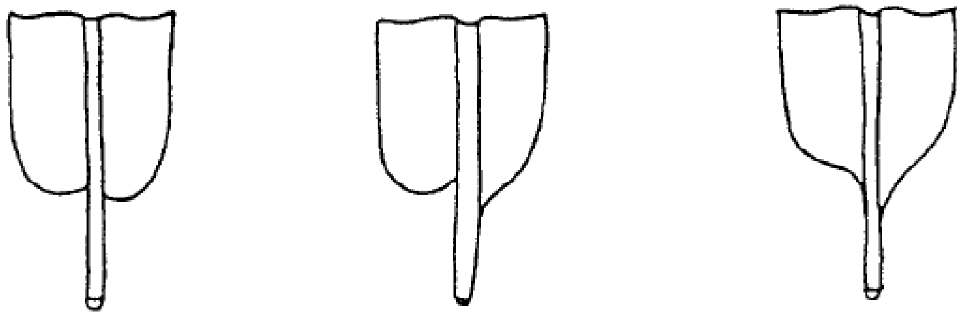
3.3.1.10 Position of suckers

Position of the suckers were observed and recorded as follows:

a) Far from parent plant (Emerging >50 cm from parent plant)
b) Close to parent (Vertical growth)
c) Close to parent (Growing at an angle)

3.3.1.11 Leaf blade base shape

a) Both sides rounded
b) One side rounded, one pointed
c) Both sides pointed



(a) (b) (c)

3.3.1.12 Petiole canal leaf III

Leaf III is the third leaf counted from the last leaf (leaf I) produced before bunch emergence. The petiole was cut half way between the pseudostem and the leaf blade and examines the cross section.

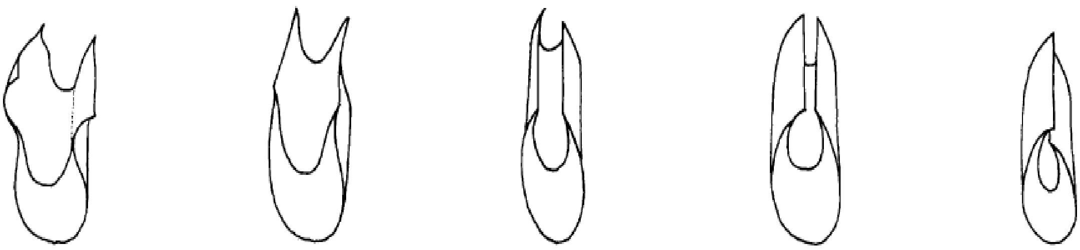
a) Open with margins spreading

b) Wide with erect margins

c) Straight with erect margins

d) Margins curved inward

e) Margins overlapping



(a) (b) (c) (d) (e)

3.3.2. Flower characters

3.3.2.1 Bract apex shape

The apex of the bract was flattened to observe the shape. Shape of the bract apex was recorded as follows:

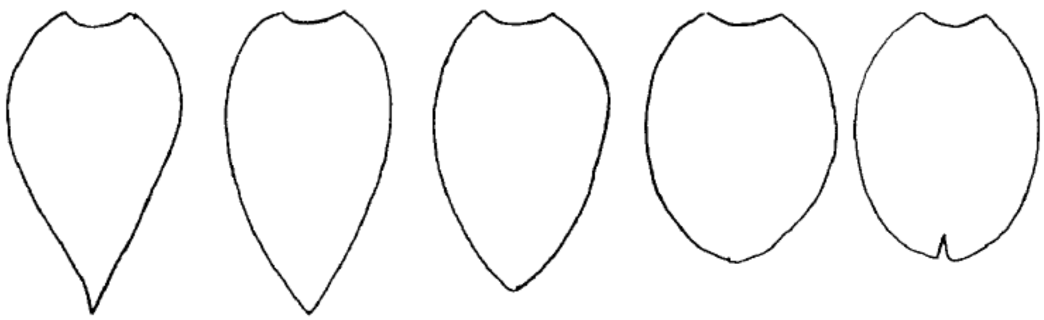
a) Pointed

b) Slightly pointed

c) Intermediate

d) Obtuse

e) Obtuse and split



(a) (b) (c) (d) e)

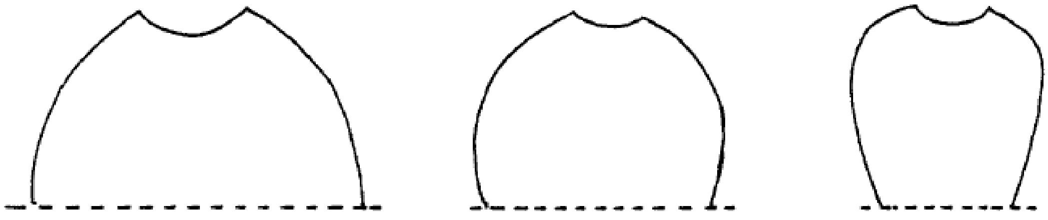
3.3.2.2 Bract base shape

Bract base shape was recorded as follows:

a) Small shoulder

b) Medium

c) Large shoulder



(a) (b) (c)

3.3.2.3 Colour of bracts (External)

External colour of bracts was recorded as follows:

a) Yellow

b) Green

c) Red

d) Red – purple

e) Purple – brown

f) Purple

g) Blue

h) Pink – purple

i) Orange – red

j) Other

3.3.2.4 Colour of the bracts (Internal)

Internal colour of the bracts was recorded as follows:

a) Whitish

b) Yellow or green

c) Orange red

d) Red

e) Purple

f) Purple brown

g) Pink – purple

h) Other

3.3.2.5 Free tepal shape

Free tepal shape was recorded as follows:

a) Rectangular

b) Oval

c) Rounded

d) Fan – shaped

3.3.2.6 Free tepal colour:

Free tepal colour was recorded as follows:

a) Translucent white

b) Opaque white

c) Tinted with yellow

d) Tinted with pink

3.3.2.7 Compound tepal colour

Compound tepal colour was recorded without considering the lobe colour as follows:

a) White

b) Yellow

c) Orange

d) Pink/pink – purple

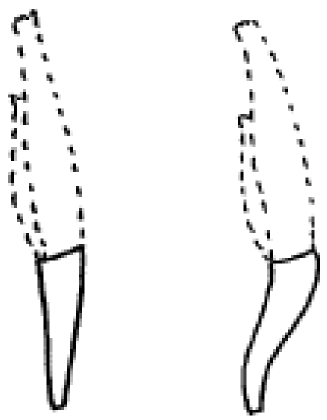
e) Other

3.3.2.8 Ovary shape

Ovary shape was recorded as follows:

a) Straight

b) Arched



(a) (b)

3.3.2.9 Stigma colour

Stigma colour was recorded as follows:

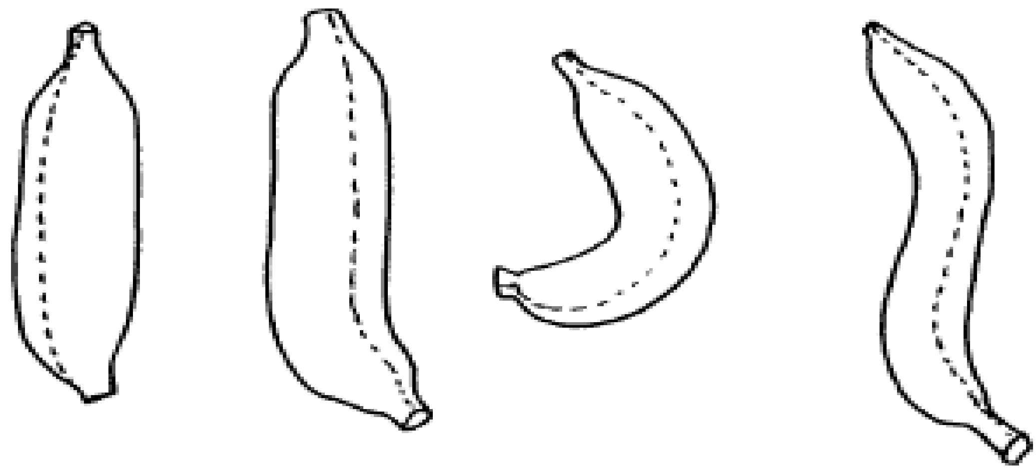
a) Cream
b) Yellow
c) Pink/pink – purple
d) Bright yellow
e) Orange
f) Other

3.3.3 Fruit characters

3.3.3.1 Fruit shape

Fruit shape was recorded as follows:

a) Straight (or slightly curved)
b) Straight in the distal part
c) Curved (sharp curve)
d) Curved in ‘S’ shape (double curvature)
e) Other



(a) (b) (c) (d)

3.3.3.2 Fruit apex

Fruit apex was observed at the distal end of the fruit and recorded as follows:

a) Pointed
b) Lengthily pointed
c) Blunt-tipped
d) Bottle-necked
e) Rounded

(a) (b) (c) (d) (e)

3.3.3.3 Immature fruit peel colour

Immature fruit peel was recorded on the youngest hand of the bunch, before maturity.

a) Yellow
b) Light green
c) Green
d) Green and pink, red or purple
e) Silvery
f) Dark green
g) Brown/rusty brown
h) Pink, red or purple
i) Black
j) Other

3.3.3.4 Mature fruit peel colour

Peel colour of the mature fruit was recorded at fruit maturity when the fruit was ripe but not over ripened; full yellow stage.

a) Yellow
b) Bright yellow
c) Orange
d) Grey spots
e) Brown/rusty brown
f) Orange red, red or pink/pink purple
g) Red-purple
h) Black
i) Other

3.3.3.5 Fruit length (cm)

Fruit length was determined by measuring the outer curve of individual fruit using a measuring tape from the distal end to the point at the proximal where the pulp was just to terminate.

3.3.3.6 Fruit width (cm)

Determined by measuring individual fruit using conventional measuring tape at the widest mid-point of each fruit.

3.3.3.7 Fruit peel thickness (mm)

Fruit peel thickness was recorded at fruit maturity when the fruit was ripened and ready to eat but not over-ripe; full yellow stage. It was measured by Vernier Calliper and express in millimetre.

3.3.3.8 Pulp colour

Pulp colour of the fruit was recorded when the fruit was ripe but not over-ripened; full yellow stage.

a) White
b) Cream
c) Ivory
d) Yellow
e) Orange
f) Beige-pink
g) Other

3.3.3.9 Flesh texture

Flesh texture was recorded either as:

a) Firm

b) Soft

3.3.3.10 Seed (Presence/absence)

The banana genotypes collected were checked for presence or absent of seed. The mature fruit were cut open horizontally and vertically and checked for presence of seed. The banana genotypes were grouped as seeded and seedless.

3.3.3.11 Bunch weight (kg)

Fully mature banana was harvested from the field and the bunch weight was recorded through digital weight machine. It was expressed in kilogram.

3.3.3.12 Number of hands/bunch

The number of hands/bunch was obtained by counting the number of hands in the whole bunch for each banana genotypes.

3.3.3.13 Number of fruits/hands

The numbers of fruit/hand were recorded by counting the number of fruits bearing in the hand for each genotype.

3.3.3.14 Fruit weight (g)

The weight of the fruit was taken by detaching a single fruit from the hand in the electronic weighing balance. Five random fruits were taken and an average fruit weight was recorded. It was expressed in gram (g).

3.3.3.15 Pulp weight (g)

The weight of the pulp was recorded after removing the peel from the fruit in the electronic weighing balance. Pulp of five random fruits was taken and average pulp weight was calculated by dividing the weight of the sample. It was expressed in gram (g).

3.3.4 Biochemical analysis of fruit

3.3.4.1 Total soluble solids (^{0}B)

The TSS content of the selected fruit samples was determined with hand refractometer. The refractometer was washed with distilled water each time after use and dried with blotting paper and was expressed in ^{o}B.

3.3.4.2 Titratable Acidity (%)

Titratable acidity of the extracted juice was determined by treating the diluted fruit juice against 0.1N NAOH solution using phenolphthalein as an indicator and expressed in terms of percentage.

3.3.4.3 Total sugar (%)

The total sugar content of the fruit juice was determined by titrating against Fehling A and Fehling B reagents using methylene blue as an indicator. From the Titratable value, percentage of total sugar was calculated (A.O.A.C., 1984).

3.3.4.4 Reducing sugar (%)

The reducing sugar content of the fruit juice was determined by titrating against Fehling A and Fehling B reagents using methylene blue as an indicator. Precipitation of deep brick colour of the solution indicated the end point and the titratable value were expressed in %.

3.3.4.5 Shelf life (Day)

To study the shelf life of banana, three fruit from each treatment per replication were kept at room temperature till the fruit start spoilage and were expressed in terms of number of days.

3.3.5 Sensory evaluation

The sensory evaluation was carried out using five level Hedonic Scale developed by Amerine *et al*., (1965). The level of appearance and taste were rated at five different levels as mentioned.

1. Bad
2. Satisfactory
3. Good
4. Very good
5. Excellent

3.4 *EX-SITU* CONSERVATION

3.4.1 Field preparation

The experimental plot was deep ploughed thoroughly prior to planting the soil was well pulverized and kept weed free and unwanted debris was cleared off. Thereafter, pits of size 45 x 45 x 45 cm were dug at a spacing o 1.8 m x 2m.

3.4.2 Treatments

Suckers were dipped and treated with chemicals of Rogor (Dimethoate), Saaf (Carbendazim 12%+ Mancozeb 63% WP) or Mancozeb (Dithane M-45) using Sticker solution in 5 litres of water for 30 minutes and the suckers were sun dried for another 1 hour before planting. Application of 10 g of Phorate was applied to the pits before planting the suckers mixed with the soil and 100g of N_2, P_2O_5, and K_2O was applied after planting of the suckers. NPK was applied through urea, SSP and MoP respectively in order to fulfil the nutritional requirement of the fruit.

3.4.3 Intercultural operation and aftercare

Weeding and earthing up of plants were done whenever required. The newly planted plants were irrigated at regular intervals when there is insufficient rain.

3.5 STATISTICAL ANALYSIS

Mean values of data obtained from various experiments was subjected to suitable statistical analysis after transformation (if necessary) to test the treatment effect of genotypes and interpretation of the results.

3.5.1 Estimation of coefficients of variation

The coefficient of variation for different characters will be estimated by formula as suggested by Burton (1952).

$$\text{GCV (\%)} = \frac{\sqrt{\sigma\ 2g}}{x} \text{X } 100$$

$$\text{PCV (\%)} = \frac{\sqrt{\sigma\ 2p}}{x} \text{ X } 100$$

Where,

PCV = Phenotypic coefficient of variation

GCV = Genotypic coefficient of variation

X = Mean of character

$\sigma^2 g$ = Genotypic variance

$\sigma^2 p$ = Phenotypic variance

The estimates of genotypic and phenotypic coefficient of variance will be classified as low (less than 10%), moderate (10 to 20%) and high (more than 20%).

3.5.2 Estimation of heritability

Heritability in broad sense $h^2_{(bs)}$ defined as the proportion of the genotypic variance to the total variance (phenotypic) will be calculated as per the formula suggested by Burton and De Vane (1953).

$$h^2_{(bs)}\ \% = \frac{\sigma^2_g}{\sigma^2_P} \times 100$$

Where,

$h^2_{(bs)}$ = Heritability in broad sense

σ^2_g = Genotypic variance

σ^2_p = Phenotypic variance

The broad sense heritability estimates were classified as low (<50%), moderate (50-70%) and high (<70%).

3.5.3 Genetic advance

Improvement in the mean genotypic value of selected plants over the parental population is known as genetic advance. The expected advance will be calculated by the formula given by Johnson *et al.* (1955) as described below.

$GA = K.h^2.\sigma p$

Where,

GA = Genetic advance

K = Constant (Standardized selection differential) having value of 2.06 at 5% level of selection intensity.

h^2 = Heritability of the character

σp = Phenotypic standard deviation

The genetic advance as percentage of mean was estimated as per the below formula.

$$\text{Genetic advance as percent of mean} = \frac{\text{Genetic advance}}{\text{General mean}} \times 100$$

The magnitude of genetic advance as percent of mean will be categorized as high (more than 20%), moderate (20-10%) and low (less than10%).

3.5.4 Path coefficient analysis

The genotypic correlation coefficients will further be partitioned into direct and indirect effects with the help of path coefficient analysis as suggested by Wright (1921) and elaborated by Dewey and Lu (1959). Path co efficient analysis is simply a standardized partial regression coefficient which splits the correlation coefficient into the measures of direct and indirect effects.

Path coefficient was estimated using, simultaneous equations, the equations showed a basic relationship between correlation coefficient and path coefficient. These equations were solved by presenting them in matrix notations.

A = B.C

The solution for the vector "C" may be obtained by multiplying both sides by inverse of "B" matrix i.e., B-1 A = C

After calculation of values of path coefficient i.e., "C" vector, it is possible to obtain path values for residual (R). Residual effect was calculated using formula referred from Singh and Chaudhary (1985).

$R = \sqrt{1 - \text{di x rij}}$

. Where,

Di = direct effect of i^{th} character

r_{ij} = correlation coefficient of i^{th} character with j^{th} character

A direct and indirect effect of different characters on bulb yield was calculated at genotypic level.

3.5.5 Genetic divergence analysis (D^2)

The Mahalanobis (1936) D^2 statistic is to be used to measure the genetic divergence between the populations. The D^2 value was estimated on the basis of "P" character by the formula:

Formula: p p

D^2 P = ∑ = ∑ = (ʎij) ʎ i ʎ j

i=1 j=1

Where,

(λ ,i,j) is the reciprocal or(λ ,i,j), the pooled common dispersion matrix (i.e., error matrix)

i = the difference in the mean value for the i^{th} character

j = the difference in the mean value for the j^{th} character

For calculating the D^2 values, the variance and covariance will calculate. The genotypes were grouped into different clusters by Ward's method. The population was arranged in order of their relative distances from each other. For including a particular population in the clusters, a level of D^2 was fixed by taking the maximum D^2 values between any two populations in the first row of the table where D^2 values were arranged in increasing order of magnitude.

CHAPTER 4

RESULTS AND DISCUSSION

RESULTS AND DISCUSSION

The present study was carried out to trace the genetic variability among wild *Musa* genotypes based on various morphological characters. Twenty-seven genotypes were collected from Chümoukedima, Dimapur, Kohima, Mokokchung, Peren, Wokha, and Tuensang districts of Nagaland. These genotypes were conserved in the Experimental Farm, Department of Horticulture, School of Agricultural Sciences, Nagaland University, Medziphema campus, as field repositories gene bank. The results obtained from the investigation have been supported by the respective tables and figures presented in this chapter to further substantiate this study.

4.1 PASSPORT DATA COLLECTION

The findings of the collected data through the passport survey are depicted in Table 4.1. Passport data was collected using the National Bureau of Plant Genetic Resources (NBPGR), New Delhi, passport data collection format. A total of 27 wild and cultivated *Musa* species were randomly collected from different locations (altitudes ranging from 100 to 1600 m above mean sea level) in the Chümoukedima, Dimapur, Kohima, Mokokchung, Peren, Wokha, and Tuensang districts of Nagaland's hilly forest area and homestead gardens.

The wild genotypes collected were *Musa aurantiaca*, *Musa balbisiana*-1, *Musa balbisiana*-2, *Musa cheesmanii*, *Musa flaviflora*, *Musa itinerans*, *Musa rubra*, *Musa sikkimensis* var. *sikkimensis*, *Musa sikkimensis* var. *simondsii*, and *Musa velutina*. The cultivars collected were Dwarf Cavendish, Grand Naine, Nendran, Monthan, African Rhino Horn Plantain, Bharatmani, Bhootmanohar, Chinichampa, Kanthali, Red Banana, and Meitei Hei.

Additionally, six unidentified genotypes were collected from regions with soil of an acidic to strongly acidic nature (pH below 5.5). These regions have an annual mean temperature ranging from 21°C to 30°C during the summer and rarely dropping below 8°C in the winter, thanks to high atmospheric humidity. The average annual rainfall in these regions ranges from 1800 to 2500mm.

Most of the species collected were found to be either resistant or tolerant to pests and diseases. The farmers stated that all parts of the banana plant are known to have many medicinal properties. The ethno-botanical benefits of bananas include the use of fruits, inflorescence, and pseudostem for culinary purposes, and some genotypes of seeds for medicinal purposes.

Table 4.1: Passport Data of different genotypes collected from Nagaland

Accession No.	Botanical Name	Vernacular Name	Collection site and District	Latitude	Longitude	Altitude (m MSL)
G-1	***Musa aurantiaca***	Ai yarang (Ao - Mongsen)	Laingchen, Alichen, Mokokchung	94.4855ºE	26.2993ºN	1055
		Yarüm homa (Sangtam)	Old Chungliyimti village, Tuensang	94.8331ºE	26.3457ºN	1315
		Yarang (Ao - Mongsen)	Ungma village, Mokokchung	94.2863ºE	26.1595ºN	1160
G-2	***Musa balbisiana* - 1**	Agha aucho (Sema)	Sukhovi village, Chumoukedima	93.7190ºE	25.7631ºN	323
			Chuchuyimpang village, Mokokchung	94.5540ºE	26.3346ºN	1309
		Phengnu kethe, Lothe kethe (Angami)	Bade village, Dimapur	93.4432ºE	25.5445ºN	145
G-3	***Musa balbisiana* - 2**	Pfekrei (Angami)	Sirhi Angami village, Chumoukedima	94.1552ºE	26.5123ºN	465
			Old Chungliyimti village, Tuensang	94.8131ºE	26.2357ºN	1305
			Longkum village, Mokokchung	94.2383ºE	26.1632ºN	1383
G-4	***Musa cheesmanii***	Lanak (Ao - Mongsen)	Kiro Ait, Alichen, Mokokchung	94.4555ºE	26.2693ºN	1097
			Sector - B, Old Jalukie, Peren	93.4224ºE	25.3462ºN	769
			Chare Town, Tuensang	94.3650ºE	26.1745ºN	963
G-5	***Musa flaviflora***		Tsiepama village, Chumoukedima	93.5714ºE	25.4634ºN	1089
		Rakannak	Seprouliezie colony, Medziphema, Chumoukedima	93.8883ºE	25.7594ºN	356
		Sumomochi (Ao - Chungli)	Chuchuyimlang village,	99.4599ºE	26.4064ºN	1054

			Mokokchung			
G-6	***Musa itinerans***	Trung homa (Sangtam)	Old Chungliyimti village, Tuensang	94.8131ºE	26.2357ºN	1305
		Henak	Sector - B, Old Jalukie, Peren	93.4306ºE	25.3415ºN	935
		Lasta (Ao - Mongsen), Ruoshi mongu (Ao - Chungli)	Longkum village, Mokokchung	94.2383ºE	26.1632ºN	1383
G-7	***Musa rubra***		Medziphema village, Chumoukedima	93.5128ºE	25.4591ºN	442
			Bade village, Dimapur	93.4930ºE	25.6445ºN	198
			Mhainamtsi, Jalukie, Peren	93.7027ºE	25.6327ºN	400
G-8	***Musa sikkimensis* var. *sikkimensis***	Jümü homa (Sangtam)	Old Chungliyimti village, Tuensang	94.8331ºE	26.3457ºN	1289
			Sector - B, Old Jalukie, Peren	93.4362ºE	25.3154ºN	1119
			Khonoma road, Kohima	94.3455ºE	25.3982ºN	1521
G-9	***Musa sikkimensis* var. *simondsii***	Yourup (Lotha)	Ward - 2, Forest colony, Wokha	94.2655ºE	26.0830ºN	1313
		Jümü homa (Sangtam)	Old Chungliyimti village, Tuensang	94.8231ºE	26.3057ºN	1327
			Poilwa village, Peren	93.8793°E	25.5636°N	1922
G-10	***Musa velutina***		House no. - 139, Vungoju Colony, Wokha	94.2651ºE	26.0629ºN	1313
		Temeremla yarang (Ao - Chungli)	Longtho village, Mokokchung	94.2107ºE	26.3022ºN	149
			Tsurang Watiyim village, Mokokchung	94.2329ºE	26.3168ºN	145
G-11	**Dwarf Cavendish (Jahaji)**		Medziphema, Chumoukedima	93.8671ºE	25.7556ºN	360
			Mhainamtsi, Jalukie, Peren	93.4077ºE	25.4228ºN	361
			Full Nagarjan, Dimapur	93.7408ºE	25.8827ºN	209

G-12	**Cavendish (Grand Naine)**		NU:SASRD, Medziphema,			
			Chumoukedima	93.8671ºE	25.7556ºN	360
			Full Nagarjan, Dimapur	93.7422ºE	25.8822ºN	205
G-13	**Nendran**		Tuli, Mokokchung	94.6465ºE	26.6569ºN	199
			SFS School, New Medziphema,			
			Chumoukedima	93.8430ºE	25.7587ºN	373
G-14	**Monthan**		Changtongya village, Mokokchung	94.6827ºE	26.5345ºN	689
			Greenland colony, Mhainamtsi,			
			Peren	93.4219ºE	25.4076ºN	382
G-15	**African Rhino Horn Plantain**		Alichen, Mokokchung	94.4555ºE	26.2693ºN	1097
			Forest colony, Wokha	94.2655ºE	26.0830ºN	1313
			Tseithrongse village,			
G-16	**Bharatmani**		Chumoukedima	93.7068ºE	25.8079ºN	214
		Butter mongo (Ao - Chungli)	ICAR Upper Colony, New Medziphema, Chumoukedima	93.8430ºE	25.7587ºN	373
			Litem village, Tuensang	94.4159ºE	26.2152ºN	937
G-17	**Bhootmanohar**		Doyang Dam, Wokha	94.1816ºE	26.1459ºN	437
			Punglwa village, Peren	93.8418ºE	25.6792ºN	428
			Tuli, Mokokchung	94.6565ºE	26.6669ºN	210
G-18	**Chinichampa**		Kukidolong village, Chumoukedima	93.8345ºE	25.7632ºN	286
		Chinikol	Sirhi Angami village, Kohima	93.9976ºE	25.7126ºN	465
			Kukidolong village, Chumoukedima	93.8202ºE	25.7720ºN	295
G-19	**Kanthali**		Greenland colony, Mhainamtsi, Peren	93.7014ºE	25.6687ºN	304
			NU:SASRD, Medziphema, Chumoukedima	93.8530ºE	25.7523ºN	323
		Shini mongu (Ao - Chungli)	Lhomithi colony, Dimapur	93.7226ºE	25.9015ºN	164
G-20	**Red Banana**		Greenland colony, Mhainamtsi, Peren	93.7014ºE	25.6687ºN	304
			Medziphema Village, Chumoukedima	93.9403ºE	25.7286ºN	176

			Greenland colony, Mhainamtsi, Peren	93.4219ºE	25.4076ºN	382
G-21	**Unidentified - 1**		Tuli, Mokokchung	94.6565ºE	26.6669ºN	210
		Gumsang	Heningkunglwa village, Peren	93.7784ºE	25.6625ºN	358
			Full Nagarjan, Dimapur	93.7407ºE	25.8825ºN	187
G-22	**Unidentified - 2**		NU:SASRD, Medziphema, Chumoukedima	93.8570ºE	25.7533ºN	415
		Kwegha	Moava village, Chumoukedima	93.8461ºE	25.7008ºN	158
			Greenland colony, Mhainamtsi, Peren	93.4210ºE	25.4080ºN	289
G-23	**Unidentified - 3**		Thaheku village, Dimapur	93.7228ºE	25.8617ºN	125
			Moava village, Chumoukedima	93.9403ºE	25.7286ºN	156
		Kwetho	Sechu Zubza, Kohima	94.0353ºE	25.7099ºN	1100
G-24	**Unidentified - 4**	Luipet	Stadium colony, Jalukie town, Peren	93.6730ºE	25.6460ºN	349
			Sochunoma village, Chumoukedima	93.8418ºE	25.6792ºN	428
			Stadium colony, Jalukie town, Peren	93.6730ºE	25.6460ºN	375
G-25	**Unidentified - 5**	Lumungashe	Sechu Zubza, Kohima	94.0353ºE	25.7099ºN	1100
			Jalukie, Peren	93.9976ºE	25.7126ºN	400
			Sechu Zubza, Kohima	94.0353ºE	25.7099ºN	1100
G-26	**Unidentified - 6**	Lumumgto	Tseipama village, Chumoukedima	93.9305ºE	25.7832ºN	823
			Bade village, Dimapur	93.4430ºE	25.5445ºN	145
			Tseithrongse village, Chumoukedima	93.7068ºE	25.8079ºN	214
G-27	**Meitei Hei**	Meitei hei	Greenland colony, Mhainamtsi, Peren	93.7014ºE	25.6687ºN	304
			Peace Camp, Dimapur	93.4654ºE	25.6625ºN	158
			Kiruphe village, Kohima	94.0248ºE	25.7274ºN	1198

Table 4.1: Passport Data of different genotypes collected from Nagaland

Accession No.	Botanical Name	Collection Site	Biological status	Frequency	Material	Breeding system	Habitat	Disease symptoms
G-1	***Musa aurantiaca***	Natural wild (Forest)	Wild	Abundant	Sucker	Seed and vegetatively propagated	Partly disturbed	
		Natural wild (Forest)	Wild	Frequent	Sucker	Seed and vegetatively propagated	Partly disturbed	Resistant
		Garden	Wild	Frequent	Sucker	Seed and vegetatively propagated	Partly disturbed	Resistant
G-2	***Musa balbisiana* - 1**	Garden	Landrace	Abundant	Sucker	Seed and vegetatively propagated	Cultivated	Resistant
		Farmers field	Landrace	Abundant	Sucker	Seed and vegetatively propagated	Cultivated	Tolerant
		Garden	Landrace	Abundant	Sucker	Seed and vegetatively propagated	Cultivated	Tolerant
G-3	***Musa balbisiana* - 2**	Garden	Landrace	Abundant	Sucker	Seed and vegetatively propagated	Cultivated	Tolerant
		Natural wild (Forest)	Landrace	Abundant	Sucker	Seed and vegetatively propagated	Cultivated	Resistant
		Natural wild (Forest)	Landrace	Abundant	Sucker	Seed and vegetatively propagated	Cultivated	Resistant
G-4	***Musa cheesmanii***	Natural wild (Forest)	Wild	Abundant	Sucker	Seed and vegetatively propagated	Partly disturbed	Resistant
		Natural wild (Forest)	Wild	Abundant	Sucker	Seed and vegetatively propagated	Partly disturbed	Resistant
		Natural wild (Forest)	Wild	Abundant	Sucker	Seed and vegetatively propagated	Partly disturbed	Resistant
G-5	***Musa flaviflora***	Natural wild (Forest)	Primitive cultivar	Occasional	Sucker	Vegetatively propagated	Cultivated	Resistant
		Garden	Primitive	Occasional	Sucker	Vegetatively propagated	Cultivated	Resistant

			cultivar					
		Farmers field	Landrace	Occasional	Sucker	Vegetatively propagated	Cultivated	Resistant
G-6	***Musa itinerans***	Disturbed wild	Wild	Rare	Sucker	Seed and vegetatively propagated	Partly disturbed	Resistant
		Garden	Wild	Rare	Sucker	Seed and vegetatively propagated	Partly disturbed	Tolerant
		Disturbed wild	Wild	Rare	Sucker	Seed and vegetatively propagated	Partly disturbed	Tolerant
G-7	***Musa rubra***	Garden	Landrace	Abundant	Sucker	Vegetatively propagated	Disturbed	Tolerant
		Garden	Landrace	Occasional	Sucker	Vegetatively propagated	Disturbed	Resistant
		Farmers field	Landrace	Abundant	Sucker	Vegetatively propagated	Disturbed	Resistant
G-8	***Musa sikkimensis* var. *sikkimensis***	Natural wild (Forest)	Landrace	Abundant	Sucker	Seed and vegetatively propagated	Partly disturbed	Resistant
		Natural wild (Forest)	Landrace	Abundant	Sucker	Seed and vegetatively propagated	Partly disturbed	Tolerant
		Natural wild (Forest)	Landrace	Abundant	Sucker	Seed and vegetatively propagated	Partly disturbed	Tolerant
G-9	***Musa sikkimensis* var. *simondsii***	Garden	Landrace	Occasional	Sucker	Seed and vegetatively propagated	Partly disturbed	Tolerant
		Natural wild (Forest)	Landrace	Occasional	Sucker	Seed and vegetatively propagated	Partly disturbed	Resistant
		Natural wild (Forest)	Landrace	Occasional	Sucker	Seed and vegetatively propagated	Partly disturbed	Resistant
G-10	***Musa velutina***	Garden	Landrace	Rare	Sucker	Vegetatively propagated	Cultivated	Resistant
		Garden	Landrace	Rare	Sucker	Vegetatively propagated	Cultivated	Tolerant
		Garden	Landrace	Rare	Sucker	Vegetatively propagated	Cultivated	Tolerant
G-11	**Dwarf Cavendish**	Institute	Primitive cultivar	Abundant	Sucker	Vegetatively propagated	Cultivated	Tolerant

	(Jahaji)	Farmers field	Primitive cultivar	Abundant	Sucker	Vegetatively propagated	Cultivated	Tolerant
		Garden	Primitive cultivar	Abundant	Sucker	Vegetatively propagated	Cultivated	Tolerant
G-12	**Cavendish (Grand Naine)**	Institute	Primitive cultivar	Abundant	Sucker	Vegetatively propagated	Cultivated	Tolerant
		Garden	Primitive cultivar	Abundant	Sucker	Vegetatively propagated	Cultivated	Tolerant
		Farmers field	Primitive cultivar	Abundant	Sucker	Vegetatively propagated	Cultivated	Tolerant
G-13	**Nendran**	Garden	Primitive cultivar	Occasional	Sucker	Vegetatively propagated	Cultivated	Tolerant
		Farmers field	Primitive cultivar	Occasional	Sucker	Vegetatively propagated	Cultivated	Tolerant
		Garden	Primitive cultivar	Occasional	Sucker	Vegetatively propagated	Cultivated	Tolerant
G-14	**Monthan**	Garden	Primitive cultivar	Abundant	Sucker	Vegetatively propagated	Cultivated	Tolerant
		Garden	Primitive cultivar	Abundant	Sucker	Vegetatively propagated	Cultivated	Tolerant
		Garden	Primitive cultivar	Abundant	Sucker	Vegetatively propagated	Cultivated	Tolerant
G-15	**African Rhino Horn Plantain**	Garden	Primitive cultivar	Frequent	Sucker	Vegetatively propagated	Cultivated	Tolerant
		Farmers field	Primitive cultivar	Frequent	Sucker	Vegetatively propagated	Cultivated	Tolerant
		Garden	Primitive cultivar	Frequent	Sucker	Vegetatively propagated	Cultivated	Tolerant
G-16	**Bharatmani**	Farmers field	Primitive cultivar	Abundant	Sucker	Vegetatively propagated	Cultivated	Tolerant
		Garden	Primitive cultivar	Abundant	Sucker	Vegetatively propagated	Cultivated	Resistant

		Garden	Primitive cultivar	Abundant	Sucker	Vegetatively propagated	Cultivated	Resistant
G-17	**Bhootmanohar**	Farmers field	Primitive cultivar	Abundant	Sucker	Vegetatively propagated	Cultivated	Resistant
		Garden	Primitive cultivar	Abundant	Sucker	Vegetatively propagated	Cultivated	Resistant
		Garden	Primitive cultivar	Abundant	Sucker	Vegetatively propagated	Cultivated	Resistant
G-18	**Chinichampa**	Institute	Primitive cultivar	Abundant	Sucker	Vegetatively propagated	Cultivated	Resistant
		Garden	Primitive cultivar	Abundant	Sucker	Vegetatively propagated	Cultivated	Resistant
		Farmers field	Primitive cultivar	Abundant	Sucker	Vegetatively propagated	Cultivated	Resistant
G-19	**Kanthali**	Farmers field	Primitive cultivar	Abundant	Sucker	Vegetatively propagated	Cultivated	Resistant
		Farmers field	Primitive cultivar	Abundant	Sucker	Vegetatively propagated	Cultivated	Resistant
		Garden	Primitive cultivar	Abundant	Sucker	Vegetatively propagated	Cultivated	Resistant
G-20	**Red Banana**	Garden	Primitive cultivar	Abundant	Sucker	Vegetatively propagated	Cultivated	Resistant
		Garden	Primitive cultivar	Abundant	Sucker	Vegetatively propagated	Cultivated	Resistant
		Institute	Primitive cultivar	Abundant	Sucker	Vegetatively propagated	Cultivated	Resistant
G-21	**Unidentified - 1**	Garden	Primitive cultivar	Abundant	Sucker	Vegetatively propagated	Cultivated	Resistant
		Garden	Primitive cultivar	Abundant	Sucker	Vegetatively propagated	Cultivated	Tolerant
		Garden	Primitive cultivar	Abundant	Sucker	Vegetatively propagated	Cultivated	Tolerant

G-22	**Unidentified - 2**	Garden	Primitive cultivar	Abundant	Sucker	Vegetatively propagated	Cultivated	Tolerant
		Garden	Primitive cultivar	Abundant	Sucker	Vegetatively propagated	Cultivated	Tolerant
		Garden	Primitive cultivar	Abundant	Sucker	Vegetatively propagated	Cultivated	Tolerant
G-23	**Unidentified - 3**	Farmers field	Primitive cultivar	Abundant	Sucker	Vegetatively propagated	Cultivated	Tolerant
		Garden	Primitive cultivar	Abundant	Sucker	Vegetatively propagated	Cultivated	Tolerant
		Farmers field	Primitive cultivar	Abundant	Sucker	Vegetatively propagated	Cultivated	Tolerant
G-24	**Unidentified - 4**	Farmers field	Primitive cultivar	Abundant	Sucker	Vegetatively propagated	Cultivated	Tolerant
		Garden	Primitive cultivar	Abundant	Sucker	Vegetatively propagated	Cultivated	Tolerant
		Garden	Primitive cultivar	Abundant	Sucker	Vegetatively propagated	Cultivated	Tolerant
G-25	**Unidentified - 5**	Garden	Primitive cultivar	Abundant	Sucker	Vegetatively propagated	Cultivated	Tolerant
		Garden	Primitive cultivar	Abundant	Sucker	Vegetatively propagated	Cultivated	Tolerant
		Garden	Primitive cultivar	Abundant	Sucker	Vegetatively propagated	Cultivated	Tolerant
G-26	**Unidentified - 6**	Garden	Primitive cultivar	Abundant	Sucker	Vegetatively propagated	Cultivated	Tolerant
		Garden	Primitive cultivar	Abundant	Sucker	Vegetatively propagated	Cultivated	Tolerant
		Garden	Primitive cultivar	Abundant	Sucker	Vegetatively propagated	Cultivated	Tolerant
G-27	**Meitei Hei**	Garden	Primitive cultivar	Frequent	Sucker	Vegetatively propagated	Cultivated	Tolerant

		Garden	Primitive cultivar	Frequent	Sucker	Vegetatively propagated	Cultivated	Tolerant
		Garden	Primitive cultivar	Frequent	Sucker	Vegetatively propagated	Cultivated	Tolerant

Table 4.1: Passport Data of different genotypes collected from Nagaland

Accession No.	Botanical Name	Insect/Pest/ Nematode infection	Cultural practices	Soil texture	Topography	*Ethnobotanical* uses		
						Parts	Kind	How used
G-1	***Musa aurantiaca***	Mild	Rainfed	Loam	Hilly dissected	Stem, Fruit and Male bud	Food, Fodder and Ornamental	Culinary & Landscaping
		Mild	Rainfed	Loam	Steepy dissected	Stem, Fruit and Male bud	Food, Fodder and Ornamental	Culinary & Landscaping
G-2	***Musa balbisiana* - 1**	Mild	Rainfed	Loam	Hilly dissected	Stem, Fruit and Male bud	Food, Fodder and Ornamental	Culinary & Landscaping
		Mild	Rainfed	Sandy clay loam	Level	Stem, Fruit and Male bud	Food, Medicine and Fodder	Culinary & Fodder
		Mild	Rainfed	Loam	Hilly dissected	Stem, Fruit and Male bud	Food, Medicine and Fodder	Culinary & Fodder
G-3	***Musa balbisiana* - 2**	Mild	Rainfed	Sandy clay loam	Level	Stem, Fruit and Male bud	Food, Medicine and Fodder	Culinary & Fodder
		Mild	Rainfed	Sandy clay loam	Hilly dissected	Stem and Male bud	Food and Fodder	Culinary & Fodder
		Mild	Rainfed	Loam	Hilly dissected	Stem and Male bud	Food and Fodder	Culinary & Fodder
G-4	***Musa cheesmanii***	Mild	Rainfed	Loam	Hilly dissected	Stem and Male bud	Food and Fodder	Culinary & Fodder
		Moderate	Rainfed	Loam	Hilly dissected	Tender male bud	Food and Fodder	Culinary & Fodder
		Moderate	Rainfed	Sandy loam	Hilly dissected	Tender male bud	Food and Fodder	Culinary & Fodder
		Moderate	Rainfed	Loam	Steepy dissected	Tender male bud	Food and Fodder	Culinary &

								Fodder
G-5	***Musa flaviflora***	Mild	Rainfed	Sandy loam	Hilly dissected	Stem and Male bud	Food, Fodder and Ornamental	Culinary & Fodder
		Mild	Irrigated	Sandy loam	Level	Stem and Male bud	Food, Fodder and Ornamental	Culinary & Fodder
G-6	***Musa itinerans***	Mild	Rainfed	Loam	Hilly dissected	Stem and Male bud	Food, Fodder and Ornamental	Culinary & Fodder
		Mild	Rainfed	Loam	Hilly dissected	Stem and Male bud	Food and Fodder	Culinary & Fodder
		Mild	Rainfed	Sandy loam	Hilly dissected	Male bud	Food and Fodder	Culinary & Fodder
G-7	***Musa rubra***	Mild	Rainfed	Sandy loam	Hilly dissected	Stem and Male bud	Food and Fodder	Culinary & Fodder
		Mild	Rainfed	Sandy loam	Level	Male bud	Food, Fodder and Ornamental	Culinary & Landscaping
		Mild	Rainfed	Sandy loam	Level	Male bud	Food, Fodder and Ornamental	Culinary & Landscaping
G-8	***Musa sikkimensis* var. *sikkimensis***	Mild	Rainfed	Sandy loam	Level	Stem and Male bud	Food, Fodder and Ornamental	Culinary & Landscaping
		Moderate	Rainfed	Loam	Steepy dissected	Stem and Male bud	Food and Fodder	Culinary & Fodder
		Moderate	Rainfed	Sandy loam	Steepy dissected	Stem and Male bud	Food and Fodder	Culinary & Fodder
G-9	***Musa sikkimensis* var. *simondsii***	Moderate	Rainfed	Loam	Steepy dissected	Stem and Male bud	Food and Fodder	Culinary & Fodder
		Moderate	Rainfed	Sandy loam	Steepy dissected	Stem and Male bud	Food and Fodder	Culinary & Fodder
		Moderate	Rainfed	Clay Loam	Steepy dissected	Stem and Male bud	Food and Fodder	Culinary & Fodder
		Moderate	Rainfed	Sandy loam	Steepy dissected	Stem and Male bud	Food and Fodder	Culinary & Fodder

