

## GENETIC DIVERSITY OF BANANA IN INDIA

H. P. Singh and S. Uma

National Research Centre on Banana, Trichirapalli - 620 017

### ABSTRACT

Long period of domestication under varying growing conditions in addition to intraspecific, interspecific crosses have created high diversity in Indian bananas. As a result, our country is the major centre of diversity especially for banana belonging to AAB and ABB clones. *Musa acuminata* cv. Burmanica, one of the earliest collections raised in Calcutta Botanical Gardens has become the major donor source for leaf spot resistance in many breeding programmes. Therefore, at National Research Centre on Banana, collection, conservation, evaluation and utilization of genetic diversity has received greater emphasis. A total of 587 accessions are conserved in field genebank. In-vitro conservation has been successful, which need refinement. Tissue culture protocol has been developed for in-vitro multiplication of banana accessions belonging to different genomic groups and ploidy levels. Evaluation using 120 characters for a large number of accessions has been completed and data base is being developed. Apart from morpho-taxonomical evaluation, germplasm has also been evaluated with respect to disease resistance, salt tolerance and post-harvest characters. *Musa* clones from North-Eastern Region have been classified using morpho-taxonomical characters. Many of the field genebanks of South India are found to be infested with banana bract mosaic and other viruses which warrant cleaning and safeguarding the gene pool. Thus, for safe exchange of germplasm indexing against virus has assumed significance at the centre. Status of genetic resources of banana in light of work done is discussed.

### INTRODUCTION

Antiquity of banana is traced back to the oldest days of cultivation and is among the oldest fruits cultivated by man. Evolution theory of present-day bananas recognizes South-East Asia, (Simmonds, 1962), especially Malayan Archipelago as the centre of origin for *acuminata* or dessert bananas and India forms the major centre of origin for bispecific clones like AB, AAB and ABB genomes. But identification of *Musa schizocarpa* has added a new dimension to the present theory (Horry, 1992).

In India, genetic diversity in *Musa* is concentrated in North-Eastern Himalayas, western-ghats and southern tips. Indigenous *Musa* wealth of bispecific origin has been enriched by new genomic groups like pure *acuminata*, which transgressed through national boundaries and then diversified with ethnic diversification usage preferences and cultivation systems. Influx of the genetic material coincided with outward geneflow to African and Mediterranean countries through ancient traders and religious missionaries, thus spreading Indian originated bananas especially plantains.

For the prevailing diversity, the course of evolution is suggested to be, (i) evolution of

parthenocarpy and sterility in diploid *acuminata*, (ii) outcrossing of edible diploids of *M. acuminata* to wild *M. acuminata* and *M. balbisiana*, (iii) occurrence of triploidy due to haploid pollination of diploid female cells, and (iv) occurrence of triploidy followed by haploid pollination and diversification by somatic mutation.

### TAXONOMIC STATUS

Earliest description of dessert banana *Musa sapientum*, and plantain *Musa paradisiaca* were suggested by Linnaeus in 1783. Considering many overlapping characters between these two, monospecific nomenclature as *M. sapientum* ssp. *paradisiaca* by Baker (1873), *M. paradisiaca* subsp. *sapientum* by Schumann (1900) and *M. sapidisiaca* by Jacob (1952) were suggested, which could not be accepted by taxonomists. More meaningful classification of genus *Musa* into four sections as *Callimusa*, *Rhodochlamys*, *Australimusa* and *Eumusa* was given by Cheesman (1948). Subsequently Linnaean binomials, *M. sapientum* and *M. paradisiaca* were abolished and both the species and clones were described utilizing the knowledge of cytotaxonomy. In this system, *M. acuminata* Colla was used to describe pure seedless, diploid (AA) such as Matti and triploid (AAA) like Robusta forms of banana, *M. balbisiana* Colla was applied to pure *balbisiana* cultivars and their hybrids, which described as *Musa* (AB) Kunnan, *Musa* (AAB) Rasthali, Nendran, Poovan and *Musa* (ABB) Monthan, Peyan etc. *Musa* assemblage at Coimbatore was studied (Bhakthavatsalu and Sathiamoorthy 1979) and clones were grouped adopting the systems of Simmonds and Shepherd (1955).

Diversity in Indian bananas of various regions has been described by various people (Jogiraju, 1931; Jacob, 1934; 1942a; Venkataramani, 1946; Chakravarti, 1948b; 1951; Chandraratna, 1951; Gandhi, 1952; Dutta, 1952; Nayar, 1958) with limited knowledge about their taxonomy. But with present understanding, efforts are made in this paper to study the *Musa* gene pool and classify accordingly.

### GERMPLASM COLLECTION AND CONSERVATION IN INDIA

#### Wild species

*Musa* is the only genus in the family Musaceae having been explored in the Indian subcontinent. However, 10 species representing *Eumusa* (7 species) and *Rhodochlamys* (3 species) were reported (Chakravarti, 1948; Simmonds, 1962). *Musa acuminata* Colla, *M. balbisiana* Colla, *M. flaviflora* Simmonds, *M. itinerans* Cheesman, *M. nagensium* Prain, *M. sikkimensis* Kury and *M. cheesmanii* Simmonds represent the *Eumusa* ( $2n = 2x = 22$ ); whereas erect bunching colourful and ornamental *M. ornata*, *M. velutina*, *M. sanguinea* represent *Rhodochlamys* section ( $2n = 2x = 22$ ).

#### Collection

Earliest taxonomic references were made by Baker (1873), and Schumann (1900) mentioned 42 species in his monograph, of which 10 belonged to the genus *Phyllocaulis*, 20 to *Eumusa* and 12 *Rhodochlamys*. Roxburg made the earliest collections and assembled for studies at Botanical Gardens at Howrah (West Bengal). This mainly included the seeded types collected from Chittagong (Bangladesh) and Madras Province. In 1942, ICAR



sponsored the first programme on 'Cytogenetics of mango and banana', in which members of *Musa* were collected from different parts of the country at Calcutta University. Species belonging to different subgenera growing wild in their natural habitat were collected and studied (Chakravorti, 1948b). Simultaneously explorations made in south India by Jacob resulted in publication of monograph *South Indian Banana* in which varieties have been described. A systematic collection and study of *Musa* assemblage were carried out through coordinated Banana Research Scheme at Aduthurai funded by ICAR in 1949, through which a large number of south Indian varieties were collected, studied and described (Venkataramani, 1949; Nayar, 1957; Nayar *et al.*, 1954, 1952, Gandhi, 1952). But none of these collections was equipped with a detailed passport data.

In 1971, the ICAR-funded banana project was shifted to Coimbatore under All India Coordinated Research Project (AICRP), where in 243 accessions belonging to various genomes were assembled for further studies. At Banana Research Station, Kannara, 190 accessions are being maintained under sub-tropical humid conditions for detailed studies. Indian Institute of Horticultural Research (IIHR), Bangalore has 240 collections of various genomes and all these three places were recognised as *Musa* genebanks in India (Amalraj, 1993). Apart from these, Kovvur, Andhra Pradesh Agricultural University (APAU), Gujarat Agricultural University, Gandevi; and Jorhat, Assam Agricultural University have some collections. *In-vitro* base collection is being maintained at NBPGR with 120 collections (Chandel and Agarwal, 1996).

