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Correlation And Path Analysis Of Grain Yield Components In Exotic Maize (Zea Mays L.) Hybrids

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Abstract

Present study was aimed to investigate the genotypic and phenotypic association among grain yield components and their direct and indirect effects on yield. Correlation studies revealed significant positive genotypic and phenotypic relationship of grain yield with cob position, rows per cob and grains per row. Cob height, number of grains per row, stem diameter and cob girth had high positive direct effects on grain yield. Cob position had high negative direct effect on yield. These result depicted that cob position, no. of rows per cob and no. of grains per cob may be used as reliable criteria for improving grain yield. Heritability and genetic advance estimates described the genetic attributes of the traits under study. All the traits except no. of rows per cob and no. of grains per row had non additive type of gene action with high heritability and low genetic advance. The exploitation of these traits would be effective in hybrid maize breeding. No. of rows per cob and no. of grains per row showed both additive and non additive type of gene action with environmental influence due to high environmental variance. These traits can be utilized effectively through selection in varietal development.

Keywords:Zea mays L.; Correlation Analysis; Path Coefficient Analysis; Heritability Analysis; Grain Yield

1. Introduction

Maize (Zea mays L.) is an important food and feed crop of the world. Globally, it is grown on more than 120 million hectares and is called the "king of grain crops".It ranks third in production close behind wheat and rice.

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Despite of staple food of many countries the average yield of maize around the world is less than to meet the food requirements of increasing world population. In Pakistan, area under maize occupies third position after wheat and rice, 98% of which is grown in Punjab and N.W.F.P. It accounts for 25.2 percent of the value added in overall agriculture and 5.4 percent to GDP. It was grown on an area of 1085 thousand hectares in 2012-13, 0.2 percent less over last year's area of 1087 thousand hectares, however the production witnessed 4631 thousand tones during 2012-13, against last year production of 4338 thousand tones suggesting an increase of 6.8 percent over the last year. The yield per hectare in 2012-13 stood at 4268 (Kg/Ha) showing a positive growth of 6.9 percent as compared to 4.9 percent growth last year [1]. The production increased due to the conversation of more area to hybrid varieties and favorable weather conditions that enhanced yield of the crop. Maize grain has high nutritional value as it contains 72% starch, 10% protein, 4.8% oil, 8.5% fiber, 3% sugar and 1% ash [2]. 35% of maize production is used for human nutrient requirement and about 65% for animal feed [3]. At present grain yield of maize in Pakistan is much lower than world average. It is mainly due to the poor genetic composition of the cultivars, non availability of good quality seed of varieties/hybrids with high yield potential and less acclimatization of exotic hybrids due to biotic and abiotic stresses. Therefore, the development of improved cultivars/hybrids of maize is the need of the day. Determination of correlation and path coefficients between yield and yield traits is important for the selection of favorable plant types for effective maize breeding programs. Correlation coefficients in general show associations among independent characteristics and the degree of linear relation between these characteristics. It is not sufficient to describe this relationship when the causal association among characteristics is needed [4]. Path analysis is used to determine the amount of direct and indirect effect of the causal components on the effect component. Keeping this in view, the present study was therefore, designed to genetic basis of grain yield components and to develop a suitable selection criteria for future maize breeding program.

2. Materials and Methods

The assessment of yield performance, genetic architecture and association of different yield components of seven exotic maize hybrids obtained from different seed companies (Table.1), had been accomplished by conducting an experiment at Research farm of Four Brothers Seed Corporation Lahore, Pakistan. The experiment was laid out in the randomized complete block designs with three replications and each plot was comprised of four rows of 5 m in length having plant spacing between rows and within row was 0.75 m and 0.25 respectively. Two seeds per hill were planted and later thinned to single plant per hill, when plants were at 2nd leaf stage (V-2 stage). Entire phosphates and potassium fertilizers were applied at the time of sowing while 1/4th of urea was applied before sowing, 1/4th was applied when crop was at knee height stage, 1/4th at tasseling stage and remaining one was applied at grain filling stage. At maturity metric data related to plant height, cob height, stem diameter, cob position, cob length, cob girth, no. of rows per cob, no. of grains per row and grain weight was recorded from 10 plants by selecting 5 continuous plants from first & fourth row of each plot.