G-10	***Musa velutina***	Moderate	Rainfed	Sandy loam	Undulating	Male bud	Fodder and ornamental	Landscaping
		Moderate	Rainfed	Sandy loam	Steepy dissected	Male bud	Fodder and ornamental	Landscaping
G-11	**Dwarf Cavendish (Jahaji)**	Moderate	Rainfed	Sandy loam	Undulating	Male bud	Fodder and ornamental	Landscaping
		Moderate	Rainfed	Sandy clay loam	Level	Fruit	Food and Fodder	Dessert
		Moderate	Rainfed	Sandy clay loam	Level	Fruit	Food and Fodder	Dessert
G-12	**Cavendish (Grand Naine)**	Moderate	Rainfed	Sandy clay loam	Level	Fruit	Food and Fodder	Dessert
		Moderate	Rainfed	Sandy clay loam	Level	Fruit	Food and Fodder	Dessert
		Moderate	Rainfed	Sandy clay loam	Level	Fruit	Food and Fodder	Dessert
G-13	**Nendran**	Moderate	Rainfed	Sandy clay loam	Level	Fruit	Food and Fodder	Dessert
		Mild	Rainfed	Sandy loam	Level	Male Inflorescence and Fruit	Food and Fodder	Dessert, Culinary & Fodder
		Mild	Rainfed	Sandy loam	Level	Male Inflorescence and Fruit	Food and Fodder	Dessert, Culinary & Fodder
G-14	**Monthan**	Mild	Rainfed	Sandy loam	Level	Male Inflorescence and	Food and Fodder	Dessert, Culinary & Fodder

						Fruit		
		Mild	Rainfed	Sandy loam	Level	Male Inflorescence and Fruit	Food and Fodder	Dessert, Culinary & Fodder
		Mild	Rainfed	Sandy loam	Level	Male Inflorescence and Fruit	Food and Fodder	Dessert, Culinary & Fodder
G-15	**African Rhino Horn Plantain**	Mild	Rainfed	Sandy loam	Level	Male Inflorescence and Fruit	Food and Fodder	Dessert, Culinary & Fodder
		Mild	Rainfed	Sandy loam	Level	Stem and Fruit	Food and Fodder	Dessert, Culinary & Fodder
		Mild	Rainfed	Sandy loam	Level	Stem and Fruit	Food and Fodder	Dessert, Culinary & Fodder
G-16	**Bharatmani**	Mild	Rainfed	Sandy loam	Level	Stem and Fruit	Food and Fodder	Dessert, Culinary & Fodder
		Moderate	Rainfed	Sandy loam	Level	Male Inflorescence and Fruit	Food and Fodder	Dessert & Culinary
		Moderate	Rainfed	Sandy loam	Level	Male Inflorescence and Fruit	Food and Fodder	Dessert & Culinary
G-17	**Bhootmanohar**	Moderate	Rainfed	Sandy loam	Level	Male Inflorescence and Fruit	Food and Fodder	Dessert & Culinary
		Moderate	Rainfed	Sandy loam	Level	Male Inflorescence and Fruit	Food and Fodder	Dessert & Culinary
		Moderate	Rainfed	Sandy loam	Level	Male Inflorescence and Fruit	Food and Fodder	Dessert & Culinary
		Moderate	Rainfed	Sandy	Level	Male	Food and Fodder	Dessert &

G-18	**Chinichampa**			loam		Inflorescence and Fruit		Culinary
		Moderate	Rainfed	Sandy loam	Level	Male Inflorescence and Fruit	Food and Fodder	Dessert & Culinary
		Moderate	Rainfed	Sandy loam	Level	Male Inflorescence and Fruit	Food and Fodder	Dessert & Culinary
G-19	**Kanthali**	Moderate	Rainfed	Sandy loam	Level	Male Inflorescence and Fruit	Food and Fodder	Dessert & Culinary
		Moderate	Rainfed	Sandy loam	Level	Male Inflorescence and Fruit	Food and Fodder	Dessert & Culinary
		Moderate	Rainfed	Sandy loam	Level	Male Inflorescence and Fruit	Food and Fodder	Dessert & Culinary
G-20	**Red Banana**	Moderate	Rainfed	Sandy loam	Level	Male Inflorescence and Fruit	Food and Fodder	Dessert & Culinary
		Moderate	Rainfed	Sandy loam	Level	Male Inflorescence and Fruit	Food and Fodder	Dessert & Culinary
		Moderate	Rainfed	Sandy loam	Level	Male Inflorescence and Fruit	Food and Fodder	Dessert & Culinary
G-21	**Unidentified - 1**	Moderate	Rainfed	Sandy loam	Level	Male Inflorescence and Fruit	Food and Fodder	Dessert & Culinary
		Moderate	Rainfed	Sandy loam	Level	Male Inflorescence and Fruit	Food and Fodder	Dessert & Culinary

		Moderate	Rainfed	Sandy loam	Level	Male Inflorescence and Fruit	Food and Fodder	Dessert & Culinary
G-22	**Unidentified - 2**	Moderate	Rainfed	Sandy loam	Level	Male Inflorescence and Fruit	Food and Fodder	Dessert & Culinary
		Mild	Rainfed	Sandy loam	Level	Male Inflorescence and Fruit	Food and Fodder	Dessert & Culinary
		Mild	Rainfed	Sandy loam	Level	Male Inflorescence and Fruit	Food and Fodder	Dessert & Culinary
G-23	**Unidentified - 3**	Mild	Rainfed	Sandy loam	Level	Male Inflorescence and Fruit	Food and Fodder	Dessert & Culinary
		Mild	Rainfed	Sandy loam	Level	Male Inflorescence and Fruit	Food and Fodder	Dessert & Culinary
		Mild	Rainfed	Sandy loam	Level	Male Inflorescence and Fruit	Food and Fodder	Dessert & Culinary
G-24	**Unidentified - 4**	Mild	Rainfed	Sandy loam	Level	Male Inflorescence and Fruit	Food and Fodder	Dessert & Culinary
		Mild	Rainfed	Sandy loam	Level	Male Inflorescence and Fruit	Food and Fodder	Dessert & Culinary
		Mild	Rainfed	Sandy loam	Level	Male Inflorescence and Fruit	Food and Fodder	Dessert & Culinary
G-25	**Unidentified - 5**	Mild	Rainfed	Sandy loam	Level	Male Inflorescence and	Food and Fodder	Dessert & Culinary

						Fruit		
		Mild	Rainfed	Sandy loam	Level	Male Inflorescence and Fruit	Food and Fodder	Dessert & Culinary
		Mild	Rainfed	Sandy loam	Level	Male Inflorescence and Fruit	Food and Fodder	Dessert & Culinary
G-26	**Unidentified - 6**	Mild	Rainfed	Sandy loam	Level	Male Inflorescence and Fruit	Food and Fodder	Dessert & Culinary
		Mild	Rainfed	Sandy loam	Level	Male Inflorescence and Fruit	Food and Fodder	Dessert & Culinary
		Mild	Rainfed	Sandy loam	Level	Male Inflorescence and Fruit	Food and Fodder	Dessert & Culinary
G-27	**Meitei Hei**	Moderate	Rainfed	Sandy loam	Level	Stem, Male Inflorescence and Fruit	Food and Fodder	Dessert & Culinary
		Moderate	Rainfed	Sandy loam	Level	Stem, Male Inflorescence and Fruit	Food and Fodder	Dessert & Culinary
		Moderate	Rainfed	Sandy loam	Level	Stem, Male Inflorescence and Fruit	Food and Fodder	Dessert & Culinary

Table 4.1: Passport Data of different genotypes collected from Nagaland

Accession No.	Botanical Name	Informants	Farmer's name	Ethnic group	Plant characteristics/Uses Additional Notes
G-1	***Musa aurantiaca***	Friend	Sakotsungba	Ao tribe	Dwarf ornamental plant, orange colour inflorescence
		Friend	Dikekmongba Sangtam	Sangtam tribe	Dwarf ornamental plant, orange colour inflorescence
		Friend	Meren	Ao tribe	Dwarf ornamental plant, orange colour inflorescence
G-2	***Musa balbisiana* - 1**	Local resident	Mughaka	Sema tribe	Tall and robust pseudostem with longer fruit apex.
		Local resident	Temjensunep	Ao tribe	Tall and robust pseudostem with longer fruit apex.
		Local resident	Khrienegulie	Angami tribe	Tall and robust pseudostem with longer fruit apex.
G-3	***Musa balbisiana* - 2**	Local resident	Viseto	Angami tribe	Compact fruit bunches
		Friend	Dikekmongba Sangtam	Sangtam tribe	Compact fruit bunches
		Local resident	Imlitoshi	Ao tribe	Compact fruit bunches
G-4	***Musa cheesmanii***	Friend	Sakotsungba	Ao tribe	Pseudostem is completely black, disease resistant and drought tolerant
		Local resident	Ramdit	Zeliang tribe	Pseudostem is completely black, disease resistant and drought tolerant
		Local resident	Dikekmongba Sangtam	Sangtam tribe	Pseudostem is completely black, disease resistant and drought tolerant
G-5	***Musa flaviflora***	Friend	Keviseto	Angami tribe	Ornamental species, drought tolerant and tolerant to diseases.
		Local resident	Kezhasolie	Angami tribe	Ornamental species, drought tolerant and tolerant to diseases.
		Friend	Bendangsenla	Ao tribe	Ornamental species, drought tolerant and tolerant to diseases.
		Friend	Dikekmongba	Sangtam tribe	Lengthy hanging rachis, spreading rhizomatous roots

G-6	***Musa itinerans***		Sangtam		
		Local resident	Ramdit	Zeliang tribe	Lengthy hanging rachis, spreading rhizomatous roots
		Friend	Bendangsenla	Ao tribe	Lengthy hanging rachis, spreading rhizomatous roots
G-7	***Musa rubra***	Friend	Keviseto	Angami tribe	Fast growth and tolerant to panama wilt and nematode
		Local resident	Khrienegulie	Angami tribe	Fast growth and tolerant to panama wilt and nematode
		Local resident	Abel	Zeliang tribe	Fast growth and tolerant to panama wilt and nematode
G-8	***Musa sikkimensis* var. *sikkimensis***	Local resident	Dikekmongba Sangtam	Sangtam tribe	Hardy pseudostem and suitable for fibre extraction
		Local resident	Ramdit	Zeliang tribe	Hardy pseudostem and suitable for fibre extraction
		Local resident	Sede	Angami tribe	Hardy pseudostem and suitable for fibre extraction
G-9	***Musa sikkimensis* var. *simondsii***	Local resident	Zunthonglo Tungoe	Lotha tribe	Hardy pseudostem and suitable for fibre extraction
		Local resident	Dikekmongba Sangtam	Sangtam tribe	Hardy pseudostem and suitable for fibre extraction
		Local resident	Akube	Zeliang tribe	Hardy pseudostem and suitable for fibre extraction
G-10	***Musa velutina***	Friend	Renny Odyuo	Lotha tribe	Dwarf ornamental plant with pink purple inflorescence
		Friend	Imtinungsang	Ao tribe	Dwarf ornamental plant with pink purple inflorescence
		Friend	Imtinungsang	Ao tribe	Dwarf ornamental plant with pink purple inflorescence
G-11	**Dwarf Cavendish (Jahaji)**	Local resident	Kethoselhou	Angami tribe	Fruits are slightly curved, green when ripe and ripe fruits easily break at the neck
		Local resident	Akube	Zeliang tribe	Fruits are slightly curved, green when ripe and ripe fruits easily break at the neck
		Local resident	Khrienegulie	Angami tribe	Fruits are slightly curved, green when ripe and ripe fruits easily break at the neck

G-12	**Cavendish (Grand Naine)**	Local resident	Chumben	Lotha tribe	Tall mutant clone of dwarf cavendish, fruits are straight and yellow when ripe
		Local resident	Abale	Angami tribe	Tall mutant clone of dwarf cavendish, fruits are straight and yellow when ripe
		Local resident	Temjen Imsong	Ao tribe	Tall mutant clone of dwarf cavendish, fruits are straight and yellow when ripe
G-13	**Nendran**	Local resident	Setinmang	Kuki tribe	The plant has distinct pink colouration in pseudostem
		Local resident	Imlitoshi	Ao tribe	The plant has distinct pink colouration in pseudostem
		Local resident	Akube	Zeliang tribe	The plant has distinct pink colouration in pseudostem
G-14	**Monthan**	Local resident	Sakotsungba	Ao tribe	Fruits are firm texture, pointed fruit apex and drought tolerant
		Local resident	Zunthonglo Tungoe	Lotha tribe	Fruits are firm texture, pointed fruit apex and drought tolerant
		Local resident	Shahchong	Sangtam tribe	Fruits are firm texture, pointed fruit apex and drought tolerant
G-15	**African Rhino Horn Plantain**	Local resident	Shyam Sharma	Manipuri tribe	No male bud and rachis
		Local resident	Temjensunep	Ao tribe	No male bud and rachis
		Local resident	Zuchamo	Lotha tribe	No male bud and rachis
G-16	**Bharatmani**	Local resident	Kailengwi	Zeliang tribe	Fruits has distinctive sweet taste and aroma
		Local resident	Temjen Imsong	Ao tribe	Fruits has distinctive sweet taste and aroma
		Local resident	Andrew	Lotha tribe	Fruits has distinctive sweet taste and aroma
G-17	**Bhootmanohar**	Local resident	Kezhasolie	Angami tribe	Fruit size is bigger compared to chinichampa
		Local resident	Andrew	Lotha tribe	Fruit size is bigger compared to chinichampa
		Local resident	Abel	Zeliang tribe	Fruit size is bigger compared to chinichampa
G-18	**Chinichampa**	Local resident	Bahadur	Nepali tribe	Fruits are smaller in size with both sweet and sour taste
		Local resident	Akash	Bihari tribe	
		Local resident	Abel	Zeliang tribe	
G-19	**Kanthali**	Local resident	Khriekevikho	Angami tribe	Seeded depending upon seasonal variability and sweetest among other commercial bananas

		Local resident	Akube	Zeliang tribe	Seeded depending upon seasonal variability and sweetest among other commercial bananas
		Local resident	Temjen Imsong	Ao tribe	Seeded depending upon seasonal variability and sweetest among other commercial bananas
G-20	**Red Banana**	Local resident	Kidosap	Zeliang tribe	Pseudostem and midrib of leaves are red in colour
		Local resident	Rampuii	Zeliang tribe	Pseudostem and midrib of leaves are red in colour
		Local resident			Pseudostem and midrib of leaves are red in colour
G-21	**Unidentified - 1**	Local resident	Lungkaho	Kuki tribe	
		Local resident	Abel	Zeliang tribe	
		Local resident	Ghusheli	Sema tribe	
G-22	**Unidentified - 2**	Local resident	Lungkaho	Kuki tribe	
		Local resident	Kezhasolie	Angami tribe	
		Local resident	Abel	Zeliang tribe	
G-23	**Unidentified - 3**	Local resident	Kevisalie	Angami tribe	
		Local resident	Abel	Zeliang tribe	
		Local resident	Kezhasolie	Angami tribe	
G-24	**Unidentified - 4**	Local resident	Akube	Zeliang tribe	
		Local resident	Kezhasolie	Angami tribe	
		Local resident	Kenino	Angami tribe	
G-25	**Unidentified - 5**	Local resident	Khrienegulie	Angami tribe	
		Local resident	Shahchong	Sangtam tribe	
		Local resident	Akube	Zeliang tribe	
G-26	**Unidentified - 6**	Local resident	Izaigulie	Zeliang tribe	
		Local resident	Nevikolie	Angami tribe	
		Local resident	Kenino	Angami tribe	
G-27	**Meitei Hei**	Friend	Lungkaho	Kuki tribe	Fruits have round yellow patches and slightly tangy
		Local resident	Akube	Zeliang tribe	Fruits have round yellow patches and slightly tangy
		Local resident	Aseto	Angami tribe	Fruits have round yellow patches and slightly tangy

4.2 GENOME GROUPINGS

In (Table 4.2), the genome grouping of twenty-seven banana genotypes, gathered from various locations within Nagaland, has been meticulously presented. Significant components of banana plants, including female flowers, male flowers, and bracts, have been systematically collected and analysed. For the purpose of genome classification, a set of twenty-five crucial characteristics of banana plants has been employed, in alignment with the criteria delineated by Simmond and Shepherd (1955). Notably, some researchers have incorporated a modified genome score card for this classification, as observed in the works of Singh and Uma (1996) and Silayoi and Chomchalow (1987).

The majority of edible bananas exhibit a triploid genome, resulting in seedless cultivars. However, there are variations, with some being tetraploid or diploid. Diploid variants are particularly uncommon and tend to produce seeded fruits. Among the twenty-five genotypes examined in this study, several were grouped according to their genome types. For instance, *Musa cheesmanii*, Monthan, Bhootmanohar, Kanthali, Unidentified - 2, Unidentified - 5, Unidentified - 6, and Meitei hei were categorized under the ABB genome group. Meanwhile, the AAB genome group encompassed genotypes such as *Musa aurantiaca*, *Musa flaviflora*, *Musa rubra*, *Musa velutina*, Nendran, African Rhino Horn Plantain, Bharatmani, Chinichampa, Unidentified - 1, and Unidentified - 3.

In contrast, three genotypes: Dwarf Cavendish (Jahaji), Cavendish (Grand Naine), and Red Banana, fell under the AAA genome group. *Musa itinerans* and Unidentified - 4 were placed in the AB genome group, notable for having seeded fruit. Solely, Musa balbisiana

- 1 and Musa balbisiana - 2 belonged to the BB/BBB genome groups. Notably, the genome score of *Musa itinerans* and Unidentified - 4 both amounted to 48, although they did not fit into a specific genome type according to the Simmond and Shepherd (1955) scoring system. Consequently, following the modified score card proposed by Singh and Uma (1996), these two genotypes were positioned within the AB genome group.

This study identified instances of overlapping scores between various genome types, suggesting the presence of the same genome types with differing scores. Hence, it is advisable to undertake further characterization using molecular markers to provide a more comprehensive understanding of these variations.

Table 4.2: Genome scores of twenty-seven genotypes in Nagaland during survey

Acc. No.	Genotypes	Scores	Species/hybrid	Genome types
G-1	***Musa aurantiaca***	44	*Musa* spp.	AAB
G-2	***Musa balbisiana* - 1**	71	*Musa balbisiana*	BB/BBB
G-3	***Musa balbisiana* - 2**	73	*Musa balbisiana*	BB/BBB
G-4	***Musa cheesmanii***	63	*Musa* spp.	ABB
G-5	***Musa flaviflora***	42	*Musa* spp.	AAB
G-6	***Musa itinerans***	48	*Musa* spp.	AB
G-7	***Musa rubra***	42	*Musa* spp.	AAB
G-8	***Musa sikkimensis* var. *sikkimensis***	-	*Musa* spp.	-

G-9	***Musa sikkimensis* var. *simondsii***	-	*Musa* spp.	-
G-10	***Musa velutina***	40	*Musa* spp.	AAB
G-11	**Dwarf Cavendish (Jahaji)**	23	*Musa acuminata*	AAA
G-12	**Cavendish (Grand Naine)**	23	*Musa acuminata*	AAA
G-13	**Nendran**	43	*Musa* spp.	AAB
G-14	**Monthan**	63	*Musa* spp.	ABB
G-15	**African Rhino Horn Plantain**	35	*Musa acuminata* **x** *Musa balbisiana*	AAB
G-16	**Bharatmani**	27	*Musa* spp.	AAB
G-17	**Bhootmanohar**	59	*Musa* spp.	ABB
G-18	**Chinichampa**	37	*Musa* spp.	AAB
G-19	**Kanthali**	63	*Musa* spp.	ABB
G-20	**Red Banana**	22	*Musa acuminata*	AAA
G-21	**Unidentified - 1**	44	*Musa* spp.	AAB
G-22	**Unidentified - 2**	59	*Musa* spp.	ABB
G-23	**Unidentified - 3**	45	*Musa* spp.	AAB
G-24	**Unidentified - 4**	48	*Musa* spp.	AB
G-25	**Unidentified - 5**	59	*Musa* spp.	ABB
G-26	**Unidentified - 6**	60	*Musa* spp.	ABB
G-27	**Meitei Hei**	61	*Musa* spp.	ABB

4.3 MORPHOLOGICAL DESCRIPTION

G-1: (*Musa aurantiaca*)

Musa aurantiaca, known as Ai yarang (Ao - Mongsen), Yarüm homa (Sangtam), and Yarang (Ao - Mongsen), is a wild *Musa* species abundant in Alichen village of Mokokchung at 94.4855ºE latitude and 26.2993ºN longitude, situated at 1055 m MSL. It is also found in Ungma village of Mokokchung, positioned at 94.2863ºE latitude and 26.1595ºN longitude, with an elevation of 1160 m MSL. Furthermore, it can be discovered in Old Chungliyimti village of Tuensang at 94.8331ºE latitude, 26.3457ºN longitude, and 1315 m MSL. This captivating plant showcases dwarf ornamental features and boasts a distinct orange-coloured inflorescence. With an AAB genome type, *Musa aurantiaca* is well-suited for both seed and vegetative propagation. It thrives in partly disturbed habitats, displaying resistance to common diseases while occasionally encountering mild insect, pest, or nematode infections. Culturally, *Musa aurantiaca* holds immense significance as its stem, fruit, and male bud are utilized for culinary purposes, fodder, and ornamental landscaping. Furthermore, its adaptability to rainfed cultural practices enhances its overall appeal (Table 4.1). Häkkinen & Väre (2008) noted its wide distribution, spanning an area bounded in the Northwest by Tibet's southern slope of the Himalayas, extending to Northern Arunachal Pradesh in the Northeast, Southern regions of Northern Assam and East to Putao in Northern Myanmar, where it was recently reported in 2006.

Musa aurantiaca displays an upright leaf habit, featuring a dark green upper leaf surface as noted by Gogoi (2014), resulting in an aesthetically pleasing presentation. Despite its dwarf stature, this species follows a regular growth pattern. The pseudostem of *Musa aurantiaca* exhibits a captivating interplay of red and green hues, enhancing its visual allure. The suckers emerge in close proximity to the parent plant, showcasing vertical growth. The leaf blade base exhibits a distinctive shape with one side rounded and the other side pointed, creating an intriguing asymmetry. The third leaf's petiole canal displays a gently curved inward margin (Table 4.3). Notably, the average length of the leaf blade measures 152.67 ± 7.51 cm, while the width spans 42.67 ± 3.88 cm. The pseudostem attains a height of 2.82 ± 0.19 meters, accompanied by a girth size of 22.67 ± 1.53 cm. On average, *Musa aurantiaca* was noticed to produce 2.00 ± 1.00 suckers. The petiole measures 64.33 ± 3.06 cm in length (Table 4.4). These precise measurements accentuate the distinct morphological attributes of *Musa aurantiaca*, contributing to its exceptional appeal. In accordance with Häkkinen & Väre (2008), the suckers are positioned closely to the parent plant and exhibit vertical growth.

The male bud of *Musa aurantiaca* assumes a lanceolate shape, lending to its distinct appearance. The bracts exhibit an obtuse apex and a generously sized shoulder base, further enriching its unique floral structure. The bracts' external colour is a vibrant orange, while the internal bracts also showcase an attractive orange hue. The free tepals, with an oval form, are delicately tinged with yellow, infusing subtle warmth into the floral arrangement. In contrast, the compound tepals boast a striking orange hue. The ovary of *Musa aurantiaca* displays a straight contour, contributing to the flower's overall symmetry. Lastly, the stigma presents a cream colour, creating an elegant contrast to the vibrant shades displayed by the bracts and tepals. These captivating floral attributes harmoniously combine to craft a visually pleasing and balanced presentation in *Musa aurantiaca* (Table 4.5). Baker (1894) observed that the external bracts of the inflorescence are bright orange-yellow and lanceolate in shape.

The fruit of *Musa aurantiaca* exhibits a straight shape with a rounded apex. During its immature stage, the fruit peel presents a green colour, which transitions into a vibrant yellow-orange hue as it reaches full maturity. The inner pulp of the fruit boasts a pleasing yellow colour and maintains a firm texture (Table 4.6). Seeds can be observed within the fruit. In terms of size, the average length of the fruit measures 7.10 ± 0.26 cm, accompanied by a width of 2.67 ± 0.21 cm. The peel thickness measures approximately 2.30 ± 0.20 mm. On average, a bunch of *Musa aurantiaca* weighs 1.35 ± 0.06 kg and comprises approximately 5.67 ± 0.58 hands, each containing around 6.33 ± 0.58 fingers. The weight of an individual fruit is about 21.33 ± 2.52 g, while the pulp weight registers at 13.00 ± 2.00 g (Table 4.7).

Musa aurantiaca showcases favourable attributes in terms of its chemical composition and shelf life. The fruit's total soluble solids (°B) register at 15.22 ± 0.60, signifying a notable concentration of dissolved solids that contribute to its distinctive flavour. The titratable acidity level is relatively modest, measuring 0.49 ± 0.04%, indicating a mild acidic taste in the fruit. The total sugar content is recorded at 9.53 ± 0.30%, contributing to the fruit's overall sweetness. Additionally, the reducing sugar content measures 1.73 ± 0.12%, further enriching the fruit's flavour. *Musa aurantiaca* boasts up a shelf life of 6.31 ± 1.18 days, highlighting its capacity to uphold quality and freshness for a reasonable duration (Table 4.8).

(A)

(B)

(C)

(D)

(E)

(F)

(G)

(H)

(I) (J)

(K) (L)

(M) (N)

Plate 1: G-1: *Musa aurantiaca*, (A) & (B) plant habitat, (C) & (D) pseudostem, (E) measuring of leaf length, (F) male bud, (G) & (H) internal and external bracts, (I) petiole canal of leaf III, (J) male flower, (K) mature fruits, (L) & (M) transverse section of immature and ripen fruits, (N) measuring of leaf width.

Table 4.3: Plant general appearance of various parameters of different genotypes

Acc. No.	Genotypes	Leaf habit	Colour of leaf upper surface	Dwarfism	Pseudostem colour	Position of suckers	Leaf blade base shape	Petiole canal leaf III
G-1	***Musa aurantiaca***	Erect	Dark green	Normal	Red-Green	Close from parent (vertical growth)	One side rounded, one pointed	Margin curved inward
G-2	***Musa balbisiana* - 1**	Intermediate	Green-yellow	Normal	Green yellow	Close from parent (vertical growth)	Both sides rounded	Margin curved inward
G-3	***Musa balbisiana* - 2**	Intermediate	Dark green	Normal	Green-red	Close from parent (vertical growth)	Both side rounded	Margin curved inward
G-4	***Musa cheesmanii***	Erect	Dark green	Normal	Black-Red	Close from parent (vertical growth)	Both sides rounded	Straight with erect margin
G-5	***Musa flaviflora***	Erect	Dark green	Normal	Green-yellow	Close from parent (vertical growth)	One side rounded, one pointed	Wide with erect margin
G-6	***Musa itinerans***	Erect	Green	Normal	Green red	Far from parent	Both side pointed	Margin curved inward
G-7	***Musa rubra***	Erect	Dark green	Dwarf	Green	Close from parent (vertical growth)	Both side pointed	Open with margin spreading
G-8	***Musa sikkimensis* var. *sikkimensis***	Erect	Green	Normal	Red	Close from parent (vertical growth)	Both side pointed	Straight with erect margin

G-9	***Musa sikkimensis* var. *simondsii***	Erect	Dark green	Normal	Green-Red	Far from parent	One side rounded, one pointed	Wide with erect margin
G-10	***Musa velutina***	Erect	Dark green	Normal	Medium green	Close from parent (vertical growth)	Both sides rounded	Straight with erect margin
G-11	**Dwarf Cavendish (Jahaji)**	Drooping	Green	Normal	Medium green	Close from parent (vertical growth)	Both sides rounded	Margin curved inward
G-12	**Cavendish (Grand Naine)**	Drooping	Green	Normal	Green - yellow	Close from parent (vertical growth)	Both sides rounded	Wide with erect margin
G-13	**Nendran**	Intermediate	Dark green	Normal	Green-yellow	Close from parent (vertical growth)	One side rounded, one pointed	Open with margin spreading
G-14	**Monthan**	Intermediate	Green	Normal	Green-red	Close from parent (vertical growth)	One side rounded, one pointed	Open with margin spreading
G-15	**African Rhino Horn Plantain**	Intermediate	Green	Normal	Medium green	Close from parent (vertical growth)	Both sides rounded	Margin curved inward
G-16	**Bharatmani**	Drooping	Green	Normal	Green-red	Close from parent (vertical growth)	One side rounded, one pointed	Margins curved inward
G-17	**Bhootmanohar**	Intermediate	Dark green	Dwarf	Green-yellow	Close from parent (vertical growth)	One side rounded, one pointed	Open with margin spreading
G-18	**Chinichampa**	Drooping	Green	Normal	Green red	Close from parent (vertical growth)	Both sides rounded	Open with margin spreading

G-19	**Kanthali**	Intermediate	Green	Normal	Green	Close from parent (vertical growth)	Both sides rounded	Straight with erect margin
G-20	**Red Banana**	Intermediate	Green	Normal	Red	Close from parent (vertical growth)	Both sides rounded	Wide with erect margin
G-21	**Unidentified - 1**	Drooping	Green	Normal	Green-yellow	Close from parent (vertical growth)	Both sides rounded	Straight with erect margin
G-22	**Unidentified - 2**	Erect	Green	Normal	Green-red	Close from parent (vertical growth)	Both side rounded	Wide with erect margin
G-23	**Unidentified - 3**	Drooping	Green	Normal	Green-yellow	Close from parent (vertical growth)	Both sides rounded	Margin curved inward
G-24	**Unidentified - 4**	Drooping	Green	Normal	Green-yellow	Close from parent (vertical growth)	Both sides rounded	Wide with erect margin
G-25	**Unidentified - 5**	Drooping	Dark green	Normal	Green-yellow	Close from parent (vertical growth)	Both sides rounded	Margins overlapping
G-26	**Unidentified - 6**	Intermediate	Dark green	Normal	Green yellow	Close from parent (vertical growth)	Both sides rounded	Straight with erect margin
G-27	**Meitei Hei**	Erect	Dark green	Normal	Green-yellow	Close from parent (vertical growth)	One side rounded, one pointed	Wide with erect margin

G-2: (*Musa balbisiana* – 1)

Musa balbisiana-1, commonly referred to as Bhimkol in Assamese, bears various vernacular names, including Agha aucho (Sema), Sati mango (Ao - Mongsen), Phengnu kethe, and Lothe kethe (Angami). This cultivated banana species thrives abundantly across multiple locations. In the Sukhovi village of Chumoukedima, it can be found at 93.7190ºE latitude and 25.7631ºN longitude, situated at an elevation of 323 m MSL. Similarly, in the Chuchuyimpang village of Mokokchung, its presence is noted at 94.5540ºE latitude and 26.3346ºN longitude, positioned at an elevation of 1309 m MSL. Lastly, in the Bade village of Dimapur, it graces the landscape at 93.4432ºE latitude and 25.5445ºN longitude, at an elevation of 145 m MSL. *Musa balbisiana*-1 showcases a genome type of BB/BBB, representing a primitive cultivar known for its tall and robust pseudostem. It primarily propagates through suckers and exhibits a remarkable tolerance to diseases, with only occasional mild instances of insect, pest, or nematode infections. Culturally, *Musa balbisiana*-1 holds profound significance, as its stem, fruit, and male bud serve as valuable resources for food, medicine, and fodder. These contributions play a pivotal role in culinary traditions and medicinal practices. Thriving in rainfed conditions and flourishing in sandy clay loam soil, particularly in areas with a level topography, *Musa balbisiana*-1 is abundant in gardens. Its adaptability to various cultural practices underscores its role as a valuable genetic resource (Table 4.1). Southeast Asia is recognized as the centre of origin for *M. balbisiana* (Hore *et al*., 1992), and it has also been reported from Sri Lanka, India, Thailand, Malaya, Indonesia, the Philippines, and New Guinea (Cheesman, 1948; Sulistyaningsih *et al*., 2014).

The *Musa balbisiana*-1 plant showcases an intermediate leaf habit with an appealing green-yellow coloration on the upper surface of its leaves. The plant maintains a typical level of dwarfism, and its pseudostem exhibits an attractive green-yellow hue. Suckers emerge in close proximity to the parent plant, displaying vertical growth. The leaf blade base is gracefully rounded on both sides, adding to its symmetrical allure (Table 4.3). Measuring on average, the leaf blade boasts a length of 351.00 ± 7.94 cm and a width of 82.67 ± 2.08 cm. The pseudostem achieves a height of approximately 5.22 ± 0.26 m, accompanied by a girth size of 45.65 ± 3.15 cm. The *Musa balbisiana*-1 plant generates around 5.33 ± 0.58 suckers. The petioles, measuring approximately 83.33 ± 2.52 cm in length, harmoniously enhance the overall plant structure. These distinct attributes collectively contribute to the visual allure and overall growth of the *Musa balbisiana*-1 plant (Table 4.4). Borborah *et al*., (2016) also reported similar findings regarding leaf colour, leaf blade dimensions, and the number of suckers.

The male bud of the *Musa balbisiana*-1 plant boasts an ovoid shape, lending a distinctive characteristic to its overall appearance. The bracts, characterized by an intermediate apex shape and a generously sized shoulder base, contribute to the plant's unique bract structure. The bracts' external colour is a captivating purple-brown, while the internal hue radiates a vibrant orange-red shade. The free tepals, gently rounded in shape, harmoniously complement the entire floral arrangement. With a delicate pink tint, the free tepals infuse an element of grace into the blossoms. In contrast, the compound tepals present a lovely pink coloration. The ovary's arched form enhances the visual allure of the flowers. Lastly, the stigma, adorned with a cream colour, boldly contrasts against the vibrant tones of the bracts and tepals (Table 4.5).

The fruits of the *Musa balbisiana*-1 plant are distinguished by a straight shape with a bottlenecked apex, giving them a unique and recognizable appearance. While in their immature state, the fruit peel displays a green hue that gradually transforms into a vibrant yellow shade with hints of rusty brown as it matures. Inside, the pulp showcases a creamy colour, and the flesh maintains a firm texture. The presence of seeds further contributes to the distinct characteristics of the fruit (Table 4.6). In terms of size, the average length of the fruit measures 10.07 ± 0.15 cm, with a width spanning 2.93 ± 0.15 cm. The peel thickness measures approximately 2.97 ± 0.12 mm. Bunches of these fruits have an average weight of 13.01 ± 1.14 kg, typically containing around 7.33 ± 0.58 hands per bunch. Each hand comprises an average of 14.67 ± 1.53 fingers. Individually, the fruit weighs approximately 208.67 ± 9.29 g, while the pulp carries a weight of about 167.67 ± 2.08 g (Table 4.7). Borborah *et al*., (2016) have also reported similar findings concerning the fruit shape and fruit apex.

The *Musa balbisiana*-1 fruits are not only visually captivating but also offer desirable taste and quality attributes. With a total soluble solid content of 22.20 ± 0.59 °B, these fruits provide a delightful level of taste. The titratable acidity level, measured at 1.71 ± 0.02%, imparts a balanced tartness that complements the overall flavour profile. Notably, the total sugar content is high, at 13.22 ± 0.22%, enhancing the fruit's natural sweetness. Additionally, the reducing sugar content is relatively low, at 0.97 ± 0.06%, indicating a harmonious sugar composition. In terms of shelf life, these fruits can be enjoyed for an average duration of 5.34 ± 1.16 days, offering a reasonable period for consumption (Table 4.8).

(A)

(B)

(C)

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(E)

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(G)

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(J)

(K)

(L)

(M)

(N)

Plate 2: G-2: *Musa balbisiana* - 1, (A) and (B) plant habitat, (C) measuring of leaf length, (D) mature fruit bunch, (E) mature fruits, (F) male flower, (G) and (H) transverse section of mature fruits, (I) petiole canal of leaf III, (J) male bud, (K) and (L) internal and external bracts, (M) ripen fruits and (N) pseudostem.

Table 4.4: Plant general appearance of various parameters of different genotypes

Particulars		Mean ± SD					
Acc. No.	**Genotypes**	**Leaf blade length (cm)**	**Leaf blade width (cm)**	**Pseudostem height (m)**	**Girth size (cm)**	**No. of suckers**	**Petiole length (cm)**
G-1	***Musa aurantiaca***	152.67 ± 7.51	42.67 ± 3.88	2.82 ± 0.19	22.67 ± 1.53	2.00 ± 1.00	64.33 ± 3.06
G-2	***Musa balbisiana - 1***	351.00 ± 7.94	82.67 ± 2.08	5.22 ± 0.26	45.65 ± 3.15	5.33 ± 0.58	83.33 ± 2.52
G-3	***Musa balbisiana - 2***	308.67 ± 10.07	58.85 ± 1.53	5.08 ± 0.18	47.33 ± 2.52	3.00 ± 1.00	84.33 ± 2.52
G-4	***Musa cheesmanii***	274.67 ± 5.51	64.33 ± 1.53	4.30 ± 0.18	62.33 ± 5.86	3.67 ± 0.58	75.00 ± 4.00
G-5	***Musa flaviflora***	230.00 ± 6.56	60.30 ± 2.14	4.97 ± 0.13	45.33 ± 2.08	3.00 ± 1.00	83.00 ± 3.61
G-6	***Musa itinerans***	226.67 ± 12.58	56.73 ± 8.59	4.50 ± 0.50	48.00 ± 3.00	1.33 ± 0.58	60.67 ± 1.53
G-7	***Musa rubra***	116.67 ± 8.74	41.00 ± 6.56	1.92 ± 0.18	17.00 ± 2.00	1.67 ± 0.58	29.33 ± 3.79
G-8	***Musa sikkimensis* var. *sikkimensis***	177.33 ± 7.09	74.67 ± 4.04	4.83 ± 0.76	41.17 ± 2.02	3.67 ± 0.58	53.67 ± 3.06
G-9	***Musa sikkimensis* var. *simondsii***	223.33 ± 8.33	83.67 ± 3.06	3.65 ± 0.30	38.33 ± 2.08	2.33 ± 1.53	54.50 ± 1.80
G-10	***Musa velutina***	117.00 ± 8.00	51.28 ± 1.59	2.65 ± 0.30	21.33 ± 1.53	5.33 ± 0.58	63.00 ± 2.00
G-11	**Dwarf Cavendish (Jahaji)**	190.33 ± 24.70	60.67 ± 2.52	2.97 ± 0.16	63.00 ± 2.00	5.00 ± 1.00	30.33 ± 2.52
G-12	**Cavendish (Grand Naine)**	211.00 ± 11.14	55.67 ± 5.69	2.78 ± 0.18	58.00 ± 3.61	4.00 ± 1.00	33.67 ± 2.52

G-13	**Nendran**	218.33 ± 7.02	65.33 ± 3.79	4.28 ± 0.19	58.67 ± 1.53	2.33 ± 0.58	55.83 ± 1.89
G-14	**Monthan**	168.67 ± 6.03	54.00 ± 3.00	5.42 ± 0.26	61.00 ± 2.00	2.33 ± 1.53	49.67 ± 1.53
G-15	**African Rhino Horn Plantain**	256.67 ± 5.51	64.67 ± 2.08	3.25 ± 0.13	75.00 ± 4.58	4.33 ± 0.58	63.00 ± 4.00
G-16	**Bharatmani**	204.67 ± 16.65	62.00 ± 4.36	3.32 ± 0.21	59.35 ± 1.60	3.00 ± 1.00	24.67 ± 2.52
G-17	**Bhootmanohar**	218.00 ± 6.56	59.80 ± 2.96	3.57 ± 0.16	69.33 ± 2.52	2.67 ± 0.58	64.33 ± 2.52
G-18	**Chinichampa**	193.33 ± 12.01	70.00 ± 4.58	2.95 ± 0.13	59.33 ± 2.52	3.00 ± 1.00	57.97 ± 2.00
G-19	**Kanthali**	202.67 ± 8.08	56.00 ± 6.24	3.75 ± 0.15	52.00 ± 2.65	2.33 ± 0.58	65.00 ± 2.00
G-20	**Red Banana**	249.67 ± 2.08	89.33 ± 4.04	4.75 ± 0.25	61.00 ± 2.65	5.00 ± 1.00	56.00 ± 2.65
G-21	**Unidentified - 1**	202.00 ± 7.21	47.80 ± 1.93	4.17 ± 0.23	63.33 ± 2.52	3.67 ± 1.15	52.72 ± 2.09
G-22	**Unidentified - 2**	255.33 ± 5.69	68.67 ± 1.53	4.50 ± 0.26	82.30 ± 3.25	2.67 ± 0.58	52.67 ± 2.52
G-23	**Unidentified - 3**	262.67 ± 11.02	76.00 ± 4.58	4.68 ± 0.28	92.67 ± 2.08	2.00 ± 1.00	61.33 ± 2.08
G-24	**Unidentified - 4**	206.50 ± 6.76	51.33 ± 2.52	5.03 ± 0.30	40.00 ± 3.00	3.33 ± 0.58	76.33 ± 1.53
G-25	**Unidentified - 5**	236.03 ± 18.09	67.92 ± 2.71	3.92 ± 0.08	83.33 ± 2.08	2.33 ± 0.58	72.67 ± 2.08
G-26	**Unidentified - 6**	198.67 ± 15.50	62.03 ± 2.44	4.12 ± 0.10	78.67 ± 3.21	2.67 ± 0.58	59.67 ± 4.16
G-27	**Meitei Hei**	180.33 ± 4.04	70.70 ± 1.74	3.80 ± 0.26	43.33 ± 3.06	2.67 ± 1.53	55.67 ± 3.06

G-3: (*Musa balbisiana* – 2)

The *Musa balbisiana*-2 genotype, known locally as Pfekrei in Angami language, is a landrace variety that thrives abundantly in several locations. It can be found in the Sirhi Angami village of Chumoukedima, positioned at 94.1552ºE latitude and 26.5123ºN longitude, with an elevation of 465 meters above sea level. Additionally, it flourishes in the Old Chungliyimti village in Tuensang at 94.8131ºE latitude and 26.2357ºN longitude, at an elevation of 1305 meters above sea level. Another location where it is prevalent is the Longkum village in Mokokchung, with coordinates at 94.2383ºE latitude and 26.1632ºN longitude, and an elevation of 1383 meters above sea level (Table 4.1). The *Musa balbisiana*-2 genotype features a BB/BBB genome type and is sourced from its natural wild habitat within the forest (Table 4.2). It is primarily propagated through suckers, with its breeding involving both seed and vegetative methods. Cultivated under rainfed conditions, it thrives in sandy clay loam soil with a hilly dissected topography. Displaying resistance to diseases while showing mild susceptibility to insects, pests, and nematode infections, this variety is valued in local communities. Both the stem and male bud of *Musa balbisiana*-2 find use as food and fodder, playing crucial roles in culinary practices and livestock feeding. Notably, this genotype is recognized for producing compact fruit bunches, highlighting one of its distinctive plant characteristics (Table 4.1).

