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GENETIC VARIABILITY AND INTERRELATIONSHIPS AMONG GRAIN YIELD AND YIELD COMPONENTS IN MAIZE

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ABSTRACT

Genetic variability and interrelationships among grain yield and its components were determined in eighty-three genotypes of maize (Zea mays L.). The differences between genotypic and phenotypic coefficients of variation were very low for all characters studied, indicating that the environmental effects in the development of these parameters are low and these characters were mostly governed by the genetic factors. High heritability coupled with high genetic advance was observed in respect of grain yield plant^{-1}, leaves plant^{-1}, 100-kernel weight, harvest index and ear length, indicating the additive genetic control in the inheritance of these characters. Grain yield plant^{-1} exhibited positive and significant association with almost all the characters studied except ear height, days to 50 per cent tasseling, days to 50 per cent silking and anthesis silking interval. Harvest index had the highest direct effect on grain yield plant^{-1} followed by days to 50 per cent tasseling and stover yield plant^{-1}, indicating that these characters are major yield contributing characters. Therefore, there is a better chance for improvement of maize yield through the direct selection of these characters since they had significant role in enhancing the yield.

Key words: Maize, heritability, genetic advance, interrelationships, yield components

INTRODUCTION

Maize is the world's most widely grown cereal grown and is primary staple food in many developing countries. It is a versatile crop with wider genetic variability and able to grow successfully throughout the world. It is the third most important grain crop of the world after wheat and rice and accounts for 4.8% of the total cropped area and 3.5% of the value of the agricultural output (Saleem *et al.*, 2008). It is a multi-purpose crop which provides edible oil for human use, feed for poultry and fodder for livestock. Estimates of genetic parameters serve as a base for selection and hybridization since degree of variability for a given character is a basic pre-requisite for its improvement. Naushad *et al.* (2007) observed considerable genotypic variability among various maize genotypes for cob length, number of kernel rows cob^{-1} , 300 grain weight and grain yield. The study of correlation of yield and yield related components is important to enhance selection of genotypes for improvement. Many researchers studied association of characters for the selection of high yielding varieties. Orlyanskll et *al.* (1999) reported that number of grains row^{-1} and number of grains ear^{-1} were the most important traits influencing grain yield. Characters like number of grains row^{-1}, 1000-grain weight, ear diameter and plant height are useful for improving grain yield in hybrids. Grain yield is a polygenic character, where direct selection would not be a reliable approach on account of being highly influenced by environmental factors. Hence, it becomes very essential to know the nature of association and to identify the direct as well as indirect contribution of component traits, which can be biometrically estimated by correlation and path coefficient analysis. The present study was undertaken to assess the genetic variability for important quantitative characters and to know association among them in order to develop high yielding desirable genotypes in maize.

MATERIALS AND METHODS

Fifteen diverse yellow seeded inbred lines of maize *viz.*, HKI 295, HKI 536, V 351, HKI 3-4-8-5ER, HKI 3-4-8-6ER, HKI 323-8, HKI 1332, HKI 1532, LM 13, LM 16, HKI 193-1, HKI 161, HKI 163, HKI 192 and LTP 1 were crossed with four testers *viz.*, WI 241, WI 249, WI 263 and WI 275 in a line x tester mating design to generate 60 hybrids. The complete set of eighty-three genotypes including 60 hybrids, 19 parents and four standard checks *viz.*, Bio 9681, Prabal, PEHM 2 and Mahi Kanchan were evaluated in randomized block design with three replications at Agricultural Research Station, Banswara (Rajasthan) during *kharif*, 2009. Each plot consisted of single row of 5.0 m length with 60 x 20 cm crop geometry. The observations were recorded on ten randomly selected competitive plants of each

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genotype in each replication for plant height, ear height, ear length, ear diameter, anthesis silking interval (ASI), leaves plant^{-1}, kernel rows ear^{-1}, 100-kernel weight, harvest index, stover yield plant^{-1} and grain yield plant^{-1}, while days to 50 per cent tesseling and days to 50 per cent silking were recorded on whole plot basis. The genotypic and phenotypic coefficient of variation, heritability and genetic advance (GA) as percentage of mean were worked out as per procedure outlined by Al-Jibouri *et al.* (1958). The genotypic and phenotypic correlation coefficients and path analysis were computed following the standard statistical procedures of Singh and Chaudhary (1979) and Dewey and Lu (1959), respectively.

