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Association Studies for Grain Yield and Yield Related Traits in Maize

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ABSTRACT: Better grain yield is ultimate objective of any crop improvement scheme. However, yield being a complex trait under polygenic control, it become imperative to decipher the contribution of component traits towards yield and then devising a selection strategy. To understand association of component traits with yield, eight inbreds and their twenty-eight hybrids were evaluated for correlation and path coefficient analysis. Eight inbreds were subjected to half diallel mating design. Crosses were made during *Kharif-19* and hybrids were analysed during *Rabi - 2019-20* at Maize farm at TCA Dholi in randomized block design with three replications. Twelve traits were selected for present study. The analysis of variance showed ample amount of genetic variability among genotypes for all the characters under study. Correlation coefficient studies indicated that eight traits viz., chlorophyll content (r = 0.5119), cob length (r = 0.6673), cob girth (r = 0.1904), number of kernel rows/ear (r = 0.5991), number of kernels/row (r = 0.7495) and 1000 grain weight (r = 0.4693) had positive significant association with grain yield. From path coefficient analysis studies, it became clear that traits viz., days to 50 % tasseling, ear height, number of kernels/row, days to 75 % brown husk, chlorophyll content had positive direct effect on grain yield. This study identifies chlorophyll content, number of kernel rows/ear and number of kernels/row as major yield contributing traits to improve yield effectively.

Keywords: Character association, Correlation, Path coefficient, Grain yield.

INTRODUCTION

Maize (*Zea mays* L.; 2n=20) is a cereal crop of great importance of family *Poaceae*; tribe *Maydeae* securing third place after wheat and rice in the world. It can thrive in a variety of environments. Maize is a crop that is widely grown worldwide and has its origin in South America. This crop can be produced all year long, including in the *Kharif*, *Rabi*, and *Summer* seasons. This crop is grown both as a standalone crop and as an intercrop with other crops like sugarcane, cotton, vegetables, and legumes. Area on which this crop is being grown in India is 9.5 mha, giving 28.7 mt production and 3006 kg of productivity per hectare (https://desagri.gov.in/, 2019-20). In Bihar it is being grown on 0.67 mha area, giving 3.19 mt production and 4771 kg of productivity per hectare. The effectiveness of a breeding programme primarily depends on the direction and strength of the association between yield and its component traits as well as the relative significance of each component that affects grain production (Kote *et al.,* 2014). Grain yield is a complex quantitative character that is influenced by plant genetics and how these factors interact with the environment (Kumar *et al.,* 2022). The contributions of two characters are assessed on a paired basis to determine their associations in correlation analysis. The correlation result is extremely valuable in determining the best methods for choosing superior genotypes (Silva *et al.,* 2016). Breeding for yield traits would be particularly successful when main component characters are positively correlated, but it would be challenging to simultaneously select for these features during varietal development if they are negatively correlated. While genotypic correlation offers an estimate of the inborn relationship between the genes governing any two traits, phenotypic correlation reflects the extent of the observed association between two traits (Joshi, 2005). The cause and effect of the trait association must be determined in order to create selection indices to improve yield genetically. Path analysis can be used to determine the cause and effect of the trait association. This approach divides the correlation coefficient between two traits into parts to assess their direct and indirect impacts on dependent character that is yield. Since this study shows the direct effects of particular yield component trait on yield as well as indirect effects via other yield component traits, it generally provides more information between variables than correlation coefficients (Ghimire and Timsina 2015). Calculating the direct and indirect effects of these traits on grain yield is crucial for fully understanding the intricate relationship between grain yield and other characters. Therefore, in order to increase the effectiveness of breeding programmes through the use of suitable selection indices, it is vital to understand the links that currently exist between grain yield and other metric traits of the crop before starting on grain yield improvement (Beluh *et al.,* 2018). In order to ascertain trait associations and the direct and indirect effects of yield-related traits on grain yield of maize inbreds and their hybrids, the current study was carried out.