#### Conservation

Though *in-situ* conservation has been made possible for other fruit crops like citrus and mango, in banana this concept has not taken proper shape for conserving wild varieties in natural state. In India, *Musa* germplasm is mainly conserved in field genebank with eight locations spread in various agroclimatic conditions of the country. In all the locations, accessions are maintained with four replications under prevailing production systems. Of eight centres, in National Research Centre on Banana (NRCB), Trichy; Indian Institute of Horticultural Research (IIHR), Bangalore; Banana Research Station (BRS), Kannara; and Tamil Nadu Agricultural University (TNAU), Coimbatore, germplasm has been described, characterized, classified and maintained and in others they are maintained as working collections (Singh and Chadha, 1993).

*In-vitro* conservation of *Musa* base genebank for utilization in germplasm movement and acquisition of material for propagation and dissemination has proved very essential (Jones, 1993). In India, *in vitro* *Musa* base genebank exists at NBPGR, New Delhi, which acts as a repository of banana germplasm. Here 120 accessions are being conserved belonging to various genomic groups under slow growth conditions (Chandel and Agrawal, 1996). Active genebanks exist at Indian Institute of Horticultural Research (IIHR), Bangalore; and National Research Centre on Banana (NRCB), Trichy; where as at NRCB germplasm management is done *in-vitro* for various commercial clones (Anon, 1996). Virus indexing has been emphasised keeping in view the safe movement and exchange of planting material (Stover, 1987).

#### DISTRIBUTION OF SPECIES AND CLONES

Earlier literature and collection missions reveal the availability of wide *Musa* diversity in North-Eastern regions, Western Ghats and southern tips of India (Hooker, 1894; Schumann, 1900; Chakravorti, 1948a; Sundararaj, 1955; Krishnamurthy and Seshadri, 1958, Bhaktavatsalu and Sathiamoorthy, 1979). Except for *acuminata* and *balbisiana*, most of the other species belonging to *Eumusa* and *Rhodochlamys* are restricted to North-Eastern India (Nayar, 1952). Chakravorti (1951) collected two erect-fruited species which later were identified as *M.ornata* and *M.velutina*; these were earlier described by Schumann (1900) in his monograph. Two more species also recognized and described by Chakravorti (1950) are *M.superba* and *M.gigantra*, found to occur between the Eastern and Western Ghats. Exploration in the foothills of Himalayas led to the identification of *M.nepalensis*, belonging to the then order Physocaulis. Nayar (1952) collected a banana clone from Singampatti hills in Tirunelveli (Tamil Nadu), growing at an elevation of 1,200 to 1,500 m; and recognized it as *Musa banksii* (ssp. *muella*). Undoubtedly, it was a mistaken identity due to the presence of some pollen in the basal female flowers. *Musa banksii* var. *singampatti* is remarkably similar to subspecies *burmannica* of *M.acuminata* (Bhaktavatsalu and Sathiamoorthy, 1979). Distribution of subgenera *Eumusa* and *Rhodochlamys* is widespread. Two species of *Eumusa*, namely *Musa balbisiana* Colla and *Musa acuminata* Colla are widely distributed. Sundararaj (1955) recorded the occurrence of fertile species similar to *M.acuminata* growing in Nilgiri-Wynaad. Wild form of *Musa acuminata* is also reported to occur in Peninsular India, especially in Western Ghat (Bhaktavatsalu and Sathiamoorthy, 1979) and North-Eastern region of the country, especially Assam (Krishnamurthy and Seshadri, 1958). Apart from these, many *Musa* species are reported to occur in the country. Chakravorti (1948a) reported the occurrence of non-stoloniferous species of *Musa* in Chittagong hill (now in Bangladesh) and identified it as *Musa agharkarii*. Sundararaj (1955) recorded *Musa acuminata* subsp. *burmannica* and *Musa laterita* from South India and *M.ochracea* from Western India are also reported (Bhaktavatsalu and Sathiamoorthy, 1979). Simmonds (1962) reported the presence of *M.cheesmanii* Simmond and *M.flaviflora* in Assam, *M.sikkimensis* Kurz in Manipur, Assam and Sikkim. In *Rhodochlamys* group, *Musa ornata* Roxb. is observed in Chittagong hill tracts, Bihar and peninsular India. *M.velutina* Wendl. & Drunde and *M.sanguinea* Hook are reported from Assam (Simmonds, 1962). Thus it appears that section *Eumusa* and *Rhodochlamys* are well represented in India, whereas *Australimusa* and *Callimusa* are not found. *Musa balbisiana* Colla has been recorded as such for a long time (Krishnamurthy and Seshadri, 1958) found growing in different parts of south India, and is referred to as Elavazhai in Tamil Nadu, Ginjali Arati in Circar of Andhra Pradesh and Kallu Bale in South Kanara of Karnataka (Venkataramani, 1949). It is also found in North-Eastern region and is known by different names like Til Atti, Athiakol, Bhimkol etc. and their ploidy status requires confirmation.

Polyclonal system of growing banana in India is predominant owing to the regional preferences. The best variety of one region may not be the best in other region. Nendran (AAB) banana is grown in Malabar from time immemorial; it led to believe Jacob (1952) that it is indigenous to Malabar, which has not appreciably spread towards Bengal and Assam. The obvious detection of Nendran (syn. Rajeli) in Western Coast of India, Moongil



and Ottamukil found in south India are similar to Nendran (Venkataramani, 1948), and are considered to be the mutant. Many ecotypes of Nendran have been recognized, such as Attu Nendran, Thiruvodan, Nedu Nendran, Chegazhikodan, Kudiravali, Velathan and Myndoli (Nayar *et al.*, 1957b).

Dutta (1952) described 19 varieties of edible banana in Assam. Kulpit or Malbhog of Assam is similar to Rasthali of south India. Champa and Chini Champa described from Assam are also found growing in Bihar (Shukla and Roy, 1956). Manohar and Kait Kjun of Khasi hills, Okthoman of Garo hills and seeded Bhimkol are unique to Assam. Bhimkol is most commonly grown in almost every home as every part of this plant is used. Matchok Grong, Digjowa and Jatikol are normally restricted due to varying size of fruit. All these cultivars appear indigenous to Assam. However, Jahaji, similar to Dwarf Cavendish, appears to be an introduction. Bor Jahaji akin to Robusta is also commonly found, particularly in lower Assam. Gandhi (1952) described the cultivars of banana, their history and nomenclature. Harichal or Bombay Green (syn. Robusta), Basrai (Cavendish), Lal Velchi (Red Banana), Safed Velchi (syn. Ney Poovan) and Rajapuri and Rajeli (syn. Nendran) are commonly grown cultivars. By and large, Dwarf Cavendish (Basrai) is predominantly grown for commerce in West-Central India.

