Genetic variability and interrelationship in maize (*Zea mays* L.) genotypes forgrainyieldand yieldcomponentcharacters

Abstract

Anexperimentwasconductedincluding20~~inbreds~~genotypesofmaizeduring*Kharif*seasonof2020-21.Allcharactersunderstudyshowedhighlysignificantvariation.Highvaluesofgenotypicandphenotypicco efficients of variation were observed for the characters like a~~A~~nthesis and silking interval, grainyieldperplant,biologicalyield,numberofgrainsperrow,numberofgrainrowspercob,harvestind ex and ear height. Biological yield per plant, plant height, grain yield per plant, ear height andharvestindexshowedhigh heritabilitycoupledwith high geneticadvance suggestingtheirimportance for direct selection. Number of cobs per plant, ear length, number of grains per row,100 grain weight, harvest index, biological yield exhibited significant positive association with grainyield per plant. Highest direct positive effect on yield per plant was observed for harvest indexfollowed biological yield, number of cobs per plant, anthesis and silking interval. Thus, priorityshouldbegiventothesecharactersduringselectionformaizeyieldimprovement.

Keywords: Maize,variability,heritability,geneticadvance,correlation,pathanalysis

Introduction

Maize(*Zeamays*L.)isthethirdforemostimportantcerealcropinIndiasucceedingriceandwheat.ItaccordtothetribeMaydeae,ofthegrassfamily,Poaceae.Globallymaizecoversanareaof 193.7 million hectares witha production of 1147.7 million tonnes and productivity of 5.75t/ha [1] and in India maize occupies an area of 9.27 million hectares with a production of 27.14million tonnes and productivity of 2965 kg ha^{-1} [2]. In Uttar Pradesh, it covers an area of 7.33lakh hectares with a production of 15.26 lakh tonnes and productivity of 2081 kg ha^{-1}. Thesuitability of maize to manifold environment is peerless by any other crop as it has an extensiverange of adaptability. The existing prominence on the development of single cross hybridsis to beexpectedtoensureenhancedgrowthratesinproductivityofthisversatilecropinthe yearstocome.Theexistence ofgeneticvariabilityistheimperativeforasuccessfulhybriddevelopment programin maize and constitution of the breeding population. Computation of genetic variability in theprevailingpopulations resumeprimeprominenceinthis context.Studyofvariability,heritability,geneticadvance,andcharacterassociationinthegermplasmwi llassisttocomprehendthegenuinepotentialofthegenotypes.

Proficiencyofselectionineverybreedingprogrammetypicallydependsupontheapprehension of association of the characters; and . Progression in every breeding programme dependsupon the enormity of useful variability present in the population and the magnitude to which thedesirablecharactersareheritable.Appropriateformulationofselection indicesforgeneticimprovement of yield, the cause and effect relationship of the trait is immensely crucial. and iseffectuated by path analysis.The correlation coefficient stipulate an association between twocharacters, is convenient as a basis for indirect selection for further improvement. Consideringtheseaspects,thepresentstudywasoutlinedandaccomplishedwiththeobjectivesofanalysingthegeneticvariability,heritability,geneticadvanceandstudy ofcharacterassociation besidespartitioningoftheirassociationintodirectandindirecteffects.in20inbreds.

Materialsandmethod

The present experiment was carried out at the Crop Research Farm of Sam HigginbottomUniversityofAgriculture,TechnologyandSciences,Prayagraj,UttarPradesh,India.Theexperimental materials consisted of 20 genotypes of maize (*Zea mays* L.) obtained from theInternationalCropResearchInstituteofSemi-AridTropics,Hyderabad,Telangana.Theexperimentwaslaidoutinrandomizedblockdesignwiththreereplications.Eachentrywassownwith a single row of 3 m length with row to row spacing of 60 cm and plant to plant spacing of20 cm. Originally two seeds per hill were planted and further one plant was thinned to optimizesingle plant per hill. Two boarder rows were even planted to minimize the boarder effect. Therecommended cultural practices were accomplished to augment a good crop. The pre and postharvest parameters were recorded on five plants selected at random from each genotype in eachreplication for 14 polygenic characters *viz.* days to fifty percent tasseling, days to fifty percentsilking,anthesis and silking interval, plantheight (cm), ear height (cm), ear length (cm),eardiameter (cm), number of cobs per plant, number of grain rows per cob, number of grains perrow,100grainweight(g),harvestindex(%),biologicalyield(g),grainyieldperplant(g).

