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Correlation and Path Analysis studies of Yield and Related Characters in QPM Maize (*Zea mays* (L.)

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Abstract: *The present investigation undertaken Correlation and path analysis study in quality protein maize [Zea mays (L.)] was association between different characters, the direct and indirect contribution of the component characters on the yield and for various characters. Correlation and path analysis were made for fifteen characters in 50 Quality Protein Maize genotypes. The grain yield per plant showed highly significant positive correlation with ear circumference, number of kernels per row, ear length, 100 grain weight, plant height, ear head height. The traits* viz., *starch content and protein content showed significant and negative correlation with grain yield. Path analysis studies revealed that days to 50% tasselling, ear circumference and ear length exhibited high direct effects on seed yield indicating true and perfect relationship between them. The yield components ear head height, 100 seed weight, shelling percentage also exhibited the positive direct effect on seed yield. The finding that association between suggests that direct selection for these traits will help in improvement of seed yield in maize.*

Keywords: *Correlation, Path analysis, Maize*

INTRODUCTION

Maize *(Zea mays* L.*)* popularly known as corn, is a well known cereal crop of global importance. It belongs to family Graminae and Tribe Maydeae. *Zea mays* is the only species in genus *Zea*. It is diploid species with chromosome number 2n= 20. Tripsacum (Gamma grass) 2n = 18 and Teosinte (*Euchleana spp*) 2n = 36 are two close relatives. Central America (Mexico) is the origin of Maize. It is the native of America from where it was introduced in south East Asia by Portuguese traders in about 16th century.

Maize is a good source of carbohydrates (starch), protein, fats and minerals, which are important in human diet. Several million people especially in the developing countries derive their protein and calories requirement from maize. In spite of several important uses, maize has an inbuilt drawback of being deficient in two essential amino acids *viz.*, lysine and tryptophan. This leads to poor net protein utilization and biological value of traditional maize genotypes. To overcome this problem, the maize breeders have developed quality protein maize (QPM) by incorporating opaque-2 mutant gene, which is particularly responsible for enhancing lysine and tryptophan content of maize endosperm protein. Quality protein maize looks and taste like normal maize with same or higher yield potential but it contain nearly twice the quantity of essential amino acids, lysine and tryptophan which makes it rich in quality proteins.

It has similar agronomic performance, appearance and taste as the normal maize. It has a reduced prolamin fraction (25-30 percent) but elevated levels of other fractions such as glutelins, albumins and globulins. There is a two-fold increase

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in the levels of lysine and tryptophan with high digestibility and biological value. QPM has a balanced leucine:isoleucine ratio and thus an enhanced production of niacin to help overcome pellagra. QPM is like eggs and milk, both low in niacin, but they offer protection from pellagra because their proteins contain high levels of tryptophan. Compared to skim milk, the nutritional value of QPM is about 90 percent. It meets the requirements of pre-school children for their protein needs. In countries or communities where low protein and tuber crops make up an infant's diet, QPM offers better prospects. There is a tendency for increased nitrogen retention when a switch over from normal to QPM is made. It should in turn translate into body weight, stature and protection from protein deficiency illnesses. Clinical studies conducted in hospitals have demonstrated that QPM can give preventative help and cure of severe protein deficiency disease *viz* Kwashiorkor in young children by simply using it as the only source of protein.QPM could be a great weaning food when used alone in maize diets. Substitution of normal maize with QPM will produce more benefits. QPM could be really helpful in catch-up growth, particularly in the malnourished and those who are sick, especially after diarrhoea.

MATERIALS AND METHODS

The present investigation was undertaken to correlation and path analysis study in quality protein maize (*Zea mays* L.) was conducted at Post Graduate Research farm, College of Agriculture, Kolhapur. Fifty genotypes of maize procured from AICRP on maize, Kolhapur were evaluated for the present study. The experiment was laid out in randomized block design with three replications. Fifty genotypes were randomly planted in three replications. Each entry was represented by a single row of 4 m length spacing at 75 × 20cm distance between the rows to plants. Two border rows were planted at both sides of blocks to reduce the border effects. The basal dose of 60 kg N, 60 kg P_2O_5 and 40 kg K_2O per hectare was applied to the whole experimental area. The remaining dose of 60 kg N was applied after one month. The cultural practices like thinning, weeding and plant protection were followed as and when required during the crop growth period.