Poovan, AAB (Mysore), is by far the most popular cultivar and Monthan, ABB (Bluggoe) is the common cooking banana. In the last few decades cultivar distribution has changed. Dwarf Cavendish and Robusta have become popular in commerce and the distribution pattern shows a predominance of Cavendish group for commercial cultivation.

#### Commercial cultivars

India harbours a wide range of *Musa* cultivars with varying genomic status. Most of the AA diploids are nurtured with care in backyards, whereas one of the AB diploids, Ney Poovan, is attaining commercial status and with monoculture Kunnan groups are cherished as baby food. AAA and AAB genomes are the basis of commercial production in India, especially Dwarf Cavendish (AAA) and Poovan (AAB) apart from Rasthali and Nendran. ABB are still the relished vegetable of traditional dining. *Balbisiana* clones of North-Eastern India are used for their medicinal applications.

**Dwarf Cavendish (AAA)** *Basrai, Bhusawal, Jahaji, Kabuli, Pacha Vazhai, Mauritius, Morris, Kuzhi Vazhai, Sindhurni, Singapuri*

It is a commercial cultivar of Gujarat, Maharashtra, Madhya Pradesh, Bihar and Karnataka. Increased productivity of these states is attributed to high-yielding Dwarf Cavendish. It is also popular in Tamil Nadu and Andhra Pradesh.

Plant is very dwarf, extending 1.5 m above the ground level. Pseudostem is stout, attaining a girth of 75-80 cm with brown-black large blotches of conspicuous size spread all over the pseudostem. Leaves are clustered at the crown with short internodes. Winged petioles have widely open canal not clasping the pseudostem. Inflorescence is pendulous, borne on a short hairy peduncle. Female phase has 8-12 hands at regular intervals. Unlike female phase, male rachis is put forth at an angle and is characterized by persistent bracts and male flowers just above the heart (male bud). Fruits are borne in clusters of 16-24 with a short pedicel and

blunt tip. Bunch is cylindrical, fruits are yellowish green in colour in tropics and in subtropics with brownish dots all over them. Several superior clones under this group have been identified and are under advanced stage of evaluation. Gandevi selection known as 'Hanuman' or 'Padarse' is gaining popularity despite its longer crop duration. The selection produces bunch weighing 55-60 kg and performs better under light soil condition with higher inputs.

Though Dwarf Cavendish is a high yielder, it is highly susceptible to leaf spot disease in humid tropics, restricting its commercial cultivation.

**Robusta (AAA)** *Bombay Green, Pedda Pacha Arati, Harichal, Borjahaji*

This semi-tall, sport of Pacha-Vazhai is the cultivar of commerce in Karnataka, Andhra Pradesh and parts of Maharashtra.

Plant is medium-tall, reaching a height of 2.0-2.25 m with a strong pseudostem. It is covered with unevenly spread black blotches all along its length. Leaves are dark green on inner surface and dull on outside. Petiolar wings do not clasp the pseudostem. Inflorescence is pendulous, emerging 10-11 months after planting. Female phase puts forth 10-12 hands of fertile flowers, developing into dark green, upcurved fruits. Each hand has about 16-24 fruits arranged in two rows. Bunch weight is about 25-30 kg. Pedicel is short and fruit is blunt. Male phase is at an angle to the main axis and has few (5-6) persistent bracts just above the male bud. Dark green fruits turn bright yellow upon ripening depending on ripening conditions. Fruit is very sweet with a good aroma.

Propping requirement makes the crop investment intensive, added with high susceptibility to sigatoka leaf spot in humid tropics. Fruit has poor keeping quality, leading to breakdown of pulp after ripening, not suited for long-distance transportation.

**Rasthali (Silk AAB)** *Rasabale, Malbhog, Amrithpani, Saapkal, Rasakeli, Mortman, Poovan (in Kerala)*

Rasthali is the choicest variety in all banana-growing states especially Tamil Nadu, Andhra Pradesh, Kerala, Karnataka and Bihar. It is also grown in patches in Maharashtra and North-East Region.

Rasthali is medium to tall-statured, reaching a height of 2.5 - 3.0 m above the ground level; 70-80 cm thick pseudostem is yellowish green, blotches appearing only at the base of petiole on both sides. Leaves are pale green with wax coating on under surface, attaining 150-175 cm length and 60-75 cm width. Leaf petiole has a narrow petiolar canal and a narrow margin with conspicuous pink tinge. Inflorescence emerges 12-14 months after planting, bearing a bunch of 15-20 kg. Female phase has 67-80 hands with 12-16 fruits. Hands are widely spaced on the rachis. Both male and female phases are at an angle of 45° to the main axis. Male phase is unusually long for an AAB group and ends with a large male bud, which is conspicuously maroon red in colour. Male flowers are characterized by pink-dotted style neck typical of silk group. Fruits are yellowish green throughout their development, but turn pale yellow and golden yellow on ripening. Fruit is very tasty, crisp, good sour-sweet blended, pleasant flavoured, firm in texture and wrapped in a paper-thin peel. Rasthali, the choicest



table variety, is threatened by the dreaded disease Fusarium wilt, which has limited its cultivation. Fruits detaching at ripening limit this variety for long-distance transportation.

**Poovan (Mysore AAB)** *Alpon, Champa, Cheni Champa, Dora Vazhai, Manga Pazham, Karpura Chakkarakeli, Mysore, Palayankodan.*

Poovan is the common cultivar grown all over the country in perennial cropping system of cultivation. It is the leading cultivar of all Southern states and North-Eastern region.

It is a medium-statured plant, reaching a height of 2.5-3.0 m and has a stout pseudostem. Pseudostem is pink pigmented with vertical black blotches spread over it. Pink pigmentation continues on under surface midrib of leaf. It comes to harvest 15-16 months after planting. Bunch is cylindrical with closely packed, short, stout and conspicuously beaked fruits. Female phase has 12-15 hands each with 12-16 fruits. Rachis is bare without any persistent male flowers or bracts. Fruit is slightly acidic, firm and has typical sour-sweet aroma. At maturity fruits are dark green, turning to attractive golden yellow on ripening.

The ease of cultivation and hardiness to abiotic factors makes Poovan a popular cultivar. But it is predominantly infected by banana streak virus (BSV), causing reduction in yield over generations.

**Nendran (Plantain AAB)** *French plantain, Rajeli, Bhorot*

It is believed to have originated in southern India, from where it had spread to Africa and diversified. It is a popular variety of Kerala, where it is relished as a fruit and fried chips. Commercial cultivation of Nendran has picked up in Tamil Nadu in the recent past.

Nendran is a slender, medium-statured variety. Stem is yellowish green with pink tinge, reaching a height of 2.3 - 2.6 m above ground level. Leaves are leathery and shiny, young suckers have pink blotches which disappear with age. Inflorescence emerges by 9th month and bunch matures 11 months after planting. Bunch has 4-6 hands each with 8-10 fruits, weighing about 8-14 kg. Male axis is covered by persistent male flowers and bracts. Fruits have a distinct neck with thick green skin turning buff yellow on ripening. Fruits remain starchy even on ripening. Skin turns black upon full ripening but does not drop off.

