



Research Article

BANANA: GENETIC RESOURCES AVAILABLE IN TRIPURA AND PARTS OF NORTH-EASTERN INDIA

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Abstract: Banana (*Musa* sp.) is a most significant fruit crop of Tripura next to Jackfruit and Pineapple is available and grown commercially by different tribal and Bengali communities. There are many local and traditional banana varieties are grown and different parts like Pseudo stem, Leaf sheath, male flower buds, unripe banana were used as vegetables. Seeds were using medicinal purpose by local tribes of Tripura and other north eastern states. Some wild species of banana like *Musa acuminata*, *Musa balbisiana*, *Musa ornata*, *Musa laterita*- hybrid, *Musa flaviflora* and *Ensete glaucum*, etc have been recorded in the Tripura. *Musa flaviflora* and *Ensete glaucum* were also found in Tripura. Most important banana cultivars are ShabriKela(AAB), Martaman(AAB), Malbhog(AAB), Samai/Gopi/BanglaKela-1(AAB), Samai/Gopi/Bangla Kela-2(ABB), ChampaKela (AAB), Mizo-Cavindish (AAA), Katch Kela-1(ABB), Katch Kela-2(ABB), Katch Kela-3(ABB), Kanai Bansi (AA), Red Banana (AAA), in addition to the commercial cultivars wild forms like AttiaKela (BB), AthiaKol(BB) and Bhimkol (BB) were distributed in Tripura. Collected genotypes were assigned their genome like AA, AAA, AAB and ABB through 15-character score card systems. *Musa acuminata* and *Musa balbisiana* designated by A and B genome. The genome scored from 1 to 5. *Musa acuminata* were given the score of 1 and *Musa balbisiana* were scored as 5. Most of the cultivars are triploids in nature and some are classified diploid. The wild banana like Attia Kela (BB), Bhimkol (BB), *Musa* spp. like *Musa flaviflora* and *Ensete glaucum* and many more seeded bananas are grown, whose pseudo stem, leaf sheath, flower bud, ripe banana are edible and used by tribal communities, rural and urban people of the state. Out of which nine important local and traditional cultivars/ varieties of banana grown for edible purpose like ShabriKela(AAB), Samai/Gopi/Bangla Kela(ABB), ChampaKela (AAB), Mizo-Cavindish (AAA), KatchKela (ABB), Kanai Basi (AA), Attia Kela (BB) AthiaKol(BB) and Bhimkol (BB), are grown in different parts of Tripura and North-Eastern states. The present finding banana genetic resources of Tripura which will be utilized in crop improvement, breeding and conservation.

Keywords: Genetic resources, Wild species, Banana, Tripura, Morphological characters

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Introduction

The North eastern states of India namely Tripura, Assam, Arunachal Pradesh, Meghalaya, Mizoram and Manipur have been richest banana sources of natural diversity. Banana is strongly believed to have originated from Southeast Asia, many of the species and clones have their homeland. Banana (*Musa* sp.) is a natural crop and most important fruit crop of Tripura next to jackfruit and Pineapple with rich source of vitamins and minerals and is very important for nutritional and health security of rural and urban area of the state. Unopened male bud, leaf sheath and pseudostem of both *balbisiana* and *acuminata* bananas are used as vegetable and ripen banana used as table and medicinal purpose by different tribal communities and rural people of Tripura, viz., Delong, Tripuri, Reang, Debbarma, Mok, Chakma, Uchoi, Halam and others. The different tribal community use for preparing local dishes like 'Gudok' with or without other local vegetables and is a favourite among the tribals in Tripura. The diverse agro-climatic condition, fertile soil, slightly acidic, sub-tropical climate and abundant rainfall area enriched with undulating tilla land with varying degree of slope play a vital role to check soil erosion and can stand even with minimum orchard care. It grows abundantly and luxuriantly as wild in forests areas in different parts of the state and expresses their original characters. Important banana types are ShabriKela (AAB), Martaman (AAB), Malbhog (AAB), Samai/Gopi/Bangla Kela-1(AAB), Samai/Gopi/Bangla Kela-2(ABB), ChampaKela (AAB), Mizo-Cavindish

