Biological Forum – An International Journal **15(2): 708-711(2023)**

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Estimation of Genetic Parameters for Yield and Kernel Iron and Zinc Concentration in Maize (*Zea mays* L.)

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(Received: 02 January 2023; Revised: 04 February 2023; Accepted: 15 February 2023; Published: 18 February 2023)
(Published by Research Trend)

ABSTRACT: Maize is one of the important cereal crop cultivated around the world. Micronutrients malnutrition is a major concern in the peoples of developing countries. Present study was done to estimate the genetic parameters of forty-six maize genotypes (inbred lines) collected from CIMMYT, Hyderabad and Banaras Hindu University (BHU), Varanasi. The research experiment was conducted in randomized complete block design (RCBD) with two replications at Agricultural Research Farm, Institute of Agricultural Sciences, BHU, Varanasi during *Kharif* 2018. ANOVA indicated a significant difference among maize genotypes for all the characters. Genotypic coefficient of variance (GCV) was lower than phenotypic coefficient of variance (PCV) for all the characters. Highest heritability (bs) was detected for plant height followed by kernel zinc content, kernel iron content, grain yield per plant, days to 50% tasseling, days to 50% silking and cob length without husk. Highest genetic advance was observed for plant height whereas, the highest genetic advance as percentage of mean (GAM) was observed for kernel zinc content followed by kernel iron content, 100 seed weight and cob length without husk. The findings of the present investigation indicated the presence of enough genetic variability among the maize genotypes analysed, which can be exploited for maize improvement programs and development of cultivars/hybrids to enrich iron and zinc content in maize kernels.

Keywords: Maize, PCV, GCV, heritability, iron and zinc.

INTRODUCTION

Maize (*Zea mays* L.) is an important cereal crop that belongs to the tribe Maydeae of the order Poales, family Poaceae, subfamily Panicoideae and genus Zea. It is known as the "queen of cereals" because of its high production potential and adaptability to a wide range of environments. It is cultivated widely throughout the world and has the highest production among all the cereals. In recent past, maize is attainment popularity among farmers mostly due to its high yield, more economic return and multipurpose uses.

In India, maizeis the third most important food crop after rice and wheat. India's maize production varies between 10-14 million tons, with 80-90% of the production being in the *Kharif* season. Karnataka and Madhya Pradesh have the highest area under maize (15% each) among Indian states followed by Maharashtra (10%), Rajasthan (9%), Uttar Pradesh (8%), Bihar (7%), Telangana State (6%), Gujarat (5%), Tamil Nadu (4%), J&K (3%) and others (18%). Bihar produces highest maize after Karnataka and Madhya Pradesh. Andhra Pradesh is having the highest state productivity (Anonymous, 2021). To develop the maize cultivar with high iron and zinc concentrations, it is a prerequisite to identify maize germplasm with higher content of both the elements in grin and comprehend genetic mechanism.

Micronutrients are required in trace amounts for the proper functioning of human metabolism. Deficiency of these micronutrients in diet will lead to micronutrient malnourishment or hidden hunger, which affects 3 billion people and will be increased when the global population is expected to reach 8 billion by 2025 (Khush *et al*., 2012). Iron plays a vital role in the metabolic processes and its deficiency causes anaemia. Zinc deficiency is a well-documented problem in food crops, causing decreased crop yields and nutritional quality. Generally, the regions in the world with zinc-deficient soils are also characterized by widespread zinc deficiency in humans. Recent estimates indicate that nearly half of the world population suffers from zinc deficiency (Cakmak, 2008).

Variability of kernel iron and zinc concentration in maize has been reported by several researchers. Banziger and Long (2000), observed kernel iron and zinc in range of 9.60-63.20 mg/kg and 12.90-57.60 mg/kg respectively. Prasanna *et al*. (2011) evaluated 30 maize inbred lines and reported kernel iron concentration in range from

11.28-60.11 mg/kg and zinc concentration in range of 15.14-52.95 mg/kg. Agrawal *et al.* (2012) evaluated 67 inbred lines and observed iron concentration between 20.38-54.29 mg/kg and zinc concentration between 7.01-29.88 mg/kg; Guleria *et al.* (2013) observed zinc concentration in range of 3.81-35.83 mg/kg; Mallikarjuna *et al*. (2014) evaluated 120 QPM inbreds and reported iron concentration between 16.60-83.40 mg/kg and zinc concentration 16.40-53.20 mg/kg; Hindu *et al*. (2018) analysed 923 maize inbreds and observed iron and zinc in range of 8.19-25.65 mg/kg and 17.11-43.69 mg/kg respectively; observed zinc concentration between range of ; Mageto *et al.* (2020) observed zinc concentration in range of 22.47-26.51 mg/kg in maize inbreds; Sharma *et al*. (2021); Goredema-Matongera *et al*. (2023) analyzed 77 maize hybrids and observed iron and zinc concentration in range of 7.10-58.4 mg/kg and 10.70-57.80 mg/kg respectively. For the improvement of any crop, genetic variability is pre-requisite for all plant breeding programmes. Present study was done to estimate the genetic parameters for yield and kernel iron and zinc content in maize.

