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Genetic variability and correlation studies of triploid ecotypes of banana (*Musa* spp.)

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Abstract
The present experiment on Genetic variability and correlation studies on triploid ecotypes of banana (*Musa* spp.) was conducted at College of Agriculture, Vellayani, Thirtuvananthapuram to determine the variability, heritability, genetic advance and correlation for their eighteen morphological and quality traits. The genotypic and phenotypic coefficient of variance, heritability and genetic advance were estimated for eighteen traits which included plant height, pseudostem height, number of suckers per plant, leaf width, days taken from planting to shooting, total crop duration, bunch weight, hand weight, number of fingers per bunch, number of fingers per hand, length, girth, weight and volume of finger, ripe fruit weight, sugar/acid ratio and pulp weight. A remarkable variability was observed among the collections for these characters. The high magnitude of PCV and GCV were recorded for number of fingers per bunch, ripe fruit weight, pulp weight, sugar: acid ratio, finger weight and number of suckers per plant. All the characters showed higher estimates of broad sense of heritability whereas genetic advance was recorded very high in bunch weight, followed by finger weight, ripe fruit weight, pulp weight and number of fingers per bunch. The value of high PCV, GCV, ECV, heritability and genetic advance make it a prime character for the direct selection. Bunch weight, number of fingers per bunch, weight of fingers and ripe fruit weight showed the high heritability coupled with high genetic advance are the important characters which have to be considered for selection of the clones. Regarding correlation studies, bunch weight had significantly positively correlated with plant height, psuedostem girth, number of leaves per plant, leaf width, days taken for planting to flowering, number of fruits pr bunch, number of fruits per hand and hand weight.

Keywords: Banana, PCV, GCV, heritability, genetic advance, correlation

Introduction
The primary object of crop improvement programme is a critical assessment of genetic variability existing in that particular crop and the extent to which the character to be improved is heritable. Burton (1952) [3] has pointed out that calculating the genetic coefficient of variation along with heritability can assess a best picture of the amount of advancement to be expected by selection. Ramanujan and Thirumalachar (1967) [16] have suggested that heritability estimate in the broad sense will be reliable, if accompanied by a high genetic advance. Johnson *et al.*, (1955) [7] and Swarup and Changle (1967) [22] also consider that heritability estimates along with genetic gain are useful and reliable than heritability estimates along in predicting the selection response. Effectiveness of selection based on phenotypic performance can be more useful and reliable only if selection is based on heritability estimates along with genetic gain. Above all these, knowledge of the extent of variability in the germplasm is an essential prerequisite in any breeding programme. In the present investigation, a critical assessment is made on the biometrical studies on eighteen characters of twenty three triploid clones of banana (*Musa* spp.) were studied.

Materials and Methods
Twenty three triploid banana ecotypes were collected from different parts of Kerala and Tamil Nadu and planted at Instructional Farm, College of Agriculture, Vellayani, Thiruvananthapuram (Table 1). The experiment was laid out in a completely randomized block design (CRD) with 23 treatments and replicated thrice as per the method was suggested by Panse and Sukhatme (1985) [13]. The cultural practices as per the Package of Practices Recommendations (KAU, 1996) [8] were followed. The observations were recorded on vegetative traits like plant height (m), pseudostem girth (m), number of leaves per plant, number of suckers per plant, leaf width (cm), days taken from planting to shooting and total crop duration (days); bunch traits like number of fingers per hand, bunch weight (kg), hand weight (kg), number of fingers per bunch and finger traits like length, girth, weight and volume of finger, ripe fruit weight (g), sugar: acid ratio and pulp weight (g).

Biometrical data were collected and analysed statistically (Fischer, 1960) [5]. From the analysis of variance, genetic parameters *viz.,* phenotypic and genotypic coefficient of variation (PCV and GCV) (Burton, 1952) [3], heritability estimates (Burton and de Vane, 1953) [4] and genetic advance (Allard, 1960) [2] and correlation studies (Al- Jibouri *et al.*, 1958) [1] were calculated.