Meanofthedatafromthesampledplantsofeachgenotypeinrespectofdifferentparameterwas utilized for various statistical analysis *viz.*, variability analysis, correlation analysis, pathanalysis.Dataw~~as~~~~ereanalysed~~analyzedusingstatisticalanalysissoftwareWindostat®V.9.3.

ResultsandDiscussion

Statisticalanalysisofdatacollectedexhibithighlysignificantvariationforallthecharactersstudied ~~(which is presented in~~ Table 1. The results of the diverse variability parameters *viz.*,phenotypicandgenotypiccoefficientsofvariation,heritabilityinbroadsenseandgenetic advanceasper~~-~~centofmeanisrepresentedinTable2.Therelativelyhighvaluesofphenotypiccoefficientof variation than their corresponding genotypic coefficient of variation stipulate the involvementof environmental factors in the inheritance of these quantitative traits. Anthesis and silkinginterval, grain yield per plant, biological yield, number of grains per row, number of grain rowspercob,harvestindexandearheightexhibitedcomparativelyhighervaluesofgenotypiccoefficientofvariation, therefore, ~~whichinsuccessionputonviewthat~~directselectionforthesetraitswouldbeeffectualandresponsive.Similarfindingsforgrainyieldperplant,numberofgrainsperrow,earheight[3-6],plantheight [~~7,~~8]revealedpresenceofconsiderablevariabilityforallcharactersstudied.Highheritabilityestimatesforallthetraitswhichindicate thatthevariationobservedforthesecharactersare mainly genotypic. Similar results of high heritability estimates for grain yield per plant and plantheight [~~9~~-11], ear height [~~12,~~ 13], days to 50 % silking [14, 15], ear length [~~16,~~ 17], ear girth [~~18,~~19], number of grains per row [20], and 100 grain weight [21]. Among the traits under study, sometraits viz., biological yield per plant, plant height, grain yield per plant, ear height, harvest indexhad shown higher estimates of geneticadvance representing the additive gene action in theinheritanceofthesetraits,therebyselectionforthesetraitswillbehighlyresponsive.Similarresultshavebeenreportedinmaizeforgrainyieldperplantandearheight[22].

High significant positive correlation with yield perplant was recorded by number of cobsper plant followed by ear length, number of grains per row, 100 grain weight, harvest index,biological yield, suggesting that indirect selection for high yield through direct selection for thesecharacters will be highly effective (Table 3). Similar type of results for number of grains per row[25~~3~~-27], number of cobs per plant [28,~~ 29~~], ear length [30], 100 grain weight [31], harvest index[32]. Flowering traits like days to 50% tasseling and days to 50% silking showed significantnegativecorrelationwithgrainyield.

Table1:Analysisofvariancefordifferentcharactersof Maize

Source	df	DFPT	DFPS	ASI	PH	EH	EL	ED	NC/P	NGR/C	NG/R	100GW	HI	BY	GY/P
Replication	2	14.06	6.86	0.01	179.73	21.66	0.42	0.56	0.006	0.06	1.21	5.63	76.18	42.23	11.41
Treatment	19	65.55**	98.57**	2.90**	1163.87**	562.24**	14.51**	9.80**	0.18**	32.94**	69.76**	118.61**	417.91**	1785.94**	572.84**
Error	38	10.82	16.35	0.03	111.94	31.08	1.42	0.81	0.005	1.08	2.32	4.83	33.71	45.53	13.54