The *Musa balbisiana*-2 genotype exhibits an intermediate leaf habit, characterized by a dark green upper leaf surface. It showcases typical dwarfism traits and a pseudostem with a green-red coloration. Suckers are positioned closely to the parent plant, growing vertically. The leaf blade base displays a rounded shape on both sides, and the petiole canal of leaf III features a margin curved inward (Table 4.3). The average length of the leaf blade measures 308.67 ± 10.07 cm, while the width spans 58.85 ± 1.53 cm. The pseudostem reaches a height of 5.08 ± 0.18 meters, accompanied by a girth size of 47.33 ±

2.52 cm. On average, the *Musa balbisiana*-2 genotype produces around 3.00 ± 1.00 suckers. The petioles have an average length of 84.33 ± 2.52 cm (Table 4.4). It's noteworthy that Borborah *et al*., (2016) have also reported similar findings regarding the colour of the pseudostem, the position of suckers close to the parent plant, the vertical growth of the suckers, and the leaf blade base shape.

The male bud of the *Musa balbisiana*-2 genotype takes on an ovoid shape. The bract apex features an obtuse and split shape, while the bract base exhibits a small shoulder. External bracts are adorned with a red-purple hue, while the internal bracts showcase a purple-brown coloration. The free tepals, with their oval shape, are translucent white in colour. In contrast, the compound tepals display a pink-purple hue. The ovary is gracefully arched in shape, and the stigma colour presents a cream shade (Table 4.5). It's worth noting that Borborah *et al*., (2016) have also reported similar observations regarding the shape and colour of the free tepals, as well as their mention of the bract apex shape and the overall male bud characteristics.

The fruits of the *Musa balbisiana*-2 genotype display a straight shape with a blunt-tipped apex. The immature fruit peel showcases a light green or silvery colour, transitioning to a vibrant yellow as it matures. The fruit's pulp maintains a creamy hue and offers a firm texture. The presence of seeds adds to the characteristic features of these fruits (Table 4.6). On average, the fruit measures approximately 9.07 ± 0.35 cm in length and 3.37 ± 0.25 cm in width. The peel thickness of the fruit spans approximately 3.17 ± 0.12 mm. A cluster of these fruits weighs around 7.96 ± 0.17 kg and contains an average of 9.33 ± 0.58 hands. Each hand consists of about 12.33 ± 0.58 fingers. The average weight of an individual fruit is 184.67 ± 7.02 g, with the pulp weighing about 135.67 ± 11.37 g (Table 4.7).

The *Musa balbisiana*-2 genotype presents total soluble solids content of 10.99 ± 0.71°B. The titratable acidity measures approximately 2.07 ± 0.25%. In terms of sugar content, the total sugar levels are around 2.43 ± 0.15%, with reducing sugar content at approximately 1.27 ± 0.06%. As for its shelf life, this genotype is estimated to last for about 8.33 ± 1.04 days (Table 4.8).

(A)

(B)

(C)

(D)

(E)

(F)

(G)

(H)

(I)

(J)

(K)

Plate 3: G-3: *Musa balbisiana* - 2, (A) plant habitat, (B) mature fruit bunch, (C) pseudostem, (D) male bud, (E) and (F)) internal and external bracts, (G) and (H) male flower, (I) transverse section of ripen fruits, (J) petiole canal of leaf III and (K) measuring of leaf length.

Table 4.5: Flower character of various parameters of different genotypes

Acc. No.	Genotypes	Male bud shape	Bract apex shape	Bract base shape	Colour of bracts (external)	Colour of bract (internal)
G-1	***Musa aurantiaca***	Lanceolate	Obtuse	Large shoulder	Orange	Orange
G-2	***Musa balbisiana* - 1**	Ovoid	Intermediate	Medium	Purple-brown	Orange-red
G-3	***Musa balbisiana* - 2**	Ovoid	Obtuse and split	Small shoulder	Red-purple	Purple-brown
G-4	***Musa cheesmanii***	Ovoid	Intermediate	Medium	Purple-brown	Orange-red
G-5	***Musa flaviflora***	Like a top	Slightly pointed	Large shoulder	Pink-purple	Orange-red
G-6	***Musa itinerans***	Ovoid	Intermediate	Medium	Purple-brown	Yellow
G-7	***Musa rubra***	Like a top	Slightly pointed	Small shoulder	Orange	Orange-red
G-8	***Musa sikkimensis* var. *sikkimensis***	Like a top	Intermediate	Large shoulder	Pink-purple	Orange-red
G-9	***Musa sikkimensis* var. *simondsii***	Lanceolate	Slightly pointed	Large shoulder	Purple-brown	Orange-red
G-10	***Musa velutina***	Like a top	Pointed	Large shoulder	Pink-purple	Red
G-11	**Dwarf Cavendish (Jahaji)**	Ovoid	Intermediate	Large shoulder	Purple-brown	Orange-red
G-12	**Cavendish (Grand Naine)**	Ovoid	Intermediate	Large shoulder	Purple-brown	Orange-red
G-13	**Nendran**	Intermediate	Obtuse and split	Large shoulder	Purple-brown	Crimson
G-14	**Monthan**	Like a top	Intermediate	Large shoulder	Purple-brown	Purple-brown

G-15	**African Rhino Horn Plantain**	Absent	Absent	Absent	Absent	Absent
G-16	**Bharatmani**	Like a top	Slightly pointed	Large shoulder	Purple-brown	Whitish
G-17	**Bhootmanohar**	Intermediate	Intermediate	Small shoulder	Orange-red	Red
G-18	**Chinichampa**	Like a top	Intermediate	Small shoulder	Purple	Red
G-19	**Kanthali**	Intermediate	Intermediate	Medium	Red-purple	Red
G-20	**Red Banana**	Like a top	Intermediate	Medium	Red	Purple
G-21	**Unidentified - 1**	Like a top	Obtuse	Large shoulder	Purple-brown	Red
G-22	**Unidentified - 2**	Like a top	Intermediate	Large shoulder	Purple-brown	Purple-brown
G-23	**Unidentified - 3**	Ovoid	Obtuse	Small shoulder	Red-purple	Red
G-24	**Unidentified - 4**	Lanceolate	Intermediate	Small shoulder	Red	Whitish
G-25	**Unidentified - 5**	Intermediate	Obtuse and split	Medium	Purple-brown	Purple-brown
G-26	**Unidentified - 6**	Like a top	Intermediate	Large shoulder	Red-purple	Purple-brown
G-27	**Meitei Hei**	Ovoid	Obtuse	Small shoulder	Purple-brown	Red

G-4: (*Musa cheesmanii*)

The *Musa cheesmanii* genotype, referred to as Lanak in the Ao-Mongsen language, is a landrace variety that thrives abundantly across several locations. It can be found in the Kiro Ait village of Alichen, Mokokchung, positioned at 94.4555ºE latitude and 26.2693ºN longitude, at an altitude of 1097 m MSL. Similarly, it graces the landscape at Old Jalukie, Peren, located at 93.4224ºE latitude and 25.3462ºN longitude, and at an altitude of 769 m MSL. Additionally, it is widely prevalent in Chare Town, Tuensang, positioned at 94.3650ºE latitude and 26.1745ºN longitude, at an altitude of 963 m MSL. With an ABB genome type, *Musa cheesmanii* is sourced from its natural wild habitat within the forest. Its primary mode of propagation is through suckers, and its breeding system involves both seed and vegetative methods. Flourishing in partly disturbed habitats, this genotype showcases resistance to diseases, although it displays moderate susceptibility to insect, pest, and nematode infections. Culturally, the tender male bud of *Musa cheesmanii* holds great value, serving as a source of food and fodder. It plays a pivotal role in culinary practices and contributes significantly to livestock feeding. Plant characteristics of *Musa cheesmanii* include a pseudostem that exhibits a distinctive black coloration and demonstrates drought tolerance. This variety is typically cultivated under rainfed conditions, thriving in loam soil with a hilly dissected topography (Table 4.1). Its remarkable adaptability to its natural environment and its resilience to drought underscore its significance as a valuable and essential landrace variety within the region. Joe *et al.*, (2014) mentioned about the *Musa cheesmanii* found at the stretch on the steep stony slopes by the Manipur Road, 26 miles above Dimapur (Dimapur is now in Nagaland State).

The *Musa cheesmanii* genotype boasts an erect leaf habit, featuring a dark green coloration on the upper surface of its leaves. It demonstrates typical dwarfism traits and showcases a pseudostem with a black-red hue. Suckers of this variety are positioned closely to the parent plant, growing vertically. The leaf blade base shape exhibits a rounded form on both sides, while the petiole canal of leaf III is straight with an erect margin (Table 4.3). The average length of the leaf blade measures approximately 274.67 ± 5.51 cm, accompanied by a width of 64.33 ± 1.53 cm. The pseudostem attains a height of around 4.30 ± 0.18 meters, featuring a girth size of 62.33 ± 5.86 cm. On average, the *Musa cheesmanii* genotype produces about 3.67 ± 0.58 suckers. The petioles have an average length of 75.00 ± 4.00 cm (Table 4.4). It's noteworthy that Rajib *et al*., (2014) have obtained comparable findings concerning the pseudostem height. Additionally, Joe *et al*., (2014) have also reported similar observations regarding the position of suckers, pseudostem height, and the number of suckers.

The male bud of the *Musa cheesmanii* genotype is characterized by an ovoid shape. The bract apex shape falls within an intermediate range, while the bract base shape is of medium size. The external bracts display a captivating purple-brown hue, creating a striking contrast with the orange-red coloration of the internal bracts. The free tepals, with their gracefully rounded shape, exhibit a translucent white colour. In contrast, the compound tepals boast a creamy appearance, adding to the visual intrigue (Table 4.5). It's worth noting that Joe *et al*., (2014) have also reported similar observations regarding the colour of the compound tepals. The ovary maintains a straight shape, while the stigma presents a delicate pink hue. It's interesting to point out that Rajib *et al*., (2014) have also documented comparable findings concerning the internal bract colour and the colour of the free tepals. These consistent observations further contribute to our understanding of the characteristics of the Musa cheesmanii genotype.

The fruits of the *Musa cheesmanii* genotype exhibit a straight shape at the distal end, culminating in a blunt-tipped apex. During its early stages, the fruit peel boasts a silvery hue, which deepens into a black colour as it reaches maturity. The fruit's pulp is characterized by a creamy colour and a firm texture (Table 4.6). Notably, the fruits contain seeds. On average, these fruits measure approximately 9.70 ± 0.26 cm in length and 3.33 ± 0.12 cm in width. The peel thickness of the fruit is approximately 1.10 ± 0.10 mm. A cluster of these fruits weighs around 8.40 ± 0.30 kg and comprises an average of 4.33 ± 0.58 hands. Each hand consists of about 13.67 ± 1.53 fingers. The individual fruit weight averages 69.82 ± 1.25 g, with the pulp weight totalling 59.53 ± 2.29 g (Table 4.7).

The *Musa cheesmanii* genotype showcases a total soluble solids content of 10.71 ± 0.09°B, contributing to its flavour profile. Its titratable acidity measures approximately 0.36 ± 0.05%, providing a subtle hint of tartness. In terms of sugar content, this genotype boasts around 2.50 ± 0.10% total sugar, with an additional 2.33 ± 0.12% of reducing sugar. These attributes contribute to its overall sweetness and taste. Furthermore, the estimated shelf life of this genotype extends to approximately 8.86 ± 0.36 days (Table 4.8).


(A) (B)


(C) (D)


(E) (F)


(G) (H)

(I)

(J)

Plate 4: G-4: *Musa cheesmanii* (A) pseudostem, (B) plant habitat, (C) male bud, (D) mature fruit bunch, (E) and (F)) internal and external bracts, (G) male flower, (H) petiole canal of leaf III, (I) and (J) transverse section of mature fruits.

Table 4.5: Flower character of various parameters of different genotypes

Acc. No.	Genotypes	Free tepal shape	Free tepal colour	Compound tepal colour	Ovary shape	Stigma colour
G-1	***Musa aurantiaca***	Oval	Tinted with yellow	Orange	Straight	Cream
G-2	***Musa balbisiana* - 1**	Rounded	Tinted with pink	Pink	Arched	Cream
G-3	***Musa balbisiana* - 2**	Oval	Translucent white	Pink-purple	Arched	Cream
G-4	***Musa cheesmanii***	Rounded	Translucent white	Cream	Straight	Pink
G-5	***Musa flaviflora***	Oval	Tinted with yellow	Orange	Arched	Cream
G-6	***Musa itinerans***	Rounded	Tinted with pink	Pink	Arched	Pink
G-7	***Musa rubra***	Rounded	Tinted with yellow	Yellow	Arched	Orange
G-8	***Musa sikkimensis* var. *sikkimensis***	Oval	Translucent white	Cream	Arched	Cream
G-9	***Musa sikkimensis* var. *simondsii***	Oval	Tinted with yellow	Cream	Arched	Yellow
G-10	***Musa velutina***	Fan-shaped	Translucent white	Orange	Arched	Yellow
G-11	**Dwarf Cavendish (Jahaji)**	Oval	Translucent white	White	Straight	Yellow
G-12	**Cavendish (Grand Naine)**	Oval	Translucent white	White	Straight	Yellow
G-13	**Nendran**	Fan-shaped	Translucent white	Orange	Arched	Cream
G-14	**Monthan**	Oval	Tinted with pink	Pink-purple	Arched	Cream

G-15	**African Rhino Horn Plantain**	Absent	Absent	Absent	Absent	Absent
G-16	**Bharatmani**	Oval	Translucent white	White	Arched	Bright yellow
G-17	**Bhootmanohar**	Oval	Translucent white	Pink-purple	Arched	Yellow
G-18	**Chinichampa**	Oval	Translucent white	Pink-purple	Arched	Cream
G-19	**Kanthali**	Oval	Translucent white	Pink-purple	Arched	Cream
G-20	**Red Banana**	Oval	Tinted with pink	Pink-purple	Arched	Cream
G-21	**Unidentified - 1**	Oval	Translucent white	White	Arched	Cream
G-22	**Unidentified - 2**	Oval	Translucent white	Pink-purple	Arched	Cream
G-23	**Unidentified - 3**	Oval	Translucent white	Pink-purple	Arched	Cream
G-24	**Unidentified - 4**	Oval	Translucent white	Cream	Arched	Orange
G-25	**Unidentified - 5**	Oval	Translucent white	Pink-purple	Arched	Cream
G-26	**Unidentified - 6**	Oval	Translucent white	Pink	Arched	Cream
G-27	**Meitei Hei**	Oval	Tinted with yellow	Pink-purple	Straight	Yellow

G-5: (*Musa flaviflora*)

The *Musa flaviflora* genotype is found in Chuchuyimlang village, Mokokchung, situated at 99.4599ºE longitude and 26.4064ºN latitude, at an elevation of 1054 m MSL. In the local Ao-Chungli language, it is referred to as Sumomochi. This genotype is also present in Tsiepama village, Chumoukedima, located at 93.5714ºE longitude and 25.4634ºN latitude, at an altitude of 1089 m MSL. Another occurrence is noted in Seprouliezie colony, Medziphema, Chumoukedima, positioned at 93.8883ºE longitude and 25.7594ºN latitude, at an elevation of 356 m MSL. It corresponds to the AAB genome type. Collected from its natural habitat within the forest, this species is classified as a primitive cultivar, displaying occasional presence in the region. The propagation of this species is done using suckers, employing both seed and vegetative methods. It demonstrates resilience to various diseases, with mild susceptibility to insects, pests, and nematode infections. Rainfed cultivation practices are employed due to its reliance on natural rainfall. The prevailing soil texture is sandy loam, within a hilly dissected topography. Ethnobotanically, the stem and male bud serve multiple purposes, offering food, fodder, and ornamental value, prominently in culinary and fodder applications. Musa flaviflora showcases remarkable attributes, such as ornamental aesthetics, drought tolerance, and disease resilience (Table 4.1).

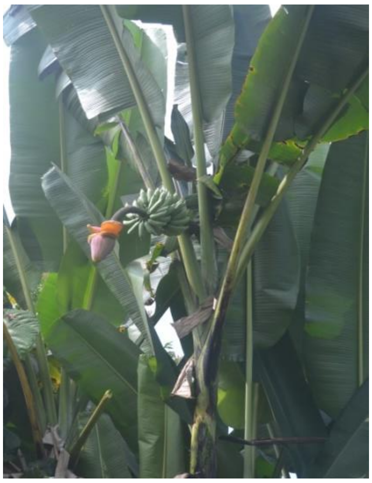
Musa flaviflora displays an erect leaf arrangement with a deep green hue on the upper leaf surface. This species showcases the common dwarfism trait, while its pseudostem, composed of leaf sheaths, exhibits a greenish-yellow tint. A notable characteristic of this species is the vertically growing suckers located in close proximity to the parent plant. The base shape of the leaf blade is asymmetric, featuring one rounded side and another pointed side. Leaf III petiole canal presents a wide, upright margin (Table 4.3). The average length of the leaf blade measures 230.00 cm ± 6.56 cm, accompanied by a width of about 60.30 ± 2.14 cm. The pseudostem attains an average height of

4.97 ± 0.13 meters, with a girth measuring approximately 45.33 ± 2.08 cm. On average, *Musa flaviflora* produces 3.00 ± 1.00 suckers. The petiole's length is approximately 83.00 ± 3.61 cm. These measurements shed light on the distinct characteristics of *Musa flaviflora*, encompassing its upright leaf orientation, vibrant green upper leaf surface, typical dwarfism, and the greenish-yellow pseudostem (Table 4.4). Joe *et al*., (2013) and Häkkinen *et al*., (2014) have observed similar findings in terms of number of sucker and their position. Furthermore, Borborah *et al*., (2020) have documented comparable findings regarding pseudostem height.

The male bud of *Musa flaviflora* takes on the appearance of a spinning top. The bracts possess a slightly pointed tip at the apex, while the base showcases a pronounced shoulder. Externally, the bracts display a pink-purple hue, revealing an internal shade of orange-red. The free tepals, individual segments of the flower, boast an oval contour with a touch of yellow tint. The compound tepals, which form the flower's outer layer, are coloured in shades of orange. The ovary assumes an arched shape, and the stigma, the receptive part of the female reproductive system, is cream-colored (Table 4.6). Similar observations regarding the male bud shape and stigma colour have been noted by Joe *et al*., (2013).

The fruit of *Musa flaviflora* exhibits a straight shape at its distal end, culminating in a blunt-tipped apex. As it matures, the initially green peel transitions to a vibrant yellow. The fruit's pulp showcases a soft texture and an appealing orange-yellow hue (Table 4.6). Embedded within the fruit are seeds. In terms of dimensions, the average fruit length measures 10.40 ± 0.10 cm, accompanied by a width of approximately 3.07 ± 0.15 cm. The peel thickness measures around 2.43 ± 0.15 mm. A bunch of *Musa flaviflora* weighs, on average, 4.84 ± 0.31 kg, consisting of about 11.00 ± 1.00 hands per bunch. Each hand contains an average of 18.67 ± 1.15 fingers. The weight of an individual fruit is approximately 35.95 ± 1.66 g, while the pulp weight is around 24.33 ± 2.08 g (Table 4.7). These measurements offer valuable insights into the fruit characteristics of *Musa flaviflora*, encompassing its shape, colour transition between immature and mature peel, pulp texture, presence of seeds, and diverse size parameters. Comparable findings regarding mature and immature peel colour have also been documented by Joe *et al*., (2013).

The *Musa flaviflora* fruit exhibits a total soluble solids content of approximately 13.76 ± 0.32 °B. The titratable acidity registers at 0.87 ± 0.12 %, indicating its level of acidity. The total sugar content is around 9.16 ± 0.26 %, with reducing sugar comprising roughly 1.63 ± 0.31 %. In terms of shelf life, *Musa flaviflora* maintains an average shelf life of 7.97 ± 0.89 days (Table 4.8).



(A)

(B)

(C)

(D)

(E)

(F)

(G) (H)

(I) (J)

(K) (L)

(M)

Plate 5: G-5: *Musa flaviflora* (A) plant habitat, (B) pseudostem, (C) mature fruit bunch, (D) male bud, (E) and (F)) internal and external bracts, (G) and (H) male flower, (I) petiole canal of leaf III, (J) measuring of pseudostem girth, (K) measuring of leaf width, (L) transverse section of ripen fruits and (M) ripen fruits.

Table 4.6: Fruit character of various parameters of different genotypes

Acc. No.	Genotypes	Fruit shape	Fruit apex	Immature fruit peel colour	Mature fruit peel colour	Pulp colour	Flesh texture	Presence of seed
G-1	***Musa aurantiaca***	Straight	Rounded	Green	Yellow	Orange yellow	Firm	Present
G-2	***Musa balbisiana* - 1**	Straight	Bottlenecked	Green	Yellow with rusty brown	Cream	Firm	Present
G-3	***Musa balbisiana* - 2**	Straight	Blunt tipped	Light green/ Silvery	Yellow	Cream	Firm	Present
G-4	***Musa cheesmanii***	Straight at the distal end	Blunt tipped	Silver	Black	Cream	Firm	Present
G-5	***Musa flaviflora***	Straight at the distal end	Blunt tipped	Green	Yellow	Orange yellow	Soft	Present
G-6	***Musa itinerans***	Straight	Bottlenecked	Light green/ Silvery	Yellow	Cream	Firm	Present
G-7	***Musa rubra***	Straight at the distal end	Blunt tipped	Light green	Yellow	White	Firm	Present
G-8	***Musa sikkimensis* var. *sikkimensis***	Straight	Blunt tipped	Dark Green	Yellow	Cream	Soft	Present
G-9	***Musa sikkimensis* var. *simondsii***	Straight	Blunt tipped	Green	Bright yellow	White	Firm	Present
G-10	***Musa velutina***	Straight	Rounded	Red	Red purple	White	Firm	Present
G-11	**Dwarf Cavendish (Jahaji)**	Sightly curved	Blunt tipped	Medium green	Yellow	Orange yellow	Soft	Absent
G-12	**Cavendish (Grand Naine)**	Straight	Blunt tipped	Light green	Bright yellow	Cream	Soft	Absent

G-13	**Nendran**	Straight at the distal end	Lengthily pointed	Medium green	Yellow	Orange yellow	Firm	Absent
G-14	**Monthan**	Straight or slightly curved	Pointed	Green	Yellow	Orange yellow	Firm	Absent
G-15	**African Rhino Horn Plantain**	Straight	Lengthily pointed	Green	Yellow	Cream	Firm	Absent
G-16	**Bharatmani**	Straight	Bottlenecked	Light green	Yellow	Orange yellow	Soft	Absent
G-17	**Bhootmanohar**	Straight	Pointed	Green	Bright yellow with red tint	Cream	Firm	Absent
G-18	**Chinichampa**	Slightly curved	Bottlenecked	Light green	Bright yellow	White	Soft	Absent
G-19	**Kanthali**	Straight	Pointed	Green	Yellow	White	Firm	Absent
G-20	**Red Banana**	Straight	Blunt tipped	Purple	Red purple	Beige pink	Firm	Absent
G-21	**Unidentified - 1**	Straight	Bottlenecked	Green	Bright yellow	Cream	Soft	Absent
G-22	**Unidentified - 2**	Straight	Bottlenecked	Light green	Yellow	Cream	Soft	Absent
G-23	**Unidentified - 3**	Straight	Bottlenecked	Green	Bright yellow	White	Soft	Absent
G-24	**Unidentified - 4**	Straight	Bottlenecked	Light green	Yellow	Beige pink	Soft	Present
G-25	**Unidentified - 5**	Straight	Blunt tipped	Green	Yellow	White	Soft	Absent
G-26	**Unidentified - 6**	Straight	Pointed	Green	Yellow	White	Firm	Absent
G-27	**Meitei Hei**	Straight	Rounded	Dark Green	Yellow	Cream	Soft	Absent

G-6: (*Musa itinerans*)

The *Musa itinerans* genotype is discovered in various locations, each with its unique local names and dialects. In the Old Chungliyimti village of Tuensang, situated at latitude of 26.2357ºN and a longitude of 94.8131ºE, this genotype thrives at an elevation of 1305 m MSL. Referred to as Trung homa in the Sangtam dialect, it showcases its adaptability in changing environments. Another site where it can be found is Sector - B, Old Jalukie, Peren, positioned at latitude of 25.3415ºN and a longitude of 93.4306ºE, at an elevation of 935 m MSL. Here, it is known as Henak in the Zeliang dialect. Additionally, it's found in Longkum, Mokokchung, with coordinates of 26.1632ºN latitude and 94.2383ºE longitude, thriving at 1383 m MSL. In the Ao dialect, it's referred to as Lasta (Mongsen)" and Ruoshi mongu (Chungli) (Table 4.1). This remarkable genotype is classified under the AB genome type (Table 4.2). Collected from a disturbed wild environment, it holds the status of a wild plant and is considered a rarity in occurrence. Its propagation primarily relies on suckers, which are vegetative shoots. The *Musa itinerans* breeding system employs both seed and vegetative methods, showcasing its versatility. It is particularly adaptable to partially disturbed habitats, reflecting its ability to cope with changing environmental dynamics. A distinguishing feature of *Musa itinerans* is its tolerance to a range of disease symptoms, while its susceptibility to insects, pests, and nematode infections remains mild. Ethnobotanically, both its stem and male bud have practical uses as food and fodder, with culinary and fodder applications being prominent. The growth pattern of *Musa itinerans* is characterized by its lengthy hanging rachis and spreading rhizomatous roots, contributing to its uniqueness and adaptability in its natural habitat. The cultivation practices associated with this genotype are rainfed, signifying its reliance on natural rainfall as a water source. The soil texture in areas where *Musa itinerans* commonly thrives is loam, while the region's topography is described as hilly dissected (Table 4.1).

Musa itinerans showcases an erect leaf habit with vibrant green upper leaf surfaces. This genotype embodies typical dwarfism, and its pseudostem is adorned with an attractive green-red coloration. Suckers, which are vegetative shoots, are positioned at a close from the parent plant. The leaf blade base of Musa itinerans culminates in pointed ends on both sides. In Leaf III, the petiole canal curves inward along its margin (Table 4.3). Häkkinen *et al*. (2010) also observed the same green upper leaf surfaces in *Musa itinerans* var. *formosana*. To be specific, the average length of the leaf blade spans 226.67 ± 12.58 cm, accompanied by a width of approximately 56.73 ± 8.59 cm. The pseudostem attains an average height of 4.50 ± 0.50 meters, with a girth size of around 48.00 ± 3.00 cm. Häkkinen *et al*. (2008) documented a comparable leaf habit in *Musa itinerans* var. *xishuangbannaensis*, and pseudostem heights were consistent in three related varieties: *Musa itinerans* var. *itinerans*, var. *chinensis*, var. *guangdongensis, and* var. *lechangensis*. On average, *Musa itinerans* produces 1.33 ± 0.58 suckers, indicating a relatively moderate number of vegetative shoots (Table 4.4). Moreover, the petiole length measures about 60.67 ± 1.53 cm. Chui *et al.* (2011) and Häkkinen *et al*. (2010) also observed the same erect leaf habit in *Musa itinerans* var. *hainanensis*, along with similar pseudostem heights in *Musa itinerans* var. *hainanensis*, var. *kavalanensis*, var. *itinerans*, var. *chinensis*, var. *guangdongensis* and var. *lechangensis*.

Musa itinerans male bud shows an ovoid shape. The bracts apex assumes an intermediate form, accompanied by a medium-sized base. On the exterior, the bracts are adorned with a purple-brown hue, while the interior presents a warm yellow tone. The free tepals, each distinct floral segment, adopt a pleasingly rounded shape and are delicately tinged with a hint of pink. Surrounding them, the compound tepals that compose the flower's outer layer exhibit a gentle pink coloration. The ovary takes on an elegantly arched structure, while the stigma, the receptive element of the female reproductive system, radiates a charming pink shade (Table 4.5). Häkkinen *et al*., (2008) noted analogous traits in the male bud, specifically an ovoid shape, across three related varieties: *Musa itinerans* var. *itinerans*, var. *chinensis*, and var. *guangdongensis*. Similarly, Chui *et al*., (2011) observed the same ovoid shape in the male bud of *Musa itinerans* var. *hainanensis*.

The fruit of *Musa itinerans* possesses a straight shape with a bottlenecked apex. During its growth, the immature fruit peel exhibits a range of colours, shifting from light green to a silvery shade, while the peel of the mature fruit turns a vibrant yellow. The fruits pulp is characterized by its creamy colour and firm texture (Table 4.6). Notably, the fruit contains seeds. Speaking of size, the average length of the fruit measures 9.87 ± 0.21 cm, and its width is approximately 3.40 ± 0.20 cm. The thickness of the fruit's peel is around 1.03 ± 0.06 mm. For clusters of these fruits, the average bunch weight is 13.50 ± 1.06 kg, typically comprising about 7.67 ± 1.53 hands per bunch. Within each hand, an average of 14.00 ± 1.00 fingers can be found. Individually, the weight of a single fruit is around 70.37 ± 16.06 g, while the pulp's weight measures approximately 47.67 ± 13.50 g. These measurements provide comprehensive insight into the distinct fruit characteristics of *Musa itinerans*, encompassing its shape, the evolving hues of its peel and pulp, its pleasing texture, the presence of seeds, and various size-related parameters (Table 4.7). Häkkinen *et al*., (2008) conducted observations that revealed resemblances in the mature fruit peel colour of *Musa itinerans*, var. *chinensis*, as well as similarities in the fruit shape of *Musa itinerans* var. *lechangensis*. Furthermore, they observed a shared characteristic in the number of fingers per hand within *Musa itinerans* var. *chinensis*. Similarly, Chui *et al*. (2011) made analogous observations, noting similarities in both fruit length and shape in *Musa itinerans* var. *formosana*.

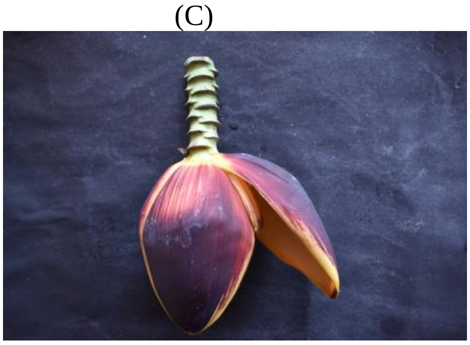
The total soluble solids (^{0}B) content of *Musa itinerans* is approximately 11.70 ± 0.07. The titratable acidity is measured at 0.41 ± 0.04 %, indicating its acidity level. The total sugar content is approximately 6.42 ± 0.26 %, with reducing sugar accounting for about 4.43 ± 0.64 %. In terms of shelf life, *Musa itinerans* has an average shelf life of 7.69 ± 0.76 days (Table 4.8).

(A)

(B)

(C)

(D)



(E)

(F)

(G)

(H)

(I)

(J)

(K)

(L)

Plate 6: G-6: *Musa itinerans* (A) plant habitat, (B) pseudostem, (C) petiole canal of leaf III, (D) mature fruit bunch, (E) male bud, (F) and (G) internal and external bracts, (H) and (I) male flower, (J) ripen fruit bunch, (K) transverse section of mature fruits and (L) leaf blade base shape.

Table 4.7: Fruit character of various parameters of different genotypes

Acc. No.	Genotypes	Fruit size length (cm)	Fruit size width (cm)	Fruit peel thickness (mm)	Bunch weight (kg)
G-1	***Musa aurantiaca***	7.10 ± 0.26	2.67 ± 0.21	2.30 ± 0.20	1.35 ± 0.06
G-2	***Musa balbisiana* - 1**	10.07 ± 0.15	2.93 ± 0.15	2.97 ± 0.12	13.01 ± 1.14
G-3	***Musa balbisiana* - 2**	9.07 ± 0.35	3.37 ± 0.25	3.17 ± 0.12	7.96 ± 0.17
G-4	***Musa cheesmanii***	9.70 ± 0.26	3.33 ± 0.12	1.10 ± 0.10	8.40 ± 0.30
G-5	***Musa flaviflora***	10.40 ± 0.10	3.07 ± 0.15	2.43 ± 0.15	4.84 ± 0.31
G-6	***Musa itinerans***	9.87 ± 0.21	3.40 ± 0.20	1.03 ± 0.06	13.50 ± 1.06
G-7	***Musa rubra***	7.17 ± 0.15	2.57 ± 0.21	2.00 ± 0.10	1.09 ± 0.18
G-8	***Musa sikkimensis* var. *sikkimensis***	8.23 ± 0.21	3.27 ± 0.15	1.90 ± 0.10	4.60 ± 0.58
G-9	***Musa sikkimensis* var. *simondsii***	8.47 ± 0.21	4.10 ± 0.20	2.20 ± 0.10	2.89 ± 0.35
G-10	***Musa velutina***	6.80 ± 0.26	3.27 ± 0.21	1.87 ± 0.15	1.20 ± 0.04
G-11	**Dwarf Cavendish (Jahaji)**	12.83 ± 0.31	2.33 ± 0.15	1.10 ± 0.10	13.17 ± 0.27
G-12	**Cavendish (Grand Naine)**	16.07 ± 0.66	3.07 ± 0.15	2.20 ± 0.10	18.13 ± 0.39
G-13	**Nendran**	14.10 ± 0.20	4.17 ± 0.15	3.27 ± 0.12	3.13 ± 0.35

G-14	**Monthan**	17.67 ± 1.53	5.53 ± 0.15	2.93 ± 0.15	16.28 ± 1.61
G-15	**African Rhino Horn Plantain**	27.00 ± 1.00	4.70 ± 0.20	5.33 ± 0.31	9.97 ± 0.57
G-16	**Bharatmani**	10.10 ± 0.30	2.57 ± 0.15	2.27 ± 0.15	8.81 ± 0.30
G-17	**Bhootmanohar**	9.17 ± 0.12	3.30 ± 0.10	1.33 ± 0.15	16.61 ± 0.91
G-18	**Chinichampa**	9.03 ± 0.21	3.17 ± 0.06	1.00 ± 0.10	17.48 ± 0.65
G-19	**Kanthali**	9.07 ± 0.15	2.27 ± 0.15	1.77 ± 0.06	7.01 ± 0.20
G-20	**Red Banana**	10.30 ± 0.16	2.53 ± 0.06	2.55 ± 0.10	7.20 ± 0.40
G-21	**Unidentified - 1**	8.93 ± 0.15	2.73 ± 0.15	1.40 ± 0.10	10.48 ± 0.41
G-22	**Unidentified - 2**	8.97 ± 0.12	3.23 ± 0.15	1.27 ± 0.06	9.95 ± 0.24
G-23	**Unidentified - 3**	8.93 ± 0.06	2.53 ± 0.12	1.37 ± 0.06	7.95 ± 0.28
G-24	**Unidentified - 4**	10.27 ± 0.15	2.90 ± 0.10	2.33 ± 0.06	2.20 ± 0.27
G-25	**Unidentified - 5**	9.23 ± 0.15	2.47 ± 0.12	1.10 ± 0.10	14.94 ± 0.42
G-26	**Unidentified - 6**	9.00 ± 0.10	2.40 ± 0.10	1.40 ± 0.10	9.28 ± 0.15
G-27	**Meitei Hei**	8.83 ± 0.06	3.33 ± 0.12	2.20 ± 0.10	6.82 ± 0.60

G-7: (*Musa rubra*)

The genotype identified for the *Musa rubra* species was discovered in three distinct locations. Firstly, in the Medziphema village of Chumoukedima, situated at latitude of 25.4591ºN and a longitude of 93.5128ºE, at an elevation of 442 m MSL. This species is also found in the Bade village of Dimapur, with coordinates of 25.6445ºN latitude and 93.4930ºE longitude, at an elevation of 198 m MSL. Lastly, it is found in Mhainamtsi, Jalukie, Peren, located at 25.6327ºN latitude and 93.7027ºE longitude, thriving at 400 m MSL (Table 4.1). This genotype corresponds to the AAB genome type (Table 4.2). Collected from a garden, it is classified as a primitive cultivar and is considered rare in occurrence. Suckers, which are vegetative shoots, serve as the primary material for propagation. The breeding system of *Musa rubra* involves both seed and vegetative methods, showcasing its versatility. It demonstrates a preference for disturbed habitats, highlighting its adaptability to changing environmental dynamics. *Musa rubra* displays resistance to various disease symptoms, while its vulnerability to insect, pest, and nematode infections remains relatively mild. The cultivation practices associated with it are rainfed, underlining its reliance on natural rainfall as a water source. The prevalent soil texture in areas where *Musa rubra* thrives is sandy loam. The region's topography is characterized as hilly dissected. Ethnobotanically, the male bud of this species finds practical use in both culinary and ornamental contexts, particularly for landscaping. *Musa rubra* boasts distinct plant attributes, such as rapid growth and resilience against panama wilt and nematode infections. These distinctive features contribute to its unique growth pattern and render it suitable for diverse practical and aesthetic applications in various settings (Table 4.1).

The leaf habit of *Musa rubra* is erect, with the upper surface of the leaves displaying a dark green colour. The species is classified as a dwarf, indicating its smaller stature. The pseudostem, or false stem formed by leaf sheaths, has a green colour. Suckers, which are vegetative shoots, are positioned close to the parent plant and exhibit vertical growth. The leaf blade base of *Musa rubra* has pointed ends on both sides (Table 4.3). In Leaf III, the petiole canal is open, with the margin spreading outwards. The average length of the leaf blade measures 116.67 ± 8.74 cm, while the width is approximately 41.00 ± 6.56 cm. The pseudostem height averages at 1.92 ± 0.18 m, with a girth size of approximately 17.00 ± 2.00 cm. On average, *Musa rubra* produces 1.67 ± 0.58 suckers, indicating a moderate number of vegetative shoots. The petiole length measures around 29.33 ± 3.79 cm. These measurements provide insights into the specific characteristics of *Musa rubra*, including its erect leaf habit, dark green upper leaf surface, dwarf stature, green pseudostem colour, and various size parameters (Table 4.4). Joe *et al.* (2016) observed similarity in leaf habit, dwarfism, position of suckers, girth size, petiole length and colour of leaf upper surface.

The male bud of *Musa rubra* resembles the shape of a top. The apex of the bracts is slightly pointed, while the base exhibits a small shoulder. The external colour of the bracts is orange, while the internal colour is orange-red. The free tepals, which are individual floral segments, have a rounded shape and are tinted with yellow. The compound tepals, forming the outer layer of the flower, are yellow in colour. The ovary has an arched shape, and the stigma, the receptive part of the female reproductive system, has an orange colour (Table 4.5). Joe *et al.* (2016) also observed similarity in internal bract colour, free tepal colour and compound tepal colour.

The fruit of *Musa rubra* has a straight shape at the distal end, with a blunt-tipped apex. The immature fruit peel displays a light green colour, which transitions to yellow upon reaching maturity. The pulp of the fruit has a white colour and a firm texture (Table 4.6). The fruit contains seeds. In terms of size, the average length of the fruit measures 7.17 ± 0.15 cm, while the width is approximately 2.57 ± 0.21 cm. The peel thickness of the fruit is around 2.00 ±

0.10 mm. The average weight of a bunch is 1.09 ± 0.18 kg, consisting of approximately 3.33 ± 0.58 hands per bunch. Each hand contains an average of 3.67 ± 0.58 fingers. The individual fruit weight is approximately 34.00 ± 1.72 g, while the pulp weight measures around 22.33 ± 1.15 g. These measurements provide an understanding of the fruit characteristics of *Musa rubra*, including its shape, peel and pulp colour, texture, presence of seeds, and various size parameters (Table 4.7). Notably, Joe *et al.* (2016) also observed similarity in mature and immature peel colour and pulp colour.

The total soluble solids (°B) content of *Musa rubra* is approximately 10.40 ± 0.08 °B. The titratable acidity is measured at 0.70 ± 0.06 %, indicating its acidity level. The total sugar content is approximately 3.17 ± 0.21 %, with reducing sugar accounting for about 1.70 ± 0.26 %. In terms of shelf life, *Musa rubra* has an average shelf life of 8.13 ± 0.91 days (Table 4.8).

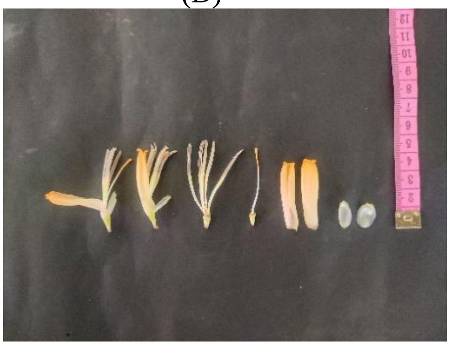

(A)


(B)


(C)


(D)


(E)


(F)


(G)


(H)


(I)


(J)

Plate 7: G-7: *Musa rubra*. (A) and (B) plant habitat, (C) measuring of leaf length, (D) petiole canal of leaf III, (E) male bud, (F) male flower, (G) and (H) internal and external bracts and (I) and (J) mature fruit.

