Assessment of Genetic Variability, Heritability, and Genetic advance as a percentage of mean in Maize (Zea mays L.) Segregating Generations.

ABSTRACT

The recent experiment aimed to investigate genetic traits for eleven characteristics, namely, Days to 50% tasselling, Days to 50% silking, Plant height (cm), Tassel length (cm), Ear length (cm), Ear diameter (cm), Ear height (cm), Number of kernel rows per cob, Number of kernels per row, Cob weight (g), and Grain yield (g) during the Kharif and Rabi seasons of 2023-24. The Alpha Lattice Design was employed with two replications. Genotypes were sown in single row, each 2 meters long in each replication. The analysis of variance revealed significant variations among all traits, with phenotypic coefficients of variation (PCV) generally exceeding genotypic coefficients of variation (GCV).grain yield (K; 53.45, 51.7: R;101.56, 101.2) and Cob weight (K;38.9, 36.92: R;91.14, 90.81) exhibited the highest phenotypic and genotypic coefficients of variation (PCV and GCV) across both seasons, signifying significant genetic variability in the studied material. rGrain yield showed the highest heritability,(99.4) with cob weight(99.2) coming in second. The high heritability indicates a strong likelihood that these traits will be successfully passed on to offspring, making selection more effective. Traits such as Grain yield(g), Cob weight(g), Ear diameter(cm), Ear height(cm), and Tassel length(cm).demonstrated high heritability and genetic advancement in both seasons, making them promising candidates for enhancement through selection based on additive genetic factors.

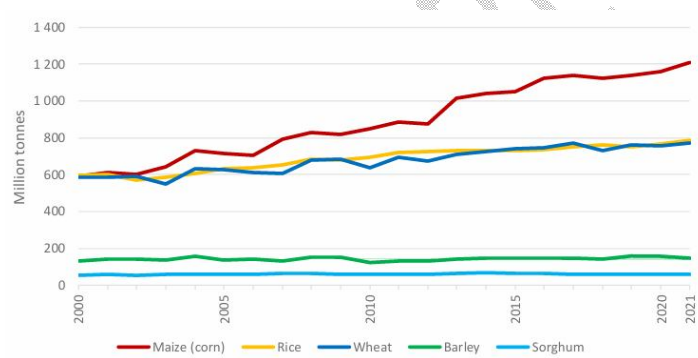
Keywords:*Heritability, Variability, Maize, yield*.

INTRODUCTION

Maize (*Zea mays* L.) is the world's most important crop and is extensively grown as a cereal grain that originated in Central America. It is one of the most flexible developing crops, offering more versatility. Maize is renowned as the "Queen of Cereals" due to its tremendous genetic yield potential. Maize is the only food cereal crop that can be cultivated in various seasons, environments, and applications[1]... It is the second most widely grown crop in the world after wheat, FAOStat, (2021) Maize is an industry-oriented crop used to extract starch, glucose, maltose syrup, ethanol, and poultry feed, contributing to the global economy in many nations[2].For billions of people, maize is a vital crop that is used for food, feed, and industrial raw materials. Currently, nearly 1137.3 million MT of maize is being produced together by over 170 countries from 197.4 million ha with an average productivity of 5.8 t/ha (FAOSTAT, 2021)[3] (According to 3rdAdvance Estimates of Production of Food grains for 2023-24, all India aize production estimated was 35.67 million tonnes. It is grown on around 1.58 lakh hectares in Telangana, accounting for 2.09% of the total cultivated area, with an estimated yield of 28.80 lakh metric tons in the state[4].

˙).In maize breeding projects, the goal perpetually is to improve economically essential characteristics while retaining a reasonable level of heterogeneityTo promote Genetic diversity in germplasm, it is necessary to understand the level of existing genetic variability in the genotypes.Estimating genetic diversity in available germplasm is an important part of any crop development strategy. hence it is necessary to assess the genotypic and phenotypic coefficients of variation, broad sense heritability, and genetic advance as a percent of the mean.Zhang et al. [5] highlighted the necessity of assessing genetic heterogeneity among maize cultivars produced in a given location before beginning a breeding effort. Genetic variability is essential for the consistent improvement of complex traits, which can be measured using phenotypic and genotypic coefficients of variation. With this consideration,

Fig .1 Scenario of a crop improvement program



Source: FAO. 2022. FAOSTAT: Production: Crops and livestock products. In: FAO. Rome. Cited December 2022. https://www.fao.org/faostat/en/#data/QCL(3).

