CHANDRA SHEKHAR AZAD UNIVERSITY OF AGRICULTURE AND TECHNOLOGY, KANPUR- 208 002

M.Sc. Semester I

Course : Breeding of Fruit crops (FSC-504)

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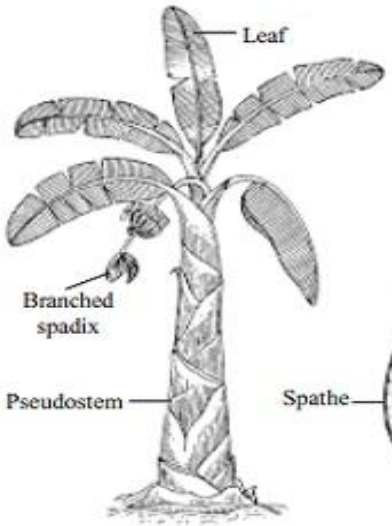
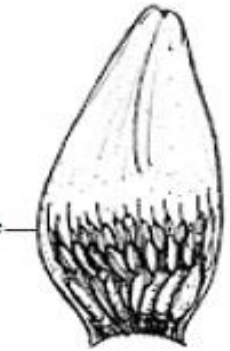
CROP IMPROVEMENT IN BANANA

History of banana breeding

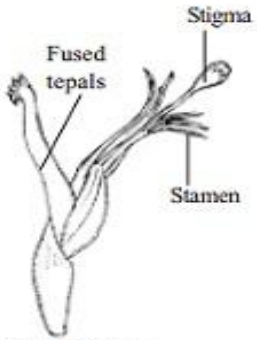
Banana breeding was started in Trinidad, West Indies in 1922 and in Jamaica in 1924 (Shepherd, 1994). The driving force for this breeding programme was to develop improved *Fusarium* wilt (*Fusarium oxsyorum* F.sp. Cubense) resistant banana for export trade. In 1960, both the programmes were combined under the Jamaica Banana Board. United Fruit Company also started a small breeding programme in Panama in 1920s. In India hybridization work was started at Central Banana Research Station, Adhuthurai, Tamil Nadu in 1949. Important banana growing states are Maharashtra, Karnataka, Kerala, Tamil Nadu, Andhra Pradesh, Orissa,Bihar, West Bengal and Assam . In recent days, in some districts of Uttar Pradesh, Harichal banana is cultivated on a commercial scale. In South India, other than its edible use, banana is extensively used in all auspicious occasions such as wedding, festivals and worshipping God. Banana is a good table fruit, besides, the cultivar Nendran is used for cooking. It is also used for preparation of chips.



Musa paradisiaca



Spathe with flowers

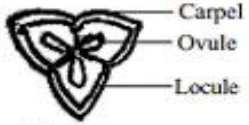


Bisexual flower

Musa paradisiaca

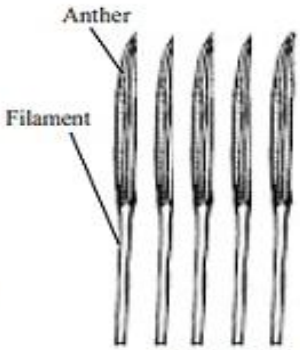
used tepals (3+2)