**P=0.01

DFPT: Days to 50% tasseling ; DFPS: Days to 50% silking; ASI: Anthesis and silking interval; PH: Plant height ; EH: Ear height; EL: Ear length;ED: Ear diameter; NC/P: Number of cobs per plant; NGR/P: Number of grains row per cob; NG/R: Number of grains per row; 100GW: 100 grainweight;HI:Harvest index; BY: Biologicalyield;GY/P:Grainyield perplant

Table2: Estimatesofvariabilityparameters foryieldandyieldtraitsinmaize<u>**See that the decimals can be reduced to one or 2**</u>

Sl.No.	Characters	Mean± SEM	Range		GCV	PCV	h^2(bs) (%)	Genetic Advance	GeneticAdvance % Mean
			Max.	Min.					
1	Days to 50% tasseling	58.47 ±1.9	66.00	51.33	7.306	9.221	62.772	6.972	11.924
2	Days to 50% silking	60.78 ±2.34	71.67	54.33	8.612	10.883	62.621	8.534	14.04
3	Anthesisandsilkinginterval	2.58 ±0.11	4.20	1.02	37.994	38.656	96.603	1.981	76.927
4	Plantheight	148.46 ±6.11	184.84	121.03	12.613	14.487	75.801	33.584	22.622
5	Earheight	64.48 ±3.22	88.97	47.40	20.636	22.374	85.066	25.281	39.207
6	Earlength	12.23 ±0.69	15.76	8.79	17.088	19.674	75.44	3.738	30.575
7	Eardiameter	11.93 ±0.52	14.55	9.00	14.514	16.366	78.655	3.163	26.517
8	Numberof cobsper plant	1.49 ±0.04	1.97	1.09	16.678	17.291	93.037	0.492	33.139
9	Numberofgrains rowpercob	12.6 ± 0.6	18.58	8.14	25.868	27.155	90.749	6.395	50.764
10	Numberofgrains per row	16.89 ±0.88	22.85	8.21	28.07	29.484	90.637	9.299	55.05
11	100grainweight	31.06 ±1.27	41.32	19.6	19.827	21.051	88.702	11.949	38.466
12	Harvest index	48.48 ±3.35	64.17	24.50	23.342	26.235	79.162	20.742	42.783
13	Biological yield	82.67 ±3.9	143.74	49.84	29.135	30.257	92.722	47.778	57.792
14	Grainyieldperplant	39.8 ±2.12	63.03	16.77	34.302	35.527	93.227	27.158	68.228

Formatted: Font: 12 pt, Bold, Font color: Red
Formatted: Font: 12 pt, Bold, Font color: Red
Formatted: Font color: Red
Formatted: Font color: Red
Formatted: Font color: Red
Formatted: Font color: Red
Formatted: Font color: Red
Formatted: Font color: Red
Formatted: Font color: Red
Formatted: Font color: Red
Formatted: Font color: Red
Formatted: Font color: Red
Formatted: Font color: Red
Formatted: Font color: Red
Formatted: Font color: Red
Formatted: Font color: Red

Table3:Correlation coefficientbetweenyieldanditsrelatedtraitsin20 maizegenotypesatgenotypicandphenotypiclevel.