Table 4.7: Fruit character of various parameters of different genotypes

Acc. No.	Genotypes	No. of hands/bunch	No. of fingers/hand	Fruit weight (g)	Pulp weight (g)
G-1	***Musa aurantiaca***	5.67 ± 0.58	6.33 ± 0.58	21.33 ± 2.52	13.00 ± 2.00
G-2	***Musa balbisiana* - 1**	7.33 ± 0.58	14.67 ± 1.53	208.67 ± 9.29	167.67 ± 2.08
G-3	***Musa balbisiana* - 2**	9.33 ± 0.58	12.33 ± 0.58	184.67 ± 7.02	135.67 ± 11.37
G-4	***Musa cheesmanii***	4.33 ± 0.58	13.67 ± 1.53	69.82 ± 1.25	59.53 ± 2.29
G-5	***Musa flaviflora***	11.00 ± 1.00	18.67 ± 1.15	35.95 ± 1.66	24.33 ± 2.08
G-6	***Musa itinerans***	7.67 ± 1.53	14.00 ± 1.00	70.37 ± 16.06	47.67 ± 13.50
G-7	***Musa rubra***	3.33 ± 0.58	3.67 ± 0.58	34.00 ± 1.72	22.33 ± 1.15
G-8	***Musa sikkimensis* var. *sikkimensis***	5.33 ± 0.58	12.33 ± 0.58	70.96 ± 2.37	52.33 ± 2.89
G-9	***Musa sikkimensis* var. *simondsii***	3.33 ± 0.58	7.67 ± 0.58	40.00 ± 7.00	21.33 ± 4.62
G-10	***Musa velutina***	5.33 ± 0.58	5.33 ± 1.15	37.54 ± 0.97	20.53 ± 1.33
G-11	**Dwarf Cavendish (Jahaji)**	8.33 ± 0.58	15.67 ± 0.58	78.13 ± 2.80	58.00 ± 3.00
G-12	**Cavendish (Grand Naine)**	9.67 ± 0.58	17.33 ± 1.15	163.67 ± 4.04	108.00 ± 2.65
G-13	**Nendran**	3.67 ± 0.58	7.33 ± 1.15	153.67 ± 5.69	119.00 ± 4.58

G-14	**Monthan**	5.33 ± 0.58	10.67 ± 1.15	199.88 ± 2.45	151.67 ± 4.04
G-15	**African Rhino Horn Plantain**	3.33 ± 0.58	12.33 ± 1.15	319.06 ± 5.29	217.34 ± 12.05
G-16	**Bharatmani**	8.33 ± 0.58	16.67 ± 1.15	111.00 ± 4.58	78.67 ± 3.51
G-17	**Bhootmanohar**	11.67 ± 1.53	16.67 ± 1.15	73.00 ± 2.00	52.00 ± 1.73
G-18	**Chinichampa**	11.33 ± 1.53	18.67 ± 1.15	68.33 ± 4.16	50.00 ± 2.65
G-19	**Kanthali**	8.33 ± 0.58	11.33 ± 1.15	58.40 ± 2.95	49.22 ± 1.19
G-20	**Red Banana**	5.33 ± 0.58	13.67 ± 0.58	119.33 ± 9.07	86.00 ± 7.00
G-21	**Unidentified - 1**	9.33 ± 0.58	14.00 ± 0.00	77.00 ± 1.73	49.67 ± 0.58
G-22	**Unidentified - 2**	7.00 ± 1.00	14.33 ± 0.58	81.67 ± 1.53	56.67 ± 1.15
G-23	**Unidentified - 3**	6.67 ± 0.58	13.33 ± 1.15	89.33 ± 2.08	65.00 ± 2.00
G-24	**Unidentified - 4**	5.00 ± 0.00	15.00 ± 1.00	29.33 ± 1.15	20.00 ± 1.00
G-25	**Unidentified - 5**	10.33 ± 0.58	13.33 ± 1.15	96.81 ± 1.60	62.50 ± 2.18
G-26	**Unidentified - 6**	6.33 ± 0.58	13.33 ± 1.15	118.33 ± 0.58	96.00 ± 1.00
G-27	**Meitei Hei**	7.33 ± 0.58	9.33 ± 1.15	76.33 ± 1.53	52.33 ± 2.52

G-8: (*Musa sikkimensis* var. *sikkimensis*)

The genotype identified for the *Musa sikkimensis* var. *sikkimensis* species is referred to as "Jümü homa" in the Sangtam dialect. This particular genotype is most commonly located in the Old Chungliyimti village, Tuensang, positioned at a latitude of 26.3457°N and a longitude of 94.8331°E, with an elevation of 1289 m MSL. It is also present in Sector - B, Old Jalukie, Peren, situated at a latitude of 25.3154°N and a longitude of 93.4362°E, at an elevation of 1119 m MSL. Furthermore, "Jümü homa" can be observed along Khonoma road, Kohima, at coordinates 25.3982°N latitude and 94.3455°E longitude, positioned at an elevation of 1521 m MSL. This particular species was collected from its natural habitat in the forest, and it is considered a landrace. *Musa sikkimensis* var. *sikkimensis* is abundant in frequency, indicating its wide distribution. Suckers, which are vegetative shoots, are the material used for propagation. The breeding system of this species involves both seed and vegetative propagation methods. *Musa sikkimensis* var. *simondsii* typically thrives in habitats that are partly disturbed, indicating its adaptability to changing environmental conditions. It exhibits tolerance to various disease symptoms and moderate susceptibility to insect, pest, and nematode infections. The cultural practices associated with its cultivation are rainfed, suggesting its reliance on natural rainfall for water supply. The soil texture where *Musa sikkimensis* var. *sikkimensis* is commonly found is loam, while the topography of the region is characterized as steep and dissected. Ethnobotanically, the male bud of this species is utilized for food and ornamental purposes, with culinary and landscaping applications being prominent. *Musa sikkimensis* var. *sikkimensis* possesses special plant characteristics, including a hardy pseudostem and suitability for fiber extraction. These features contribute to its resilience and versatility in various applications (Table 4.1).

The leaf habit of *Musa sikkimensis* var. *sikkimensis* is erect, with the upper surface of the leaves displaying a green colour. The species exhibits normal dwarfism, and its pseudostem has a red colour. Suckers, which are vegetative shoots, are positioned close to the parent plant and exhibit vertical growth. The leaf blade base of *Musa sikkimensis* var. *sikkimensis* has pointed ends on both sides (Table 4.3). In Leaf III, the petiole canal is straight, with an erect margin. The average length of the leaf blade measures 177.33 ± 7.09 cm, while the width is approximately 74.67 ± 4.04 cm. The pseudostem height averages at 4.83 ± 0.76 m, with a girth size of approximately 41.17 ± 2.02 cm. On average, *Musa sikkimensis* var. *sikkimensis* produces 3.67 ± 0.58 suckers, indicating a relatively high number of vegetative shoots. The petiole length measures around 53.67 ± 3.06 cm (Table 4.4). These measurements provide insights into the specific characteristics of *Musa sikkimensis* var. *sikkimensis*, including its erect leaf habit, green upper leaf surface, normal dwarfism, red pseudostem colour, and various size parameters. Joe *et al.* (2015) observed similarity in leaf habit, position of sucker, leaf blade length and width, pseudostem height, girth size and petiole length.

The male bud of *Musa sikkimensis* var. *sikkimensis* resembles the shape of a top. The apex of the bracts exhibits an intermediate shape, while the base has a large shoulder. The external colour of the bracts is pink-purple, while the internal colour is orange-red. The free tepals, which are individual floral segments, have an oval shape and are translucent white in colour. The compound tepals, forming the outer layer of the flower, are cream in colour. The ovary has an arched shape, and the stigma, the receptive part of the female reproductive system, has a cream colour (Table 4.5). Joe *et al.* (2015) also observed similarity in compound tepal colour and stigma colour.

The fruit of *Musa sikkimensis* var. *sikkimensis* has a straight shape with a blunt-tipped apex. The immature fruit peel is dark green, which changes to yellow upon reaching maturity. The pulp of the fruit is cream in colour and has a soft texture. The fruit contains seeds (Table 4.6). In terms of size, the average length of the fruit measures 8.23 ± 0.21 cm, while the width is approximately 3.27 ± 0.15 cm. The peel thickness of the fruit is around 1.90 ± 0.10 mm. The average weight of a bunch is 4.60 ± 0.58 kg, consisting of approximately 5.33 ± 0.58 hands per bunch. Each hand contains an average of 12.33 ± 0.58 fingers. The individual fruit weight is approximately 70.96 ± 2.37 g, while the pulp weight measures around 52.33 ± 2.89 g (Table 4.7). These measurements provide an understanding of the fruit characteristics of *Musa sikkimensis* var. *sikkimensis*, including its shape, peel and pulp colour, texture, presence of seeds, and various size parameters. Joe *et al.* (2015) also observed similarity in immature and mature peel colour and peel thickness.

The total soluble solids (°B) content of *Musa sikkimensis* var. *sikkimensis* is approximately 13.89 ± 0.10. The titratable acidity is measured at 0.34 ± 0.08 %, indicating its acidity level. The total sugar content is approximately 3.40 ± 0.20 %, with reducing sugar accounting for about 3.87 ± 0.06 %. In terms of shelf life, *Musa sikkimensis* var. *sikkimensis* has an average shelf life of 9.91 ± 1.27 days (Table 4.8). These measurements provide valuable information regarding the fruit's chemical composition and characteristics, including its sweetness, acidity, and the duration it can be stored before deteriorating.

(A)

(B)

(C)

(D)

(E)

(F)

(G)

(H)

(I)

(J)

(K)

Plate 8: G-8: *Musa sikkimensis* var. *sikkimensis* (A) and (B) plant habitat, (C) mature fruits, (D) pseudostem, (E) petiole canal of leaf III, (F) measuring of leaf width, (G) male bud, (H) and (I) internal and external bracts and (J) male flower and (K) half ripen fruit.

Table 4.8: Biochemical characters of various parameters of different genotypes

Acc. No.	Genotypes	Total soluble solids (^{0}B)	Titratable Acidity (%)	Total sugar (%)	Reducing sugar (%)	Shelf life
G-1	***Musa aurantiaca***	15.22 ± 0.60	0.49 ± 0.04	9.53 ± 0.30	1.73 ± 0.12	6.31 ± 1.18
G-2	***Musa balbisiana* - 1**	22.20 ± 0.59	1.71 ± 0.02	13.22 ± 0.22	0.97 ± 0.06	5.34 ± 1.16
G-3	***Musa balbisiana* - 2**	10.99 ± 0.71	2.07 ± 0.25	2.43 ± 0.15	1.27 ± 0.06	8.33 ± 1.04
G-4	***Musa cheesmanii***	10.71 ± 0.09	0.36 ± 0.05	2.50 ± 0.10	2.33 ± 0.12	8.86 ± 0.36
G-5	***Musa flaviflora***	13.76 ± 0.32	0.87 ± 0.12	9.16 ± 0.26	1.63 ± 0.31	7.97 ± 0.89
G-6	***Musa itinerans***	11.70 ± 0.07	0.41 ± 0.04	6.42 ± 0.26	4.43 ± 0.64	7.69 ± 0.76
G-7	***Musa rubra***	10.40 ± 0.08	0.70 ± 0.06	3.17 ± 0.21	1.70 ± 0.26	8.13 ± 0.91
G-8	***Musa sikkimensis* var. *sikkimensis***	13.89 ± 0.10	0.34 ± 0.08	3.40 ± 0.20	3.87 ± 0.06	9.91 ± 1.27
G-9	***Musa sikkimensis* var. *simondsii***	15.86 ± 0.59	0.47 ± 0.05	2.23 ± 0.06	2.83 ± 0.12	7.21 ± 0.58
G-10	***Musa velutina***	11.69 ± 0.09	0.47 ± 0.07	4.03 ± 0.15	2.43 ± 0.31	7.47 ± 0.88
G-11	**Dwarf Cavendish (Jahaji)**	20.84 ± 0.46	0.57 ± 0.08	15.38 ± 0.25	4.27 ± 0.31	3.43 ± 0.42
G-12	**Cavendish (Grand Naine)**	21.93 ± 0.60	0.62 ± 0.04	15.94 ± 0.23	4.33 ± 0.15	6.63 ± 0.43
G-13	**Nendran**	18.27 ± 0.42	0.55 ± 0.05	15.00 ± 0.30	7.33 ± 0.25	6.36 ± 0.45

G-14	**Monthan**	24.02 ± 0.09	0.78 ± 0.03	13.16 ± 0.22	5.00 ± 0.26	8.31 ± 0.47
G-15	**African Rhino Horn Plantain**	22.77 ± 0.68	0.59 ± 0.06	16.17 ± 0.41	5.37 ± 0.31	5.35 ± 0.78
G-16	**Bharatmani**	16.96 ± 0.17	0.53 ± 0.04	11.03 ± 0.21	5.83 ± 0.25	4.74 ± 1.24
G-17	**Bhootmanohar**	23.10 ± 0.41	0.45 ± 0.06	13.90 ± 0.20	7.37 ± 0.38	7.86 ± 0.84
G-18	**Chinichampa**	21.43 ± 0.57	0.80 ± 0.08	9.48 ± 0.30	6.00 ± 0.26	6.16 ± 0.87
G-19	**Kanthali**	20.63 ± 0.07	0.50 ± 0.03	9.97 ± 0.15	4.70 ± 0.17	5.45 ± 0.73
G-20	**Red Banana**	16.37 ± 0.40	0.59 ± 0.07	10.49 ± 0.19	4.77 ± 0.15	5.66 ± 0.68
G-21	**Unidentified - 1**	11.43 ± 0.50	0.48 ± 0.07	9.50 ± 0.33	3.03 ± 0.12	5.15 ± 1.02
G-22	**Unidentified - 2**	15.85 ± 0.79	0.63 ± 0.07	8.04 ± 0.12	2.60 ± 0.42	4.68 ± 1.15
G-23	**Unidentified - 3**	20.48 ± 0.83	0.39 ± 0.04	9.33 ± 0.32	5.17 ± 0.21	4.56 ± 0.98
G-24	**Unidentified - 4**	13.45 ± 0.33	0.57 ± 0.07	8.28 ± 0.13	3.63 ± 0.14	5.07 ± 0.66
G-25	**Unidentified - 5**	14.78 ± 0.09	0.70 ± 0.02	12.93 ± 0.32	5.60 ± 0.36	6.17 ± 0.38
G-26	**Unidentified - 6**	13.33 ± 0.50	0.80 ± 0.03	7.80 ± 0.53	4.10 ± 0.20	5.63 ± 0.58
G-27	**Meitei Hei**	16.48 ± 0.89	0.58 ± 0.05	14.23 ± 0.42	8.07 ± 0.15	7.62 ± 0.35

G-9: (*Musa sikkimensis* var. *simondsii*)

The genotype identified for the *Musa sikkimensis* var. *simondsii* species in the Forest Colony of Ward-2, Wokha, known as "Yourup" in the Lotha vernacular, corresponds to a specific genome type. This particular species was collected from a garden and is categorized as a landrace. *Musa sikkimensis* var. *simondsii* occurs occasionally in frequency, indicating its sporadic presence. Suckers, which are vegetative shoots, are the material used for propagation. The breeding system of this species involves both seed and vegetative propagation methods. *Musa sikkimensis* var. *simondsii* typically thrives in habitats that are partly disturbed, indicating its adaptability to changing environmental conditions. It exhibits tolerance to various disease symptoms and moderate susceptibility to insect, pest, and nematode infections. The cultural practices associated with its cultivation are rainfed, suggesting its reliance on natural rainfall for water supply. The soil texture where *Musa sikkimensis* var. *simondsii* is commonly found is sandy loam, while the topography of the region is characterized as steep and dissected. Ethnobotanically, the male bud of this species is utilized for food and ornamental purposes, with culinary and landscaping applications being prominent. *Musa sikkimensis* var. *simondsii* possesses special plant characteristics, including a hardy pseudostem and suitability for fiber extraction. These features contribute to its resilience and versatility in various applications (Table 4.1).

The leaf habit of *Musa sikkimensis* var. *simondsii* is erect, with the upper surface of the leaves displaying a dark green colour. The species exhibits normal dwarfism, and its pseudostem has a green-red coloration. Suckers, which are vegetative shoots, are positioned far from the parent plant. The leaf blade base of *Musa sikkimensis* var. *simondsii* has a rounded shape on one side and pointed on the other. In Leaf III, the petiole canal is wide, with an erect margin (Table 4.3). The average length of the leaf blade measures 223.33 ± 8.33 cm, while the width is approximately 83.67 ± 3.06 cm. The pseudostem height averages at 3.65 ± 0.30 m, with a girth size of approximately 38.33 ± 2.08 cm. On average, *Musa sikkimensis* var. *simondsii* produces 2.33 ± 1.53 suckers, indicating a moderate number of vegetative shoots. The petiole length measures around 54.50 ± 1.80 cm (Table 4.4). These measurements provide insights into the specific characteristics of *Musa sikkimensis* var. *simondsii*, including its erect leaf habit, dark green upper leaf surface, normal dwarfism, green-red pseudostem colour, and various size parameters. Joe *et al.* (2015) observed similarity in colour of leaf upper surface, pseudostem height and girth size.

The male bud of *Musa sikkimensis* var. *simondsii* has a lanceolate shape. The apex of the bracts is slightly pointed, while the base exhibits a large shoulder. The external colour of the bracts is purple-brown, while the internal colour is orange-red. The free tepals, which are individual floral segments, have an oval shape and are tinted with yellow. The compound tepals, forming the outer layer of the flower, are cream in colour. The ovary has an arched shape, and the stigma, the receptive part of the female reproductive system, has a yellow colour (Table 4.5). Joe *et al.* (2015) observed similarity in internal and external bract colour, compound tepal colour and stigma colour.

The fruit of *Musa sikkimensis* var. *simondsii* has a straight shape with a blunt-tipped apex. The immature fruit peel is green, which changes to a bright yellow colour upon reaching maturity. The pulp of the fruit is white in colour and has a firm texture (Table 4.6). The fruit contains seeds. In terms of size, the average length of the fruit measures 8.47 ± 0.21 cm, while the width is approximately 4.10 ± 0.20 cm. The peel thickness of the fruit is around 2.20 ± 0.10 mm. The average weight of a bunch is 2.89 ± 0.35 kg, consisting of approximately 3.33 ± 0.58 hands per bunch. Each hand contains an average of 7.67 ± 0.58 fingers. The individual fruit weight is approximately 40.00 ± 7.00

g, while the pulp weight measures around 21.33 ± 4.62 g (Table 4.7). These measurements provide an understanding of the fruit characteristics of *Musa sikkimensis* var. *simondsii*, including its shape, peel and pulp colour, texture, presence of seeds, and various size parameters. Joe *et al.* (2015) also observed similarity in immature fruit peel colour, fruit length and pulp colour.

The total soluble solids (°B) content of *Musa sikkimensis* var. *simondsii* is approximately 15.86 ± 0.59. The titratable acidity is measured at 0.47 ± 0.05 %, indicating its acidity level. The total sugar content is approximately 2.23 ± 0.06 %, with reducing sugar accounting for about 2.83 ± 0.12 %. In terms of shelf life, *Musa sikkimensis* var. *simondsii* has an average shelf life of 7.21 ± 0.58 days (Table 4.8). These measurements provide valuable information regarding the fruit's chemical composition and characteristics, including its sweetness, acidity, and the duration it can be stored before deteriorating.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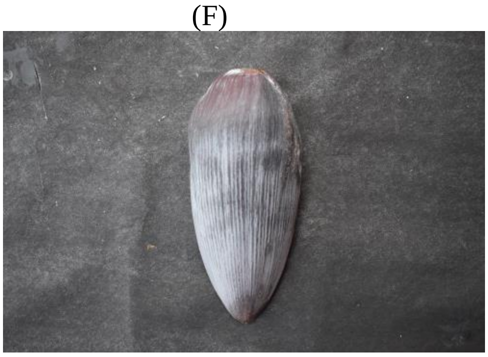
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Plate 9: G-9: *Musa sikkimensis* var. *simondsii* (A) and (B) plant habitat, (C) pseudostem, (D) measuring of leaf length, (E) petiole canal of leaf III, (F) mature fruits, (G) male bud, (H) and (I) internal and external bracts and (J) male flower.

Table 4.9: Sensory evaluation of various parameters of different genotypes

Acc. No.	Genotypes	Appearance	Flavour	Texture	Taste	Overall acceptability
G-11	**Cavendish (Jahaji)**	3.83 ± 0.15	4.17 ± 0.15	4.06 ± 0.16	4.02 ± 0.16	4.10 ± 0.16
G-12	**Cavendish (Grand Naine)**	4.36 ± 0.19	4.19 ± 0.19	3.86 ± 0.19	4.06 ± 0.19	4.12 ± 0.13
G-13	**Nendran**	2.72 ± 0.03	3.24 ± 0.03	3.43 ± 0.02	2.77 ± 0.02	3.06 ± 0.03
G-14	**Monthan**	2.31 ± 0.02	2.49 ± 0.03	3.19 ± 0.03	2.60 ± 0.03	3.11 ± 0.02
G-15	**African Rhino Horn Plantain**	3.31 ± 0.18	3.39 ± 0.18	2.59 ± 0.17	2.93 ± 0.17	3.13 ± 0.17
G-16	**Bharatmani**	2.46 ± 0.06	3.49 ± 0.04	3.20 ± 0.05	3.66 ± 0.05	3.43 ± 0.05
G-17	**Bhootmanohar**	3.54 ± 0.05	3.15 ± 0.06	3.96 ± 0.04	4.12 ± 0.13	3.67 ± 0.04
G-18	**Chinichampa**	4.07 ± 0.22	3.85 ± 0.22	3.63 ± 0.22	4.01 ± 0.22	3.86 ± 0.22
G-19	**Kanthali**	2.31 ± 0.36	2.89 ± 0.36	3.31 ± 0.36	3.99 ± 0.36	3.12 ± 0.36
G-20	**Red Banana**	3.74 ± 0.06	3.16 ± 0.06	3.31 ± 0.05	3.46 ± 0.07	3.75 ± 0.07
G-21	**Unidentified - 1**	2.18 ± 0.09	2.75 ± 0.05	2.78 ± 0.08	3.15 ± 0.08	3.48 ± 0.08
G-22	**Unidentified - 2**	2.43 ± 0.10	2.66 ± 0.09	3.06 ± 0.09	3.36 ± 0.09	3.09 ± 0.09
G-23	**Unidentified - 3**	3.27 ± 0.18	3.34 ± 0.18	3.28 ± 0.18	2.72 ± 0.18	3.12 ± 0.18
G-24	**Unidentified - 4**	2.10 ± 0.19	2.20 ± 0.19	2.68 ± 0.19	2.70 ± 0.19	2.68 ± 0.19

G-25	**Unidentified - 5**	2.57 ± 0.14	2.43 ± 0.14	3.11 ± 0.14	3.01 ± 0.14	2.80 ± 0.14
G-26	**Unidentified - 6**	2.78 ± 0.11	2.25 ± 0.16	2.83 ± 0.11	3.00 ± 0.09	2.62 ± 0.11
G-27	**Meitei Hei**	3.39 ± 0.12	2.40 ± 0.12	2.72 ± 0.11	1.80 ± 0.11	2.55 ± 0.10

G-10: *Musa velutina*

The genotype of the plant is *Musa velutina*, commonly known as Temeremla yarang (Ao - Chungli) in the local language. It is found in the Longtho village, Mokokchung block (Table 4.1). The genome types of this plant are AAB, and it is considered a landrace with a rare frequency (Table 4.2). The material used for propagation is suckers, and it is vegetatively propagated. The habitat for this plant is cultivated, and it exhibits tolerance to disease symptoms while facing moderate insect, pest, or nematode infections. The cultural practices for its cultivation are rainfed, and it thrives in sandy loam soil with steepy dissected topography. Ethnobotanically, specific parts of the plant, such as the male bud, are utilized for fodder and ornamental purposes, particularly in landscaping due to its dwarf ornamental characteristics (Table 4.1).

Musa velutina exhibits an erect leaf habit, with its leaves held upright. The upper surface of the leaves displays a rich, dark green colour, adding to the plant's vibrant appearance. In terms of dwarfism, the banana plant follows the normal growth pattern for its variety. The pseudostem, the part of the plant resembling a trunk, possesses a medium green hue. Suckers, the shoots emerging from the plant's base, are positioned close to the parent plant, growing vertically in close proximity (Table 4.3). As for the leaf blade characteristics, both sides feature a rounded base shape, contributing to the plant's aesthetically pleasing overall look. Leaf blades demonstrate a considerable length, measuring approximately 117.00 ± 8.00 cm, while their width spans around 51.28 ± 1.59 cm. The pseudostem height reaches an impressive 2.65 ± 0.30 meters, signifying a healthy and robust plant. The girth size of the pseudostem, which measures approximately 21.33 ± 1.53 cm, adds to its sturdy and substantial appearance. The plant also tends to produce a moderate number of suckers, with an average count of 5.33 ± 0.58. These additional shoots contribute to the plant's ability to propagate and establish new growth. When examining the petioles, the leaf stalks that connect the leaf blade to the stem, the petiole canal of leaf III appears straight with an erect margin, further enhancing the plant's overall symmetry. The length of the petioles measures around 63.00 ± 2.00 cm, providing adequate support and attachment for the large and lush banana leaves (Table 4.4).

The male bud of the banana plant exhibits a distinctive shape, resembling that of a top, adding to its uniqueness and visual appeal. The bracts, protective modified leaves surrounding the bud, display pointed apexes, enhancing the plant's ornamental value. The bract base shape is characterized by large shoulders, providing a sturdy and stable support structure for the developing inflorescence. The external colour of the bracts appears in beautiful shades of pink-purple, contributing to the plant's vibrant and captivating appearance. Internally, the bracts display a rich red colour, adding further visual interest and contrast. The free tepals, individual segments of the flower's outer whorl, are shaped like fans, creating an elegant and graceful floral arrangement. These free tepals exhibit a translucent white colour, giving the flower a delicate and ethereal quality. In contrast, the compound tepals, which make up the flower's inner whorl, boast a warm and radiant orange hue, infusing the bloom with a burst of vivid colour and attracting pollinators. The ovary of the flower is uniquely arched, providing a distinctive feature in the floral structure. The stigma, the receptive tip of the female reproductive organ, appears in a cheerful yellow colour, serving as an alluring target for pollination (Table 4.5).

The banana fruit features a straight shape, with a rounded apex, contributing to its streamlined and uniform appearance. During its immature stage, the fruit peel displays an eye-catching red colour, which gradually transforms into a rich red-purple hue as it reaches maturity. The combination of these colours makes the banana fruit visually appealing at different stages of its development. Upon reaching maturity, the banana fruit reveals a pulp colour that is strikingly white, adding to its allure and making it stand out as a refreshing and delightful treat. The flesh texture is firm, offering a satisfying and enjoyable eating experience. The fruit contains seeds, characteristic of its botanical nature. Despite the presence of seeds, the focus remains on the delectable flesh and its culinary versatility (Table 4.6). In terms of size, the banana fruit measures approximately 6.80 ± 0.26 cm in length and 3.27 ± 0.21 cm in width. The fruit peel thickness is around 1.87 ± 0.15 mm, providing a suitable protective layer for the succulent pulp inside. Bunched together, the fruits demonstrate an average weight of 1.20 ± 0.04 kg, making them convenient to handle and transport. Each bunch typically contains around 5.33 ± 0.58 hands, with each hand holding approximately 5.33 ± 1.15 fingers. These specifications collectively contribute to the practicality and market appeal of the banana bunch. Individually, the average weight of a single banana fruit is approximately 37.54 ± 0.97 gm, making them a convenient and portable snack option. The pulp weight, which makes up the edible portion of the fruit, is around 20.53 ± 1.33 gm, adding to the overall value and culinary versatility of the banana (Table 4.7).

The fruit exhibits a desirable composition of total soluble solids (°B), measuring approximately 11.69 ± 0.09 °B. This value indicates the concentration of dissolved solids in the fruit, contributing to its overall sweetness and palatability. Regarding acidity, the banana fruit possesses a titratable acidity of around 0.47 ± 0.07 %. This level of acidity provides a subtle and balanced tanginess to the fruit's flavour, complementing its natural sweetness. The total sugar content in the banana is approximately 4.03 ± 0.15 %, contributing to its delightful sweetness and making it a satisfying and enjoyable treat. Among the total sugar content, the reducing sugar percentage is approximately 2.43 ± 0.31%. Reducing sugars play a significant role in the fruit's sweetness and its ability to undergo desirable browning reactions when exposed to heat during cooking or ripening. In terms of shelf life, the banana fruit can typically be stored and enjoyed for approximately 7.47 ± 0.88 days under suitable storage conditions. This reasonable shelf life allows for ample time for distribution, sale, and consumption before spoilage occurs (Table 4.8).

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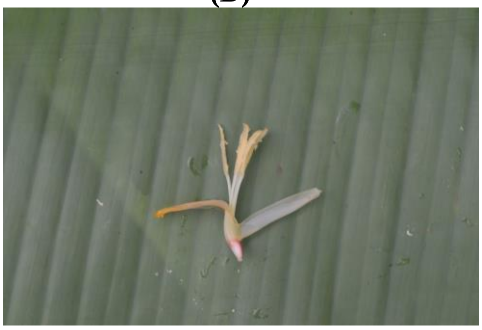

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Plate 10: G-10: *Musa velutina* (A) and (C) plant habitat, (B) pseudostem, (D) measuring of leaf width, (E) male bud, (F) male flower, (G) and (H) internal and external bracts (I) petiole canal of leaf III and (J) mature fruits.

G -11: (Dwarf Cavendish)

The banana genotype identified is the Dwarf Cavendish variety, specifically known as Jahaji. This particular variety is abundant in the Medziphema and Chumoukedima areas, where it is cultivated in farmers' fields. The banana's genome type is denoted as AAA, indicating its genetic classification (Table 4.2). As a primitive cultivar, the banana is predominantly propagated vegetatively using suckers. This means that new plants are grown from the offshoots or "suckers" that emerge from the base of the parent plant. The natural habitat of this banana variety is in cultivated areas, where it thrives under rainfed conditions. It prefers a soil texture that is sandy clay loam, and it is commonly found in level topography. Regarding its biological characteristics, the banana exhibits disease tolerance, indicating its ability to withstand certain diseases without significant adverse effects. However, it is moderately susceptible to insect, pest, and nematode infections. In terms of ethnobotanical uses, the fruit of the Jahaji banana is primarily utilized as food and fodder. The ripe fruits are commonly consumed as a delicious dessert due to their sweet and pleasant taste. Additionally, parts of the plant may also serve as fodder for animals. One of the distinguishing features of the Jahaji banana is the curved C shape of its fruits, giving it a unique and recognizable appearance (Table 4.1).

The banana plant showcases a drooping leaf habit, with its leaves gracefully curving downwards. The upper surface of the leaves presents a lush green colour, representing the plant's healthy and vibrant state. The dwarfism of this banana variety is categorized as normal, adhering to typical growth patterns for its kind. The pseudostem, resembling a trunk, displays a medium green colour, contributing to the plant's overall aesthetic appeal. Suckers, emerging shoots from the plant's base, are positioned close to the parent plant, growing vertically in proximity, facilitating easy propagation. The leaf blade base features a rounded shape on both sides, enhancing the plant's symmetry and elegance. The petiole canal of leaf III is distinguished by its curved inward margin, adding to the leaf's unique characteristics (Table 4.3). As for the leaf blade measurements, the length averages around 190.33 ± 24.70 cm, while the width spans approximately 60.67 ± 2.52 cm. These large and broad leaves contribute to the plant's lush foliage and ornamental value. The pseudostem reaches an impressive height of 2.97 ± 0.16 m, making it a tall and visually striking plant. The girth size of the pseudostem measures around 63.00 ± 2.00 cm, indicating a robust and sturdy structure. This particular banana plant typically produces around 5.00 ± 1.00 suckers, contributing to its ability to propagate and form new growth clusters. The petiole, which serves as the leaf stalk, has an average length of approximately 30.33 ± 2.52 cm, providing ample support and attachment for the large and drooping banana leaves (Table 4.4).

The male bud of the banana plant exhibits an ovate shape, adding to its distinctive appearance. The bracts, modified leaves surrounding the bud, display an intermediate apex shape, creating an attractive and balanced look. The bract base shape features large shoulders, providing a sturdy and supportive structure for the developing inflorescence. Externally, the bracts showcase an intriguing purple-brown colour, adding to the plant's visual allure. Internally, the bracts reveal a captivating orange-red hue, creating a striking contrast and enhancing the overall beauty of the flower cluster. The free tepals, individual segments of the flower's outer whorl, possess an oval shape, contributing to the flower's elegant and graceful appearance. These free tepals exhibit a translucent white colour, giving the flower a delicate and ethereal quality. In contrast, the compound tepals, which form the inner whorl of the flower, are of a pristine white colour, further accentuating the flower's purity and charm. The ovary of the flower is straight, adding to the flower's neat and organized structure. The stigma, the receptive tip of the female reproductive organ, appears in a cheerful yellow colour, serving as an attractive target for pollination (Table 4.5).

The banana fruit is characterized by a slightly curved shape, giving it a graceful and appealing appearance. The fruit apex is blunt-tipped, adding to its smooth and rounded outline. During its immature stage, the fruit peel is of a medium green colour, transitioning into a vibrant yellow hue as it ripens and matures. The pulp inside the fruit displays an attractive orange-yellow colour, adding to the fruit's visual allure. In terms of texture, the banana's flesh is soft, contributing to its melt-in-your-mouth quality and making it a delightful and enjoyable treat. The absence of seeds in this variety further enhances its desirability as a convenient and fuss-free fruit option (Table 4.6). When considering the fruit's size, it measures approximately 12.83 ± 0.31 cm in length and 2.33 ± 0.15 cm in width. The fruit peel thickness is around 1.10 ± 0.10 mm, providing a suitable protective layer for the tender and flavourful pulp inside. When harvested and bunched together, bunches of this banana variety have an average weight of approximately 13.17 ± 0.27 kilograms. Each bunch typically contains around 8.33 ± 0.58 hands, and each hand holds an average of 15.67 ± 0.58 fingers. These specifications collectively contribute to the generous yield and market appeal of the banana bunch. Individually, the average weight of a single banana fruit is approximately 78.13 ± 2.80 grams, while the pulp weight, which makes up the edible portion of the fruit, is around 58.00 ± 3.00 grams. These measurements highlight the substantial and flavourful nature of this particular banana variety (Table 4.7).

The banana fruit boasts an impressive composition of total soluble solids (°B), measuring approximately 20.84 ± 0.46. This high value indicates a significant concentration of dissolved solids in the fruit, resulting in its delightful sweetness and palatability. The titratable acidity of the banana fruit is approximately 0.57 ± 0.08%, providing a slight tanginess that complements its natural sweetness, resulting in a well-balanced flavour profile. The total sugar content in the banana is notably high, reaching approximately 15.38 ± 0.25%. This abundance of sugars contributes to the fruit's delectable sweetness, making it a desirable and enjoyable treat for consumers. Among the total sugar content, the percentage of reducing sugars is approximately 4.27 ± 0.31%. Reducing sugars play a crucial role in the fruit's sweetness and its ability to undergo desirable browning reactions during cooking or ripening. When considering shelf life, the banana fruit can typically be stored and enjoyed for approximately 3.43 ± 0.42 days under suitable storage conditions. This relatively short shelf life highlights the importance of timely consumption and proper handling to maintain the fruit's quality and freshness (Table 4.8).

The banana fruit is known for its appealing appearance, receiving a high rating of 3.83 ± 0.15 on a scale from 1 to 5, reflecting its visually attractive and distinctive features. Its vibrant colour, characteristic shape, and overall aesthetic appeal contribute to its positive sensory experience. In terms of flavour, the banana is highly regarded, scoring 4.17 ± 0.15. It’s delicious taste, combining natural sweetness with a subtle tanginess, makes it a delightful and satisfying fruit option for consumers. When it comes to texture, the banana fruit receives a favourable rating of 4.06 ± 0.16. The soft and creamy flesh, along with the smoothness of the fruit, adds to its overall enjoyable eating experience. The taste of the banana is also highly appreciated, receiving a rating of 4.02 ± 0.16. Its pleasant sweetness and appealing flavour make it a favoured choice among consumers. Overall, the banana's acceptability is remarkably high, scoring 4.10 ± 0.16. This indicates that consumers find the fruit to be highly satisfactory and enjoyable in terms of both taste and sensory attributes (Table 4.9).


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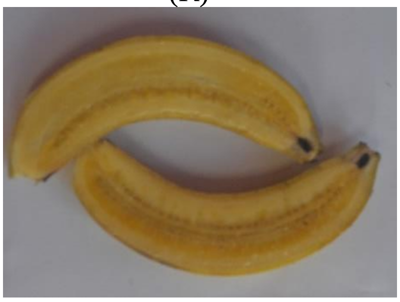

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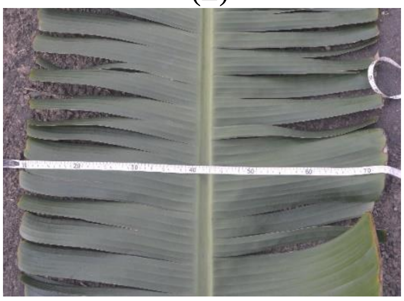

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Plate 11: G-11: Dwarf cavendish (A) and (B) plant habitat, (C) position of suckers, (D) pseudostem, (E) measuring of leaf length, (F) male bud, (G) and (H) internal and external bracts (I) petiole canal of leaf III, (J) male flower, (K) mature fruits, (L) and (M) transverse section of ripen fruits and (N) measuring of leaf width.

G -12: (Cavendish)

The genotype under investigation is identified as the Cavendish (Grand Naine) variety, commonly known as such. It was sourced from the Medziphema and Chumoukedima villages/blocks. The genome classification for this variety is AAA (Table 4.2). The collection of specimens was conducted within farmers' fields, reflecting its prevalence as a primitive cultivar with an abundant occurrence frequency. In terms of cultivation, this genotype is propagated vegetatively through suckers and is typically found in cultivated habitats. It displays a commendable tolerance to disease symptoms, and while moderate levels of insect, pest, and nematode infections were observed, its performance remains noteworthy. The cultural practices employed for its cultivation predominantly rely on rainfed methods. The region's soil texture is characterized as sandy loam, complemented by a generally level topography. Ethnobotanically, the fruit of this genotype holds significance, finding use as both food and fodder, with its consumption being especially favoured as a dessert. An interesting attribute of this plant is its straight-shaped fruits, rendering them particularly suited for table consumption and enhancing its appeal for such purposes (Table 4.1).

The leaf habit of this variety is characterized as drooping, and the upper surface of the leaves exhibits a vibrant green colour. The dwarfism of the plants falls within the normal range. The pseudostem displays a green-yellow hue, while the position of suckers is closely situated to the parent plant with a vertical growth pattern. The base shape of the leaf blade is rounded on both sides. Regarding specific leaf characteristics, the petiole canal of leaf III is notably wide, with an erect margin (Table 4.3). The measurements of the leaf blade are as follows: a length of 211.00 ± 11.14 cm and a width of 55.67 ± 5.69 cm. The pseudostem reaches a height of 2.78 ± 0.18 m, while the girth size is recorded at 58.00 ± 3.61 cm. The number of suckers per plant averages at 4.00

± 1.00. The petiole length is measured to be 33.67 ± 2.52 cm, indicative of the plant's physiological characteristics (Table 4.4).

The male bud of this genotype exhibits an ovoid shape, while the apex of the bracts displays an intermediate form. The bract base is characterized by a large shoulder. The external colour of the bracts is a distinctive purple-brown, while the internal bract colour presents an eye-catching orange-red hue. The free tepals take on an oval shape and are of a translucent white colour. In contrast, the compound tepals are uniformly white. The ovary of this genotype is notably straight, and the stigma is prominently yellow in colour (Table 4.5).

The fruit of this genotype is characterized by a straight shape with a blunt-tipped apex. The immature fruit peel exhibits a light green colour, transitioning to a vibrant bright yellow upon reaching maturity. The pulp of the fruit is a creamy colour and possesses a soft texture. Notably, the fruit is devoid of seeds, contributing to its desirability for consumption (Table 4.6). Quantitative fruit attributes further elucidate its characteristics. The fruit's dimensions include a length of 16.07 ± 0.66 cm and a width of 3.07 ± 0.15 cm. The peel thickness measures 1.10 ± 0.10 mm. Bunches of this genotype have an average weight of 18.13 ± 0.39 kg, consisting of approximately 9.67 ± 0.58 hands per bunch and an average of 17.33 ± 1.15 fingers per hand. The individual fruit weight averages at 163.67 ± 4.04 grams, with the pulp weighing approximately 108.00 ± 2.65 gm (Table 4.7).

The total soluble solids (°B) content of this genotype's fruit is recorded at 21.93 ± 0.60, indicating its sweetness level. The titratable acidity is measured at 0.62 ± 0.04%, revealing the level of acidity present in the fruit. Notably, the total sugar content is substantial, averaging at 15.94 ± 0.23%, with a proportion of this being reducing sugar, which measures 4.33 ± 0.15%. In terms of storage quality, the fruit exhibits a shelf life of 6.63 ± 0.43, indicating its capacity to maintain its attributes over a specific duration (Table 4.8).

The sensory evaluation results reveal that the genotype's appearance is rated at 4.36 ± 0.19, indicating its visual appeal. The flavour is highly regarded, scoring an average of 4.19 ± 0.19, contributing to the overall taste experience. The texture is rated at 3.86 ± 0.19, reflecting the tactile sensation of consuming the fruit. The taste is notably pleasing, with a score of 4.06 ± 0.19, demonstrating its palatability. The culmination of these sensory attributes leads to an overall acceptability score of 4.12 ± 0.13, signifying the genotype's positive reception among evaluators (table 4.9).


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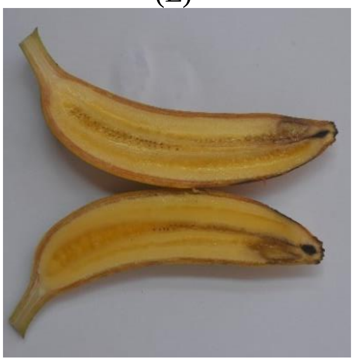
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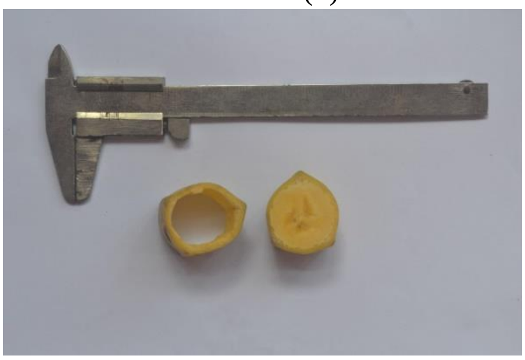
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Plate 12: G-12: Cavendish (A) plant habitat, (B) pseudostem, (C) petiole canal of leaf III, (D) male flower, (E) mature fruits, (F) male bud, (G) and (H) transverse section of ripen fruits and (I) and (J) internal and external bracts.

G-13: (Nendran)

The genotype examined in this study is identified as Nendran, a variety known by its vernacular name. Specimens were collected from the villages/blocks of Medziphema and Chumoukedima. The genome classification for this variety is AAB, reflecting its genetic composition (Table 4.2). Collection took place within a garden setting. This genotype holds the status of a primitive cultivar and occurs occasionally in its frequency of occurrence. The material used for study purposes consisted of suckers, with a breeding system that involves vegetative propagation. Its habitat is primarily cultivated areas. However, it exhibits susceptibility to disease symptoms, and the presence of insect, pest, and nematode infections is notably high. Rainfed cultural practices are predominantly employed for its cultivation. The soil texture of the cultivation site is characterized as sandy loam, complemented by a level topography. Ethnobotanically, both the male inflorescence and the fruit of this genotype find use as food and fodder. They are employed in various forms, such as dessert, culinary applications, and fodder. An intriguing feature of this plant is the distinct pink coloration observed in its pseudostem, setting it apart visually (Table 4.1).