Results and Discussion

The phenotypic and genotypic coefficient of variation for eighteen morphological characters of twenty three ecotypes of triploid banana was studied. Phenotypic coefficient of variation (PCV) were higher than their respective genotypic coefficient of variation (GCV) for all the characters, while reflects the influence of environment of the phenotypic expression of these characters. A significant difference was recorded among the various ecotypes of triploid banana for different plant parameters studied that range and general mean for each character under the study with wide variations in mean values (Table 2). The highest range of variation was shown by number of fingers per bunch, finger weight, volume of finger, ripe fruit weight, plant height, days taken from planting to shooting, pulp weight, total crop duration and number of suckers per plant. The lowest range of variation was recorded by number of leaves per plant, bunch weight, leaf width, number of fingers per hand, sugar: acid ratio, pseudostem girth, finger length, hand weight and finger girth. The each trait of twenty three triploid ecotypes of banana under the study with wide variation in general mean range.

Generally, phenotypic coefficient of variation found higher than the genotypic coefficient of variation and the extent of latter component also showed that they are mostly heritability in nature (Table 3 & 4). PCV ranged from 10.54 per cent for leaf width to number of fingers per bunch of 65.22 per cent. The highest magnitude of PCV observed for characters like number of fingers per bunch (65.22%) followed by ripe fruit weight (52.35%), pulp weight (50.69%), sugar: acid ratio (49.77%), finger weight (47.15%) and number of suckers per plant (44.84%). The moderate magnitude of variation was recorded for the traits like number of fingers per hand (27.421%), volume of finger (25.081%), finger girth (21.787%) and number of leaves per plant (15.79%). The lowest magnitude of PCV value was observed in leaf width (10.54%) followed by total crop duration (11.35%), plant height (13.94%), days taken from planting to shooting (14.11%) and pseudostem girth (14.63%). Sreerangaswamy *et al.* (1980) [20] also obtained similar results in culinary and dessert types of banana.

GCV is a better tool to understand useful variability as it is free from the environmental components. GCV helps in comparison and measurement of genetic variability among different characters and it is ranged from 9.92 per cent for leaf width to 64.86 per cent for number of fingers per bunch. The high magnitude of GCV was recorded for the characters like number of fingers per bunch (64.86%) followed by ripe fruit weight (52.23%), pulp weight (50.56%), sugar: acid ratio (49.59%), finger weight (47.07%) and number of suckers per plant (42.36%). The moderate magnitude of variation was observed in bunch weight (33.86%), hand weight (32.868%), number of fingers per hand (26.162%), volume of fruit (24.079%) and fruit girth (20.691%). The lowest magnitude of GCV was observed in leaf width (9.92%) followed by total crop duration (11.23%), plant height (13.84%), days taken from planting to shooting (13.91%), pseudostem girth (14.32%) and number of leaves per plant (13.44%). Rajeevan and Geetha (1982) [15] noticed that the high PCV and GCV were the higher in bunch weight, number of fingers per bunch, number of hands per bunch, finger length and finger weight of 40 banana cultivars. The work difference in PCV and GCV and very low estimates of GCV indicate the immense influence of environment of the manifestation of this character. This results were also consonance with the findings of Rekha and Prasad (2001) [17]; Sawant *et al.,* (2016) [19] in banana and Rai *et al.,* (2001) [14] in mango. A very difference between phenotypic and genotypic coefficient of variation met with the number of fingers per bunch, bunch weight, pulp weight, ripe fruit weight, sugar: acid ratio and number of suckers per plant suggests that in these characters were the environmental influence was not marked.

