International Journal of Environment and Climate Change

Volume 13, Issue 12, Page 225-239, 2023; Article no.IJECC.110219
ISSN: 2581-8627
(Past name: British Journal of Environment & Climate Change, Past ISSN: 2231–4784)

Evaluation on Genetic Variation, Correlation and Path Analysis in Zaid Maize (*Zea mays* L.) for Quantitative Characters

Daryl K. Marak [a++*], Shailesh Marker [b#] and Kamlesh Lal [c†]

[a] Department of Genetics and Plant Breeding, Naini Agricultural Institute, (SHUATS), Sam Higginbottom University of Agriculture, Technology and Sciences Prayagraj, Uttar Pradesh, India.
[b] (PBG), SKNCOA, Jobner, Jaipur, India.
[c] Department of Farm Machinery and Power Engineering, Vaugh Institute of Agricultural Engineering, (SHUATS), Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJECC/2023/v13i123678

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/110219

Original Research Article

Received: 10/10/2023
Accepted: 16/12/2023
Published: 18/12/2023

ABSTRACT

The present investigation was carried out to evaluate genetic variability parameters, correlation and path analysis in twenty-one maize genotypes for 21 quantitative traits in *Zaid* 2023 at Field Experimentation Centre, Department of Genetics and Plant Breeding, Naini Agricultural Institute, Sam Higginbottom University of Agriculture Technology and Sciences, Uttar Pradesh in Randomized Block Design replicated thrice. Analysis of Variance for all characters revealed that

++ M.Sc. Scholar;
 # Professor;
† Assistant Professor;
**Corresponding author: E-mail: darylkmarakcau@gmail.com;*

treatment differences were highly significant under study at 1% level. Genotype MZ-1917 depicted highest grain yield in the grown environment. The values of PCV were higher than GCV values for all the characters and large differences PCV between the values of PCV and GCV of characters like number of leaves per plant, leaf length, tassel length, cob length, cob girth and shelling percentage indicating that environmental factors significantly influenced the expression of these traits. All the traits studied had higher heritability, high genetic advance coupled with high heritability was observed for anthesis-silking intervals, ear height, cob weight, number of kernels per row, shank weight, 100 kernels weight, biological yield and grain yield per plant indicating the presence of large proportion of additive genetic action deciding these traits. Correlation and path coefficient analysis suggest that selection based on characters cob length, cob weight, shank weight, 100 kernels weight had positive correlation and direct effects with grain yield per plant. Therefore, it concludes that effective selection must be attempted for these traits, which would help in improvement of grain yield in maize genotypes grown during *Zaid* season of eastern Uttar Pradesh.

Keywords: Association analysis; maize and variability parameters (Zea mays L.).

1. INTRODUCTION

Maize is an important cereal crop in as many as 169 countries across North America, South America, Africa, Asia, Europe. Maize grains are consumed in various forms such as flat bread, porridge, boiled and roasted grains/cobs [1]. Genetic improvement in traits of economic importance along with maintaining sufficient amount of variability in maize germplasm is always the desired objective in maize hybrid breeding programme [2].

In India, maize is principally grown in two seasons *viz*: *Kharif* (July to October) and *Rabi* (October to February) and comparatively less area under *Zaid* season (March to June), which is perhaps due to low production of maize in summer and non-availability of irrigation facilities. *Zaid* maize, also known as summer maize, plays a crucial role in fulfilling the nutritional requirements of many populations, particularly in regions with short growing seasons. The improvement of quantitative characters in *Zaid* maize is of paramount importance to enhance productivity and meet the increasing demand for food and feed. Currently, 1147.7 million MT of maize is being produced together by over 170 countries from an area of 193.7 million ha with an average productivity of 5.75 t/ha [3]. In India, during the 2020-2021 cropping seasons, 9.89 million ha of land was covered with an average productivity of 3.19 q/ha and production of 31.65 million tonnes (Department of Agriculture Cooperation and Farmers Welfare Network, 2020-2021).

Inbred lines are prerequisite in production of commercial hybrid varieties in maize. Therefore, study of genetic variability in inbred lines specific to environmental conditions is essential before planning an efficient hybridization programme aiming to develop high yielding hybrid varieties. Yield is a complex inherited character resulted from the interaction between the vital processes [4] and associated with various contributing characters, therefore, direct selection for yield per se may not be the most efficient method for its improvement, but indirect selection for other yield related characters, which are closely associated with yield and high heritability estimates will be more effective [5].

For developing suitable selection strategies knowledge on presence of genetic variability on available germplasm for yield and its related components and heritable differences among cultivars, within a population is always desirable in plant breeding programme. Also study on association of various attributing characters to yield essential, for accumulating the optimum contribution of such trait to yield. Genetic correlation analysis is a handy technique which elaborates the degree of association among important quantitative traits [6]. Correlation coefficient analysis measures the mutual relationship among various plant characters and determines the point on which selection can be based for improving yield [7]. Path-coefficient analysis is the most valuable tool to establish the exact correlation in terms of cause and effect. The relative importance of direct and indirect effects of measured traits on grain yield will be determined by path analysis. It is simple standardized partial regression coefficient which splits the correlation coefficient into direct and indirect effects of the yield components on yield estimated as suggested by Wright, [8] and elucidated by Dewey and Lu, [9]. For example, if we need to formulate selection indices for genetic improvement of yield, the cause and effect of the trait is very essential and can be done by path analysis Singh *et al*., [10].

An understanding of the nature and magnitude of variability for grain yield and its components among the inbred lines of maize and to ascertain the association among and between each component and yield is necessary for selecting an appropriate breeding procedure for evolving high yielding varieties. Therefore, this investigation was undertaken for the estimation of coefficient of variation, heritability and expected genetic advance for yield and yield attributing traits, the extent of correlation among traits at both phenotypic and genotypic levels, path coefficient analysis for direct and indirect effect of yield contributing traits on grain yield per plant during *Zaid* season which would be helpful for enhancing the maize grain productivity under respective environmental conditions. Hence, in this study coefficient of variation, heritability and expected genetic advance for yield attributing traits, correlation studies among traits at both phenotypic and genotypic levels and path coefficient analysis for direct and indirect effects which provide valuable insights into the relationships among different yield contributing traits on grain yield per plant was carried out for improving the grain productivity under irrigated conditions of Eastern Uttar-Pradesh during the respective season. is discussed in this research paper and has been aimed to obtain an information on genetic variation in maize for grain yield and its components in inbred lines having different genetic background in order to provide promising material for future hybridization programmes and ultimately enhancing the productivity and production.