The leaf habit of this genotype is intermediate, falling between distinct categories. The upper surface of the leaves displays a rich dark green colour, contributing to its visual appearance. The dwarfism of the plants is within normal parameters, maintaining expected growth proportions. The pseudostem is characterized by a green-yellow hue, adding to its distinctive features. Suckers are positioned in close proximity to the parent plant, with a vertical growth pattern. The leaf blade's base shape showcases a unique asymmetry, with one side being rounded and the other pointed. Notably, the petiole canal of leaf III is open, and its margin spreads outward (Table 4.3). Morphometric measurements reveal specific leaf attributes. The leaf blade exhibits a length of

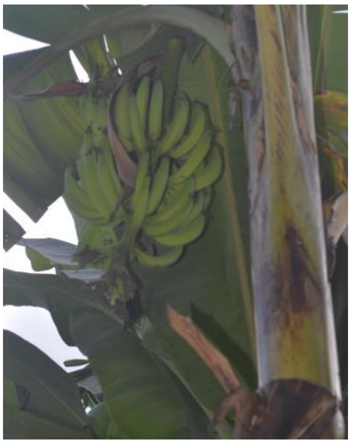
218.33 ± 7.02 cm and a width of 65.33 ± 3.79 cm, contributing to its overall dimensions. The pseudostem attains a notable height of 4.28 ± 0.19 meters, while the girth size measures 58.67 ± 1.53 cm. The number of suckers per plant averages at 2.33 ± 0.58, contributing to the plant's reproductive strategy. Additionally, the petiole length measures 55.83 ± 1.89 cm, adding to the overall plant structure (Table 4.4).

The male bud of this genotype exhibits an intermediate shape, showing characteristics that fall between distinct forms. The apex of the bracts is characterized as obtuse and split, contributing to its unique appearance. The bract base is marked by a large shoulder, adding to its structural features. Distinctive colours adorn the bracts, with the external surface displaying a captivating purple-brown hue, while the internal side reveals a vivid crimson coloration. The free tepals take on a fan-shaped form, contributing to its floral structure, and they exhibit a translucent white colour. In contrast, the compound tepals are marked by an appealing orange hue. The ovary of this genotype is arched in shape, adding to its floral configuration. The stigma, which holds particular significance in pollination, is a creamy colour (Table 4.5).

The fruit of this genotype boasts a straight shape, particularly at the distal end, adding to its distinctive appearance. The fruit apex is elongated and pointed, contributing to its overall structure. During its immature stage, the fruit peel exhibits a medium green colour, which matures into a vibrant yellow hue. The pulp of the fruit takes on an inviting orange-yellow colour and maintains a firm texture upon consumption. An interesting trait of this fruit is the absence of seeds, enhancing its desirability for consumption. Morphometric measurements provide insight into its size and weight parameters (Table 4.6). The fruit's dimensions include a length of 14.10 ± 0.20 cm and a width of 4.17 ± 0.15 cm. The peel thickness measures 3.27 ± 0.12 mm. Bunches of this genotype demonstrate an average weight of 3.13 ± 0.35 kg, comprising an average of 3.67 ± 0.58 hands per bunch, with each hand containing approximately 7.33 ± 1.15 fingers. Individually, the fruit weighs an average of 153.67 ± 5.69 grams, with the pulp accounting for approximately 119.00 ± 4.58 grams (Table 4.7).

The total soluble solids (°B) content of this genotype's fruit is measured at 18.27 ± 0.42, indicating its sweetness level. The titratable acidity is found to be 0.55 ± 0.05%, reflecting the level of acidity present in the fruit. Notably, the total sugar content is substantial, with an average of 15.00 ± 0.30%, and a significant proportion of this is in the form of reducing sugar, measuring 7.33 ± 0.25%. The fruit is characterized by a shelf life of 6.36 ± 0.45, indicating its capacity to maintain its attributes over a specified duration of time (Table 4.8).

The sensory evaluation results provide insights into the sensory attributes of the genotype's fruit. The appearance is rated at 2.72 ± 0.03, indicating its visual characteristics. The flavour is measured at 3.24 ± 0.03, contributing to the overall taste experience. The texture is rated at 3.43 ± 0.02, reflecting the tactile sensation of consuming the fruit. The taste aspect receives a rating of 2.77 ± 0.02, contributing to its palatability. In terms of overall acceptability, the fruit receives an average score of 3.06 ± 0.03, suggesting a generally positive reception among evaluators (Table 4.9).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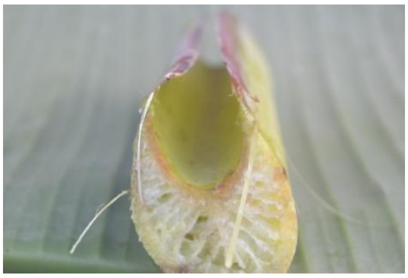
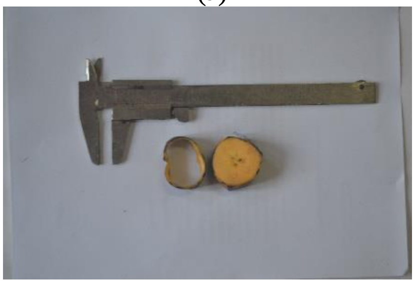


(I) (J)



(K) (L)

Plate 13: G-13: Nendran (A) plant habitat, (B) measuring of leaf length, (C) pseudostem, (D) male bud, (E) male flower, (F) measuring of leaf width (G) and (H) internal and external bracts, (I) petiole canal of leaf III, (J) mature fruits and (K) and (L) transverse section of ripen fruits.

G-14: Monthan

The genotype under scrutiny is identified as Monthan, known by its vernacular names Sobjikol (Nagamese) and Kubza mango (Ao-Mongsen). Specimens were collected from the Alichen village in the Mokokchung block. Its genome classification falls within the ABB category, reflecting its genetic composition. Collection of specimens occurred within a garden setting. This genotype holds the status of a primitive cultivar and is characterized by its abundant frequency in occurrence. The material used for study purposes comprises suckers, reflecting a vegetative propagation strategy for breeding. The habitat of this genotype is primarily cultivated areas, demonstrating its adaptability to human cultivation. Notably, it exhibits a commendable tolerance to disease symptoms and maintains a moderate level of insect, pest, and nematode infections. The cultural practices employed for its cultivation predominantly rely on rainfed methods, reflecting the local agricultural practices. The soil texture of the cultivation site is characterized as sandy loam, complemented by a level topography, contributing to its growth conditions. Ethnobotanically, both the male inflorescence and the fruit of this genotype find use as food and fodder, serving a variety of purposes, including dessert, culinary applications, and fodder. Special characteristics of this plant include its remarkable drought resistance, adding to its agricultural significance, and its valued use in culinary endeavours (Table 4.1).

The leaf habit of this genotype is intermediate, reflecting characteristics that fall between distinct leaf types. The upper surface of the leaves displays a lush green colour, contributing to its visual appearance. The dwarfism of the plants aligns with normal growth proportions, maintaining expected sizes. The pseudostem is characterized by a vivid green-red colour, adding to its distinctiveness. Suckers are situated in close proximity to the parent plant, exhibiting vertical growth. The leaf blade's base shape showcases a unique asymmetry, with one side being rounded and the other pointed. The petiole canal of leaf III is open, with its margin spreading outward (Table 4.3). Specific leaf measurements provide insight into its attributes. The leaf blade length measures 168.67 ± 6.03 cm, while its width spans 54.00 ± 3.00 cm. The pseudostem reaches an impressive height of 5.42 ± 0.26 meters, while the girth size measures 61.00 ± 2.00 cm. The number of suckers per plant averages at 2.33 ± 1.53, contributing to the plant's reproductive strategy. Additionally, the petiole length is measured at 49.67 ± 1.53 cm, adding to the overall plant structure (Table 4.4).

The male bud of this genotype exhibits a distinctive shape reminiscent of a top. The apex of the bracts is characterized as intermediate, showcasing characteristics between distinct forms. The bract base is marked by a large shoulder, contributing to its overall structure. The external colour of the bracts is a captivating purple-brown, while the internal bract colour maintains the same shade of purple-brown, adding to its visual appeal. The free tepals take on an oval shape, while their colour is subtly tinted with pink, adding a delicate hue. The compound tepals, on the other hand, present a more vibrant pink-purple coloration. The ovary of this genotype is arched in shape, adding to its floral configuration. The stigma, which holds particular significance in pollination, is a creamy colour (Table 4.5).

The fruit of this genotype exhibits a straight or slightly curved shape, with a pointed apex, contributing to its distinctive appearance. As the fruit progresses from an immature to a mature stage, the peel transitions from a vibrant green to a radiant yellow hue. The pulp of the fruit boasts an inviting orange-yellow colour and maintains a firm texture upon consumption. A notable feature of this fruit is the absence of seeds, enhancing its appeal for consumption (Table 4.6). Morphometric measurements offer insights into its size and weight characteristics. The fruit's dimensions include a length of 17.67 ± 1.53 cm and a width of 5.53 ± 0.15 cm. The peel thickness measures 2.93 ±

0.15 mm. Bunches of this genotype demonstrate an average weight of 16.28 ± 1.61 kg, comprising an average of 5.33 ± 0.58 hands per bunch, with each hand containing approximately 10.67 ± 1.15 fingers. Individually, the fruit weighs an average of 199.88 ± 2.45 gm, while the pulp contributes approximately 151.67 ± 4.04 gm (Table 4.7).

The comprehensive analysis of this genotype's fruit reveals insightful data on its biochemical composition and attributes. The total soluble solids (°B) content measures at 24.02 ± 0.09, highlighting its elevated sweetness level. The titratable acidity is noted at 0.78 ± 0.03%, indicating the level of acidity present in the fruit. The total sugar content averages at 13.16 ± 0.22 %, with a notable proportion of reducing sugar, accounting for 5.00 ± 0.26 %. An important consideration for fruit quality is its shelf life, which is recorded at 8.31 ± 0.47, signifying its capacity to maintain its attributes over a specified duration (Table 4.8).

The sensory evaluation results offer valuable insights into the sensory attributes of the genotype's fruit. The appearance is rated at 2.31 ± 0.02, indicating its visual characteristics. The flavour is measured at 2.49 ± 0.03, contributing to the overall taste experience. The texture receives a score of 3.19 ± 0.03, reflecting the tactile sensation of consuming the fruit. The taste aspect is rated at 2.60 ± 0.03, contributing to its palatability. In terms of overall acceptability, the fruit receives an average score of 3.11 ± 0.02, suggesting a generally positive reception among evaluators (Table 4.9).

(A)

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(J)

Plate 14: G-14: Monthan (A) plant habitat, (B) male bud, (C) pseudostem, (D) measuring of leaf width, (E) and (F) internal and external bracts, (G) petiole canal of leaf III, (H) male flower, (I) mature fruits and (J) transverse section of ripen fruits.

G-15: African Rhino Horn Plantain

The genotype under investigation is identified as the African Rhino Horn Plantain, known by its vernacular names Sobjikol (Nagamese) and Kubza mango (Mongsen). The specimens were collected from the New Medziphema village in the Chumoukedima block. Its genome classification falls within the AAB category, reflecting its genetic composition (Table 4.2). The collection of specimens took place within a garden setting. This genotype holds the status of a primitive cultivar and is characterized by its frequent occurrence. The material used for study purposes consists of suckers, reflecting a vegetative propagation strategy for breeding. The habitat of this genotype is primarily cultivated areas, and it demonstrates a commendable tolerance to disease symptoms, with mild insect, pest, and nematode infections. Cultural practices employed for its cultivation predominantly rely on rainfed methods, complemented by a sandy loam soil texture and a level topography. Ethnobotanically, both the stem and the fruit of this genotype find use as food and fodder, with a variety of applications including dessert, culinary purposes, and fodder for livestock. An interesting attribute of this plant is the absence of male buds and rachis. This distinctive feature sets it apart from other varieties and contributes to its uniqueness within its botanical classification (Table 4.1).

The leaf habit of this genotype is intermediate, exhibiting characteristics that fall between distinct leaf types. The upper surface of the leaves displays a vibrant green colour, contributing to its visual appearance. The dwarfism of the plants aligns with normal growth proportions, maintaining expected sizes. The pseudostem is characterized by a medium green hue, adding to its overall visual appeal. Suckers are positioned in close proximity to the parent plant, displaying vertical growth. The leaf blade's base shape showcases rounded characteristics on both sides, contributing to its symmetrical structure. The petiole canal of leaf III is notable for its margin, which curves inward (Table

4.3). Specific leaf measurements provide insight into its attributes. The leaf blade boasts a length of 256.67 ± 5.51 cm and a width of 64.67 ± 2.08 cm. The pseudostem reaches a height of 3.25 ± 0.13 meters, while the girth size measures 75.00 ± 4.58 cm. The number of suckers per plant averages at 4.33 ± 0.58, contributing to the plant's reproductive strategy. Additionally, the petiole length is measured at 63.00 ± 4.00 cm, adding to the overall plant structure (Table 4.4).

The fruit of this genotype is characterized by a straight shape, with a lengthily pointed apex, contributing to its distinctive appearance. As the fruit progresses from an immature to a mature stage, the peel transitions from a vibrant green to a radiant yellow hue. The pulp of the fruit boasts a creamy colour and maintains a firm texture upon consumption. An intriguing feature of this fruit is the absence of seeds, enhancing its appeal for consumption (Table 4.6). Morphometric measurements offer insights into its size and weight characteristics. The fruit's dimensions include a length of 27.00 ± 1.00 cm and a width of 4.70 ± 0.20 cm. The peel thickness measures 5.33 ± 0.31 mm. Bunches of this genotype demonstrate an average weight of 16.28 ± 1.61 kg, comprising an average of 3.33 ± 0.58 hands per bunch, with each hand containing approximately 12.33 ± 1.15 fingers. Individually, the fruit weighs an average of 319.06 ± 5.29 grams, while the pulp contributes approximately 217.34 ± 12.05 grams (Table 4.7).

The thorough analysis of this genotype's fruit reveals significant insights into its biochemical composition and attributes. The total soluble solids (°B) content is measured at 22.77 ± 0.68, indicating its sweetness level. The titratable acidity is noted at 0.59 ± 0.06%, which provides insight into the level of acidity present in the fruit. The total sugar content is notable, with an average of 16.17 ± 0.41%, and a significant proportion of this is in the form of reducing sugar, measuring 5.37 ± 0.31%. The fruit is characterized by a shelf life of 5.35 ± 0.78, signifying its capacity to maintain its attributes over a specified duration of time (Table 4.8).

The sensory evaluation results provide valuable insights into the sensory attributes of the genotype's fruit. The appearance is rated at 3.31 ± 0.18, indicating its visual characteristics. The flavour is measured at 3.39 ± 0.18, contributing to the overall taste experience. The texture receives a score of 2.59 ± 0.17, reflecting the tactile sensation of consuming the fruit. The taste aspect is rated at 2.93 ± 0.17, contributing to its palatability. In terms of overall acceptability, the fruit receives an average score of 3.13 ± 0.17, suggesting a generally positive reception among evaluators (Table 4.9).


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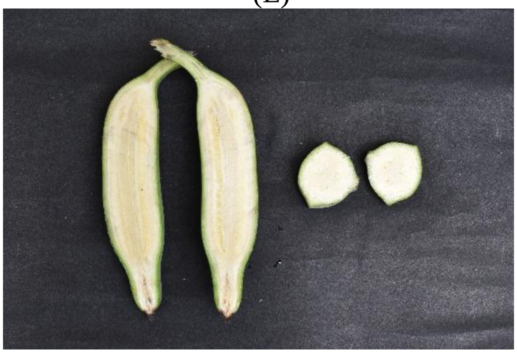
(G)


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Plate 15: G-15: African Rhino Horn Plantain (A) and (B) plant habitat, (C) mature fruit bunch, (D) measuring of leaf width, (E) petiole canal of leaf III, (F) ripen fruits, (G) & (H) transverse section of mature and ripen fruits, (I) and (J) measuring of leaf length.

G-16 Bharatmani

The genotype under scrutiny is identified as Bharatmani, known by its vernacular name "Butter mongo" (Ao - Chungli). Specimens were collected from the Tuli village in the Mokokchung block. Its genome classification falls within the AAB category, reflecting its genetic composition (Table 4.2). Collection of specimens occurred within a garden setting. This genotype holds the status of a primitive cultivar and is characterized by its abundant frequency in occurrence. The material used for study purposes comprises suckers, indicating a vegetative propagation strategy for breeding. The habitat of this genotype is primarily cultivated areas, where it showcases resistance to disease symptoms, with moderate levels of insect, pest, and nematode infections. Cultural practices employed for its cultivation predominantly rely on rainfed methods, complemented by a sandy loam soil texture and a level topography. Ethnobotanically, both the male inflorescence and the fruit of this genotype find use as food and fodder, serving various purposes, including dessert and culinary applications (Table 4.1).

The leaf habit of this genotype is characterized as drooping, with the leaves displaying a vibrant green colour on the upper surface. The dwarfism of the plants adheres to normal growth proportions, maintaining expected sizes. The pseudostem exhibits a notable green-red coloration, enhancing its visual appeal. Suckers are positioned close to the parent plant, showcasing vertical growth tendencies. The leaf blade's base shape is marked by one side being rounded, while the opposite side is pointed, contributing to its asymmetrical configuration. The petiole canal of leaf III is notable for its margin, which curves inward (Table 4.3). Specific leaf measurements provide insights into its attributes. The leaf blade boasts a length of 204.67 ± 16.65 cm and a width of 62.00 ± 4.36 cm. The pseudostem reaches a height of 3.32 ± 0.21 meters, while the girth size measures 59.35 ± 1.60 cm. The number of suckers per plant averages at 3.00 ± 1.00, contributing to the plant's reproductive strategy. Additionally, the petiole length is measured at 24.67 ± 2.52 cm, contributing to the overall plant structure (Table 4.4).

The male bud of this genotype is characterized by a shape resembling that of a top. The apex of the bracts is slightly pointed, contributing to its overall structure. The bract base displays a large shoulder, enhancing its distinctive appearance. The external colour of the bracts is a subtle whitish shade, while the internal bract colour exhibits a rich purple-brown hue. The free tepals take on an oval shape, with a translucent white colour, adding to its delicate visual appeal. The compound tepals, however, maintain a pure white coloration. The ovary of this genotype is arched in shape, adding to its floral configuration. The stigma, a crucial part for pollination, is characterized by a bright yellow colour, contributing to its visual contrast and attractiveness (Table 4.5).

The fruit of this genotype exhibits a straight shape, with a unique bottlenecked apex, contributing to its distinctive appearance. As the fruit progresses from an immature to a mature stage, the peel transitions from a light green to a vibrant yellow hue. The pulp of the fruit boasts an inviting orange-yellow colour and maintains a soft texture upon consumption. A notable feature of this fruit is the absence of seeds, enhancing its appeal for consumption (Table 4.6). Morphometric measurements offer insights into its size and weight characteristics. The fruit's dimensions include a length of 10.10 ± 0.30 cm and a width of 2.57 ± 0.15 cm. The peel thickness measures 2.27 ± 0.15 mm. Bunches of this genotype demonstrate an average weight of 8.81 ± 0.30 kg, comprising an average of 8.33 ± 0.58 hands per bunch, with each hand containing approximately 16.67 ± 1.15 fingers. Individually, the fruit weighs an average of 111.00 ± 4.58 grams, while the pulp contributes approximately 78.67 ± 3.51 grams (Table 4.7).

The thorough analysis of this genotype's fruit offers significant insights into its biochemical composition and attributes. The total soluble solids (0B) content measures at 16.96 ± 0.17, indicating its sweetness level. The titratable acidity is noted at 0.53 ± 0.04%, which provides insight into the level of acidity present in the fruit. The total sugar content is an average of 11.03 ± 0.21%, with a significant proportion of reducing sugar, measuring 5.83 ± 0.25%. The fruit is characterized by a shelf life of 4.74 ± 1.24, signifying its capacity to maintain its attributes over a specified duration of time (Table 4.8).

The sensory evaluation results provide valuable insights into the sensory attributes of the genotype's fruit. The appearance is rated at 4.74 ± 1.24, indicating its visual characteristics. The flavour is measured at 3.49 ± 0.04, contributing to the overall taste experience. The texture receives a score of 3.20 ± 0.05, reflecting the tactile sensation of consuming the fruit. The taste aspect is rated at 3.66 ± 0.05, contributing to its palatability. In terms of overall acceptability, the fruit receives an average score of 3.43 ± 0.05, suggesting a generally positive reception among evaluators (Table 4.9).

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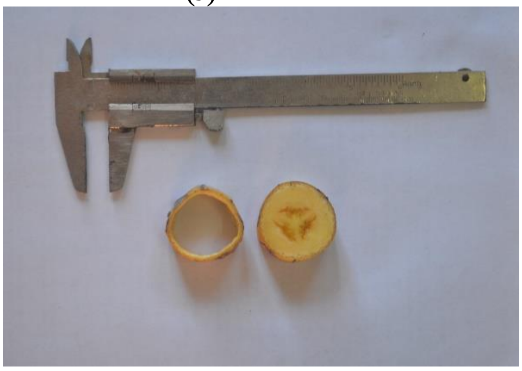


(L)

Plate 16: G-16: Bharatmani (A) & (B) plant habitat, (C) pseudostem, (D) measuring of leaf width, (E) and (F) internal and external bracts, (G) petiole canal of leaf III, (H) male flower, (I) mature fruit bunch, (J) male bud and (K) and (L) transverse section of ripen fruits.

G-17: Bhootmanohar

The genotype under investigation is identified as Bhootmanohar. Specimens were collected from the Sirhi Angami village in Kohima. Its genome classification falls within the ABB category, reflecting its genetic composition (Table 4.2). Collection of specimens took place in farmers' fields, suggesting its relevance to local agriculture. This genotype holds the status of a primitive cultivar and is characterized by its abundant frequency in occurrence. The material used for study purposes consists of suckers, indicating a vegetative propagation strategy for breeding. The habitat of this genotype is primarily cultivated areas, where it showcases resistance to disease symptoms and moderate levels of insect, pest, and nematode infections. Cultural practices employed for its cultivation predominantly rely on rainfed methods, complemented by a sandy loam soil texture and a level topography. Ethnobotanically, both the male inflorescence and the fruit of this genotype find use as food and fodder, serving various purposes, including dessert and culinary applications. A distinctive feature of this plant is its fruit size, which is notably larger when compared to the Chinichampa variety (Table 4.1).

The leaf habit of this genotype is intermediate, demonstrating characteristics that lie between distinct leaf types. The upper surface of the leaves is characterized by a deep, dark green colour, enhancing its visual appearance. In terms of dwarfism, this genotype exhibits a dwarf stature, deviating from normal growth proportions. The pseudostem displays a green-yellow coloration, adding to its aesthetic attributes. Suckers are situated in close proximity to the parent plant, showcasing vertical growth tendencies. The base of the leaf blade is marked by one side being rounded, while the opposite side is pointed, contributing to its asymmetrical structure. The petiole canal of leaf III displays an open configuration with the margin spreading outward (Table 4.3). Precise leaf measurements offer insights into its attributes, with a leaf blade length of 218.00 ± 6.56 cm and a width of 59.80 ± 2.96 cm. The pseudostem achieves a height of 3.57 ± 0.16 m, while the girth size measures 69.33 ± 2.52 cm. The number of suckers per plant averages at 2.67 ± 0.58, contributing to the plant's reproductive strategy. Additionally, the petiole length is measured at 64.33 ± 2.52 cm, adding to the overall plant structure (Table 4.4).

The male bud of this genotype is characterized as having an intermediate shape, with features that lie between distinct forms. The apex of the bracts is also intermediate in shape, contributing to its overall appearance. The bract base showcases a small shoulder, adding to its structural intricacies. The external colour of the bracts is a vivid orange-red hue, while the internal bract colour displays a rich red shade. The free tepals take on an oval shape, with a translucent white colour, enhancing its delicate appearance. In contrast, the compound tepals exhibit a charming pink-purple coloration. The ovary of this genotype is arched in shape, adding to its floral composition. The stigma, a critical component for pollination, features a bright yellow colour, contributing to its visual contrast and allure (Table 4.5).

The fruit of this genotype exhibits a straight shape, with a pointed apex, contributing to its distinctive appearance. As the fruit progresses from an immature to a mature stage, the peel transitions from a green colour to a bright yellow hue with a noticeable red tint, adding to its visual allure. The pulp of the fruit boasts a creamy colour and maintains a firm texture upon consumption. Notably, this fruit is absent of seeds, enhancing its appeal for consumption (Table 4.6). Quantitative measurements provide insights into its size and weight characteristics. The fruit's dimensions include a length of 9.17 ± 0.12 cm and a width of 3.30 ± 0.10 cm. The peel thickness measures 1.33 ± 0.15 mm. Bunches of this genotype demonstrate an average weight of 16.61 ± 0.91 kg, comprising an average of 11.67 ± 1.53 hands per bunch, with each hand containing approximately 16.67 ± 1.15 fingers. Individually, the fruit weighs an average of 73.00 ± 2.00 grams, while the pulp contributes approximately 52.00 ± 1.73 grams (Table 4.7).

The comprehensive analysis of this genotype's fruit reveals significant insights into its biochemical composition and attributes. The total soluble solids (°B) content measures at 23.10 ± 0.41, reflecting its sweetness level. The titratable acidity is noted at 0.45 ± 0.06%, offering insight into the level of acidity present in the fruit. The total sugar content averages at 13.90 ± 0.20%, with a substantial proportion of reducing sugar, measuring 7.37 ± 0.38%. The fruit is characterized by a shelf life of 7.86 ± 0.84, indicating its capacity to maintain its attributes over a specified duration of time (Table 4.8).

The sensory evaluation results provide valuable insights into the sensory attributes of the genotype's fruit. The appearance is rated at 3.54 ± 0.05, reflecting its visual characteristics. The flavour is measured at 3.15 ± 0.06, contributing to the overall taste experience. The texture receives a score of 3.96 ± 0.04, indicating the tactile sensation of consuming the fruit. The taste aspect is rated at 4.12 ± 0.13, suggesting its palatability. In terms of overall acceptability, the fruit receives an average score of 3.67 ± 0.04, indicating a generally positive reception among evaluators (Table 4.9).


(A)


(B)


(C)


(D)


(E)


(F)

(G)

(H)

(I)

Plate 17: G-17: Bhoot Manohar (A) plant habitat, (B) pseudostem, (C) and (D) internal and external bracts, (E) petiole canal of leaf III, (F) male flower, (G) ripen fruit bunch, (H) male bud and (I) transverse section of ripen fruits.

G-18: (Chinichampa)

The genotype under study is known as Chinichampa, and it is collected from the Medziphema and Chumoukedima regions. This genotype belongs to the AAB genome type, indicating its genetic makeup (Table 4.2). The collection site for specimens is a garden setting, reflecting its relevance in horticulture. Chinichampa is identified as a primitive cultivar, prevalent with abundant frequency. For research purposes, suckers are employed as material, indicative of its vegetative propagation for breeding. Its habitat primarily encompasses cultivated areas, where it exhibits resistance to disease symptoms and moderate susceptibility to insect, pest, and nematode infections. Cultural practices associated with the growth of this genotype involve rainfed methods, while the soil texture is characterized as sandy loam. The topography of the growing environment is level, contributing to its ease of cultivation. Ethnobotanically, both the male inflorescence and the fruit of Chinichampa hold value as sources of food and fodder, serving various culinary and dessert purposes. A unique feature of this plant is its fruit characteristics. The fruits are smaller in size compared to other varieties and offer a combination of sweet and sour tastes (Table 4.1).

The leaf habit of this genotype is characterized as drooping, with the leaves exhibiting a graceful downward orientation. The upper surface of the leaves is a vibrant green colour, contributing to its aesthetic appeal. In terms of dwarfism, this genotype demonstrates a normal growth pattern, aligning with typical proportions. The pseudostem, which resembles a stem but is formed by leaf bases, displays a green-red coloration, adding to its visual interest. Suckers, the shoots that emerge from the base of the plant, are positioned in close proximity to the parent plant, with vertical growth tendencies. The leaf blade is distinguished by a rounded base on both sides, contributing to its symmetrical structure. The petiole canal of leaf III is open with a spreading margin, further enhancing its visual intricacies (Table 4.3). Precise measurements of the leaf provide insights into its attributes, with a leaf blade length of 193.33 ± 12.01 cm and a width of 70.00 ± 4.58 cm. The pseudostem achieves a height of 2.95 ± 0.13 meters, while the girth size measures 59.33 ± 2.52 cm. The number of suckers per plant averages at 3.00 ± 1.00, contributing to the plant's reproductive strategy. Additionally, the petiole length is measured at 57.97 ± 2.00 cm, adding to the overall plant structure (Table 4.4).

The male bud of this genotype is characterized by a distinctive shape, resembling that of a spinning top. The bract apex exhibits an intermediate form, displaying characteristics between distinct shapes. The base of the bract is marked by a small shoulder, contributing to its overall structural intricacies. External bract coloration is a rich purple hue, while the internal bract colour takes on a vibrant red shade, adding to its visual allure. The free tepals are oval in shape and feature a delicate translucent white colour, enhancing its ethereal appearance. In contrast, the compound tepals display a captivating pink-purple coloration. The ovary of this genotype is arched in shape, contributing to its floral structure. The stigma, a crucial component for pollination, showcases a creamy colour, adding to its visual contrast and allure (Table 4.5).

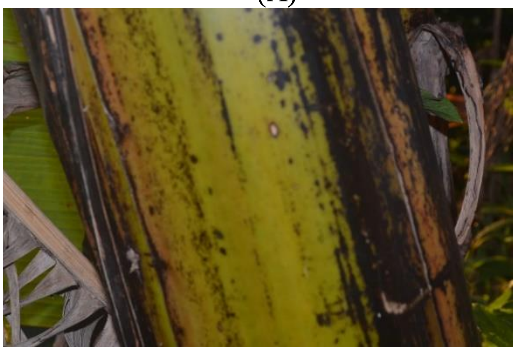
The fruit of this genotype is characterized by a slightly curved shape, contributing to its distinct appearance. The apex of the fruit takes on a bottlenecked form, adding to its visual intricacies. As the fruit progresses from an immature stage to maturity, the peel undergoes a transformation from light green to a vibrant bright yellow colour. Internally, the pulp of the fruit displays a pristine white colour, enhancing its visual contrast. The texture of the flesh is soft, contributing to its palatability and ease of consumption (Table 4.6). Notably, the absence of seeds adds to the overall appeal and convenience of consuming this fruit. Quantitative measurements provide precise insights into the fruit's dimensions and weight attributes. The fruit measures approximately 9.03 ± 0.21 cm in length and 3.17 ± 0.06 cm in width. The peel thickness is recorded at 1.00 ± 0.10 mm. Bunches of this genotype exhibit an average weight of 17.48 ± 0.65 kg, comprising an average of 11.33 ± 1.53 hands per bunch, each containing an impressive 18.67 ± 1.15 fingers. Individually, the fruit weighs an average of 68.33 ± 4.16 grams, while the pulp contributes around 50.00 ± 2.65 grams (Table 4.7).

The biochemical analysis of this genotype's fruit reveals significant insights into its nutritional and storage attributes. The total soluble solids (°B) content measures at 21.43 ± 0.57, indicating the presence of dissolved solids contributing to its flavour and sweetness. The titratable acidity is noted at 0.80 ± 0.08%, offering insight into the level of acidity present in the fruit. The total sugar content averages at 9.48 ± 0.30 %, with a proportion of reducing sugar measuring 6.00 ± 0.26 %, contributing to its overall sweetness and taste profile. The shelf life is measured at 6.16 ± 0.87, indicating its capacity to maintain its attributes over a specified duration of time (Table 4.8).

The sensory evaluation of this genotype's fruit yields valuable insights into its organoleptic attributes. The appearance is rated at 4.07 ± 0.22, indicating its visual appeal and aesthetic qualities. The flavour is assessed at 3.85 ± 0.22, reflecting the taste experience and aromatic profile. The texture of the fruit is evaluated at 3.63 ± 0.22, contributing to the tactile experience during consumption. The taste is scored at 4.01 ± 0.22, indicating the overall flavour perception and palatability. In terms of overall acceptability, the fruit receives a rating of 3.86 ± 0.22, reflecting the combination of its appearance, flavour, texture, and taste, as well as its suitability for consumption (Table 4.9).


(A)


(B)


(C)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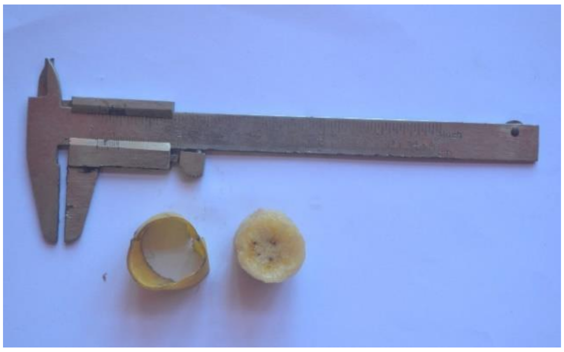


(J)

Plate 18: G-18: Chinichampa (A) plant habitat, (B) male bud, (C) pseudostem, (D) measuring of leaf width, (E) and (F) internal and external bracts, (G) petiole canal of leaf III, (H) male flower, (I) mature fruit bunch and (J) transverse section of ripen fruits.

G-19: (Kanthali)

The genotype of this cultivar is recognized as Kanthali, bearing the vernacular name "Shini mongu" (Ao - Chungli) within the local community. Its natural habitat includes Medziphema Village, Chumoukedima, where it thrives abundantly in cultivated areas. The genome types are classified as ABB, contributing to its genetic identity and characteristics (Table 4.2). This cultivar holds significance as a primitive cultivar, indicating a link to traditional agricultural practices. It is frequently collected from farmers' fields, attesting to its local importance and prevalence. As part of its unique attributes, the plant displays a notable resistance to various diseases, further enhancing its desirability in agricultural contexts. Within its cultivated habitat, the plant demonstrates a moderate susceptibility to insect, pest, and nematode infections, a factor that must be managed through suitable agricultural practices. The cultivation of this plant largely adheres to rainfed techniques, aligning with local climatic conditions and resource availability. Notably, the plant's biological role extends beyond cultivation, as its male inflorescence and fruit serve as essential components with diverse ethnobotanical uses. These parts find application in both food and fodder, making a meaningful contribution to dietary and agricultural practices. Specifically, they are integrated into dessert and culinary preparations, enriching the local cuisine and dietary diversity (Table 4.1).

The leaf habit of this cultivar is identified as intermediate, representing a balanced and transitional growth pattern. The upper surface of the leaves is characterized by a vibrant green coloration, indicative of its health and vigour. In terms of size, the plant demonstrates a normal level of dwarfism, contributing to its compact and manageable stature. The pseudostem, a notable feature, maintains a consistent green colour, reflecting its vitality and connection to the plant's overall health. Suckers emerge closely to the parent plant in a vertical growth pattern, emphasizing a proximity that encourages efficient resource sharing. Leaf morphology further reveals a base with rounded edges on sides, enhancing its aesthetic appeal and contributing to its overall symmetry. The petiole canal of leaf III is straight and features an erect margin, indicating structural integrity and efficient nutrient transport (Table 4.3). The leaf itself possesses a substantial blade length, measuring at 202.67 ± 8.08 cm, and an impressive width of 56.00 ± 6.24 cm. In terms of height, the pseudostem reaches approximately 3.75 ± 0.15 meters, while the girth size averages at 52.00 ± 2.65 cm. Moreover, the plant produces an average of 2.33 ± 0.58 suckers, each contributing to its potential for propagation and growth. The petioles, connecting the leaves to the stem, exhibit a length of 65.00 ± 2.00 cm, serving as vital conduits for nutrient exchange and structural support (Table 4.4).

The male bud of this cultivar is characterized by an intermediate shape, reflecting its transitional nature. Similarly, both the apex and base of the bracts showcase an intermediate form, signifying a balanced and harmonious arrangement. The external colour of the bracts is a rich red-purple, evoking a striking visual contrast. Internally, the bracts exude a deep red hue, lending depth to their overall appearance. The free tepals, shaped in ovals, exhibit a delicate and graceful presence, with a coloration that is reminiscent of translucent white, inviting a sense of purity. Conversely, the compound tepals showcase an enchanting pink-purple colour, contributing to an alluring and vibrant aesthetic. The ovary assumes an arched shape, infusing a sense of curvature and elegance. Finally, the stigma, a crucial element in the reproductive process, displays a soft and understated cream colour, further highlighting its role in the plant's reproductive biology (Table 4.5).

The fruit exhibits a straight shape with a pointed apex. During the immature stage, the fruit peel boasts a vibrant green hue, which matures into a vivid yellow colour. The pulp of the fruit is characterized by a pristine white appearance and a firm texture. Remarkably, the absence of seeds further distinguishes this cultivar (Table 4.6). The fruit dimensions are recorded as follows: a length of 9.07 ± 0.15 cm and a width of 2.27 ± 0.15 cm. The peel thickness measures approximately 1.77 ± 0.06 mm. On average, bunches of this fruit weigh around 7.01 ± 0.20 kg and typically consist of about 8.33 ± 0.58 hands, each containing an average of 11.33 ± 1.15 fingers. Individually, the fruit weighs approximately 58.40 ± 2.95 gm, with the pulp contributing a weight of 49.22 ± 1.19 gm (Table 4.7).

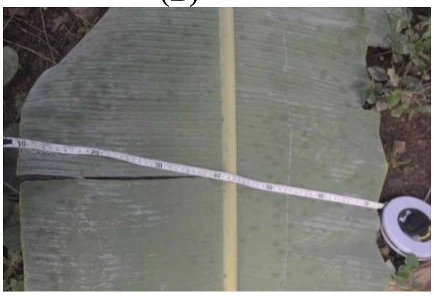
The comprehensive biochemical analysis of this specific genotype's fruit provides valuable insights into its nutritional composition and potential for post-harvest preservation. The total soluble solids (°B) content registers at 20.63 ± 0.07, underscoring the presence of dissolved solids that significantly contribute to its flavour and inherent sweetness. The titratable acidity, measured at 0.50 ± 0.03 %, offers a pertinent glimpse into the fruit's acidity level. The evaluation of total sugar content, averaging at 9.97 ± 0.15 %, encompasses a notable proportion of reducing sugar, quantified at 4.70 ± 0.17 %, which plays a pivotal role in enhancing the fruit's overall sweetness and flavour profile. Furthermore, the documented shelf life of 5.45 ± 0.73 emphasizes the fruit's ability to maintain its attributes over a defined period (Table 4.8).

The evaluation of sensory attributes provides a comprehensive understanding of the fruit's organoleptic qualities. The appearance, rated at 2.31 ± 0.36, contributes to the initial impression, while the flavour, scoring 2.89 ± 0.36, encompasses the distinctive taste profile. Texture, an essential sensory component, is quantified at 3.31 ± 0.36, reflecting the tactile experience. Taste, a pivotal aspect, is registered at 3.99 ± 0.36, encapsulating the overall gustatory sensation. The aggregate assessment of overall acceptability, measured at 3.12 ± 0.36, provides a comprehensive perspective on the fruit's desirability in terms of its combined sensory attributes (Table 4.9).


(A)


(B)

(C)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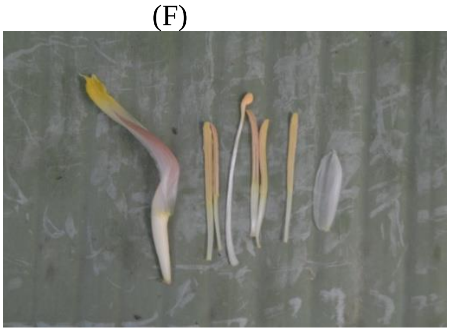
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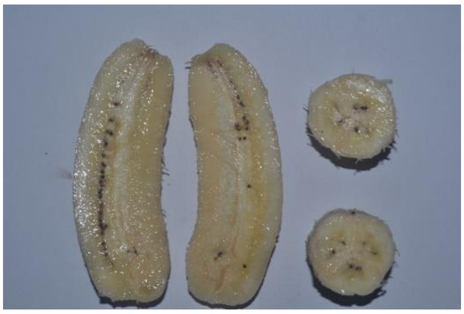


(J)

Plate 19: G-19: Kanthali (A) plant habitat, (B) male bud, (C) pseudostem, (D) measuring of leaf width, (E) and (F) internal and external bracts, (G) petiole canal of leaf III, (H) male flower, (I) mature fruit bunch and (J) transverse section of ripen fruits.

G-20: (Red Banana)

The genotype attributed to this particular cultivar is known as the Red Banana. While the vernacular name is not specified, its significance lies in the unique characteristics it embodies. This cultivar thrives within the surroundings of Heningkunglwa, Peren, marking its presence within this locale. The genome types are categorized as AAA, signifying its genetic classification (Table 4.2). Found primarily within cultivated gardens, the biological status of this cultivar is that of a primitive variant, reflecting a connection to traditional agricultural practices. Its abundant frequency underscores its importance within local agriculture. Suckers serve as the primary material for propagation, and the breeding system predominantly involves vegetative propagation, further emphasizing its cultivation for desired traits. Within its cultivated habitat, this cultivar showcases remarkable resistance to various diseases, highlighting its potential to contribute to disease-resistant agricultural practices. It exhibits a moderate susceptibility to insect, pest, and nematode infections, which necessitate balanced pest management strategies. The cultivation practices primarily follow rainfed methods, harmonizing with the local climate and water availability. The soil texture within its habitat is characterized as sandy loam, contributing to its growth and adaptability. The level topography further influences its cultivation, facilitating ease of maintenance and resource management. Ethnobotanically, this cultivar plays a multifaceted role. Both the male inflorescence and fruit are employed, serving as crucial components for sustenance in the form of food and fodder. These parts find their way into culinary and dessert preparations, enriching the local diet and culinary traditions. A distinctive feature of this cultivar lies in its unique plant characteristics, where the pseudostem and midrib of leaves are adorned with a striking red coloration (Table 4.1).

