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Genetic Variability, Heritability and Genetic Advance Studies on *Rabi* Maize (*Zea mays L.*)

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A B S T R A C T

The present study was carried out on 40 maize genotypes during rabi 2018 at Agriculture farm, Palli Siksha Bhavana (Institute of Agriculture), Visva-Bharathi. The experiment was carried out in RBD design, with the objectives to study genetic variability, heritability, genetic advance on fifteen quantitative traits and the analysis of variance has revealed that all the 15 characters under study are showing significant difference among all the 40 genotypes. The values of Phenotypic Coefficient of Variation (PCV) are higher while compared to the values of Genotypic Coefficient of variation (GCV). The estimates of GCV and PCV values for characters like shelling (%), ear height, cobs per plant, test weight, ear leaf length, and grain yield have shown higher difference among other characters. Heritability estimates were high to moderate for most of the characters under study. Where in the results of PCV, GCV, heritability and genetic advance have been furnished that selection for cob wt, grain yield, ear length, no of cobs per plant, test weight, ear height would be effective for selection for improvement of yield in this population.

Introduction

Maize (*Zea mays* L.) (2n=2x=20) is an important cereal crop belonging to the Poaceae family and tribe Maydeae. Centre of origin of maize is believed to be in Southern Mexico and had been domesticated about 7000 years ago. Because of its high genetic yield potential compared to other cereal crops it is also known as "queen of cereals". Maize exhibits greater diversity in phenotype and habitat than any other cereal crop. It can be cultivated from tropical to temperate regions of the world. It is cultivated over a wide range of climatic conditions, from latitude 58^0 N to 40^0 S, from mean sea level to altitude above 3000 m and in areas receiving annual rainfall from 250 mm to 5000 mm, making it considered as a promising option for diversifying agriculture in various agro-climatic zones. It is grown at 8.67 mha with 22.25 mt of production and an average productivity of 2.5 - 3 t ha^{-1} (Economics and Statistics Department, 2018). At present, maize accounts for nearly 9% of the national food basket and more than 400 billion rupees of GDP of our country. Among other cereals maize is rich in starch, sucrose and oil content. Globally 67 percent of maize is used for livestock feed, 25% human consumption, industrial purposes and balance is used as seed and demand for grain is increasing worldwide.

Making all these aspects in consideration, plant breeder is particularly interested in genetic diversity of maize as it plays a crucial role in performing successful breeding program. The heritability of a metric trait is a parameter of particular importance to the breeder, since it tests the degree of resemblance between the parents and the offspring and its magnitude indicates the heritability with which a genotype can be defined by its phenotypic expression while genetic advance aids in exercising the necessary selection intensity. Studying variations, heritability and genetic advance in the genotypes can help assess the true potential value of the genotypes. Heritability and genetic advance are very important parameters for selection of genotypes; however, it is not necessary that characters showing high heritability will be definitely show high genetic advance. Heritability is a heritable portion of a phenotypic variance in which the estimation of heritability helps the plant breeder to selecting out elite genotype from diverse genetic population. Genetic advance is a measure of genetic gain under the selection and understanding types of gene action for polygenic traits.

Materials and Methods

The field experiment was conducted in one season at the Agricultural Farm of Palli Siksha Bhavana (Institute of Agriculture), Visva-Bharati, Sriniketan. The experimental plant material in the present investigation comprised of forty genotypic lines of maize obtained from Indian Institute of Maize Research (IIMR), Winter Nursery Centre (WNC), Hyderabad. The experiment was carried out during *rabi* 2018. The design adopted for this experiment was Randomized Block Deign (RBD) with 3 replications. Each entry in each replication was sown in 5 rows of 2.5 m length with spacing 60 cm apart from each other with plant to plant distance of 20 cm. The recommended doses of fertilizers such as N, P and K were applied in the ratio of 120:60:60 kg ha^{-1}. The entire P and K and one third dose of nitrogen was applied as basal dose while remaining dose of N was applied in two equal split doses at knee height and tasseling stages. Irrigation and intercultural operations like weeding were followed as per shedules. Necessary prophylactic plant protection measures were adopted to protect the crop from pests and diseases as per the guidelines of IIMR recommendations, so as to raise a normal healthy crop. Observations on fifteen different quantitative characters were recorded on ten randomly selected competitive plants for each genotype in various phenotypes of the crop except for day's to50% tasseling, days to 50% silking and days to maturity where data is recorded on plot basis. Mean values from the ten randomly selected plants from each of the three replications were averaged and expressed as the mean of the respective character. The mean values were considered for statistical analysis of variance (ANOVA) was done as per the procedure given by (Panse, 1957) following the procedure of Randomized Block Design (RBD) analysis, estimation of broad sense heritability was calculated by formula given by to Hanson *et al.*,(1956), Genetic advance in per cent of mean was estimated by the formula given by Comstock and Robinson *et al.*, (1949).

