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Screening of Elite Maize (*Zea mays* L.) inbred Lines Grown under Rainfed Conditions of Eastern Uttar Pradesh for Yield, Oil and Protein content

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ABSTRACT: Rainfed maize rarely has access to enough moisture since the irregular or uneven distribution of monsoon rainfall frequently results in sporadic drought, heat, or excessive moisture/waterlogging at various crop growth stages (s). This is the main cause of the rainfed maize's relatively poor production. Therefore, to fill the research gap, the experiment was conducted on twenty-one CIMMYT-maize inbred lines, that were grown in rainfed conditions of eastern Uttar Pradesh during *kharif* 2021 for assessment of genetic variability, correlation, and path analysis for fifteen quantitative variables and two biochemical traits, *i.e.*, oil and protein content. The inbred lines were examined under Randomized Block Design with three replications at Field Experimentation Center of Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj. The observations and analysis of data indicated that with the exception of the number of anthesis-silking intervals, analysis of variance for all characters showed significant differences at 1% level. Genotype CML-579 depicted highest grain yield in the rainfed environment. The higher value of PCV with large difference than GCV for characters *viz.*, like grain yield per plant, cob weight, shank weight and anthesis-silking interval, indicated that environmental factors significantly influenced the expression of these traits. High genetic advance coupled with high heritability was observed for grain yield per plant, cob weight, plant height and ear height indicating the presence of large proportion of additive genetic action deciding these traits. Correlation and path coefficient studies suggested that selection based on characters like number of kernels per row, cob girth and cob weight had positive correlation and direct effects with grain yield per plant. Hence, it can be concluded that for the improvement of CIMMYT inbred lines of maize in rainfed environment of eastern U.P., the effective selection must be attempted for the above traits.

Keywords: Variability parameters, Association analysis and Maize (*Zea mays* L.).

INTRODUCTION

Maize (*Zea mays* L.; 2n=20) is the world's leading crop and is widely cultivated as cereal grain that was domesticated in Central America. It is one of the most adaptable crops, able to be produced in a variety of seasons and ecologies, and is also referred to as the "Miracle Crop" and the "Queen of the Cereals" due to its highest genetic production potential (Dowswell *et al*., 1996). However the productivity of maize in Uttar Pradesh in rainfed environment is as less as 1.67 t/ha, which is comparatively low from world's productivity, i.e., 5.75 t/ha (The International Plant Nutrition Institute (IPNI), Regional Profiles-India, 2018). Rainfed maize rarely has access to enough moisture since the irregular or uneven distribution of monsoon rainfall frequently results in sporadic drought, heat, or excessive moisture/waterlogging at various crop growth stages (s) (Manohari *et al.*, 2018). This is the main cause of the rainfed maize's relatively poor production (Azam *et al.*, 2011; Kumar *et al.*, 2015; Rafique *et al.*, 2020). Additionally, grain yield in maize is quantitative in nature and polygenically regulated, therefore simultaneous enhancement of all yield components and effective yield improvement are essential. Planning an effective breeding programme to create high yielding inbreds and hybrids requires taking into account genetic characteristics and correlation studies between yield and yield components. Hence, in this research an attempt was made on studying the performance of CIMMYT maize inbred lines for various quantitative characters in kharif season. This can play an important role in enhancing maize productivity in rainfed, stress-prone ecologies, and ultimately help boost national maize productivity and production (Rafique *et al.*, 2020).

The study 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 in *kharif* season that was carried out for enhancing the maize grain productivity under rainfed conditions of Eastern Uttar-Pradesh is discussed in this research paper.

MATERIALS AND METHODS

Twenty CIMMYT inbred maize lines and one check variety were sown in Randomized Block Design replicated thrice at the Field Experimentation Center of the Department of Genetics and Plant Breeding, Naini Agricultural Institute, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj (U.P.) during *kharif*, 2021.The recommended agronomical and plant protection practices were adopted for good crop growth. Fifteen quantitative and two biochemical traits were recorded during the study on five randomly selected plants in each entry of each replication. Further, the data were subjected to statistical analysis for analysis of variance, correlation and path coefficient analysis with the help of INDOSTAT software.