"The success of any crop improvement programis not only dependent on the amount of genetic variability present in the population but also on the extent to which it is heritable, which sets the limit of progress that can be achieved through selection",Bello, O.B.*et al,* 2012[6]."Variability is the presence of variations between genotypes as a result of variances in their genetic composition or the environment in which they are cultivated". Wedwessene*et al*, [7] .The present investigation aimed to find out the genetic variability, heritability, and genetic advance as percent of mean, to find out the association of different morphological and yield traits, and also to analyze the nature and magnitude of the association of the studied c using 54 different maize segregating lines in the kharif season and 49 $f_{2\text{-}3}$ lines in the rabi season.Majhi, P.K. *et al.*, (2020) defined heritability as the extent of genotype's contribution to phenotypic variation for a trait in a population, which is often represented as the ratio of genetic variance to the total variance.According to Robinson et al. (1949),heritability estimates in cultivated plants can be placed in the categories; low (0-30%), moderate (30-60%), and high (>

60%).Genetic advance for each character was estimated by using the formula of Johnson et al. (1955)and genetic advance as percent of mean (GAM) was categorized according to him as low (0-10%), moderate (10-20%) and high (> 20%).

MATERIALS AND METHODS

The experiments including selfing was carried out in *Kharif* 2023, and further segregating generation in *Rabi,* 2023-24 were carried out at Winter Nursery Centre, Rajendranagar, Hyderabad. Winter Nursey Centre, Hyderabad is located at the Southern Telangana agro-climatic zone of Telangana state. Geographically it lies at 17.19 ^{o}N latitude, 78.24 ^{o}E longitude with an altitude of 542.6 meters above Mean Sea Level (MSL). The rainfall of the Research Station ranged from 606 to 853 mm (long-term range).

The experimental material consists of 54 maize segregating lines in the first season(Kharif 2023) and 49 f_{2-3} lines and these were sown in two replications with Alpha Lattice Design. Each genotype was planted in a single row, 2 meters in length in each replication, with a spacing of 60 cm between rows and 20 cm within rows. The crop was cultivated with the recommended agricultural practices. Observations were recorded for eleven quantitative traits *viz.,*Days to 50 percent tasselling, Days to 50 percent silking, Plant height (cm), tassel length (cm), ear length (cm), ear diameter (cm), ear height (cm), Number of kernel rows per cob, Number of kernels per row, cob weight (g) and grain yield (g).

Johnson et al.] developed a method to determine heritability in the broad sense (h2 bs) and genetic progress. Burton's techniques[] were used to calculate the genotypic and phenotypic coefficients of variation. The PCV and GCV estimations were classified as low (0-10%), moderate (10-20%), and high (>20%) using Sivasubramanian and Madhavamenon's criteria (12).

Statistical analysis:

The analysis of variance (Table 1) was conducted for F2 and F3 generations. Two analyses of variance were conducted. The first was for all genotypes in selected families, and the second was for the chosen families to determine heritability and GCVand PCV. R 4.4.1-win was used to carry out the analysis.

Coefficient of variation

The genotypic and phenotypic coefficients of variation were calculated using the formulae given by Burton (1952).**Phenotypic coefficient of variation (PCV %)**= $\frac{\sqrt{V_p}}{\bar{X}} \times \mathbf{100}$

Genotypic coefficient of variation (GCV %)= $\frac{\sqrt{V_g}}{\bar{X}} \times \mathbf{100}$

Where,

Vp = Phenotypic variance

Vg = Genotypic variance

$\bar{X}$ = Mean of the character

- Heritability in a broad sense was estimated as **H= σg/ 2 σp2x 100**.

RESULTS AND DISCUSSION

Analysis of variance

The analysis of variance revealed significant differences among genotypes for all traits in both seasons viz., including Days to 50 percent tasselling, Days to 50 percent silking, Plant height (cm), Tassellength (cm), Earlength (cm), Eardiameter (cm), Earheight (cm), Number ofkernel rows per cob, Number of kernels per row, Cobweight (g), Grain yield (g). (Table 1), indicating genotypic variation among the evaluated genotypes. There is a chance to choose favorable genotypes with improved yield component qualities, which might perform well and lead to greater yield. These findings are congruent with those of other studies, including Ahmad, M.S.H., 2016,Chandel *et al.* (2019), Sinha and Thakur (2017), Meena *et al.* (2016).

Variability and Heritability

The variability of eleven quantitative traits in 54 maize segregating lines in the first season(Kharif 2023) and 49 f_{2-3} lines in rabi (2023-24) were assessed using a phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability, and genetic advance as a percentage of the mean (Table 2).

In this study, the Phenotypic Coefficient of Variation (PCV) was higher than the Genotypic Coefficient of Variation (GCV) for almost all quantitative traits (Table 2) in both the Kharif and rabi seasons of 2023-24. Although the value of the phenotypic coefficient of variation (PCV) for all characters were always found to be higher than the genotypic coefficient variation (GCV) the differences were small in magnitude. This suggests the environment's lower influence on the characters' expression.