Results and Discussion

Genetic variability: The mean performance valus for 40 maize genotypes for 15 quantitative characters and analysis of variance for the same are given in table 1 & 2 indicated that plant height, cobs per plant, ear height, ear leaf length, shelling (%), test weight, cob wt, no. of kernel per row, days 75% dry husk, exhibited significant difference among 40 maize genotypes. Thus, the presence of variability among these genotypes in the present study indicated ample scope for improvement through selection of these traits. Similar results were recorded by Saleem *et al.,* (2007), Nzuve *et al.,* (2014), and Sharma *et al.,* (2014).

PCV and GCV: In general the value of the phenotypic coefficient of variation (PCV) was higher than that of genotypic coefficient of variation for all the characters given in table 3. The phenotypic coefficient of variation was estimated to be high (>20%) for grain yield (32.37%), cobs per plant (23.97%), cob wt (21.80%), ear height (20.21%), while moderate (20-10%) for test weight (14.08%), ear leaf length (12.42%), no. of kernel per row (11.20%), plant height (11.17%), and low (<10%) for no. of rows per cob (8.94%), shelling (%) (7.95%), cob length (7.83%), cob diameter (5.62%), days 50% pollen shed (3.72%), days 50% silking (2.07%), days 75% dry husk (2.07%). This was confirmed by previous reports of Kumar, and Satyanarayana (2001), Akbar *et al.,*(2008). Those characters with low magnitude of genetic variability can have limited utility in selection for their improvement programe. Genotypic coefficient of variation (GCV) observed higher (>20%) for cob wt (20.29%), while moderate (20-10%) for Cobs per plant (13.9%), ear height (13.5%), grain yield (13.15), low (<10%) for test weight (9.85%), plant height (8.03%), no. of kernel per row(7.94%), no. of rows per cob (7.8%), ear leaf length (7.67%), cob length (4.81%), cob diameter (4.09%), shelling (%) (3.19%), days 50% pollen shed (1.47%), days 75% dry husk (1.22%), days 50% silking (1.14%). The estimates of GCV and PCV values for characters shelling (%), ear height, cobs per plant, test weight, ear leaf length, grain yield have shown higher difference which indicates the presence of grater environmental factors influencing the expression of this character. Very low difference was observed for characters like days 75% dry husk, days 50% pollen shed, day's 50% silking, cob wt, cob diameter, cob length, no. of rows per cob indicating low sensitivity to environment and consequently greater role for genetic factors influencing the expression of these characters. Similar results were reported by Shakoor *et al*., (2007), Sharma *et al*., (2014), and Ghosh *et al*., (2014) in their findings.

Heritability

Heritability in broad sense were high for cob wt, and no of rows per cob, and moderate for plant height, cob diameter, no. of kernel per row, test weight, ear height, ear leaf length, cob length, days 75% dry husk, cobs per plant, days 50% silking. High heritability estimates for cob wt and no of rows per cob were also reported by Sumathi *et al.,* (2005), Akbar *et al.,* (2008), and satyanarayana (2001), while moderate estimates of heritability for plant height, cob diameter, no of kernel per row, test weight, cob length, days 75% dry husk, cobs per plant, days 50% silking were observed by Sumathi *et al.,*(2005), Akbar *et al.,*(2008), Pradeep Kuma, and Satyanarayana (2001), while moderate estimate of heritability for plant height, cob diameter, no. of kernel per row, test weight, cob length, days 75% dry husk, cobs per plant, days 50% silking were observed by singhal *et al.,*(2006),Bekele *et al.,*(2014), Sesay *et al.,* (2016), Begum *et al.,* (2016) and Ojo *et al.,* (2006), estimates of heritability were low for characters like grain yield, shelling, days 50% pollen shed, which indicate higher influence of environment for the expression of these characters. These were supported with findings of Singhal *et al.,* (2006) for days 50% pollen shed.