RESULTS AND DISCUSSION

A. Analysis of variance and Mean

Analysis of variance for all seventeen quantitative characters revealed that treatment differences were highly significant under study at 1% level (as manifested in Table 1) except for anthesis silking interval during *Kharif* season indicating the presence of inherent genetic differences in the experimental material. This denotes the significance of their genetic value in determining the ideal genetic profile for rainfed condition and so improving the selection process. Similar finding in maize genotypes have been reported by Azam *et al*. (2011); Kumar *et al.* (2015); Gurpinder *et al.* (2017).

The mean values, coefficient of variation (C.V.), standard error of the mean (SE), critical difference (C.D.) at 5% and range of 21 genotypes for 17 quantitative characters are presented in (Table 2) which revealed a wide range of variation for all traits studied. The isolation of the best genotypes to be incorporated into the maize breeding programme has a larger chance of success due to the extensive or broad spectrum of variability for all traits.

A review of mean values of yield and yield contributing character revealed that among the twenty one genotypes *viz.*, CML-579 (108.70), CML-580 (103.47), CML-563 (99.30), CML-575 (95.60), CML-582 (95.07) were identified as the best performers for yield and yield related traits.

B. Genetic variability, Heritability and GAM

Variability has a significant impact in crop breeding. Genetic variability is an essential component of every programme aimed at improving crops. An effective long-term plant breeding programme requires a considerable degree of genetic variation, which should also be a heritable difference among gene pools, within a population. According to research, the degree of genetic variance in the population is directly correlated with the progress made through selection. The level of variety found in the trait's basic material is the only variable that can be improved. Variability is therefore essential 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 seventeen characters are explained under the following heads (Table 3). Higher differences were observed between phenotypic and genotypic variance for traits *viz.*, ear height, number of kernels per row, cob weight, shank weight, oil content and grain yield per plant indicating that the characters studied were greatly influenced by environment in growing season. The results of GCV and PCV are in agreement with the findings of Bello *et al.* (2012); Rajesh *et al.* (2013); Vashistha *et al.* (2013); Kumar *et al.* (2015); Patil *et al.* (2016); Rahman *et al.* (2017); Khan *et al.* (2018); Alam *et al*. (2022).

Heritability of all characters studied was higher for all the characters except anthesis silking interval which has shown the low heritability amongst all the characters which was 18.20. In this study, estimates of broad sense heritability are the proportion of total genetic variance involving both additive and non-additive types to total phenotypic variance. In this study all the traits had higher genetic advance at 5% selection intensity and genetic advance as percent of mean. This is because of higher magnitude of heritability for all the characters which indicate GA and GAM more responsive for all characters. High expected genetic advance as per cent of mean coupled with high heritability was observed for grain yield per plant, plant height, ear height, number of leaves per plant, cob length, cob girth, number of kernel rows, number of kernels per row, cob weight, shank weight, 100 kernel weight and oil content. These indicate 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 are in agreement with the findings of Badawy (2012); Rajesh *et al.* (2013); Bekele and Rao (2014); Beulah *et al.* (2018); Hassan *et al.* (2018); Bartaula *et al.* (2019); Supraja *et al.* (2019); Alam *et al*. (2022).

C. 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 same direction indicating the masking effect of environment on the association of characters except for anthesis-silking interval. Grain yield per plant showed phenotypically and genotypically significant positive correlation with plant height, ear height, days to maturity, cob length, cob girth, number of kernel rows per cob, number of kernels per row, cob weight and shank weight. Therefore, characters under study except anthesis-silking interval has contribution in increasing. From the above result, we can show that traits such as cob girth, number of kernel rows per cob and cob weight has the maximum contribution for increasing grain yield. However, oil content exhibited highly positive significant correlation with protein content (0.87**) and was negative non-significant with grain yield per plant (-0.01). Moreover, protein content was negative non-significant with grain yield per plant (0.12).

