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Studies on Genetic Variability, Heritability, Genetic Advance of Maize Inbred Lines

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Abstract The 43 maize inbreds were evaluated for 16 different quantitative characters. Analysis of variance revealed highly significant differences among the inbreds for all the character under study indicating existence of wide range of variation. Co-efficient of variation at genotypic (GCV) and phenotypic (PCV) levels and high heritability (broad sense) with expected genetic advance (as percentage of mean) were high for ear height, leaf breadth, cob length, no. of kernels per row, no. of kernels per cob, cob weight, grain yield/plant. Days to 50% tasseling, days to 50% silking and days to 75% husk, showed low PCV, GCV and GA with very high heritability suggesting that there is very little scope for improving these characters by selection.

Keywords Maize, Variability, Heritability, Genetic advance.

Introduction

Maize (*Zea mays* L, 2n = 20) which is referred as queen of cereals has the highest production potential among cereals and it occupies a prominent position in global agriculture. It is a unique crop which can be used as food, feed fodder, fuel in addition to hundreds of industrial uses. In India, it is the third important crop next to rice and wheat. It is an important cereal crop belonging to tribe *Maydeae*, of the grass family, Poaceae. Single cross bybrids have the highest yield potential than other type of hybrids. Now research efforts have been focused on the development of high yielding single cross hybrids of different maturity, suitable for different agro-ecological regions of India. Success of any single cross hybrid development program largely depends on the selection of elite parental inbreds. Selection of superior inbreds will be possible only when adequate variability exists in the gene pool. Hence, an attempt was made in the current study to estimate the genetic variability among the available inbreds with the aid of genetic parameters such as phenotypic coefficient of variation

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Table 1. Analysis of variance (RBD) for 16 agro-economic traits in 43 maize inbreds. Significant at **1% and *5%.

Source of variation	Character	DT	DS	DH	EHT	PHT	LL	LB	CL
DF	Replication	1	1	1	1	1	1	1	1
	Variety	42	42	42	42	42	42	42	42
	Error	42	42	42	42	42	42	42	42
MSS	Replication	4.651	10.467	2.256	69.950	253.08	45.92	0.114	33.759
	Variety	42.76	38.553	21.61	202.17	706.32	174.4	3.361	12.871
	Error	2.246	55	2.018	6.719	26.843	7.235	0.113	0.810
F-value	Replication	2.07NS	2.84NS	1.12NS	10.41**	9.43**	6.35*	1.01NS	41.70**
	Variety	19.05**	10.84**	10.71**	30.09**	26.31**	24.12**	29.67**	15.90**

Table 1. Continued

Source of variation	Character	CG	KR/C	K/R	K/C	100 g	CW	SL	GY/P
DF	Replication	1	1	1	1	1	1	1	1
	Variety	42	42	42	42	42	42	42	42
	Error	42	42	42	42	42	42	42	42
MSS	Replication	16.841	20.499	171.5	62244.7	35.342	3405.46	54.785	2050.45
	Variety	4.452	10.972	66.68	19.338	15.896	1358.84	139.412	916.62
	Error	0.558	1.748	8.119	3862.89	1.075	92.6285	32.667	59.83626
F-value	Replication	30.18**	11.73**	21.13**	16.11**	32.89**	36.76**	1.68NS	34.27**
	Variety	7.98**	6.28**	8.21**	5.01**	14.79**	14.67**	4.27**	15.32**

(PCV), genotypic coefficient of variation (GCV), broad sense heritability and genetic advance (GA) as per cent of mean.

Materials and Methods

A set of 120 maize populations were initially received from different sources from which 43 inbreds were developed by ear to row method and subsequently further purified and maintained by selfing at EB-II section, Department of Plant Breeding and Genetics, College of Agriculture, OUAT, Bhubaneswar. The field experiment was laid out in a randomized complete block design (RCBD) with two replications. The field experiment was conducted at EB-II section of the Department of Plant Breeding and Genetics, College of Agriculture, OUAT, Bhubaneswar during *kharif* 2015.

Observations on 16 different quantitative characters were recorded. Observation on days to 50% tasselling, days to 50% silking and days to 75% dry husk were recorded on plot basis and observations for other characters were taken from a sample of 5 randomly chosen competitive plants from each treatment per replication and average was calculated. Sixteen observations recorded are days to 50% tasseling, days to 50% silking, days to 75% dry husk maturity, leaf length (cm), leaf breadth (cm), plant height (cm), ear height (cm), cob length (cm), cob girth (cm), number of kernels rows per cob. The data recorded for various character were subjected to statistical analysis based on their sample means to study variability and other genetic parameter like genetic variability, heritability and genetic advance.

