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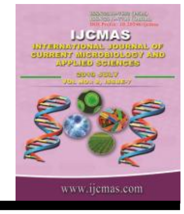

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Correlation and Path Coefficient Analysis for Yield Contributing Traits and Grain Zinc Concentration in Biofortified Inbred Lines of Maize (*Zea mays* L.)

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A B S T R A C T

The present investigation was undertaken with the objective to study correlation and path coefficient analysis for yield contributing traits and grain zinc concentration in 30 biofortified inbred lines of maize (*Zea mays* L.). Trials were conducted during kharif 2017 at Agricultural Research farm, Institute of Agricultural Sciences, BHU in Randomized Block Design with three replications. Each entry was planted in row-to-row and plant-to-plant spacing of 60 cm x 20 cm. All the recommended packages of practices were followed to raise a good crop. In general, genotypic correlation coefficients were higher than the phenotypic correlation coefficients, indicating that there is strong inherent association between the various traits investigated in this work. Tassel length, ear height and plant height was positively and significantly associated with grain yield per plant and grain zinc concentration which indicates the importance of these traits in selection for high yielding inbred lines. Path analysis studies showed direct positive effect of cob diameter, tassel length, ear height, days to 50% silking, 100 seed weight and plant height on grain yield per plant. Hence, these traits can be considered as important attributes for suitable selection criteria for both direct and indirect selection

Introduction

Maize (*Zea mays* L.) is one of the most important food crops grown in the world. It serves as an important human food, a basic element of animal feed and a highly demanded raw material for manufacture of many industrial products. In India, it is one of the three most important cereal next to wheat and rice and cultivated over an area of 8.69 million hectares, grains production 21.81 million tons and the average productivity 2509 kg /ha (2015-2016, Annual report DAC & FW). Maize kernels are good source of protein (9-10%), oil (2.5-4%), carbohydrate (65-70%), albuminoides (10.4%), crude fibre (2.3%) and ash (1. 3%) (Cortez and Wild-Altamirano, 1972). Maize is a predominant crop in context of supplementing global nutrition by bridging the gap of malnutrition through "biofortification" which is a process to increase the bioavailability and the concentration of nutrients in crops through both conventional plant breeding (White and Broadley, 2008) and recombinant DNA technology (Zimmermann and Hurrell, 2002). Yield being a complex trait is governed by a large number of genes and it depends on plant genotype and its interaction with environment (Khatab *et al.,* 2016). The influence of each trait on yield could be known through correlation studies with a view to determine the extent and nature of relationships prevailing among yield and yield attributing traits. In general, genotypic correlation was higher than phenotypic correlation indicating a low influence of environmental factors and relative stability of the genotypes (Bhole and Patil, 1984). Path analysis is a multivariate analysis, which deals with a closed system of variables, which are linearly related. Dewey and Lu (1959) firstly employed this method to disentangle the direct and indirect influences of components of seed yield. The path coefficient quantifies the inter relationship among different components and their direct and indirect effect on grain yield.

Materials and Methods

In this present study the experimental material is comprised of 30 biofortified inbred lines of maize which were used to assess correlation and path coefficient analysis for yield contributing traits and grain zinc concentration. The field experiments were conducted in Randomized Block Design (RBD) with three replications during kharif 2017 at Agricultural Research farm, Institute of Agricultural Sciences, BHU Varanasi. The border effect was avoided by planting two border rows. The crop was raised following recommended packages of agronomic practices.

Observations for the pre and post-harvest parameter were recorded on five plants selected at random from each genotype for each replication and averaged. Observations on one biochemical and ten morphological traits viz., Days to 50 % tasseling, Days to 50 % silking, Width of leaf (cm), ear height (cm), plant height (cm), cob length without husk (cm), cob diameter (cm), 100 seed weight (g), grain yield per plant (g) were recorded. Biochemical analysis for kernel zinc concentration was carried out with diacid (HNO3 and HClO4) digestion of seeds followed by atomic absorption spectrometry (AAS) method as per the protocol described by Zarcinas *et al.,* (1987) with some modifications suggested by Singh *et al.,* (2005). Grain Zinc concentration was estimated following AAS based on the Beer - Lambert law using the relation Element concentration (mg/kg) = AAS reading × dilution factor.