Heritability in broad sense gives the amount of heritable portion of a character. Characters possessing high heritability can be improved directly through selection as they are less affected by the environment. In the present study, all characters exhibited high heritability (>70%), which ranged from 72.52 per cent for number of leaves per plant to 99.57 per cent of finger weight. The characters like weight of finger (99.57%) followed by ripe fruit weight (99.50%), pulp weight (99.50%), bunch weight (99.28%), number of fingers per bunch (98.80%), plant height (98.60%), total crop duration (98.24%), length of finger (97.50%), days taken from planting to shooting (97.19%), pseudostem girth (95.90%), volume of finger (92.17%), number of fingers per hand (91.03%), girth of finger (90.19%), number of suckers per plant (89.27%), leaf width (88.71%), sugar: acid ratio (88.19%), weight of hand (85.15%) and number of leaves per plant (72.52%) had high heritability. Their relatively higher values of heritability imply that large proportion of phenotypic variance was attributable to the genotypic variance. The above traits having high estimate of heritability will slow fairly ease selection for traits which may be due to most correspondence between genotypic and phenotypic levels with narrow association of environment. The high heritability for the traits like plant height, number of fingers per bunch, weight of finger and ripe fruit weight obtained in the present studies are in agreement with the findings of Sreerangaswamy *et al.,* (1980) [20] and Kavitha *et al.,* (2008) [9] in banana. The high heritability was also reported for leaves at flowering and number of hands per bunch (Rajeevan and Geetha, 1982) [15], leaf area per plant and bunch weight (Valsalakumari and Nair, 1986) [24] and bunch weight (Uma *et al.,* 2000) [23].

Regarding genetic advances as per cent over mean, there was a wide variation among the characters. In the present study, genetic advance varied from 19.26 per cent for leaf width to 132.81 per cent finger weight. The characters like weight of finger (132.81%) followed by ripe fruit weight (107.38%), pulp weight (103.89%), bunch weight (107.79%), number of fingers per bunch (96.71%), number of suckers per plant (82.46%) and length of finger (71.67%) recorded the high magnitude of genetic advance (>70%).

The moderate magnitude of variation was observed in (30 to 50%) volume of fruit (47.623%) and finger girth (40.480%). Whereas the lowest magnitude of variation (<25%) was noticed in leaf width (19.26%) followed by total crop duration (22.96%), number of leaves per plant (23.58%), days taken from planting to shooting (28.26%), plant height (28.32%) and pseudostem girth (28.90%). This clearly suggests that these characters are mainly of additive types reported by Johnson *et al.,* (1955) [6]. The trait number of fingers per bunch recorded the high value of PCV, GCV and heritability coupled with genetic advance indicated that the character is

predominantly controlled by additive gene action. Jagadeesha *et al.,* (2007) [7] reported that high heritability coupled with high genetic advance as per cent of mean was observed in plant height, stem girth, days to flowering, days to maturity, crop duration, fingers per bunch that indicating a possible role of additive gene effects. Similar association between traits studied also been reported in guava by Mrinalini and Tiwari (2008) [11]. Panse (1957) [12] suggested that characters exhibiting high heritability and GA were governed by additive gene effects. Uma *et al.,* (2000) [23] reported that plant height with very high value of heritability and moderate value of genetic advance, revealing relatively low influence of environment on this trait of silk ecotypes of banana.

Correlation provides information on the nature and extent of association between characters in a population. When selection pressure is applied on a trait, the population under selection is improved not only for trait but also for other characters associated with it. This facilitates simultaneous improvement of two or more characters. The phenotypic and genotypic correlations are presented in Table 5 & 6. In the present study, bunch weight had significantly positively phenotypic correlation with plant height, psuedostem girth, Number of leaves per plant, leaf width, days taken for planting to flowering, number of fruits pr bunch, number of fruits per hand and hand weight. Significant genotypic correlation with bunch weight was seen for plant height, pseudostem girth, leaf width, days taken for planting to flowering, total crop duration. The number of fruits per bunch is positively correlated with number of fruits per hand and hand weight. The highly significant phenotypic correlation of bunch weight with number of fruits per bunch obtained in the present study is in agreement with the findings of Rosamma and Namboodiri (1990) [18]. Significant association of bunch weight of banana with fingers per hand at genotypic level was reported by Krishnan and Shanmugavelu (1983) [10] and Rosamma and Namboodiri (1990) [18]. Positive significant phenotypic and genotypic correlation of plant height with bunch weight as seen in the present studies was earlier reported by Krishnan and Shanmughavelu (1983) [10]. Weight of finger showed the positive correlation with girth of finger and length of finger supported by the findings of Sunilkumar (1997) [21] in banana.