Table.1 Mean performance of forty genotypes for fifteen quantitative characters in *rabi* maize

	SHELLING (%)	PLANT HEIGHT(cm)	EAR HEIGHT(cm)	DAYS75% DRYHUSK	DAYS50% POLLENSHED	DAYS50% SILKING	COB WT (kg)	COBS PER PLANT (NO)	COB DIAMETER (cm)	COB LENGTH (cm)	NO.OF ROWS PER COB	TEST WEIGHT (gm)	EAR LEAF LENGTH (cm)	NO.OF KERNEL PER ROW	GRAIN YIELD (kg)
PM17208L	85.18	280.03	120.93	134.33	92.00	100.00	15.43	125.66	4.27	27.16	15.40	30.97	77.10	27.83	13.51
ADV7043	85.06	238.53	95.73	136.66	95.33	99.66	14.42	102.66	4.18	28.30	13.80	26.52	91.03	33.13	13.03
Rasi4118	79.77	302.00	129.43	135.33	94.66	99.00	19.24	119.66	4.63	24.80	14.93	27.27	87.00	39.06	14.66
DKC9197(IS8638)	83.62	287.73	122.23	137.66	101.66	100.00	17.42	97.66	4.30	25.66	14.66	30.97	100.20	36.63	13.80
PM17201L	87.61	262.53	107.06	135.66	93.66	99.66	19.90	125.00	4.68	26.66	16.33	30.47	77.80	33.06	19.10
PM17205L	86.46	274.50	97.70	135.33	94.33	99.00	16.63	119.66	4.52	25.31	15.13	28.04	77.70	29.60	14.06
KMH25K45(C)	84.24	293.00	124.00	135.66	96.00	99.66	18.40	116.66	4.47	25.76	14.53	29.89	85.40	35.00	15.96
P3522(C)	84.75	284.80	135.13	135.66	94.66	97.66	17.23	132.66	4.17	24.00	14.00	27.82	80.20	28.03	13.90
NMH713(C)	84.69	243.23	90.80	135.66	94.33	99.33	12.04	95.33	4.41	24.86	15.53	27.19	85.36	30.33	10.30
GK3208	82.09	229.13	95.76	137.66	97.33	100.33	14.75	117.33	4.33	24.33	13.40	26.36	81.60	27.53	12.63
BLH 113	84.60	275.20	127.86	133.33	96.33	99.66	17.22	120.33	4.51	27.16	15.33	28.04	93.50	32.30	12.10
DKC9188	84.91	283.46	130.73	142.33	93.66	98.33	11.42	112.66	4.33	28.36	15.46	28.73	104.23	33.70	16.06
Bio305	79.94	269.73	122.06	133.66	97.00	100.00	17.22	123.00	4.45	25.76	15.73	26.45	100.90	30.26	14.43
ADV7037	83.54	227.50	109.56	138.66	100.00	100.66	15.54	128.33	4.10	28.23	14.53	23.81	95.06	31.83	10.57
DKC9181	85.00	304.50	122.63	138.33	97.66	101.00	18.75	153.00	4.09	25.50	12.73	27.66	97.23	33.40	13.06
HT16047	83.46	278.36	145.00	133.66	96.33	99.00	15.36	114.00	4.20	28.93	14.06	22.86	96.81	29.40	11.03
PM16202L	83.38	297.20	143.30	132.33	93.33	98.33	16.00	154.00	4.31	29.26	13.73	28.69	91.00	29.70	15.80
PM16201L	81.86	286.76	108.40	138.33	94.00	98.00	15.84	136.00	4.49	26.10	17.20	25.43	98.80	27.70	14.46
VNR32994	85.16	252.37	107.63	139.66	97.00	98.66	11.89	117.33	4.31	25.33	16.40	21.81	84.90	28.90	10.22
PM16205LPM5L	85.70	265.63	125.60	133.33	92.33	96.66	17.28	146.33	4.17	25.30	13.26	29.28	91.06	26.20	14.73
Rasi2015	65.15	256.43	127.10	135.66	97.66	99.33	11.88	101.66	4.21	28.03	13.73	23.86	85.56	30.16	10.20
BLH116	82.27	276.43	112.80	134.66	95.33	98.33	15.80	115.66	4.51	28.93	16.33	26.58	99.70	30.10	16.23
MM2033	83.06	286.40	137.70	135.00	97.66	99.00	14.97	149.33	4.23	28.10	14.13	24.81	97.66	32.86	17.93
DAS-MH-904	87.71	234.26	86.63	137.00	96.33	100.33	12.73	116.33	4.12	25.46	14.66	25.48	87.16	29.33	11.93