Characters		DFPS	ASI	PH	EH	EL	ED	NC/P	NGR/C	NG/R	100GW	HI	BY	GY/P
DFPT	r_g	0.824**	-0.116	0.218	0.365*	0.0738	0.487**	-0.484**	0.440**	0.1618	-0.401*	-0.1769	-0.375*	-0.446**
	r_p	0.581**	-0.1284	0.1574	0.294*	0.0238	0.374*	-0.350*	0.304*	0.1249	-0.273*	-0.1247	-0.308*	-0.350*
DFPS	r_g	1.000	-0.014	0.0009	0.303*	0.0797	0.337*	-0.338*	0.488**	0.364*	-0.2192	-0.0251	-0.379*	-0.337*
	r_p	1.000	0.0101	0.0153	0.1051	0.0402	0.1682	-0.255*	0.356*	0.2481	-0.2246	-0.0160	-0.2478	-0.2430
ASI	r_g		1.0000	-0.246	-0.342*	-0.1892	-0.392*	-0.0669	-0.2500	0.1203	-0.0360	0.317*	-0.315*	-0.0313
	r_p		1.0000	-0.2101	-0.314*	-0.1758	-0.355*	-0.0670	-0.2301	0.1277	-0.0400	0.289*	-0.294*	-0.0190
PH	r_g			1.000	0.853**	0.359*	0.365*	-0.1155	-0.1214	-0.2067	-0.0729	0.1678	-0.314*	-0.1167
	r_p			1.0000	0.674**	0.2291	0.350*	-0.1137	-0.0822	-0.1590	-0.0809	0.0978	-0.255*	-0.1033
EH	r_g				1.000	0.1980	0.292*	-0.2365	0.0667	0.0207	-0.2172	0.0752	-0.373*	-0.2378
	r_p				1.0000	0.1161	0.2321	-0.1978	0.0874	0.0088	-0.1740	0.0757	-0.348*	-0.2120
EL	r_g					1.0000	0.602**	0.438**	-0.0079	0.543**	0.518**	0.1054	0.478**	0.402*
	r_p					1.0000	0.447**	0.369*	-0.0091	0.434**	0.435**	0.0761	0.382*	0.320*
ED	r_g						1.0000	-0.0432	0.264*	0.338*	0.0846	-0.1267	0.288*	0.0931
	r_p						1.0000	-0.0070	0.2296	0.292*	0.0910	-0.0764	0.2153	0.0873
NC/P	r_g							1.0000	-0.1657	0.418**	0.987**	0.619**	0.705**	0.958**
	r_p							1.0000	-0.1489	0.383*	0.919**	0.548**	0.641**	0.897**
NGR/C	r_g								1.0000	-0.0723	-0.2378	-0.385*	0.0067	-0.2148
	r_p								1.0000	-0.0721	-0.2206	-0.318*	-0.0030	-0.1940
NG/R	r_g									1.0000	0.549**	0.405*	0.359*	0.494**
	r_p									1.0000	0.487**	0.336*	0.332*	0.456**
100GW	r_g										1.0000	0.707**	0.699**	0.995**
	r_p										1.0000	0.580**	0.635**	0.896**
HI	r_g											1.0000	-0.0032	0.636**
	r_p											1.0000	-0.0865	0.630**
BY	r_g												1.0000	0.762**
	r_p												1.0000	0.701**

*P=0.05;**P=0.01

DFPT:Daysto50%tasseling; DFPS:Daysto50%silking;ASI:Anthesis andsilkinginterval;PH: Plantheight;EH:Earheight;EL:Earlength;ED:Eardiameter;NC/P: Numberofcobsperplant;NGR/P: Numberofgrainsrowpercob;NG/R:Numberof grainsperrow; 100GW:100grainweight;HI:Harvest index; BY: Biologicalyield; GY/P: Grainyield perplant

Table4:Directandindirecteffectsbetweenyieldanditsrelatedtraitsin20maizegenotypesatgenotypicandphenotypiclevel