Results and Discussion

Correlation coefficient analysis

Genotypic and phenotypic correlation among the eleven quantitative traits of studied maize genotypes was computed and presented in table 1. Tassel length showed positive and significant phenotypic correlation with grain yield per plant and positive and highly significant genotypic correlation with grain yield (0.2286P, 0.2777G). It had positive correlation with GZC (0.0439P, 0.0549G). Ear height showed positive correlation with grain yield (0.1039 P, 0.156G) (Kumar *et al.,* 2006; Jawaharlal *et al.,* 2011; Barua *et al.,* 2017; Gazal *et al.,* 2018). It had positive and significant genotypic correlation with GZC (0.2335) and positive non-significant phenotypic correlation with GZC (0.159). Plant height had positive and non-significant correlation with grain yield (0.0267P, 0.0632G) (Gazal *et al.,* 2018) and GZC

(0.0417P, 0.0582G). Cob length without husk showed positive and non-significant correlation with GZC (0.0114P, 0.0373 G). It had negative and non- significant correlation with grain yield (-0.0174P,-0.178 G).Cob diameter had positive and significant correlation with grain yield (0.2353P, 0.3299G) (Kumar *et al.,* 2014) and negative and highly significant correlation with GZC (-0.3491P, -0.4741 G). Hundred seed weight showed positive and non-significant correlation with grain yield (0.0699P, 0.0859G) (Gazal *et al.,* 2018) while negative and highly significant correlation with GZC (-0.2863 P, -0.3129 G). Days to 50% tasseling showed negative correlation with grain yield (-0.086 P and -0.330 G) and also significant and negative correlation with grain zinc concentration (GZC) (-0.2514P, -0.6421G). Days to 50% silking showed significant negative genetic correlation with grain yield while non-significant phenotypic correlation with grain yield (-0.047 P, -0.298G) (Sumalini and Manjulata, 2012 and Kumar *et al.,* 2014). It had negative correlation with GZC (-0.105P, -0.3473 G). Leaf width showed negative correlation with grain yield (-0.1016P, -0.1096 G) and GZC (-0.0495P, -0.0737G). Zinc concentration showed negative and non-significant correlation with grain yield (-0.0386P, -0.0714G) (Banziger and Long, 2000; Brkic *et al.*, 2003 and Chakrabarti *et al.*, 2009). In the present investigation the traits cob diameter, tassel length showed positive and highly significant genotypic correlation and positive and significant phenotypic correlation with yield. Ear height, 100 seed weight and plant height hadpositive correlation with grain yield both at phenotypic and genotypic level, indicating the importance of these traits in selection for yield.