PM16203L	82.50	257.13	103.50	133.66	94.00	97.66	17.39	139.33	4.48	27.76	15.60	22.81	84.33	29.93	13.32
Super3366	84.58	257.13	95.63	138.00	95.00	98.66	16.40	109.00	4.39	27.46	15.33	24.02	91.20	31.50	11.56
HT16052	81.15	258.33	104.20	134.33	98.33	102.33	11.12	106.00	3.96	26.13	14.00	20.87	89.60	31.50	9.16
P3522(C)	74.13	293.80	131.10	133.33	95.33	98.00	13.56	165.33	4.21	28.30	14.53	26.34	89.86	32.63	16.96
Seedtech2324(C)	87.84	250.83	126.56	134.33	91.33	96.66	13.23	162.00	4.46	29.80	13.93	29.86	89.45	28.03	17.00
Buland(C)	74.28	242.96	92.20	137.00	98.33	102.00	8.12	63.33	4.87	29.00	16.20	25.32	104.83	28.03	9.10
Bio9681(C)	83.10	281.00	114.33	132.66	92.00	95.66	11.30	121.33	4.51	27.26	17.46	25.77	93.50	31.96	14.20
CMH9999	84.23	239.36	86.33	137.33	92.66	96.66	19.12	160.00	4.29	28.50	13.93	31.56	83.30	28.56	19.18
AH8181	82.08	243.26	91.66	134.66	95.00	99.33	11.53	114.33	3.89	28.60	13.53	29.41	81.80	28.00	11.44
MMH17-22	81.91	261.40	135.16	135.33	96.66	99.66	8.46	124.66	4.29	27.53	16.00	24.94	85.30	30.23	13.22
DH291	83.98	204.20	72.60	135.00	95.33	98.00	11.57	118.00	4.25	27.23	12.46	34.42	76.53	28.40	13.26
BLH111	83.82	267.96	100.40	137.33	95.00	98.66	12.51	133.66	4.49	29.80	13.86	33.81	83.20	33.53	18.69
100K-18	79.93	248.76	95.40	139.00	95.66	100.00	16.45	162.66	4.37	29.30	14.73	25.21	88.23	33.00	18.55
Bio9637(C)	84.55	227.10	98.96	135.33	94.33	99.33	11.26	174.33	3.94	27.03	13.80	22.79	66.96	34.33	17.96
Bio9544(C)	86.01	238.50	101.86	135.00	96.66	101.00	11.81	146.00	4.16	28.93	12.80	27.82	77.70	35.96	20.47
DHM117(C)	72.93	231.90	92.66	135.00	101.33	102.66	11.10	106.66	4.34	29.10	13.66	26.32	92.76	29.36	9.57

Table.2 Analysis of variance for fifteen quantitative characters in *rabi* maize

Source	DEGREE OF FREEDOM	Mean sum of square														
		SHELLING (%)	PLANT HEIGHT(cm)	EAR HEIGHT(cm)	DAYS75% DRYHUSK	DAYS50% POLLENSHED	DAYS50% SILKING	COB WT (kg)	COBS PER PLANT (NO)	COB DIAMETER (cm)	COB LENGTH (cm)	NO.OF ROWS PER COB	TEST WEIGHT (gm)	EAR LEAF LENGTH (cm)	NO.OF KERNEL PER ROW	GRAIN YIELD (kg)
REPLICATION	2	36.03	171.57	328.49	1.300	9.43	4.90	0.117	147.10	0.091*	8.97*	1.16	11.17	297.71	38.59**	26.83
GENOTYPES	39	57.16*	1748.93***	969.62 ***	13.48***	16.67*	6.81***	27.54***	1531.6** *	0.122* **	7.98** *	4.34** *	28.64* **	213.91** *	24.24***	27.66*
ERROR	78	36.25	415.64	280.23	5.16	10.72	2.96	1.34	607.03	0.027	2.82	0.41	7.37	75.03	6	17.37