MATERIAL AND METHODS

Experimental Site. The experimental site was located at Tirhut College of Agriculture, Dholi, Muzaffarpur under DRPCAU, Pusa, Samastipur (Bihar) during *kharif* 2019. The experimental plot had sandy loam soil type with fairly uniform topography and normal fertility status (pH range of soil was 5.5 to 5.7). The field was well drained with good irrigation water facility.

Experimental Material. Eight inbred lines were crossed in half diallel fashion during *Kharif* 2019 to generate 28 hybrids. Inbreds and their hybrids were evaluated during *Rabi* 2019-20 in randomized complete block design with three replications along with two checks i.e., DMRH-1308 and BIO-9637.

Data Collection and Statistical Analysis. Five randomly and replication wise chosen plants of every treatment were considered to record the data for all traits *viz*, plant height, ear height, chlorophyll content, cob length, cob girth, no. of kernel rows per ear, no. of kernels per row, 1000 grain weight and grain yield except for three characters naming days to 50% tasseling, days to 50% silking along with days to 75 %brown husk. Data for these three traits were collected on plot basis. Simple correlation coefficients were calculated between traits using the procedure given by Panse and Sukhatme (1967). Correlation coefficient was partitioned into measures of direct and indirect effects of independent traits on the dependent trait i.e., yield as per procedure given by Wright (1921) and further applied by Dewey and Lu (1959).

RESULTS AND DISCUSSION

Correlation Analysis. Character association studies revealed positive significant correlation of grain yield with chlorophyll content (0.5119), cob length (0.6673), cob girth (0.1904), no. of kernel rows per cob (0.5991), no. of kernels per row (0.7495) and 1000 grain weight (0.4693) whereas grain yield had negative significant association with days to 50 % tasseling (-0.2120), days to 50% silking (-0.2153). Rest of the characters had non-significant association with grain yield. The data from correlation are presented in Table 1.

Negative significant correlation of days to 50 % tasseling was found with chlorophyll content (-0.4487) and number of kernels per rows (-0.2101) while it was positive significantly correlated with ear height (0.1975). Negative, significant association for days to 50 % silking was also found with chlorophyll content (-0.4453) along with kernels per row (-0.2112) and significant correlation in positive direction with ear height (0.1981). Days to 75 % brown husk showed significant negative association with chlorophyll content (-0.2868) only. Positive significant association was found for plant height with ear height (0.5440), chlorophyll content (0.3303), cob length (0.3912), kernel rows per cob (0.3491) along with kernels per row (0.3764). Ear height had positive correlation with cob length (0.2779). Chlorophyll content was found positively and significantly correlated with cob length (0.4295), kernel rows per cob (0.5293), kernels per row (0.5108) along with 1000 grain weight (0.2703). Cob length had positive significant association with kernel rows per cob (0.5618), kernels per row (0.7125) along with 1000 grain weight (0.2127). Cob girth showed positive significant association with 1000 grain weight (0.2870). Kernel rows per cob had significant positive correlation with kernels per row (0.7376) along with 1000 grain weight (0.3115).

Table 1: Correlation coefficients of different characters.

Characters	Days to 50% Tasseling	Days to 50% Silking	Days to 75% Brown Husk	Plant Height	Ear Height	Chlorophyll Content	Cob Length	Cob Girth	No. of Kernel Rows/Cob	No. of Kernels/Row	1000 Grain Weight
Days to 50% Tasseling		0.9904**	0.7437**	-0.0354	0.1975*	-0.4487**	-0.1437	0.1204	-0.1799	-0.2101*	-0.0682
Days to 50% Silking			0.7360**	-0.0327	0.1981*	-0.4453**	-0.1373	0.1334	-0.1567	-0.2112*	-0.0544
Days to 75% Brown Husk				0.0226	0.1695	-0.2868**	-0.0243	0.0715	-0.0137	-0.0302	0.0691
Plant Height					0.5440**	0.3303**	0.3912**	-0.0826	0.3491**	0.3764**	-0.0613
Ear Height						0.1529	0.2779**	0.0964	0.1814	0.1444	0.0377
Chlorophyll Content							0.4295**	0.0526	0.5293**	0.5108**	0.2703**
Cob Length								0.0500	0.5618**	0.7125**	0.2127*
Cob Girth									0.0069	-0.1058	0.2870**
No. of Kernel Rows/Cob										0.7376**	0.3115**
No. of Kernels/Row											0.2955**
1000 Grain Weight											
Grain Yield	-0.2120*	-0.2153*	-0.035	0.1806	0.1648	0.5119**	0.6673**	0.1904*	0.5991**	0.7495**	0.4693**

"*, **Significant at 5 % and 1 % level of significance, respectively".