2. MATERIALS AND METHODS

A set of twenty inbred maize lines and one check variety were sown Randomized Block Design with three replications at Field Experimentation Center of Department of Genetics and Plant Breeding, Naini Agricultural Institute, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj (U.P) during *Zaid* season (2023). Prayagraj is located in south eastern part of Uttar Pradesh state of India. The site of experiment is located at 25.57 ºN latitude, 81.56 ºN longitude and 98 meters above mean sea level. This region has subtropical climate with extreme of summer and winter. The temperature falls down to as low as 1°C-2°C during winter season especially in the month of December and January. The mercury rises up to 46°C-48°C during summer. The average precipitation is around 983 mm annually with maximum concentration during July to October with a few occasional showers in winter also. The recommended agronomical and plant protection practices were adopted for a good crop growth. The soil type of the experimental sites is sandy loam, low in organic carbon, nitrogen, phosphorous and potash. The experimental material was provided by the Directorate of Research, SHUATS, Prayagraj and some were obtained from the district of West Garo hills, Meghalaya 20 quantitative characters were recorded on five randomly selected plants for each inbred line in each replication. The technique of random sampling was adopted for recording the observations of various quantitative characters of maize. Five plants of each treatment from each replication were selected at random at the time of recording the data on various characters. Data of five plants were averaged replication wise and mean data was used for statistical analysis for analysis of variance (ANOVA), correlation and path analysis with the help of variability package available in R-studio software.

3. RESULTS AND DISCUSSION

The present investigation entitled “Evaluation on genetic variation, correlation and path analysis in zaid Maize (*Zea mays* L.) for quantitative characters” was carried to estimate the genetic variability, heritability, genetic advance, correlation between yield and yield contributing traits and direct and indirect effects of yield component on yield through path analysis. The results of the present experiment are presented and discussed under the following headings:

3.1 Analysis of Variance

Analysis of variance for all quantitative characters revealed that treatment differences were highly significant under study at 1% level of significance indicating the presence of significant variation among genotypes indicated the presence of genotypic differences suggesting the importance of their genetic value in order to identify the best genetic makeup, thereby providing better scope for selection for maize yield improvement.

This broad spectrum of variability for all characters provides greater opportunity for the isolation of best genotypes to be utilized in maize breeding programme.

This also showed that there was sufficient space for selection of promising lines suitable for different environments amongst the experimental material aimed to enhance the genetic yield potential of maize in *Zaid* season.

Similar finding on the presence of significant variability for various characters in maize was also reported by many researchers in their study *viz*., Azam et al. [11] Kumar et al. [12] Gurpinder et al. [13] Kharel et al. [14] Sravanti et al. [15] Jakhar et al. [16] Sharma et al. [17] Kandel et al. [18] and Verma et al. [19].

Chart 1. List of experimental material used in the investigation

S. No	Genotypes	Characters	Source
1	MZ-1912	Yield potential (42.1q/ha), Cob weight (97.4 g), matures in 90-94 days	Directorate of Research,SHUATS,Prayagraj
2	MZ-1913	Yield potential (38.7q/ha), Cob weight (66.6 g), matures in 90-95 days	Directorate of Research,SHUATS,Prayagraj
3	MZ-1914	Yield potential (40.5q/ha g), Cob weight (94.6 g), matures in 90-93 days	Directorate of Research,SHUATS,Prayagraj
4	MZ-1917	Yield potential (42.9q/ha), Cob weight (86.5 g), matures in 90-93 days	Directorate of Research,SHUATS,prayagraj
5	M-410	Yield potential (37.1q/ha), Cob weight (95.2 g), matures in 90-92 days	Directorate of Research,SHUATS,Prayagraj
6	M-618	Yield potential (37.1q/ha), Cob weight (91.1), matures in 85-90 days	Directorate of Research,SHUATS,Prayagraj
7	M-710	Yield potential (32.7q/ha), Cob weight (109.5), matures in 90-95 days	Directorate of Research,SHUATS,Prayagraj
8	M-608	Yield potential (31.4q/ha), Cob weight (111.7 g), matures in 90-92 days	Directorate of Research,SHUATS,Prayagraj
9	M-502	Yield potential (33.45q/ha), Cob weight (105.9 g), matures in 90-93 days	Directorate of Research,SHUATS,Prayagraj
10	MK-10	Yield potential (35.2q/ha), Cob weight (98.4 g), matures in 90-92 days	Directorate of Research,SHUATS,prayagraj
11	M-100	Yield potential (26.8q/ha), Cob weight (73.9 g), matures in 90-96 days	Directorate of Research,SHUATS,Prayagraj
12	Minil Meraku-1	Yield potential (31.4q/ha), Cob weight (51.3 g), matures in 90-93 days, sticky kernels	West Garo hills, Meghalaya
13	Minil Meraku-2	Yield potential (34.8q/ha), Cob weight (95.7 g), matures in 90-96 days, sticky kernels	West Garo hills, Meghalaya
14	Minil Meraku-3	Yield potential (32.8q/ha), Cob weight (52 g), matures in 90-91 days, sticky kernels	West Garo hills, Meghalaya
15	Minil Meraku-4	Yield potential (21.5q/ha), Cob weight (81.9 g), matures in 90-91 days. sticky kernels	West Garo hills, Meghalaya
16	Jagiting Sarang	Yield potential (26.1q/ha), Cob	West Garo hills, Meghalaya