Traits		**DFPT**	**DFPS**	**ASI**	**PH**	**EH**	**EL**	**ED**	**NC/P**	**NGR/C**	**NG/R**	**100GW**	**HI**	**BY**	**Correlation coefficient with GY/P**
DFPT	G	**-0.0054**	-0.0060	0.0006	-0.0012	-0.0020	-0.0004	-0.0026	0.0026	-0.0024	-0.0009	0.0021	0.0009	0.0020	-0.446**
	P	**0.0016**	0.0009	-0.0002	0.0002	0.0005	0.0000	0.0006	-0.0005	0.0005	0.0002	-0.0004	-0.0002	-0.0005	-0.350*
DFPS	G	-0.0093	**-0.0084**	0.0001	0.0000	-0.0025	-0.0007	-0.0028	0.0028	-0.0041	-0.0031	0.0018	0.0002	0.0032	-0.337*
	P	-0.0321	**-0.0553**	-0.0006	-0.0008	-0.0058	-0.0022	-0.0093	0.0141	-0.0197	-0.0137	0.0124	0.0009	0.0137	-0.2430
ASI	G	-0.0129	-0.0016	**0.1107**	-0.0273	-0.0378	-0.0209	-0.0434	-0.0074	-0.0277	0.0133	-0.0040	0.0350	-0.0348	-0.0313
	P	-0.0015	0.0001	**0.0116**	-0.0024	-0.0037	-0.0020	-0.0041	-0.0008	-0.0027	0.0015	-0.0005	0.0034	-0.0034	-0.0190
PH	G	-0.1007	-0.0004	0.1135	**-0.4608**	-0.3931	-0.1655	-0.1683	0.0532	0.0559	0.0952	0.0336	-0.0773	0.1448	-0.1167
	P	0.0124	0.0012	-0.0166	**0.0788**	0.0531	0.0181	0.0276	-0.0090	-0.0065	-0.0125	-0.0064	0.0077	-0.0201	-0.1033
EH	G	0.1315	0.1094	-0.1231	0.3075	**0.3605**	0.0714	0.1051	-0.0853	0.0240	0.0074	-0.0783	0.0271	-0.1346	-0.2378
	P	-0.0103	-0.0037	0.0110	-0.0237	**-0.0351**	-0.0041	-0.0082	0.0069	-0.0031	-0.0003	0.0061	-0.0027	0.0122	-0.2120
EL	G	0.0088	0.0095	-0.0226	0.0428	0.0236	**0.1192**	0.0717	0.0522	-0.0009	0.0647	0.0617	0.0126	0.0570	0.402*
	P	-0.0010	-0.0017	0.0072	-0.0094	-0.0048	**-0.0411**	-0.0183	-0.0151	0.0004	-0.0178	-0.0179	-0.0031	-0.0157	0.320*
ED	G	0.1050	0.0728	-0.0846	0.0789	0.0629	0.1299	**0.2159**	-0.0093	0.0569	0.0730	0.0183	-0.0274	0.0621	0.0931
	P	-0.0088	-0.0039	0.0083	-0.0082	-0.0054	-0.0105	**-0.0234**	0.0002	-0.0054	-0.0069	-0.0021	0.0018	-0.0050	0.0873
NC/P	G	-0.2927	-0.2046	-0.0404	-0.0699	-0.1431	0.2649	-0.0261	**0.6049**	-0.1003	0.2528	0.5971	0.3744	0.4265	0.958**
	P	-0.0391	-0.0284	-0.0075	-0.0127	-0.0221	0.0411	-0.0008	**0.1116**	-0.0166	0.0428	0.1026	0.0612	0.0716	0.897**
NGR/C	G	-0.0364	-0.0404	0.0207	0.0100	-0.0055	0.0007	-0.0218	0.0137	**-0.0827**	0.0060	0.0197	0.0318	-0.0006	-0.2148
	P	0.0193	0.0227	-0.0147	-0.0052	0.0056	-0.0006	0.0146	-0.0095	**0.0637**	-0.0046	-0.0141	-0.0203	-0.0002	-0.1940
NG/R	G	-0.0458	-0.1029	-0.0341	0.0585	-0.0058	-0.1537	-0.0957	-0.1183	0.0205	**-0.2830**	-0.1555	-0.1146	-0.1015	0.494**
	P	0.0031	0.0062	0.0032	-0.0040	0.0002	0.0109	0.0074	0.0096	-0.0018	**0.0252**	0.0123	0.0085	0.0084	0.456**
100GW	G	0.1635	0.0894	0.0147	0.0297	0.0886	-0.2111	-0.0345	-0.4025	0.0970	-0.2241	**-0.4078**	-0.2885	-0.2851	0.995**
	P	0.0070	0.0057	0.0010	0.0021	0.0045	-0.0111	-0.0023	-0.0235	0.0056	-0.0125	**-0.0256**	-0.0149	-0.0163	0.896**
HI	G	-0.1174	-0.0167	0.2100	0.1113	0.0499	0.0699	-0.0840	0.4105	-0.2552	0.2685	0.4693	**0.6633**	-0.0022	0.636**
	P	-0.0809	-0.0104	0.1875	0.0635	0.0492	0.0494	-0.0496	0.3560	-0.2063	0.2182	0.3767	**0.6493**	-0.0562	0.630**
BY	G	-0.2342	-0.2368	-0.1968	-0.1964	-0.2334	0.2987	0.1798	0.4407	0.0042	0.2242	0.4370	-0.0020	**0.6251**	0.762**
	P	-0.2196	-0.1764	-0.2095	-0.1815	-0.2481	0.2723	0.1533	0.4567	-0.0021	0.2367	0.4524	-0.0616	**0.7120**	0.701**
GY/P	G	-0.446**	-0.337*	-0.0313	-0.1167	-0.2378	0.402*	0.0931	0.958**	-0.2148	0.494**	0.995**	0.636**	0.762**	1.0000
	P	-0.350*	-0.2430	-0.0190	-0.1033	-0.2120	0.320*	0.0873	0.897**	-0.1940	0.456**	0.896**	0.630**	0.701**	1.0000