Number of kernels per row showed positive significant correlation with 1000 grain weight (0.2955). The above findings about association of different traits with grain yield and among themselves showed parallelism with earlier results of Reddy *et al.* (2012); Natraj *et al.* (2014); Reddy and Jabeen (2016); Kandel *et al*. (2018); Hosmani *et al*. (2018); Bartaula *et al.* (2019); Dash *et al.* (2020) in maize.

Path Analysis. Positive extent of direct effect on grain yield was depicted by days to 50 % tasseling (0.4011), days to 75 % brown husk (0.0448), ear height (0.0882), ear length (0.2320), ear girth (0.1727), kernel rows/cob (0.0166), chlorophyll content (0.0975), kernels/row (0.5241), 1000 grain weight (0.1677) and negative direct effect by days to 50 % silking (-0.5039) and plant height (-0.1717) (Table 2).

Days to 50 % tasseling depicted positive indirect effect on grain yield through days to 75 % brown husk (0.0333), cob height (0.0174), cob girth (0.0208) and negative indirect effect via days to 75 % silking (-0.4991), chlorophyll content (-0.0437), ear length (-0.0333), kernels/row (-0.1101) along with 1000 grain weight (-0.0114). Days to 50 % silking depicted indirect effect in positive direction on grain yield via days to 50 % tasseling (0.4072), days to 75 % brown husk (0.0329), cob height (0.0175) and cob girth (0.0230) and negative indirect effect via chlorophyll content (-0.0434), ear length (-0.0319) and kernels/row (-0.1107). Days to 75% brown husk depicted positive indirect effect on grain yield via days to 50 % tasseling (0.3057), 1000 grain weight (0.0116), cob girth (0.0123), ear height (0.0149), while negative indirect effect via days to 50 % silking (-0.3708), chlorophyll content (-0.0280), ear length (-0.0056), and kernels/row (-0.0158).

Plant height depicted positive indirect effect via ear length (0.0480), kernels/row (0.1973), cob length (0.0908), days to 50 % tasseling (0.0165), chlorophyll content (0.3220), kernels rows/cob (0.0058) and negative indirect effect via cob girth (-0.0143) along with 1000 grain weight (-0.0103). Ear height depicted positive indirect effect via chlorophyll content (0.0149), kernels/row (0.0757), ear length (0.0645), ear girth (0.0167), days to 50 % tasseling (0.0812), and negative indirect effect via days to 50 % silking (-0.0998) along with plant height (-0.0934).Chlorophyll content had positive indirect effect via days to 50 % silking (0.2244), 1000 grain weight (0.0453), cob length (0.0997), cob height (0.0135), kernels/row (0.2677), whereas negative indirect effect via days to 50 % tasseling (-0.1845), days to 75 % brown husk (-0.0128) and height of plant (-0.0567). Cob length had positive indirect effect on grain yield via kernels/row (0.3734), 1000 grain weight (0.0357), cob height (0.0245), days to 50 % silking (0.0692), chlorophyll content (0.0419) and negative indirect effect via days to 50 % tasseling (-0.0591) and height of plant (-0.0672). Cob girth depicted positive indirect effect on grain yield viaear length (0.0116), height of plant (0.0142), days to 50 % tasseling (0.0495), 1000 grain weight (0.0481), and negative indirect effect via days to 50 % silking (-0.0672) along with kernel rows/cob (-0.0554).