S. No	Genotypes	Characters	Source
		weight (92.5), matures in 90-93 days, dark red cob colour	
17	Jagiting Kongbron	Yield potential (21.1q/ha), Cob weight (57.2 g), matures in 90-96 days, red cob colour	West Garo hills, Meghalaya
18	Bolma	Yield potential (15.2q/ha), Cob weight (49.2 g), matures in 90-95 days, red cob colour	West Garo hills, Meghalaya
19	Bolma Kongbron	Yield potential (18.4q/ha), Cob weight (84.1 g), matures in 90-94 days, red cob colour	West Garo hills, Meghalaya
20	Egitchi	Yield potential (15.5q/ha), Cob weight (71.3 g), matures in 90-91 days, red cob colour	West Garo hills, Meghalaya
21	SHIATS Makka-3	Yield potential (46.5q/ha), Cob weight (118.6 g), matures in 90-96 days, stay green habit and two cobs/plant	Directorate of Research, SHUATS, Prayagraj

3.2 Mean Performance of Genotypes

The mean values, coefficient of variation (C.V.), Standard error of the mean (SE), critical difference (C.D.) at 5% and 1% and the range of 21 genotypes for 20 quantitative characters are presented in (Table 2) which revealed a wide range of variation for all traits studied. The broad spectrum of variability allows for the isolation of the best performing genotypes to be incorporated into maize breeding programme for a greater chance of success.

Among the genotypes, the mean values of yield and yield contributing characters revealed that MZ-1917 (85.8), MZ-1912 (84.2), MZ-1914 (81.3), MZ-1913 (77.4), M-410 (74.3) were observed as the best performing genotypes for yield and yield related traits

3.3 Estimation of Variability Parameters

Variability plays an important role in crop breeding. Genetic variability is the pre requisite for any crop improvement program. Genetic variability, which is a heritable difference among gene pool, is required at an appreciable level within a population to facilitate and sustain an effective long term plant breeding program. Progress from selection has been reported to be directly related to the magnitude of genetic variance in the population. Improvement in any trait depends solely on the amount of variability present in the base material for that trait. Therefore, variability is a key for crop improvement.

The variability estimates such as phenotypic variance, genotypic variance, phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability in broad sense (h^2), genetic advance (GA), genetic advance as a percent of mean (GAM) for twenty characters are explained under the following headings. (Table 3). Higher differences were observed between phenotypic and genotypic variance for traits viz., leaf length, tassel length, plant height, ear height, cob length, cob weight, number of kernels per cob, number of kernels per row, shelling percentage, biological yield and grain yield per plant indicating that the characters studied were greatly influenced by the environment in *Zaid* season. The estimates of phenotypic coefficient of variation (29.67) and genotypic coefficient of variation (28.39) were found to be high for grain yield per plant. This finding was similar to the results reported by Bhusal et al. [20] and Sharma et al. [17]. The results of GCV and PCV are in the agreement with the findings of Bello et al. [21] Rajesh et al. [22] Kumar et al. [12] Patil *et al*. [23] Rahman et al [7] and Khan et al. [24].

Heritability for characters studied was observed to be high for 100-kernels weight, shank weight, number of kernel rows per cob, grain yield per plant, anthesis-silking intervals, cob weight, days to first tassel emergence (50%), number of kernels per row, days to first silking (50%), days to maturity, ear height, biological yield, leaf width and medium for cob length, number of leaves per plant, shelling percentage, leaf length, cob girth, tassel length and plant height. In this study estimates of broad sense heritability are proportioned of total genetic variance involving both additive and non-additive types to the total phenotypic variance.

In this study all the traits had higher genetic advance at 5% level of selection intensity and genetic advance as percent of mean. This may be due to higher magnitude of heritability for all the characters which indicates more response of GA and GAM for all the characters. High GAM was observed for grain yield per plant followed by cob weight, number of kernels per row, shank weight, anthesis-silking intervals, 100-kernels weight, ear height, biological yield. This indicates the genotypic variation present in the genetic material studied is probably due to additive genetic variance, which can be effectively exploited in crop improvement programme by proper selection. The results of heritability, genetic advance is in agreement with the findings of Nagabhusan et al. [25] Badawy et al. [26] Rajesh et al. [22] Bekele and Rao [27] Beulah et al. [28] Bartaula et al. [29] and Supraja et al. [30].

3.4 Correlation Coefficient Analysis

The phenotypic and genotypic correlation coefficients among yield and yield components in maize are presented in Table 4 and 5. It is observed that genotypic correlation coefficients are higher than phenotypic correlation coefficients and in the same direction indicating the effect of environment on the association of characters. Grain yield per plant showed phenotypically and genotypically significant positive correlation with anthesis-silking intervals, Leaf length, tassel length, leaf width, cob girth, cob weight, cob length, number of kernel rows per cob, number of kernels per row, shank weight and 100 kernels weight. Therefore, characters under study. Therefore, the respective characters mentioned has contribution in increasing yield in maize. Kumar et al. (2014), Kumar et al. [12] Vijay et al. [31] Gurpinder et a*l*. [13] and Varalaksmi et al. [32].

3.5 Path Coefficient Analysis

It is simple standardized partial regression coefficient which splits the correlation coefficient into direct and indirect effects of the yield components on yield estimated as suggested by Wright, [8] and elucidated by Dewey and Lu, [9]. Hence, path coefficient analysis was carried out in irrigated environment of *Zaid* season, to determine the interrelationship of different components and their direct and indirect effects on grain yield at both phenotypic and genotypic level, as depicted in Table 6 and 7 respectively.