Results and Discussion

The analysis of variance for sixteen different quantitative characters was done and the results are presented in Table 1. It revealed from the *F*-test that there was significant differences among the inbreds for all the characters under investigation. However, the replication differences were significant for all the characters except days to 50% tasseling, days to 50% silking, days to 75% dry husk, leaf breadth, shelling %. However, replication differences were significant for the characters i.e., ear height, plant height, leaf length, cob length, cob diameter, number of kernels rows/cob, number of kernels/row, number of kernels/cob, 100-kernels weight (g), cob weight and grain yield per plant. Similar findings of present study wide variation for most of the characters were also reported by Homayoun [1], Kumar et al. [2], Jawaharlal et al. [3],

Table 2. Mean performance of 43 inbred for different agro-economic traits.

Sl. No.	Genotype	DT	DS	DH	EHT	PHT	LL	LB	CL
1.	QPM-10-1-1	51.00	51.50	88.00	36.00	90.88	42.38	2.93	10.33
2.	QPM-1-15-2	50.50	51.00	87.50	35.38	98.13	39.50	2.01	15.00
3.	QPM-6-4	52.50	52.50	88.50	48.00	101.63	55.25	5.25	11.00
4.	QPM-8-7-1	54.00	54.00	88.50	28.30	67.60	37.00	4.02	5.81
5.	QPM-1-15-4	52.50	53.50	87.50	36.63	91.82	35.65	2.51	7.00
6.	QPM-2-1-12	53.50	53.50	94.00	36.00	92.00	44.00	3.51	9.25
7.	QPM-2-15-2	52.50	50.50	89.50	28.50	73.95	41.63	4.31	8.65
8.	QPM-8-7-2	53.50	54.00	88.00	18.17	66.50	35.83	3.42	7.00
9.	QPM-7-4-4	50.50	51.50	89.50	42.13	99.38	51.13	3.36	11.13
10.	QPM-7-3-2	45.50	48.00	89.50	37.30	101.90	56.00	5.20	9.38
11.	QPM-3-7-2	51.50	52.50	89.50	43.75	116.25	45.25	3.75	11.50
12.	QPM-2-1-2	51.00	51.00	94.00	42.88	126.50	61.75	8.18	16.17
13.	QPM-10-13	51.50	51.00	97.50	57.88	128.38	60.38	5.38	13.88
14.	QPM-9-2	48.50	49.00	89.50	16.80	57.63	23.35	2.31	10.75
15.	QPM-8-7-3	48.50	48.50	90.00	35.60	103.70	48.55	3.41	10.43
16.	QPM-3-6-1	47.00	49.00	90.00	37.00	96.10	43.90	3.95	10.75
17.	1130-7-1	51.00	51.50	90.00	41.10	101.90	62.90	5.29	12.40
18.	1131-8-2	46.00	48.50	89.50	32.50	98.83	63.34	5.08	7.10
19.	VL-1017054	53.50	55.50	90.00	34.50	99.50	51.67	4.25	13.50
20.	VL-109288	54.50	55.00	98.00	38.83	118.33	63.33	6.51	11.50
21.	VL-1016453	54.00	56.00	99.00	62.15	151.73	63.15	7.51	16.50
22.	VL-1016475	53.50	53.50	90.50	32.00	99.00	40.00	3.20	13.50
23.	VL-1052	53.50	54.50	91.00	49.60	133.70	62.00	6.35	11.10
24.	VL-109467	57.50	60.50	90.50	28.30	94.30	50.80	5.15	10.63
25.	VL-109412	62.50	65.00	97.50	20.30	88.70	53.50	4.65	14.50
26.	VL-1017230	63.50	64.50	95.00	28.63	96.38	49.25	5.30	15.50
27.	VL-1019288	63.50	64.50	97.50	44.63	100.38	51.50	4.95	14.50
28.	VL-109403	52.00	53.50	93.00	48.00	103.00	36.30	3.96	11.55
29.	VL-109263	52.50	54.50	95.00	43.80	103.20	55.40	4.73	9.08
30.	VL-1016926	53.00	55.00	89.50	26.20	81.10	50.30	4.66	8.30
31.	VL-10165907	53.50	54.50	94.00	37.80	89.83	45.17	4.68	14.75
32.	VL-109954.	56.00	57.50	94.50	35.20	101.40	57.10	4.66	10.91
33.	VL-109378	54.50	55.50	97.50	51.20	114.50	46.30	3.99	12.50
34.	VL-11381	51.50	54.50	92.50	32.70	96.00	48.30	3.30	11.34
35.	VL-1016492	56.00	54.50	92.00	47.70	117.40	62.00	4.42	13.65
36.	VL-10512388	59.00	59.00	93.00	28.00	116.20	55.50	5.75	10.50
37.	VL-109072	55.50	57.00	92.00	25.10	89.70	60.00	4.65	11.50
38.	VL-1019415	54.50	55.00	95.50	31.40	96.10	55.10	4.91	11.34
39.	VL-1016417	54.50	56.00	92.00	50.63	142.88	54.88	4.60	12.67
40.	VL-1056	54.50	55.50	95.00	34.50	115.75	59.63	6.63	11.75
41.	VL-111382	57.50	59.00	90.50	44.75	94.13	42.75	3.47	13.50
42.	VL-10169306	65.50	66.00	91.50	27.97	84.50	51.17	4.20	14.50
43.	VL-1018419	65.00	60.50	97.00	26.50	89.90	50.40	5.40	11.97
	GM	54.00	54.79	92.19	36.84	100.17	50.31	4.57	11.59
	CV (%)	2.78	3.50	1.54	7.04	5.14	5.35	7.37	7.76
	CD	3.03	3.87	2.87	5.24	10.47	5.43	0.68	1.82