The learning purpose of the experiment is that selection based on these characters would be useful for desired improvement of maize crop towards the yield with help of genotypes which can withstand with the grown environment. The findings of correlation coefficient is in agreement with the findings of Kumar *et al.* (2014); Kumar *et al.* (2015); Vijay *et al.* (2015); Gurpinder *et al.* (2017); Bhiusal *et al.* (2017); Varalakshmi *et al.* (2018).

D. Path coefficient analysis

Path analysis furnishes the cause and effect of different yield components with would provide superior index for selection rather than mere correlation coefficient. Correlation gives only the relation among two variables whereas path coefficient analysis permits separation of the direct effect and their indirect effects through other attributes by partitioning the correlation (Wright, 1921). Hence, path coefficient analysis was carried out in rainfed environment of *Kharif* season, to quantify the interrelationship of different components and their direct and indirect effects on grain yield at phenotypic and genotypic level, as shown 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 number of kernels per row, cob girth, ear height, oil content, days to first silk emergence (50%), number of leaves per plant, plant height, cob weight, shank weight, 100 kernel weight but are weakened due to their negative indirect effects on grain yield. While anthesis silking interval, cob length, number of kernel rows per cob, protein content and days to maturity exhibited negative direct effect on grain yield which indicates that the improvement of these traits is required before selection of these traits for higher grain yield. Correlation and path coefficient studies suggest that selection based on characters cob weight, number of kernels per row, ear height, shank weight, number of kernel rows per cob, number of leaves per plant, number of kernels per cob, cob girth and cob length had positive correlation and direct effects with grain yield per plant and would bring out desired improvement in yield and hybridization programme based on these traits in maize and the traits showing the direct negative effect in path studies should be essentially be improved before there selection for high grain yield. Similar findings were reported with some deviation by Patil *et al.* (2012); Langade *et al.* (2013); Kumar *et al.* (2015); Vijay *et al.* (2015); Kumar *et al.* (2016); Patil *et al.* (2016); Varalakshmi *et al.* (2018); Mannohari *et al.* (2018).

Table 1: ANOVA for various quantitative characters in maize.

Sr. No.	Character	Replications (df=2)	Treatments (df=20)	Error (df=40)
1.	Days to first tassel emergence (50%)	1.15	47.33**	1.42
2.	Days to first silk emergence (50%)	0.76	49.53**	1.52
3.	Anthesis silking interval	0.20	0.81	0.49
4.	Plant height	8.17*	763.93**	1.57
5.	Ear height	0.79	493.10**	0.85
6.	Number of leaves per plant	1.14**	4.42**	0.16
7.	Days to maturity	3.57	23.66**	2.78
8.	Cob length	6.01**	10.59**	0.4
9.	Cob girth	6.08**	5.43**	0.26
10.	Number of kernel rows per cob	0.09	7.65**	0.11
11.	Number of kernel per row	3.64**	57.77**	0.38
12.	Cob weight	8.21**	1020.63**	0.96
13.	Shank weight	1.92**	39.30**	0.36
14.	Grain yield per plant	42.54*	2344.53**	9.34
15.	100-kernel weight	0.87	19.59**	0.72
16.	Oil content	0.88**	1.94**	0.10
17.	Protein content	0.01	1.10**	0.02