(AAA), Katch Kela-1(ABB), Katch Kela-2(ABB), Katch Kela-3(ABB), Kanai Basi (AA), Red Banana (AAA), Attia Kela (BB), AthiaKol(BB) and Bhimkol (BB), *Musa* spp., wild seeded types and others. Some wild species of banana like *Musa acuminata*, *Musa balbisiana*, *Musa ornata*, *Musa flaviflora* and *Ensete glaucum*, etc have been recorded in the state. *Musa Flaviflora* and *Ensete Glaucum* were also distributed in Tripura [1,2]. Area under Banana cultivation in Tripura is 13,274.0 ha with an annual production is 130085.20 MT with a productivity of 9.8t/ha. However, maximum (70%) area of banana cultivation is under Shabri Kela (AAB) compared to Samai/Gopi/Bangla Kela (ABB) and Champa Kela (AAB). Shabri Kela (AAB) and Mizo-Cavindish (AAA) are very popular and excellent (in respect of flavour, texture, aroma and TSS) cultivars of Tripura for fresh consumption with medium plant stature. Banana is used in four to five way i.e., Banana Fruits are used in religious puja, table and medicinal purpose throughout the year; Pseudo stem, Pseudo sheath, male unopened flower buds, including vegetable types Banana are used as vegetables dish; Banana plants used in religious puja and marriage ceremony; Banana leaf used for plate/ disc and compost preparation. Ripen banana used as traditional medicine. Stover and Simmonds have reported the genus *Musa* has 30-40 species [3]. Das, et al., (2014) [4] studies the Banana Diversity in Tripura. Many cultivated bananas are classified as diploid ($2n=2x=22$) and triploid ($2n=3x=33$), with genome constitution of AA, AAA, AAB and ABB etc.

Table-1 The areas explored during the survey works

SN	Survey works and exploration (District/States)	Areas covered
1	Dhalai district, Tripura	(Gandachara, Kaylan Singh, KalajuriPahar, Chawmanu, S. K. Para, Chailangta, Lalcherra, Karamcherra, Mashli, Kamalpur, Talchara, Gobindabari, Natinmanu, etc.),
2	Gomati district, Tripura	(Amarpur, Udaipur, Bagma, Karbhog, Silaichari, Killa, Ompi etc.)
3	South Tripura, Tripura	(Hrismukh, Sabroom, Belonia, Motai, Jolaibari, Santirbazar, Birchandramanu, Gurakappa, Sillacherri, Takatulshipahar etc.)
4	North Tripura, Tripura	Jampuihill, Damcherra, Kanchanpur, Pachartal, Dharmanagar, Panisagar, choraibari etc,
5	Sipahijala district	Bishalgarh, Golaghati, Debipur, Bishramgangh, Nalchar, Jumdeppa etc,
6	Khowai district	Khowai district (Taliamura, Khowai, Rankhalpara, Hawaibari, Tushindai etc),
7	Unakoti district	Kailashar, Unokuti Temple area, Unakotipahar, Senibagan, Kumarghat, Darchoi, Pechartal Block, Ananda Bazar, etc
8	West Tripura district	Mandwai, Jirania, Hazamara, Mohanpur, Dhukli etc.
9	Arunachal Pradesh	Nirjuli, Itanagar
10	Nagaland	Dimapur, Paglapahar, New chumukdima, Malvpom, Malvpom village, Medziphema village.
11	Manipur	Imphel, Durgabari, Okrul, Langol farm-2, ANDO Farm-1, ANDO Farm-2, CAU campus,
12	Mizoram	Kan Mun, Dhamcherra.
13	Assam	Barjhar (Near Airport), Guwahati University, KVK Kahikuchi, Assam Agricultural University, Jorhat, Brahmaputra areas, Gita Nagar, Chandra pur, Olobari, Guwahati Zoo areas, Narangi, Banda.
14	Sikkim	Sikkim University areas
15	Aizawl	Seling