Table 1. Analysis of variance for quantitative characters of Maize

Sr.No.	Characters	Mean Sum of Squares		
		Replications (df =2)	Treatments (df =20)	Error (df =40)
1	Days to first tassel emergence (50%)	2.20*	13.35**	0.63
2	Days to first silk emergence (50%)	1.96	13.04**	0.70
3	Anthesis-silking intervals	0.02	0.68**	0.02
4	Number of leaves per plant	0.39	3.31**	0.76
5	Leaf length	25.86	128.27**	37.02
6	Tassel length	10.34	9.51**	3.58
7	Leaf width	0.25	0.45**	0.06
8	Plant height	838.31**	199.73**	77.46
9	Ear height	59.83	416.15**	40.61
10	Days to maturity	2.39	10.01**	0.66
11	Cob length	1.49	8.14**	1.76
12	Cob girth	1.67	3.28**	0.99
13	Cob weight	46.91	1283.15**	51.35
14	Number of kernel rows per cob	0.28**	0.91 **	0.02
15	Number of kernels per row	26.08*	107.13**	5.48
16	Shank weight	0.95	56.90**	1.32
17	100 kernels weight	0.18	31.46 **	4.01
18	Shelling percentage	24.72	98.32**	24.89
19	Biological yield	782.0	3938.70**	533.0
20	Grain yield per plant	70.62	990.63**	29.41

*** and * significant at 1 % and 5 % level of significance respectively*

Table 2. Mean values of maize genotypes for different quantitative characters

Sr. No.	Genotypes	Days to first tassel emergence (50%)	Days to first silk emergence (50%)	Anthesis-Silking Intervals	Number of leaves per plant	Leaf length (cm)	Tassel length (cm)	Leaf width (cm)	Plant height (cm)	Ear height (cm)	Days to maturity	Cob length (cm)	Cob girth (cm)	Cob weight (cm)	Number of kernel rows per cob	Number of kernels per row	Shank weight (g)	100 kernels weight (g)	Shelling percentage (%)	Biological yield (g)	Grain yield per plant (g)
1	MZ-1912	63.67	66.33	2.67	12.67	86.13	37.93	8.73	197.40	71.97	94.33	17.03	13.07	97.43	12.80	34.57	27.33	20.53	71.77	308.87	84.20
2	MZ-1913	64.67	67.67	3.00	14.33	102.67	37.07	8.70	184.70	75.20	94.67	15.70	12.23	66.60	10.40	29.30	23.80	18.07	64.00	276.73	77.40
3	MZ-1914	70.00	72.00	2.00	13.33	94.50	38.93	8.30	192.17	74.87	93.33	15.53	13.07	94.60	11.73	28.43	28.20	21.40	68.93	285.80	81.33
4	MZ-1917	69.67	72.67	3.00	13.33	88.57	37.67	8.10	187.10	78.87	92.67	15.80	11.90	86.47	11.60	29.50	20.00	19.73	77.03	220.87	85.77
5	M-410	67.33	69.67	2.33	12.67	89.03	38.30	7.70	186.27	81.53	91.67	16.47	12.33	95.17	11.43	34.40	24.00	22.13	74.63	212.53	74.27
6	M-618	68.67	71.67	3.00	12.33	88.03	38.57	8.07	185.57	76.80	89.67	16.47	12.80	91.07	11.33	33.27	28.80	18.80	69.03	293.47	74.33
7	M-710	69.00	71.00	2.00	11.33	85.20	38.50	8.30	186.17	77.53	95.33	15.13	13.97	109.53	11.33	26.13	28.07	22.87	74.13	279.00	65.53
8	M-608	68.00	71.33	3.33	12.67	87.43	37.10	8.37	185.80	78.47	91.67	15.90	12.43	111.67	11.33	29.47	26.40	20.47	76.33	260.47	62.93
9	M-502	69.67	72.00	2.33	12.00	85.30	37.83	8.20	186.10	78.47	93.00	15.87	13.23	105.87	11.33	28.87	25.40	20.67	76.33	278.73	66.93
10	MK-10	69.67	72.33	2.67	12.33	85.90	37.33	8.50	186.80	80.20	91.67	16.20	12.87	98.37	11.20	28.50	21.07	20.33	78.73	281.13	70.43
11	M-100	70.67	73.33	2.67	12.33	85.37	36.40	8.33	193.83	74.03	95.67	15.73	11.70	73.90	11.07	29.33	21.67	17.73	72.40	247.60	53.57
12	Minil meraku-1	68.00	70.67	2.67	12.67	82.27	36.83	7.80	184.87	92.17	93.33	11.50	10.27	51.30	11.07	20.83	21.07	14.10	58.00	276.53	62.83
13	Minil meraku-2	68.00	70.67	2.67	11.33	89.47	39.30	7.97	197.03	87.00	96.00	16.77	12.57	95.67	11.07	27.07	22.07	20.93	77.00	265.80	69.70
14	Minil meraku-3	67.00	69.00	2.00	13.00	81.23	33.10	8.00	206.33	99.17	91.33	12.93	9.90	52.00	10.80	13.53	14.93	11.80	70.70	369.80	65.60
15	Minil meraku-4	66.67	69.67	3.00	12.33	89.60	39.20	8.60	194.20	106.77	91.00	12.80	11.80	81.93	10.80	26.73	19.13	15.40	76.70	207.27	43.13
16	Jagiting-sarang	68.00	70.33	2.33	11.33	81.83	35.23	7.77	184.90	74.53	93.00	15.47	12.27	92.47	10.80	18.47	18.20	18.13	80.20	223.07	52.07
17	Jagiting-	64.67	67.33	2.67	15.00	88.43	37.70	8.00	185.30	101.43	95.67	12.93	12.13	57.20	10.80	17.47	14.87	14.07	73.97	269.53	42.13