Table 1: Cultivars, banana types, ploidy and genomic composition of triploid clones of banana.

Sl. No	Ecotypes	Type	Ploidy	Genomic Composition
1.	Red banana	Dessert	3X	AAA
2.	Vellakappa	Dessert	3X	AAA
3.	Robusta	Dessert	3X	AAA
4.	Vellayani Nendran	Dessert / Cooking	3X	AAB
5.	Padalamurian	Dessert / Cooking	3X	AAB
6.	Myndoli	Dessert / Cooking	3X	AAB
7.	Chengazhikodan	Dessert / Cooking	3X	AAB
8.	Attu Nendran	Dessert / Cooking	3X	AAB
9.	Kaliethan	Dessert / Cooking	3X	AAB
10.	Koonoor Ethen	Dessert / Cooking	3X	AAB
11.	Mysore Ethan	Dessert / Cooking	3X	AAB
12.	Zanzibar	Dessert / Cooking	3X	AAB
13.	Quintal banana	Dessert / Cooking	3X	AAB
14.	Changanasseri Nendran	Dessert / Cooking	3X	AAB
15.	Manjeri Nendran	Dessert / Cooking	3X	AAB
16.	Palode Palayankodan	Dessert	3X	AAB
17.	PKNNR	Dessert	3X	AAB
18.	Chandra Bale	Dessert	3X	AAB
19.	Pisang Ceylon	Dessert	3X	AAB
20.	Motta poovan	Dessert	3X	AAB
21.	Vellapalayankodan	Dessert	3X	AAB
22.	Monthan	Cooking	3X	ABB
23.	Peyan	Cooking	3X	ABB

Table 2: Phenotypic variability of twenty three triploid ecotypes of banana

Characters	Mean S.E.	Range	CD at 5%
Plant height (cm)	316.5 ± 9.1	417.2 – 239.6	19.0
Pseudostem girth (cm)	65.2± 2.0	96.1 – 55.4	4.1
Number of leaves per plant	8.8 ±0.3	11.6 – 7.2	0.5
Leaf width (cm)	74.5 ±1.6	87.6 – 64.0	3.2
Number of suckers per plant	9.8 ±0.9	24.8 – 5.4	1.8
Days taken for planting to shooting (days)	240.0 ± 7.6	310 – 174.2	15.7
Total crop duration (days)	338.0 ±8.5	420.0 – 265.8	17.6
Bunch weight (kg)	15.4 ±1.1	30.4 – 6.5	2.3
Number of fingers per hand	12.8 ±0.7	18.9 – 7.6	1.5
Number of fingers per bunch	99.7 ±13.5	254.0 – 18.4	28.0
Hand weight (g)	2.4 ±0.2	4.5 – 1.5	0.3
Finger length (cm)	19.5 ±1.4	37.3 – 8.4	3.0
Finger girth (cm)	12.9 ±0.6	17.7 – 8.1	1.2
Finger weight (g)	202.6 ±19.9	507.4 – 90.1	41.3
Volume of fruit (cc)	193.7 ±20.0	503.9 – 82.5	41.6
Ripe fruit weight (g)	189.7 ±20.7	490.9 – 72.7	42.9
Pulp weight (g)	147.7 ±15.6	362.0 – 52.3	32.0
Sugar: acid ratio	24.3 ±2.8	79.7 – 31.9	5.9

Table 3: PCV, GCV. ECV, heritability and genetic advance of eighteen characters of triploid clones of banana