Kernels/row depicted positive indirect effect on dependent trait via ear length (0.1653), ear height (0.0127), days to 50 % silking (0.1064), chlorophyll content (0.0498), kernel rows/cob (0.0122), 1000 grain weight (0.0496), whereas negative indirect effect via days to 50 % tasseling (-0.0864), height of plant (-0.0646) along with cob girth (-0.0183). Trait 1000 grain weight depicted positive indirect effect on grain yield *via* days to 50 % silking (0.0274), height of plant (0.0105), chlorophyll content (0.0264), cob length (0.0494), cob girth (0.0496), kernels/row (0.1549) whereas negative indirect effect via days to 50 % silking (-0.0280). Above findings about path coefficient was in parallelism with earlier results of Beiragi *et al.* (2011); Tulu (2015); Pandey *et al*. (2017); Hosmani *et al*. (2018); Singh *et al.* (2020); Borkhatariya *et al.* (2022).

Table 2: Path coefficient of different characters.

Characters	Days to 50% Tasseling	Days to 50% Silking	Days to 75% Brown Husk	Plant Height	Ear Height	Chlorophyll Content	Cob Length	Cob Girth	No. of Kernel Rows/Cob	No. of Kernels/Row	1000 Grain Weight
Days to 50% Tasseling	**0.4111**	0.4072	0.3057	-0.0146	0.0812	-0.1845	-0.0591	0.0495	-0.0739	-0.0864	-0.0280
Days to 50% Silking	-0.4991	**-0.5039**	-0.3708	0.0165	-0.0998	0.2244	0.0692	-0.0672	0.0790	0.1064	0.0274
Days to 75% Brown Husk	0.0333	0.0329	**0.0448**	0.001	0.0076	-0.0128	-0.0011	0.0032	-0.0006	-0.0014	0.0031
Plant Height	0.0061	0.0056	-0.0039	**-0.1717**	-0.0934	-0.0567	-0.0672	0.0142	-0.0599	-0.0646	0.0105
Ear Height	0.0174	0.0175	0.0149	0.0480	**0.0882**	0.0135	0.0245	0.0085	0.0160	0.0127	0.0033
Chlorophyll Content	-0.0437	-0.0434	-0.0280	0.0322	0.0149	**0.0975**	0.0419	0.0051	0.0516	0.0498	0.0264
Cob Length	-0.0333	-0.0319	-0.0056	0.0908	0.0645	0.0997	**0.2320**	0.0116	0.1304	0.1653	0.0494
Cob Girth	0.0208	0.0230	0.0123	-0.0143	0.0167	0.0091	0.0086	**0.1727**	0.0012	-0.0183	0.0496
No. of Kernel Rows/Cob	-0.0030	-0.0026	-0.0002	0.0058	0.0030	0.0088	0.0093	0.0001	**0.0166**	0.0122	0.0052
No. of Kernels/Row	-0.1101	-0.1107	-0.0158	0.1973	0.0757	0.2677	0.3734	-0.0554	0.3866	**0.5241**	0.1549
1000 Grain Weight	-0.0114	-0.0091	0.0116	-0.0103	0.0063	0.0453	0.0357	0.0481	0.0522	0.0496	**0.1677**
Grain Yield	-0.2120	-0.2153	-0.0350	0.1806	0.1648	0.5119	0.6673	0.1904	0.5991	0.7495	0.4693

Diagonal values indicate direct effects, Residual effect = 0.5269

CONCLUSIONS

Positive and significant association of grain yield with component traits makes selection for higher yield easy and reliable. Significant association of chlorophyll content, cob length, cob girth, no. of kernel rows per cob, no. of kernels per row and 1000 grain weight revealed importance of these traits in order to improve yield effectively. Results from path analysis indicated that traits such as no. of kernels per row, cob length, cob girth, 1000 grain weight had direct effect on grain yield indicating the usefulness of these traits for direct selection.

FUTURE SCOPE

Maize yield has improved over the years as a result of single cross hybrids mainly. However, stagnation of yield in African and Asian countries in recent years has forced to define selection scheme based on yield contributing traits (Ray *et al.,* 2012). In current study, Days to 50% tasseling, Chlorophyll content, number of kernel rows per ear, number of kernels per row and 1000 grain weight have been found promising in increasing grain yield. Further these results can be subjected to multilocation evaluation for reliability of findings. Hence, these findings hold a great importance for improving grain yield in maize in future breeding programme.

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Conflict of Interest. None.

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