Ten random plants from each treatment in each replication were selected for recording observations. The selected plants were tagged at the age of 35 days. The following observations were recorded on the ten plants from each genotype at different growth stages of crop and average values per plant were worked out. Observations were recorded on as Morphological characters: Days to 50% tasselling, Days to 50% silking, Days to maturity, Plant height (cm), Ear head height (cm), Ear length (cm), Ear circumference (cm), Number of Kernel rows per cob, Number of Kernels per row, 100 grain weight (g), Shelling percentage (%), Grain yield per plant (g) as well as some Qualitative characters *viz.*,, Grain colour and Grain shape and Bio-chemical characters: Starch, Protein and Tryptophan. Genotypic and phenotypic correlations coefficient was worked out by adopting method described by Singh and Chaudhary (1977). Path coefficient analysis was done according to the procedure suggested by Dewey and Lu (1959).

RESULT AND DISCUSSION

Correlation coefficient is a statistical measure which is used to find out the degree and direction of relationship between two or more variables. The information on the interrelationship among the traits facilitates the choice of a suitable breeding method to be applied and selecting the parents for crop improvement. The genetic correlation coefficients between the characters at genotypic as well as phenotypic levels, as an important from breeding point of view, those only are described below. Table 1

Association between grain yield and its components: The grain yield per plant showed highly significant positive correlation with ear circumference (0.674), number of kernels per row (0.658), ear length (0.566), 100 grain weight (0.554), plant height (0.424) and ear head height (0.408). The characters days to maturity (0.133), tryptophan content (0.126) and shelling percentage (0.025) showed positive and non significant Association with yield. It had significant and negative correlation with protein content (-0.339) and starch content (-0.295).

Inter-relationships between yield components: Days to 50% tasselling was significantly and positively correlated with days to 50% silking (0.997), days to maturity (0.882), plant height (0.189), ear head height (0.463), ear circumference (0.322), number of kernel rows per cob (0.385), shelling percentage (0.319), starch (0.182) and grain yield per plant (0.200). It was significantly and negatively correlated with tryptophan content (-0.167) where as it was positively and non significantly correlated with 100 grain weight (0.032). It was non significantly and negatively, correlated with protein content (-0.114).

Days to 50% silking was significantly and positively related with days to 50% tasselling (0.955), days to maturity (0.829), plant height (0.177), ear head height (0.454), ear circumference (0.288), number of kernel rows per cob (0.356) shelling percentage (0.360) starch content (0.190), and grain yield per plant (0.205) and significantly and negatively correlated with tryptophan content (-0.170). It showed non significant and negative correlation with ear length (-0.112) and protein content (-0.100) and number of kernes per row (-0.076) non significant and positively correlated with 100 grain weight (0.057).

Days to maturity was significantly and positively correlated with days to 50% tasselling (0.791), days to 50% silking (0.773), plant height (0.274), ear head height (0.536) ear circumference (0.307), number of kernel rows per cob, (0.377), shelling percentage (0.331). The trait protein content (-0.174) was significantly and negatively associated with days to maturity While, grain yield per plant (0.133) and number of kernels per row (0.005) had non significant and positive correlation. Other characters ear length (-0.088), 100 grain weight (-0.039) and tryptophan content (-0.082) showed non significant and negative association with days to maturity.

Plant height was significantly and positively correlated with days to 50% tasselling (0.161), days to 50% silking (0.165), days to maturity (0.263), ear head height (0.740) ear length (0.316), ear circumference (0.486) number of kernel rows (0.294), number of kernels per row (0.381), 100 grain weight (0.334) tryptophan content (0.161) and grain yield per plant (0.424). It was non significant and positively correlated with shelling percentage (0.122). It was non significantly and negatively correlated with protein content (-0.025). Ear head height was significantly and positively correlated with days to 50% tasselling (0.418), days to 50% silking (0.409), days to maturity (0.498), plant height (0.707), ear circumference (0.359), number of kernel rows per cob (0.271), number of kernels per row (0.235), 100 grain weight (0.266), shelling percentage (0.380) and grain yield per plant (0.408). It was non significantly and positively correlated with ear length (0.098). The starch content (-0.265) showed significant and negatively association with ear head height.