Table 2. Continued.

Sl. No.	Genotype	CG	KR/C	K/R	K/C	100 g wt	CW	SL	GY/P
1.	QPM-10-1-1	11.50	15.34	20.50	313.25	15.72	49.904	80.00	39.891
2.	QPM-1-15-2	10.50	14.00	25.00	350.00	15.70	71.209	77.38	55.078
3.	QPM-6-4	10.00	13.00	16.00	207.00	14.30	37.213	75.01	29.611
4.	QPM-8-7-1	7.99	13.00	13.00	172.00	19.50	42.124	80.75	33.800
5.	QPM-1-15-4	6.50	5.00	4.00	20.00	12.93	5.700	44.97	2.590
6.	QPM-2-1-12	8.31	9.25	10.13	93.56	16.25	19.773	76.83	15.169
7.	QPM-2-15-2	9.84	13.34	13.16	177.04	17.10	38.769	78.65	30.570
8.	QPM-8-7-2	8.00	9.34	9.00	81.00	13.52	16.145	68.67	11.110
9.	QPM-7-4-4	9.68	13.50	18.88	254.88	15.68	50.223	79.54	39.890
10.	QPM-7-3-2	10.31	13.50	17.50	235.50	16.25	46.729	82.79	38.543
11.	QPM-3-7-2	10.75	15.00	23.50	352.00	15.20	63.561	84.08	53.408
12.	QPM-2-1-2	11.08	14.67	22.00	290.64	20.58	85.316	77.22	65.948
13.	QPM-10-13	11.84	11.75	32.75	384.13	23.99	111.146	82.57	92.225
14.	QPM-9-2	10.50	13.50	16.50	149.50	19.13	54.871	81.55	44.369
15.	QPM-8-7-3	10.12	15.25	19.38	159.43	20.33	75.318	79.81	59.890
16.	QPM-3-6-1	10.75	14.25	18.75	162.13	17.05	56.482	80.72	45.460
17.	1130-7-1	11.65	13.20	24.20	317.68	18.15	70.129	82.28	57.680
18.	1131-8-2	10.50	13.60	18.90	255.88	17.72	57.561	79.42	45.639
19.	Vl-1-17054	10.00	13.00	16.00	210.00	18.93	49.742	79.75	38.252
20.	VL-109288	8.25	10.00	12.50	140.00	15.80	27.775	79.63	22.190
21.	VL-1016453	15.00	16.00	29.00	464.00	26.61	152.157	81.13	123.470
22.	VL-1016475	10.15	15.00	22.50	340.00	15.85	67.116	80.25	53.890
23.	VL-1052	11.96	13.25	21.80	289.00	20.67	72.170	82.55	59.595
24.	VL-109467	9.00	11.50	11.25	126.75	21.28	36.415	77.68	28.185
25.	VL-109412	8.50	10.00	15.00	152.00	21.85	46.429	70.96	33.392
26.	VL-1017230	7.50	9.00	18.00	164.00	18.40	40.879	75.35	30.824
27.	VL-1019288	9.00	10.00	15.00	156.00	20.51	42.965	73.72	32.135
28.	VL-109403	11.55	12.20	27.40	334.36	18.53	90.899	80.31	62.026
29.	VL-109263	9.84	8.66	14.00	121.97	18.97	29.345	63.93	23.183
30.	VL-1016926	10.25	10.00	10.25	99.25	16.10	22.846	69.46	16.030
31.	VL-10165907	10.00	12.50	15.25	191.25	17.68	45.785	73.67	33.901
32.	VL-109954	9.41	12.67	17.83	227.70	15.78	45.308	81.25	36.636
33.	VL-109378	9.57	12.00	21.65	259.80	18.77	63.482	77.45	49.095
34.	VL-11381	10.91	14.67	20.33	298.35	15.67	59.894	78.90	46.950
35.	VL-1016492	10.65	13.40	19.90	267.32	18.16	61.582	78.79	48.548
36.	VL-10512388	7.50	10.00	14.50	145.00	18.69	32.991	82.29	27.118
37.	VL-109072	9.00	12.00	13.75	165.00	20.88	44.141	78.28	34.627
38.	VL-1019415	9.13	9.34	14.67	147.01	16.51	37.091	64.29	26.232
39.	VL-1016417	10.25	12.00	19.33	231.96	20.78	61.817	78.01	48.192
40.	VL-1056	8.75	8.00	6.50	53.00	20.55	22.938	46.98	11.000
41.	VL-111382	11.50	13.00	23.00	395.50	16.36	78.668	81.48	64.112
42.	VL-10169306	10.00	11.00	18.00	200.00	22.25	67.311	65.57	44.500
43.	VL-1018419	10.51	10.33	19.17	199.00	19.03	50.189	47.98	37.892
	GM	9.59	12.09	17.67	217.53	18.25	53.554	76.02	41.694
	CV (%)	7.51	10.93	16.13	28.57	5.68	17.97	7.52	18.55
	CD	1.51	2.67	5.76	125.55	2.09	19.441	11.55	15.625