A number of ecotypes are known: Nendran Zanzibar, Otta Moongil, Moongil (horn plantain), Kalethan, Velathan (wine plantain), Manjeri Nendran, Chengali Kodan, Nedu Nendran, Chenganacheri Nendran, Attu Nendran, Nana Nendran, Myndoli, Padali Murian, which have perhaps originated as bud mutants. Other types are "Anil Vazhai", a variegated mutant with young leaf and fruit showing different degrees of variegation. Tiger plantain has fruit spotted with round black circles. Moongil (Zanzibar, Otta Moongil, Horn plantain) is a typical ecotype of Nendran characterized by the absence of male phase. Female phase has only one or two hands, rarely three with 10-12, 1 foot long and big fruits. Fruits are angular (5 ridges), somewhat flattened, slightly curved with conspicuously longer beak. Beak tapers in a gradual manner. Skin is tough and thick, enclosing golden yellow pulp. Though it has exceptional keeping qualities, taste is medium with sugar content less than 22°Brix. Due to poor quality, less consumer preference and low yield, it is yet to become a commercial variety.

Myndoli (Giant plantain) is a robust form of Nendran, reaching a height of 2.75 to 3.0 m. Pseudostem is stout and strong. Plant is a heavy yielder with a bunch weight of 20-28 kg with 6-8 hands. Fruits are light green in colour, each weighing up to 150-200 g. It is a heavy feeder, requiring double the dose of fertilizer given to Nendran. Rest of the plant characters are similar to Nendran. Chengazhikodan has the tastiest fruit. Veliethan (Wine plantain), a distinct ecotype of Nendran with deep red pseudostem, petiole and midrib, is favoured as backyard variety of central Kerala (Travancore). Fruits are dark green in colour, comparatively smaller than Nendran. Pulp of the genome develops to deep golden yellow upon ripening. Kaliethan from same region has hard flesh. Attu Nendran thrives even under rainfed conditions, whereas Nana Nendran is grown under irrigation.

Manjeri Nendran is characterized by green and robust pseudostem as against pink pigmented lanky pseudostem typical of other Nendran ecotypes; it is popular in northern Kerala. Pseudostem, petiole and undersurface of leaves have wax coating. Fruits are pale green and curved. Bunch weighs about 12-13 kg.

Nedu Nendran is commercially important in Cauvery delta of Tiruchirapalli (Trichy), Thanjavur (Tanjore) and southern tips of Tamil Nadu. Fruits characteristically lack curvature and are placed almost at right angles to the bunch axis. Plants grow tall and need support at fruiting. Bunches weigh 12-15 kg with 5-6 hands.

**Hill Banana (Pome, AAB)** *Virupakshi, Sirumalai, Malavazhai, Vannan, Marabale, Ladan*

It is an elite variety of south India, especially grown on Palney and Sevroy hills of Tamil Nadu under perennial cultivation. It is also relished in Karnataka, Kerala and Andhra Pradesh and is grown only in patches. It is a tall, strong and sturdy plant reaching a height of 3.0 - 3.50 m. Pseudostem is greenish yellow with dark blotches spread all over, especially at the petiolar base. Inflorescence takes 12-13 months to emerge and is horizontal to the main axis. Only male phase is pendulous, ending with a top-shaped heart (male bud) enclosed by maroon-red bracts. Rachis itself is purple pigmented, which intensifies towards the male flower. Male axis is short and has whip-like ending. Male flowers have typical twisted (once or twice) style. Fruits are angular (4-5 ridges), somewhat flattened, thick skinned and are loosely arranged on the female axis. Fruits turn yellowish green on ripening, with cream coloured pulp having distinctive flavour.

**Red Banana (AAA)** *Lal Kela, Chenkadali, Chevvezhai, Yerra Arati, Chandra Bale, Kembale*

Red Banana is the most relished and highly prized variety of Kerala and Tamil Nadu. Its commercial cultivation is prominent in Kanniyakumari (Kanyakumari) and Tirunelveli districts of Tamil Nadu. It is also popular in Karnataka, Andhra Pradesh and to some extent in Western and Central India.

As the name indicates, it is characterized by uniformly purple red pigmented pseudostem, leaf pedicel and bunch peduncle. Plant is a robust, tall variety, growing to a height of 2.75 - 3 m. Black circular blotches are seen on the lower half of the pseudostem, which either



reduce in size or disappear at crown region. Basically a shy-yielder but has the potential to yield 30-40 kg bunch under favourable conditions. Bunch is oriented at 45° angle to the pseudostem, female axis has 5-8 hands with 12-14 fruits/hand. Fruits are slightly curved, with blunt beak and thick skin and pulp is sweet, orange yellow coloured and with a pleasant aroma.

**Venkadali (AAA)***Green Red, Pacha Kappa, Ney Vazhai*

This is the bud-sport of Red Banana with normal green pseudostem and fruit instead of red. Unripe green fruits turn yellow upon ripening with the disappearance of ribs. Fruit texture, colour and taste remains akin to Chenkadali. This finds place in backyard gardens.

**Monthan (ABB)***Bontha, Karibale, Bainsa, Kashkal.*

It is a widely distributed variety in all the banana-growing states. Backyard cultivar of earlier days, it has become popular in commercial cultivation owing to its acceptability among users.

Monthan is a fairly tall and robust plant, growing to a height of 10-12 feet. Stem is water green, shiny, lacks pigmentation. It is a short-duration crop, coming to harvest in 12 months with early ratooning capacity. Inflorescence is pendulous with a smooth peduncle as long as 40-50 cm. Fruits are borne in clusters of 12-14 fruits in 5-6 hands fruits each. Bunch of 60-70 fruits weighs about 20-22 kg. Fruits are bold, stocky, knobbed and pale green in colour. Male phase is characterized by a bold bud and a comparatively shorter rachis. Apart from culinary use of its fruits, pith is a highly relished vegetable with many medicinal properties. Male flowers without stamens are also a popular side dish. Few allied members of Monthan are suited for making chips.

**Ney Poovan (AB)***Elakki Bale, Njali Poovan, Safed Velchi, Cheeni Champa, Hoobale, Ney Kadali, Vadakkan Kadali, Elarasi, Deva Bale*

Ney Poovan is the unique diploid, assuming commercial monoclonal cultivation on a large scale, especially in Karnataka. It is also popular in Tamil Nadu, Bihar and Maharashtra.