Genotypic ResidualEffect =0.112;Phenotypic Residual Effect = 0.138;Direct effectsareon maindiagonal

*P=0.05;**P=0.01

DFPT: Days to 50% tasseling ; DFPS: Days to 50% silking; ASI: Anthesis and silking interval; PH: Plant height ; EH: Ear height; EL:Ear length;ED: Ear diameter; NC/P: Number of cobs per plant; NGR/P: Number of grains row per cob; NG/R: Number of grains per row; 100GW: 100 grainweight;HI:Harvest index;BY: Biologicalyield;GY/P:Grainyieldperplant; G:Genotypicpath; P:Phenotypic path

Thestudy revealedthatthemajorportion ofthehighly significantpositivecorrelationbetweengrain yieldperplantandharvestindexisduetoitsdirecteffectonly, alsoitisexpressedhighdirectpositiveeffectongrainyieldperplantamongallthetraitsstudied(Table4).Biologicalyield,numberof cobs per plant, ear height, ear diameter, ear length, anthesis and silking interval also has highdirectpositiveeffectonyieldperplant.Similarresultshavebeenreportedforearheight,earlength,ear diameterwerepositivelyassociatedwithgrainyield in respect to grain yield[33].Plantheighthadhighestdirectnegativeeffect on grain yield per plant. The results of path coefficient analysis suggest that the selectionfor higher harvest index, biological yield, number of cobs per plant, ear height, ear diameter, earlength, anthesisand silkingintervalwillbehighlyeffectiveinimprovingthe grainyieldperplantinthemaize in maize.

Conclusion

In maize breeding, occuranceoccurrence of a variability in germplasm is essential for selection and is the principalfactor for the success of the breeding programme. A geno-typically distinct population genotypesareis a priority for theselectionofbetterinbredstobesubsumeinsinglecrosshybriddevelopmentinmaize.Thepresentinvestigation stipulated the presence of genetic variability for most of the characters in genotypesunder study. Character association study and path-coefficient analysis unveiled the significance of componentcharacterslikeharvestindex,biologicalyield,numberofcobsperplantinadvancement of yield as they were found significantly and positively associated with yield. Thus,from the present investigation, it has been presumed that due prominance importanceshould be given onthesetraitsduringtheselectioninmaizeforimprovementofgrainyield.