Characters	GCV (%)	PCV (%)	ECV (%)	Heritability (%)	Genetic Advance as per cent mean
Plant height (cm)	13.843	13.941	1.653	98.60	28.315
Pseudostem girth (cm)	14.327	14.630	2.960	95.90	28.902
Number of leaves per plant	13.443	15.785	8.274	72.52	23.583
Leaf width (cm)	9.925	10.538	3.541	88.71	19.257
Number of suckers per plant	42.368	44.841	14.688	89.27	82.463
Days taken for planting to shooting (days)	13.915	14.11	2.365	97.19	28.259
Total crop duration (days)	11.234	11.349	1.507	98.24	22.956
Bunch weight (kg)	33.861	36.056	12.388	99.28	101.790
Number of fingers per hand	26.162	27.421	8.213	91.03	51.42
Number of fingers per bunch	64.860	65.221	7.161	98.80	96.705
Hand weight (g)	32.868	35.621	13.728	85.15	62.478
Finger length (cm)	35.240	35.680	5.630	97.50	71.668
Finger girth (cm)	20.691	21.787	6.823	90.19	40.480
Finger weight (g)	47.047	47.149	3.109	99.57	132.806
Volume of fruit (cc)	24.079	25.081	7.016	92.17	47.623
Ripe fruit weight (g)	52.238	52.352	3.445	99.50	107.378
Pulp weight (g)	50.560	50.687	3.579	99.50	103.894
Sugar: acid ratio	49.596	49.770	4.225	88.19	65.507

Table: 4. Summary of estimates of PCV, GCV heritability and genetic advance of triploid clones of banana

Characters	GCV (%)	PCV (%)	Heritability (%)	Genetic Advance as per cent over mean
Plant height (cm)	L	L	H	M
Pseudostem girth (cm)	L	L	H	M
Number of leaves per plant	M	L	H	L
Leaf width (cm)	L	L	H	L
Number of suckers per plant	H	H	H	H
Days taken for planting to shooting (days)	L	L	H	M
Total crop duration (days)	L	L	H	L
Bunch weight (kg)	H	M	H	H
Number of fingers per hand	M	M	H	H
Number of fingers per bunch	H	H	H	H
Hand weight (g)	H	M	H	H
Finger length (cm)	H	H	H	H
Finger girth (cm)	M	M	H	M
Finger weight (g)	H	H	H	H
Volume of fruit (cc)	M	M	H	M
Ripe fruit weight (g)	H	H	H	H
Pulp weight (g)	H	H	H	H
Sugar: acid ratio	H	H	H	H

Table 5. Genotypic correlation coefficient of variation of 18 traits of twenty three triploid ecotypes of banana

	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X16	X17	X18
X1	1.000	0.700	0.365	0.180	0.310	0.534	0.644	0.549	0.173	0.110	0.184	0.093	0.181	-0.003	0.001	0.007	-0.023	0.554
X2		1.000	0.217	0.236	0.382	0.373	0.467	0.703	0.413	0.388	0.235	0.069	0.219	-0.025	-0.039	-0.042	0.043	0.426
X3			1.000	0.316	0.410	0.102	0.138	0.004	-0.232	-0.289	0.495	0.411	0.344	0.362	0.355	0.366	0.361	0.523
X4				1.000	-0.013	-0.213	-0.160	0.297	0.535	0.400	0.368	-0.235	0.122	0.121	-0.144	-0.158	-0.114	-0.020
X5					1.000	0.184	0.178	-0.067	-0.119	-0.199	0.513	0.525	0.408	0.540	0.559	0.549	0.459	0.451
X6						1.000	0.972	0.155	-0.013	-0.035	-0.224	0.152	-0.048	-0.068	-0.059	-0.040	-0.120	0.355
X7							1.000	0.262	0.044	-0.023	-0.125	0.189	-0.012	-0.037	-0.029	-0.010	-0.087	0.432
X8								1.000	0.538	0.492	0.194	-0.166	0.068	-0.262	-0.277	-0.279	-0.280	-0.033
X9									1.000	0.942	-0.128	-0.607	-0.477	-0.581	-0.588	-0.602	-0.621	-0.360
X10										1.000	-0.283	-0.739	-0.612	-0.717	-0.715	-0.737	-.0746	-0.391
X11											1.000	0.678	0.724	0.731	0.730	0.720	0.721	0.377
X12												1.000	0.760	0.938	0.936	0.943	0.922	0.501
X13													1.000	0.771	0.751	0.759	0.787	0.390
X14														1.000	0.997	0.997	0.987	0.478
X15															1.000	0.999	0.980	0.486
X16																1.000	0.982	0.484
X17																	1.000	0.478
X18																		1.000

