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Components of variances, Genetic Variability, Heritability and genetic advance among fifty Indigenous Maize (*Zea mays* L.) inbred lines

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ABSTRACT

Analysis of variance revealed significant differences for all the characters under study which Showed the presence of sufficient amount of variability offering adequate opportunity for improving the population for these characters. The ranges of mean values revealed sufficient variation for all the traits under study. The phenotypic variances and phenotypic coefficients of variation were slightly higher than the corresponding genotypic variances and genotypic coefficients of variation for all the characters. Traits viz., Ear height and rind weight showed high GCV, PCV. Therefore these traits can be used further in crop improvement program.

Key words: *Genetic Variability, Heritability, Genetic advance*

Introduction

Maize (*Zea mays* L.; 2n=20) is the third most important cereal crop in India after rice and wheat. Globally, maize is known as queen of cereals because of its highest genetic yield potential among the cereals (Downswell *et al*., 1996). Grain yield is the economically important character in maize. Grain yield is a complex trait influenced by environmental factors. Thus direct selection would not be effective. Information of heritability coupled with genetic advance is most useful in estimating the genetic improvement through selection as heritability alone provides the basis for selection on phenotypic performance. High estimates of heritability along with higher genetic advance are usually more useful parameters taken alone in predicting the resultant effect of selecting the best individuals. Heritability estimates are useful for breeding quantitative traits as it provides information on the extent to which a particular trait can be inherited to subsequent generations (Aditi Ghosh *et al.,* 2014).

Materials and Methods

This present study was carried out to assess the magnitude of genetic variability, heritability and genetic advance for growth, yield and yield contributing traits on fifty Indigenous Maize inbred lines by utilizing fourteen characters, which was conducted at Mathod, Shivamogga, Karnataka during Kharif 2018. The crop was sown in Randomized Block Design with two replications with spacing of 60X 30cm and the standard agronomical package of practices followed to raise healthy crop. The experimental site which is geographically situated between 13^{o} 27′ to 14^{o} 39′ N 2018 and latitude and 74^{o} 37′ to 75^{o} 52′ E longitude with an altitude of 650 m above the MSL.

The place lying in Southern transition Zone (Zone-7).

The following Observation of fourteen characters viz., Germination %, Plant height(cm), Ear height(cm), Days to 50% tasseling, Days to 50% silking, Cob Length (cm), Cob width(cm) , No. Rows per cob, Grains/ Row, Dehusk cob weight(g), Rind weight(g), Test Weight(g), Shelling %, Grain Yield per plant (g) were recorded.

The mean values of all the characters of fifty maize inbred lines were analyzed for their variance following Randomized complete block design outlined by Cochran and Cox (1957). Analysis was done using WINDOW stat 9.2 software. The significance was tested by referring to the table given by Fisher (1936). Standard error of mean (SEm), critical difference (CD) and coefficient of variation (CV) were worked out using appropriate formulae comparing means of the genotypes..

Results and Discussion

The aim of this study was to evaluate the performance of fifty indigeneous maize genotypes based on their yield and yield contributing characters to determine existing genetic variability. The estimate of ANOVA for different yield contributing parameters showed a high degree of variation among the genotypes used.

The analysis of variance revealed the existence of significant differences among the genotypes for all the traits (Table 1), indicating the presence of considerable genetic variability among the experimental material under study. Based on ANOVA statistics, the 50 inbred lines tested showed significant differences for all the characters. The IC-273359, IC-280440, IC-331028, IC-470443 and IC- 273358 recorded superior to all other entries with respect to the characters viz. cob length, cob width, Number of rows per cob, grains per row and grain yield per plant.

The mean values, range, standard error and CV of the fifty indigenous for different characters are given in Table 2.