Path coefficient analysis

Degree and direction of association between various yield attributing traits and grain yield is key to determine suitable selection criteria for both direct and indirect selection through components. The phenotypic path coefficient of different yield attributing traits and grain Zinc concentration was partitioned into direct and indirect effects on grain yield and the data is presented in Table 2. In the present study it was found that cob diameter (0.2933) exhibited the largest direct effect on grain yield per plant followed by tassel length (0.2336), ear height (0.1696),(Kumar *et al.,* 2006; Munwar *et al.,* 2013) days to 50% silking (0.1608) (Sadaiah *et al.,* 2014) 100 seed weight (0.1086)(Kumar *et al.*, 2006; Sofi & Rather, 2001) and plant height (0.0371) (Venugopal *et al.,* 2003; Jakhar *et al.,* 2017) contrary to these finding days to 50% tasseling (-0.2087), leaf width (-0.1469) and cob length without husk (-0.0419) showed negative direct effect on grain yield per plant. Grain zinc concentration has no significant direct or indirect effect on grain yield per plant (Chakrabarti *et al.,* 2009). Among studied traits days to 50% tasseling showed positive indirect effect on grain yield per plant via grain zinc concentration (0.0525), plant height (0.0207), tassel length (0.0175), leaf width (0.0029) and negative indirect effect via cob length without husk (-0.0525), cob diameter (-0.0227). Days to 50% silking showed indirect effect on grain yield per plant via days to 50% tasseling (0.1327), cob length without husk (0.0337), 100 seed weight (0.0214) cob diameter (0.0030) and negative indirect effect via plant height (-0.0196), grain zinc concentration (-0.0169). Leaf width showed positive indirect on grain yield per plant via cob length without husk (0.0121), grain zinc concentration (0.0073) and negative indirect effect via tassel length (-0.0197), 100 seed weight (-0.0155). Tassel length showed positive indirect effect via leaf width (0.0314), cob length without husk (0.0164) cob diameter (0.0146), grain zinc concentration (0.0103) and negative indirect effect via plant height (-0.0203), days to 505 tasseling (-0.0196).

Table.1 Estimates of Genotypic and phenotypic Correlation co-efficient between yield and its related trait in thirty genotypes of maize

Traits		DTT	DTS	LW	TL	EH	PH	CLWOH	CD	100 SW	Zn	GY/P
DTT	**G**	**1.0000**	1.1769**	-0.0500	-0.1500	0.0176	-0.5194**	-0.0474	0.3049**	0.2722**	-0.6421**	-0.3304**
	P	**1.0000**	0.8250 **	-0.014	-0.084	-0.0013	-0.099	0.2516 *	0.1087	0.0821	-0.2514 *	-0.086
DTS	G		**1.0000**	-0.1490	-0.1102	-0.1344	-0.3241**	0.2153*	0.2003	0.3133**	-0.3473**	-0.2982**
	P		**1.0000**	-0.0319	-0.0836	-0.0097	-0.122	0.2096 *	0.0189	0.1329	-0.105	-0.0474
LW	G			**1.0000**	0.1307	-0.0022	0.0378**	-0.0798	0.1137	0.1186	-0.0737	-0.1096
	P			**1.0000**	0.1343	0.0116	0.0429	-0.0827	0.0843	0.1055	-0.0495	-0.1016
TL	G				**1.0000**	-0.0169	-0.1055	0.3561**	0.0163	0.0002	0.0549	0.2777**
	P				**1.0000**	0.0117	-0.0869	0.0704	0.0626	-0.0023	0.0439	0.2286
EH	G					**1.0000**	-0.3706	-0.3751**	0.2543*	0.1733	0.2335*	0.156
	P					**1.0000**	-0.2349 *	-0.1338	0.1765	0.1512	0.159	0.1039
PH	G						**1.0000**	-0.5668**	-0.1725	0.0167	0.0582	0.0632
	P						**1.0000**	-0.135	-0.0921	0.0332	0.0417	0.0267
CLWOH	G							**1.0000**	-0.4258**	-0.2436*	0.0373	-0.1787
	P							**1.0000**	-0.0517	-0.1122	0.0114	-0.0174
CD	G								**1.0000**	0.1178	-0.4741**	0.3299**
	P								**1.0000**	0.0698	-0.3491 **	0.2352
100 SW	G									**1.0000**	-0.3129**	0.0859
	P									**1.0000**	-0.2863 **	0.0699
Zn	G										**1.0000**	-0.0714
	P										**1.0000**	-0.0386

*and ** Significant at 5% and 1% level of significance, respectively. Where PH (cm) = plant height, DTT (50%) = days to 50% tasseling, DTS(50%) = days to 50% silking, LW(cm)=leaf width, EH(cm) = ear height, TL(cm) = tassel length, CLWOH(cm) =cob length without husk, CD(cm) = cob diameter, 100SW(g) =100 seed weight, Y/P = yield per plant, Zn (mg/kg)=Zinc content.