Singh and Jamwal [4] and Turi et al. [5].

In present investigation all the characters exhibited coefficient of error variation (CVe) less than 11% except number of kernel per row, number of kernel per cob, cob weight, grain yield per plant. CVe value were relatively low within 11% for almost of character indicating good degree of precision of experiment (Table 2). The variation in grain yield per plant of different QPM inbred ranged between 2.59 g (QPM-1-15-4) to

123.47 (VL-1016453). In present investigation inbred VL-1016453 yield highest and next to this QPM-10-13. The above mean performance parameter were similar with Homayoun [1], Singh and Jamwal [4] and Turi et al. [5].

The observed coefficient of error variation ranged from 1.54% for days to 75% dry husk to 18.55% for grain yield per plant. CVe value was relatively low within 11% for almost of character indicating good degree of precision of experiment. The phenotypic coefficient of variation ranged from 3.57% for days to 75% dry husk to 51.35 for grain yield per plant (Table 3). The PCV estimates shared that the phenotypic variability was low (below 10%) for days to 75% dry husk, days to 50% tasseling, days to 50% silking (3.57 to 8.57), moderate (10-20%) for plant height, leaf length, 100 kernel weight (g), ear girth, number of kernel row per ear and shelling % (10.98 to 19.37). And high (above 20%) for ear height, leaf breadth, ear length, no. of grain per row, number of grain per ear, ear weight and grain yield per plant (21.88 to 51.35). The genotypic coefficient of variation (GCV) ranged between 3.40% for days to 75% dry husk to 49.94% for grain yield/plant and followed almost a similar trend as phenotypic coefficient of variation except for the character shelling % which fell under low (below 10%) for GCV. Low GCV for days to 50% tasseling and days to 50% silking which is close agreement with Bharathiveeramani et al. [6] and Yusuf [7] and highest GCV and PCV for grain yield per plant is accordance with other scientist Reddy et al. [8], Rajesh et al. [9] and Hepziba et al. [10].

In present study the GCV estimates are smaller than the corresponding PCV, indicating some amount of environment in expression of the character is because the later includes the variation due to environment as well as variation due to interaction (G × E). Similar findings is also reported by Homayoun et al. [1], Jawaharlal et al. [3], Bharathiveeramani et al. [6], Hepziba et al. [10], Chouhan and Jitendra [11] and Khorasani et al. [12]. Further high GCV for character viz., grain yield per plant, ear height also indicated better scope for genetic improvement in these characters which could be achieved through simple selection procedure which is similar correspondence with Hepziba et al. [10] and Vashistha [13]. Majority of traits showed smaller difference between PCV and GCV indicating little influence of the environment, therefore, selection on the basis of phenotypic values for most of the characters is expected to be effective. But low values of GCV for, days to 50% tasseling, days to 50% silking, days to 75% dry husk, shelling % 3.57 to 8.57%, indicated the limited scope for the improvement of these traits.