Germination % ranged from 84.00 (IC-551794) to 100.00 (IC-470443) and overall mean performance was 91.96 ± 2.37 whereas, the C.V. was 2.57%. The plant height genotype IC-550356 (173.07 cm) was found tall, while IC-470443 (140.24 cm) was found Dwarf. The observed mean value was 158.24 ± 4.82 and C.V. was 3.05%. The days to 50% tasseling ranged from 54.00 (IC-447802) to 64.50 (IC-551794) and overall mean performance was 59.63 ± 1.55 whereas, the C.V. was 2.59%. The days to 50% silking range was from 56.50 (IC-273348) to 67.00 (IC-551794) and with mean value being 61.87 ± 1.71 while, C.V. was 2.77%. The ear height was varied from 38.44 cm (IC-447802) to 76.02 cm (IC-280451) and overall means value was found 56.88 ± 3.30 and C.V. was 5.80%. In cob length, the mean value was varying from 13.00 cm (IC-280218) to 17.60 cm (IC-273359). The value of overall mean was found to be 14.94 ± 0.66 and C.V. was 4.44%. For cob width trait, the mean value was varying from 2.82 cm (IC-309931) to 4.03 cm (IC-331028). The value of overall mean was found to be 3.55 ± 1.37 and C.V. was 3.87%. The number of rows per cob, the range of means was from 9.50 (IC-552505) to 14.00 (IC-331028). The value of grand mean was found 11.32 ± 0.73 and C.V. was 6.49%. The number grains per row ranged from 15.50 (IC-551794) to 24.00 (IC-331028) whereas, overall mean value was 20.16 ± 1.68 and C.V. was 8.35%. Dehusk cob weight ranged from 96.24 g (IC-551794) to 197.16 g (IC-273359). The value of grand mean was found 131.35 ± 11.52 and C.V. was 8.77%. Rind weight ranged from 17.27 g (IC-470470) to 55.89 g (IC-331028). The value of grand mean was found 29.48 ± 5.32 and C.V. was 18.05%. The grain yield per plant was found lowest for IC-551794 (73.06 g) and highest for genotype IC-273359 (151.16 g) with 101.86 ± 7.99 g being the mean value and C.V. was 7.84% for this character. Test weight ranged from 22.58 g (IC-280438) to 28.71 g (IC-273359). The value of grand mean was found 25.92 ± 1.67 C.V. was 6.45%. Shelling % ranged from 70.74 (IC-280449) to 85.71 (IC-333085) and overall mean performance was 77.97 ± 2.67 whereas, the C.V. was 3.43%.

The variability was highly significant for all the traits of the genotypes. The presence of sufficient amount of variability is due to different source of the material as well as environmental influence, which prominently governed the phenotype. Hence, the presence of variability in present experiment indicated the adequate scope of selection for these traits. Same trends were observed by Parimala *et al.*, 2011 and Patil *et al.*, 2016 in maize.

Estimates of phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability in broad sense, genetic advance as percentage of means and components of variances for the fourteen characters among fifty Indigenous