Inner posterior free tepal



T.S. of ovary

Spathe with flowers



Stamens

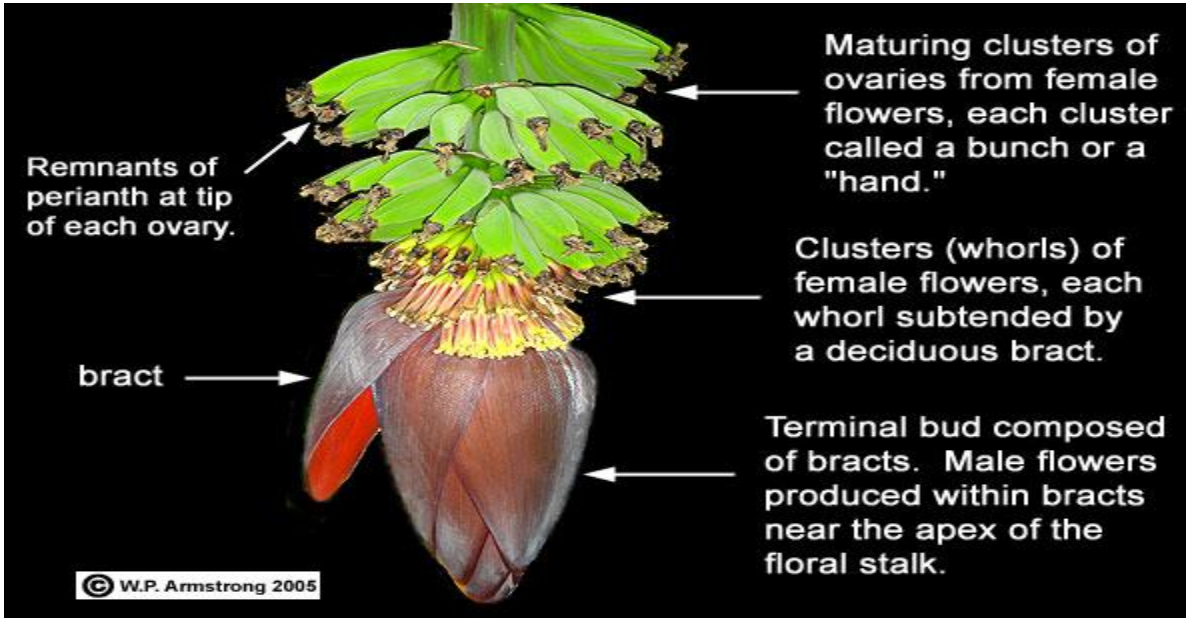
Gynoecium

Floral formula : Bisexual flower

Br., Ebrl., ⊗, ♀, $P_{(3+2)+1}$, A_{3+3}, $\overline{G}_{(3)}$.

Fig. ***Musa paradisiaca***

Floral diagram



Centre of diversity

Edible banana is native to old world especially South East Asia (Simmonds, 1962). Malayan area seems to be the primary centre of origin of cultivated banana (*M.acuminata*). *M.acuminata,* was probably introduced into India and Burma where *M.balbisiana* is a native species. Natural hybridization between these two species might have resulted in many hybrid progenies (AAB, ABB etc).

Genetic resources

Musa has about 50 species and this genus is divided into five sections:

a) **Eumusa:** Includes about 13-15 species of edible and wild banana. The chromosome number is 2n=22 in wild species and most of the cultivated varieties are having 2n=33 (2n=44 rarely) e.g. *M.acuminata*, *M.balbisiana*, *M.basjoo* etc.

b) **Rhodochlamys:** Mostly diploid, spread from India to Indonesia. Five to seven species are kept in this group. Parthenocarpy is absent in this group e.g. *M.ornata*, *M.velutina*.

c) **Callimusa:** This is of ornamental value and x=10 and 2n =20. It is found in Indo-China, Malaya and Borneo. Parthenocarpy is absent in this type. It includes about 5-6 species e.g. *M.coccinea*.

d) **Australimusa:** Like Callimusa it has x = 10 and 2n=20 chromosome. Species of this group is common in Queensland and Philippines. Important species of this group are *M. textilis* or manilahemp, *M.maclavi* etc.

e) **Incertae sedis:** It includes *M.ingens* (x=7, 2n=14) of New Guinea which grows to a height of over 10 m. This is the largest known herb. Another species in this group is *M.beccarii* (x=9, 2n=18) from North Borneo.

The most important *Musa* cultivars are almost sterile triploids (2n=3x=33) and also tetraploid and diploid banana cultivars have also local importance in Asia. All banana and plantain land races are farmers selection from intra and inter specific hybridization of two different species, *M.acuminata* Colta, donor of the A genome and *M.balbisiana* Colta, donor of the B genome. Simmonds and Shepherd (1955) reported scoring technique to indicate the relative contribution of the two wild species for the constitution of a given cultivar. Fifteen distinguishing characters between *Musa acuminata* and *Musa balbisiana* were identified by them. Score one was given for each character in which a cultivar agreed with *Musa acuminata* and score five was given for each character to which agreed

with *Musa balbisiana*. Intermediate expressions of the characters were assigned score of 2, 3, or 4 depending on their intensity.