*significant at 5% level ; **significant at 1% level

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

Sr. No.	Genotype	Days to first Tassel Emergence (50%)	Days to first Silk Emergence (50%)	Anthesis Silking Interval	Plant Height (cm)	Ear Height (cm)	Number of leaves per plant	Days to Maturity	Cob Length (cm)	Cob Girth (cm)	Number of Kernel Rows Per Cob	Number of Kernels Per Row	Cob Weight (g)	Shank Weight (g)	100 Kernel Weight (g)	Oil content (%)	Protein content (%)	Grain Yield Per Plant (g/plant)
1.	CML-427	55.33	57.67	2.33	126.71	32.37	9.53	87.67	10.32	8.23	8.53	11.67	27.80	11.01	20.73	2.82	8.19	50.39
2.	CML-451	46.00	47.67	1.67	130.65	24.92	11.13	85.33	11.86	8.90	9.33	18.87	30.11	10.14	21.75	2.83	8.05	59.93
3.	CML-452	55.33	57.00	1.67	144.07	33.43	10.20	87.00	12.39	9.90	10.67	18.93	36.52	11.75	19.73	3.93	8.41	74.29
4.	CML-465	52.00	54.67	2.67	127.32	24.78	8.87	83.33	12.12	10.43	9.60	13.87	29.36	9.90	23.72	3.24	8.48	58.39
5.	CML-470	47.33	49.00	1.67	130.05	30.02	7.87	84.67	12.59	10.85	9.87	12.60	20.00	7.46	20.05	3.96	8.96	40.37
6.	CML-473	52.67	55.33	2.67	135.20	30.33	10.00	90.67	16.20	12.50	10.40	19.40	21.17	7.75	16.82	3.26	8.49	40.26
7.	CML-474	44.00	45.67	1.67	126.90	32.06	11.00	84.33	9.47	8.30	9.20	14.40	23.77	7.51	15.20	3.22	8.16	48.76
8.	CML-496	46.00	48.00	2.00	128.23	35.03	10.53	83.33	13.43	8.17	10.00	12.87	21.80	6.74	21.31	3.41	8.49	45.19
9.	CML-497	42.67	44.00	1.33	130.38	26.35	10.67	87.33	12.00	8.43	8.93	16.13	17.75	7.20	16.98	2.08	7.21	42.32
10.	CML-563	50.00	52.33	2.33	171.10	62.65	11.20	87.00	12.77	10.43	9.60	20.87	42.57	9.47	20.03	3.60	8.61	99.30
11.	CML-564	48.67	50.67	2.00	149.20	36.33	9.67	81.67	12.27	10.36	11.60	18.00	41.61	11.72	16.12	4.25	9.13	89.69
12.	CML-565	42.00	45.33	3.33	128.77	34.81	9.07	86.67	10.09	8.47	8.67	15.13	18.37	5.70	18.98	4.90	9.01	41.07
13.	CML-575	45.33	47.33	2.00	144.97	58.22	10.87	86.67	16.20	10.53	13.60	25.13	87.24	15.29	21.03	3.21	8.43	95.60
14.	CML-578	49.67	51.67	2.00	131.80	26.35	9.93	84.67	9.85	8.44	9.20	13.53	14.19	6.53	21.45	4.29	9.30	38.56
15.	CML-579	51.33	53.33	2.00	155.07	53.14	10.73	90.67	11.87	10.92	10.27	23.87	47.07	10.84	17.50	2.84	7.63	108.70
16.	CML-580	44.00	46.67	2.67	156.17	51.20	10.20	81.67	12.03	10.96	11.33	21.33	55.14	11.77	24.24	4.94	9.46	103.47
17.	CML-581	47.67	50.33	2.67	126.22	34.28	11.07	86.67	13.40	10.30	13.20	17.20	28.15	14.44	20.65	4.91	9.00	41.14
18.	CML-582	46.33	49.00	2.67	157.27	52.06	10.80	87.67	15.06	11.90	13.60	24.80	53.06	11.97	18.13	2.38	8.17	95.07
19.	CML-612	44.67	46.33	1.67	132.83	28.28	10.20	82.67	12.80	9.82	11.47	17.80	38.27	8.53	22.85	3.91	8.53	89.22
20.	CML-613	45.33	47.67	2.33	137.15	24.47	9.07	84.67	10.50	10.17	9.60	14.87	20.54	8.17	19.38	3.88	8.99	37.11
21.	HQPM-5	52.33	55.33	3.00	182.77	61.03	14.00	91.67	14.15	12.27	12.53	25.93	66.60	21.33	23.63	4.17	9.80	117.70
	Mean	48.03	50.24	2.21	140.61	37.72	10.31	86.00	12.45	10.01	10.53	17.96	35.29	10.25	20.01	3.62	8.60	67.45
	Range Min.	42.00	44.00	1.33	126.22	24.47	7.87	81.67	9.47	8.17	8.53	11.67	14.19	5.70	15.20	2.08	7.21	37.11
	Range Max.	55.33	57.67	3.33	182.77	62.65	14.00	91.67	16.20	12.50	13.60	25.93	87.24	21.33	24.24	4.94	9.80	117.70
	C.D. at 5%	1.97	2.04	-	2.07	1.52	0.67	2.76	1.04	0.84	0.55	1.03	1.62	0.99	1.41	0.52	0.22	5.04
	C.V.	2.49	2.46	31.72	0.89	2.44	3.94	1.94	5.08	5.08	3.15	3.47	2.78	5.86	4.26	8.68	1.53	4.53
	S.E.	0.69	0.71	0.40	0.73	0.53	0.23	0.96	0.37	0.29	0.19	0.36	0.57	0.35	0.49	0.18	0.08	1.76