It is a slender medium-tall plant, assuming a height of 2.25-2.75 m. Stem is thin, slender and yellowish green in colour with an uneven spread of brown black blotches. Leaves are erect and narrower with a yellowish green pedicel. Inflorescence emerges 9-10 months after planting and the female axis is horizontal to the main axis. It bears about 10-12 hands with 14-16 fruits-hand. Fruits are small, slender with a prominent beak, are packed closely round the axis, having a wind-blown appearance. Unripe green fruits turn bright yellow upon ripening, pulp is ivory white in colour, being firm in nature. It is known for its good keeping quality and non-detaching nature of fruit from the bunch, making it suitable for long-distance transportation. Male axis ends in a lanceolate male bud with regular pink flowers having their compound split into two. Stamens have pollen and style is bent.

**Karpuravalli (ABB)***Kanthali, Pey Kunnan, Bhat Manohar, Pisang Awak, Boodida Bokkisa, Jhurmani, Kostha Bontha*

It is a popular variety in medium rich soils. Its commercial cultivation is spread in central and southern districts of Tamil Nadu and Kerala. In Bihar, cultivation is in patches under the name Kanthali.

Plant is tall, robust, growing to a height of 3.0 - 3.25 m. Pseudostem has a circumference of about 1 m with light pink streaks, which continue up to two-thirds of the pseudostem height. Leaves are dark green in colour with conspicuous veins and incurved lamina all along the margin. Inflorescence emerges in 12-13 months after planting and bunch is harvested after 15-16 months. Bunch is pendulous and so is the male axis. Bunch weighs about 25-30 kg with neat geometrically oriented 12-15 hands, each with 12-16 fruits. Fruits are ash coated, medium-sized and have a conspicuous beak. Pulp is white, firm and very sweet. Fruits have a long keeping quality and they do not drop off upon ripening rendering, it suitable for long-distance transportation.

This dual-purpose hardy crop is suited for drought, salt-affected areas, for low input conditions.

**Matti (AA)**

It is nurtured in salubrious climate, and is grown largely as backyard variety in southern districts of Tamil Nadu especially Kanyakumari and Tirunelveli.

It is medium-sized, slender plant. Grows to a height of 2.0 - 2.5 m. Yellowish green pseudostem has brown blotches spread unevenly. Leaves are pale green in colour. Inflorescence emerges 12-13 months after planting and is horizontal to the main axis. Peduncle is very short and fruits appear right from the axil of the leaves. Female phase has 8-15 hands and each hand has 14-20 fruits.

This slender plant has the potential to put forth a bunch as heavy as 25 kg. Male axis has 5-8 persistent male flowers just below the bunch and is inclined at an angle of 45°. Male flowers are white in colour. Fruit is thin and slender with a conspicuous beak. Pulp is juicy, very sweet, cream coloured with characteristic aroma.

**Thella Chakkarakeli (AAA)** *Chakkarakeli, Honda, Rajabale, Raja Vazhai, Leyon, Kere*

It is a choicest backyard cultivar of Tamil Nadu, Kerala, Karnataka and North-Eastern Region and occupies commercial significance in Andhra Pradesh especially in Godavari delta.

Plant is medium-statured and delicate. They grow to a height of 2.25 - 2.4 m above ground with greenish yellow pseudostem covered with uneven array of brown blotches. Leaves are pale, attached to the pseudostem with a yellowish pedicel. Petiolar wings are broad and with a conspicuous reddish pink margin. Inflorescence is put forth 10-12 months after planting which has 45° orientation with the main axis. Female phase has 4-6 hands each with 12-14 short, stout and stocky fruits. Male phase has 5-6 hands of persistent male flowers just below the fruiting hands. Male bud is bold, covered with unequal pink coloured bracts. Male flower is cream coloured with lot of nectar. Fruits are characteristic greenish yellow in colour which when ripe turn golden yellow. Pulp enclosed in a thick skin is firm, very sweet, juicy with characteristic aroma.



**Sakkai (ABB) :** *Chakia, Gauria, Muthia*

It is commercially cultivated under low-input conditions owing to its tolerance to drought as well as salt and nematodes. It is a dual-purpose fruit in Bihar and southern states of Tamil Nadu and Kerala. Commercial plantation of Sakkai are seen in Madurai, Tirunelveli and Kanyakumari districts of Tamil Nadu.

Chakia has medium-tall plant with sturdy pseudostem, growing to a height of 2.75 - 3.0 m. Blotches are seen sparsely spread on the pseudostem. Plant takes 12-14 months to come to harvesting. Inflorescence is pendulous, female axis has 5-8 hands each with 12-14 fruits. Bunch weighs about 15-18 kg. Fruits are short, stout and have no knob; thus it is grouped under 'bluggoe'. A small inconspicuous beak is uniformly green coloured without any cap. Fruits are of dual purpose, both culinary and dessert. Fruit skin peels off easily from the fruit and is 0.3 - 0.4 mm thick. Green Sakkai also has an ash-coated mutant, which is similar to Sakkai in all aspects except for the ash coating of fruits.

**Bhimkol (M. balbisiana, BBB)**

Restricted to the hilly tract of North-Eastern Region it is the tallest and most robust plant recorded among Indian cultivars, named after Bhima, who was the most robust person in ancient times. It grows as tall as a coconut tree, reaching a height of 4.0 - 4.55 m. Pseudostem is uniformly pure green in colour without any blotches or pigmentation. Leaves are dark green and shiny. Inflorescence emerges only 16-17 months after planting. It is pendulous, having a female phase with 6-8 hands and 8-12 fruits in each hand. Bunch weighs about 20-25 kg. Male phase has bare rachis without any persistent bracts of flowers. Fruit short, stout, stocky and has a conspicuous bottled neck. Ridges are prominent; green colour of raw fruit turns golden yellow on ripening. Fruit is full of seeds with a layer of pulp around it and each fruit has 50-200 seeds, capable of germination. Both the time for maturity and time to ripe are longer.

Bhimkol is the most useful variety grown in North-Eastern Region for its medicinal values. Pith dried, made into ash is given to patients with ulcers. Dried and powdered fruit pulp is the popular nourished baby food. Rhizomes and pseudostem are also used to cure many ailments by the North-Eastern Tribals.

**PROMISING HYBRIDS****H-1 (Agniswar x Pisang Lilin)**

Is a promising hybrid owing to short cropping cycle and resistance to leaf spot, Fusarium wilt and burrowing nematode (*Radopholus similis*). Medium-tall plant, supporting 14-16 kg bunch without propping. Elongated fruits turn attractive golden yellow on ripening. Slightly acidic, fruit, vanishes upon full ripening with high sugar content. H-1 has a remarkable early ratooning ability, completing 4 crop cycles in 3 years. This hybrid is immune to sigatoka leaf spot diseases. Multilocational trials have shown its acceptability among growers and consumers, especially in Andhra Pradesh.

**H-2**

A hybrid of Vannan x Pisang Lilin, developed at KAU, Kannara, is medium-statured, growing up to 7-8 ft. Crop cycle is short with bunch coming to harvest in 11-12 months. Average weight of the bunch is 15-20 kg with short, stout, dark green Poovan-like fruits, which are arranged very compactly. Fruits are slightly acidic with pleasant sweet-sour aroma. High tolerance to leaf-spot disease and nematodes make it a suitable for subsistence cultivation.