The leaf habit of this cultivar is classified as intermediate, showcasing a balanced growth pattern that is neither exclusively large nor small. The upper surface of its leaves exhibits a lush green coloration, signifying its health and vitality. In terms of size, the plant demonstrates normal levels of dwarfism, contributing to a well-proportioned stature that is typical for this type. A distinguishing characteristic of this cultivar is the vibrant red colour of its pseudostem, a unique feature that adds to its visual allure. Suckers emerge in close proximity to the parent plant, adopting a vertical growth pattern that maximizes resource sharing and efficient propagation. The leaf morphology reveals a base with rounded edges on both sides. The petiole canal of leaf III is notably wide and exhibits an erect margin, indicating structural stability and efficient nutrient transport (Table 4.3). The leaves themselves are impressive in dimensions, boasting a length of 249.67 ± 2.08 cm and a width of 89.33 ± 4.04 cm. In terms of height, the pseudostem reaches an imposing 4.75 ± 0.25 meters, while the girth size averages at 61.00 ± 2.65 cm. This cultivar showcases the emergence of an average of 5.00 ± 1.00 suckers, each contributing to its propagation potential and growth. Petioles, which serve as essential conduits for nutrient exchange and support, display a length of 56.00 ± 2.65 cm, underscoring their structural importance (Table 4.4).

The male bud of this cultivar exhibits a distinctive shape, akin to that of a top, which adds to its unique visual identity. The apex of the bracts showcases an intermediate shape, striking a balance between different structural elements. Similarly, the base of the bracts adopts a medium shape, contributing to its overall symmetry and aesthetics. The external colour of the bracts is a vivid red, creating a bold and eye-catching contrast that enhances its ornamental appeal. On the internal side, the bracts are adorned with a regal purple hue, imbuing them with an air of sophistication and elegance. The free tepals, forming oval shapes, lend an element of grace and delicacy to the overall flower structure. Their coloration is tinted with shades of pink, imparting a subtle and alluring blush. In contrast, the compound tepals exhibit a captivating pink-purple coloration, contributing to a vibrant and captivating visual display. The ovary of this flower type boasts an arched shape, adding to the curvature and structural intrigue of the floral components. The stigma, a pivotal element in the plant's reproductive process, is characterized by a soft and refined cream colour, underscoring its significance in pollination and reproduction (Table 4.5).

The fruit of this cultivar is characterized by a straight shape, imparting a sense of symmetry and uniformity to its appearance. The apex of the fruit exhibits a blunt-tipped form, contributing to its distinct visual profile. During the immature stage, the fruit peel assumes a striking purple colour, which matures into a captivating red-purple hue, evoking a sense of vibrancy and allure. Upon peeling away the exterior, the pulp of the fruit reveals a delicate beige-pink colour, enhancing its visual appeal and presentation. The flesh boasts a firm texture, further contributing to its overall sensory experience. A notable feature of this fruit is the absence of seeds, making it particularly desirable for consumption and culinary purposes (Table 4.6). The dimensions of this fruit are impressive, with a length of 10.30 ± 0.16 cm and a width of 2.53 ± 0.06 cm. The fruit peel is characterized by a thickness of approximately 2.55 ± 0.10 mm, adding substance to its structure. Bunches of this fruit carry an average weight of 7.20 ± 0.40 kg, and each bunch is composed of about 5.33 ± 0.58 hands. Each hand consists of an average of 13.67 ± 0.58 fingers, contributing to its abundant yield potential. Individually, the fruit weighs around 119.33 ± 9.07 gm, with the pulp contributing to this weight with a value of 86.00 ± 7.00 gm (Table 4.7).

The comprehensive biochemical analysis of this cultivar's fruit provides valuable insights into its nutritional composition and post-harvest potential. The total soluble solids (°B) content is measured at 16.37 ± 0.40, indicating the presence of dissolved solids that significantly contribute to its flavour and inherent sweetness. Titratable acidity, quantified at 0.59 ± 0.07%, offers a pertinent glimpse into the fruit's acidity level, which is crucial for its overall taste profile. In terms of sweetness, the total sugar content averages at 10.49 ± 0.19%, contributing to its palatability. A notable proportion of these sugars is in the form of reducing sugar, which is quantified at 4.77 ± 0.15%, playing a pivotal role in enhancing the fruit's overall sweetness and flavour complexity. Furthermore, the fruit's capacity to maintain its attributes over time is underscored by its shelf life, which measures 5.66 ± 0.68 days. This attribute highlights the fruit's potential for post-harvest preservation and commercial viability (Table 4.8).

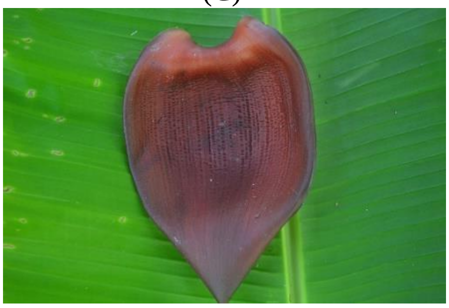
The sensory evaluation of this cultivar's fruit offers valuable insights into its organoleptic attributes. The appearance of the fruit, rated at 3.74 ± 0.06, speaks to its visual appeal, making a notable impression on observers. The flavour, with a score of 3.16 ± 0.06, contributes to its taste profile, adding to the overall gustatory experience. The texture, rated at 3.31 ± 0.05, plays a crucial role in the tactile sensation of consuming the fruit. Taste, an essential aspect, is quantified at 3.46 ± 0.07, encapsulating the combined sensory perception of flavour and mouth feel. Ultimately, the aggregate assessment of overall acceptability is noted at 3.75 ± 0.07, providing a comprehensive perspective on the desirability of the fruit in terms of its sensory attributes (Table 4.9).

(A)

(B)

(C)

(D)



(E)

(F)

(G)

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(I)

(J)

Plate 20: G-20: Red Banana (A) plant habitat, (B) male bud, (C) pseudostem, (D) leaf blade base shape, (E) and (F) internal and external bracts, (G) petiole canal of leaf III, (H) male flower, (I) mature fruit bunch and (J) transverse section of ripen fruits.

G-21: (Unidentified – 1)

The botanical specimen, referred to as "Gumsang" locally, possesses an intriguing genotype labelled as "Unidentified - 1." Thriving abundantly in Greenland Colony, Mhainamtsi, Peren, this plant exhibits a genome type classified as AAB (Table 4.2). It was sourced from a garden, indicating its cultivated nature, and is characterized as a primitive cultivar of significant historical value. Gumsang growth is predominantly sustained through the propagation of suckers, a testament to its vegetative propagation method. It thrives under rainfed cultural practices, adapting well to natural watering patterns. Flourishing in sandy loam soil and preferring level topography, Gumsang showcases adaptability to its environment. Remarkably, Gumsang displays resilience against disease symptoms, showcasing resistance even when faced with moderate levels of insect, pest, and nematode infection. This natural resistance enhances its potential for sustainable cultivation. Beyond its botanical attributes, Gumsang holds cultural significance. Its male inflorescence and fruit play a crucial role in local food and fodder resources. These plant parts are skilfully transformed into delectable desserts and culinary delights, showcasing Gumsang's versatility in traditional cuisine (Table 4.1).

The botanical characteristics of this specimen are notable and intriguing. Its leaf habit is characterized as drooping, lending a distinct visual appeal. The upper surface of its leaves displays a vibrant shade of green, contributing to its overall aesthetic. Despite its dwarfism, the plant exhibits a normal growth pattern, showcasing a fascinating aspect of its development. The pseudostem of this specimen boasts a captivating green-yellow coloration, adding to its allure. Suckers emerge in close proximity to the parent plant, featuring a vertical growth pattern that emphasizes its proximity. The leaf blade base shape is elegantly rounded on both sides, creating a harmonious and visually pleasing structure. Intriguingly, the petiole canal of the third leaf is straight, with an erect margin, reflecting a unique and precise anatomical characteristic (Table 4.3). The measurements of this specimen are equally impressive. The leaf blade measures an average length of 202.00 ± 7.21 cm, accompanied by a width of 47.80 ± 1.93 cm, showcasing its distinctive proportions. Standing tall at an average height of 4.17 ± 0.23 meters, the pseudostem girth measures 63.33 ± 2.52 cm, making a substantial visual impact. The specimen produces an average of 3.67 ± 1.15 suckers, adding to its growth and presence. The petiole, an essential component of this botanical marvel, extends to an average length of 52.72 ± 2.09 cm, underscoring its significance in the overall structure (Table 4.4).

The botanical characteristics of this specimen present a captivating array of features. The male bud shape resembles that of a top, adding a distinctive visual element to its morphology. The bract apex takes on an obtuse shape, while the bract base is characterized by a large shoulder, creating an intriguing structure. The external colour of the bracts displays a rich purple-brown hue, contributing to its overall visual appeal. Internally, the bracts are adorned with a striking red colour, further enhancing its allure. The free tepals exhibit an elegant oval shape, contributing to the specimen's overall aesthetic. Their colour is a translucent white, adding a delicate and ethereal quality to the plant's appearance. The compound tepals, on the other hand, feature a pure white coloration, creating a stunning contrast against the backdrop of the plant's other features. The ovary shape is arched, contributing to the overall symmetry and balance of the specimen. The stigma, an essential element of the reproductive structure, is adorned with a cream-colored hue, highlighting its significance in the plant's reproductive process (Table 4.5).

The botanical characteristics of this specimen's fruit are both distinct and captivating. The fruit shape is characterized as straight, imparting a sense of symmetry to its appearance. The apex of the fruit takes on a bottlenecked form, adding an intriguing dimension to its overall structure. During its immature stage, the fruit peel boasts a vivid green colour, signifying its youthful state. As the fruit matures, the peel transforms into a vibrant and eye-catching bright yellow, contributing to the plant's visual allure. The inner pulp of the fruit displays a creamy colour, adding a soft and inviting quality to its edible portion. The texture of the flesh is notably soft, enhancing the sensory experience of consuming the fruit. Interestingly, the fruit is devoid of seeds, highlighting its potential as a seedless variety (Table 4.6). Its compact size is also notable, with an average length of 8.93 ± 0.15 cm and a width of 2.73 ± 0.15 cm. The thickness of the fruit peel measures 1.40 ± 0.10 mm, striking a balance between protection and accessibility. The botanical specimen's fruiting clusters are equally impressive. The bunch weight averages 10.48 ± 0.41 kg, underscoring the substantial yield potential of this plant. Each bunch contains an average of 9.33 ± 0.58 hands, while each hand is comprised of 14.00 ± 0.00 fingers, contributing to the overall abundance. The individual fruit weight averages 77.00 ± 1.73 g, with the pulp weight measuring 49.67 ± 0.58 g. These measurements highlight the fruit's substantial edible portion, making it a potential source of nourishment (Table 4.7).

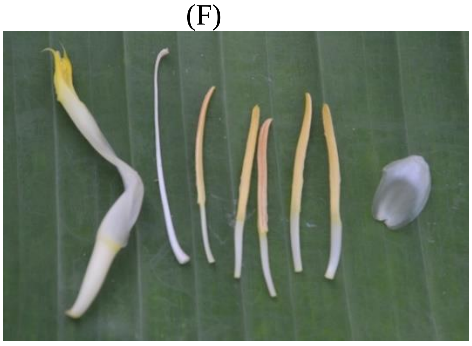
The comprehensive analysis of this botanical specimen's chemical composition provides valuable insights into its attributes. The total soluble solids (°B) measure at an average of 11.43 ± 0.50, indicating the concentration of dissolved substances in its fluid content. The titratable acidity is determined to be 0.48 ± 0.07%, reflecting the level of acidity present in the specimen. Total sugar content is notably high at 9.50 ± 0.33%, underscoring its potential for sweetness. Reducing sugar, an important component contributing to sweetness, is present at a level of 3.03 ± 0.12%. This highlights the specimen's potential as a source of natural sweetness. Shelf life, a crucial parameter for assessing the durability of the specimen, is estimated at 5.15 ± 1.02 units, indicating its potential to remain viable and suitable for consumption over a specified period (Table 4.8).

The sensory evaluation of this botanical specimen reveals valuable information about its attributes. The appearance is rated at an average of 2.18 ± 0.09, indicating its visual appeal and aesthetic qualities. In terms of flavour, the specimen scores 2.75 ± 0.05, suggesting a distinct and noteworthy taste experience. Texture is rated at 2.78 ± 0.08, reflecting the tactile sensation and mouthfeel of the specimen when consumed. The taste of the specimen is notable, scoring at 3.15 ± 0.08, indicating a flavourful and enjoyable sensory experience. The overall acceptability is particularly high at 3.48 ± 0.08, underscoring the specimen's potential to be well-received and enjoyed by individuals (Table 4.9).


(A) (B)

(C) (D)


(E) (F)

(G) (H)

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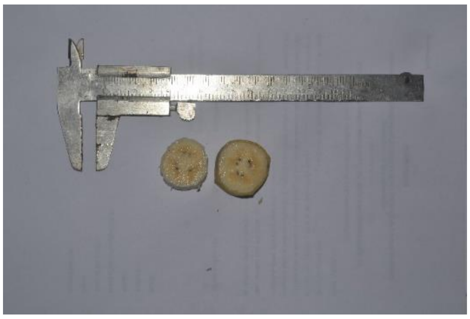


(J)

Plate 21: G-21: Unidentified-1 (A) plant habitat, (B) male bud, (C) pseudostem, (D) measuring of leaf width, (E) and (F) internal and external bracts, (G) petiole canal of leaf III, (H) male flower, (I) mature fruit bunch and (J) transverse section of ripen fruits.

G-22: (Unidentified – 2)

The botanical attributes of this specimen, identified as "Kwegha" locally, offer a fascinating glimpse into its unique qualities. The genotype is labelled as "Unidentified - 2," signifying its distinct genetic makeup. Thriving within the village/block of Sechu Zubza, Kohima, this botanical treasure showcases an ABB genome type (Table 4.2). Originating from a garden setting, Kwegha is characterized as a primitive cultivar, hinting at its historical and cultural significance. Its abundant presence in this habitat underscores its vitality. Kwegha reproduces predominantly through suckers, a testament to its vegetative propagation method. This cultivar exhibits a remarkable resistance to disease symptoms, even in the face of moderate insect, pest, and nematode infection. This natural resilience bodes well for its sustainable cultivation. Culturally, Kwegha holds significant importance. Its male inflorescence and fruit contribute to local sustenance and fodder resources. These parts are transformed into delectable desserts and culinary delights, showcasing the plant's versatile role in traditional cuisine. The specimen's growth is sustained through rainfed cultural practices, reflecting its adaptation to natural watering patterns. Flourishing in sandy loam soil and preferring level topography, Kwegha demonstrates its ability to thrive in specific environmental conditions. In summary, the botanical attributes of Kwegha, including its unique genotype, resistance to disease, and cultural significance, make it a subject of interest for further exploration (Table 4.1).

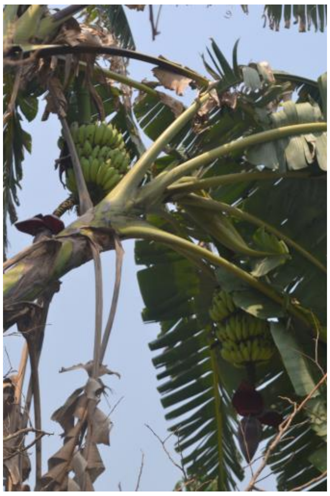
The botanical attributes of this specimen paint a vivid picture of its unique characteristics. Its leaf habit is categorized as erect, contributing to its upright and striking appearance. The upper surface of its leaves boasts a rich green colour, lending vitality to its foliage. Despite its dwarfism, the plant displays a normal growth pattern, showcasing a balance in its development. The pseudostem colour is a captivating blend of green and red, adding to its visual appeal. Suckers emerge in close proximity to the parent plant, displaying vertical growth that emphasizes their proximity. The leaf blade base exhibits an elegantly rounded shape on both sides, creating a harmonious and visually pleasing structure. The petiole canal of the third leaf is notably wide, accompanied by an erect margin, showcasing a distinctive anatomical feature (Table 4.3). The specimen's measurements are equally impressive. The leaf blade spans an average length of 255.33 ± 5.69 cm, accompanied by a width of 68.67 ± 1.53 cm, underscoring its remarkable proportions. Standing tall at an average height of 4.50 ± 0.26 meters, the pseudostem girth measures 82.30 ± 3.25 cm, making a substantial visual statement. The specimen produces an average of 2.67 ± 0.58 suckers, contributing to its growth and presence. The petiole, an essential component of this botanical marvel, extends to an average length of 52.67 ± 2.52 cm, playing a crucial role in the overall structure (Table 4.4).

The intricate botanical details of this specimen's male reproductive structures offer a captivating glimpse into its unique attributes. The male bud shape resembles that of a top, adding a distinct visual element to its floral anatomy. The bract apex shape is described as intermediate, contributing to a balanced and visually appealing structure. The bract base, characterized by a large shoulder, further enhances the overall visual composition. Externally, the bracts exhibit a rich purple-brown hue, creating an eye-catching contrast against the other floral elements. Internally, the bracts maintain the same purple-brown coloration, adding depth and complexity to the floral arrangement. The free tepals, a vital component of the reproductive structure, display an elegant oval shape, contributing to the overall aesthetic. Their colour, a translucent white, adds an ethereal and delicate quality to the specimen. In contrast, the compound tepals feature a captivating pink-purple coloration, creating a stunning visual impact and complementing the rest of the floral features. The ovary shape is described as arched, contributing to the overall symmetry and balance of the reproductive structure. The stigma, a crucial component for the plant's reproductive process, is adorned with a cream-colored hue, highlighting its significance in pollen reception and fertilization (Table 4.5).

The botanical attributes of this specimen's fruit offer a comprehensive view of its unique characteristics. The fruit shape is described as straight, contributing to a sense of symmetry and balance in its appearance. The apex of the fruit takes on a bottlenecked form, adding an intriguing visual dimension. During its immature stage, the fruit peel exhibits a delicate light green colour, signifying its youthful state. As the fruit matures, the peel transitions to a vibrant yellow hue, contributing to the overall visual allure. The inner pulp of the fruit showcases a creamy colour, adding a soft and inviting quality to its edible portion. The texture of the flesh is notably soft, enhancing the sensory experience of consuming the fruit. A distinctive feature of this fruit is the absence of seeds, underscoring its potential as a seedless variety (Table 4.6). Its compact size is notable, with an average length of 8.97 ± 0.12 cm and a width of 3.23 ± 0.15 cm. The thickness of the fruit peel measures 1.27 ± 0.06 mm, striking a balance between protection and accessibility. The botanical specimen's fruiting clusters are equally impressive. The bunch weight averages 9.95 ± 0.24 kg, indicating a substantial yield potential. Each bunch contains an average of 7.00 ± 1.00 hands, while each hand is comprised of 14.33 ± 0.58 fingers, contributing to the overall abundance. The individual fruit weight averages 81.67 ± 1.53 g, with the pulp weight measuring 56.67 ± 1.15 g. These measurements highlight the fruit's substantial edible portion, making it a potential source of nourishment (Table 4.7).

The comprehensive chemical analysis of this botanical specimen's attributes provides valuable insights into its composition. The total soluble solids (°B) measure at an average of 15.85 ± 0.79, reflecting the concentration of dissolved substances in its fluid content. The titratable acidity is determined to be 0.63 ± 0.07%, indicating the level of acidity present in the specimen. The total sugar content is notably high at 8.04 ± 0.12%, suggesting its potential for sweetness. Reducing sugar, a crucial component contributing to sweetness, is present at a level of 2.60 ± 0.42%, showcasing its potential as a source of natural sweetness. Shelf life, an important parameter for evaluating the durability of the specimen, is estimated at 4.68 ± 1.15 units, indicating its potential to remain viable and suitable for consumption over a specific period (Table 4.8).

The sensory evaluation of this botanical specimen's attributes offers valuable insights into its sensory qualities. In terms of appearance, it receives a rating of 2.43 ± 0.10, indicating its visual appeal and aesthetic attributes. Flavour is assessed at 2.66 ± 0.09, reflecting the distinct taste experience that the specimen offers. Texture receives a rating of 3.06 ± 0.09, underscoring the tactile sensation and mouthfeel when consuming the specimen. The taste is notably high at 3.36 ± 0.09, suggesting a rich and enjoyable sensory experience. Overall acceptability is assessed at 3.09 ± 0.09, showcasing the specimen's potential to be well-received and enjoyed by individuals (Table 4.9).


(A)

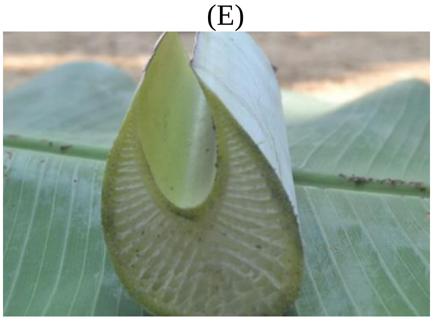

(B)

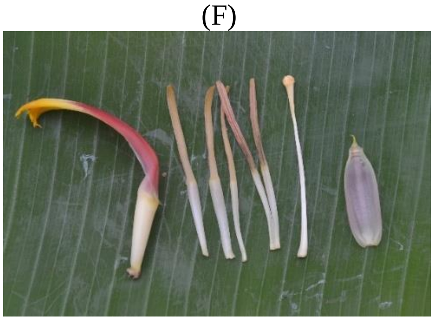
(C)


(D)


(E)


(F)


(G)


(H)

(I)

Plate 22: G-22: Unidentified-2 (A) plant habitat, (B) male bud, (C) pseudostem, (D) measuring of leaf width, (E) and (F) internal and external bracts, (G) petiole canal of leaf III, (H) male flower and (I) mature fruit bunch.

G-23: (Unidentified – 3)

The botanical characteristics of this specimen, locally known as "Kwetho," offer a unique insight into its attributes. The genotype is denoted as "Unidentified - 3," highlighting its distinct genetic makeup. Thriving in the village/block of Sechu Zubza, Kohima, this specimen showcases an AAB genome type (Table 4.2). Originating from a garden setting, Kwetho is characterized as a primitive cultivar, indicating its historical and cultural importance. Its abundant presence in this habitat underscores its significance. Kwetho reproduces predominantly through suckers, illustrating its vegetative propagation method. The cultivar's ability to resist disease symptoms, even in the face of moderate insect, pest, and nematode infection, highlights its potential for sustainable cultivation. From a cultural perspective, Kwetho holds notable value. Its male inflorescence and fruit serve as vital resources for food and fodder. These plant parts are transformed into delectable desserts and culinary delights, underscoring the plant's versatile role in traditional cuisine. The specimen's growth thrives under rainfed cultural practices, indicating its adaptation to natural watering patterns. Flourishing in sandy loam soil and preferring level topography, Kwetho demonstrates its ability to thrive in specific environmental conditions (Table 4.1).

The botanical attributes of this specimen are both captivating and unique, providing valuable insights into its morphology. The leaf habit is described as drooping, lending a graceful and distinct appearance to the plant. The upper surface of its leaves displays a vibrant green colour, contributing to its overall visual appeal. Despite its dwarfism, the plant exhibits a normal growth pattern, showcasing a harmonious development. The pseudostem of this specimen is adorned with a captivating green-yellow coloration, adding to its aesthetic allure. Suckers emerge in close proximity to the parent plant, featuring vertical growth that emphasizes their proximity. The leaf blade base is characterized by rounded sides on both ends, creating a balanced and visually pleasing structure. The petiole canal of the third leaf exhibits a margin curved inward, reflecting a unique anatomical feature that adds to the plant's distinctiveness (Table 4.3). The measurements of this specimen are equally impressive. The leaf blade spans an average length of 262.67 ± 11.02 cm, accompanied by a width of 76.00 ± 4.58 cm, underscoring its substantial proportions. Standing tall at an average height of 4.68 ± 0.28 meters, the pseudostem girth measures 92.67 ± 2.08 cm, making a substantial visual impact. The specimen produces an average of 2.00 ± 1.00 suckers, contributing to its growth and presence. The petiole, a vital component of this botanical marvel, extends to an average length of 61.33 ± 2.08 cm, underscoring its significance in the overall structure (Table 4.4).

The botanical characteristics of this specimen's male reproductive structures are both intriguing and distinctive. The male bud shape takes on an ovoid form, contributing to a rounded and visually pleasing structure. The bract apex shape is described as obtuse, adding a gentle curvature to the structure. The bract base, characterized by a small shoulder, adds to the overall balanced appearance. Externally, the bracts showcase a striking red-purple hue, creating a vibrant and eye-catching contrast. Internally, the bracts maintain a rich red coloration, adding depth and intensity to the floral arrangement. The free tepals, an integral part of the reproductive structure, feature an elegant oval shape, contributing to the overall visual appeal. Their colour, a translucent white, adds an ethereal and delicate quality to the specimen. In contrast, the compound tepals display a captivating pink-purple coloration, creating a stunning visual impact and complementing the rest of the floral features. The ovary shape is described as arched, contributing to the overall symmetry and balance of the reproductive structure. The stigma, a critical component for the plant's reproductive process, is adorned with a cream-colored hue, highlighting its significance in pollen reception and fertilization (Table 4.5).

The botanical attributes of this specimen's fruit provide a comprehensive view of its distinctive characteristics. The fruit shape is described as straight, imparting a sense of symmetry and elegance to its appearance. The apex of the fruit takes on a bottlenecked form, adding an intriguing visual dimension. During its immature stage, the fruit peel boasts a vibrant green colour, signifying its youthful state. As the fruit matures, the peel transforms into a bright and captivating shade of yellow, contributing to the plant's visual allure. The inner pulp of the fruit exhibits a pure white colour, adding a clean and inviting quality to its edible portion. The texture of the flesh is notably soft, enhancing the sensory experience of consuming the fruit. An interesting feature of this fruit is the absence of seeds, highlighting its potential as a seedless variety (Table 4.6). The compact size of the fruit is notable, with an average length of 8.93 ± 0.06 cm and a width of 2.53 ± 0.12 cm. The thickness of the fruit peel measures 1.37 ± 0.06 mm, striking a balance between protection and accessibility. The botanical specimen's fruiting clusters are equally impressive. The bunch weight averages 7.95 ± 0.28 kg, indicating its potential for substantial yield. Each bunch contains an average of 6.67 ± 0.58 hands, while each hand consists of 13.33 ± 1.15 fingers, contributing to the overall abundance. The individual fruit weight averages 89.33 ± 2.08 g, with the pulp weight measuring 65.00 ± 2.00 g. These measurements highlight the fruit's substantial edible portion, making it a potential source of nourishment (Table 4.7).

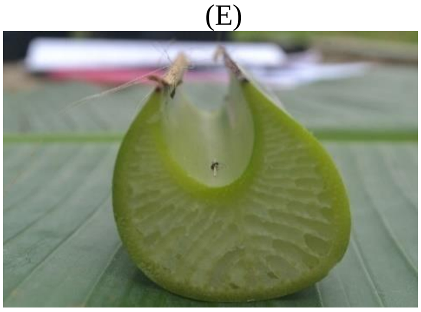
The comprehensive chemical analysis of this botanical specimen's attributes offers valuable insights into its composition. The total soluble solids (Brix) measure at an average of 20.48 ± 0.83, indicating the concentration of dissolved substances in its fluid content. The titratable acidity is determined to be 0.39 ± 0.04%, reflecting the level of acidity present in the specimen. The total sugar content is notably high at 9.33 ± 0.32%, suggesting its potential for sweetness. Reducing sugar, an important component contributing to sweetness, is present at a level of 5.17 ± 0.21%, highlighting its potential as a source of natural sweetness. Shelf life, an essential parameter for evaluating the durability of the specimen, is estimated at 4.56 ± 0.98 units, indicating its potential to remain viable and suitable for consumption over a specified period (Table 4.8).

The sensory evaluation of this botanical specimen's attributes provides valuable insights into its sensory qualities. In terms of appearance, it receives a rating of 3.27 ± 0.18, suggesting a visually appealing and well-presented specimen. Flavour is assessed at 3.34 ± 0.18, reflecting a distinct and memorable taste experience that the specimen offers. Texture is rated at 3.28 ± 0.18, highlighting the tactile sensation and mouthfeel when consuming the specimen. The taste of the specimen is rated at 2.72 ± 0.18, indicating a notable taste experience that may vary in its appeal. Overall acceptability is assessed at 3.12 ± 0.18, underscoring the potential of the specimen to be well-received and enjoyed by individuals (Table 4.9).


(A) (B)

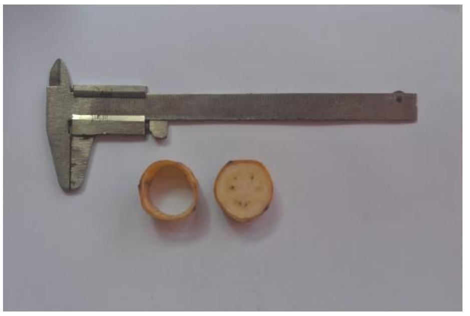

(C) (D)


(E) (F)




(I) (J)

(K)



(L)

Plate 23: G-23: Unidentified-3 (A) plant habitat, (B) male bud, (C) pseudostem, (D) measuring of leaf width, (E) and (F) internal and external bracts, (G) petiole canal of leaf III, (H) male flower and (I) mature fruit bunch.

G-24: (Unidentified – 4)

The botanical characteristics of this specimen, referred to locally as "Luipet," offer a fascinating glimpse into its distinctive attributes. The genotype is classified as "Unidentified - 4," highlighting its unique genetic makeup. Thriving in the village/block of Jalukie, Peren, this specimen showcases an AB genome type (Table 4.2). Emerging from farmers' fields, Luipet is characterized as a primitive cultivar, suggesting its historical and cultural significance. Its abundant presence in this habitat underscores its importance within the local ecosystem. Luipet reproduces primarily through suckers, indicating its vegetative propagation method. The cultivar displays an impressive resistance to disease symptoms and a mild susceptibility to insect, pest, and nematode infection, showcasing its potential for sustainable cultivation. Culturally, Luipet holds notable value. Its male inflorescence and fruit serve as essential resources for both sustenance and fodder. These plant parts are transformed into delectable desserts and culinary delights, underscoring the versatile role the plant plays in traditional cuisine. The specimen's growth thrives under rainfed cultural practices, reflecting its adaptation to natural watering patterns. Flourishing in sandy loam soil and preferring level topography, Luipet demonstrates its ability to thrive within specific environmental conditions (Table 4.1).

The botanical attributes of this specimen provide a comprehensive view of its unique characteristics. The leaf habit is described as drooping, contributing to an elegant and distinctive appearance. The upper surface of its leaves displays a vibrant green colour, adding to its overall vitality. Despite its dwarfism, the plant exhibits a normal growth pattern, striking a balance in its development. The pseudostem of this specimen features a captivating green-yellow coloration, enhancing its visual appeal. Suckers emerge in close proximity to the parent plant, demonstrating vertical growth that accentuates their proximity. The leaf blade base showcases a rounded shape on both sides, creating a harmonious and visually pleasing structure. The petiole canal of the third leaf is notably wide, accompanied by an erect margin, showcasing a unique anatomical feature. The measurements of this specimen are equally impressive (Table 4.3). The leaf blade spans an average length of 206.50 ± 6.76 cm, accompanied by a width of 51.33 ± 2.52 cm, underscoring its substantial proportions. Standing tall at an average height of 5.03 ± 0.30 meters, the pseudostem girth measures 40.00 ± 3.00 cm, making a substantial visual statement. The specimen produces an average of 3.33 ± 0.58 suckers, contributing to its growth and presence. The petiole, a vital component of this botanical marvel, extends to an average length of 76.33 ± 1.53 cm, playing a crucial role in the overall structure (Table 4.4).

The intricate botanical details of this specimen's male reproductive structures provide a captivating glimpse into its unique attributes. The male bud shape is described as lanceolate, contributing to a slender and elongated appearance. The bract apex shape is noted as intermediate, striking a balance between curvature and sharpness. The bract base, characterized by a small shoulder, further enhances the overall visual composition. Externally, the bracts exhibit a striking red colour, adding a bold and eye-catching contrast to the floral arrangement. Internally, the bracts take on a whitish hue, creating an interesting interplay of colours. The free tepals, a pivotal component of the reproductive structure, display an elegant oval shape, contributing to the overall visual appeal. Their colour, a translucent white, adds an ethereal and delicate quality to the specimen. In contrast, the compound tepals feature a soothing cream coloration, creating a harmonious visual impact and complementing the rest of the floral features. The ovary shape is described as arched, contributing to the overall symmetry and balance of the reproductive structure. The stigma, a critical component for the plant's reproductive process, is adorned with a distinctive orange coloration, highlighting its significance in pollen reception and fertilization (table 4.5).

The botanical attributes of this specimen's fruit offer a comprehensive view of its distinct characteristics. The fruit shape is described as straight, contributing to a balanced and symmetrical appearance. The apex of the fruit takes on a bottlenecked form, adding an intriguing visual dimension. During its immature stage, the fruit peel boasts a light green colour, signifying its youth and freshness. As the fruit reaches maturity, the peel transitions into a vibrant and appealing shade of yellow, enhancing its visual allure. The inner pulp of the fruit displays a delicate beige-pink colour, adding a soft and inviting quality to its edible portion. The texture of the flesh is notably soft, contributing to a pleasant sensory experience. A distinctive feature of this fruit is the presence of seeds, underscoring its potential for natural propagation (Table 4.6). The fruit size is notable, with an average length of 10.27 ± 0.15 cm and a width of 2.90 ± 0.10 cm. The thickness of the fruit peel measures 2.33 ± 0.06 mm, providing a protective layer. The fruiting clusters of this specimen are characterized by a bunch weight averaging 2.20 ± 0.27 kg, indicating its potential yield. Each bunch contains an average of 5.00 ± 0.00 hands, while each hand consists of 15.00 ± 1.00 fingers, contributing to its overall abundance. The individual fruit weight averages 29.33 ± 1.15 g, with the pulp weight measuring 20.00 ± 1.00 g. These measurements highlight the substantial edible portion of the fruit, making it a potential source of nourishment (Table 4.7).

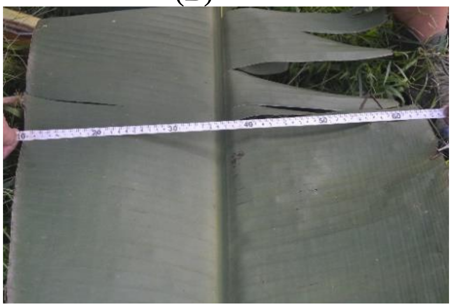
The comprehensive chemical analysis of this botanical specimen's attributes provides valuable insights into its composition and potential utility. The total soluble solids (°B) measure an average of 13.45 ± 0.33, indicating the concentration of dissolved substances in its fluid content. The titratable acidity is determined to be 0.57 ± 0.07%, reflecting the level of acidity present in the specimen. The total sugar content is noteworthy, measuring 8.28 ± 0.13%, suggesting its potential for sweetness. The reducing sugar content, an important factor contributing to sweetness, is present at a level of 3.63 ± 0.14%, further highlighting its potential as a source of natural sweetness. The shelf life, an essential parameter for evaluating the durability and longevity of the specimen, is estimated at 5.07 ± 0.66 units, indicating its potential to remain viable and suitable for consumption over a specified period (Table 4.8).

The sensory evaluation of this botanical specimen's attributes provides a comprehensive understanding of its sensory qualities. In terms of appearance, it receives a rating of 2.10 ± 0.19, suggesting a moderate visual appeal and presentation. Flavour is assessed at 2.20 ± 0.19, indicating a subtle and nuanced taste experience. Texture is rated at 2.68 ± 0.19, highlighting the tactile sensation and mouthfeel when consuming the specimen. The taste of the specimen is rated at 2.70 ± 0.19, indicating a moderately enjoyable taste experience. Overall acceptability is assessed at 2.68 ± 0.19, suggesting a moderate level of overall enjoyment and satisfaction (Table 4.9).

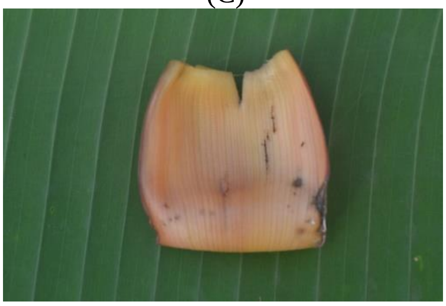
(A)

(B)

(C)



(D)



(E)

(F)

(G)

(H)

(I)

(J)

Plate 24: G-24: Unidentified-4 (A) plant habitat, (B) male bud, (C) pseudostem, (D) measuring of leaf width, (E) and (F) internal and external bracts, (G) petiole canal of leaf III, (H) male flower, (I) mature fruit bunch and (J) transverse section of ripen fruits.

G-25: (Unidentified – 5)

The botanical attributes of the specimen, known by the vernacular name "Lumungashe," offer an intriguing perspective into its unique characteristics. Classified as "Unidentified - 5" in terms of genotype, this specimen hails from the village/block of Bade in Dimapur. With an ABB genome type, Lumungashe is nurtured within a garden collection site (Table 4.2). Its status as a primitive cultivar signifies its historical and cultural importance. Its abundant presence within its habitat underscores its significance in the local ecosystem. Lumungashe reproduces primarily through suckers, showcasing its vegetative propagation method. It demonstrates an impressive resistance to disease symptoms and a mild susceptibility to insect, pest, and nematode infection, signifying its potential for resilient cultivation. Culturally, Lumungashe holds substantial value. Its male inflorescence and fruit serve as essential resources for both sustenance and fodder. These plant parts contribute to a variety of uses, including culinary purposes and dessert preparation, adding depth to its role in traditional cuisine. Thriving under rainfed cultural practices, Lumungashe adapts to natural watering patterns. Flourishing in sandy loam soil and level topography, it demonstrates an affinity for specific environmental conditions that contribute to its growth (Table 4.1).

The botanical attributes of this specimen provide a comprehensive understanding of its unique characteristics. The leaf habit is described as drooping, contributing to an elegant and graceful appearance. The upper surface of its leaves displays a deep and lush dark green colour, adding to its overall visual appeal. Despite its dwarfism, the plant exhibits a normal growth pattern, maintaining a balanced development. The pseudostem of this specimen features a captivating green-yellow coloration, enhancing its visual allure. Suckers emerge in close proximity to the parent plant, demonstrating vertical growth that accentuates their nearness. The leaf blade base showcases a rounded shape on both sides, creating a harmonious and visually pleasing structure. The petiole canal of the third leaf features overlapping margins, highlighting a distinct anatomical feature (Table 4.3). The measurements of this specimen are equally impressive. The leaf blade spans an average length of 236.03 ± 18.09 cm, accompanied by a width of 67.92 ± 2.71 cm, underscoring its substantial proportions. Standing at an average height of 3.92 ± 0.08 meters, the pseudostem girth measures 83.33 ± 2.08 cm, making a substantial visual statement. The specimen produces an average of 2.33 ± 0.58 suckers, contributing to its growth and presence. The petiole, a vital component of this botanical marvel, extends to an average length of 72.67 ± 2.08 cm, playing a crucial role in the overall structure (Table 4.4).

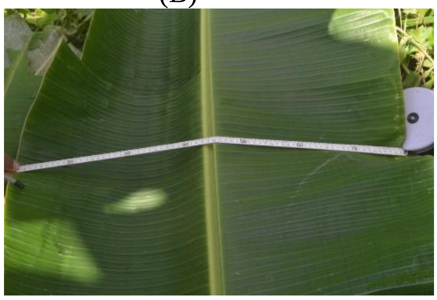
The intricate botanical details of this specimen's male reproductive structures provide a captivating glimpse into its unique attributes. The male bud shape is described as intermediate, contributing to a balanced and harmonious appearance. The bract apex shape is noted as obtuse and split, adding complexity and visual interest to the floral structure. The bract base, characterized by a medium size, further enhances the overall visual composition. Externally, the bracts showcase a striking purple-brown colour, adding a bold and striking contrast to the floral arrangement. Internally, the bracts maintain the same purple-brown hue, creating a consistent and captivating coloration. The free tepals, crucial components of the reproductive structure, display an elegant oval shape, contributing to the overall visual appeal. Their colour, a translucent white, adds an ethereal and delicate quality to the specimen. In contrast, the compound tepals feature a captivating pink-purple coloration, creating a vibrant and enchanting visual impact and complementing the rest of the floral features. The ovary shape is described as arched, contributing to the overall symmetry and balance of the reproductive structure. The stigma, a critical component for the plant's reproductive process, is adorned with a distinctive cream coloration, highlighting its significance in pollen reception and fertilization (Table 4.5).

The botanical attributes of this specimen's fruit offer a comprehensive view of its distinct characteristics. The fruit shape is described as straight, contributing to a balanced and symmetrical appearance. The apex of the fruit is noted as blunt-tipped, adding a subtle modification to the typical fruit structure. During its immature stage, the fruit peel showcases a verdant green colour, signifying its early growth phase. As the fruit matures, the peel transitions into a bright and appealing shade of yellow, enhancing its visual allure. The inner pulp of the fruit displays a clean and pristine white colour, adding a soft and inviting quality to its edible portion. The texture of the flesh is notably soft, contributing to a pleasant sensory experience. A noteworthy feature of this fruit is the absence of seeds, highlighting its potential for consumption without the need for seed removal (Table 4.6). The fruit size is notable, with an average length of 9.23 ± 0.15 cm and a width of 2.47 ± 0.12 cm. The thickness of the fruit peel measures 1.10 ± 0.10 mm, providing a protective layer. The fruiting clusters of this specimen are characterized by a substantial bunch weight, averaging 14.94 ± 0.42 kg, indicating its potential yield. Each bunch contains an average of 10.33 ± 0.58 hands, while each hand consists of 13.33 ± 1.15 fingers, contributing to its overall abundance. The individual fruit weight averages 96.81 ± 1.60 g, with the pulp weight measuring 62.50 ± 2.18 g (Table 4.7).

The detailed chemical analysis of this botanical specimen's attributes provides valuable insights into its composition and potential utility. The total soluble solids (°B) measure an average of 14.78 ± 0.09, indicating the concentration of dissolved substances in its fluid content. The titratable acidity is determined to be 0.70 ± 0.02%, reflecting the level of acidity present in the specimen. Notably, the total sugar content is substantial, measuring 12.93 ± 0.32%, suggesting its potential for sweetness. The reducing sugar content, a significant contributor to sweetness, is present at a level of 5.60 ± 0.36%, further highlighting its potential as a source of natural sweetness. The shelf life, an essential parameter for evaluating the durability and longevity of the specimen, is estimated at 6.17 ± 0.38 units, indicating its potential to remain viable and suitable for consumption over an extended period (Table 4.8).