Table 3: Genetic variability parameters for quantitative and biochemical characters of maize.

Genetic characters		Days to 50% Tasseling	Days to 50% Silking	Anthesis Silking Interval	Plant Height	Ear Height	Number of leaves per plant	Days to Maturity	Cob Length	Cob Girth	Number of Kernel Rows Per Cob	Number of Kernels Per Row	Cob Weight	Shank Weight	100 Kernel Weight	Oil content	Protein content	Grain Yield Per Plant
Genotypic variance		15.30	16.00	0.11	254.12	164.09	1.42	6.96	3.40	1.73	2.52	19.13	339.89	12.98	6.29	0.62	0.363	778.40
Phenotypic variance		16.73	17.53	0.60	255.70	164.94	1.58	9.75	3.80	1.99	2.63	19.52	340.86	13.34	7.02	0.72	0.38	787.74
Environmental Variance		1.43	1.53	0.49	1.58	0.85	0.17	2.79	0.40	0.26	0.11	0.39	0.97	0.36	0.73	0.10	0.017	9.34
Coefficient of variation (%)	GCV	8.14	7.96	14.95	11.34	33.96	11.55	3.07	14.81	13.12	15.06	24.35	52.24	35.16	12.53	21.68	7.01	41.36
	PCV	8.52	8.33	35.06	11.37	34.05	12.20	3.63	15.66	14.07	15.39	24.60	52.32	35.64	13.23	23.35	7.17	41.61
	ECV	2.49	2.46	31.72	0.89	2.44	3.94	1.94	5.08	5.08	3.15	3.47	2.78	5.86	4.26	8.68	1.534	4.53
Heritability		91.50	91.30	18.20	99.40	99.50	89.60	71.40	89.50	87.00	95.80	98.00	99.70	97.30	89.70	86.20	95.4	98.80
Genetic Advance		7.71	7.87	0.29	32.74	26.32	2.32	4.59	3.59	2.52	3.20	8.92	37.93	7.32	4.89	1.50	1.212	57.13
Genetic advance as percent mean		16.05	15.67	13.12	23.28	69.78	22.51	5.34	28.86	25.21	30.37	49.66	107.47	71.44	24.44	41.45	14.106	84.70

Table 4: Phenotypic correlation coefficients among yield and yield components of maize.