**Co-1**

Is a promising pome hybrid resultant of 3 - way sequential crosses. It retains the typical acid/apple flavour of Virupakshi even when grown on plains, contrary to Virupakshi which develops aroma only when grown at higher altitudes. However, its commercial adoption has remained restricted due to small-sized bunch and low fruit yield.

**CHARACTERIZATION**

Characterization was attempted by earlier workers who tried describing Indian bananas but systematic classification for proper identification was lacking in their characterization studies. In 1962, Simmonds and Shepherd gave the 15 character classification and corresponding score card for tentative genomic classification. Using this, Bhakthavatsalu and Sathiamoorthy (1979) attempted genomic classification of Indian bananas for the first time (Table 1). The earlier germplasm collections of BRS, Aduthurai and other accessions after shifting to TNAU, Coimbatore were characterized and classified. Duplications and synonyms were recognised and identified 81 distinctive clones and 23 mutants in the gene-pool of 240 accessions (Sathiamoorthy, 1994).

At NRCB, 610 accessions both indigenous and exotic were collected and maintained in the 'Base Collection Block' irrespective of their genomic group. Simmonds and Shepherd's 15 character classification system was tried for assigning the genomic status. But due to some lacunae like discontinuity and ambiguity with respect to score ranges in Simmonds and Shepherd's score card, a modified score card was developed by Silayoi and Chomchoiow (1987).

**Table 1. Genomic grouping of banana accessions**

Score	Genomic group	No. of accessions
15-25	diploid AA	20
	triploid AAA	37
26-46	AAB	120
47-59	AB	30
60-63	ABB	257
67-69	ABBB	8
>69	BB/BBB	8
	Unidentified	130
	<b>Total</b>	<b>610</b>



During the course of data collection, it was observed that there is a need for refinement of score card of Silaloy and Chomcholow as well as scoring characters, especially to have better distinction within genomes having more of *balbisiana* characters, since this score card posed deficiencies like exclusion of AB and ABBB genomes. Hence at NRCB efforts were made to score 435 accessions belonging to various genomes. The trend of scoring in most of the accessions of a particular genome was used as the score range (Table 2).

Though a modified new scoring system has been suggested, providing a distinct cut-off score for different genomes was not easy. Many overlapping scores were noticed between the genomes like AAB and AB; ABB and ABBB. With the same scoring of 15-23 for *acuminata* diploids and triploids, distinction within triploid genomes was difficult. Similarly, the limitation of identification of accessions within the sub-group like Kanthali and Karpuravalli of Pisang Awak, subgroup look-like for most of the morpho-taxonomic characters but differing with respect to sucker pigmentation, intensity of pink colouration of male bud and some of the fruit parameters. Another example is Kunnan and Aktoman accessions belonging to AB genome and Kunnan subgroup. They resemble for most of the characters except for presence of a few persistent male flowers, floral pigmentation and fruit parameters. The classic example being Poovan and Palayankodan of Mysore sub-group. Though they differ for most of the taxonomists, they are the same, basically they differ for minute characters like bunch shape and fruit orientation. Palayankodan is a taller ecotype of Poovan with conical bunch and slightly upturned fruits, whereas Poovan has cylindrical bunch, straight fruits and more acidic fruits. They also differ with respect to their field susceptibility to BSV with Poovan being more susceptible. But these characters become less authentic when influenced by biotic and abiotic factors. This difficulty of overlapping scores and unreliability of some parameters suggest characterization using molecular techniques for authentic identity.

Table 2. Modified score card for assigning tentative genomic groups

Genome	Score card of		
	Simmonds & Shepherd (1955)	Silaloy & Chom Chalow (1987)	Singh & Uma (1996)
AA/AAA	15-23	15-25	15-25
AAB	24-46	26-46	26-45
AB	49	-	46-49
ABB	59-63	59-63	59-65
ABBB	67	-	66-69
BB/BBB	-	70-75	70-75

Now at NRCB, Trichy, after preliminary characterization 370 accessions have been shifted to working collection block for detailed morpho-taxonomic characterization according to group and sub-groups. Data both in vegetative and reproductive phases were collected using banana descriptor (IPGRI-INIBAP/CIRAD, 1996). While using the INIBAP descriptor, many parameters described were found to be restrictive in describing the Indian bananas.

Hence modification of the descriptor was attempted. This included the additional parameters like:

- a. 6.2.6 Brown pigmentation of the underlying pseudostem.
- b. 6.3.1 Black and brown black blotches at the base of the petiole.
- c. 6.3.4 Margins of the petiole canal curved outwards.
- d. 6.3.14 Colour of lower surface of leaf-silvery green.
- e. 6.3.18 Shape at base of leaf blades, auriculated round on both sides.
- f. 6.5.8 Bract scars on the rachis, medium prominent.
- g. 6.6.4 Lobe colour of the compound tepal tinted with pink.
- h. 6.6.6 Colour of the free tepal, uniform pink colour.
- i. 6.6.7 Shape of the free tepal, boat or elongated bowl shaped.
- j. 6.6.8 Appearance of the free tepal, folded at the middle.
- k. 6.6.10 Shape of apex of the free tepal, spear shaped.
- l. 6.6.12 Colour of the filament, pink and tinted with pink at the anther base.
- m. 6.6.13 Colour of the dorsal face of the anther, orange.
- n. 6.6.20 Colour of the stigma, orange tinted with pink and pale brown.
- o. 6.6.22 Basic colour of the ovary, pink.
- p. 6.6.24 Dominant colour of the male flower orange yellow.
- q. 6.6.26 Arrangement of ovules irregular in three rows.

At NRCB, in an endeavour to distinguish subgroups within a genomic group for better understanding, accessions were assessed for the successive years using important characters of subgroups. In AA diploids a majority of accessions had distinct characteristics, thus they could not be put into subgroups whereas in other genomic groups it was possible to assign the subgrouping to the accessions.

#### AA Diploids

Though South-East Asia is considered to be the centre of origin for *acuminata* diploids, India has a few but distinctive members, some of which have assumed commercial significance. Most of its members are choice cultivars grown in backyard gardens.

e.g. Matti, Kadali, Surya Kadali, Sannachenkadali, Namarai, Anai komban, Hatidat, Chingan, etc.

The *acuminata* diploids have distinct characteristics and cannot be classified into subgroups. Among the members, Matti assumes commercial significance in the southern tips of Tamil Nadu, where the hot and humid climate can induce the exhibit its full potential to yield 30-35 kg bunch with 18-20 hands. Fingers are short and curved with sweet pulp known for its medicinal properties. Finger orientation has a typical wind-blown appearance. This lacks any synonyms and is well known in all southern states. Kanai Bansi or Anaikomban is the choice cultivar of southern districts of Tamil Nadu, Kerala and parts of North-Eastern India owing to its tolerance to leaf spot disease and yield potential of 13-15 kg. Straight finger orientation and fruit smoothness without angularity makes it one of the desirable quality parameters.