RESULTS AND DISCUSSION

The differences between genotypic coefficients of variance (GCV) and phenotypic coefficients of variance (PCV) were very low for all characters studied, indicating that the environmental effects in the development of these parameters are low and these characters were mostly governed by the genetic factors (Table 1).

Table 1: Range, mean, TMS and genetic parameters for grain yield and component traits in maize

SN	Characters	Range	Mean ± SEm	TMS	Genetic parameters			
					Genotypic coefficient of variation (GCV)	Phenotypic coefficient of variation (PCV)	Herita-bility (bs)	Genetic advance (% of mean)
1	Days to 50% tasseling	39.33-54.67	46.46 ± 1.57	27.8188**	7.62	8.11	48.00	8.02
2	Days to 50% silking	42.33-58.33	49.80 ± 1.59	30.9434**	7.60	7.87	50.61	8.21
3	Anthesis silking intervel	3.00-4.33	3.35 ± 0.23	0.4101**	12.69	14.68	35.03	10.59
4	Plant height (cm)	140.63-207.20	169.85 ± 6.62	702.4810**	9.12	10.56	59.16	12.87
5	Ear height (cm)	56.80-108.67	76.12 ± 4.72	467.6916**	15.18	18.60	66.65	25.54
6	Leaves plant^{-1}	9.37-16.13	12.02 ± 0.50	9.3977**	14.13	15.84	79.57	25.97
7	Ear length (cm)	11.23-16.23	13.60 ± 0.24	3.9210**	8.21	8.77	87.62	15.84
8	Ear diameter (cm)	3.40-5.82	4.30 ± 0.29	1.0612**	12.10	16.77	52.03	17.97
9	Kernel rows ear^{-1}	11.13-16.13	13.36 ± 0.53	4.4908**	9.27	10.72	59.60	13.16
10	100-kernel weight (g)	19.60-32.95	25.79 ± 0.23	29.0863**	12.04	12.14	98.43	24.60
11	Harvest index (%)	27.47-43.02	35.98 ± 1.02	40.5638**	9.82	10.98	79.98	18.09
12	Stover yield plant^{-1} (g)	100.08-120.75	112.07 ± 1.84	82.7401**	4.39	5.23	70.52	7.59
13	Grain yield plant^{-1} (g)	39.57-89.46	63.80 ± 2.63	386.0314**	17.30	18.71	85.41	32.93

Although the values of GCV were higher than the corresponding PCV values for all the characters. High GCV estimates are an indicative of less amenability of these traits to environmental fluctuations. The range of mean values for all the traits was relatively high and treatment mean squares (TMS) were significant for all the characters studied. The estimates of genotypic and phenotypic coefficient of variation (GCV and PCV) were high for grain yield plant^{-1}, ear height, leaves plant^{-1}, anthesis silking interval, ear diameter and 100-kernel weight, indicating the presence of high amount of variation for these traits (Table 1). Similar findings in maize were also reported by Rafique *et al.* (2004), Abirami *et al.* (2005), Alake *et al.* (2008) and Reddy *et al.* (2008). Heritability estimates for 100-kernel weight, ear length, grain yield plant^{-1}, harvest index and leaves plant^{-1} were higher than other traits studied (Table 1), showing heritable variation among genotypes. Thus, these characters may be used as selection criteria in breeding programmes. According to Johnson *et al.* (1955) and Panse (1957), heritability estimate along with genetic advance is more useful than heritability alone in predicting the effectiveness of selection. In the present investigation, high heritability coupled with high genetic advance was observed in respect of grain yield plant^{-1}, leaves plant^{-1}, 100-kernel weight, harvest index and ear length, indicating that these parameters were under the control of additive gene action. These observations are in confirmation with the findings of Rafique *et al.* (2004), Reddy *et al.* (2008) and Hefny (2011).