Characters	DT50	DS50	ASI	PH	EH	NLPP	DM	CL	CG	NKRC	NKPR	CW	SW	KW	OC	PC	GYPP
DT50	1																
DS50	0.98**	1															
ASI	0.03	0.21	1														
PH	0.22	0.25*	0.20	1													
EH	0.09	0.13	0.23	0.85**	1												
NLPP	0.08	0.10	0.10	0.59**	0.55**	1											
DM	0.39**	0.41**	0.15	0.34**	0.34**	0.44**	1										
CL	0.13	0.14	0.10	0.34**	0.43**	0.29*	0.28*	1									
CG	0.28*	0.31*	0.19	0.60**	0.48**	0.22	0.36**	0.63**	1								
NKRC	-0.01	0.01	0.13	0.44**	0.53**	0.41**	0.12	0.66**	0.61**	1							
NKPR	0.06	0.09	0.13	0.79**	0.79**	0.62**	0.43**	0.59**	0.65**	0.69**	1						
CW	0.06	0.08	0.10	0.69**	0.81**	0.50**	0.17	0.54**	0.50**	0.73**	0.83**	1					
SW	0.33**	0.36**	0.19	0.63**	0.61**	0.64**	0.34**	0.44**	0.52**	0.70**	0.68**	0.77**	1				
KW	0.08	0.11	0.14	0.13	0.11	0.12	-0.20	0.08	0.07	0.15	0.05	0.27*	0.33**	1			
OC	-0.06	-0.01	0.25*	0.06	0.03	-0.07	-0.26*	-0.16	0.06	0.15	-0.08	-0.02	0.12	0.33**	1		
PC	0.05	0.11	0.34**	0.30*	0.17	0.04	-0.18	-0.01	0.27*	0.24*	0.02	0.14	0.30*	0.43**	0.80**	1	
GYPP	0.15	0.16	0.08	0.84**	0.81**	0.52**	0.15	0.35**	0.50**	0.55**	0.82**	0.85**	0.64**	0.23	-0.01	0.12	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 Interval); PH (Plant height); EH (Ear height); NLPP (Number of leaves per plant); DM (Days to maturity); CL (Cob length); CG (Cob girth); NKRC (Number of kernel rows per cob); NKPR(Number of kernels per row); CW(Cob weight); SW(Shank Weight); KW(100 Kernel Weight); OC(Oilcontent); PC(Protein content) and GYPP(Grain yield per plant).

Table 5: Genotypic correlation coefficients among yield and yield components of maize.

Characters	DT50	DS50	ASI	PH	EH	NLPP	DM	CL	CG	NKRC	NKPR	CW	SW	KW	OC	PC	GYPP
DT50	1																
DS50	0.99**	1															
ASI	0.23	0.30*	1														
PH	0.24*	0.27*	0.46**	1													
EH	0.10	0.14	0.52**	0.85**	1												
NLPP	0.09	0.10	0.13	0.62**	0.59**	1											
DM	0.47**	0.49**	0.48**	0.40**	0.41**	0.50**	1										
CL	0.14	0.16	0.24*	0.37**	0.45**	0.34**	0.39**	1									
CG	0.31*	0.36**	0.73**	0.64**	0.52**	0.23	0.41**	0.73**	1								
NKRC	-0.02	0.01	0.36**	0.45**	0.54**	0.44**	0.11	0.75**	0.64**	1							
NKPR	0.06	0.09	0.36**	0.80**	0.80**	0.66**	0.50**	0.63**	0.69**	0.70**	1						
CW	0.07	0.09	0.26*	0.69**	0.81**	0.53**	0.21	0.57**	0.53**	0.74**	0.84**	1					
SW	0.34**	0.37**	0.47**	0.64**	0.62**	0.69**	0.40**	0.47**	0.55**	0.72**	0.68**	0.78**	1				
KW	0.12	0.15	0.43**	0.14	0.12	0.13	-0.22	0.09	0.08	0.17	0.06	0.28*	0.35**	1			
OC	-0.11	-0.05	0.72**	0.08	0.04	-0.12	-0.34**	-0.18	0.09	0.16	-0.10	-0.02	0.12	0.34**	1		
PC	0.06	0.13	0.86**	0.31*	0.18	0.05	-0.23	-0.01	0.31*	0.27*	0.04	0.15	0.33**	0.47**	0.87**	1	
GYPP	0.16	0.17	0.20	0.85**	0.81**	0.55**	0.18	0.38**	0.54**	0.56**	0.83**	0.85**	0.66**	0.24	-0.01	0.12	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 Interval); PH (Plant height); EH (Ear height); NLPP (Number of leaves per plant); DM (Days to maturity); CL (Cob length); CG (Cob girth); NKRC (Number of kernel rows per cob); NKPR(Number of kernels per row); CW (Cob weight); SW(Shank Weight); KW(100 Kernel Weight); OC(Oil content); PC(Protein content) and GYPP (Grain yield per plant).