Kadali is a small fruited, sweet variety restricted to hot and humid regions of southern tips. A mutant, Naivedya Kadali, is grown mainly in temple backyards to offer it to god. Sannachenkadali is another choice variety restricted to backyard orchards. It is distinct from other diploids due to red pigmentation of its pseudostem and fruits. Apart from indigenous diploids, exotic diploids like Pisang Lilin, Tongat, Cultivar Rose are also maintained for use in breeding programmes.

### AAA Triploids

Triploid *acuminata* was distinguished into five broad subgroups, viz. Cavendish, Gros Michel, Lacatan, Red Banana, Rajavazhai and Unique, of which Cavendish, Red Banana and Unique groups show much diversity.

Cavendish subgroup has three major sub-subgroups, viz. Dwarf Cavendish, Robusta and Giant Cavendish. Dwarf Cavendish has Morris, Singapur, Basrai and Pachavazhai Bhusawal as its members. This group forms the basis of commercial banana production in India due to its short robust stature, resistant to wind damage and high productivity. They are distinguished from Robusta by persistent bract and flowers and closely spaced internodes. A tall mutant of Dwarf Cavendish has been identified for its high productivity with a bunch weighing 45-60 kg.

Robusta is comparatively tall in stature, pendulous and has a barren male axis with a bend at its tip. Cylindrical bunches weigh 30-35 kg. Harichal, Pedda Pacha Arati and Borjahaji form the Robusta subgroup. Giant Cavendish has limited spread in India. Gros Michel, an imported cultivar, is found for academic studies like Lacatan. Apart from these, Grand Naine and Petite Naine have assumed commercial significance in Gujarat and Maharashtra.

Red Banana has little diversity, except Agnisagar from North-Eastern region having yellow mixed red pigmentation with dark red blotches on pseudostem. Commercial cultivation of Red Banana is restricted to Kerala and southern tips of Tamil Nadu. Agnisagar and Tulsi Manohar are the other members of this group. Rajavazhai subgroup is distinguished by its shiny, greenish yellow pseudostem, spreading petiole margin with conspicuous pink pigmentation. Bunch orientation is at an angle with a maroon-coloured male bud, and fruits are pale green, short, stout, with a prominent beak and rich yellow colour at ripeness. There is no variability in this subgroup and Thella Chakkarakeli is the sole member of this group with many synonyms.

### AB Diploids

These are characterized by medium stature, erect leaf orientation and long petioles. The basal colour of male flower is pink with 2-5 irregular flowers per hand. Bunch has a short peduncle and orientation is either horizontal or at an angle but never pendulous. This genomic group has been subdivided into Kunnan, Ney Poovan and Unique subgroups. Kunnan has members like Adukka Kunnan, Thaen Kunnan, Naattu Poovan, Adukkan and Narmine with slight variability with respect to fruit size, waxiness of fruit and plant stature. Till date Ney Poovan was considered to be the sole member of this group. But in an exploration to southern

tips of Tamil Nadu, two ecotypes have been identified. Commercial Ney Poovan has an angular bunch and bold fruits, whereas its ecotype has horizontal bunch, and small fruits with strong wind-blown appearance. This has tastier fruits than the bold fruits. Kunnan subgroup is distinguishable from Ney Poovan subgroup by its erect leaf orientation, black blotches at petiolar junction and angular bunch orientation. Though Kunnan and Ney Poovan subgroups have common genomic constitution, many of the characters of Ney Poovan subgroup like smoothness of leaves, light pigmentation, sweet pulp, presence of blotches etc. brings it more nearer to *acuminata* genome. Under the Unique subgroup Kodapanilla Kunnan and Padali Moongil find their place owing to the absence of male bud and elongated plantain-like fruits. But pulp quality of Padali Moongil is very sweet, powdery from pulp and has unique taste. Kodapanilla Kunnan, by virtue of its high-cost fruits, finds commercial cultivation in Tirunelveli district of southern Tamil Nadu.

### AAB Triploids

Careful characterization of AAB genomic group led to the identification of five subgroups, viz. Silk (Rasthali), Mysore (Poovan), Pome (Pachanadan), Plantain (Nendran) and Nendra Padathi (Jawari Bale).

#### Silk subgroup

It is characterized by yellowish green pseudostem and pink pigmentation all along the margin. Male bud is maroon in colour and flowers have a unique pink-dotted stigmatic base and curved style, once or twice. Short-statured members grow to a height of 3.5 m which includes Malbhog, Amrithpani, Rasthali, Mortman, Rasabale etc. Robust members of silk-like Saapkal Amrithpani are characterized by tall stature, huge male bud and bold fruits. Fruits at maturity show pale yellow colour, and firm and slightly acidic nature. Immature fruits when broken show slimy ooze with extended strands. On the contrary, normal members of silk have small-sized male buds, smaller fruits, bright yellow at maturity, pulp is firm, powdery and very sweet.

Robust members	—	Amrith Pani	-	Malbhog, Saapkal, Kozhikkodu, Mortman
Normal members	—	Rasthali	-	Rasabale, Nanjangud Rasabale, Rasaketi, Kadali (TN)
Short members	—	Rasthali	-	Shakkarchayna, Chinia, Soneri

Variability was noted for skin thickness. This character is vital in deciding the major physiological disorder — fruit cracking. Accession 0445 belongs to Robust Rasthali group shows thick skinned nature, resistance to fruit cracking but the rest of the characters are similar to those of Malbhog.

Short members grow to a height of 2.75-3.0 m, which includes Chakkar Chayna, Soneri etc.

#### Mysore subgroup

It has members with predominant pink pigmentation, including the ventral side of the



midrib, ovoid male bud and acidic fruits. Palayankodan of Kerala and Rani Poovan of Tamil Nadu are the tall and robust members of Mysore with conical bunch shape, whereas Poovan of Tamil Nadu is short, medium-statured and with a cylindrical bunch.

Palayankodan	- Rani Poovan, Kadali (southern tips of Tamil Nadu)
Poovan	- Palayankottai (T.N.), Cheeni Champa (Bihar and North-Eastern Region), Chandra Bale (Karnataka), Nepali Chinia (North-Eastern Region)

#### *Pome subgroup*

Its members are comparatively more robust, bunch orientation is either horizontal or at an angle. Male phase is short with a whip-like rachis ending with a top-shaped male bud. Anthers abort and turn black at flag-end stage of male phase and fruits are invariably angular.

#### *Ladan group*

It has members like Pachanadan, Kaali and Lady Finger, whereas Nadan group comprises bananas suited to higher altitudes like Virupakshi, Sirumalai, Ladan small, Ladan pointed etc. Variability was noticed with respect to male bud colour (bract) in Lady Finger. Unlike other members, it has a pink colour. Pigmentation on external bract surface terminates with yellowish green at the tip. Male bud is slightly elongated than typical top-shaped in other members. Variability was also conspicuous with respect to acidity (0.962). Nadan group showed 0.80 acidity, whereas Ladan group showed a range of 0.650 to 0.686. Accession 0141 was uniquely acidic with 0.981 acidity, making it more suited for product preparation like Panchamritam.