Table 1. Analysis of Variance for Yield and Yield-Contributing Traits in Maize

S.No.	Character/trait	Mean sum of squares									
		Replication		Genotypes		Blocks		Error		CV%	
		Kharif 2023	Rabi 2023-24	Kharif 2023	Rabi 2023-24	Kharif 2023	Rabi 2023-24	Kharif 2023	Rabi 2023-24	Kharif 2023	Rabi 2023-24
1	**Daysto50percentsilking**	137.81	25.51	52.09**	46.83**	4.12	6.39	4.241	6.003	2.6	3.3
2	**Daysto50percentanthesis**	78.3	36.73	58.05**	45.20**	0.881	5.92	3.96	7.37	2.6	3.4
3	**Plantheight(cm)**	4.32	38.65	2519.38**	846.96**	35.39	6.38	20.41	35.07	2.9	4.1
4	**Tassel length (cm)**	0.106	1.17	84.74**	102.67**	0.461	0.314	0.80	0.46	2.8	2.1
5	**Ear length(cm)**	9.61	0.29	11.63**	24.56**	6.39	0.193	3.81	0.302	15.8	6
6	**Ear diameter(cm)**	12.62	0.24	8.86**	20.94**	2.52	0.1643	1.62	0.08	18	3.8
7	**Ear height (cm)**	7.01	0.33	1391.87**	389.62**	20.37*	2.39	7.61	1.31	3.5	1.9
8	**KernelrowsPer Ear**	46.01	119.179	132.10**	27.439**	5.42	8.03	85.3	2.99	20	15.8
9	**Kernel Per Row**	89.87	6.221	188.02**	107.376**	36.8	4.097	124.77	1.87	19.89	9.7
10	**Cob weight (g)**	2.72	29.23	520.12**	2777.7*	4.17	13.94	29.98	9.57	12.9	7.6
11	**Grain yield (g)**	0.81	22.30	443.91**	2105.65**	4.56	7.44	15.49	5.89	13.9	7.6

**Significantat1%level *Significantat 5%level

Table 2. Genetic Variability Parameters for Yield and Yield-Contributing Traits in Maize

S. No.	Character	Mean		Range				Coefficientof Variation				Heritability (broadsense) h^2(bs) (%)		GAM	
				Minimum		Maximum		PCV (%)		GCV (%)					
		K	R	K	R	K	R	K	R	K	R	K	R	K	R
1	DS	75.61	74.7	64	62	87	86	7.34	6.87	6.89	6.04	88.1	77	13.3	10.9
2	DA	79.46	78.7	66	65	99	88	6.67	6.50	6.15	5.53	84	72	11.6	9.7
3	PH	157.9	145.06	55.8	96.86	217.3	216.32	22.56	14.4	22.37	13.9	98.2	92.83	45.69	27.62
4	TL	32.44	32.02	22.8	12.24	68.2	65.52	20.17	22.42	19.96	22.32	98.19	99.14	40.76	45.78
5	EL	12.36	9.16	6.3	2.85	18.5	18.21	22.65	38.46	15.74	38.01	48.3	97	22.54	77.3
6	ED	7.7	7.712	2.90	3.14	13.4	14.65	32.4	42.03	26.7	41.83	67.6	99.1	45.2	85.7
7	EH	77.76	61.65	17.15	31.98	17.7	94.72	34	22.68	33.8	22.59	98.7	99.2	69.2	46.37
8	KRPE	38.59	10.93	15.3	4.52	65.1	24.01	26.5	36.05	13.05	31.56	25.8	76.6	14.14	56.94
9	KPR	46.9	14.08	16.7	3.30	78.17	33.02	26.3	52.5	12.75	51.52	23.4	96	12.73	104

10	**CW**	42.50	40.96	16.11	5.06	81.45	148.56	38.9	91.14	36.92	90.81	89.9	99.2	72.1	186.39
11	**GY**	28.31	31.99	5.10	3.01	65..85	125.22	53.45	101.56	51.7	101.2	93.6	99.4	103.17	208.1

PCV=Phenotypiccoefficientof variation GCV=Genotypic coefficientofvariation

DA:Daysto 50percent Anthesis, DS: Daysto 50percent Silking, PH: Plant height, TL: Tassel Length, EH: EarHeight, EL: EarLength, ED: Ear Diameter, KRPE: KernelRowsPer Ear, KPR: Kernels Per Row, CW: Cob Weight, GY: Grain Yield.

K: Kharif 2023, R: Rabi 2023-2024.