Ear length was significantly and positively correlated with plant height (0.266), ear circumference (0.165), number of kernels per row (0.887), 100 grain weight (0.177) and grain yield per plant (0.566). It was non significantly and positively associated with ear head height (0.060) and protein content (0.014). Starch content (-0.272) was significantly and negatively correlated with ear length. It was non significantly and negatively correlated with days to 50% tasselling (-0.109), days to 50% silking (-0.113), days to maturity (-0.059) shelling percentage (-0.029) and tryptophan content (-0.034). Ear circumference was significantly and positively associated with days to maturity (0.212), plant height (0.321), ear head height (0.214), ear length (0.202), number of kernel rows per cob (0.640), number of kernels per row (0.372) 100 grain weight (0.641) and grain yield per plant (0.674).Protein content (0.233) and shelling percentage (-0.172) were significantly and negatively correlated with ear circumference. It was non significantly and positively correlated with days to 50% tasselling (0.118), days to 50% silking (0.108) and tryptophan content (0.123). Starch content (-0.122) was non significantly and negatively correlated with ear circumference.

Number of kernel rows per cob showed significant and positive association with days to 50% tasselling (0.246), days to 50% silking (0.212), days to maturity (0.334), plant height (0.212), ear head height (0.228), ear circumference (0.510), shelling

Table 1
Genotypic (above diagonal) and phenotypic (below diagonal) correlation of 15 characters in fifty Quality Protein Maize genotypes

Sr. No	*Characters*	*Days to 50% Tasselling*	*Days to 50% silking*	*Days to maturity*	*Plant Height*	*Earned Height*	*Ear Length*	*Ear circum-ference*	*No. of kernel rows per cob*	*No. of kernel per row*	*100 grain weight*	*Shell-ing %*	*Starch %*	*Protein %*	*Trypto-phan %*	*grain yield/ Plant*
1	Days to 50% Tasselling	1.00	0.997**	0.882**	0.189*	0.463**	-0.06	0.322**	0.385**	-0.027	0.032	0.319**	0.182*	-0.114	-0.167*	0.200**
2	Days to 50% silking	0.955**	1.00	0.829**	0.177*	0.454**	-0.112	0.288**	0.356**	-0.076	0.057	0.360**	0.190*	-0.100	-0.170*	0.205*
3	Days to maturity	0.791**	0.773**	1.00	0.274**	0.536**	-0.088	0.307**	0.377**	0.005	-0.039	0.331**	0.001	-0.174*	-0.082	0.133
4	Plant Height	0.167*	0.165*	0.263**	1.00	0.740**	0.316**	0.486**	0.294**	0.381**	0.334**	0.122	-0.292**	-0.025	0.161*	0.424**
5	Ear head Height	0.418**	0.409**	0.498**	0.707**	1.00	0.098	0.359**	0.271**	0.235**	0.266**	0.380**	-0.265**	-0.161*	-0.060	0.408**
6	Ear Length	-0.109	-0.113	-0.059	0.266**	0.060	1.00	0.165*	-0.071	0.887**	0.177*	-0.029	-0.272**	0.014	-0.034	0.566**
7	Ear circumference	0.118	0.108	0.212**	0.321**	0.214**	0.202*	1.00	0.640**	0.372**	0.641**	-0.172*	-0.122	-0.223**	0.123	0.674**
8	No. of kernel rows per cob	0.246**	0.212**	0.334**	0.212**	0.228**	-0.024	0.510**	1.00	-0.020	0.069	0.172*	-0.218**	-0.290**	0.237**	0.256**
9	No. of kernels per row	-0.041	-0.066	-0.050	0.293**	0.171*	0.701**	0.203*	-0.109	1.00	0.213**	0.029	-0.316**	-0.068	-0.070	0.658**
10	100 grain weight	0.046	0.054	-0.006	0.266**	0.185*	0.091	0.334**	0.027	0.118	1.00	0.034	0.142	0.239**	-0.069	0.554**
11	Shelling %	0.217**	0.236**	0.219**	0.107	0.259**	-0.016	0.049	0.046	0.078	-0.014	1.00	-0.080	-0.059	0.030	0.025
12	Starch %	0.168*	0.177*	0.004	-0.279	-0.262**	-0.205*	-0.080	-0.169*	-0.224**	0.111	-0.053	1.00	0.433**	-0.168*	-0.295**
13	Protein %	-0.107	-0.104	-0.155	-0.018	-0.146	0.052	-0.110	-0.191*	-0.067	0.159	-0.066	0.411**	1.00	-0.048	-0.339**
14	Tryptophan %	-0.154	-0.161*	-0.079	0.157	-0.058	-0.030	0.095	0.185*	-0.059	-0.053	0.028	-0.164*	-0.044	1.00	0.126
15	Grain yield/Plant	0.104	0.114	0.092	0.315	0.281	0.420	0.560	0.140	0.523	0.332	0.273	-0.214	-0.218	0.088	1.00

*,** significant at 5% and 1 % respectively.

percentage (0.172), tryptophan content (0.237) and grain yield per plant (0.256). It was non significant and positively correlated with 100 grain weight (0.069). Starch content (-0.218) and protein content (-0.290) were significantly and negatively correlated with number of kernel rows per cob. It was non significantly and negatively correlated with ear length (-0.024) and number of kernels per row (-0.020).