MATERIAL AND METHODS

Plant material and location. Forty-six maize inbred lines used in this study were obtained from CIMMYT, Hyderabad and Maize Improvement Program BHU, Varanasi (Table 1). The experimental trial was conducted in RCBD during *Kharif* 2018 at Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi (25.18°N latitude; 83.03°E longitude and at an altitude of 123.23 m above the sea level). Each genotype was sown into two rows of 3 m each with 70 cm row to row and 20 cm plant to plant distance. The soil of the experimental plot was characterized as the type of soil of Indo-Gangetic plains which is fertile and alluvial loam.

Table 1: List of maize inbred lines used in the experiment.

Sr. No.	Inbred Line	S. No.	Inbred Line
1.	CML-162	24.	VL-1248
2.	CML-163	25.	VL-1010923
3.	CML-164	26.	VL-055199
4.	CML-187	27.	VL-1018148
5.	CML-229	28.	VL-108720
6.	VL-108866	29.	VL-1010848
7.	VL-1010856	30.	VL-1033
8.	VL-1018162	31.	VL-1037
9.	VL-1028	32.	VL-1056
10.	VL-108725	33.	VL-109452
11.	SNL-153277	34.	VL-109582
12.	VL-1030	35.	VL-109800
13.	VL-102	36.	VL-121096
14.	VL-1018604	37.	HUZM-58
15.	VL-05552	38.	HUZM-65-1
16.	VL-1016173	39.	HUZM-77
17.	VL-1012837	40.	HUZM-185
18.	SNL-153292	41.	HUZM-320
19.	VL-0512595	42.	HUZM-265
20.	VL-109309	43.	HUZM-97-1-2
21.	VL-109524	44.	HUZM-90
22.	VL-1016210	45.	HUZM-242
23.	VL-1016211	46.	HUZM-55

Observations recorded. The observations were taken for 12 important traits of maize, five randomly selected competitive plants from each plot and each replication, and their mean values were recorded. Observations were taken for days to 50% tasseling, days to 50% silking, plant height (cm), tassel length (cm), cob length without husk (cm), cob diameter without husk (cm), number of kernel rows per cob, number of kernels per row, 100 seed weight (g), grain yield per plant (g), kernel iron content (mg/kg) and kernel zinc content (mg/kg). Biochemical analysis of iron and zinc concentration in maize kernels was done at the Department of Soil Science and Agricultural Chemistry, Institute of Agricultural Sciences, BHU, Varanasi. Triplicate milled samples of each genotype was digested with 9:4 diacid mixture (HNO_3:$HClO_4$) followed by atomic absorption spectrometry (AAS) using (Agilent 240FS AA) as per the procedure described by Zarcinas *et al.* (1987) with some revisions recommended by Singh *et al.* (2005).

Statistical analysis. Analysis of variance and estimation of genetic parameters were done by using R software (version 4.1) package: variability (version 0.1). Broad senseheritability was calculated according to the formula given by Johnson *et al.* (1955); Hanson (1961). Genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) were calculated according to Burton (1952); Singh and Choudhury (1985). Genetic advance (GA) was calculated by the formula suggested by Johnson *et al.* (1955); Allard (1975). Genetic advance in per cent of mean (GMA) was calculated by the formula given by Comstock *et al.* (1952).

RESULTS AND DISCUSSION

Analysis of variance. Analysis of variance reviled that, all the forty-six maize inbred lines exhibited a significant variation for all the twelve characters (Table 2). Significant variance among genotypes demonstrated the existence of genotypic variations, emphasizing the significance of their genetic worth in identifying the ideal genetic makeup for a given condition and therefore providing a wider range of selection options. Patil *et al.* (2016) also observe significant genetic variation in maize inbreds for days to 50% tasseling, days to 50% silking, plant height, cob length, cob diameter, number of kernel rows per cob, number of kernels per row, 100 seed weight and grain yield per plant. Significant variations in iron and zinc concentration in maize kernel were also observed by Banziger and Long (2000); Chakraborti *et al.* (2011); Agrawal *et al.* (2012); Guleria *et al.* (2013); Mallikarjuna *et al.* (2014); Sharma *et al.* (2021); Goredema-Matongera *et al.* (2023).

Table 2: ANOVA for twelve characters of forty-six maize inbred lines evaluated during *Kharif* 2018.

Sources of variance	d.f.	Mean Sum of Square					
		DFT	DFS	PHT	TL	CLWH	CDWH
Replication	1	2.45	9.78	45.57	9.93	1.62	1.52
Treatment	45	10.34**	10.77**	316.52**	3.52*	12.79**	0.43*
Error	45	1.85	1.94	12.74	1.85	2.79	0.22
Sources of variance	**d.f.**	**Mean Sum of Square**					
		NKRPC	NKPR	HSW	GYPP	FE	ZN
Replication	1	6.77	7.82	1.61	15.69	2.04	1.05
Treatment	45	4.52**	28.03**	21.93**	68.31**	45.10**	41.03**
Error	45	2.04	7.29	3.60	11.41	4.52	4.06

'*', '**' indicates significant at 5% and 1% respectively.
DFT - days to 50% tasseling, DFS - days to 50% silking, PHT - plant height (cm), TL - tassel length (cm), CLWH - cob length without husk (cm), CDWH - cob diameter without husk (cm), NKRPC - number of kernel rows per cob, NKPR - number of kernels per row, HSW - 100 seed weight (g), GYPP - grain yield per plant (g), FE - iron content (mg/kg), ZN - zinc content (mg/kg).

