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Research Note

Genetic variability of banana (*Musa* spp.) in west coastal zone of India

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Abstract
The investigation was carried out to assess growth, yield performance and the extent of genetic variation in thirty banana genotypes found in West Coastal Zone of India for fourteen characters. The genotypes showed substantial variation and the PCV was found greater than GCV for all the characters studied. High heritability in broad sense (h^2_b) coupled with high genetic advance (GAM) was noticed for 'number of living leaves at harvest' and 'fruit peel thickness' indicating the role of additive gene action. The important yield characters *viz*., bunch and fruit weight with high PCV, GCV, heritability and moderate to high GAM were proved as the primary selection criteria. The genomic group AAA was found better than others in both yield and quality characters at a time. The genotypes 'Pache Bontha Bathesa' (ABB) and 'Udhayam' (ABB) were found high yielding but considering quality characters, 'Grand Naine' (AAA) was found as the best in ecological conditions of the West Coastal Zone of India.

Key words
Banana, Genetic variability, heritability, Genetic advance, Genotypic and Phenotypic coefficient of variance.

Banana (*Musa* spp.) is the second most important fruit crop in India next to mango. Botanically banana is the large herbaceous perennial monocot flowering plant of the genus *Musa* belonging to the family Musaceae of order Scitamineae (Madhava Rao, 1984). Although the Konkan area is untraditional to the banana crop, some pockets are developing to cultivate bananas as a cash crop where irrigation facilities are available. Through breeding strategies, we have to develop improved genotypes with high and stable yield, improved agronomic traits, superior fruit quality and improved keeping quality also. The success of any breeding programme depends upon the quantum of genetic variability available for exploitation. Hence, the present investigation was laid out to assess the growth and yield performance of thirty banana genotypes and also to study the extent of genetic variation in West Coastal Zone of India.

The experiment was conducted at Central Experimental Station, Wakawali at Tetawali of Maharashtra. Konkan region is located at Western side of India having an area of about 30,000 sq km adjoining to Arabian Sea. The germplasm material comprising of 30 genotypes of banana and plantains were having 5 diploid and 25 triploid genotypes. They were collected from the National Research Centre for Banana (NRCB), Trichy, Tamilnadu and planted at the experimental block during 2012 with a spacing of 2.5m x 2.5m. The experiment was raised in Randomised Block Design with three replications. Observations regarding twelve quantitative and two qualitative traits (Table 1) were recorded on 3 plants of each genotype. The crop was raised successfully by adopting recommended cultural practices. The data on twelve characters were subjected to statistical analysis as suggested by Panse and Sukhatme, 1967. The phenotypic, genotypic and environmental variances were calculated as per procedure by Gomez and Gomez (1984), PCV and GCV as per Burton and De Vane (1953), heritability as shown by Weber and Moorty (1952) and the Genetic Advance as percentage of Mean (GAM) as suggested by Johnson *et al*., (1955).

In present experiment, the thirty genotypes of banana exhibited wide range of variation for all the fourteen characters (Table 1).The analysis of variance showed that the differences among the genotypes were highly significant for all the characters.. This indicated that, the choice of the genotypes was appropriate and that the genotypes were quite distinct from each other with respect to the characters studied and hence, suitable for genetic analysis.

Regarding the pseudostem height, the most dwarf genotype 'Dwarf Cavendish' (AAA) with 1.54 m height was found significantly shorter than all the other genotypes. The tallest of 4.92 m was recorded by the wild genotype '*Musa balbisiana'* (BB). The genomic group ABB had the genotypes with somewhat taller stature. The longest leaf blade was recorded by 'Red Banana' (AAA) (283.53 cm) while the widest leaves (90.67 cm) by 'Jwari Bale' (AAB). Considerable variability was observed in mean number of living leaves at harvest ranging from 0.67 recorded by 'Pache Bontha Bathesa' (ABB) and 'Ashy Bathesa' (ABB) to 8.33 observed in *Musa balbisiana*. Roman *et al*. (1997) and Lessa *et al*. (2010) also reported such a wide range of variation for number of living leaves at harvest.