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

Traits	DT	DS	ASI	PH	EH	NLPP	DM	CL	CG	NKRC	NKPR	CW	SW	KW	OC	PC
DT	**0.220**	0.216	0.007	0.049	0.020	0.018	0.086	0.029	0.062	-0.003	0.015	0.014	0.075	0.019	-0.014	0.012
DS	-0.078	**-0.080**	-0.017	-0.021	-0.011	-0.008	-0.033	-0.012	-0.025	-0.001	-0.007	-0.007	-0.029	-0.009	0.001	-0.009
ASI	0.001	0.005	**0.023**	0.005	0.005	0.002	0.004	0.002	0.004	0.003	0.003	0.002	0.005	0.003	0.006	0.008
PH	0.142	0.162	0.130	**0.631**	0.538	0.372	0.219	0.217	0.380	0.281	0.500	0.438	0.399	0.084	0.043	0.191
EH	-0.011	-0.016	-0.028	-0.101	**-0.119**	-0.066	-0.041	-0.052	-0.057	-0.063	-0.094	-0.097	-0.073	-0.013	-0.004	-0.020
NLPP	0.007	0.009	0.009	0.051	0.048	**0.087**	0.038	0.026	0.019	0.036	0.055	0.044	0.056	0.011	-0.007	0.004
DM	-0.063	-0.066	-0.025	-0.056	-0.055	-0.071	**-0.160**	-0.046	-0.059	-0.020	-0.069	-0.029	-0.055	0.032	0.043	0.030
CL	-0.024	-0.027	-0.019	-0.064	-0.081	-0.055	-0.053	**-0.185**	-0.117	-0.124	-0.111	-0.101	-0.082	-0.016	0.030	0.001
CG	0.018	0.019	0.012	0.037	0.030	0.014	0.023	0.039	**0.062**	0.038	0.041	0.031	0.032	0.005	0.004	0.017
NKRC	-0.002	0.001	0.016	0.053	0.063	0.049	0.015	0.080	0.073	**0.119**	0.083	0.087	0.084	0.018	0.018	0.030
NKPR	0.004	0.006	0.009	0.050	0.050	0.040	0.027	0.038	0.042	0.044	**0.063**	0.053	0.043	0.003	-0.005	0.002
CW	0.041	0.052	0.067	0.443	0.519	0.322	0.114	0.348	0.323	0.467	0.535	**0.638**	0.494	0.174	-0.013	0.090
SW	-0.088	-0.095	-0.052	-0.164	-0.159	-0.168	-0.088	-0.115	-0.136	-0.183	-0.177	-0.201	**-0.259**	-0.086	-0.032	-0.080
KW	0.008	0.010	0.014	0.012	0.010	0.011	-0.018	0.008	0.007	0.014	0.005	0.025	0.030	**0.091**	0.031	0.039
OC	-0.008	-0.002	0.034	0.009	0.004	-0.010	-0.036	-0.022	0.009	0.021	-0.011	-0.003	0.016	0.046	**0.134**	0.108
PC	-0.016	-0.035	-0.104	-0.091	-0.051	-0.014	0.056	0.001	-0.082	-0.075	-0.009	-0.042	-0.093	-0.130	-0.242	**-0.301**
GYPP	0.150	0.161	0.075	0.845	0.813	0.523	0.153	0.356	0.507	0.554	0.822	0.854	0.644	0.231	-0.005	0.119
Partial R^2	0.033	-0.013	0.002	0.533	-0.097	0.045	-0.025	-0.066	0.031	0.066	0.052	0.546	-0.167	0.021	-0.001	-0.036