Genomic group using by Stover and Simmonds, (1987) [5], Singh and Uma, (1996) [6] and 15-character score card of taxonomic scoring for banana cultivars by Simmonds and Shepherd, (1955) [7] were used for genome classification of Banana. Ancestors of present-day edible banana are *Musa acuminata* and *Musa balbisiana* are designated as "A" and B genome. The genome scored from 1 to 5. Expressions of *Musa acuminata* were given the score of 1 and *Musa balbisiana* were scored as 5.



Fig-1 Map showing different district of Tripura

Banana originated from South-East Asia with *M. acuminata* and *M. balbisiana* as its ancestral species. Great diversity has been observed for *Musa acuminata* in north- Eastern region of India. India harbours a greater diversity for *Musa balbisiana* and *acuminata-balbisiana* bispecific clones (AB, AAB, ABB and BB/BBB). In India, more than 90 distinct clones have been identified at different field gene banks located in various locations. There is huge banana diversity across the state as well as North eastern states have been observed. Many numbers of local cultivars are available across the states as well as other north eastern states with many wild species. Linnaeus was the first person given scientific nomenclature for banana, based on morpho-taxonomic traits, as *Musa paradisiaca* Linnaeus in [8]. He referred this to the plantains with long slender fruits which are starchy and needed-cooking prior to cooking.

Simmonds and Shepherd, (1955) [7] presented the theory of origin of edible bananas. The new classification system using 15 differentiating traits and the score card gave a fine-tuning to the *Musa* classification scheme. Different forms or subspecies of *Musa acuminata* were found in S.E. Asia where their distribution overlapped with pure *Musa balbisiana* clones especially in Malaysia, Philippines, and NE India etc. This led to natural introgression resulting in *acuminata-balbisiana* hybrids. Depending on the relative contribution of these two species various genomic combination AA, AAA, AB, AAB, ABB, BB, BBB, ABBB have developed. The ploidy level ranged from diploid, triploid and tetraploid denoted by the number of letters of *acuminata* and *balbisiana*.

Material and Methods

Survey, collection of the samples and characterization: Made extensive survey for collection of *Musa* wild and cultivated varieties throughout the states and collected [Table-1]. All the 20-banana local, traditional cultivars and wild species have been collected from all the eight district of Tripura [Fig-1] and other North- eastern states. The important part parts like different flowers, pseudostem colours, petiolar canal, peduncle, pedicel, ovules, bract shoulder ratio, curling, shape, colour, colour fading, free tepal of male flower, male flower colour and stigma colour scoring systematically done.

Preliminary survey

The preliminary exploration for *Musa* germplasms diversity (available) in Tripura and other North eastern states was undertaken 2009-2014 to prepare a base for main survey. Initially Tripura state were explored resulting in the identification of number of *acuminata* and *balbisiana* clones in wild, semi wild and backyards which includes clones like ShabriKela Martaman, Malbug, Samai/Gopi/Bangla Kela, ChampaKela, Mizo-Cavindish, KatchKela Kanai Basi, Red Banana, Attia Kela, AthiaKoland Bhimkol (BB), wild seeded types. Some others wild species like *Musa acuminata*, *Musa balbisiana*, *Musa ornata*, *Musa flaviflora* and *Ensete glaucum*, were also been collected. The collected suckers planted at collage of Agriculture, Tripura (CAT), Lembucherra for further characterization. In Assam survey cum visit to K.V.K. Kahikuchi, Assam Agricultural University, Jorhat, Guwahati University areas, Brahmaputra areas, Kamikka temple areas, Gita Barjhar(Near Airport), Guwahati University, KVK Kahikuchi, Assam Agricultural University, Jorhat, Brahmaputra areas, Gita Nagar, Chandra pur, Olobari, Guwahati Zoo areas, Narangi, Banda. Some available clones like Jahaji (AAA), Malbhog (AAB), CheniChampa, Kachkel (ABB), Bhimkol (BB) Giant Cavindish (AAA) etc are grown in small scale as well as grown in all home sheds along with household territory and also grown in band or boundary of pond and roadsides. Major exploration to study the diversity of Banana in Tripura states along with other North eastern states like Assam, Mizoram, Nagaland, Manipur and Arunachal Pradesh with GPS reading [Table-5].

