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Research Note

Study on segregation pattern of morphological characters in hybrids of *Musa acuminata and M. balbisiana*

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Abstract
Thirty F_1 hybrids of *Musa* were evaluated for 12 morphological traits under field conditions. High variation was observed for all the characters among the population. The morphological character male bud shape varied highly followed by bract apex shape, wax on the bract, compound tepal basic color of male flower, stigma color, lobe color of compound tepal, blotches at the petiole base, leaf petiole canal and bunch position. The characters like bract behavior before curling, style shape and peduncle hairiness did not show any variation in F_1 population. The UPGMA clustering dendrogram shows the segregation pattern of morphological characters between two contrasting characters of parents and also relationship of the F_1 hybrids with parents.

Key words
Banana, dendrogram, F_1 hybrids, segregation

Banana is one of the important fruit crops grown in the tropical and sub tropical area of the country. India produces 29.78 million tones of banana from 8.3 lakh ha and ranks first in the world in area and production. Plantains and bananas (*Musa spp.* sect. *Eumusa*) are originated from intra and inter specific hybridization between two wild species. *M. acuminata* Colla. and *M. balbisiana* Colla., which contributed A and B genomes, respectively. Polyploidy and hybridization have given rise to a number of diploid, triploid, and tetraploid clones with different combinations of A and B genomes. Thus, dessert and highland bananas are classified mainly as AAA, plantains are AAB, and cooking bananas are ABB. Considerable advances have recently been made in the understanding of the genetic basis of specific traits in *Musa* (Ortiz, 1995 and 1997). However, there is an urgent need to make similar progress in understanding the genomic structure and genetic relationship of the parental and progeny genotypes used in *Musa* breeding programs.

The experiment was conducted at the experimental field of Indian Institute of Horticultural Research (IIHR), Bangalore. Hybrid plants of the F_1 was obtained from the cross of *M. acuminata* x *M. balbisiana*. The F_1 progeny indicated with D symbol comprised of 30 plants (D-19, D-8, D-14, D-33, D-38, D-50, D-20, D-33, D-29, D-71, D-44, D-36, D-31, D-49, D-40, D-22, D-73, D-23, D-13, D-32, D-58, D-55, D-5, D-6, D-26, D-28, D-45, D-21, D-74 and D-51) which were evaluated along with two parents by using the descriptors given by INIBAP/CIRAD (1996). The interspecific crosses were carried out in January 2011 from 9:00 am to 10.00 am during that time only the flowers will open. The wild species, *M. acuminata* ssp. burmannicoides 'Calcutta-4' (AA genomic group as female parent) and *M. balbisiana* 'Bee Hee Kela' (BB genomic group as male parent) which is collected from the North eastern hilly region of India were crossed to produce F_1 progeny.

The morphological evaluations were carried out from January to March of 2012. Twelve characters which were selected from INIBAP/CIRAD (1996) descriptors were used for morphological evaluation. The following characters were analyzed: i) Blotches at the petiole base; ii) Petiole canal leaf; iii) Peduncle hairiness; iv) Bunch position; v) Male bud shape; vi) Bract apex shape vii) Bract behavior before curling viii) Wax on the bract ix) Compound tepal basic color; x) Lobe color of compound tepal; xi) Style shape and xii) Stigma color. Qualitative traits depicting an array of characters were converted to binary characters (Sneath and Sokal, 1973) based on variations present in each trait. The presence or absence of a phenotype was given the score of 1 and 0, respectively. Analysis of data was done using NTSYSpc Version 2.02 (Rohlf, 1994).

Musa F_1 hybrids displayed a wide segregation in all selected morphological characteristics. The female parent Calcutta-4 *i.e. M. acuminta* ssp *burmannicoides* had extensive pigmentation at the petiole base, wide petiole canal with erect margins, slightly hairy peduncle, horizontal bunch position, lanceolate male bud shape, intermediate bract apex shape, revolute (rolling) type bract behavior before falling, very little or no visible sign of wax on the bract, cream color compound tepal basic color, yellow lobe color of compound tepal, straight style shape and bright / rich yellow color stigma.