Sr. No.	Genotypes	Days to first tassel emergence (50%)	Days to first silk emergence (50%)	Anthesis-Silking Intervals	Number of leaves per plant	Leaf length (cm)	Tassel length (cm)	Leaf width (cm)	Plant height (cm)	Ear height (cm)	Days to maturity	Cob length (cm)	Cob girth (cm)	Cob weight (cm)	Number of kernel rows per cob	Number of kernels per row	Shank weight (g)	100 kernels weight (g)	Shelling percentage (%)	Biological yield (g)	Grain yield per plant (g)
	kongbron																				
18	Bolma	63.33	66.33	3.00	12.33	85.83	36.10	8.27	187.33	100.23	95.00	13.23	10.40	49.20	10.67	21.07	18.13	15.13	63.00	292.07	30.37
19	Bolma-kongbron	66.00	68.00	2.00	11.67	75.80	34.47	7.70	198.50	103.30	94.00	13.00	11.93	84.13	10.67	31.13	18.27	16.73	78.13	265.07	36.93
20	Egitchi	66.67	69.67	3.00	12.33	78.47	34.53	7.90	198.67	66.80	93.33	13.10	11.23	71.27	10.53	26.20	17.93	17.27	74.43	263.87	31.07
21	SHIATS Makka-3	66.00	68.00	2.00	15.00	102.50	40.13	9.23	214.93	79.60	96.00	16.13	13.40	118.60	12.00	36.80	26.13	24.44	77.83	294.47	93.10
Mean		67.40	69.98	2.59	12.68	87.31	37.25	8.22	191.62	83.76	93.44	14.94	12.17	84.97	11.14	27.19	22.17	18.60	73.01	270.13	63.03
Range Min.		63.33	66.33	2.00	11.33	75.80	33.10	7.70	184.70	66.80	89.67	11.50	9.90	49.20	10.40	13.53	14.87	11.80	58.00	207.27	30.37
Range Max.		70.67	73.33	3.33	15.00	111.70	40.13	9.23	214.93	106.77	96.00	17.03	13.97	118.60	12.80	36.80	28.80	24.44	80.20	369.80	93.10
C.D. at 5%		1.32	1.38	0.25	1.44	10.04	3.13	0.44	14.52	10.52	1.34	2.19	1.65	11.83	0.26	3.86	1.90	3.30	8.23	38.10	8.95
C.V.		1.19	1.20	6.14	6.89	6.97	5.09	3.21	4.59	7.61	0.87	8.89	8.20	8.43	1.42	8.61	5.21	10.77	6.83	8.55	8.60
S.E.		0.46	0.48	0.09	0.50	3.51	1.09	0.15	5.08	3.68	0.47	0.77	0.58	4.14	0.09	1.35	0.67	1.15	2.88	13.33	3.13

Table. 3. Genetic variability parameters for quantitative characters of maize

Genetic characters		Days to 50% Tasselling	Days to 50% Silking	Anthesis-Silking Intervals	Number of leaves per plant	Leaf length	Tassel length	Leaf width	Plant height	Ear height	Days to maturity	Cob length	Cob girth	Cob weight	Number of kernel rows per cob	Number of kernels per row	Shank weight	100 kernels weight	Shelling percentage	Biological yield	Grain yield per plant
Genotypic variance		4.23	4.11	0.21	0.85	30.4	1.97	0.12	40.75	125.1	3.11	2.12	0.76	410.5	0.29	33.88	18.52	9.14	24.47	1135.2	320.4
Phenotypic variance		4.87	4.81	0.24	1.61	67.4	5.56	0.19	118.2	165.7	3.77	3.89	1.75	461.9	0.32	39.36	19.84	13.16	49.37	1668.2	349.8
Environmental variance		0.63	1.19	0.02	0.76	37.0	3.58	0.06	77.45	40.6	0.66	1.76	0.99	51.35	0.02	5.48	4,01	10.77	24.89	533.0	29.41
Coefficient of variation (%)	GCV	3.05	2.89	19.05	7.27	6.31	3.77	4.34	3.33	13.32	1.88	9.76	7.18	23.84	4.87	21.40	19.41	16.25	6.77	12.47	28.39
	PCV	3.27	3.13	20.02	10.01	9.4	6.33	5.40	5.67	15.43	2.08	13.20	10.89	25.29	5.07	23.07	20.1	19.50	9.62	15.12	29.67
	ECV	1.18	1.19	6.14	6.88	6.96	5.08	3.21	4.59	7.60	0.87	8.88	8.19	8.43	1.42	8.61	10.77	3.40	6.83	8.54	8.60
Heritability		86.8	85.4	90.57	52.7	45.1	35.5	64.71	34.48	75.51	82.44	54.71	43.43	88.8	92.18	86.07	69.48	96.38	49.57	68.05	91.59
Genetic advance		3.95	3.86	0.91	1.37	7.62	1.72	0.59	7.72	20.02	3.30	2.22	1.18	39.35	1.07	11.12	5.19	6.74	7.17	57.25	35.28
Genetic advance as percent mean		5.86	5.51	37.36	10.87	8.73	4.63	7.20	4.03	23.91	3.53	14.88	9.75	46.31	9.64	40.90	27.91	35.56	9.82	21.19	55.98

Table 4. Phenotypic correlation coefficient among yield and yield components of maize

Traits	DT 50	DS 50	ASI	NLPP	LL	TL	LW	PH	EH	DM	CL	CG	CW	NKRC	NKPR	SW	KW	SP	BY	GYPP
DT 50	**1**																			
DS 50	0.96**	1																		
ASI	0.27*	0.31*	1																	
NLPP	-0.29*	-0.29*	0.01	1																
LL	-0.10	-0.07	0.22	0.44**	1															
TL	0.09	0.08	0.26*	0.06	0.49**	1														
LW	-0.17	-0.18	0.17	0.43**	0.46**	0.26*	1													
PH	-0.13	-0.21	-0.34**	0.21	0.11	0.04	0.22	1												
EH	-0.33**	-0.34**	-0.51**	0.13	-0.13	-0.11	-0.18	0.07	1											
DM	-0.28*	-0.31*	-0.25	0.14	0.15	0.09	0.21	0.10	-0.03	1										
CL	0.20	0.21	0.52**	0.15	0.29*	0.12	0.33**	-0.01	-0.44**	-0.03	1									
CG	0.18	0.16	0.38**	0.23	0.26*	0.28*	0.35**	0.05	-0.28*	0.05	0.70**	1								
CW	0.33**	0.30*	0.43**	-0.05	0.19	0.37**	0.32*	0.10	-0.40**	-0.06	0.65**	0.74**	1							
NKRC	-0.01	0.01	0.76**	0.04	0.24	0.27*	0.22	-0.22	-0.41**	-0.08	0.43**	0.29*	0.21	1						
NKPR	0.07	0.09	0.48**	0.15	0.31*	0.35**	0.39**	0.14	-0.35**	-0.01	0.64**	0.61**	0.65**	0.34**	1					
SW	0.26*	0.24	0.70**	-0.01	0.34**	0.46**	0.40**	-0.09	-0.53**	-0.04	0.55**	0.56**	0.66**	0.56**	0.65**	1				
KW	0.29*	0.25*	0.51**	-0.06	0.27*	0.37**	0.28*	0.02	-0.46**	0.13	0.66**	0.61**	0.77**	0.28*	0.65**	0.66**	1			
SP	0.25*	0.23	-0.02	-0.12	-0.09	0.02	0.00	0.21	-0.08	-0.12	0.29*	0.37**	0.52**	-0.17	0.19	-0.05	0.32**	1		
BY	-0.21	-0.27*	-0.06	0.17	0.07	-0.19	0.19	0.37**	0.07	0.01	-0.05	-0.08	-0.16	0.10	-0.22	0.07	-0.21	-0.24	1	
GYPP	0.25	0.22	0.58**	0.35**	0.46**	0.38**	0.40**	0.10	-0.37**	-0.07	0.64**	0.48**	0.53**	0.55**	0.52**	0.62**	0.55**	0.02	0.15	1