Reference

1. FAOSTATStatisticalDatabase.FoodandAgricultureOrganizationoftheUnitedNations.[Rome]:FAO.2020
2. ICAR-IndianInstituteofMaizeResearch.DepartmentofAgriculturalResearchandEducation,MinistryofAgriculture,GovernmentofIndia.
3. Babu KS, Gaibriyal ML and Mohana Krishnan N. Studies on Genetic Association and

PathCoefficient Analysis for Yield and Yield Attributing Characters in Maize (*Zea mays* L.).InternationalJournalofPlant&SoilScience.2022;34(22):49-54.

4. GuptaSP,SalgotraRK.Variabilityandcorrelationstudiesin(*Zeamays*L.)underintermediatezoneof Jammu.EnvironmentandEcology.2004;22(Spl-3):554-557.

5. RafiqCM,RafiqueM,HussainA,AltafM.Studiesonheritability,correlationandpathanalysisinmaize(*Zeamays*L.).JournalofAgriculturalResearch,Lahore.2010;48(1):35-38.

6. Tengan KML, ObengAntwi K, Akromah R. Genetic variances, heritability, and correlationstudies on selected phenotypic traits in a backcross breeding program involving normal andopaque-2maize.AgricultureandBiologyJournalofNorthAmerica.2012;3(7):287-291.

~~7. Robin S, Subramanian M. Genetic variability studies in biparental progenies in maize. CropResearch.1994;7(1):77-83.~~

~~8.~~7. AbiramiS,VanniarajanC,ArmugachamyS.GeneticvariabilityStudiesinmaize(*Zeamays* L.)germplasm.PlantArchieves.2005;5(1):105-108.

~~9. AyalaOT,ChurataBG.Estimatesofgeneticparametersinthemaizecomposites(*ZeamaysL.*)Arquitetura, In memoriasde laIII ReunionLatinomericana Y XVI Reunionde la Zona Andianade Investigadores in maize. Cochabamba, Santa Cruz, Bolvia, Tomo II (edited by Avila, L.G.andCespedes,P.L.M.)Cochabamba,Bolvia.1995;769-779.~~

~~10. ChoudharyAK,ChaudaryLE.Geneticstudiesinsomecrossesofmaize(*Zeamays*L.).JournalofResearchBisraAgriculturalUniversity.2002;14:87-90.~~

~~11.~~8. Rafique,Muhammad,HussainA,MahmoodT,AlviAW,AlviMB.Heritabilityandinterrelationships among grain yield and yield components in maize. International Journal ofAgricultureandBiology,2004;6:1113-1114.

~~12. RobinsonHF,ComstockRE,HarveyPH.Estimatesofheritabilityandthedegreeofdominanceincorn.AgronomyJournal.1949;41:45-60.~~

~~13.~~9. Chenling,Cuishaoping,ChenL,CuiAP,SunYB.Analysisofthegeneeffectonearcharactersinmaize.ActaAgricultureBareliSinica.1996;11(2):28-32.

~~14.~~10. SaikiaRB,GargiSharma.Variabilitystudiesinsomeexoticmaizegenotypes.IndianJournal ofHillFarming.2000;13(1-2):106-107.

~~15.~~11. Muhammad Akbar, Shakoor MS, Amer Hussain, MuhmmadSarwar. Evaluation of maize 3 waycrosses through genetic variability, broad sense heritability, character association and pathanalysis.JournalofAgricultural Research,Lahore.2008;46(1):39-45.

~~16. Singh KD, Rao SRM, Harbir S. Correlation and path coefficient analysis of yield and yieldcomponenttraitsinmaizeGangahybrid-5.JournalofResearch,HaryanaAgriculturalUniversity.1987;17:64-67.~~

~~17.~~12. Kumar PP, Satyanarayana E. Variability and correlation studies of full season inbred lines ofmaize(*Zeamays*L.).JournalofResearch,ANGRAU.2001;29:71-75.