Table 1. Maize hybrids obtained from different sources

Sr. #	Hybrid	Source	Sr. #	Hybrid	Source
1	HM-902	Anhuie Seeds, China	5	PL-71	Polon Seeds, Turkey
2	HM-903	Anhuie Seeds, China	6	DK-6525	Monsanto, Pakistan
3	HM-904	Anhuie Seeds, China	7	32B33	Pioneer seeds, Pakistan
4	Bolson	Polen Seeds, Turkey			

Analysis of variance was used to check significance of differences among genotypes for all traits [5]. Genotypic and phenotypic components of variations were computed following Burton and Devane [6]. Broad sense heritability and genetic advance was computed using formula given by Falconer and Mackay [7]. 5% selection intensity (2.06) was used in estimation of genetic advance. Phenotypic and Genotypic correlation coefficients were estimated using formula given by Kown and Torrie [8]. Path analysis for estimating direct and indirect effects of traits in yield was performed using formula given by Dewey and Lu [9].

3. Results and Discussions

Analysis of variance indicated significant differences (P<0.01) for all the traits among genotypes that showed diverse variability among the yield traits of different maize hybrids (Table 2).

Table 2: Mean squares for grain yield related traits of different maize hybrids

Character	PH	CH	CP	SD	CL	CG	R/C	G/R	GW	Y
Treatment SS	5453.31	6514.00	8.43	0.13	70.54	0.54	19.45	191.69	259.96	1.20E-7
Replication SS	98.13	124	0.42	0.0014	5.10	0.0003	0.12	4.88	9.07	35456
Error SS	383.94	390.44	1.79	0.0091	9.64	0.054	12.22	114.36	38.66	14667.33
Total SS	5935.938	7028.438	10.643	0.1351	85.286	0.594	31.790	310.937	47.731	50123.33
G.M.	210.292	114.231	7.229	0.56	18.264	1.903	15.995	32.426	24.19	9917.90
Replication MS (df=2)	49.06	62	0.21	0.0007	2.55	0.0002	0.06	2.44	4.54	17728
Treatment MS (df= 6)	908.89**	1085.67**	1.41**	0.02**	11.76**	0.09**	3.24*	31.95*	43.33**	2129899**
Error MS	32.00	32.54	0.15	0.0008	0.8	0.004	1.02	9.53	3.22	14667.33

PH= Plant Height (cm), CH= Cob Height (cm), CP= Cob Position, SD= Stem Diameter (Inches), CL= Cob Length (cm), CG= Cob girth (Inches), R/C= No. of row per cob, G/R= No. of grains per row, GW= Grain Weight (g), Y= Yield (Kg/Ha), *, ** significant at 5% and 1% level of significance respectively

Correlation among the traits may be the consequence of the genetic association among the characters. From the breeder's view point, the type of association of grain yield and its component traits is of supreme importance. Higher genotypic correlations than their corresponding phenotypic correlations showed the higher genetic association among traits with the yield and the lower differences among both GCV and PCV for most of the traits attributed to lower modifying effect of environment on the association of characters [10]. Heritability and genetic advance estimates (Table 3) described the genetic attributes of the traits. All the traits except no. of rows per cob and no. of grains per row had non additive type of gene action with high heritability and low genetic advance values. These results depicted that these traits can effectively be used in hybrid maize breeding as these possess high dominance. Both additive and non additive type of gene action was observed in no. of rows per cob and no. of grains per row due to medium scoring of heritability and low genetic advance. The high environmental variance for both traits also described the modifying effects of environment on both traits.