Peduncle length varied considerably in the present study ranging from 21.17 cm recorded by 'Anai

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Komban' (AA) to 59.57 cm by 'Birbutia' (ABB). Heslop-Harrison and Schwarzacher (2007) and Brandao *et al*. (2013) also reported wide range of variability for peduncle length. The character 'number of hands per bunch' had shown wide variability in the range starting from 5.00 (Anai Komban and Nendran) up to 14.33 in 'Udhayam' (ABB) proving to be superior for this character than all the other genotypes. Number of fruits per hand ranged from 9.67 recorded by 'Nendran' (AAB) to 22.00 observed in 'Grand Naine' (AAA) which is in conformity with the findings of Roman *et al*. (1997), Kavitha *et al*. (2008), Rajamanickam and Rajmohan (2008 and 2010), Mattos *et al*. (2010), Ramirez Pedraza *et al*. (2010) and Samarasinghe *et al*. (2010). The genotypes 'Grand Naine' (AAA) and 'Dwarf Cavendish' (AAA) were found to be the outstanding for this character.

Fruit length and fruit diameter also showed wide range of variation. 'Saba' (ABB) recorded longest fruit length (19.60 cm) while 'Nutepong' (ABB) was found to be the widest (55.00 mm) fruit among all. Fruit peel thickness also recorded considerable variability with 'Red Banana' (AAA) having the thickest peel (4.00 mm) and 'Ney Poovan' (AB) having the thinnest peel (0.50 mm). This is also supported by the findings of Gibert *et al*. (2009) and Brandao *et al*. (2013).

The most important yield character bunch weight recorded a wide range of variability starting from 6.33 kg recorded by 'Anai Komban' (AA) up to 32.87 kg by 'Pache Bontha Bathesa' (ABB) which is closely followed by 'Udhayam' (ABB). Fruit weight also varied over a wide range from 76.53 g expressed by 'Ney Poovan' (AB) to 277.57 g recorded in 'Saba' (ABB).

Flesh texture was observed as firm or soft with the least variation. Both types were found in the present study. These textures were also reported by Onyango *et al*. (2011) and Brandao *et al*. (2013). Considerable variation was found for taste like mild or slightly tasty or tasteless, sweet, sugary and 'sweet and acidic'. None of the genotype has shown astringent or any other type of taste. All the types of tastes were reported by Javed *et al*. (2002), Onyango *et al*. (2011) and Rodrigues *et al*. (2012).

Among the all, the genomic group AAA (Dwarf Cavendish, Grand Naine, Amrit Sagar, Red Banana) was found with many good characteristic combinations *viz.* short stature, heavy bunches, good quality fruits with sweet and soft pulp.

Genotypes from AB genomic group *viz.* 'Kunnan' and 'Ney Poovan' were also found with the good quality fruits sweet in taste, small in size but yielding somewhat less heavier bunches. Most of the genotypes in AA and AAB genomic group could be preferred for their characteristic sweet and acidic taste accompanied with optimum bunch weight. The genomic group ABB was found to be with mixture of desirable and undesirable traits having genotypes.

The estimates of Phenotypic and Genotypic Coefficients of Variation (PCV and GCV) are given in Table 2. In general, much difference was not observed between PCV and GCV for the traits studied, (indicating maximum expression of genotype with less effect of environment on the characters). Number of living leaves at harvest (48.78 %), fruit peel thickness (47.58 %) recorded the highest PCV. In case of GCV, fruit peel thickness (47.18%) and number of living leaves at harvest (47.07) recorded comparatively higher GCV Based on this, fruit peel thickness and number of living leaves at harvest are the characters to be relied up on for selection.

The estimates of heritability in broad sense (h^2_b) and genetic advance along with GAM are also presented in Table 2 and depicted in Fig. 1. The heritability ranged from 83.32 per cent for No. of fruits per hand to 99.38 per cent for leaf blade length. All the twelve quantitative characters showed higher amount of heritability. The genetic advance ranged between 1.80 for pseudostem height to 103.92 for fruit weight. However, GAM ranged from 26.96 % (fruit diameter) to 96.36 % (fruit peel thickness). The character like fruit peel thickness (96.36 %) showed highest estimates of GAM followed by number of living leaves at harvest (93.57 %). While, the lowest estimates of GAM were recorded for leaf blade width (28.57%) and fruit diameter (26.96 %).