Table.2 Estimates of Phenotypic path matrix of direct (diagonal) and indirect effects of yields components on yield per plant in thirty maize genotypes

Character	DTT	DTS	LW	TL	EH	PH	CLWOH	CD	100 SW	Zn	GY/P
DTT	**-0.2087**	-0.1722	0.0029	0.0175	0.0003	0.0207	-0.0525	-0.0227	-0.0171	0.0525	-0.086
DTS	0.1327	**0.1608**	-0.0051	-0.0134	-0.0016	-0.0196	0.0337	0.0030	0.0214	-0.0169	-0.0474
LW	0.0020	0.0047	**-0.1469**	-0.0197	-0.0017	-0.0063	0.0121	-0.0124	-0.0155	0.0073	-0.1016
TL	-0.0196	-0.0195	0.0314	**0.2336**	0.0027	-0.0203	0.0164	0.0146	-0.0005	0.0103	0.2286
EH	0.0002	0.0016	-0.0020	-0.0020	**0.1696**	0.0398	0.0227	-0.0299	0.0256	-0.0270	0.1039
PH	-0.0037	-0.0045	0.0016	-0.0032	-0.0087	**0.0371**	-0.0050	-0.0034	0.0012	0.0015	0.0267
CLWOH	-0.0106	-0.0088	0.0035	-0.0030	0.0056	0.0057	**-0.0419**	0.0022	0.0047	-0.0005	-0.0174
CD	0.0319	0.0056	0.0247	0.0184	0.0518	-0.0270	-0.0152	**0.2933**	0.0205	-0.1024	0.2352
100 SW	-0.0089	-0.0144	-0.0115	0.0003	0.0164	-0.0036	0.0122	-0.0076	**0.1086**	0.0311	0.0699
Zn	-0.0014	-0.0006	-0.0003	0.0002	0.0009	0.0002	0.0001	-0.0019	-0.0016	**0.0055**	-0.0386

Where PH (cm) = plant height, DTT (50%) = days to 50% tasseling, DTS(50%) = days to 50% silking, LW(cm)=leaf width, EH(cm) = ear height, TL(cm) = tassel length, CLWOH(cm) =cob length without husk, CD(cm) = cob diameter, 100SW(g) =100 seed weight, Y/P = yield per plant, Zn (mg/kg)=Zinc content

Ear height showed positive indirect effect via plant height (0.0314), 100 seed weight (0.0256), cob length without husk (0.0227) and negative indirect effect via cob diameter (-0.0299) and grain zinc concentration (-0.0270). Cob diameter showed positive indirect effect via ear height (0.0518), days to 50% tasseling (0.0319), leaf width (0.0247), 100 seed weight (0.0205) and negative indirect effect via grain zinc concentration (-0.1024) and cob length without husk (-0.0152). 100 seed weight showed positive indirect effect via grain zinc concentration (0.0311), ear height (0.0164) and negative indirect effect via days to 50% tasseling (-0.0144) and leaf width (-0.0115).

Tassel length, ear height and plant height was positively and significantly associated with grain yield per plant and grain zinc concentration which indicates the importance of these traits in selection for higher yield and grain zinc concentration. Cob length show positive association with GZC but negative association with grain yield as against of cob diameter and 100 seed weight, which had positive association with grain yield but a negative association with GZC. Days to 50% tasselling and silking and leaf width has negative association with grain yield and GZC while GZC itself had a negative association with grain yield. Path analysis studies showed that cob diameter, tassel length, ear height, days to 50% silking, 100 seed weight and plant height had direct positive effect on grain yield per plant, contrary to these finding days to 50% tasselling, leaf width and cob length without husk showed negative direct effect on grain yield per plant.

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