Heritability depends upon the amount of genetic variation exist in the population and environmental conditions under which the population is evaluated. The estimate of heritability (broad sense) alone is not very much useful in predicting resultant effect for selecting the best individuals or genotypes, because it includes both additive as well as non-additive gene effects. High genetic advance occurs only due to additive gene action. So, heritability estimates coupled with the genetic advance would be more useful than heritability alone. In present study highest heritability (broad sense) was reported for ear height and similar finding was also reported by Reddy et al. [8], Ojha et al. [14] and Lata et al. [15] and other character for high heritability for number of kernel per cob, number of kernel per row, days to 50% silking, days to 75% dry husk, 100 kernel weight, cob weight, grain yield per plant days to 50% tasseling, leaf length, leaf breadth, similar results have been obtained by Kumar et al. [2] and Singh et al. [4].

The genetic advance ranged from 2.205 for leaf breadth to 138.492 for number of kernels per cob. The expected genetic advance for different character expressed as percentage of population mean ranged from 5.69% for days to 75% dry husk to 84.47% for grain yield per plant. The related expected genetic advance was low (below 20%) for days to 50% tasseling, days to 50% silking days to 75% dry husk and shelling %. Moderate (20%–30%) for ear girth, number of kernel row per cob, 100 kernel weight, high (above 30%) for ear height, plant height, leaf length, leaf breadth, ear length and number of grain per row, number of kernel per cob, cob weight and grain yield per plant. Burton 1952, had suggested than a expected amount of genetic advance can be estimated by genetic coefficient of variation along with heritability, high heritability coupled with genetic advance expressed as percentage of population mean was ob-

Table 3. Genetic parameters of variability for grain yield and ancillary agro-economic traits in 43 maize inbred. **Bold figures indicates maximum and minimum values.

Character	DT	DS	DH	EHT	PHT	LL	LB	CL
PCV (%)	8.57	8.01	3.57	27.29	18.66	18.57	28.40	21.88
GCV (%)	8.34	7.62	3.40	26.83	18.30	18.18	27.19	21.18
Hb^2 %	94.75	90.46	60.67	96.68	96.20	95.85	96.63	93.71
GA	7.713	6.990	5.246	17107	31.818	15.757	2.205	4.184
GA (% of mean)	14.28	12.76	5.69	46.63	31.59	31.32	48.29	36.09
CV (%)	2.78	3.50	1.54	7.04	5.14	5.35	7.37	7.76
CD	3.03	3.87	2.87	5.24	10.47	5.43	0.68	1.82

Table 3. Continued.

Character	CG	KR/C	K/R	K/C	100 g	CW	SL	GY/P
PCV (%)	14.99	19.37	32.68	45.20	15.45	48.67	10.98	51.35
GCV (%)	14.02	17.76	30.63	40.44	14.92	46.98	9.61	49.67
Hb^2 %	87.47	84.07	87.83	80.02	93.24	93.18	76.65	93.57
GA	2.297	3.466	8.926	138.492	4.626	42.747	11.251	35.218
GA (% of mean)	23.08	28.66	50.25	63.67	25.35	79.82	14.80	84.47
CV (%)	7.51	10.93	16.13	28.57	5.68	17.97	7.52	18.55
CD	1.51	2.67	5.76	125.55	2.09	19.441	11.55	15.625

served for plant height, leaf length, leaf width, cob length, number of kernel per row, number of kernel per ear, cob weight and grain yield per plant which indicated that this characters controlled by additive gene action and phenotypic selection for this character would be effective, similar finding was reported by Hepziba et al. [10] and Hemavathy et al. [16]. Moderate to high heritability with moderate to low genetic advance were found in case of days to 50% silking, days to 50% silking, days to 75% dry husk, cob girth, number of kernel row per cob, 100 kernel weight and shelling % that suggested both additive and dominance gene action in their inheritance. Similar results have been reported by Bharathiveeramani et al. [6] and Chouhan and Jitendra [11].

Conclusion

The present investigation revealed that days to 50% tasselling attained as early as around 45–46 days in QPM-7-3-2, 1131-8-2 and QPM-8-7-3 while some of inbred i.e. VL-10169306 came to tasseling after 65–66 days after sowing. Medium height plant type with strong and stout stem is desirable for maize hybrids. The inbred QPM-9-2, QPM-8-7-1, QPM-2-15-2, QPM-8-7-2 exhibited significantly dwarf plant type while VL-1016453 was the tallest and its height was nearly 1.5 m (151.73 cm). High heritability coupled with high genetic advance for number of kernel per cob, number of kernel per row, cob weight, grain yield per plant, leaf length, leaf breadth and ear height which indicated that this characters controlled by additive gene action and selection for this character would be effective.

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