Number of kernels per row showed significant and positive association with plant height (0.293), ear head height (0.171), ear length (0.701), ear circumference (0.203), 100 grain weight (0.213) and grain yield per plant (0.658). Shelling percentage (0.029) was non -significantly and positively correlated with number of kernels per row. It was non significantly and negatively correlated with days to 50% tasselling (-0.041), days to 50% silking (-0.066), days to maturity (-0.050), number of kernel rows per cob (-0.109), protein content (-0.068) and tryptophan content (-0.070).

It was observed that 100 grain weight showed significant and positive association with plant height (0.266), ear head height (0.185), ear circumference (0.334), protein content (0.239) and grain yield per plant (0.554). It showed non significant and negative correlation with days to maturity (-0.006) and tryptophan content (-0.069). It was non significantly and positively correlated with days to 50% tasselling (0.046), days to 50% silking (0.054), ear length (0.091), number of kernel rows per cob (0.027), number of kernels per row (0.118), shelling percentage (0.034) and starch content (0.142).

It was observed that shelling percentage showed significant and positive correlation with days to 50% tasselling (0.217), days to 50% silking (0.236), days to maturity (0.219), ear head height (0.259). It was non significantly and positively correlated with plant height (0.107), ear circumference (0.049), number of kernel rows per cob (0.046), number of kernels per row(0.078), tryptophan content (0.030) and grain yield per plant (0.025), ear length (-0.016), 100 grain weight (-0.014), starch content (-0.080) and protein content (-0.059) were non significant and negatively correlated with shelling percentage.

Starch content was significantly and negative correlated with plant height (-0.205), ear head height (-0.261), ear length (-0.205).Number of kernel rows per cob (-0.169), number of kernels per row (-0.244), and tryptophan content (-0.169), and tryptophan content (-0.168). It was significantly and positively correlated with days to 50% tasselling (0.168), days 50% silking (0.177) and protein content (0.433). Days to maturity (0.004) and 100 grain weight (0.111) were non significantly and positively correlated with starch content. Shelling percentage (-0.053) was non significantly & negatively correlated with starch content.

Protein content was significantly and negatively correlated with number of kernel rows per cob (-0.191) where as significant and positive association between starch content and protein content. It was non significantly and negatively correlated with days to 50% tasselling (-0.107), days to 50% silking (-0.104), days to maturity (-0.155), plant height (-0.018), ear head height (-0.146), ear circumference (-0.110), Number of kernels per row (-0.067), shelling percentage (-0.066) and tryptophan content (-0.048), Ear length (0.052) and 100 grain weight (0.159) were non significant and positively correlated with protein content.

Tryptophan content was significantly and positively correlated with number of kernel rows per cob (0.185) where as significantly and negatively correlated with days to 50% silking (-0.161) and starch content (-0.164). It showed non significant and positive correlation with plant height (0.157), ear circumference (0.095), shelling percentage (0.028) days to 50% tasselling (-0.154), days to maturity (-0.079), ear head height (-0.058), ear length (-0.030), kernels per row (-0.059) 100 grain weight (-0.053), protein content (-0.044) were non significantly and negatively correlated with protein content.

The direct and indirect contribution of each character as revealed by path analysis is presented in Table 2. The genotypic correlation coefficient is only considered for path analysis. Direct effects: In present investigation it was found that days to 50% tasselling recorded the highest positive effect on yield and was also significantly and positively correlated with yield (1.525), followed by ear

circumference (0.768). The other characters, ear length (0.426), ear head height (0.304), tryptophan content (0.198), shelling % (0.190) and 100 grain weight (0.092) had positive direct effect of low magnitude. The trait days 50% silking (-0.924), days to maturity (-0.415), number of kernels per row (-0.101), starch content (-0.161), protein content (-0.225) had negative direct effect on grain yield.

Indirect effects: Days to 50% tasselling showed significant and positive association with grain yield (0.200). It was observed that days to 50% tasselling showed positive indirect effect through, ear head height (0.141), ear circumference (0.247), shelling percentage (0.060) and protein content (0.025).