Table 1. Mean performance of among fifty Indigenous Maize inbred lines

Sl. No.	Inbred line	Germination %	Plant height (cm	Ear height (cm)	Days to 50% tasseling	Days to 50% silking	Cob Length (cm)	Cob width (mm)	No. Rows per cob	Grains/ Row (no.)	Dehusk cob weight (g)	Rind weight (g)	Grain Yield per plant (g)	Test Weight (g)	Shelling %
1	IC-2 73346	90.00	147.20	56.58	58.50	60.50	14.78	36.78	11.50	20.00	145.16	41.43	103.73	27.51	71.63
2	IC-280217	89.00	149.42	62.13	58.00	60.00	13.78	36.97	11.00	19.50	131.01	38.15	92.87	25.11	71.22
3	IC-273348	88.00	150.30	66.50	55.00	56.50	14.69	35.55	10.00	18.00	127.99	33.61	94.38	25.69	73.83
4	IC-273353	93.00	149.02	60.14	60.00	61.50	14.89	36.27	10.50	18.50	138.42	36.67	101.75	25.73	73.84
5	IC-273356	94.00	155.60	65.61	55.00	56.50	13.91	35.67	10.50	18.50	132.92	35.91	97.01	24.22	72.99
6	IC-273358	95.00	164.74	72.86	57.50	59.50	17.20	39.56	12.00	22.00	176.65	52.67	123.98[5]	28.55	73.16
7	IC-273359	94.50	161.62	69.82	62.50	64.00	17.60	40.33	13.00	23.50	197.16	45.99	151.16[1]	28.71	75.22
8	IC-280159	93.50	140.35	59.89	58.50	61.50	16.67	35.28	12.00	20.00	128.00	26.75	101.25	26.99	79.12
9	IC-280164	93.00	156.14	60.13	58.00	60.50	14.33	36.48	10.50	19.00	121.60	22.51	99.09	24.55	81.54
10	IC-280209	91.50	157.79	64.21	62.50	64.00	14.51	35.36	11.50	20.50	125.50	26.75	98.74	25.57	78.66
11	IC-280213	88.50	156.27	68.82	61.00	63.50	13.40	35.16	10.50	19.50	126.04	26.13	99.91	25.32	79.30
12	IC-280218	89.50	158.37	59.24	61.50	63.50	13.00	34.67	11.50	20.00	122.22	25.15	97.06	24.30	79.41
13	IC-280408	90.50	166.42	68.41	58.50	61.00	13.42	34.70	12.00	19.00	127.46	24.80	102.66	25.07	80.55
14	IC-280409	87.50	163.65	70.22	60.50	62.50	13.24	34.02	11.50	20.50	127.24	30.13	97.11	24.41	76.29
15	IC-280411	87.00	156.55	61.55	63.00	66.00	13.09	35.57	11.50	20.50	123.04	29.13	93.90	23.29	76.25
16	IC-280418	90.50	156.90	62.70	62.00	64.00	16.40	35.30	12.00	22.00	129.18	26.00	103.18	24.67	79.91
17	IC-280430	90.00	158.12	61.19	61.00	63.00	16.53	34.00	11.00	20.00	133.04	30.92	102.12	23.70	76.81
18	IC-280438	92.50	156.50	62.44	60.75	62.50	13.49	34.74	11.50	20.50	125.66	27.59	98.07	22.58	78.12
19	IC-280440	95.50	162.93	69.58	58.00	60.50	17.47	40.02	12.50	23.00	187.88	42.64	145.24[2]	28.51	77.47
20	IC-280441	93.50	163.24	72.05	57.00	59.50	14.18	35.22	12.00	22.00	142.72	39.84	102.88	26.26	72.11
21	IC-280445	91.50	163.67	70.93	60.50	62.50	13.59	31.49	10.50	19.50	127.64	32.78	94.86	24.92	74.81
22	IC-280448	93.00	164.90	73.14	60.00	62.00	14.19	34.17	11.50	21.50	146.20	40.40	105.80	24.50	72.51
23	IC-280449	94.50	169.45	75.16	58.50	61.00	14.78	35.88	12.50	22.50	157.60	46.15	111.45	27.92	70.74
24	IC-280451	97.00	166.42	76.02	59.50	61.50	15.00	37.07	12.00	22.00	160.26	43.93	116.33	28.24	72.62
25	IC-280461	93.50	166.67	75.52	61.00	63.00	15.90	33.05	12.00	20.50	146.08	40.98	105.10	26.99	71.97
26	IC-280464	95.00	165.53	67.14	63.00	65.50	14.63	36.95	12.00	20.50	139.32	36.93	102.39	26.60	73.34
27	IC-280465	94.00	162.04	70.02	62.50	64.50	16.28	38.49	11.50	21.50	148.52	35.33	113.19	28.42	76.20
28	IC-309931	92.50	151.07	63.22	58.00	60.50	13.79	28.22	12.50	19.00	132.64	36.24	96.40	26.27	72.95
29	IC-331028	99.50	167.95	64.36	62.00	64.00	17.20	40.37	14.00	24.00	194.52	55.89	138.63[3]	28.67	71.32
30	IC-331086	92.50	140.62	54.62	60.50	62.50	16.86	29.99	11.00	20.50	130.96	23.73	107.23	25.33	81.97
31	IC-333085	99.00	142.49	48.06	58.00	60.50	16.62	39.83	11.00	22.00	140.09	19.96	120.14	25.04	85.71
32	IC-337001	99.00	141.10	49.64	58.50	60.50	16.45	38.39	11.00	22.00	136.21	20.12	116.09	25.88	85.18
33	IC-470443	100.00	140.24	46.63	60.00	62.50	17.01	39.83	12.50	22.00	145.92	21.08	124.84[4]	26.83	85.56
34	IC-337057	96.50	163.40	40.44	62.50	64.50	14.01	36.49	11.00	21.00	130.06	22.62	107.44	27.73	82.48
35	IC-337090	97.00	151.49	39.75	56.50	59.50	15.60	36.28	11.50	21.00	116.48	19.64	96.84	28.27	83.16
36	IC-447802	85.00	153.42	38.44	54.00	57.00	14.40	33.90	10.50	17.00	101.45	17.87	83.57	25.73	82.46
37	IC-447811	85.00	148.07	38.75	55.00	57.50	14.40	34.27	10.00	16.00	96.24	18.62	77.62	25.73	80.62