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M. balbisiana (Bee Hee Kela) is a collection from NEH region of India had leaves with sparse blotching at the petiole base, leaf petiole margins curved inward type petiole canal leaf, hair less peduncle, bunch hanging at angle 45°, rounded male bud, obtuse bract apex, non revolute (not rolling) bract, very waxy bract, pink/ pink-purple color compound tepal, yellow lob of compound tepal, straight style and pale yellow color stigma.

All F_1 populations had hairless peduncle inherited from male parent, straight style shape and bract rolling behavior before falling; this may be probably due to the dominance of these characters over the other characters. Partial dominance was observed in characters like blotches at the petiole base, leaf petiole canal and bunch position. The shape of male bud follows all the modes of inheritance like dominant, partially dominant and intermediary. The bract apex shape found to be pointed in two accessions (6.66 %), slightly pointed in four accessions (13.32 %), intermediate in 19 (63.27 %) accession and obtuse in five (16.65 %) exhibiting all modes of inheritance from parents to progeny.

Observations recorded on blotches at the petiole base revealed that 22 F_1 (73.26%) had small blotches and remaining eight (26.64%) had large blotches. The petiole canal of leaf observed to be straight with erect margins in four (13.32%) hybrids and 26 (86.58%) had margins curved inward. The peduncle hairiness observed to be hair less in 30 (100 %) hybrids. With respect to bunch position, 10 (33.33%) hybrids were found to have slightly angled, 20 (66.6%) were found to be horizontal. The shape of male bud was like a top in six (19.98 %), lanceolate in seven (23.31%) intermediate in 16 (53.28 %) and ovoid in one (3.33%) hybrids. The bract apex shape found to be pointed in two (6.66%), slightly pointed in four (13.32 %), intermediate in 19 (63.27 %) and obtuse in five (16.65 %) hybrids. With respect to bract behavior all 30 numbers (100%) had revolute (rolling) character. With regards to wax on the bract, 17 (56.61 %) had moderate wax, 12 (39.96 %) had very waxy and one (3.33%) had very few wax. This was due to the fact that wax on the bract may be controlled by large number of genes. The compound tepal basic color was observed to be white in four (13.32%), cream in seven (23.31 %) and pink/pink-purple in 19 (63.27 %), this variation also due to the polygenic control of this character. Observations recorded on lobe color of compound tepal revealed that eight (26.64%) had yellow color and 22 (73.26 %) had orange color and this variation is due to the partial dominance of orange color over yellow color. Style shape found to be straight in all 30 (100%) numbers. The color of stigma was yellow in 19 (63.27 %), cream in seven (23.31 %) and orange in four (13.32 %) hybrids showed polygenic nature and all modes of inheritance of the character.

Frequency were calculated (Table 1) for all 12 morphological descriptors separately based on the variation observed in F_1 hybrids of banana. The morphological character, male bud shape varied highly followed by bract apex shape, wax on the bract, compound tepal basic color of male flower, stigma color, lobe color of compound tepal, blotches at the petiole base, leaf petiole canal and bunch position. This variation indicates the high segregation of these floral morphological characters. The characters like bract behavior before curling, style shape and peduncle hairiness did not show any variation among F_1 population. This indicates that there was no segregation of these characters.

Dendrogrm analysis: The UPGMA clustering dendrogram illustrates the segregation pattern of morphological characters between two contrasting characters of parents and also relationship of the F_1 hybrids with parents. The data presented in table 1 showed the grouping pattern of F_1 hybrids based on the morphological descriptors used in this study.