Table 3: Estimates of Genotypic, Phenotypic and Environmental variances and coefficient of variability, Heritability (Broad sense) and Genetic Advance for yield related traits of different maize hybrids

Characters	PH	CH	CP	SD	CL	CG	R/C	G/R	GW	Y
Vg	292.3	351.04	0.42	0.0067	3.65	0.028	0.74	7.47	13.37	705073.8
Vp	324.29	383.58	0.57	0.007	4.45	0.033	1.76	17	16.59	719751.1
Ve	32.01	32.54	0.15	0.001	0.8	0.005	1.02	9.53	3.22	14677.3
PCV	8.11	16.41	8.95	14.59	10.466	8.87	5.38	8.43	15.12	8.47
GCV	8.54	17.15	10.42	15.4	11.56	9.55	8.29	12.72	16.84	8.55
h2 b.s.	0.90	0.92	0.74	0.90	0.82	0.86	0.42	0.44	0.81	0.98
GA	0.16	0.32	0.16	0.28	0.20	0.17	0.07	0.12	0.28	0.17

Vg = Genotypic variances, Vp = Phenotypic variances, Ve = Environmental variances, PCV = Phenotypic coefficient of Variability, GCV = Genotypic coefficient of Variability, h2 bs = Broad sense Heritability, GA = Genetic Advance.

The results related to correlation studies (Table 4) revealed that grain yield had significant genotypic and phenotypic relationship with cob position, rows per cob and grains per row. These findings suggested that improvement of grain yield in maize is linked with the development of these traits that might have good impact on grain yield [11]. Other traits i.e. plant height, stem diameter, cob height, cob length, cob girth and grain weight also had significant but negative correlation with the yield at both genotypic and phenotypic level. No. of grains per row had significant negative correlation with grain yield at phenotypic level only [12].

Table 4: Estimation of genotypic and phenotypic correlation coefficients for yield related traits of maize hybrids

Character		PH	CH	CP	SD	CL	CG	R/C	G/R	GW	Y
PH	G	1									
	P	1									
CH	G	0.671	1								
	P	0.661	1								
CP	G	-0.017	0.730	1							
	P	0.025	0.642	1							
SD	G	0.534	-0.149	-0.614	1						
	P	0.539	-0.128	-0.436	1						
CL	G	0.743	0.279	-0.484	0.444	1					
	P	0.714	0.290	-0.265	0.439	1					
CG	G	0.620	0.199	-0.563	0.269	0.766*	1				
	P	0.587	0.161	-0.424	0.322	0.730	1				
R/C	G	-0.166	0.261	0.118	-0.363	-0.018	-0.115	1			
	P	-0.025	0.124	0.137	-0.062	0.010	0.106	1			
G/R	G	0.198	-0.080	-0.734	0.029	0.884**	0.669**	0.123**	1		
	P	0.320	0.060	-0.172	0.176	0.785*	0.561*	0.239*	1		
GW	G	0.532	0.052	-0.549	0.272	0.482	0.916**	0.417**	0.294**	1	
	P	0.481	0.073	-0.404	0.252	0.520	0.852*	-0.285*	0.308*	1	
Y	G	-0.814*	-0.367*	0.072*	-0.728*	-0.496*	-0.170*	0.281*	0.060*	-0.169*	1
	P	-0.781*	-0.349*	0.401*	-0.684*	-0.486*	-0.167*	0.205*	-0.006*	-0.176*	1

** indicates significant at 1% level of significance, * indicates significant at 5% level of significance, G = Genotypic correlation coefficient, P = Phenotypic correlation coefficient

Path analysis depicted the strength of association of all independent variables under study on the grain yield (Table 5). This analysis also allows separating direct effect and their indirect effects through other attributes by partitioning correlation which helps breeders to find out the characters that could be used as selection criteria in maize breeding programme [13]. Path coefficient analysis (Table 4) revealed that number of grains per row had maximum direct effect on yield followed by stem diameter, cob girth and cob height. However overall positive effects of cob girth, stem diameter and cob height on yield is diluted due to their negative indirect effects. These results showed that the selection of these characters except no. of grains per row would be less effective for improving grain yield per plant. Direct negative effects on grain yield were attributed by plant height, cob position cob length, no. of rows per cob, and grain weight which indicated that improvement of these traits is essential before selecting them for high grain yield [14].Cob girth possessed high positive direct effect (1.3357) on grain yield but its negative indirect effects through plant height (-1.0863), cob length (-0.8014) and grain weight (-0.4774) as well as its significant negative genotypic (-0.1701) and phenotypic (-o.1671) coefficients contributed negative association with grain yield per plant.