Taxonomic Scoring of banana based on distinguishing features

Characters	***Musa acuminata***	***Musa balbisiana***
Pseudostem colour	More or less heavily marked with black or brown blotches	Blotches slight or absent
Petiolar canal	Margin erect or spreading with scarious wings below, not clasping pseudostem	Margins not winged below, clasping pseudostem
Peduncle	Usually downy or hairy	Glabrous
Pedicel	Short	Long
Ovules	Two regular rows in each locule	Four irregular rows in each locule
Bract shoulder ratio	Usually high (ratio:0.28)	Usually low (ratio:0.30)
Bract curling	Bracts roll	Bracts lift but do not roll
Bract shape	Lanceolate or narrowly ovate tapering sharply from the shoulder Acute	Broadly ovate, not tapering sharply
Bract apex	Red dull purple or yellow Inside pink, dull purple	Obtuse
Bract color	Inside bract colour fades to yellow towards base	Inside bract colour continues to base
Bract scars	Prominent	Scarcely prominent
Free tepal of male flower	Variably corrugated below tip	Rarely corrugated
Male flower colour	Creamy white	Variably flushed with pink

Objectives of breeding

- To develop dwarf statured banana suitable for high density planting and to prevent damage from high wind velocity.
- Production of good quality fruits.
- Resistant to biotic and biotic stresses i.e. nematodes, panama wilt, bunchy top, sigatoka leaf spot, moko disease and pseudostem weevil etc.
- To develop varieties with wider agro-ecological adaptability.
- Development of male fertile parthenocarpic diploids with resistance to major diseases and pests.
- Developing longer finger size.
- Suitability for export.
- Good keeping quality.

Introduction

Introduction of some cultivators of banana was made with resistance to biotic stresses e.g. Lady Finger (EC 160160) resistant to bunchy top virus introduced from Australia and is being evaluated at IIHR, Bangalore and TNAU, Coimbatore. Further, cultivars Naine MS (EC 27237) from France and Valery from West Indies were introduced for utilization in improvement programme (Singh and Rana, 1993).

Lady Finger

Hybridization

In India, breeding work was started at Central Banana Research Station, Aduthurai (Tamil Nadu) in 1949 (Sathiamoorthy and Balamohan, 1993). Afterwards breeding programme was also initiated at TNAU, Coimbatore and Kerala Agricultural University, Trichur. Technique of hybridization in banana is different from other crops. Pollination is best carried out in the morning. The bunches of female parent are bagged at shooting and each successive hand is pollinated as it is exposed. At maturity and ripening the bunch is cut and seeds are extracted. Seeds are sown at once in the green house.

Evaluation of hybrid progenies from seedlings to harvest may not be the correct phase instead, evaluation of the same under next vegetative phase i.e., sucker to harvest stage will be ideal as full expression of yield potential could be observed only in the second crop of the F_1 progeny. The first crop (seedling to harvest) takes more than 15-19 months, where most of the energy of the plants is needed for corm formation.

Three main approaches in breeding dessert bananas of the Cavendish types are:

1. 3n x 2 n superior diploid; there is no chromosome reduction in the egg cells thus yielding tetraploids
2. 4 n bred tetraploids hybrids x 2n superior diploids producing 'Natural triploids'
3. 2 n meiotic restituting clones x 2n superior diploids producing 'Natural triploids'.

Developing new diploid male parent

In many banana growing countries, initially wild diploid bananas (AA) were utilized as male parent and as a result, the resultant tetraploids had inherited many undesirable traits. Hence, it has been felt by banana breeders that the primary objective is to synthesize a good male parent. An ideal male parent must be highly resistant to Panama and Sigatoka diseases, must have vertical and compact bunch and fruits as large as the diploidy can allow and must be parthenocarpic having sufficient pollen to permit its use as a male parent. *Musa acuminata* subsp. *burmannica* and its hybrids offer a good source of resistance to black Sigatoka. One such diploid developed in Honduras is SH 2989. Other male diploids worthy to be mentioned are SH 3142 for nematode resistance and SH 3176 evolved through multiple crosses for resistance to Black Sigatoka with desirable horticultural traits.

Breeding work at TNAU

Since 1971, extensive inter-diploid crosses were made to synthesize new diploid forms at the Tamil Nadu Agricultural University, Coimbatore using the following parents:

Matti

Matti (AA) is a diploid cultivar commercially grown in the southern most part of India. It exhibits a strong resistance to Sigatoka disease but is highly susceptible to nematodes. Its bunches weigh 12 to 19kg with 9 to 10 hands containing fairly long fingers. It sets seeds when pollinated, though it is highly male sterile. This cultivar is extensively used as female parent in the diploid breeding programmes. *M.acuminata* subsp. *burmannica* has been shown to have resistance to fusarium wilt Races 1 and 2, sigatoka diseases and nematodes.