*KEY- *=Significant at 0.05 probability level; **=Significant at 0.01 probability level;DT50 (Days to first tassel emergence [50%]);DS 50 (Days to first silk emergence [50%]); ASI (Anthesis-silking intervals); NLPP (Number of leaves per plant); LL (Leaf length); TL (Tassel length); LW (Leaf width); PH (Plant height); EH (Ear height); DM (Days to maturity); CL (Cob length); CG (Cob girth); CW (Cob weight); NKRC (Number of kernel rows per cob); NKPR (Number of kernels per row); SW (Shank weight); KW (100-kernels weight); SP (Shelling percentage); BY (Biological yield); GYPP (Grain yield per plant).*

Table 5. Genotypic correlation coefficient among yield and yield components of maize

Traits	DT 50	DS 50	ASI	NLPP	LL	TL	LW	PH	EH	DM	CL	CG	CW	NKRC	NKPR	SW	KW	SP	BY	GYPP
DT 50	**1**																			
DS 50	0.99**	1																		
ASI	0.31	0.34	1																	
NLPP	-0.39	-0.39	0.06	1																
LL	-0.13	-0.14	0.41	0.89**	1															
TL	0.20	0.23	0.48*	0.43	0.92**	1														
LW	-0.21	-0.18	0.23	0.50*	0.93**	0.75	1													
PH	-0.29	-0.39	-0.55*	0.23	0.09	-0.21	0.52	1												
EH	-0.40	-0.43	-0.60**	-0.01	-0.28	-0.21	-0.22	0.13	1											
DM	-0.29	-0.35	-0.31	0.25	0.30	0.18	0.25	0.38	-0.03	1										
CL	0.36	0.37	0.75**	-0.23	0.60**	0.94	0.36	-0.11	-0.86	0.04	1									
CG	0.33	0.26	0.70**	-0.27	0.57**	1.18	0.47	-0.22	-0.69	0.23	0.74	1								
CW	0.40	0.36	0.49*	-0.27	0.33	0.76**	0.39	0.12	-0.55	-0.05	0.79	0.99	1							

Traits	DT 50	DS 50	ASI	NLPP	LL	TL	LW	PH	EH	DM	CL	CG	CW	NKRC	NKPR	SW	KW	SP	BY	GYPP
NKRC	0.02	0.05	0.82**	0.05	0.30	0.32	0.25	-0.42	-0.49	-0.07	0.65	0.46	0.24	1						
NKPR	0.12	0.12	0.56**	0.01	0.49*	0.77**	0.47	0.19	-0.52	-0.01	0.67	0.65	0.69	0.42	1					
SW	0.29	0.29	0.75**	-0.06	0.55*	0.83**	0.45	-0.11	-0.63	-0.05	0.78	0.88	0.72	0.59	0.74	1				
KW	0.33	0.30	0.60**	-0.02	0.61**	0.95**	0.47	0.10	-0.75	0.18	0.92	1.08	0.98	0.37	0.82	0.85	1			
SP	0.28	0.23	-0.06	-0.28	-0.16	0.19	0.05	0.27	-0.13	-0.02	0.44	0.60	0.74	-0.25	0.28	-0.08	0.49	1		
BY	-0.24	-0.31	-0.05	0.21	-0.09	-0.34	0.23	0.45	0.05	0.12	-0.13	-0.22	-0.23	0.06	-0.24	0.07	-0.20	-0.48	1	
GYPP	0.29	0.25	0.63**	0.31	0.74**	0.72**	0.48	0.16	-0.53	-0.06	0.74	0.55	0.52	0.61	0.50	0.67	0.67	0.02	0.20	1

*KEY- *=Significant at 0.05 probability level; **=Significant at 0.01 probability level;DT50 (Days to first tassel emergence [50%]);DS 50 (Days to first silk emergence [50%]); ASI (Anthesis-silking intervals); NLPP (Number of leaves per plant); LL (Leaf length); TL (Tassel length); LW (Leaf width); PH (Plant height); EH (Ear height); DM (Days to maturity); CL (Cob length); CG (Cob girth); CW (Cob weight); NKRC (Number of kernel rows per cob); NKPR (Number of kernels per row); SW (Shank weight); KW (100-kernels weight); SP (Shelling percentage); BY (Biological yield); GYPP (Grain yield per plant).*

Table 6. Direct and indirect effects of component traits attributing to grain yield of maize at phenotypic level