Table-2 Taxonomic scoring for banana cultivars by Simmonds and Shepherd, [7]

Characters	<i>Musa acuminata</i>	<i>Musa balbisiana</i>
Pseudostem colour	More or less heavily marked with black or brown blotches	Blotches slight or absent
Petiole canal	Margin erect or spreading with scarious wings below, not clasping	Margins enclosed, not winged below, clasping pseudostem
Peduncle	Usually downy or hairy	Glabrous
Pedicel	Short	Long
Ovules	Two regular rows in each loculus	Four irregular rows in each loculus
Bract shoulder	Usually high (ratio <0.28)	Usually low (ratio>0.30)
Bract curling	Bracts roll after opening	Bracts lift but do not roll
Bract shape	Lanceolate or narrowly ovate, tapering sharply from the shoulder	Broadly ovate, not tapering sharply
Bract apex	Acute	Obtuse
Bract colour	Red, dull purple or yellow outside, pink dull purple or yellow inside	Distinctive brownish purple outside, bright crimson inside
Bract scars	Prominent	Scarcely prominent
Colour fading	Inside bract colour fades to yellow towards base	Inside bract colour continues to base
Free tepal of male flower	Variably corrugated below	Rarely corrugated
Male flower colour	Creamy white	Variably flushed with pink
Stigma colour	Orange or rich yellow	Cream, pale yellow or pale pink

We made systematic exploration studies to cover all the eight district of Tripura [Fig-1] like Dhalai district (Gandachara, Samanu, Manu, Karamchara, Mashli, Kamalpur, Talcherra, Gobindabari, Natinmanu etc.), Gomati district (Amarpur, Udaipur, Bagma, Karbhog, Silaichari, Killa, Ompi etc.), South Tripura (Hrishmukh, Sabroom, Belonia, Motai, Jolaibari, Santirbazar, Birchandramanu etc.), North Tripura (Jampuihill, Damchara, Kanchanpur, Pachartal, Dharmanagar, Panisagar, choraibari etc), Sipahijala district (Bishalgarh, Golaghati, Debipur, Bishramgangh, Nalchar, Jumdeppa etc), Khowai district (Taliamura, Khowai, Rankhalpara, Hawaibari, Tushindai etc), West Tripura district (Mandwai, Jirania, Hazamara, Mohanpur, Dhukli etc.) and Unakoti district (Kailashar, Unakotipahar, Senibagan, Kumarghat, Darchoi etc) along with other North Eastern states in the year 2012-2017. The collected *Musa* germplasms were planted and taken for further evaluation and characterization at College of Agriculture and well grown plants were systematically classified and assigned their genome through morphological scoring system and data recorded using International Plant Genetic Resources Institute (IPGRI) descriptors [9] the different agronomic parameters like Plant height, Plant breath, Number of leaf, leaf length, leaf breadth, petioles lengths and fruiting character like figure weight, figure length, figure diameters, pulp and pile weight, TSS and shelf life of fruits etc.

Morphological identification and Characterization

Assigned genomic group using the Simmonds and Shepherd, (1955) [7] 15-character score card. Here the plant is scored from 1 to 5 as per description available in [Table-2]. All the traits mentioned under *Musa acuminata* were given the score of 1 and those coinciding with *Musa balbisiana* were scored as 5. The variations between these two extreme characters were given the intermediary score based on the experience. The total score ranged from 15-75 depending upon the genomic groups. The total scores thus obtained were compared with the score card [Table-2] and corresponding genomic status was assigned to a particular genotype. The taxonomical classification and identification of collected local genotypes done by evaluating pseudostem, leaf, floral and fruit characteristics using the identification keys by Singh, *et al.*, (2008) [10].