Days to 50% silking had positive and significant association with grain yield (0.205) and contributed indirectly to yield through days to 50% tasselling (1.526), ear head height 0.138, ear circumference (0.221), shelling percentage (0.068) and protein content (0.022). Days to maturity had

It was observed that plant height showed positive indirect effect through days to 50% tasselling (0.289), ear head height (0.225), ear length (0.135), ear circumference (0.372), 100 grain weight (0.031), shelling percentage (0.023) and starch content (0.047). Ear head height was positively and significantly correlated with grain yield (0.408) and showed indirect positive effect through days to 50% tasselling. (0.707), ear circumference (0.276), 100 grain weight (0.024), shelling percentage (0.072), starch content (0.043) and protein content (0.036).

Ear length was positively and significantly correlated with grain yield (0.566) and showed positive indirect effect through days to 50% silking (0.104), days to maturity (0.059) ear head height (0.030), ear circumference (0.126). Number of kernel rows per cob (0.029), 100 grain weight (0.016) and starch content (0.044). Ear circumference was positively and significantly correlated with grain yield (0.674) and showed positive indirect effect through days to 50% tasselling (0.492), days to 50% silking (0.266), ear head height (0.109), ear length (0.070), 100 grain weight (0.059), protein content (0.050) and tryptophan content (0.024).

It was observed that kernel rows per cob showed positive indirect effect through days to 50% tasselling (0.588), ear head height (0.082) and ear circumference (0.491) shelling percentage (0.032), starch content (0.035), protein content (0.065) and tryptophan content (0.047). It had positive and significant association with grain yield (0.256).

Number of kernels per row was positively and significantly correlated with grain yield (0.658) and showed positive indirect effect through days to 50% silking (0.070), ear head height (0.071), ear length (0.378), ear circumference (0.285), 100 grain weight (0.019), starch content (0.051) and protein content (0.015). 100 grain weight indirectly contributed to yield through days to 50% tasselling (0.049), days to maturity (0.026), ear head height (0.081), ear length (0.075), ear circumference (0.492). It showed positive and significant association with grain yield (0.554) Shelling percentage indirectly contributed to yield through days to 50% tasselling (0.487), ear head height (0.116), starch content (0.013), protein content (0.013). It showed positive and significant association with grain yield (0.025).

Starch content was negatively and significantly correlated with grain yield (-0.295) and contributed indirectly to yield through days to 50% tasselling (0.278), plant height (0.067), kernel rows per cob (0.090), number of kernels per row (0.032) and 100 grain weight (0.013). Protein content was negatively and significantly correlated with grain yield (-0.339) and contributed indirectly to yield through days to 50% silking (0.093), days to maturity (0.116) kernel rows per cob (0.120), and 100 grain weight (0.022). It was observed that tryptophan content showed positive indirect effect through days to 50% silking (0.157), days to maturity (0.055), ear circumference (0.095), starch content (0.027) and protein content (0.010). It showed positive and non significant association with grain yield (0.126).

Correlation: In the present investigation the characters ear circumference, number of kernels per row, ear length, 100 grain weight, plant height, ear head height showed significant positive correlation with grain yield both at phenotypic and genotypic levels indicating dependence of these characters on each other. The other traits, *viz.*, days to maturity,

Table 2
Direct (Diagonal) and indirect path effects using genotypic correlation of different characters towards grain yield