Table 1. *Continued ...*

Sl. No.	Inbred line	Germination %	Plant height (cm	Ear height (cm)	Days to 50% tasseling	Days to 50% silking	Cob Length (cm)	Cob width (mm)	No. Rows per cob	Grains/ Row (no.)	Dehusk cob weight (g)	Rind weight (g)	Grain Yield per plant (g)	Test Weight (g)	Shelling %
38	IC-447813	86.00	153.62	40.69	54.00	56.75	15.73	35.17	9.50	17.50	104.16	21.35	82.81	24.40	79.51
39	IC-447910	92.50	170.38	41.25	55.00	58.00	15.87	37.93	11.50	21.00	122.05	19.45	102.60	27.87	84.05
40	IC-470148	91.00	167.07	41.69	56.50	59.00	16.27	37.62	11.50	22.00	128.56	28.97	99.59	25.67	77.47
41	IC-550373	93.00	158.80	44.69	63.50	65.50	13.66	39.90	11.00	21.00	126.98	24.33	102.65	27.87	80.83
42	IC-470470	91.50	164.76	42.75	62.50	65.00	15.41	31.07	11.50	19.50	110.92	17.27	93.65	26.00	84.40
43	IC-470521	92.50	157.62	43.19	63.50	66.00	13.38	33.06	11.00	19.50	118.77	22.19	96.58	25.87	81.40
44	IC-542343	87.50	165.47	41.69	61.00	63.50	15.87	30.83	10.50	16.00	99.11	18.23	80.88	25.60	81.61
45	IC-542346	89.00	160.33	43.19	60.00	63.00	13.91	30.73	11.50	20.50	114.50	21.69	92.81	25.33	81.03
46	IC-550356	91.50	173.07	45.25	58.00	60.00	13.40	30.10	11.00	20.50	113.82	20.89	92.93	25.47	81.63
47	IC-550367	91.50	167.18	43.81	60.50	62.00	13.09	37.68	11.00	20.00	100.71	19.99	80.72	24.53	80.15
48	IC-553429	91.50	162.27	43.94	62.00	64.00	14.67	34.95	11.00	20.50	115.95	22.41	93.54	25.07	80.70
49	IC-552505	85.50	162.22	43.38	62.00	64.50	13.21	36.70	9.50	15.50	96.90	19.39	77.51	25.07	79.98
50	IC-551794	84.00	160.05	42.63	64.50	67.00	15.60	32.89	10.00	15.50	96.24	23.18	73.06	23.87	76.04