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

Traits	DT	DS	ASI	PH	EH	NLPP	DM	CL	CG	NKRC	NKPR	CW	SW	KW	OC	PC
DT	**0.003**	0.003	0.001	0.001	0.000	0.000	0.002	0.000	0.001	0.000	0.000	0.000	0.001	0.000	0.000	0.000
DS	0.235	**0.236**	0.073	0.065	0.033	0.023	0.118	0.037	0.087	0.001	0.021	0.021	0.088	0.035	-0.011	0.030
ASI	-0.015	-0.020	**-0.064**	-0.030	-0.033	-0.008	-0.031	-0.016	-0.047	-0.023	-0.024	-0.017	-0.031	-0.028	-0.046	-0.055
PH	0.041	0.047	0.080	**0.170**	0.146	0.106	0.068	0.063	0.110	0.078	0.136	0.118	0.110	0.024	0.014	0.053
EH	0.033	0.046	0.172	0.284	**0.331**	0.196	0.139	0.152	0.172	0.180	0.266	0.270	0.206	0.040	0.013	0.059
NLPP	0.017	0.018	0.025	0.119	0.113	**0.190**	0.097	0.066	0.044	0.084	0.127	0.101	0.131	0.025	-0.023	0.010
DM	-0.259	-0.275	-0.266	-0.221	-0.231	-0.280	**-0.550**	-0.218	-0.226	-0.062	-0.277	-0.117	-0.221	0.121	0.190	0.126
CL	-0.025	-0.029	-0.045	-0.068	-0.084	-0.064	-0.073	**-0.184**	-0.134	-0.139	-0.117	-0.106	-0.087	-0.016	0.033	0.001
CG	0.106	0.124	0.248	0.219	0.176	0.078	0.139	0.247	**0.338**	0.217	0.236	0.181	0.187	0.028	0.031	0.106
NKRC	0.005	-0.001	-0.067	-0.085	-0.101	-0.082	-0.021	-0.141	-0.119	**-0.186**	-0.131	-0.138	-0.134	-0.031	-0.030	-0.051
NKPR	0.026	0.039	0.160	0.348	0.348	0.290	0.218	0.277	0.304	0.306	**0.434**	0.367	0.299	0.027	-0.042	0.016
CW	0.011	0.015	0.045	0.117	0.136	0.089	0.036	0.097	0.090	0.124	0.141	**0.167**	0.131	0.047	-0.003	0.025
SW	0.031	0.034	0.044	0.059	0.057	0.064	0.037	0.044	0.051	0.067	0.063	0.072	**0.092**	0.033	0.011	0.031
KW	0.008	0.011	0.031	0.010	0.009	0.010	-0.016	0.006	0.006	0.012	0.004	0.020	0.025	**0.071**	0.025	0.034
OC	-0.030	-0.013	0.204	0.023	0.011	-0.034	-0.098	-0.051	0.026	0.045	-0.027	-0.006	0.034	0.098	**0.282**	0.247
PC	-0.030	-0.065	-0.437	-0.158	-0.091	-0.025	0.116	0.003	-0.158	-0.140	-0.018	-0.075	-0.169	-0.239	-0.445	**-0.507**
GYPP	0.157	0.171	0.201	0.852	0.820	0.554	0.181	0.382	0.543	0.564	0.835	0.859	0.662	0.235	-0.001	0.123
PartialR^2	0.001	0.040	-0.013	0.145	0.272	0.105	-0.099	-0.070	0.183	-0.105	0.362	0.144	0.061	0.017	0.000	-0.062

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CONCLUSIONS

It is concluded that based on mean performance for grain yield and taken into characters on account, the line CML-579 followed by CML-580 and CML-563 were found best for growing under rainfed conditions of Eastern Uttar Pradesh. CML-580 showed highest oil content and HQPM-5 had highest protein content. Variance due to oil content and protein content were significant, however the effective selection can be done for oil content. Selection based on characters like cob weight, number of kernels per row, ear height, shank weight, number of kernel rows per cob, number of kernels per cob, cob girth and cob length may bring out desired improvement towards development of high yielding maize variety suitable for growing under abiotic stress.

FUTURE SCOPE

For the improvement of CIMMYT inbred lines, under rainfed condition, the effective selection of cob weight, number of kernels per row, ear height, shank weight, number of kernel rows per cob, number of kernels per cob, cob girth and cob length should be carried out during a breeding programme.

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Conflict of Interest. None.

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