Characters	DT 50	DS 50	ASI	NLPP	LL	TL	LW	PH	EH	DM	CL	CG	CW	NKRC	NKPR	SW	KW	SP	BY
DT 50	0.549	-0.332	-0.016	-0.114	-0.011	0.012	0.006	-0.005	0.003	0.0001	0.059	-0.054	0.153	-0.001	0.006	-0.021	0.076	-0.026	-0.037
DS 50	0.529	-0.345	-0.018	-0.111	-0.007	0.011	0.006	-0.008	0.003	0.0001	0.062	-0.048	0.140	0.001	0.008	-0.020	0.088	-0.024	-0.047
ASI	0.148	-0.105	-0.059	0.003	0.022	0.035	-0.006	-0.013	0.004	0.00009	0.152	-0.117	0.201	0.070	0.042	-0.057	0.264	0.002	-0.011
NLPP	-0.162	0.099	0.000	0.388	0.045	0.008	-0.014	0.008	-0.001	-0.00005	0.043	-0.071	-0.021	0.004	0.013	0.001	-0.031	0.013	0.029
LL	-0.057	0.023	-0.013	0.170	0.102	0.066	-0.015	0.004	0.001	-0.00005	0.085	-0.081	0.090	0.022	0.026	-0.027	0.048	0.009	0.012
TL	0.049	-0.029	-0.015	0.023	0.050	0.134	-0.009	0.001	0.001	-0.00003	0.036	-0.084	0.174	0.025	0.030	-0.037	0.071	-0.002	-0.034
LW	-0.095	0.062	-0.010	0.168	0.047	0.035	-0.033	0.008	0.001	-0.00008	0.097	-0.106	0.149	0.021	0.033	-0.032	0.017	0.000	0.034
PH	-0.072	0.072	0.020	0.081	0.011	0.005	-0.007	0.038	-0.001	-0.00004	-0.002	-0.016	0.048	-0.020	0.012	0.007	-0.117	-0.022	0.066
EH	-0.183	0.118	0.030	0.052	-0.013	-0.015	0.006	0.003	-0.008	0.00001	-0.129	0.084	-0.189	-0.038	-0.030	0.043	-0.126	0.008	0.012
DM	-0.151	0.108	0.014	0.053	0.015	0.012	-0.007	0.004	0.000	-0.00036	-0.008	-0.015	-0.026	-0.008	-0.001	0.004	-0.079	0.012	0.002
CL	0.110	-0.073	-0.031	0.057	0.030	0.017	-0.011	0.000	0.003	0.00001	0.293	-0.215	0.309	0.040	0.055	-0.044	0.134	-0.029	-0.008
CG	0.097	-0.055	-0.022	0.090	0.027	0.037	-0.011	0.002	0.002	-0.00002	0.207	-0.305	0.350	0.027	0.052	-0.045	0.073	-0.038	-0.013
CW	0.179	-0.102	-0.025	-0.017	0.020	0.049	-0.010	0.004	0.003	0.00002	0.192	-0.226	0.471	0.020	0.056	-0.053	0.056	-0.053	-0.028
NKRC	-0.008	-0.002	-0.045	0.017	0.024	0.036	-0.007	-0.008	0.003	0.00003	0.126	-0.089	0.099	0.093	0.030	-0.045	0.294	0.017	0.018
NKPR	0.041	-0.032	-0.028	0.058	0.031	0.047	-0.013	0.005	0.003	0.00001	0.187	-0.185	0.307	0.032	0.086	-0.052	0.087	-0.019	-0.038
SW	0.145	-0.084	-0.041	-0.005	0.035	0.062	-0.013	-0.003	0.004	0.00002	0.162	-0.169	0.312	0.052	0.056	-0.080	0.174	0.005	0.012
KW	0.127	-0.092	-0.047	-0.036	0.015	0.029	-0.002	-0.013	0.003	0.00009	0.119	-0.067	0.080	0.083	0.023	-0.042	0.330	0.021	-0.001
SP	0.138	-0.080	0.001	-0.048	-0.009	0.003	0.000	0.008	0.001	0.00004	0.085	-0.113	0.244	-0.016	0.016	0.004	-0.067	-0.102	-0.042
BY	-0.116	0.092	0.004	0.064	0.007	-0.025	-0.006	0.014	-0.001	0.00000	-0.013	0.023	-0.075	0.009	-0.019	-0.005	-0.002	0.024	0.176
GYPP	0.702	0.649	0.584	0.275	0.465	0.385	0.415	0.103	-0.416	-0.072	0.575	0.365	0.505	0.279	0.466	0.633	0.584	0.023	0.151

KEY- DT50 (Days to first tassel emergence [50%]);DS 50 (Days to first silk emergence [50%]); ASI (Anthesis-silking intervals); NLPP (Number of leaves per plant); LL (Leaf length); TL (Tassel length); LW (Leaf width); PH (Plant height); EH (Ear height); DM (Days to maturity); CL (Cob length); CG (Cob girth); CW (Cob weight); NKRC (Number of kernel rows per cob); NKPR (Number of kernels per row); SW (Shank weight); KW (100-kernels weight); SP (Shelling percentage); BY (Biological yield); GYPP (Grain yield per plant).

Table 7. Direct and indirect effects of component traits attributing to grain yield of maize at genotypic level