Moderate values of PCV and GCV and very high heritability with moderate GAM was observed for pseudostem height revealing relatively low influence of environment on this trait. This is in accordance with the findings reported by Uma *et al*. (2000), Kulkarni *et al*. (2002), Kavitha *et al*. (2008) and Rajamanickam and Rajmohan (2008 and 2010). Leaf blade length and leaf blade width showed comparatively lower (17.79 % and 14.29 % respectively) PCV and GCV with also the least difference between them indicating maximum reflection of genotype into phenotypic expression of these characters. Leaf blade length exhibited the highest amount of heritability (99.38 %) among the characters observed, along with moderate GAM. It indicates the less environmental influence on the expression of leaf blade length. Leaf blade width had shown high heritability values with lower GAM indicating the heritability might be due to non-additive gene effects. This indicated that, the simple selection may not be rewarding for this character. This is in total agreement with the findings of Uma *et al*. (2000) and Rajamanickam and Rajmohan (2008 and 2010). The highest PCV

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(48.78 %) and GCV (47.07 %) with also a very high heritability (93.13 %) and highest GAM (93.57 %) were observed for number of living leaves at harvest indicating preponderance of additive gene action and more effectiveness of simple directional selection.

Peduncle length had shown moderate values for GCV, PCV and high heritability values with moderate GA indicating the influence of environment on the trait. The character 'number of hands per bunch' had shown moderate values of GCV, PCV and high heritability values with moderate GA indicating the importance of selection.. Kavitha *et al*. (2008) also reported moderate values of PCV and GCV whereas Rekha and Prasad (1993) reported high estimates of genetic coefficients of variation, heritability and genetic advance for Peduncle length and number of hands per bunch. Number of fruits per hand exhibited lower PCV, GCV with a small difference between them and high heritability coupled with moderate estimate of GAM indicating relatively low influence of environment on the trait. This is in accordance with the findings of Rajamanickam and Rajmohan (2008 and 2010).

Fruit length and fruit diameter were observed with lower values of PCV, GCV and higher values of heritability coupled with moderate to low GAM which is in agreement with the findings of Baruah *et al*. (2007) and Rajamanickam and Rajmohan (2008 and 2010). It indicates the expression of heritability in these characters might be due to non-additive gene effects, suggesting that, the simple selection may not be effective for these characters.

Fruit peel thickness recorded higher values of PCV, GCV and very high estimates of heritability coupled with GAM in the present study. This clearly suggests that this character is mainly of additive type and therefore simple directional selection would be effective for improvement.

Bunch weight and fruit weight recorded high estimates of PCV, GCV with also high heritability and moderate to high GAM revealing relatively low influence of environment on the traits proving themselves as primary selection criteria for improvement in banana. This is in accordance with the findings of Rekha and Prasad (1993), Uma *et al*. (2000), Kulkarni *et al*. (2002), Kavitha *et al*. (2008) and Rajamanickam and Rajmohan (2008 and 2010).

Among all genomic groups, the genomic group AAA was found with many good characteristics combined *viz*. short stature, heavy bunches, good quality fruits with sweet and soft pulp. The most high yielding genotypes found in the present study were 'Pache Bontha Bathesa' ABB (32.87 kg), followed by 'Udhayam' (ABB) (30.47 kg). But considering yield along with the quality characters viz. sweetness, soft pulp texture and dwarfism, the genotype 'Grand Naine' AAA (26.40 kg) was found to be the best in the ecological conditions of the West Coastal Zone of India and could be recommended for cultivation. Among the culinary genotypes having mild taste and more firm texture, 'Nendran' (AAB) was found as the best. In general, much difference was not observed between PCV and GCV for all the characters studied. High heritability in broad sense (h^2_b) coupled with high genetic advance as per cent of mean (GAM) was noticed for number of living leaves at harvest and fruit peel thickness (mm) indicating role of additive gene action. The most important yield characters bunch weight (kg) and fruit weight (g) with high estimates of PCV, GCV and also a very high amount of heritability and moderate to high GAM proved to be the prime selection criteria for improvement in banana.