Table-3 Genomic group by Stover and Simmonds [5]

Genomic group	Score
AA Diploid	15-23
AAA Triploid	15-23
AAB Triploid	24-46
AB Diploid	49
ABB Triploid	59-63
ABBB Tetraploid	67

Table-4 Modified score card for assigning tentative genomic groups

Genomes	Score card of	
	Silayoi and Chomchalow [11]	Singh and Uma, [6]
AA/AAA	15-25	15-25
AAB	26-46	26-45
AB	-	46-49
ABB	59-63	59-65
ABBB	-	66-69
BB/BBB	70-75	70-75

For each character in which the cultivar agreed with wild *M. acuminata* the score of 1 was given and for *M. balbisiana* the score of 5 was given and intermediate expressions of the characters were assigned score of 2, 3 or 4 according to their intensity. According to this scoring technique, the scores range from 15 (15x1) for *M. acuminata* to 75 (15x5) for *M. balbisiana*.

Characterisations

Morphotaxonomic / Morphotaxonomic Characterisation have carried out during exploration using banana descriptor, IPGRI [9] the accretion is classified based on genome using fifteen-character score card systems by Simmonds and Shepherd, (1955) [7]. The collected genotypes have been confirmed by studying important characters with Silayoi and Chomchalow, (1987) [11] and Singh and Uma [6], the results are presented in [Table-3] and [Table-4].

Table-5 GPS reading of banana samples collected from different parts of Tripura and other North-Eastern states

	Name of the Places	Longitude	Latitude
1	Babusimointilla	23 32.49	91 44.72
2	Babusimointilla	23 32.67	91 44.73
3	Babusimointilla	23 33.67	91 44.92
4	Gandacherra	23 35.82	91 55.43
5	Kanchanpur	23 58.58	92 16.73
6	Vaisam	24 79.48	92 16.57
7	Vaisam1	24 70.09	92 16.53
8	Vanghmun	24 78.90	92 16.59
9	Guwahati	26 61.90	91 35.20
10	Guwahati2	26 6.19	91 35.21
11	Guwahati3	26 6.24	91 35.23
12	SK para	23 58.81	91 58.86
13	Talcherra	23 42.72	91 2.38
14	Sukantapalli	23 13.88	91 46.64
15	Nabachandra para	23 10.69	91 47.21
16	Durgacherra	23 50.89	91 28.34
17	Kamtingbari	23 48.89	91 33.05
18	Nahalandcheckpost	25 47.59	93 48.15
19	Dimapur	25 46.95	93 48.98
20	Malpom	25 44.14	93 50.95
21	Lalcherra	24 18.26	92 0.15
22	Unokoti Tripura	24 19.03	92 4.07
23	Panisagar	24 14.41	92 15.76
24	Sunai Nuri, Kumar ghat	24 11.42	92 2.70
25	Sunai Nuri, Kumar ghat	24 11.41	92 2.69
26	Sunai Nuri, Kumar ghat	24 11.41	92 2.70
27	Sunai Nuri, Kumar ghat	24 11.41	92 2.69
28	Sunai Nuri, Kumar ghat	24 11.41	92 2.70
29	Sunai Nuri, Kumar ghat	24 11.42	92 2.70
30	Chini Bagan, Unnokoti	24 18.14	92 3.07

Results and Discussion

In Tripura most of the cultivated edible bananas are triploid (AAA, AAB, ABB) in nature, some are recorded diploid (AA, BB) and remaining are recorded different *Musa* species. Out of 20 local and traditional genotypes including four (4) species recorded, 11 genotypes are found triploid, four (4) are found diploid and four (4)