~~18. Debnath SC. Genetic variability in maize (*Zea mays L.*). Bangladesh Journal of Agriculture.1987;12:217-221.~~

~~19.~~13. DawoodKM,MohammedASA.Estimatesofheritabilityandpathcoefficientanalysisforsomecharacters inmaize(*Zeamays*L.).MesopotamiaJournalofAgriculture.1989;21:246-254.

~~20.~~14. BhallaSK,BaliS,SharmaS,SharmaBK.Assessmentofgeneticvariabilityandcorrelationsinindigenous maize germplasm of Himachal Pradesh. Himachal Journal Agricultural Research.1986;12(2):75-81.

~~21.~~15. Liao SJ, Xu ZB, Wen SP. Analysis of combining ability for major quantitative characters insomemaizeinbredlines.PlantBreedingAbstracts.1987;57:3724.

~~22.~~16. Kabdal MK, Verma SS, Ahmad N, Panwar UBS. Genetic variability and correlation studies ofyieldanditsattributingcharacters inmaize(*Zeamays*L.).AgriculturalScienceDigest,2003;23:137-139.

~~23. Viola G, Ganesh M, Reddy SS, Kumar CV. Studies on correlation and coefficient analysis ofelitebabycorn(*Zeamays*L.)lines.ProgressiveAgriculture,2003;3:22-24.~~

~~24. TangH,HuangYQ,YanJB,LiuZH,TangJH,ZhengYL,LiJS.Geneticanalysisofyieldtraitswithelitemaizehybrid-Yuyu22.ActaAgronomica-Sinica,2004;30:922-926.~~

25.17. MalikHN,MalikSI,HussainMOZAMIL,ChughtaiSUR,JavedHI.Geneticcorrelationamongvarious quantitative characters in maize (*Zea mays* L.) hybrids. Journal of Agriculture andSocialSciences,2005;1:262-265.

26.18. HemavathyAT,BalajiK,IbrahimSM,AnandG,SankarD.Geneticvariabilityandcorrelationstudiesinmaize(*Zeamays*L.).AgriculturalScienceDigest,2008;28:112-114.

27.19. Moradi M, Azarpour E. Determination of most important part of yield components by pathanalysisincorn.TheJournalofAmericanScience,2011;7(5):646-650.

28.20. Taiwo O. P, Nwonuala AI, Foby IB, Olawamide DO, Agbugba IK. Correlation and PathCoefficient Analysis Studies on Grain Yield and Its Contributing Characters in Maize (*Zeamays* L.).InternationalJournalofPlant&SoilScience.2020;3(7):7-13.

29. Bupesh K, Razdan AK, Gupta BB. Heterosis and character association for grain yield and itscomponent traits in single cross maize hybrids under mid hillsof Jammu and Kashmir, India.AgriculturalScienceDigest.2013;33(3):198-202.

30.21. Rajasekhar D, Naveen kumar KL, Pandey PK, Sen D. Analysis of Morphological Variation,Grouping and Path Coefficient Studies in a Set of Maize Inbred Lines Local to North East HillRegionofIndia.InternationalJournalofPlant&SoilScience.2022;34(17):105-113.

31.22. Jawaharlal J, Reddy GL, Kumar RS. Genetic variability and character association studies inmaize.AgriculturalScienceDigest.2011;31(3):173-177.

32.23. Panwar LL, Mahawar RK, Narolia RS. Genetic variability and interrelationships among grainyield and yield components in maize (*Zea mays* L.). Annals of Plant and Soil Research.(2013);15(1):15-18.

33.24. VenugopalM,AnsariNA,RajanikanthT.Correlationandpathanalysisinmaize.(*Zeamays* L.).CropResearchHisar.2003;25(3): 525-529.