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Table 1. Mean performances of different parameters of banana genotypes

Sl. No.	Name of Genotype	Genomic Group	Pseudostem height (m)	Leaf Blade Length (cm)	Leaf Blade Width (cm)	No. of living leaves at harvest	Peduncle length (cm)	No. of hands	No. of Fruits per hand
1	Anai Komban	AA	2.18	166.43	54.63	5.67	21.17	5.00	13.67
2	Kanai Bansi	AA	2.74	198.00	69.07	5.00	34.70	6.00	16.67
3	Dwarf Cavendish	AAA	1.54	137.23	64.30	4.33	29.77	8.00	21.33
4	Grand Naine	AAA	1.97	177.23	71.90	4.00	34.80	9.00	22.00
5	Robusta	AAA	2.40	182.73	77.70	5.33	32.43	8.00	18.33
6	Amrit Sagar	AAA	2.23	214.57	81.37	5.00	37.23	6.00	12.33
7	Red Banana	AAA	3.89	283.53	83.30	5.00	35.10	7.00	14.00
8	Jwari Bale	AAB	1.82	152.90	90.67	4.67	27.27	6.67	12.67
9	Nendran	AAB	2.84	185.97	63.70	4.67	30.13	5.00	9.67
10	Poovan	AAB	2.88	188.63	63.77	6.00	44.60	12.00	14.33
11	Pacheladan	AAB	2.89	187.63	46.10	3.67	45.73	8.33	13.67
12	Malaikali	AAB	3.23	273.17	79.80	5.00	28.87	7.00	14.00
13	Ladan Pointed	AAB	3.44	241.57	66.17	4.67	35.10	8.00	14.00
14	Nendra Padathi	AAB	3.17	201.03	66.57	3.00	37.43	7.00	12.33
15	Sabri	AAB	3.08	260.03	66.00	4.00	28.53	6.67	13.33
16	Kunnan	AB	2.47	210.63	67.77	4.33	26.43	7.00	14.33
17	Ney Poovan	AB	2.95	159.53	53.53	6.33	24.40	9.00	16.00
18	Karpuravalli	ABB	4.86	182.87	63.23	5.33	40.90	8.33	13.67
19	Peyan	ABB	4.25	240.03	68.17	4.00	27.37	6.33	16.67
20	Udhayam	ABB	4.33	240.33	60.97	7.33	44.63	14.33	17.67
21	Ankur II	ABB	4.53	187.90	60.53	7.67	37.80	8.00	13.00
22	Kachkel	ABB	4.11	219.70	61.67	1.67	44.57	6.00	13.33
23	Bangrier	ABB	3.23	249.57	69.17	3.00	30.40	8.00	14.00
24	Kothia	ABB	3.66	214.33	81.03	2.00	33.17	11.00	15.00
25	Saba	ABB	4.44	249.87	72.13	2.33	33.13	6.00	13.00
26	Nutepong	ABB	3.41	248.93	75.17	1.00	39.93	7.33	13.33
27	Pache Bontha Bathesa	ABB	3.28	194.73	66.50	0.67	45.63	12.33	12.00
28	Ashy Bathesa	ABB	3.57	208.10	67.00	0.67	53.77	12.00	12.67
29	Birbutia	ABB	3.33	221.80	83.83	1.33	59.57	9.00	16.67
30	*Musa balbisiana*	BB	4.92	165.27	72.37	8.33	32.63	9.00	14.00
	General mean		3.25	208.14	68.94	4.20	35.91	8.11	14.59
	Range	**Min**	1.54	137.23	46.10	0.67	21.17	5.00	9.67
		Max	4.92	283.53	90.67	8.33	59.57	14.33	22.00
	SE ±		0.089	1.680	0.970	0.310	2.015	0.205	0.660
	C.D. at 5%		0.252	4.755	2.745	0.878	5.704	0.580	1.867