Table-6 Traditional and wild Banana of Tripura and other North Eastern States

	Name of the Local Varieties/ wild species	Score no.	Genome group/ types
1	<i>Musa acuminata</i> vr. <i>Sabri</i> (AAB)	29	AAB
2	<i>Musa acuminata</i> vr. <i>Martaman</i> (AAB)	28	AAB
3	<i>Musa acuminata</i> vr. <i>Malbhog</i> (AAB)	28	AAB
4	<i>Musa acuminata</i> vr. <i>Champa</i> (AAB)	42	AAB
5	<i>Musa acuminata</i> vr. <i>Gopi -1</i> (ABB)	60	ABB
6	<i>Musa acuminata</i> vr. <i>Gopi 2</i> (ABB)	61	ABB
7	<i>Musa acuminata</i> vr. <i>KachKela (R1)</i> (ABB)	64	ABB
8	<i>Musa acuminata</i> vr. <i>kachKela 2 (VL)</i> (ABB)	65	ABB
9	<i>Musa acuminata</i> vr. <i>kachkela 3 (R2)</i> (ABB)	64	ABB
10	<i>Musa acuminata</i> vr. <i>MezoCavandish</i> (AAA)	21	AAA
11	<i>Musa acuminata</i> vr. <i>Kanai Basi</i> (AA)	18	AA
12	<i>Musa acuminata</i> vr. <i>Red Banana</i> (AAA)	17	AAA
13	<i>Musa acuminata</i> vr. <i>Manipur -1</i> (ABB)	60	ABB
14	<i>Musa Balbisiana</i> vr. <i>Aitta Kela-1 (Ram Kela)</i> (BB)	71	BB
15	<i>Musa Balbisiana</i> vr. <i>Aitta Kela-2</i> (BB)	70	BB
16	<i>Musa Balbisiana</i> vr. <i>Bhimkol</i> (BB)	72	BB
17	<i>Musa acuminata</i> vr. <i>Almora</i> (ABB)	64	ABB
18	<i>Musa flaviflora</i>	-	-
19	<i>Enseteglaucum</i> .	-	-
20	<i>Musa ornata</i> ,	-	-
21	<i>Musa laterita</i> - hybrid	-	-

are found new species like *Musa flaviflora*, *Musa ornata*, *Musa laterita*-hybrid and *Ensete glaucum*. Total 20 local and tradition cultivar including table fruits, vegetables types and seeded types have been included for the studies and wide diversity have been observed among the different edible types, vegetables types as well as wild seeded types have been recorded. During characterisation we observed many unique features like pseudo stem colour, leaf character, petiole cannel, flower like back shape, back solder ratio, stigma colour and fruit characters etc. The morphological scoring ranges from 18 to 72 the different types of genomes have been recorded like AA, AAA, AAB, ABB, BB with wide diversity have been recorded [Table-6]. This information supported by Das, *et al.*, (2010) [12] and Das, *et al.*, (2015) [13].

Conclusion

Total 20 different local and traditional genotypes have been recorded including many wild species. Some wild species of banana like *Musa acuminata*, *Musa balbisiana*, *Musa ornata*, *Musa laterita*- hybrid, *Musa flaviflora* and *Ensete glaucum*, etc have been recorded in the state. While characterising *Musa* species and local cultivars of Tripura, some of the genotypes were not fallen in the scoring because they are different species like *Musa flaviflora*, *Musa ornata*, *Musa laterita*-hybrid and *Ensete glaucum*.

Application of research: Study of banana genetic resources available in Tripura and parts of North- Eastern India

Research Category: Plant genetics

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Study area / Sample Collection: Tripura and other North- Eastern states

Cultivar / Variety / Breed name: *Musa acuminata*, *Musa balbisiana*, *Musa ornata*, *Musa laterita*- hybrid, *Musa flaviflora* and *Ensete glaucum*

Conflict of Interest: None declared

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.

Ethical Committee Approval Number: Nil

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