X1- Plant height X2- Pseudo stem girth X3- No, of leaves/plant X4- Leaf width X5 – No. of suckers per plant
X6- Days taken from planting to flowering X7- Total crop duration X8- Bunch weight X9- No. of fruits/hand
X10-No. of fruits/bunch X11- Hand weight X12-Finger length X13- Girth of finger X14- Finger weight
X15-Volume of finger X16-Ripe fruit weight X17-Pulp weight X18- Sugar/acid ratio

Table 6: Phenotypic correlation coefficient of variation of 18 traits of twenty three triploid ecotypes of banana

	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X16	X17	X18
X1	1.000	0.685	0.318	0.172	0.298	0.521	0.633	0.510	0.164	0.109	0.164	0.089	0.168	-0.005	-0.001	0.005	-0.024	0.523
X2		1.000	0.202	0.219	0.358	0.360	0.452	0.654	0.389	0.383	0.216	0.066	0.202	-0.026	-0.041	-0.043	-0.041	0.406
X3			1.000	0.257	0.336	0.074	0.109	0.011	-0.177	-0.241	0.385	0.340	0.268	0.302	0.293	0.307	0.301	0.411
X4				1.000	0.005	-0.198	-0.152	0.267	0.477	0.382	0.291	-0.218	0.138	-0.114	-0.137	-0.149	-0.106	-0.026
X5					1.000	0.164	0.161	-0.046	-0.133	-0.112	0.430	0.482	0.375	0.510	0.524	0.517	0.433	0.429
X6						1.000	0.967	0.146	-0.006	-0.036	-0.194	0.151	-0.044	-0.066	-0.057	-0.038	-0.118	0.338
X7							1.000	0.243	0.047	-0.022	-0.107	0.189	-0.007	-0.036	-0.028	-0.009	-0.086	0.412
X8								1.000	0.494	0.469	0.201	-0.154	0.085	-0.245	-0.260	-0.261	-0.261	-0.048
X9									1.000	0.905	-0.094	-0.565	-0.429	-0.555	-0.559	-0.573	-0.592	-0.346
X10										1.000	-0.256	-0.726	-0.573	-0.711	-0.708	-0.728	-0.740	-0.373
X11											1.000	0.626	0.659	0.672	0.672	0.663	0.662	0.330
X12												1.000	0.730	0.925	0.922	0.929	0.909	0.465
X13													1.000	0.731	0.711	0.720	0.744	0.342
X14														1.000	0.996	0.997	0.986	0.460
X15															1.000	0.997	0.977	0.468
X16																1.000	0.980	0.465
X17																	1.000	0.461
X18																		1.000

X1- Plant height	X2- Pseudo stem girth	X3- No. of leaves/plant	X4- Leaf width	X5 - No. of suckers per plant
X6 - Days taken from planting to flowering		X7- Total crop duration	X8- Bunch weight	X9 - No. of fruits/hand
X10 - No. of fruits/bunch	X11- Hand weight	X12- Finger length	X13- Girth of finger	X14 - Finger weight
X15 - Volume of finger	X16 - Ripe fruit weight	X17- Pulp weight	X18- Sugar/acid ratio	

Conclusion

Exploiting available variation is mandatory for domestication and clonal deployment of triploid banana ecotypes for desirable traits. The present experiment it was concluded that bunch weight, number of fingers per bunch, finger weight and ripe fruit weight showed the high genetic advance, high heritability and significant genotypic correlation were the other important characters which have to be considered for selection of the clones.

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