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Table 1. Contd.,

Sl. No.	Name of Genotype	Fruit length (cm)	Fruit diameter (mm)	Fruit peel thickness (mm)	Bunch weight (kg)	Fruit weight (g)	Flesh texture	Predominant taste
1	Anai Komban	12.27	30.33	1.17	6.33	91.27	Soft	Sweet and acidic
2	Kanai Bansi	16.93	36.33	2.00	9.73	100.47	Soft	Slightly tasty
3	Dwarf Cavendish	12.47	34.33	1.33	20.80	121.43	Soft	Sweet
4	Grand Naine	14.93	38.33	2.00	26.40	131.30	Soft	Sweet
5	Robusta	18.63	39.33	0.50	24.10	165.03	Firm	Sweet
6	Amrit Sagar	14.40	40.67	1.00	11.73	161.00	Soft	Sweet
7	Red Banana	14.33	45.67	4.00	20.73	219.13	Soft	Sweet
8	Jwari Bale	14.77	40.67	3.00	12.07	140.20	Soft	Slightly tasty
9	Nendran	16.83	42.33	1.33	11.30	218.07	Firm	Slightly tasty
10	Poovan	11.13	39.67	2.00	14.87	82.63	Firm	Sweet and acidic
11	Pacheladan	13.73	36.67	3.00	12.93	110.33	Firm	Sweet and acidic
12	Malaikali	13.37	37.00	3.00	12.87	130.57	Soft	Sweet and acidic
13	Ladan Pointed	15.60	32.33	4.00	16.63	150.65	Soft	Sweet and acidic
14	Nendra Padathi	13.43	39.67	3.33	16.63	190.97	Soft	Sweet and acidic
15	Sabri	13.80	45.33	2.00	16.10	181.10	Soft	Sugary
16	Kunnan	12.70	42.67	0.67	13.93	137.93	Firm	Sweet
17	Ney Poovan	10.53	33.67	0.50	11.60	76.53	Firm	Sweet
18	Karpuravalli	14.17	39.67	2.00	17.27	146.47	Firm	Sugary
19	Peyan	11.73	36.67	3.00	9.07	82.90	Firm	Slightly tasty
20	Udhayam	15.37	35.00	2.00	30.47	118.30	Firm	Sweet and acidic
21	Ankur II	15.27	37.33	3.00	12.50	111.70	Firm	Sweet and acidic
22	Kachkel	14.80	51.67	3.00	19.30	240.37	Firm	Sweet and acidic
23	Bangrier	18.80	41.00	4.00	27.50	238.57	Firm	Tasteless
24	Kothia	15.33	42.67	3.00	29.03	174.50	Soft	Sweet and acidic
25	Saba	19.60	43.67	4.00	22.17	277.57	Firm	Slightly tasty
26	Nutepong	18.93	55.00	4.00	19.37	202.17	Soft	Sweet
27	Pache Bontha Bathesa	15.17	41.67	4.00	32.87	220.07	Soft	Sweet
28	Ashy Bathesa	13.57	43.33	4.00	27.67	175.10	Soft	Sweet
29	Birbutia	15.50	39.33	3.33	29.37	199.90	Soft	Slightly tasty
30	*Musa balbisiana*	10.50	49.33	1.00	21.30	167.43	Soft	Sweet
	General mean	14.62	40.38	2.51	18.55	158.79		
	Range	10.50	30.33	0.50	6.33	76.53		
		19.60	55.00	4.00	32.87	277.57		
	SE ±	0.417	0.658	0.090	1.029	7.606		
	C.D. at 5%	1.181	1.862	0.253	2.914	21.532		

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Table 2. Estimates of genetic parameters for twelve characters in banana

Sl. No.	Characters	PCV (%)	GCV (%)	h^2 (%)	GA	GAM (%)
1	Pseudostem height (m)	27.65	27.25	97.07	1.80	55.30
2	Leaf Blade Length (cm)	17.79	17.73	99.38	75.81	36.42
3	Leaf Blade Width (cm)	14.29	14.08	97.09	19.70	28.57
4	No. of living leaves at harvest	48.78	47.07	93.13	3.93	93.57
5	Peduncle length (cm)	25.42	23.48	85.37	16.05	44.70
6	No. of hands	28.13	27.79	97.58	4.59	56.54
7	No. of Fruits per hand	19.18	17.50	83.32	4.80	32.91
8	Fruit length (cm)	16.80	16.05	91.35	4.62	31.61
9	Fruit diameter (mm)	13.67	13.38	95.74	10.89	26.96
10	Fruit peel thickness (mm)	47.58	47.18	98.31	2.41	96.36
11	Bunch weight (kg)	39.76	38.59	94.16	14.31	77.13
12	Fruit weight (g)	33.81	32.77	93.98	103.92	65.44