UPGMA clustering of F_1 hybrids divided dendrogram (Fig. 1) into two major clusters cluster I and cluster II, cluster I contains Calcutta-4 and cluster II was further divided into two sub-clusters' *i.e.*, IIa and IIb. The cluster IIa containing Beeheekela and D-51, cluster IIb was divided into IIb1 and IIb2 clusters. Cluster IIb1 had only one hybrid, D-74, and IIb2 was separated into two sub clusters *i.e.*, IIb2a and IIb2b. Sub cluster IIb2a possess D-28, D-45 and D-21 and cluster IIb2b was again bifurcated into IIb2b1 and IIb2b2. The cluster, IIb2b1 comprised D-32, D-58, D-55, D-5, D-6, and D-26 and IIb2b2 was the largest cluster having D-19, D-8, D-14, D-33, D-38, D-50, D-20, D-33, D-29, D-71, D-44, D-36, D-31, D-49, D-40, D-22, D-73, D-23 and D-13. The cluster IIb2b2 had highest number of 19 progenies in a group and the cluster IIb1 had only D-74, which may be distinct and D-51 showed close resemblance to Bee Hee Kela.

These results emphasized the effectiveness of floral characters in identification of variation among the hybrids than the vegetative characters. This segregation of characters in F_1 generation itself has reflected the high heterozygous nature of banana. This result confirms the high level of heterozygosity of both parental genotypes and the high rate of recombination during the formation of megaspores by Calcutta 4 (Crouch *et al*. 1998).

The clustering pattern of parents and hybrids also showed the contrasting characters of parents and intermediate characters of F_1 hybrids because the

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two parents fell into two separate clusters and hybrids grouped in between these parents (Table 2). The analysis further revealed that floral morphological traits, particularly of male bud shape, bract apex shape and compound tepal basic color can be used to make distinctions between parents and hybrids and to isolate various subgroups within hybrids. Selected morphological traits can be used confidently to describe various banana subgroups (Onyango *et al.*, 2011). In clustering all the F_1 hybrids would have separated mainly based on floral characters than vegetative characters because of high segregation of floral characters.

This successful interspecific hybridization also revealed the possibility of obtaining hybrids of *M. acuminata* with other *M. balbisiana* species and also indicates ample scope for genetic enhancement of *M. acuminata* through interspecific gene transfer. It gave an idea about the crossing of cultivated *Musa* with wild *Musa* accessions for specific characters like disease resistance, pest resistance, quality improvement, drought resistance etc. Diploid *Musa* species are morphologically diverse, yet remain highly inter fertile, making the group an ideal model for the study of the genetic basis of phenotypic differences between species through map-based investigation using quantitative trait loci. The segregating interspecific hybrids proved to be suitable for such investigations and could also provide insights into the nature and extent of genome evolution within the cultivated *Musa* cultivars (Sargent *et al*., 2004). The cluster analysis has revealed the uniqueness of parents Calcutta-4 and Bee Hee Kela. Majority of the F_1 hybrids were grouped in one cluster where as the D-74 and D-51 were observed to be unique one closely related to the Bee Hee Kela and the others remained single in a cluster. Selfing and back crossing in these F_1 and within the progenies of a cluster may give better insight tot segregation pattern of the selected distinct morphological characters. This study revealed that segregation of specific character male flower color and wax on the bract which is seen in the natural hybrids. This further confirms presence of 'B' in evolution of hybrid banana cultivars.

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Table 1. Frequency distribution of qualitative characters

Sl. No.	Descriptor	Number of accessions grouped in descriptor state codes					
		1	2	3	4	5	6
1	Blotches at the petiole base		22	8			
2	Petiole canal leaf			4	26		
3	Peduncle hairiness	30					
4	Bunch position		10		20		
5	Male bud shape	6	7	16	1		
6	Bract apex shape	2	4	19	5		
7	Bract behavior before curling	30					
8	Wax on the bract		1	17	12		
9	Compound tepal basic color without considering lobe color	4	7			19	
10	Lobe color of compound tepal		8	22			
11	Style shape	30					
12	Stigma color	7	19			4	

Table 2. Clustering of F_1 hybrids of banana in Dendrogram

Cluster	Grouping of F_1 Hybrids
I	Cal-4
IIa	BHK, D-51
IIb1	74
IIb2a	D-28, D-45, D-21
IIb2b1	D-32, D-58, D-55, D-5, D-6, D-26
IIb2b2	D-19, D-8, D-14, D-33, D-38, D-50, D-20, D-33, D-29, D-71, D-44, D-36, D-31, D-49, D-40, D-22, D-73, D-23, D-13