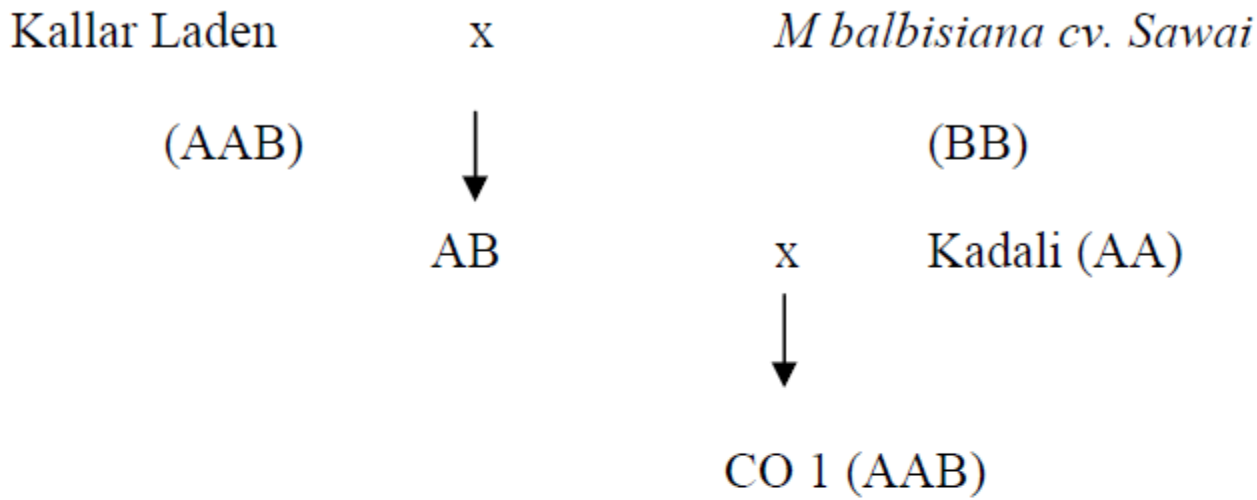
Other diploid clones involved in the diploid male parents synthesis at Coimbatore are the indigenous cultivars Anaikomban (AA) and Namarai (AA). Anaikomban is resistant to nematodes and fusarium wilt but susceptible to yellow sigatoka. It has long fingers (15

to 18 cm) and usually produces a smaller bunch weighing 6 to 8 kg. Namarai is a small slender plant, grown in Pulney and Sirumalai hills of Tamil Nadu. With small fruits having piquant flavor and pleasant acid sweet taste. It has very short pedicel. It is susceptible to both Sigatoka disease and nematodes but no incidence of Panama disease is known so far.

The introduced diploids are Pisang lilin (AA) and Tongat (AA), known for their resistance to Panama disease and nematodes.

Many synthetic hybrids (diploids) have been developed which have good horticultural characters including resistance to Sigatoka, Panama wilt and burrowing nematodes. These hybrids are now used as the male parents to cross with local triploid varieties or inter crossed to synthesise new triploid hybrids.

3n x 2n breeding programme taken up at TNAU has resulted in the development of CO_1 banana.



It is a Pome group of banana of the genome AAB and closely resembles Virupakshi (AAB), a pome type banana popular in the hills of Tamil Nadu. Presently three pre-release cultures viz., H.96/7 (akin to Karpooravalli)

At Kerala Agricultural University, two hybrids viz., BRS-1 (Agniswar x Pisang lilin) and BRS -2 (Vannan x Pisang lillin) have been developed. BRS -1 (AAB) is 100 days earlier than Rasthali with significant differences in bunch weight. It has been released for homestead cultivation in Kerala, as it is resistant to sigatoka leaf spot. BRS-2 (AAB) is a medium statured hybrid, tolerant to leaf spot and panama disease, rhizome

weevil and nematodes. The average bunch weight is 14 kg with 8 hands and 118 fruits in crop duration of 314 days.

Breeding work in other Countries

PITA-9: A Black Sigatoka Resistant (BSR) hybrid from the "False Horn" plantain, a tetraploid hybrid having black Sigatoka resistance has been developed at International Institute of Tropical Agriculture (IITA), Nigeria.'BITA-3' is a tetraploid starchy banana hybrid with low partial resistance to black Sigatoka disease developed at IITA High Rainfall Station in Onne (Southeastern Nigeria), where both (Banana streak virus) and cucumber mosaic virus (CMV) have been observed. 'BITA-3' is a hybrid from the interspecific cross 'Laknau' x 'Taju Lagada', 'Laknau' is a female –fertile AAB starchy banana that closely resembles plantains. 'Taju Lagada' is an AA diploid Banana having a long bunch with many hands. BITA-3' produces heavy bunches.