Analysis of genetic parameters. For the improvement of any crop genetic variability is pre-requisite for all plant breeding programmes. In any species the phenotypic variability present in a genotype or a set of genotypes can be divided into genotypic and environmental components. The genotypic component is the heritable portion of the total variability, its magnitude on yield and yield attributing characters influence the selection schemes to be followed by the plant breeders. Thus the success of genetic improvement of crops for any trait depends on the nature of the variability present in the germplasms.

In the present study, higher PCV was observed than GCV for all the characters (Table 2). It shows that environmental conditions affect their phenotypic expression. These findings are accordance with Patil *et al.* (2016); Hosamani *et al.* (2018). On the basis of magnitude of heritability Johnson *et al.* (1955) classified heritability as low (>30%), medium (30-60%) and high (>60%). They also classified genetic advance as percentage of mean values, low (0-10%), moderate (10-20%) and high (>20%). Highest broad sense heritability was observed for plant height (92.26%) followed by kernel zinc content (82.00%), kernel iron content (81.80%), grain yield per plant (71.38%), days to 50% tasseling (69.70%), days to 50% silking (69.50%) and cob length without husk (64.19%). High broad sense heritability for grain yield and zinc concentration also reported by Mageto *et al.* (2020). The highest genetic advance was reported only for plant height (24.36%) while, genetic advance as percentage of mean (GAM) was observed for kernel zinc content (35.87%) followed by kernel iron content (29.27%), 100 seed weight (23.38%) and cob length without husk (23.29%). High heritability in broad sense (92.26%) with high genetic advance (24.39%) was observed for plant height. Larik *et al.* (2000) suggested that the most effective condition for selection is when high genetic advance with high heritability is present.

Table 3: Estimation of genetic parameters of twelve traits of 46 maize inbred lines.

Traits	Range		Grand Mean	PCV (%)	GCV (%)	h^2bs (%)	GA (%)	GAM
	Max.	Min.						
Days to 50% tasseling	52.00	42.00	47.95	5.15	4.30	69.70	3.54	7.39
Days to 50% silking	55.00	45.00	50.22	5.02	4.18	69.50	3.61	7.19
Plant height (cm)	150.30	100.00	126.38	10.15	9.75	92.26	24.39	19.30
Tassel length (cm)	32.82	24.90	28.50	5.75	3.21	31.20	1.05	3.69
Cob length without husk (cm)	20.37	10.00	15.84	17.62	14.11	64.19	3.69	23.29
Cob diameter without husk (cm)	4.88	2.00	3.21	17.75	9.90	31.11	0.37	11.37
Number of kernel rows per cob	16.43	10.16	12.51	14.47	8.89	37.73	1.41	11.25
Number of kernels per row	39.32	22.84	30.71	13.69	10.49	58.72	5.08	16.55
100 seed weight (g)	36.90	18.00	22.60	15.81	13.39	71.80	5.28	23.38
Grain yield per plant (g)	67.08	41.69	53.94	11.71	9.89	71.38	9.28	17.21
Kernel iron content (mg/kg)	38.18	13.47	28.68	17.37	15.71	81.80	8.39	29.27
Kernel zinc content (mg/kg)	33.50	14.22	22.36	21.23	19.23	82.00	8.02	35.87

CONCLUSION AND FUTURE SCOPE

Maize inbred lines exhibited a significant variation for all the traits studied. High heritability with high genetic advance was observed for plant height. Based on mean performance, promising maize inbreds were identified for kernel iron content *viz.*, CML-229, VL-109524, HUZM-242 and VL-1016211; for zinc content *viz*., HUZM-97-1-2, VL-109309, VL-109582, HUZM-77 and VL-1028. These maize inbreds can be utilize for the improvement of iron and zinc content through appropriate breeding methods. Identified maize inbred lines with high micronutrient can be used for the development of bio-fortified maize cultivars/hybrids to reduce the malnutrition problem.

Acknowledgement. The authors extend sincere thanks to CIMMYT and BHU for providing maize inbred lines. First author also sincerely thanks Indian Council of Agricultural Research (ICAR, New Delhi) for supporting the research financially by awarding Senior Research Fellowship (ICAR-SRF).
Conflict of Interest. None.

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How to cite this article: Pavan Devesh, Rajesh Singh, Kartikeya Srivastava, M. Shankar, Pargat Singh and Munnesh Kumar (2023). Estimation of Genetic Parameters for Yield and Kernel Iron and Zinc Concentration in Maize (*Zea mays* L.). *Biological Forum – An International Journal, 15*(2): 708-711.