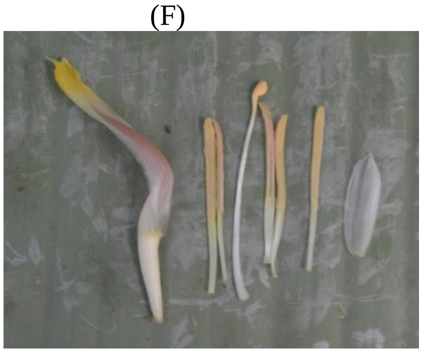
The sensory evaluation of this botanical specimen's attributes offers a comprehensive insight into its sensory qualities, contributing to a holistic understanding of its potential appeal. In terms of appearance, it receives a rating of 2.57 ± 0.14, indicating a moderate to satisfactory visual presentation. Flavour is assessed at 2.43 ± 0.14, suggesting a mild to moderate taste experience that may have room for enhancement. Texture is rated at 3.11 ± 0.14, highlighting a satisfactory and enjoyable tactile sensation when consuming the specimen. The taste of the specimen is rated at 3.01 ± 0.14, indicating a positive taste experience that is notably pleasing. Overall acceptability is assessed at 2.80 ± 0.14, suggesting a moderate level of overall enjoyment and satisfaction (Table 4.9).

(A) (B)



(C) (D)

(E) (F)



(G) (H)

(I)

(J)

Plate 25: G-25: Unidentified-5 (A) plant habitat, (B) male bud, (C) pseudostem, (D) measuring of leaf width, (E) and (F) internal and external bracts, (G) petiole canal of leaf III, (H) male flower, (I) mature fruit bunch and (J) transverse section of ripen fruits.

G-26: (Unidentified – 6)

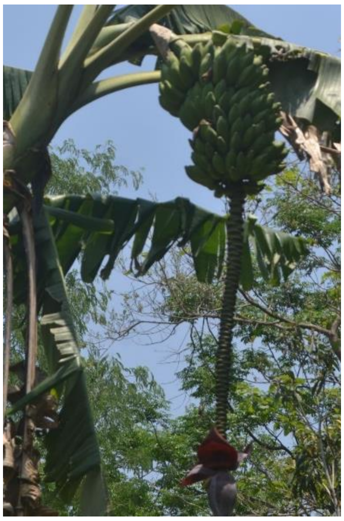
The botanical attributes of the specimen, known by the vernacular name "Lumumgto," provide valuable insights into its unique characteristics and cultural significance. Designated as "Unidentified - 6" in terms of genotype, this specimen originates from the village/block of Peace Camp in Dimapur. With an ABB genome type, Lumumgto is cultivated within a garden collection site (Table 4.2). Its biological status as a primitive cultivar underlines its historical and cultural importance. Its abundant presence in its habitat highlights its ecological significance and potential utility. Lumumgto reproduces through suckers, showcasing its vegetative propagation method. It displays impressive resistance to disease symptoms and mild susceptibility to insect, pest, and nematode infection, underscoring its potential for resilient cultivation. Culturally, Lumumgto holds substantial value. Both its male inflorescence and fruit contribute to essential resources for sustenance and fodder. These plant parts are utilized in various ways, including culinary applications and dessert preparation, adding depth to its role in traditional cuisine. Thriving under rainfed cultural practices, Lumumgto adapts to natural watering patterns. Flourishing in sandy loam soil with a level topography, it exhibits an affinity for specific environmental conditions that contribute to its growth and development (Table 4.1).

The botanical characteristics of this specimen offer an intriguing insight into its unique attributes. Its leaf habit is classified as intermediate, contributing to a balanced and harmonious appearance. The upper surface of its leaves displays a deep and lush dark green colour, adding to its overall visual appeal. Despite its dwarfism, the plant demonstrates a normal growth pattern, maintaining a balanced development. The pseudostem of this specimen features a captivating green-yellow coloration, enhancing its visual allure. Suckers emerge in close proximity to the parent plant, demonstrating vertical growth that accentuates their nearness. The leaf blade base showcases a rounded shape on both sides, creating a harmonious and visually pleasing structure. The petiole canal of the third leaf features a straight configuration with an erect margin, contributing to its overall structural integrity. The measurements of this specimen are equally impressive (Table 4.3). The leaf blade spans an average length of 236.03 ± 18.09 cm, accompanied by a width of 62.03 ± 2.44 cm, underscoring its substantial proportions. Standing at an average height of 4.12 ± 0.10 meters, the pseudostem girth measures 78.67 ± 3.21 cm, making a substantial visual statement. The specimen produces an average of 2.67 ± 0.58 suckers, contributing to its growth and presence. The petiole, a vital component of this botanical marvel, extends to an average length of 59.67 ± 4.16 cm, playing a crucial role in the overall structure (Table 4.4).

The intricate floral details of this botanical specimen's male reproductive structures provide an engaging glimpse into its captivating attributes. The male bud shape is reminiscent of a top, contributing to a distinctive and recognizable appearance. The bract apex shape falls within the intermediate category, adding a touch of complexity and visual interest to the overall structure. The bract base boasts a sizeable shoulder, creating a visually striking foundation for the floral arrangement. Externally, the bracts showcase a vibrant red-purple colour, catching the eye and infusing the structure with a bold and energetic hue. Internally, the bracts exhibit a rich purple-brown colour, creating a harmonious and captivating contrast. The free tepals, key components of the floral structure, assume an elegant oval shape, adding a sense of grace and fluidity to the composition. Translucent white hues characterize the colour of the free tepals, bestowing an ethereal and delicate quality upon the specimen. In contrast, the compound tepals feature a delicate pink coloration, infusing the arrangement with a soft and charming visual appeal. The ovary takes on an arched shape, contributing to the overall symmetry and balance of the floral structure. The stigma, an essential part of the reproductive process, showcases a cream coloration, signifying its importance in pollen reception and fertilization (Table 4.5).

The comprehensive chemical analysis of this botanical specimen's attributes provides valuable insights into its composition and potential utility. The total soluble solids, measured in degrees (°B), average at 13.33 ± 0.50, indicating the concentration of dissolved substances in its fluid content. Titratable acidity, a crucial measure of acidity levels, is determined to be 0.80 ± 0.03%, highlighting its overall acidity. The total sugar content is recorded at 7.80 ± 0.53%, suggesting its potential for a mild sweetness profile. The reducing sugar content, a significant contributor to sweetness, is present at a level of 4.10 ± 0.20%, further contributing to its overall taste profile. The shelf life, an important parameter for assessing the durability and longevity of the specimen, is estimated at 5.63 ± 0.58 units, suggesting its potential to remain viable and suitable for consumption over a certain period (Table 4.8).

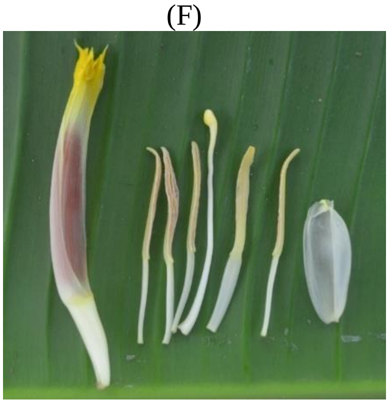
The sensory evaluation of this botanical specimen's attributes offers valuable insights into its taste, texture, and overall acceptability. In terms of appearance, the specimen is rated at 2.78 ± 0.11, suggesting a visually pleasing and satisfactory presentation. Flavour, a crucial component of sensory perception, is evaluated at 2.25 ± 0.16, indicating a distinct taste profile. Texture, an essential factor in sensory experience, receives a rating of 2.83 ± 0.11, implying a pleasing and enjoyable mouthfeel. The taste of the specimen is assessed at 3.00 ± 0.09, indicating a favourable and satisfying taste experience. Overall acceptability, encompassing multiple sensory aspects, is scored at 2.62 ± 0.11, suggesting a generally positive reception and potential for enjoyment (Table 4.9).




(A) (B)


(C) (D)


(E) (F)

(I) (J)

(K)

(L)

Plate 26: G-26: Unidentified-6 (A) plant habitat, (B) male bud, (C) pseudostem, (D) measuring of leaf width, (E) and (F) internal and external bracts, (G) petiole canal of leaf III, (H) male flower, (I) mature fruit bunch and (J) transverse section of ripen fruits.

G-27: (Meitei Hei)

The botanical profile of the specimen labelled as "Meitei Hei" provides a comprehensive overview of its genetic, ecological, and cultural attributes, underscoring its potential significance. The genotype is identified as Unidentified - 7, representing a unique and distinctive genetic composition. The vernacular name "Meitei Hei" captures its regional identity and cultural association. It is commonly found in the village of Molvom, Chumoukedima, reflecting its localized distribution. The genome type is classified as ABB, indicating its genetic lineage and botanical classification (Table 4.2). The collection site is a garden, where the specimen is cultivated and observed. This primitive cultivar exhibits a robust and abundant growth pattern, thriving under rainfed and rain-fed cultural practices. It demonstrates a high level of resistance to diseases and a moderate susceptibility to insect, pest, and nematode infections. The biological status of this specimen as a primitive cultivar highlights its historical and cultural significance, suggesting a long-standing presence within local agricultural practices. Culturally, various parts of the plant are utilized for food and fodder purposes, with a focus on stem, male inflorescence, and fruit. These parts are commonly incorporated into culinary endeavours, particularly desserts and other culinary preparations. Notably, the plant's distinctive feature is the presence of round yellow patches on its fruits, adding to its visual allure and potential appeal (Table 4.1).

The botanical characteristics of the "Meitei Hei" specimen's leaves provide valuable insights into its growth pattern, appearance, and potential uses. The leaf habit of this specimen is classified as erect, indicating an upright and vertical orientation in its growth. The upper surface of the leaves exhibits a dark green coloration, contributing to a lush and vibrant visual appearance. Dwarfism is considered normal for this specimen, suggesting a typical size range within its growth pattern. The pseudostem, which resembles the main stem of the plant, is characterized by a green-yellow color, adding to its visual appeal and overall aesthetics. Suckers, which are new shoots that emerge from the base of the plant, are positioned in close proximity to the parent plant and exhibit vertical growth. The leaf blade base shape is intriguingly asymmetrical, with one side rounded and the other pointed, contributing to its unique and distinctive appearance. The petiole canal of the third leaf is wide, with an erect margin, suggesting a structural feature that may influence its overall growth and appearance (Table 4.3). The dimensions of the leaf blade are noteworthy, with a length averaging 180.33 ± 4.04 cm and a width of 70.70 ± 1.74 cm, underscoring its substantial size. The pseudostem reaches a height of 3.80 ± 0.26 meters, with a girth size of 43.33 ± 3.06 cm, contributing to its overall stature and presence. An average of 2.67 ± 1.53 suckers is produced by this specimen, which may play a role in its propagation and growth. The petiole, which connects the leaf blade to the stem, has an average length of 55.67 ± 3.06 cm, highlighting its role in leaf support and nutrient transport (Table 4.4).

The botanical features of the male bud of the "Meitei Hei" specimen offer valuable insights into its reproductive structures and visual attributes. The male bud shape is described as ovoid, resembling an oval shape that contributes to its distinctive appearance. Bract apex shape is obtuse, indicating a rounded and less pointed structure at the tip of the bracts. Bract base shape features a small shoulder, suggesting a subtle protrusion or extension at the base of the bracts. The external colour of the bracts is described as purple-brown, imparting a rich and visually appealing hue to the male bud. Internally, the bracts exhibit a vibrant red colour, providing a striking contrast to the external coloration. The free tepals, which are separate floral segments, have an oval shape and are tinted with yellow, contributing to a multi-dimensional and nuanced colour palette. Compound tepals, which are multiple tepals fused together, exhibit a pink-purple colour, enhancing the overall visual appeal of the male bud. The ovary shape is characterized as straight, suggesting a structural aspect of the reproductive organs. The stigma, which is the receptive part of the female reproductive system, is coloured yellow, indicating its role in pollination and fertilization processes (Table 4.5).

The botanical characteristics of the fruit of the "Meitei hei" specimen provide essential insights into its visual attributes, structure, and potential uses. The fruit shape is described as straight, indicating a linear and elongated form that contributes to its distinctive appearance. The fruit apex is rounded, suggesting a smoothly curved top that adds to the fruit's visual appeal and approachability. During the immature stage, the fruit peel colour is dark green, gradually transitioning to a vibrant yellow when mature, contributing to an appealing colour transformation. The pulp colour of the fruit is cream, offering a soft and inviting hue that may influence its culinary applications. The flesh texture of the fruit is categorized as soft, implying a tender and palatable quality that may enhance its sensory experience. The absence of seeds within the fruit highlights its potential as a seedless variety, adding to its desirability for consumption (Table 4.6). The dimensions of the fruit are noteworthy, with a length of 8.83 ± 0.06 cm and a width of 3.33 ± 0.12 cm, underscoring its size and proportion. The thickness of the fruit peel is measured at 2.20 ± 0.10 mm, contributing to the overall structure and tactile experience of the fruit. The bunch weight, averaging 6.82 ± 0.60 kg, provides insights into the collective weight of the fruit clusters. An average of 7.33 ± 0.58 hands per bunch and 9.33 ± 1.15 fingers per hand underscores the arrangement and abundance of the fruit clusters. The fruit weight, measured at 76.33 ± 1.53 g, and the pulp weight, at 52.33 ± 2.52 g, offer precise measurements of the fruit's mass and pulp content (Table 4.7).

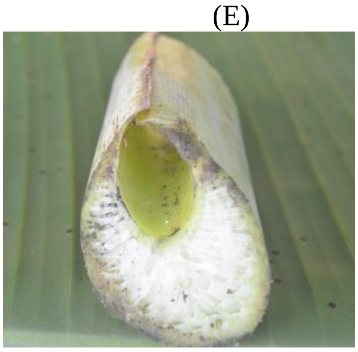
The compositional attributes of the fruit of the "Meitei Hei" specimen provide valuable insights into its nutritional content, sensory characteristics, and potential storage capabilities. The total soluble solids content, measured at 16.48 ± 0.89 (°B), reflects the concentration of dissolved solids in the fruit, which can contribute to its sweetness and overall flavour profile. The titratable acidity, quantified at 0.58 ± 0.05 %, offers insights into the fruit's acidity level, which plays a crucial role in determining its taste and balance of flavour. A total sugar content of 14.23 ± 0.42 % showcases the presence of naturally occurring sugars within the fruit, contributing to its sweetness and potential use as a natural sweetener. The reducing sugar content, measured at 8.07 ± 0.15%, highlights the portion of sugars that can undergo chemical reactions, potentially influencing the fruit's taste, color, and overall quality. The calculated shelf life of 7.62 ± 0.35 days suggests the duration for which the fruit can maintain its quality, taste, and freshness under appropriate storage conditions (Table 4.8).

The sensory evaluation of the "Meitei Hei" fruit provides valuable insights into its sensory attributes, taste profile, and overall acceptability. The appearance of the fruit is rated at 3.39 ± 0.12, indicating a favourable visual impression that highlights its aesthetic appeal and visual attractiveness. The flavour of the fruit is assessed at 2.40 ± 0.12, reflecting its taste profile and sensory experience in terms of taste nuances and flavour intensity. The texture of the fruit is evaluated at 2.72 ± 0.11, providing insights into its mouthfeel and tactile sensations experienced upon consumption. The taste of the fruit receives a rating of 1.80 ± 0.11, suggesting that the taste profile may have room for improvement or may not align with certain preferences. The overall acceptability of the fruit is rated at 2.55 ± 0.10, indicating a moderate level of acceptability among the evaluators based on the combined sensory attributes (Table 4.9).

(A) (B)

(C) (D)

(E) (F)



(G) (H)

(I)

(J)

Plate 27: G-27: Meitei Hei (A) plant habitat, (B) male bud, (C) pseudostem, (D) measuring of leaf width, (E) and (F) internal and external bracts, (G) petiole canal of leaf III, (H) male flower, (I) mature fruit bunch and (J) transverse section of ripen fruits.

GENETIC PARAMETERS

In order for any selection to be considered, it is necessary to understand the influence of the environment on the genotype. This involves separating the environmental influences from the total variability and incorporating selection accordingly. This process allows for the extraction of accuracy, which helps in deciphering the expression of the genotype through its phenotypic performance. The genotypic and phenotypic coefficients of variation serve as simple measures of variability and are commonly used for assessing variability. By comparing these coefficients, we can gain an idea of the magnitude of variability present in a genetic population. Therefore, the genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) were compared. The ranges of both GCV and PCV are categorized as low (less than 10%), moderate (10-20%), and high (more than 20%), as suggested by Subramaniam and Menon (1973).

The genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), environmental coefficient of variation (ECV), heritability, and genetic advance as a percentage of the mean were evaluated for the 21 genotypes, and the results are presented in (Table 4.10). In this study, higher PCV values were observed compared to GCV values. The PCV values ranged from 18.25% to 75.78%. The highest PCV value was found in Pulp weight (g) (75.78%), followed by Fruit weight (g) (75.06%), Bunch weight (kg) (65.63%), and Titratable Acidity (%) (64.09%). The lowest PCV values were observed in Leaf blade width (cm) (18.25%), Shelf life (23.21%), and Fruit size width (cm) (24.69%). On the other hand, GCV values ranged from 17.94% to 75.66%. The highest GCV value was recorded in Pulp weight (g) (75.66%), followed by Fruit weight (g) (75%), Bunch weight (kg) (65.5%), and Titratable Acidity (%) (63.76%). The lowest GCV values were observed in Leaf blade width (cm) (17.94%), followed by Shelf life (22.09%) and Fruit size width (cm) (24.52%) (Table 4.10). Sawant *et. al*, (2016) observed similar results.

In the results above, it is evident that the phenotypic coefficient of variation (PCV) was slightly higher than the corresponding genotypic coefficient of variation (GCV) for all the traits, indicating the influence of the environment on the phenotypic expression of the studied characters. Overall, there was not a significant difference observed between PCV and GCV for the traits, suggesting that the genotype had a maximum expression with minimal impact of the environment on these traits. Traits exhibiting high PCV and GCV values were economically important, indicating potential for improvement through selection (Table 4.10).

Heritability estimates provide information about the proportion of transmissible genetic variation in relation to total variation. They help determine genetic improvement and the response to selection, indicating the relative contribution of genetic factors in shaping the phenotypes. Heritability and genetic advance are important genetic parameters that assist in selecting genotypes by isolating environmental influences from total variability.

The combined measurement of heritability and genetic advance helps distinguish between additive and non-additive gene actions, providing insights into the potential for crop improvement through selection or hybridization.

Heritability is commonly classified as low (less than 30%), moderate (between 30% and 60%), or high (above 60%) (Robinson *et al*., 1949). As suggested by Johnson *et al*. (1955), genetic advance as a percentage of the mean can be categorized as low (0-10%), moderate (10-20%), and high (20% and above).

In the present study, the results revealed that the heritability ranged from 79.20% to 99.9%, indicating a high degree of genetic control for the studied traits. Total sugar (%) exhibited the highest heritability value (99.9%), followed by Fruit weight (g) (99.8%), Pulp weight (g) (99.7%), and Total soluble solids (°B) (99.7%). The trait No. of suckers (79.2%) displayed the lowest heritability value (Table 4.10). Sawant *et. al*, (2016) observed similar results.

Furthermore, the genetic advance as a percentage of the mean ranged from 36.3% to 155.61%. The trait Pulp weight (g) exhibited the highest genetic advance value (155.61%), followed by Fruit weight (g) (154.36%) (Table 4.10).

The high values of PCV and GCV, along with the very high heritability and genetic advance as a percentage of the mean, indicate the presence of additive gene action with minimal environmental influence. This suggests a strong potential for considering Pulp weight (g) and Fruit weight (g) as selection criteria in crop improvement projects.

Table 4.10: Genetic parameters

Characters	ECV	GCV	PCV	h^2 (Broad Sense)	Genetic Advancement 5%	Gen.Adv as % of Mean 5%
Leaf blade length (cm)	4.31	27.25	27.37	99.20	118.93	55.91
Leaf blade width (cm)	5.87	17.94	18.25	96.60	22.25	36.30
Pseudostem height (m)	7.53	26.37	26.73	97.40	2.04	53.60
Girth size (cm)	5.25	34.96	35.09	99.30	36.96	71.75
No. of suckers	28.94	32.59	36.63	79.20	1.89	59.75
Petiole length (cm)	4.66	31.09	31.21	99.30	36.80	63.81
Fruit size length (cm)	4.47	43.23	43.31	99.60	9.92	88.91
Fruit size width (cm)	5.09	24.52	24.69	98.60	1.66	50.14
Fruit peel thickness (mm)	5.84	46.62	46.74	99.50	2.13	95.78
Bunch weight (kg)	7.17	65.50	65.63	99.60	12.01	134.65
No. of hands/bunch	12.06	39.86	40.46	97.00	5.65	80.88
No. of fingers/hand	8.38	36.51	36.83	98.30	9.23	74.55
Fruit weight (g)	5.46	75.99	75.78	99.80	162.36	154.36
Pulp weight (g)	7.34	75.66	75.06	99.70	118.62	155.61

Total soluble solids (0B	2.55	28.08	28.12	99.70	9.92	57.76
Titratable Acidity (%)	11.17	63.76	64.09	99.00	0.91	130.68
Total sugar (%)	2.54	54.95	54.97	99.90	10.49	113.16
Reducing sugar (%)	7.03	51.79	51.95	99.40	4.11	106.36
Shelf life	12.38	22.09	23.21	90.50	3.00	43.29

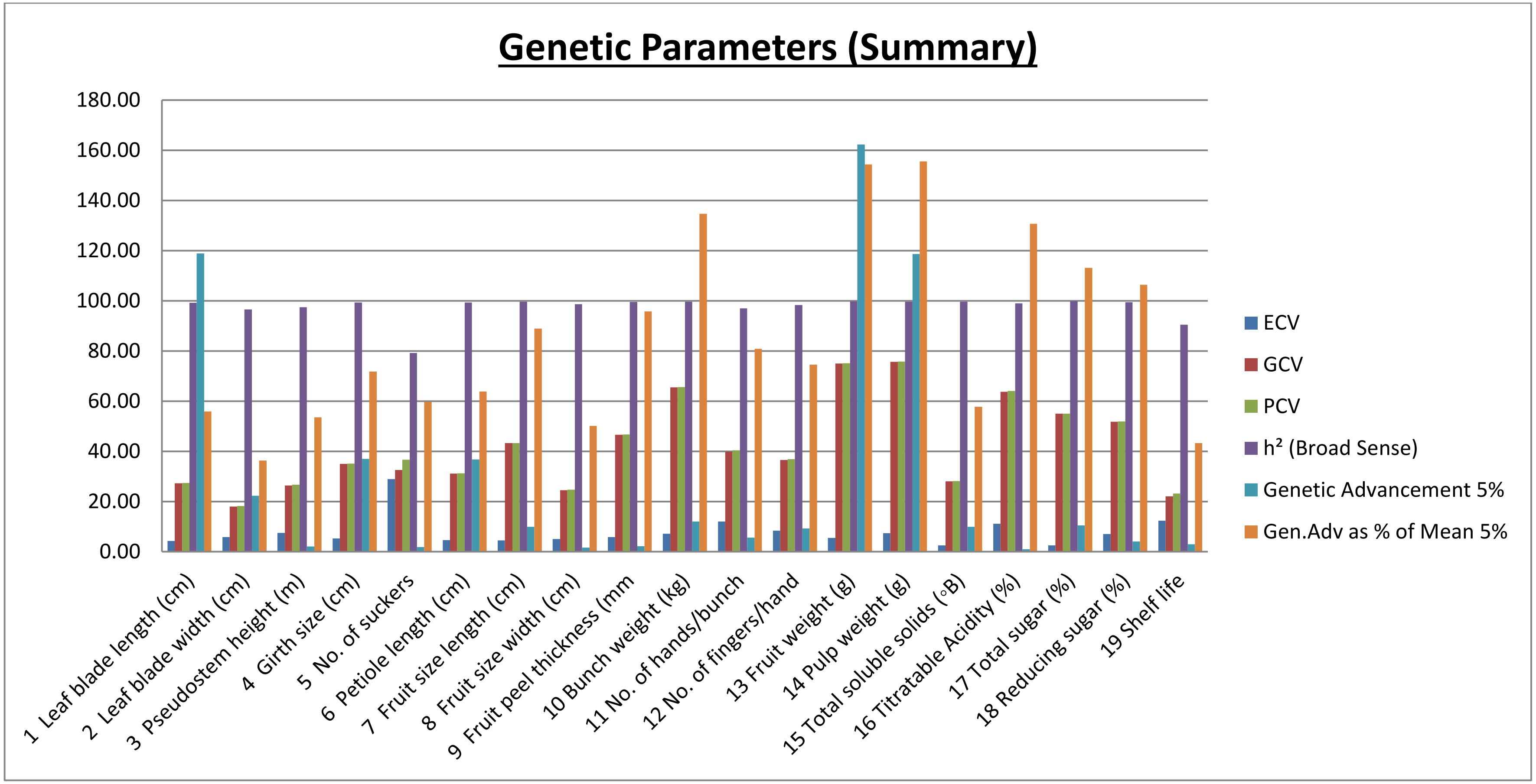


Figure 4.1. Bar graph of genetic parameters

CORRELATION STUDIES

The genotypic and phenotypic correlation coefficients were calculated for the 21 genotypes of banana across nineteen different characters. The significance of these correlations was tested at the 1 percent and 5 percent levels of significance. The results of the analysis are presented in (Table 4.11 and 4.12)

The present study revealed significant correlations between various traits. Bunch weight (kg) (0.5851) and No. of fingers/hands (0.7939) showed a positive genotypic correlation with No. of hands/bunch, while Fruit size width (cm) (-0.4173) and Fruit peel thickness (cm) (-0.3853) displayed a significant negative genotypic correlation with No. of hands/bunch. Pseudostem height (m) (0.3936) showed a positive genotypic correlation with shelf life, whereas Total soluble solids (°B) (-0.5491) and Total sugar (%) (-0.669) exhibited a significant negative genotypic correlation with shelf life (Table 4.11 and 4.12).

For Reducing sugar (%), Girth size (cm) (0.6621), Fruit size length (cm) (0.3876), Bunch weight (kg) (0.4406), Total soluble solids (°B) (0.5747), and Total sugar (%) (0.5646) showed positive genotypic correlations. Conversely, Petiole length (cm) (-0.3811) and Titratable Acidity (%) (-0.4557) displayed significant negative genotypic correlations with shelf life (Table 4.11 and 4.12).

Regarding Total sugar (%), Girth size (cm) (0.674), Fruit size length (cm) (0.65), Bunch weight (kg) (0.5486), No. of fingers/hand (0.3917), Fruit weight (g) (0.526), Pulp weight (g) (0.5228), and Total soluble solids (°B) (0.8502) showed significant positive genotypic correlations. Leaf blade length (cm) (0.6205), Pseudostem height (m) (0.4364), Petiole length (cm) (0.4654), Fruit weight (g) (0.4325), and Pulp weight (g) (0.4725) also exhibited significant positive genotypic correlations with Titratable Acidity (%). Additionally, Girth size (cm) (0.6714), Fruit size length (cm) (0.5645), Bunch weight (kg) (0.6615), No. of fingers/hand (0.3937), Fruit weight (g) (0.5063), and Pulp weight (g) (0.5131) showed significant positive genotypic correlations with Total soluble solids (°B) (Table 4.11 and 4.12).

In terms of Pulp weight (g), Leaf blade length (cm) (0.592), Girth size (cm) (0.5161), Fruit size length (cm) (0.7872), Fruit size width (cm) (0.5441), Fruit peel thickness (cm) (0.7668), Bunch weight (kg) (0.4091), and Fruit weight (g) (0.9927) displayed significant positive genotypic correlations. Leaf blade length (cm) (0.532), Girth size (cm) (0.5204), and Bunch weight (kg) (0.7422) also showed significant positive genotypic correlations with No. of fingers/hand. Furthermore, Girth size (cm) (0.7623) exhibited a significant positive genotypic correlation with Bunch weight (kg), and Fruit size length (cm) (0.7061) and Fruit size width (cm) (0.5416) showed significant positive genotypic correlations with Fruit peel thickness (cm). Pseudostem height (m) (0.4139) and Fruit size length (cm) (0.6172) demonstrated significant positive genotypic correlations with Fruit size width (cm). Moreover, Girth size (cm) (0.6306) displayed a significant positive genotypic correlation with Fruit size length (cm). Leaf blade length (cm) (0.592) and Pseudostem height (m) (0.5924) showed significant positive genotypic correlations with Petiole length (cm) (Table 4.11 and 4.12).

Additionally, Leaf blade width (cm) (0.6074), Pseudostem height (m) (0.6136), and Girth size (cm) (0.4004) exhibited significant positive genotypic correlations with Leaf blade length (cm). Leaf blade width (cm) showed a significant positive genotypic correlation with Pseudostem height (m) (Table 4.11 and 4.12).

Moving on to phenotypic correlations, Bunch weight (kg) (0.5776) and No. of fingers/hands (0.7828) displayed a significant positive correlation with No. of hands/bunch. Fruit size width (cm) (-0.403) and Fruit peel thickness (cm) (-0.38) showed significant negative phenotypic correlations with No. of hands/bunch. Total soluble solids (°B) (-0.5266) and Total sugar (%) (-0.6369) were observed to have significant negative phenotypic correlations with shelf life (Table 4.11 and 4.12).

Girth size (cm) (0.6568**), Fruit size length (cm) (0.3846*), Bunch weight (kg) (0.4388), Total soluble solids (°B) (0.5726), Titratable Acidity (%) (-0.4531), and Total sugar (%) (0.5631) all showed significant positive phenotypic correlations with Reducing sugar (%). The characters Girth size (cm) (0.6718), Fruit size length (cm) (0.6484), Bunch weight (kg) (0.5471), No. of fingers/hand (0.3885), Fruit weight (g) (0.5254), Pulp weight (g) (0.522), and Total soluble solids (°B) (0.8487) showed significant positive phenotypic correlations with Total sugar (%) (Table 4.11 and 4.12).

Leaf blade length (cm) had significant positive phenotypic correlations with Leaf blade width (cm) (0.5978), Pseudostem height (m) (0.6005), Girth size (cm) (0.3972), Petiole length (cm) (0.5850), No. of fingers/hand (0.4579), Fruit weight (g) (0.5307), Pulp weight (g) (0.5732), and Titratable Acidity (%) (0.6142). Pseudostem height (m) (0.4296), Petiole length (cm) (0.4609), Fruit weight (g) (0.4303), and Pulp weight (g) (0.4715) had significant positive phenotypic correlations with Titratable Acidity (%) (Table 4.11 and 4.12).

Girth size (cm) (0.6681), Fruit size length (cm) (0.5635), Bunch weight (kg) (0.6597), No. of fingers/hand (0.39), Fruit weight (g) (0.5051), and Pulp weight (g) (0.5112) all showed significant positive phenotypic correlations with Total soluble solids (°B). Regarding Pulp weight (g), the characters Pseudostem height (m) (0.3827), Girth size (cm) (0.5131), Fruit size length (cm) (0.7854), Fruit peel thickness (cm) (0.7634), Bunch weight (kg) (0.4082), and Fruit weight (g) (0.9921) exhibited significant positive phenotypic correlations. Girth size (cm) (0.5175), Fruit size length (cm) (0.8285), Fruit peel thickness (cm) (0.7936), and Bunch weight (kg) (0.401) showed significant negative phenotypic correlations with Fruit weight (g) (Table 4.11 and 4.12). Jullien *et al*. (2001) observed positive related to bunch weight through pulp weight.

Girth size (cm) (0.6929) and Bunch weight (kg) (0.7325) showed significant negative phenotypic correlations with No. of fingers/hand. Bunch weight (kg) and Girth size (cm) (0.7592) displayed a significant positive phenotypic correlation. Fruit size length (cm) (0.7040) and Fruit size width (cm) (0.5380) recorded significant positive phenotypic correlations with Fruit peel thickness (cm). For Fruit size width (cm), Pseudostem height (m) (0.4064) and Fruit size length (cm) (0.6114) showed significant positive phenotypic correlations. Girth size (cm) (0.6272) and Fruit size length (cm) exhibited significant positive phenotypic correlations. Pseudostem height (m) (0.5839) and Petiole length (cm) displayed significant positive phenotypic correlations. Leaf blade width (cm) (0.4413) and Pseudostem height (m) showed significant positive phenotypic correlations (Table 4.11 and 4.12).

Overall, the genotypic correlation coefficient (rg) values were higher than the phenotypic correlation coefficient (rp) values, suggesting that environmental factors have minimal influence on the observed correlations. Bhagat *et al*. (2022) and Bruno *et al*. (2014) accorded similar results.

Table 4.11: Genotypic correlation

	Leaf blade length (cm)	Leaf blade width (cm)	Pseudostem height (m)	Girth size (cm)	No. of suckers	Petiole length (cm)	Fruit size length (cm)	Fruit size width (cm)	Fruit peel thickness (cm)	Bunch weight (kg)	No. of fingers/hand	Fruit weight (g)	Pulp weight (g)	Total soluble solids (^{0}B)	Titratable Acidity (%)	Total sugar (%)	Reducing sugar (%)	Shelf life
Leaf blade length (cm)	1																	
Leaf blade width (cm)	0.6074**	1																
Pseudostem height (m)	0.6136**	0.4491*	1															
Girth size (cm)	0.4004*	0.2726	0.1532	1														
No. of suckers	0.2667	0.3539	-0.0754	0.251	1													
Petiole length (cm)	0.5920**	0.2597	0.5924**	-0.1204	0.0852	1												
Fruit size length (cm)	0.2167	0.0713	0.0774	0.6306**	0.2669	-0.1166	1											
Fruit size width (cm)	0.1005	0.2094	0.4139*	0.2485	-0.122	0.1448	0.6172**	1										
Fruit peel thickness (cm)	0.3080	0.1001	0.1928	0.0994	0.1671	0.1832	0.7061**	0.5416**	1									
Bunch weight (kg)	0.3184	0.1711	0.1602	0.7623**	0.1706	-0.1002	0.3739	0.1579	-0.1548	1								
No. of fingers/hand	0.4643*	0.3434	0.2667	0.6993**	0.2605	0.0824	0.1811	-0.1691	-0.2051	0.7422**	1							
Fruit weight (g)	0.5320**	0.2408	0.3197	0.5204**	0.3552	0.1027	0.8304**	0.5616**	0.7968**	0.4020*	0.1703	1						
Pulp weight (g)	0.5748**	0.2686	0.3891*	0.5161**	0.3509	0.1440	0.7872**	0.5441**	0.7668**	0.4091*	0.1769	0.9927**	1					

Total soluble solids (^{0}B)	0.1470	0.2522	0.0177	0.6714**	0.2453	-0.1615	0.5645**	0.2625	0.2516	0.6615**	0.3937*	0.5063**	0.5131**	1				
Titratable Acidity (%)	0.6205**	0.1756	0.4364*	-0.0693	0.1934	0.4654*	-0.0261	-0.0048	0.3497	0.1421	0.1468	0.4325*	0.4725*	0.0083	1			
Total sugar (%)	0.1222	-0.0023	-0.0558	0.6740**	0.2559	-0.2255	0.6500**	0.1404	0.3302	0.5486**	0.3917*	0.5260**	0.5228**	0.8502**	-0.0362	1		
Reducing sugar (%)	-0.1609	0.0805	-0.1143	0.6621**	-0.1870	-0.3811*	0.3876*	0.2755	-0.0125	0.4406*	0.2767	0.2016	0.1868	0.5747**	-0.4557*	0.5646**	1	
Shelf life	-0.1096	-0.0666	0.3936*	-0.3378	-0.3229	0.3237	-0.2983	0.3336	-0.1494	-0.2211	-0.2100	-0.2323	-0.2281	-0.5491**	-0.0216	-0.6690**	-0.2693	1
No. of hands/bunch	0.1920	-0.0191	0.0923	0.3782	0.0357	0.1444	-0.2032	-0.4173*	-0.3853*	0.5851**	0.7939**	-0.1423	-0.1356	0.2755	0.2782	0.2675	0.1745	-0.1558

Table 4.12: Phenotypic correlation

	Leaf blade length (cm)	Leaf blade width (cm)	Pseudostem height (m)	Girth size (cm)	No. of suckers	Petiole length (cm)	Fruit size length (cm)	Fruit size width (cm)	Fruit peel thickness (cm)	Bunch weight (kg)	No. of fingers/hand	Fruit weight (g)	Pulp weight (g)	Total soluble solids (^{0}B)	Titratable Acidity (%)	Total sugar (%)	Reducing sugar (%)	Shelf life
Leaf blade length (cm)	1																	
Leaf blade width (cm)	0.5978**	1																
Pseudostem height (m)	0.6005**	0.4413*	1															
Girth size (cm)	0.3972*	0.2683	0.1513	1														
No. of suckers	0.2239	0.3116	-0.0524	0.2235	1													
Petiole length (cm)	0.5850**	0.2545	0.5839**	-0.1203	0.0768	1												
Fruit size length (cm)	0.2147	0.0708	0.078	0.6272**	0.2308	-0.1151	1											
Fruit size width (cm)	0.0994	0.206	0.4064*	0.2434	-0.0959	0.1429	0.6114**	1										
Fruit peel thickness (cm)	0.3052	0.1004	0.1929	0.0982	0.1492	0.1844	0.7040**	0.5380**	1									
Bunch weight (kg)	0.3169	0.1706	0.1584	0.7592**	0.1487	-0.0998	0.3743	0.1563	-0.1537	1								
No. of fingers/hand	0.4579*	0.3399	0.2648	0.6929**	0.2347	0.0834	0.1779	-0.1623	-0.2035	0.7325**	1							
Fruit weight (g)	0.5307**	0.239	0.3151	0.5175**	0.3157	0.1022	0.8285**	0.5579	0.7936**	0.4010*	0.1692	1						
Pulp weight (g)	0.5732**	0.267	0.3827*	0.5131**	0.3126	0.1432	0.7854**	0.5403	0.7634**	0.4082*	0.1755	0.9921**	1					

Total soluble solids (^{0}B)	0.1457	0.2475	0.0168	0.6681**	0.2161	-0.1609	0.5635**	0.2619	0.2509	0.6597**	0.3900*	0.5051**	0.5112**	1				
Titratable Acidity (%)	0.6142**	0.1736	0.4296*	-0.0686	0.1768	0.4609*	-0.0261	-0.0041	0.3472	0.1419	0.1416	0.4303*	0.4715*	0.0072	1			
Total sugar (%)	0.1216	-0.0016	-0.0556	0.6718**	0.2284	-0.2248	0.6484**	0.1393	0.3290	0.5471**	0.3885*	0.5254**	0.5220**	0.8487**	-0.0361	1		
Reducing sugar (%)	-0.1594	0.0805	-0.1141	0.6568**	-0.1654	-0.3797	0.3846*	0.2747	-0.0132	0.4388*	0.2746	0.2011	0.1861	0.5726**	-0.4531**	0.5631**	1	
Shelf life	-0.1021	-0.0732	0.3622	-0.3211	-0.3084	0.3123	-0.2843	0.3071	-0.1372	-0.2081	-0.2008	-0.2248	-0.2210	-0.5266**	-0.0255	-0.6369**	-0.2492	1
No. of hands/bunch	0.1928	-0.0123	0.0897	0.3718	0.0481	0.142	-0.2008	-0.403*	-0.3800*	0.5776**	0.7828**	-0.1376	-0.1300	0.2707	0.2715	0.2636	0.1726	-0.149

PATH COEFFICIENT

Direct effect

The variable that exhibited the highest positive direct effect on the number of hands per bunch was Fruit weight (g) (4.3742), followed by Pseudostem height (m) (0.5839) and Titratable acidity (%) (0.565).

Conversely, the variable that demonstrated the highest negative direct effect on the number of hands per bunch was Pulp weight (g) (-4.8557), followed by Fruit size width (cm) (-0.4823) and Fruit size length (cm) (-0.3751) (Table 4.13 and 4.14).

Indirect effect

The variable showing the highest positive indirect effect on the number of hands per bunch for Leaf blade length (cm) was Reducing sugar (%) (0.055). Conversely, the highest negative indirect effect was observed for Titratable acidity (%) (-0.2123).

Leaf blade width (cm) demonstrated the highest positive indirect effect on the number of hands per bunch through Shelf life (0.0128). The highest negative indirect effect was revealed by Leaf blade length (cm) (-0.1166) and Pseudostem height (m) (-0.0863).

Pseudostem height (m) showed the highest positive indirect effect on the number of hands per bunch through Leaf blade length (cm) (0.3583), followed by Petiole length (cm) (0.3459). The highest negative indirect effect was observed through Reducing sugar (%) (-0.0667) and Total sugar (%) (-0.0326) (Table 4.13 and 4.14).

The trait Girth size (cm) exhibited the highest positive indirect effect on the number of hands per bunch via Bunch weight (kg) (0.2609), followed by No. of fingers/hand (0.2393). The highest negative indirect effect was observed through Shelf life (-0.1156), followed by Petiole length (cm) (-0.0412).

No. of suckers showed the highest positive indirect effect on the number of hands per bunch via Fruit weight (g) (0.02), followed by leaf blade width (cm) (0.0199). The highest negative indirect effect was observed through Shelf life (-0.0181), followed by Reducing sugar (%) (-0.0105).

For the parameter Petiole length (cm), the highest positive indirect effect on the number of hands per bunch was observed via Pseudostem height (m) (0.1607), followed by Leaf blade length (cm) (0.1606). The highest negative indirect effect was attributed to Reducing sugar (%) (-0.1034).

Fruit size length (cm) demonstrated the highest positive indirect effect on the number of hands per bunch via Shelf life (g) (0.1119), followed by Petiole length (cm) (0.0437). The highest negative indirect effect was observed through Pulp weight (g) (-0.2624), followed by Fruit peel thickness (cm) (-0.2612) (Table 4.13 and 4.14).

Fruit size width (cm) showed the highest positive indirect effect on the number of hands per bunch via No. of fingers/hand (0.0815), followed by No. of suckers (0.0588). The highest negative indirect effect was observed through Fruit weight (g) (-0.2709) and Pulp weight (g) (-0.2624).

For the parameter Fruit peel thickness (cm), the highest positive indirect effect on the number of hands per bunch was observed via Fruit weight (g) (0.0872), followed by Pulp weight (g) (0.0823). The highest negative indirect effect was attributed to No. of fingers/hand (-0.0224).

Bunch weight (kg) showed the highest positive indirect effect on the number of hands per bunch via Girth size (cm) (0.2343), followed by No. of fingers/hand (0.2282). The highest negative indirect effect was observed through Shelf life (-0.068), followed by Fruit peel thickness (cm) (-0.0476).

No. of fingers/hand demonstrated the highest positive indirect effect on the number of hands per bunch via Girth size (cm) (0.1386), followed by No. of fingers/hand (0.092). The highest negative indirect effect was observed through Shelf life (-0.0416), followed by Fruit peel thickness (cm) (-0.0407).

