Original Research Article

Evaluation on genetic variation, correlation and path analysis in zaidMaize (*Zea mays*L.) for quantitative characters

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 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 – Variability parameters, Association analysisand Maize (*Zea mays* L.)

Comment [WU1]: Keywords in alphabetical order

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 **(Hossain *et al*., 2019a)**. 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 **(Shengu*et al.*, 2016)**.

In India, maize is principally grown in two seasons *viz*: *Kharif* and *Rabi* and comparatively less area under *Zaid* season, 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 **(FAOSTAT, 2020)**.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 **(Naushad *et al*., 2007)** 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 **(Mohammadia*et al*., 2003).**

Comment [WU2]: it is necessary to explain about numberinbred line maize that has been developed

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 **(Malik *et al*.,**

2005). Correlation coefficient analysis measures the mutual relationship among various plant characters and determines the point on which selection can be based for improving yield **(Rahman *et al*., 2017).**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, 1921)** and elucidated by **(Dewey and Lu, 1959)**. 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*., 1977)**.

Comment [WU3]: References must be update

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 levelsand path coefficient analysis for direct and indirect effectswhich 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 *Zaid* season is discussed in this research paper.

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). The recommended agronomical and plant protection practices were adopted for a good crop growth. 20 quantitative characters were recorded on five randomly selected plants for each inbred line in each replication. The data recorded were then subjected to statistical analysis for analysis of variance, correlation and path analysis with the help of variability package in R-studio software.

Comment [WU4]: methods should be disclosed in more detail

3. Results and Discussion

Comment [WU5]: the discussion of each point is still shallow

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*. (2011), Kumar *et al*. (2015), Gurpinder *et al*. (2017), Kharel *et al*. (2017), Sravanti *et al*. (2017), Jakhar *et al*. (2017), Sharma *et al*. (2018), Kandel *et al*. (2018) and Verma *et al*., (2020).**

3.2 Mean performance of genotypes

Comment [WU6]: It is necessary to group of the 21 genotype using a biplot

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*., (2017) and Sharma *et al*., (2018)**.The results of GCV and PCV are in the agreement with the findings of **Bello *et al*., (2012), Rajesh *et al*., (2013), Kumar *et al*., (2015), Patil *et al*., (2016), Rahman *et al* (2017) and Khan *et al*., (2018)**.

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*., (2012), Badawy *et al*., (2012), Rajesh *et al*., (2013), Bekele and Rao (2014), Beulah *et al*., (2018), Bartaula*et al*., (2019) and Supraja *et al*., (2019)**.

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*., (2015), Vijay *et al*., (2015), Gurpinder*et al*., (2016) and Varalaksmi*et al*., (2018)**.

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, 1921)** and elucidated by **(Dewey and Lu, 1959)**. 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.

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*., (2015), Vijay *et al*., (2015), Kumar *et al*., (2016), Patil *et al*., (2016), Takhar *et al*., (2017) and Varalaksmi*et al*., (2018)**.

Table 1: Analysis of variance for quantitative characters of Maize

Sr.No.	**Characters**	**MeanSumofSquares**		
		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

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-kongbron	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
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 2: Mean values of maize genotypes for different quantitative characters.

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																	

Traits	DT 50	DS 50	ASI	NLPP	LL	TL	LW	PH	EH	DM	CL	CG	CW	NKRC	NKPR	SW	KW	SP	BY	GYPP
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

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							
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

Characters	**DT 50**	**DS 50**	**ASI**	**NLPP**	**LL**	**TL**	**LW**	**PH**	**EH**	**DM**	**CL**	**CG**	**CW**	**NKRC**	**NKPR**	**SW**	**KW**	**SP**	**BY**

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

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	0.152	-0.001	0.005	-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

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).

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 bring out desired improvement towards higher yield in maize grown in *Zaid* season.

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