Table 5: Direct and indirect effects of yield related traits in different maize hybrids

Characters	PH	CH	CP	SD	CL	CG	R/C	G/R	G.W	Y
PH	-1.751	0.800	0.004	0.202	-0.778	0.829	0.051	0.106	-0.277	-0.814*
CH	-1.176	1.192	-0.150	-0.056	-0.291	0.265	-0.081	-0.043	-0.027	-0.367*
CP	0.030	0.871	-0.206	-0.233	0.507	-0.752	-0.037	-0.394	0.286	0.072*
SD	-0.936	-0.178	0.126	0.378	-0.465	0.360	0.112	0.016	-0.142	-0.728*
CL	-1.302	0.3322	0.100	0.168	-1.047	1.023	0.006	0.475	-0.251	-0.496*
CG	-1.086	0.237	0.116	0.102	-0.801	1.336	0.036	0.370	-0.477	-0.170*
R/C	0.291	0.312	-0.024	-0.137	0.019	0.153	-0.309	0.066	0.217	0.281*
G/R	-0.347	-0.095	0.151	0.011	-0.925	0.918	-0.038	0.537	-0.153	0.060*
G.W	-0.932	0.062	0.113	0.103	-0.504	1.224	0.129	0.158	-0.521	-0.169*

Plant height is an important trait that effect grain yield. Taller plants need more plant nutrients to complete more vegetative growth than reproductive phase that results in late maturation of cob. The results indicated that plant height had negative direct effect (-1.7514) on yield because of its negative indirect effect through cob length and grain weight [15,16]. The direct effect of cob height was positive (1.1923) but the magnitude of negative direct effects through almost all other yield contributing traits computed his negative association with grain yield. Plant having the cob at high position lowers the grain yield due to late pollination and less or no grain filling. It also showed significantly negative correlation coefficient at both genotypic (-0.814) and phenotypic (-0.781) level [17]. Cob position had direct effects on grain yield and plants bearing cob at lower node position are desirable. Plants with cobs at higher node result in low grain yield due to more vegetative growth and delay maturation of cob because of high temperature effects at later stage. The negative direct influence of cob position on grain yield was nullified by the higher magnitude of its positive indirect effects via plant height, cob height cob length and grain weight. It also put negative influence indirectly through stem diameter, cob girth, no. of rows per cob and no. of grains per row.

Positive association of stem diameter with grain yield is undesirable character as more stem diameter would mitigate the grain yield due to more pronounced vegetative growth and late reproductive phase. The direct effect of stem diameter on grain yield was positive (0.3784) but the extent of its indirect effect via grain weight (-0.1419) and cob height (-0.1777) was highly negative. Significant negative correlation coefficients at both genotypic (-0.684) and phenotypic (-0.011) level made its impact negative on grain yield per plant. Cob length had negative direct effect (-1.047) on grain yield. Its indirect effects via plant height and grain weight was also negative [14]. The negative values of correlation at both genotypic (-0.460) and phenotypic (-0.680) level also confirmed its negative linkage with grain yield. No. of rows per cob had negative direct effect (-0.3094) on grain yield but high positive magnitude of indirect effect via grain weight, no. of grains per row and cob girth nullified its direct negative influence on grain yield. Cob having more grain rows results in more grain yield. Significant positive correlation coefficients at genotypic (0.281) and phenotypic (0.205) level also confined it most effective trait for using in maize breeding.

No. of grains per cob had positive direct effect (0.5374) on grain yield per plant but had negligible indirect effect via plant height, cob height, cob length, no. of rows per cob and grain weight. The high significant genotypic correlation coefficient (0.281) showed its high positive association with grain yield per plant. Number of grains per row may be used as reliable criteria for high yielding maize open pollinated varieties/ hybrids. Grain yield was negatively influenced by grain weight (-0.521). The magnitude of indirect effects through plant height (-0.932) and cob length (-0.504) were also negative that demonstrated its negative alliance with grain yield.

Grain yield in Maize is directly influenced by cob position, no. of rows per cob and no. of grains per cob. The selection of these traits would be effective in maize hybrid program. The non additive behavior of the traits like no. of rows per cob and no. of grains per row with high heritability also favors the selection for the development of maize hybrids. No. of rows per cob and no. of grains per row having both additive and non additive type of gene action with high environmental variance can be utilized through selection in varietal development.

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5. References

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