For the parameter Fruit weight (g), the highest positive indirect effect on the number of hands per bunch was observed via Pulp weight (g) (4.3421), followed by Fruit size length (cm) (3.6325). The highest negative indirect effect was attributed to Shelf life (-1.0162).

Pulp weight (g) demonstrated the highest positive indirect effect on the number of hands per bunch via Shelf life (g) (1.1076). The highest negative indirect effect was observed through Fruit size length (cm) (-3.8225), followed by Fruit peel thickness (cm) (-3.7235) (Table 4.13 and 4.14).

Total soluble solids (°B) showed the highest positive indirect effect on the number of hands per bunch via Total sugar (%) (0.1885). The highest negative indirect effect was observed through Shelf life (-0.1218).

For the parameter Titratable acidity (%), the highest positive indirect effect on the number of hands per bunch was observed via Leaf blade length (cm) (0.3506), followed by Pulp weight (g) (0.267). The highest negative indirect effect was attributed to Reducing sugar (%) (-0.2575).

Total sugar (%) showed the highest positive indirect effect on the number of hands per bunch via Total soluble solids (°B) (0.047). The highest negative indirect effect was observed through Shelf life (-0.037).

Reducing sugar (%) demonstrated the highest positive indirect effect on the number of hands per bunch via Girth size (cm) (0.19), followed by Total soluble solids (°B) (0.162). The highest negative indirect effect was observed through Titratable acidity (%) (-0.1307).

For the parameter Shelf life, the highest positive indirect effect on the number of hands per bunch was observed via Reducing sugar (%) (0.039), and the highest negative indirect effect was attributed to Pseudostem height (m) (-0.023) (Table 4.13 and 4.14).

The maximum positive indirect effect on the number of hands per bunch was observed in Fruit weight (g) via Pulp weight (g) (4.3421), while the maximum negative indirect effect was observed in Pulp weight (g) via Fruit size length (cm) (-3.8225). The present study suggests that more emphasis should be given to selecting genotypes that emphasize traits like Fruit weight (g), Pseudostem height (m), pulp weight, and Fruit size length (cm), which directly and indirectly contribute to the number of hands per bunch. Tak *et al*. (2015) and Bhagat *et al*. (2022) observed similar results.

Table 4.13: Genotypic path coefficient

Parameters	Leaf blade length (cm)	Leaf blade width (cm)	Pseudostem height (m)	Girth size (cm)	No. of suckers	Petiole length (cm)	Fruit size length (cm)	Fruit size width (cm)	Fruit peel thickness (cm)	Bunch weight (kg)	No. of fingers/hand	Fruit weight (g)	Pulp weight (g)	Total soluble solids (^{0}B)	Titratable Acidity (%)	Total sugar (%)	Reducing sugar (%)	Shelf life
Leaf blade length (cm)	-0.3421	-0.2078	-0.2099	-0.137	-0.0912	-0.2025	-0.0741	-0.0344	-0.1053	-0.1089	-0.1588	-0.182	-0.1966	-0.0503	-0.2123	-0.0418	0.055	0.0375
Leaf blade width (cm)	-0.1166	-0.192	-0.0863	-0.0524	-0.068	-0.0499	-0.0137	-0.0402	-0.0192	-0.0329	-0.066	-0.0462	-0.0516	-0.0484	-0.0337	0.0004	-0.0155	0.0128
Pseudostem height (m)	0.3583	0.2623	0.5839	0.0894	-0.044	0.3459	0.0452	0.2417	0.1126	0.0935	0.1557	0.1867	0.2272	0.0103	0.2548	-0.0326	-0.0667	0.2298
Girth size (cm)	0.137	0.0933	0.0524	0.3423	0.0859	-0.0412	0.2158	0.085	0.034	0.2609	0.2393	0.1781	0.1766	0.2298	-0.0237	0.2307	0.2266	-0.1156
No. of suckers	0.015	0.0199	-0.0042	0.0141	0.0562	0.0048	0.015	-0.0069	0.0094	0.0096	0.0146	0.02	0.0197	0.0138	0.0109	0.0144	-0.0105	-0.0181
Petiole length (cm)	0.1606	0.0705	0.1607	-0.0327	0.0231	0.2713	-0.0316	0.0393	0.0497	-0.0272	0.0224	0.0279	0.0391	-0.0438	0.1262	-0.0612	-0.1034	0.0878
Fruit size length (cm)	-0.0813	-0.0267	-0.029	-0.2366	-0.1001	0.0437	-0.3751	-0.2316	-0.2649	-0.1402	-0.068	-0.3115	-0.2953	-0.2118	0.0098	-0.2438	-0.1454	0.1119

Fruit size width (cm)	-0.0485	-0.101	-0.1996	-0.1198	0.0588	-0.0699	-0.2977	-0.4823	-0.2612	-0.0761	0.0815	-0.2709	-0.2624	-0.1266	0.0023	-0.0677	-0.1328	-0.1609
Fruit peel thickness (cm)	0.0337	0.011	0.0211	0.0109	0.0183	0.02	0.0773	0.0593	0.1094	-0.0169	-0.0224	0.0872	0.0839	0.0275	0.0383	0.0361	-0.0014	-0.0163
Bunch weight (kg)	0.0979	0.0526	0.0492	0.2343	0.0525	-0.0308	0.1149	0.0485	-0.0476	0.3074	0.2282	0.1236	0.1258	0.2033	0.0437	0.1686	0.1355	-0.068
No. of fingers/hand	0.092	0.0681	0.0529	0.1386	0.0516	0.0163	0.0359	-0.0335	-0.0407	0.1471	0.1982	0.0338	0.0351	0.0781	0.0291	0.0776	0.0549	-0.0416
Fruit weight (g)	2.327	1.0532	1.3986	2.2762	1.5535	0.4492	3.6325	2.4567	3.4852	1.7586	0.7448	4.3742	4.3421	2.2147	1.892	2.3007	0.8816	-1.0162
Pulp weight (g)	-2.7912	-1.3044	-1.8891	-2.506	-1.7039	-0.6991	-3.8225	-2.6419	-3.7235	-1.9864	-0.8592	-4.8201	-4.8557	-2.4915	-2.2945	-2.5383	-0.9071	1.1076
Total soluble solids (^{0}B)	0.0326	0.0559	0.0039	0.1489	0.0544	-0.0358	0.1252	0.0582	0.0558	0.1467	0.0873	0.1123	0.1138	0.2217	0.0018	0.1885	0.1274	-0.1218
Titratable Acidity (%)	0.3506	0.0992	0.2466	-0.0392	0.1093	0.263	-0.0147	-0.0027	0.1976	0.0803	0.083	0.2444	0.267	0.0047	0.565	-0.0204	-0.2575	-0.0122
Total sugar (%)	0.0068	-0.0001	-0.0031	0.0373	0.0141	-0.0125	0.0359	0.0078	0.0183	0.0303	0.0217	0.0291	0.0289	0.047	-0.002	0.0553	0.0312	-0.037

Reducing sugar (%)	-0.0462	0.0231	-0.0328	0.19	-0.0537	-0.1093	0.1112	0.079	-0.0036	0.1264	0.0794	0.0578	0.0536	0.1649	-0.1307	0.162	0.2869	-0.0773
Shelf life	0.0064	0.0039	-0.023	0.0197	0.0188	-0.0189	0.0174	-0.0195	0.0087	0.0129	0.0122	0.0135	0.0133	0.032	0.0013	0.039	0.0157	-0.0583
No. of hands/bunch	0.192	-0.0191	0.0923	0.3782	0.0357	0.1444	-0.2032	-0.4173	-0.3853	0.5851	0.7939	-0.1423	-0.1356	0.2755	0.2782	0.2675	0.1745	-0.1558
Partial R^2	-0.0657	0.0037	0.0539	0.1294	0.002	0.0392	0.0762	0.2013	-0.0422	0.1799	0.1574	-0.6223	0.6586	0.0611	0.1572	0.0148	0.0501	0.0091

Table 4.14: Phenotypic path coefficient

	Leaf blade length (cm)	Leaf blade width (cm)	Pseudostem height (m)	Girth size (cm)	No. of suckers	Petiole length (cm)	Fruit size length (cm)	Fruit size width (cm)	Fruit peel thickness (cm)	Bunch weight (kg)	No. of fingers/hand	Fruit weight (g)	Pulp weight (g)	Total soluble solids (^{0}B)	Titratable Acidity (%)	Total sugar (%)	Reducing sugar (%)	Shelf life
Leaf blade length (cm)	0.8374	0.5006	0.5029	0.3326	0.1875	0.4899	0.1798	0.0833	0.2556	0.2654	0.3835	0.4444	0.48	0.122	0.5143	0.1018	-0.1335	-0.0855
Leaf blade width (cm)	-0.5224	-0.8739	-0.3857	-0.2345	-0.2723	-0.2224	-0.0619	-0.1801	-0.0878	-0.1491	-0.297	-0.2089	-0.2334	-0.2163	-0.1517	0.0014	-0.0704	0.064
Pseudostem height (m)	0.0673	0.0495	0.1121	0.017	-0.0059	0.0655	0.0087	0.0456	0.0216	0.0178	0.0297	0.0353	0.0429	0.0019	0.0482	-0.0062	-0.0128	0.0406
Girth size (cm)	-0.3583	-0.242	-0.1365	-0.9021	-0.2016	0.1085	-0.5658	-0.2196	-0.0886	-0.6849	-0.6251	-0.4668	-0.4629	-0.6027	0.0618	-0.6061	-0.5925	0.2896
No. of suckers	0.0199	0.0278	-0.0047	0.0199	0.0891	0.0068	0.0206	-0.0085	0.0133	0.0132	0.0209	0.0281	0.0278	0.0192	0.0157	0.0203	-0.0147	-0.0275
Petiole length (cm)	-0.0403	-0.0175	-0.0402	0.0083	-0.0053	-0.0688	0.0079	-0.0098	-0.0127	0.0069	-0.0057	-0.007	-0.0099	0.0111	-0.0317	0.0155	0.0261	-0.0215

Fruit size length (cm)	0.0454	0.015	0.0165	0.1326	0.0488	-0.0243	0.2115	0.1293	0.1489	0.0791	0.0376	0.1752	0.1661	0.1192	-0.0055	0.1371	0.0813	-0.0601
Fruit size width (cm)	0.0285	0.059	0.1164	0.0697	-0.0275	0.0409	0.1752	0.2865	0.1541	0.0448	-0.0465	0.1598	0.1548	0.075	-0.0012	0.0399	0.0787	0.088
Fruit peel thickness (cm)	-0.6595	-0.2171	-0.4168	-0.2122	-0.3225	-0.3985	-1.5214	-1.1626	-2.1609	0.3322	0.4397	-1.7149	-1.6496	-0.5421	-0.7503	-0.711	0.0286	0.2965
Bunch weight (kg)	-0.5846	-0.3147	-0.2923	-1.4007	-0.2743	0.1841	-0.6905	-0.2884	0.2836	-1.8449	-1.3513	-0.7398	-0.753	-1.2171	-0.2618	-1.0093	-0.8095	0.3839
No. of fingers/hand	0.603	0.4475	0.3487	0.9124	0.309	0.1099	0.2343	-0.2137	-0.2679	0.9645	1.3168	0.2228	0.2311	0.5136	0.1864	0.5116	0.3615	-0.2644
Fruit weight (g)	3.2999	1.4861	1.9593	3.2179	1.9633	0.6356	5.1519	3.4694	4.9347	2.4936	1.052	6.2182	6.169	3.1406	2.6759	3.2672	1.2508	-1.3978
Pulp weight (g)	-3.1308	-1.4586	-2.0907	-2.8025	-1.7073	-0.782	-4.2898	-2.9511	-4.1698	-2.2296	-0.9586	-5.419	-5.4623	-2.7921	-2.5755	-2.8515	-1.0166	1.207
Total soluble solids (^{0}B)	0.2061	0.3501	0.0237	0.9449	0.3056	-0.2276	0.797	0.3704	0.3548	0.9331	0.5517	0.7144	0.723	1.4144	0.0102	1.2004	0.81	-0.7448
Titratable Acidity (%)	0.5087	0.1438	0.3559	-0.0568	0.1465	0.3818	-0.0216	-0.0034	0.2876	0.1175	0.1173	0.3564	0.3906	0.006	0.8283	-0.0299	-0.3753	-0.0211
Total sugar (%)	-0.0012	0	0.0006	-0.0068	-0.0023	0.0023	-0.0066	-0.0014	-0.0033	-0.0055	-0.0039	-0.0053	-0.0053	-0.0086	0.0004	-0.0101	-0.0057	0.0064

Reducing sugar (%)	-0.1004	0.0507	-0.0719	0.4138	-0.1042	-0.2392	0.2423	0.173	-0.0083	0.2764	0.173	0.1267	0.1173	0.3608	-0.2855	0.3548	0.63	-0.157
Shelf life	-0.026	-0.0186	0.0922	-0.0818	-0.0785	0.0795	-0.0724	0.0782	-0.0349	-0.053	-0.0511	-0.0572	-0.0563	-0.1341	-0.0065	-0.1622	-0.0635	0.2547
No. of hands/bunch	0.1928	-0.0123	0.0897	0.3718	0.0481	0.142	-0.2008	-0.403	-0.38	0.5776	0.7828	-0.1376	-0.13	0.2707	0.2715	0.2636	0.1726	-0.149
Partial R^2	0.1614	0.0107	0.0101	-0.3354	0.0043	-0.0098	-0.0425	-0.1154	0.8211	-1.0656	1.0308	-0.8557	0.7101	0.3829	0.2249	-0.0027	0.1087	-0.0379

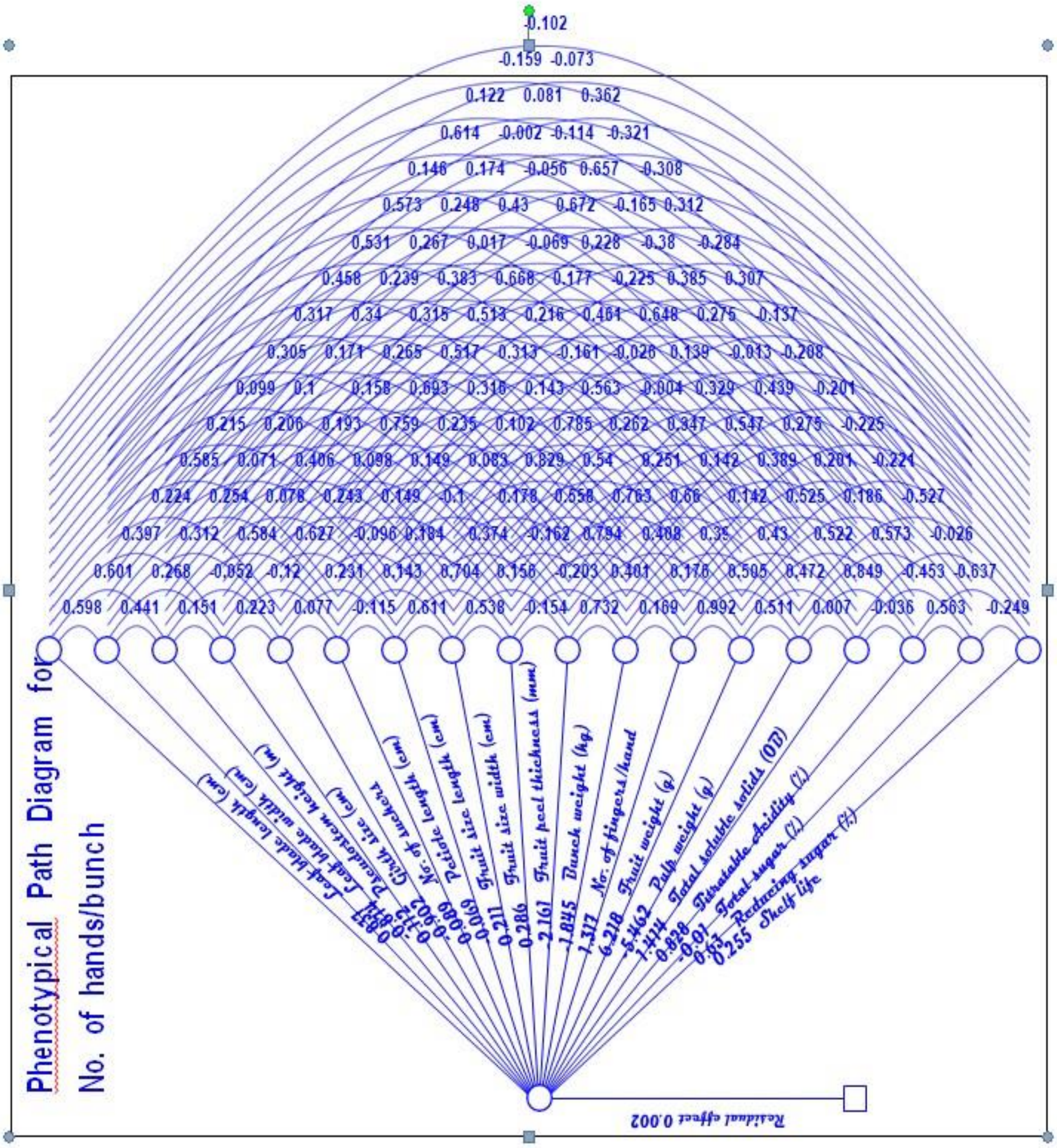


Figure 4.2. Path Diagram

GENETIC DIVERSITY ANALYSIS (D2) / DIVERGENCE ANALYSIS

The D2 values were estimated using Mahalanobis D2 statistical analysis for 27 genotypes to assess the genetic divergence among them. The clustering of the 27 genotypes was performed using the Tocher method (Rao, 1952). The results revealed that the 27 genotypes could be grouped into 4 clusters. Cluster I was the largest, consisting of 15 genotypes, followed by cluster II with 6 genotypes, cluster III with 5 genotypes, and cluster IV with 1 genotype. The formation of different clusters for the 8 genotypes is presented in the table.

Table 4.15: Distribution of 27 (twenty-seven) genotypes into different clusters.

Clusters	Number of genotypes	Genotypes
I	15	1, 5, 6, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27
II	6	3, 4, 7, 8, 9, 10
III	5	2, 11, 12, 13, 14
IV	1	15

Table 4.16: Intra and inter cluster distance

Cluster	I	II	III	IV
I	**34.71**	51.94	55.63	88.07
II		**38.16**	81.44	108.44
III			**48.23**	66.14
IV				**0**

The table presents the intra and inter cluster distances from the divergence analysis for all four clusters.

Cluster I showed the maximum intra cluster distance of 34.71, followed by cluster II with 38.16 and cluster III with the highest value of 48.23. Cluster IV had a minimum intra cluster distance of zero, indicating that all genotypes within this cluster were similar.

The inter cluster D2 value was highest (108.44) between cluster II and IV, indicating a significant genetic divergence between these clusters. On the other hand, the minimum distance of 51.94 was observed between cluster I and II, suggesting a close relationship among the genotypes included in these two clusters.

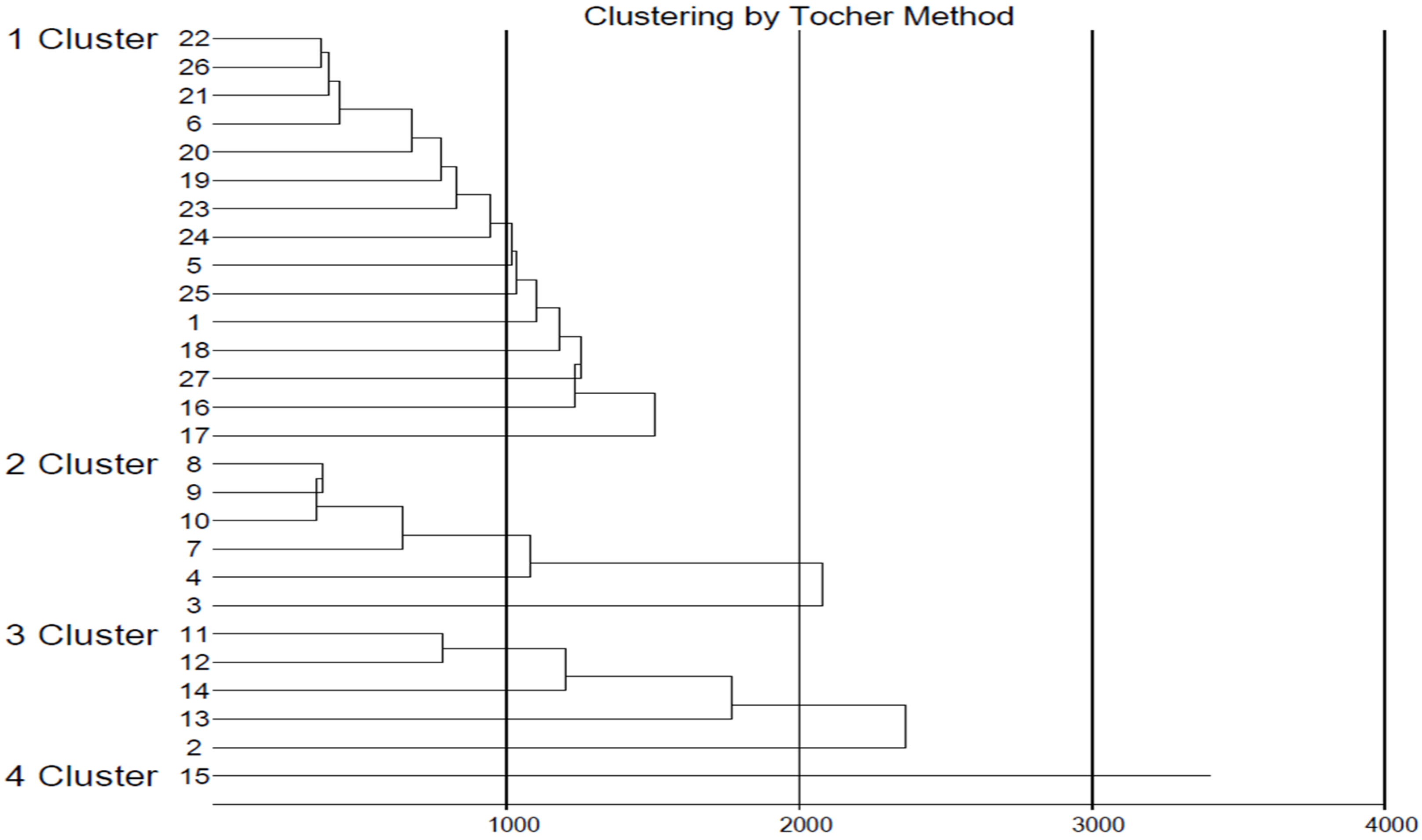


Figure 4.3. Cluster diagram

CLUSTER MEAN ANALYSIS

The cluster mean analysis was conducted for all four clusters across 19 studied traits, and the results are presented in the table. Each cluster exhibited its unique characteristics that distinguished it from the others.

For leaf blade length (cm), cluster VI had the highest mean value of 256.67, while cluster II had the lowest mean value of 202.94. Cluster IV recorded the highest mean value for leaf blade width (cm) at 64.67, whereas cluster II had the lowest mean value of 62.3.

Regarding pseudostem height (m), cluster III had the highest mean value of 4.13, while cluster IV had the lowest mean value of 3.25. Cluster III showed the maximum mean value for girth size at 62.46, whereas cluster II had the minimum mean value of 37.92.

The highest mean value for the number of suckers was found in cluster I at 4.33, while cluster I had the lowest mean value of 2.78. Cluster IV exhibited the highest mean value for petiole length at 63, and cluster III had the lowest mean value of 50.57.

Cluster IV displayed the maximum mean value for fruit size length (cm) at 27, while cluster II had the minimum mean value of 8.24. For fruit size width (cm), cluster IV had the highest mean value of 4.7, while cluster I had the lowest mean value of 2.84.

The mean values for fruit peel thickness were the highest in cluster IV at 5.33, and the lowest in cluster I at 1.72. Cluster III recorded the highest mean value for bunch weight at 12.75, while cluster II had the lowest mean value of 4.36.

The number of fingers/hand had the maximum mean value in cluster I at 8.09, and the minimum mean value was in cluster IV at 3.33. Cluster I exhibited the highest mean value for fruit weight (g) at 13.91, while cluster II had the lowest mean value of 9.17.

For total soluble solids (°B), cluster IV had the highest mean value of 217.34, and cluster II had the lowest mean value of 51.95. Titratable acidity (%) was highest in cluster IV at 22.77 and lowest in cluster II at 12.26.

The highest mean value for total sugar (%) was found in cluster III at 0.85, while cluster I and IV had the lowest mean values at 0.59. Cluster IV had the highest mean value for reducing sugar (%) at 16.17, and cluster II had the lowest mean value of 2.96.

Shelf life had the highest mean value in cluster IV at 5.37, and the lowest mean value was in cluster II at 2.41. Cluster II had the maximum mean value for the number of hands per bunch at 8.32, while cluster IV had the minimum mean value of 5.35.

The cluster mean values for different traits provided insight into the nature of diversity among the clusters. Significant differences in mean values were observed for all the studied traits.

Table 4.17 Cluster mean analysis of nineteen parameters.

Parameters	Cluster. 1	Cluster. 2	Cluster. 3	Cluster. 4
Leaf blade length (cm)	214.61	202.94	227.87	256.67
Leaf blade width (cm)	62.75	62.3	63.67	64.67
Pseudostem height (m)	4.06	3.74	4.13	3.25
Girth size (cm)	60.75	37.92	62.46	75
No. of suckers	2.78	3.28	3.73	4.33
Petiole length (cm)	60.47	59.97	50.57	63
Fruit size length (cm)	9.28	8.24	14.15	27
Fruit size width (cm)	2.84	3.32	3.61	4.7
Fruit peel thickness (cm)	1.72	2.04	2.49	5.33
Bunch weight (kg)	9.23	4.36	12.75	9.97
No. of fingers/hand	8.09	5.17	6.87	3.33
Fruit weight (g)	13.91	9.17	13.13	12.33
Pulp weight (g)	75.1	72.83	160.8	319.06
Total soluble solids (0B)	53.54	51.95	120.87	217.34
Titratable Acidity (%)	16.33	12.26	21.45	22.77
Total sugar (%)	0.59	0.73	0.85	0.59
Reducing sugar (%)	10.01	2.96	14.54	16.17
Shelf life	4.58	2.41	4.38	5.37
No. of hands/bunch	6.05	8.32	6.01	5.35

PRINCIPAL COMPONENT ANALYSIS

The first two PCs explained 67.83 % of the total variance, with PC1 explaining 43.25 % variance and PC2 explaining 24.57 % variance. Traits associated with PC1 with highest positive loadings (>0.75) were (Girth size (cm) (0.915), Fruit size length (cm) (0.773), Bunch weight (kg) (0.753), Total soluble solids (°B) (0.964), Total sugar (%) (0.972) and Reducing sugar (%) (0.858) and traits associated with PC2 with highest positive loadings (>0.75) were Fruit peel thickness (cm) (0.936), Fruit weight (g) (0.843) and Pulp weight (g) (0.862).

Traits associated with highest negative loadings (>-0.75) with PC1 and PC2 were PC1: Leaf blade length (cm) (-0.274), Leaf blade width (cm) (-0.169), Pseudostem height (m) (-0.708) and Titratable Acidity (%) (-0.497), PC2: Girth size (cm) (-0.134), Bunch weight (kg) (-0.355), No. of fingers/hand (-0.541), Reducing sugar (%) (-0.284) and Shelf life (-0.054). The PCA also indicated the formation of four broad clusters among the genotypes. Osuji *et al*. (1997) observed similar results.

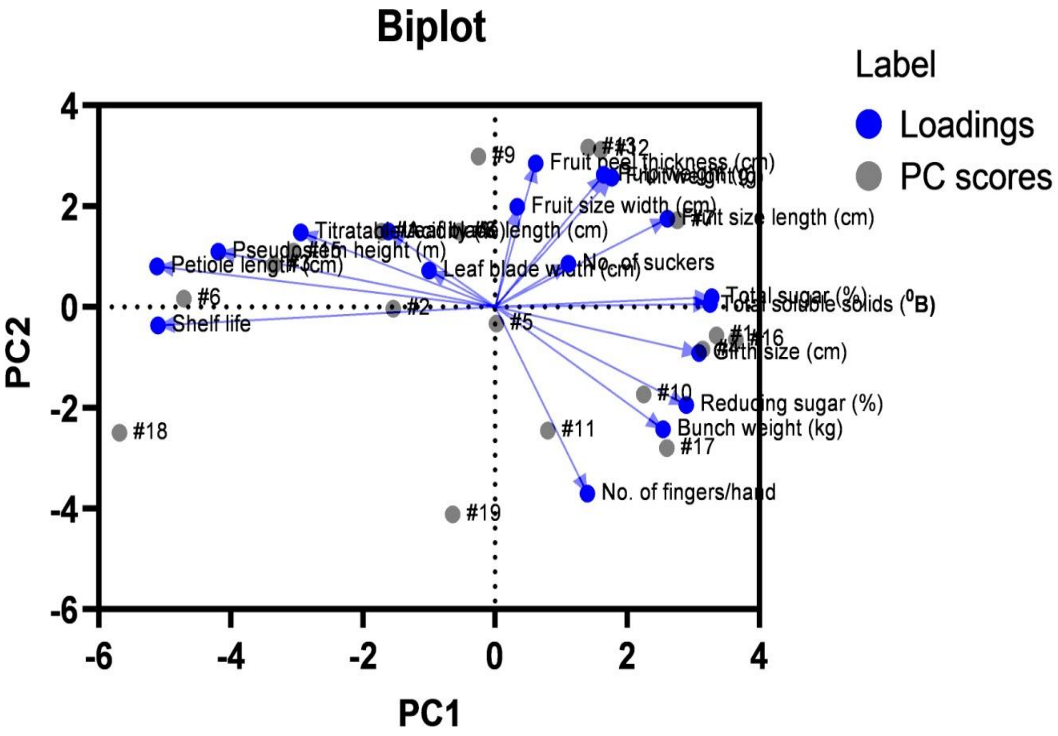


Figure 4. Biplot diagram of principal component analysis.

Table 4.16: Principal component analysis

Parameters	PC1	PC2	PC3
Leaf blade length (cm)	-0.274	0.492	-0.786
Leaf blade width (cm)	-0.169	0.236	-0.610
Pseudostem height (m)	-0.708	0.359	-0.234
Girth size (cm)	0.915	-0.134	-0.230
No. of suckers	0.328	0.281	-0.574
Petiole length (cm)	-0.865	0.264	-0.298
Fruit size length (cm)	0.773	0.575	0.220
Fruit size width (cm)	0.098	0.653	0.617
Fruit peel thickness (cm)	0.181	0.936	0.235
Bunch weight (kg)	0.753	-0.355	-0.377
No. of fingers/hand	0.413	-0.541	-0.673
Fruit weight (g)	0.523	0.843	-0.011
Pulp weight (g)	0.486	0.862	-0.059
Total soluble solids (^{0}B)	0.964	0.019	-0.114
Titratable Acidity (%)	-0.497	0.486	-0.549
Total sugar (%)	0.972	0.062	-0.084
Reducing sugar (%)	0.858	-0.284	0.248
Shelf life	-0.862	-0.054	0.363

CHAPTER 5

SUMMARY AND CONCLUSIONS

SUMMARY AND CONCLUSIONS

The experiment titled "Studies on Genetic Diversity in Banana (*Musa* spp.) Landraces in Nagaland" was carried out at the Department of Horticulture, School of Agricultural Sciences, Nagaland University, Medziphema Campus, Nagaland, from 2019-2022. The objective of the study was to investigate the genetic variability and diversity within *Musa* spp. landraces. The research involved an extensive survey of these landraces within their natural populations.

A total of 27 *Musa* spp., both wild and cultivated, were collected in a random manner from various altitudes (ranging from 100 to 1600 m MSL) across districts including Chümoukedima, Dimapur, Kohima, Mokokchung, Peren, Wokha, and Tuensang in Nagaland's hilly forested regions and homestead gardens.

The collected wild genotypes were encompassed with *Musa aurantiaca*, *Musa balbisiana*-1, *Musa balbisiana*-2, *Musa cheesmanii*, *Musa flaviflora*, *Musa itinerans*, *Musa rubra*, *Musa sikkimensis* var. *sikkimensis*, *Musa sikkimensis* var. *simondsii*, and *Musa velutina*. The cultivated varieties were included as Dwarf Cavendish, Grand Naine, Nendran, Monthan, African Rhino Horn Plantain, Bharatmani, Bhootmanohar, Chinichampa, Kanthali, Red Banana, and Meitei Hei.

Moreover, an additional six genotypes with unidentified classifications were also gathered from various regions of hilly topography of Nagaland. These genotypes were later identified and conserved as gene repositories and biodiversity corridor at the Instructional cum Experimental farm, Department of Horticulture, School of Agricultural Sciences at Nagaland University.

The research documented and compiled as essential plant morphological traits and passport data, which are succinctly summarized as follows:

1. **Plant general appearances**

Based on the findings, the genotype G-2 (*Musa balbisiana*-1), exhibited the highest leaf blade length of (351.00 ± 7.94 cm), while the lowest measurement was recorded in G-7 (*Musa rubra*), with a length of (116.67 ± 8.74 cm). Notably, the largest leaf blade width was observed in G-9 (*Musa sikkimensis* var. *simondsii*), measuring (83.67 ± 3.06 cm), whereas the smallest width was found in G-7 (*Musa rubra*), measuring (41.00 ± 6.56 cm).

In terms of pseudostem height, G-14 (Monthan) displayed the highest measurement of (5.42 ± 0.26 m), whereas G-7 (*Musa rubra*) exhibited the lowest height at (1.92 ± 0.18 m). The greatest pseudostem girth was recorded in G-23 (Unidentified – 3), measuring (92.67 ± 2.08 cm), while G-7 (*Musa rubra*) showed the smallest girth at (17.00 ± 2.00 cm).

Furthermore, the genotype G-2 (*Musa balbisiana*-1) and G-10 (*Musa velutina*) both presented the highest number of suckers, with an average of (5.33 ± 0.58) whereas, G-6 (*Musa itinerans*) displayed the lowest sucker count, averaging at (1.33 ± 0.58).

Lastly, G-3 (*Musa balbisiana* – 2) exhibited the greatest petiole length at (84.33 ± 2.52 cm), whereas G-16 (Bharatmani) displayed the shortest petiole length at (24.67 ± 2.52 cm).

2. **Fruit characters**

The genotype G-15 (African Rhino Horn Plantain), exhibited the largest fruit size in terms of length, measuring (27.00 ± 1.00 cm), while the smallest fruit length was observed in G-10 (*Musa velutina*) measuring (6.80 ± 0.26 cm). Similarly, for fruit width, G-14 (Monthan) displayed the greatest width at (5.53 ± 0.15 cm), whereas G-11 (Dwarf Cavendish) had the smallest width at (2.33 ± 0.15 cm).

When considering fruit peel thickness, G-15 (African Rhino Horn Plantain) recorded the thickest peel, measuring (5.33 ± 0.31 mm), while G-18 (Chinichampa) had the thinnest peel at (1.00 ± 0.10 mm). In terms of bunch weight, the highest weight was recorded in G-18 (Chinichampa), weighing (17.48 ± 0.65 kg), while the lowest weight was found in G-7 (*Musa rubra*), with a weight of (1.09 ± 0.18 kg).

Examining the number of hands per bunch, the greatest count was observed in G-17 (Bhootmanohar), averaging (11.67 ± 1.53 hands), whereas the lowest counts were recorded in three genotypes: G-7 (*Musa rubra*), G-9 (*Musa sikkimensis* var. *simondsii*), and G-15 (African Rhino Horn Plantain), each having (3.33 ± 0.58 hands). For the number of fingers per hand, the highest count of (18.67 ± 1.15) was recorded in G-5 (*Musa flaviflora*) and G-18 (Chinichampa), while the lowest count of (3.67 ± 0.58) was observed in G-7 (*Musa rubra*).

Furthermore, G-15 (African Rhino Horn Plantain) displayed the maximum fruit weight at (319.06 ± 5.29 g), while G-1 (*Musa aurantiaca*) had the minimum fruit weight of (21.33 ± 2.52 g). As for pulp weight, G-15 (African Rhino Horn Plantain) also exhibited the highest weight at (217.34 ± 12.05 g), whereas G-1 (*Musa aurantiaca*) had the lowest pulp weight of (13.00 ± 2.00 g).

3. Biochemical analysis and sensory evaluation

Among the different genotypes studied, G-14 (Monthan) displayed the highest total soluble solids content at (24.02 ± 0.09 °B), while the lowest content was observed in G-7 (*Musa rubra*), measuring (10.40 ± 0.08 °B).

For titratable acidity, the genotype G-3 (*Musa balbisiana*-2) exhibited the highest value at (2.07 ± 0.25 %), whereas the lowest acidity was recorded in G-8 (*Musa sikkimensis* var. *sikkimensis*), with a value of (0.34 ± 0.08 %).

In terms of total sugar content, G-15 (African Rhino Horn Plantain) had the highest measurement at (16.17 ± 0.41 %), while the lowest content was observed in G-8 (*Musa sikkimensis* var. *simondsii*), with a value of (2.23 ± 0.06 %).

Regarding reducing sugar content, G-27 (Meitei Hei) had the highest level at (8.07 ± 0.15 %), whereas the lowest reducing sugar content was found in G-8 (*Musa balbisiana*-1), with a value of (0.97 ± 0.06 %).

Considering the shelf life, G-27 (Meitei Hei) exhibited the longest shelf life at (9.91 ± 1.27 days), whereas the shortest shelf life was observed in G-11 (Dwarf Cavendish,) lasting (3.43 ± 0.42 days).

4. Biometrical analysis

The genetic parameters focused on assessing the influence of the environment on genotype expression and variability in a genetic population. Phenotypic and genotypic coefficients of variation were compared, indicating that traits with high values had potential for improvement through selection. Heritability and genetic advance were high for several traits, suggesting strong genetic control. PCV and GCV values, coupled with high heritability and genetic advance, suggested potential for selection based on Pulp weight and Fruit weight in crop improvement.

The study examined genotypic and phenotypic correlation coefficients across 21 genotypes of bananas and 19 different traits. Positive and negative correlations were observed between various traits, with significant values tested at different significance levels. Genotypic correlations generally exhibited stronger values than phenotypic correlations, implying minimal environmental influence.

The study investigated the direct and indirect effects of various traits on the number of hands per bunch in bananas. Fruit weight (g), Pseudostem height (m), and Titratable acidity (%) had the highest positive direct effects, while Pulp weight (g), Fruit size width (cm), and Fruit size length (cm) had the highest negative direct effects. Indirect effects were observed through various traits on the number of hands per bunch. The findings suggest that traits like Fruit weight (g), Pulp weight (g), Pseudostem height (m), and Fruit size length (cm) are important contributors to the number of hands per bunch.

The divergence analysis of the four clusters revealed varying intra and inter cluster distances. Cluster I had the highest intra-cluster distance (34.71), followed by cluster II (38.16), and cluster III had the highest value (48.23). Cluster IV had a minimum intra-cluster distance of zero, indicating its genotypes were very similar. The highest inter-cluster distance (108.44) was between clusters II and IV, denoting significant genetic divergence. Conversely, the smallest distance (51.94) was between clusters I and II, indicating a close relationship among their genotypes.

The cluster mean analysis across 19 traits showed distinct characteristics for each cluster. Traits like leaf blade length, fruit weight, and total soluble solids exhibited cluster-specific variations. For instance, cluster VI had the highest mean leaf blade length (256.67), while cluster II had the lowest (202.94). Cluster IV had the highest mean fruit peel thickness (5.33), and cluster I had the lowest (1.72). The analysis highlighted significant differences in mean values across all studied traits, providing insight into cluster diversity.

The first two principal components (PCs) collectively accounted for 67.83% of the total variance. PC1 explained 43.25% variance, and PC2 explained 24.57% variance. Traits strongly associated with PC1 (with loadings >0.75) included Girth size (cm), Fruit size length (cm), Bunch weight (kg), Total soluble solids (°B), Total sugar (%), and Reducing sugar (%). Traits highly correlated with PC2 (with loadings >0.75) were Fruit peel thickness (cm), Fruit weight (g), and Pulp weight (g). Traits with the most negative associations (loadings >-0.75) with PC1 and PC2 were PC1: Leaf blade length (cm), Leaf blade width (cm), Pseudostem height (m), and Titratable Acidity (%); PC2: Girth size (cm), Bunch weight (kg), No. of fingers/hand, Reducing sugar (%), and Shelf life.

CONCLUSIONS

A total of 27 Musa spp., both wild and cultivated, were traced out and collected in a random manner from various altitudes (ranging from 100 to 1600 m MSL) across districts including Chümoukedima, Dimapur, Kohima, Mokokchung, Peren, Wokha, and Tuensang in natural ecological niche in Nagaland's hilly forested regions and homestead gardens to find out the wide spectrum of variability and diversity as *in-situ*.

The collected wild genotypes encompassed Musa spp. such as *Musa aurantiaca*, *Musa balbisiana-1*, *Musa balbisiana-2*, *Musa cheesmanii*, *Musa flaviflora*, *Musa itinerans*, *Musa rubra*, *Musa sikkimensis* var. *sikkimensis*, *Musa sikkimensis* var. *simondsii, and Musa velutina.* The cultivated varieties included Dwarf Cavendish, Grand Naine, Nendran, Monthan, African Rhino Horn Plantain, Bharatmani, Bhootmanohar, Chinichampa, Kanthali, Red Banana and Meitei Hei. Moreover, an additional six genotypes with unidentified classifications were also gathered from various regions.

The variation in plant morphological and biochemical characters like TSS, total sugar and acidity were noticed in different genotypes and documented systematically.

The combined measurement of heritability and genetic advance helped in distinguishing between additive and non-additive gene actions providing insights into the potential crop improvement through selection. The high GCV value was recorded in pulp weight (g), fruit weight (g), bunch weight (kg) and titratable acidity (%). The high heritability was exhibited in total soluble solids, total sugar, fruit weight and pulp weight. The genetic advance ranged from 36.3% to 155.61% under different traits. Pulp weight exhibited the highest genetic advance followed by fruit weight. The first two PCs explained 67.83% of the total variance, with PC1 explaining 43.25% variance and PC2 explaining

24.57% variance. The highest positive direct effect on the number of hands per bunch was fruit weight, pseudostem height and acidity.

These genotypes were conserved in instructional cum experimental farm, Department of Horticulture, School of Agricultural Sciences, Nagaland University as *ex-situ* repositories gene banks. The systematic exploration and documentation of *Musa* spp. may contain useful alleles and different ploidy level that may be valuable tools for further crop improvement in future.

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