The highest values of phenotypic and genotypic coefficients of variation (PCV and GCV) were recorded for grain yield(K; 53.45, 51.7: R;101.56, 101.2) in both seasons followed by cob weight (K;38.9, 36.92: R;91.14, 90.81), indicating significant genetic variability in the material studied. High PCV and GCV values for grain yield and cob weight in maize were also reported byMagar, B.T*et al*. (2021), Bartaula, S*et al.* (2019). The traits Ear height(K;34, 33.8; R 22.68, 22.59) and ear diameter(K; 32.4,26.7; R 42.03: 41.83)show height PCV and GCV during both the seasons. The traits KRPE (K;26.5:R; 36.05), KPR (K;26.3: R; 52.5), Ear length(K; 22.65: R;38.46) and Tassel length(K; 20.17, 22.42)showedthe highest PCV for both seasons.

"Moderate GCV and PCV values were observed for the traits of Tassel length(K;19.96), Ear length(K; 15.74), KRPE(K; 13.05), and KPR(K; 12.75)showed moderate GCV values during Kharif season 2023-24 and Plant height (R; 13.9) showed moderate PCV during Rabi season.These results are consistent with the experimental findings" of Barathi*et al*.(2021),Kandel*et al*. (2018)

"Low GCV and PCV were observed for the traits of days to 50% anthesis (K; 6.67, 6.15: R; 6.50, 5.53)and days to 50% silking (K; 7.34,6.89: R; 6.87, 6.04) in both seasons. The minimal difference between genotypic and phenotypic coefficients of variation suggests that environmental factors had little effect on the expression of these traits. These findings are consistent with the experimental results" of Barathi*et al*. (2021) and Ellandula*et al*.(2023).

A large number of traits had considerably high heritability estimates, indicating that additive gene action predominated. The highest heritability was found in Grain yield (R; 99.4),followed by Cob weight(99.2), Earheight(R; 99.2) during rabi season and during Kharif season highest heritability was found in Ear height(K; 98.7) followed by Plant height (K; 98.2). However, improving such traits may not be beneficial as broad sense heritability is based on total genetic variance, including additive, dominant, and epistatic variances. Heritability values with high genetic progress are more trustworthy for determining selection criteria.Higher heritability suggests additive gene activity, which allows selection to be successful in early generations. Akbar et al. [23], Rafiq et al. [24], and Rafique et al. [25] have similarly found substantial heritability for many yield-controlling characteristics in maize.

Moderate heritability was found in Ear length (K; 48.3) duringthe Kharif seasonwhich aligns with findings reported byKhan, S.*et al*. (2021),least heritability was observed in KPR (K; 23.4) followed by KRPE (K; 25.8)indicating a considerable effect of environmental influences. These data show the occurrence of non-additive gene activities.These findings are consistent with the experimental results of Magar, B.T. *et al*.(2021).

Genetic advance as a percentage of the mean indicated that additive genetic factors predominantly influence these traits. Utilizing heritability estimates alongside genetic advances enhances the reliability and utility of selection procedures. According to Johnson *et al*. (1955), the observed GAM values were classified as low (less than 10%),moderate (10–20%), and high (greater than 20%).In the present study, genetic advance was calculated and expressed as a percentage of the mean for all traits (Table 2). High genetic advances were observed for total grain yield(K; 103.17: R; 208.1), followed by cob weight (K; 72.1: R; 186.39)inthe bothseasons.Beulah, G et al. (2018), and Bharathi,*et al*.(2021) [] reported high genetic advance values for total grain yield. Moderate GAM values were observed in days to 50% silking and days to 50% anthesis in both seasons. Similar values were obtained by Wedwessen*et al*. (2020)[].DA and DS showed high heritability but low GAM. This could be due to environmental factors, indicating that selection for these traits might not be beneficial.Similar findings were reported byTesfaye, D. *et al* (2021) and Beulah, G.*et al*.(2018)

High heritability combined with high genetic advance was observed for Grain yield,Cob weight, Ear diameter, Ear height, and Tassel length. These findings suggest that these traits are promising targets for improvement through selection, likely driven by additive genetic factors. Beulah, G. *et al.* (2018), Lal, K. *et al*. (2020), and Wedwessen, T. *et al*. (2020) all discovered significant heritability and high genetic progress for the previously mentioned characteristics in maize.

CONCLUSION

The analysis of variance revealed significant variation between the inbred lines, with phenotypic coefficients of variation (PCV) greater than genotypic coefficients of variation (GCV) for all traits. This suggests that direct selection will be effective in improving these traits. The highest PCV and GCV traits were total grain yield and cob weight during both seasons, indicating significant variability among the genotypes and indicating that phenotypic selection will be beneficial for improving these traits due to their high heritability and high genetic advance.Heritability is the proportion of phenotypic variance that can be attributable to genetic variation. In the current study, heritability was high (more than 60%) for many characteristics. A high heritability means that environmental influences are minimal on traits. As a result, any of the characters can be selected.High heritability combined with high genetic advance for ear height, total grain yield, cob weight, ear diameter, and tassel lengthillustrates that these traits are governed by additive gene action, making them heritable and fixable, implying that phenotypic selection for these traits would be advantageous.

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