*, **, ***, **** Significant at P=0.05, 0.01, 0.005 and 0.001 respectively

Table.3 Phenotypic and genotypic coefficients of variability, heritability and genetic advance for fifteen quantitative characters in *rabi* maize

	Grand mean	Range		Coefficient of Variation (%)		Heritability (%)	Genetic advance	Genetic advance as percent of mean
		Min	Max	GCV	PCV			
SHELLING (%)	82.65	65.15	87.84	3.19	7.95	16.1	2.183	2.64
PLANT HEIGHT(cm)	262.33	204.200	304.50	8.03	11.17	51.7	31.21	11.90
EAR HEIGHT(cm)	111.71	72.60	145.00	13.57	20.21	45.1	20.96	18.76
DAYS 75% DRY HUSK	135.82	132.33	142.33	1.22	2.07	35.0	2.02	1.49
DAYS 50%POLLEN SHED	95.64	91.33	101.66	1.47	3.72	15.6	1.146	1.19
DAYS 50% SILKING	99.20	95.66	102.66	1.14	2.07	30.2	1.28	1.29
COB WT (kg)	14.56	8.12	19.90	20.29	21.80	86.6	5.66	38.90
COBS PER PLANT (NO)	126.17	63.33	174.33	13.91	23.97	33.7	20.98	16.63
COB DIAMETER (cm)	4.32	3.89	4.87	4.09	5.62	53.1	0.266	6.14
COB LENGTH (cm)	27.22	24.00	29.80	4.81	7.83	37.8	1.66	6.10
NO.OF ROWS PER COB	14.67	12.46	17.46	7.80	8.94	76.2	2.06	14.03
TEST WEIGHT (gm)	27.01	20.87	34.42	9.85	14.08	49.0	3.84	14.22
EAR LEAF LENGTH (cm)	88.64	66.96	104.83	7.67	12.42	38.2	8.65	9.76
NO.OF KERNEL PER ROW	31.02	26.20	39.06	7.94	11.20	50.3	3.60	11.61
GRAIN YIELD (kg)	14.47	9.10	20.47	13.15	32.37	16.5	1.55	11.00

Genetic advance

The higher estimate of genetic advance as percent of mean was exhibited by cob wt (38.90%), whereas moderate estimate of genetic advance as percent of mean were exhibited by ear height (18.76%), cobs per plant (16.63%), test weight (14.22%), no. of rows per cob(14.03%), plant height(11.90%), no. of kernel per row (11.61%), grain yield (11.0%), Lower estimates of genetic advance as percent of mean were shown by ear leaf length (9.76%), cob diameter (6.14%), cob length (6.10%), shelling (2.64%%), days 75% dry husk (1.49%), days 50% silking (1.29%), days 50% pollen shed (1.19%).These results are in agreement with the findings of Shakoor *et al.*,(2007), Kumar *et al.,* (2006), Kumar, and Satyanarayana (2001), Singh *et al.*, (2006)Sesay *et al.,* (2016), and Nataraj *et al.,*(2014).

According to Johnson *et al.*, (1955) heritability used in conjunction with genetic advance provides better information for selecting the best individuals then the heritability alone. High to moderate estimates of heritability accompanied with high to moderate genetic advance for indicated the predominance of additive gene action for the expression of the characters. Hence selection of the characters with moderate to high estimates of heritability accompanied with high to moderate genetic advance would be effective in this population.

A perusal of the Table 3, where in the results of PCV, GCV, heritability and genetic advance have been furnished, revealed that selection for cob wt, grain yield, ear length, no of cobs per plant, test weight, ear height would be effective for improvement of yield in this population.

In conclusion the analysis of variance revealed significant differences among all the characters under study in the forty maize genotypes. Thus the findings show that, sufficient amount of variability were present in this maize population. High GCV and PCV were observed for cob wt., and moderate values for cobs per plant, ear height, and grain yield emphasizing the existence of variation suggesting simple selection for these traits would be effective. High heritability with high genetic advance was recorded in cob weight, and no. of rows per cob while moderate heritability and genetic advance was recorded for plant height, ear height, no. of kernel per row, test weight, no. of rows per cob, cobs per plant, ear leaf length, cob length, and grain yield indicating greater importance for additive gene effect, and possibility of improvement of these traits through simple selection, mass selection and pedigree method of plant breeding might be effective.

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