Banana breeding programme has been taken up in Honduras by the Fundacion Hondurena De Investigation Agricola (FHIA) with the aim of developing superior diploid plantations combining desirable agronomic traits with resistance, which is then used for production of primary tetraploids. This organization has developed many FHIA hybrids, which possess resistance to nematodes, Fusarium wilt etc. Introduction and testing of these hybrids in India in various centers revealed superior performance of FHIA-1, FHIA-3, FHIA-21 and FHIA-25.

Mutation breeding

Bud mutation in Indian banana is very common perhaps due to spontaneous rearrangement of chromosomes in somatic meristem and structural re-assortment. A great majority of edible bananas are triploids, a condition that interferes with normal equilibrium of plants and may provide the requisite stimulus to structural rearrangement of chromosomes, leading ultimately to the evolution of a new gene complex. Several natural sports of well established commercial clones have been recognized e.g) High gate (AAA) is a semi-dwarf mutant of Gros Michel (AAA), Motta Poovan (AAB) is a sport of Poovan (AAB), Ayiranka Rasthali a sport of Rasthali (or Silk), Barhari Malbhog is a sport of Malbhog, Krishna Vazhai is a natural mutant of Virupakshi (or Pome), and Sambrani Monthan (ABB), a mutant of Monthan (ABB).

In Nendran, more than six mutants have been recognized. One of these, Moongil, has undergone such a radical change that there is no male phase and a bunch has only one or two hands with biggest size fruits. Attu Nendran, Nana Nendran, Myndoli, Velathan and Nenu Nendran are a few mutants which have been selected for one or the other desirable character. Similarly, Ambalakadali and Erachi vazhai are mutants of Red Banana. The Kunnan variety of Malabar has provided a few mutants known as Thattilla Kunnan (male phase absent), Veneetu Kunnan,


Nendran

Adakka Kunnan and Thaen Kunnan. From cv.Monthan, Sambal Monthan, Nalla Bontha Batheesa, Sambrani Monthan, Pidi Monthan and Thellatti Bontha have been recognized as sports. At INIVIT, Cuba induced mutations of ABB cooking banana, Burrow Cemsa, was obtained (Rodriguez Nodals *et.al*., 1992). At TBRI, Taiwan, Tai Chiao 1 and GCTV, triploid bananas with Fusarium wilt resistance are obtained as a result of clonal variation of AAA Cavendish banana (Hawang 1991, Hwang and KO, 1988, 1989). The early flowering FATOM 1 was developed as a result of *in vitro* gamma irradiated meristem culture of cv.Grand Naine has been released in Malaysia.

Biotechnology

Plant tissue culture and molecular biology techniques are applied to enhance the handling and improvement of banana. Important application of a cell biology are micro propagation for rapid multiplication and germplasm exchange, embryo culture/rescue for in-vitro seed germination, cryopreservation of germplasm and genome manipulation through genetic engineering using cell suspensions or protoplast culture. Although, Vylsteke et al. (1996) reported that somaclonal variation through micropropagation is of limited use in plantain breeding, it has been successfully applied in Taiwan for the development of improved Cavendish banana cultivars with resistance to Fusarium wilt and acceptable fruit quality (Hwang 1991, Hwang and Ko, 1989). In gene transfer methods, Sagi *et al*. (1995), from Katholieke University, Leuven. Belgium reported that the transgenic triploid cooking banana showing transient expression of GUS marker gene in pot growing in the green house from DNA particle bombardment on ABB cooking banana. The molecular markers are providing tools for phylogenetic investigations and cultivar identification, basic genetic research, marker assisted selection and diagnostics in pathogen identification.

Source of resistance

Name of the clone/cultivars	Name of the biotic and abiotic stress
Musa balbisiana	Drought
Calcutta-4	Black sigatoka
Pisang Lilin	Panama wilt (Race1)
SH3142 (Diploid hybrid)	Race 1 of *Fusarium*
Musa acuminata sp malaccensis	Race 1 and Race 2 of *Fusarium*
Musa acuminata sp burmannica	Bacterial wilt race 2, Moko disease
Pisang Jari Buaya (PJB)	Burrowing nematode
Tongat and Anaikomban	Nematodes