Table 2. Analysis of variance for fourteen characters in maize

Sources of Variation	DF	Germination %	Plant height (cm)	Ear height (cm)	Days to 50% tasseling	Days to 50% silking	Cob Length (cm)	Cob width (mm)	No. Rows per cob	Grains/ Row (no.)	Dehusk cob weight (g)	Rind weight (g)	Grain Yield per plant (g)	Test Weight (g)	Shelling %
Replication	1	0.16	16.03	12.95	0.30	0.90	0.44	0.0002	0.58	0.82	3.08	0.33	0.004	8.07	3.16
Genotypes	49	29.56**	142.66**	308.78**	14.62**	13.90**	3.76**	16.87 **	1.52**	7.58 **	1061.67 **	193.92**	492.93**	4.83*	38.49**
Error	49	5.62	23.31	10.90	2.40	2.94	0.44	1.89	0.54	2.84	132.79	28.33	63.89	2.79	7.15
Sem		2.37	4.82	3.30	1.55	1.71	0.66	1.37	0.73	1.68	11.52	5.32	7.99	1.67	2.67
CV		2.57	3.05	5.80	2.59	2.77	4.44	3.87	6.49	8.35	8.77	18.05	7.84	6.45	3.43
CD 5%		4.76	9.69	6.63	3.11	3.44	1.33	2.76	1.47	3.38	23.14	10.69	16.05	3.35	5.37
CD 1%		6.34	12.92	8.84	4.15	4.59	1.78	3.68	1.96	4.51	30.85	14.25	21.40	4.47	7.16

Maize inbred lines are furnished in Table 3.

The characters studied in the present investigation exhibited low (less than 10%), moderate (10-20%) and high (more than 20%) phenotypic and genotypic coefficients of variation.

GCV value ranged from 3.76 % for Germination % to 30.85 % for Rind weight, whereas PCV ranged from 4.56 % for Germination % to 35.74 % for Rind weight. Genotypic coefficient of variation was high (> 20) for Ear height and rind weight thus indicating presence of sufficient inherent genetic variance over which selection could be effective.

However, Moderate PCV and GCV (10-20) values were recorded for Dehusk cob weight and Grain Yield per plant. Similar results of moderate GCV were observed by Choudhary and Choudhary (2002); Alake *et al.,* (2008); Salman *et al.,* (2011); Praveenkumar and Sridevi (2014); and Kumar *et al.,* (2014). High to moderate GCV and PCV for these traits indicated sufficient variability and offers scope to improve these traits through phenotypic selection.

On the other hand, Germination %, Plant height, Days to 50% tasseling, Days to 50% silking, Cob Length, Cob width, No. Rows per cob, Grains/ Row (no.), Test Weight and Shelling % showed low PCV and GCV estimates (<10) therefore, there is a limited scope of selection.

The differences between Genotypic coefficient of variation (GCV) and Phenotypic coefficient of variation (PCV) were narrow indicating was close for all traits indicating that these characters were less influenced by environment. High GCV, heritability and relatively high genetic advance was observed for the traits viz., ear height and rind weight . Thus suggesting for improvement through selection of these characters by Aditi Ghosh et al (2014).

In the present study, moderately high estimate of heritability and high GAM value was observed for Rind weight, Ear height, Dehusk cob weight and Grain Yield per plant.

Heritability (b.s.) was observed to be higher (> 60%) for Germination %, Plant height, Ear height, Days to 50% tasseling, Days to 50% silking, Cob Length, Cob width, Dehusk cob weight, Rind weight, Grain Yield per plant and Shelling % suggesting that improvement of these characters would be effective through selection.

High heritability estimates is indicative to preponderance of additive gene action indicating character is less influenced by environmental effects. High estimates of broad-sense heritability for most of the traits revealed that variations were transmitted to the progeny and indicated potential for developing high yielding varieties through selection of desirable plants in succeeding generations (Aminu and Izge, 2012). However, the selection for improvement of such characters may not be useful because broad sense heritability is based on total genetic variance which includes additive, dominant and epistatic variances. Thus, heritability values coupled with high genetic advance would be more reliable and useful on correlating selection criteria (Ram Reddy *et al.,* 2012).