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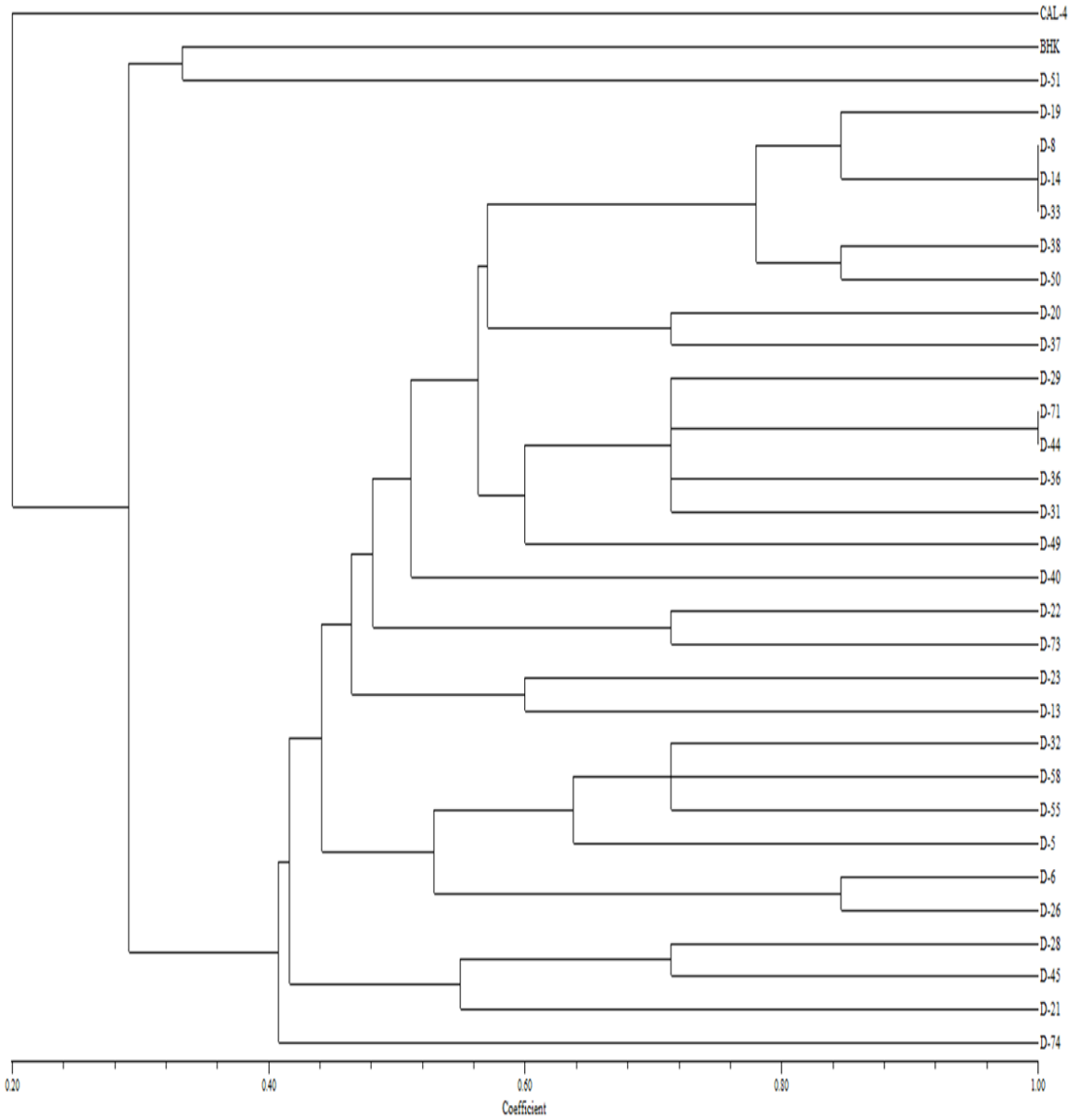

Fig. 1. Dendrogram of *Musa* F_1 hybrids for qualitative characters using UPGMA based on Jaccard's coefficient