Characters	*Days to 50% Tasselling*	*Days to 50% Silking*	*Days to Maturity*	*Plant Height*	*Ear head Height*	*Ear Length*	*Ear circum-ference*	*No. of kernel rows per cob*	*No. of kernel per row*	*100 grain weight*	*Shell-ing %*	*Starch content (%)*	*Protein content (%)*	*Trypto-phan content %*	*grain yield/ Plant*
Days to 50% Tasselling	**1.525**	-0.922	-0.591	-0.043	0.141	-0.025	0.247	-0.160	0.002	0.003	0.060	-0.029	0.025	-0.033	0.200*
Days to 50% silking	1.526	**-0.924**	-0.555	-0.040	0.138	-0.048	0.221	-0.147	0.007	0.005	0.068	-0.030	0.022	-0.033	0.205*
Days to Maturity	1.347	-0.767	**-0.669**	-0.062	0.163	-0.037	0.235	-0.156	-0.000	-0.003	0.063	-0.000	0.039	-0.016	0.133
Plant Height	0.289	-0.164	-0.184	**-0.228**	0.225	0.135	0.372	-0.122	-0.038	0.031	0.023	0.047	0.005	0.031	0.424**
Ear head Height	0.707	-0.420	-0.359	-0.169	**0.304**	0.042	0.276	-0.112	-0.023	0.024	0.072	0.043	0.036	-0.012	0.408**
Ear Length	-0.091	0.104	0.059	-0.072	0.030	**0.426**	0.126	0.029	-0.089	0.016	-0.005	0.044	-0.003	-0.006	0.566**
Ear Circumference	0.492	0.266	-0.205	-0.110	0.109	0.070	**0.768**	-0.265	-0.037	0.059	-0.032	0.019	0.050	0.024	0.674**
No. of kernel rows per cob	0.588	-0.329	-0.253	-0.067	0.082	-0.030	0.491	**-0.415**	0.002	0.006	0.032	0.035	0.065	0.047	0.256**
No. of kernels per row	-0.042	0.070	-0.003	-0.087	0.071	0.378	0.285	0.008	**-0.101**	0.019	0.005	0.051	0.015	-0.014	0.658**
100 grain weight	0.049	-0.052	0.026	-0.076	0.081	0.075	0.492	-0.029	-0.021	**0.092**	0.006	-0.023	-0.053	-0.013	0.554**
Shelling %	0.487	-0.333	-0.221	-0.028	0.116	-0.012	-0.013	-0.071	-0.003	0.003	**0.190**	0.013	0.013	0.006	0.025
Starch(%)	0.278	-0.176	-0.001	0.067	-0.081	-0.116	-0.094	0.090	0.032	0.013	-0.015	**-0.161**	-0.097	-0.033	-0.295**
Protein(%)	-0.174	0.093	0.116	0.005	-0.049	0.006	-0.171	0.120	0.007	0.022	-0.011	-0.070	**-0.225**	-0.009	-0.339**
Tryptophan%	-0.255	0.157	0.055	-0.036	-0.018	-0.014	0.095	-0.098	0.007	-0.006	0.005	0.027	0.010	**0.198**	0.126

*.** significant at 5% and 1% respectively.positive and non significant association with grain yield (0.133) and contributed indirectly to yield through days to 50% tasselling (1.347), ear head height (0.163) ear circumference (0.235) and protein content (0.039).

shelling percentage and tryptophan content recorded non significant positive correlation with yield, both at genotypic and phenotypic levels. Similar findings were reported by Rahman *et al*. (1995).

The traits *viz.*, starch content and protein content showed significant and negative correlation with grain yield. The traits plant height showed significant and positive correlation with ear head height, ear length, ear circumference number of kernel rows per cob, number of kernels per row, 100 grain weight, tryptophan content suggesting that the selection for increased grain yield production. The trait cob length was significantly and positively correlated with plant height, ear circumference, number of kernels per row, 100 grain weight, suggesting that the selection for increased cob length will be rewarded with increased grain yield per plant. Starch content only show significant positive correlation with only protein content.

Path analysis: Path coefficient analysis is simply a standardized partial regression coefficient, which splits the correlation coefficient into measures of direct and indirect effects. In the present investigation path analysis was worked out by following Dewey and Lu (1959) to estimate the magnitude and direction of direct and indirect effects of various yield and yield contributing characters. Correlation coefficients along with path effects together provide more reliable information, which can be best used in crop improvement. If the correlation between a causal factor and direct effects is more or less of equal magnitude it explains the true relationship between the traits direct selection through these traits will be rewarding. However, if the correlation coefficient is positive and the direct effect is negative or negligible the indirect causal factors are to be considered in simultaneous selection Singh and Kakar (1977).

In the present study the characters *viz.*, days to 50% tasselling, ear circumference and ear length recorded high magnitude of direct effects, indicating true and perfect relationship between them thus suggesting that selection for these traits will be highly rewarding for improving the grain yield. Similar results were obtained by Sharma and Kumar (1987), Alok kumar *et al* (1999), Venugopal *et al*. (2003) for ear circumference. Kumar et al. (2006) and Shakoor et al. (2007) for days to 50% tasselling.

The yield component days to 50% tasseling recorded high magnitude of indirect effect through earhead height, ear circumference, shelling percentage and protein content. These findings suggest indirect selection of days to 50% tasselling for grain yield. The another yield component, ear circumference recorded high magnitude of indirect effect through days to 50% tasselling, days to 50% siliking, ear head height, ear length, 100 grain weight, these findings suggest indirect selection of ear circumference for grain yield.

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