High heritability for these characters indicates the scope of genetic improvement of these charac-

Table 3. Genetic variability parameters for fourteen characters in maize

Sl No.	Character	Mean	Range		Vp	Vg	Ve	GCV	PCV	h^2 (bs)	GA	GAM
			Mini	Max								
1	Germination %	91.96	84	100	17.59	11.97	5.62	3.76	4.56	0.68	5.88	6.39
2	Plant height(cm)	158.24	140.23	173.07	82.98	59.67	23.31	4.88	5.75	0.71	13.49	8.52
3	Ear height(cm)	56.88	38.44	76.02	159.84	148.93	10.90	21.45	22.22	0.93	24.26	42.66
4	Days to 50% tasseling	59.63	54.00	64.50	8.51	6.11	2.40	4.14	4.89	0.71	4.31	7.23
5	Days to 50% silking	61.87	56.50	67.00	8.42	5.48	2.94	3.78	4.69	0.65	3.89	6.28
6	Cob Length(cm)	14.94	13.00	17.60	2.10	1.65	0.44	8.61	9.69	0.78	2.35	15.77
7	Cob width (mm)	35.50	28.21	40.37	9.38	7.48	1.89	7.76	8.62	0.79	5.03	14.18
8	No. Rows per cob	11.32	9.50	14.00	1.03	0.49	0.54	6.20	8.97	0.47	0.99	8.82
9	Grains/ Row (no.)	20.16	15.50	24.00	5.21	2.37	2.84	7.63	11.32	0.45	2.13	10.61
10	Dehusk cob weight (g)	131.35	96.23	197.15	596.98	464.18	132.79	16.40	18.60	0.77	39.13	29.79
11	Rind weight(g)	29.48	17.26	55.89	111.13	82.79	28.33	30.85	35.74	0.74	16.17	54.86
12	Grain Yield per plant (g)	101.86	73.06	151.16	278.41	214.51	63.89	14.37	16.38	0.77	26.48	25.99
13	TestWeight(g)	25.92	22.57	28.70	3.81	1.01	2.79	3.89	7.53	0.26	1.07	4.13
14	Shelling %	77.97	70.28	85.70	22.82	15.66	7.15	5.07	6.12	0.68	6.75	8.66

ters through selection, which revealed that these characters are less influenced by environment and there could be greater correspondence between phenotypic and breeding values. Ghimire and Timsina (2015) also reported higher heritability for ear height.

Genetic advance as a percent of mean is classified as low (less than 10 %), moderate (10-20 %) and high (more than 20 %).

The genetic advances (GA) at 10% selection intensity for the traits studied are also presented in Table 3. The estimates of GA were of high magnitude (>20%) for ear height, dehusk cob weight and grain yield per plant and of low magnitude (<10.00%) for Germination %, Days to 50% tasseling, Days to 50% silking, Cob Length(cm), Cob width (mm), No. Rows per cob, Grains/ Row (no.), Test Weight(g) and Shelling %.

Estimate of genetic advance as percent of mean (GAM) in the present study was very high (>20%) only for Rind weight, Ear height, Dehusk cob weight and Grain Yield per plant. Moderate GAM values (10-20%) were recorded for, cob length, cob width and Grains/ Row (no.). Remaining Traits showed low GAM values (<10%)

According to Panse (1957) traits combining high heritability and genetic advance are controlled by additive gene action while high heritability coupled with low genetic advance indicates the non-additive gene effects in the inheritance of a particular trait. Hence, high estimates of heritability and GAM for grain yield in this study involved additive gene effects in controlling in expression of the trait and improvement of this trait could be made through direct selection.

The data would be useful for proper identification and selection of appropriate parents in breeding programs to develop new maize varieties.

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