#### *Plantain subgroup*

It has distinct yellowish green pseudostem and pink-pigmented petiolar base, which is clasping in nature. Male axis has persistent male flowers and bracts. Compound tepal is orange yellow and fruits are starchy with orange coloured pulp. Plantains are grouped into French plantain, French Horn plantain, Horn plantain, and False Horn plantain of which India has a greater diversity for French plantain. Nedu Nendran has perpendicular fruit orientation, Manjeri Nendran with pink pigmentation of pseudostem, Kali Ethan with elongated fruits and Myndoli is a giant plantain. Moongil is considered as a mutant of Nendran with only on hand with large fruits and is grouped as Horn Plantain (Nayar, 1957).

#### *Nendra Padathi subgroup*

It is characterized by the presence of persistent male bract and flowers throughout the male rachis with distinctly pink-pigmented male flowers. This group has dual characters of Plantain and Pome sub groups. Persistent bract and female flowers resemble that of Plantain with orange stigma whereas fruits and other plant parameters are that of Pome. Nendra Padathi is the tall member, whereas Jawari Bale is the dwarf member of this group. Jawari Bale, otherwise synonym for Dwarf Prata, is one of the parents of FHIA-01, and has been under commercial cultivation in central Karnataka from a long time.

#### **ABB Triploids**

Characterization of ABB genomic group resulted in the identification of five subgroups, viz. Pisang Awak, Monthan, Bluggoe, Peyan and Unique.

#### *Pisang Awak*

It is distinguished by robust, pink-pigmented pseudostem, droopy leaves and curved laminar edges. Bunch is pendulous, compact and cylindrical with geometrically circular arrangement of hands around the peduncle. Variability in this group is observed with respect to male flowers and fruit parameters and especially with respect to stature. Kanthali is the short selection of Pisang Awak; other members are Kostha Bontha, Pey Kunnan, Boodi Bale and Nukala Bontha. Its commercial cultivation is in south-central Tamil Nadu on marginal lands. Fruits are ash coated with a high TSS up to 31 Brix.

#### *Peyan subgroup*

It is distinguishable by circular black blotches on petiolar sides. Pink male bud is intensely ash coated, very pointed with deep pink flowers. Fingers short, stout with 4-5 unequal sides with orange pulp. No diversity is observed for this subgroup. It is a unimember group with synonyms like Bhurkel, Madavazhai, Nanguneri Peyan etc. of which Madavazhai has unique sourness with wide medicinal utilities.

#### *Monthan subgroup*

It is characterized by yellowish green pseudostem, pendulous bunch orientation and short male axis. Male bud is lanceolate and fruits have conspicuous cap. Much variability is observed with respect to fruit shape; one such variety, Bangrier with intermediary characters of Monthan and Bluggoe is found very promising.

#### *Bluggoe subgroup*

It is distinguishable from Monthan by its dark green pseudostem. Bunch is cylindrical with short fingers without conspicuous cap and is tapering at the end. Both subgroups have ash-coated mutants. Many members with slight variation are present in this group. Kothia, Chakia, Sakkai and Nadan have ecological significance for their commercial cultivation. Most of the ABB subgroups have ash-coated mutants. Kothia and Naadu have dual-purpose utilities.

Apart from these, many unique cultivars like Manohar, Borkal Bahista, Ney Mannan also occur, with little economical significances but greater values for their desirable traits like resistance to biotic and abiotic stresses.

#### **BB/BBB diploid / triploids**

Morpho-taxonomic classification of wild accessions has led to the identification of seeded BB/BBB clones. Bhimkal is an important backyard seeded banana of North-Eastern Region. The pulp after seed extraction is dried and used as weening food. It is highly tolerant to banana bunchy top virus, panama wilt and leaf-spot diseases apart from pests and nematodes. Another slender member of this group is Attiakol with yellowish green pseudostem unlike Bhimkol. Seeds are fertile and germinate without any constraint. Another seeded wild banana is from Western Ghats with closely spaced internodes, shorter leaf petiole and length, giving a clustered, ornamental appearance to the plant; healthy, shiny leaves are widely used as eating plates in south India.



### Characterization using molecular markers

Chemo-taxonomic characterization of *Musa* germplasm was carried out by Bhat *et al.* (1992a, b) for 70 *Musa* cultivars belonging mainly to *acuminata-balbisiana* hybrids and *acuminata* triploids using seven enzyme systems RAPD markers were also used to characterize the germplasm and Jaccard's similarity co-efficient was generated and analysed phenotically (Bhat and Jarret, 1995). Apart from these, use of alternative PCR-base markers such as Simple Sequence Repeats (SSRs) to differentiate overlapping accessions was emphasised by Bhat and Jarret (1995). Identification of very closely related germplasm has been attempted successfully using DNA fingerprinting (Bhat *et al.*, 1995a). Use of anthocyanins and flavonoids in bracts of banana to outline the evolution of bananas has been reviewed by Horry and Jay (1988). Morpho-taxonomy complements with chemo-taxonomy and molecular markers can aid in characterizing *Musa* germplasm and will assist in tracing the evolution of present-day bananas.

### FUTURE THRUST

Long periods of domestication, wide ecological diversity and in combination with ethnic diversity, usage pattern and location-specific rituals have contributed to the great diversity of *Musa* in India. This invaluable plant wealth requires to be identified, systematically collected, conserved and appropriately used. Some of the identified future thrust areas are:

- Identification of areas of natural diversity and collection through prospection and exotic introduction.
- Conservation of *Musa* germplasm should be addressed and accomplished as a holistic approach with *in-situ* and *ex-situ* strategies.
- *In-vitro* conservation should be attempted with all base collections at NBPGRI, New Delhi, and working collections at NRCB, Trichy.
- Characterization of germplasm using reference cultivars from INIBAP and development of computerized database management system on *Musa* germplasm. These data should be easily accessible to the banana researchers.
- Evaluation of germplasm for their useful characters and resistance to biotic and abiotic stresses.
- Use of biotechnological tools for widening the genetic base.
- Characterization of all global *Musa* germplasm at different locations for clonal identification and to trace their origin.
- Establishment of Central Germplasm Information System (CGIS) having accessibility to breeders for the choice of parents in breeding for specific objectives.
- Identification of cultivars suited to various prevailing cultivation systems based on their tolerance to biotic and abiotic stresses.

### CONCLUSION

Domestication and long periods of cultivation of banana in India have led to the great diversity in *Musa* germplasm. Sporadic attempts have been made from 1890s to document

Indian bananas but the work lacked systematic attempts. After the genomic classification provided by Simmonds and Shepherd (1955), characterization of Indian banana was attempted with restriction to south Indian bananas. At National Research Centre on Banana, Trichy, systematic attempts have been made to collect all Indian *Musa* variability and characterize them. While doing so, modification of the score card for assigning the genomic status was attempted to encompass the Indian variability.

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