Characters	DT 50	DS 50	ASI	NLPP	LL	TL	LW	PH	EH	DM	CL	CG	CW	NKRC	NKPR	SW	KW	SP	BY
DT 50	-4.783	4.918	0.271	-0.573	0.062	-0.078	0.168	-0.234	-0.461	-0.349	0.192	-0.710	1.125	0.000	-0.176	0.654	0.113	0.059	0.095
DS 50	-4.733	4.970	0.296	-0.571	0.067	-0.088	0.147	-0.315	-0.492	-0.418	0.193	-0.563	0.994	0.001	-0.186	0.644	0.132	0.048	0.121
ASI	-1.479	1.679	0.877	0.095	-0.192	-0.186	-0.180	-0.435	-0.694	-0.366	0.398	-1.498	1.358	0.010	-0.834	1.680	0.393	-0.014	0.018
NLPP	1.859	-1.926	0.057	1.473	-0.414	-0.168	-0.398	0.183	-0.016	0.301	-0.122	0.568	-0.757	0.001	-0.012	-0.128	-0.043	-0.060	-0.083
LL	0.637	-0.713	0.362	1.313	-0.464	-0.359	-0.744	0.068	-0.319	0.358	0.315	-1.222	0.919	0.004	-0.731	1.221	0.099	-0.034	0.034
TL	-0.960	1.122	0.418	0.635	-0.427	-0.390	-0.604	-0.167	-0.236	0.220	0.495	-2.534	2.121	0.004	-1.152	1.862	0.136	0.040	0.133
LW	1.004	-0.913	0.197	0.732	-0.431	-0.295	-0.801	0.411	-0.248	0.301	0.192	-1.007	1.075	0.003	-0.697	0.995	0.038	0.010	-0.091
PH	1.405	-1.962	-0.478	0.338	-0.040	0.082	-0.413	0.797	0.153	0.451	-0.056	0.478	0.332	-0.005	-0.279	-0.255	-0.276	0.057	-0.175
EH	1.921	-2.130	-0.530	-0.021	0.129	0.080	0.173	0.106	1.148	-0.032	-0.453	1.477	-1.523	-0.006	0.779	-1.404	-0.199	-0.028	-0.020
DM	1.397	-1.739	-0.269	0.372	-0.139	-0.072	-0.202	0.301	-0.030	1.193	0.022	-0.499	-0.137	-0.001	0.020	-0.107	-0.121	-0.004	-0.046
CL	-1.744	1.819	0.662	-0.340	-0.277	-0.366	-0.292	-0.084	-0.986	0.049	0.528	-1.594	2.209	0.008	-0.997	1.732	0.272	0.092	0.050
CG	-1.586	1.307	0.614	-0.391	-0.265	-0.462	-0.377	-0.178	-0.792	0.278	0.393	-2.140	2.765	0.006	-0.977	1.974	0.164	0.127	0.087
CW	-1.932	1.773	0.427	-0.400	-0.153	-0.297	-0.309	0.095	-0.628	-0.059	0.418	-2.124	2.786	0.003	-1.025	1.609	0.086	0.156	0.090
NKRC	-0.076	0.254	0.721	0.073	-0.138	-0.125	-0.201	-0.338	-0.561	-0.088	0.340	-0.991	0.671	0.012	-0.621	1.306	0.440	-0.051	-0.022
NKPR	-0.564	0.618	0.489	0.012	-0.227	-0.301	-0.373	0.149	-0.598	-0.016	0.352	-1.397	1.910	0.005	-1.495	1.649	0.137	0.058	0.092
SW	-1.401	1.433	0.660	-0.085	-0.254	-0.326	-0.357	-0.091	-0.722	-0.057	0.409	-1.893	2.008	0.007	-1.104	2.232	0.256	-0.017	-0.026
KW	-1.180	1.433	0.754	-0.140	-0.101	-0.116	-0.067	-0.482	-0.501	-0.316	0.314	-0.770	0.523	0.011	-0.448	1.254	0.457	-0.057	-0.001
SP	-1.335	1.134	-0.057	-0.417	0.074	-0.075	-0.039	0.218	-0.151	-0.025	0.232	-1.289	2.069	-0.003	-0.413	-0.177	-0.124	0.210	0.188
BY	1.159	-1.546	-0.040	0.312	0.041	0.134	-0.188	0.357	0.060	0.141	-0.068	0.476	-0.645	0.001	0.353	0.148	0.001	-0.101	-0.390
GYPP	0.797	0.748	0.701	0.368	0.745	0.717	0.753	0.156	-0.506	-0.061	0.778	0.638	0.533	0.460	0.526	0.669	0.699	0.020	0.203

KEY- DT50 (Days to first tassel emergence [50%]);DS 50 (Days to first silk emergence [50%]); ASI (Anthesis-silking intervals); NLPP (Number of leaves per plant); LL (Leaf length); TL (Tassel length); LW (Leaf width); PH (Plant height); EH (Ear height); DM (Days to maturity); CL (Cob length); CG (Cob girth); CW (Cob weight); NKRC (Number of kernel rows per cob); NKPR (Number of kernels per row); SW (Shank weight); KW (100-kernels weight); SP (Shelling percentage); BY (Biological yield); GYPP (Grain yield per plant).

The path coefficient analysis revealed that highest positive direct effect on grain yield per plant at genotypic level was exhibited by days to first silk emergence (50%), cob weight, shank weight, number of leaves per plant, days to maturity, ear height, anthesis-silking intervals, plant height, cob length, 100-kernels weight, shelling percentage, number of kernel rows per cob but are weakened due to their negative indirect effects on grain yield. While biological yield, tassel length, leaf length, leaf width, number of kernels per row, cob girth and days to first tassel emergence (50%) exhibited negative direct effects on grain yield indicating the requirement for improvement of these traits before selection of these traits can commence for higher grain yield. Kumar et al. [12] Vijay et al. [31] Kumar et al. (2016), Patil et al. [23] Takhar et al. (2017) and Varalaksmi et al. [32-34].

4. CONCLUSION

It is concluded that based on the mean performance for grain yield and characters taken into account for *Zaid* season, the genotype MZ-1917 followed by MZ-1912, MZ-1914, MZ-1913, M-410 were found best as they showed highest grain yield. Correlation and path coefficient analysis revealed that selection based on characters cob length, cob weight, number of kernel rows per cob, shank weight and 100 kernels weight may help farmers bring out desired improvement towards higher yield in maize grown in *Zaid* season. The maximum yield were observed for genotypes MZ-1917 (85.8), MZ-1912 (84.2), MZ-1914 (81.3), MZ-1913 (77.4) and M-410 (74.3) which can be utilized as genetic stock in future breeding programme for higher yield. Therefore, it is suggested that effective selection based on these traits must be attempted and provide use to the breeder to formulate appropriate breeding plans for selection of the genotypes for summer sowing in order to bring the desirable genetic improvement in maize.

It is concluded that maize genotypes MZ-1917 and MZ-1912, were found best as depicted the highest grain yield and its associated characters and farmers can utilize the respective genotypes for production of better yield performances in Maize.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
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