Genotypic correlation coefficients were, in general, similar in direction but higher in magnitude than phenotypic correlation coefficient (Table 2). Grain yield per plant was observed positively and significantly correlated with almost all the characters studied except ear height, days to 50 per cent tasseling, days to 50 per cent silking and anthesis silking interval. Similar findings were reported by Orlyanskll *et al.* (1999) and Alake *et al.* (2008). Harvest index had significant correlation with grain yield plant^{-1} and appeared to directly contribute to grain yield plant^{-1} followed by leaves plant^{-1}, stover yield plant^{-1}, ear diameter, plant height, kernel rows ear^{-1}, 100-kernel weight and ear length. These data confirm the findings of Yousuf *et al.* (2001), Rafique *et al.* (2004) and Selvaraj and Nagarajan (2011).

Table 2: Genotypic (G) and phenotypic (P) correlation coefficients of various component traits with grain yield in maize

S. No	Characters	r	Days to 50% silking	Anthesis silking interval	Plant height (cm)	Ear height (cm)	Leaves plant^{-1}	Ear length (cm)	Ear diame-ter (cm)	Kernel rows ear^{-1}	100-kernel weight (g)	Harvest index (%)	Stover yield plant^{-1} (g)	Grain yield plant^{-1} (g)
1	Days to 50% tasseling	G	1.00**	0.58**	-0.06	-0.05	-0.19	-0.01	-0.12	-0.20	-0.15	-0.02	-0.04	-0.03
		P	0.99**	0.25*	-0.08	-0.07	-0.12	-0.01	-0.05	-0.13	-0.10	-0.01	-0.06	-0.03
2	Days to 50% silking	G		0.65**	-0.05	-0.05	-0.18	-0.02	-0.13	-0.21	-0.15	-0.03	-0.04	-0.04
		P		0.37**	-0.08	-0.07	-0.12	-0.01	-0.06	-0.13	-0.10	-0.02	-0.06	-0.04
3	Anthesis silking intervel	G			0.06	-0.04	-0.07	-0.06	-0.14	-0.18	-0.07	-0.10	-0.06	-0.10
		P			-0.05	-0.02	-0.01	-0.03	-0.08	-0.05	-0.05	-0.06	-0.01	-0.06
4	Plant height (cm)	G				0.74**	0.71**	0.05	0.15	0.08	0.16	0.61**	0.44**	0.61**
		P				0.66**	0.52**	0.03	0.10	0.02	0.12	0.41**	0.32**	0.44**
5	Ear height (cm)	G					0.35**	-0.11	-0.07	-0.12	0.07	0.14	0.02	0.13
		P					0.27*	-0.11	-0.05	-0.06	0.06	0.12	0.03	0.12
6	Leaves plant^{-1}	G						0.46**	0.67**	0.63**	0.46**	0.66**	0.40**	0.68**
		P						0.38**	0.42**	0.43**	0.40**	0.49**	0.43**	0.56**
7	Ear length (cm)	G							0.72**	0.78**	0.58**	0.50**	0.23*	0.51**
		P							0.51**	0.58**	0.54**	0.42**	0.17	0.43**
8	Ear diameter (cm)	G								1.03	0.74**	0.65**	0.23*	0.65**
		P								0.57**	0.50**	0.38**	0.19	0.42**
9	Kernel rows ear^{-1}	G									0.74**	0.50**	0.25*	0.53**
		P									0.57**	0.34**	0.15	0.37**
10	100-kernel weight (g)	G										0.47**	0.42**	0.53**
		P										0.43**	0.32**	0.49**
11	Harvest index (%)	G											0.52**	0.98**
		P											0.31**	0.97**
12	Stover yield plant^{-1} (g)	G												0.67**
		P												0.53**

** and ** significant at P = 0.05 and 0.01, respectively*

The information derived from the correlation studies indicates only mutual association among the characters whereas, path coefficient analysis helps in understanding the magnitude of direct and indirect contribution for grain yield. Harvest index had the highest direct effect on grain yield plant^{-1} (Table 3) followed by days to 50 per cent tasseling and stover yield plant^{-1} and direct selection for these traits would be fruitful. These results are in consonance with the results of Venugopal *et al.* (2003), Jayakumar *et al.* (2007) and Hefny (2011). On the other hand, leaves plant^{-1}, plant height and 100-kernel weight exhibited maximum indirect effects on grain yield plant^{-1} via. harvest index and stover yield plant^{-1}, while ear

Table 3: Path analysis showing direct (diagonal) and indirect effects of yield attributing traits on grain yield plant^{-1} in maize

Character	Days to 50% tasseling	Days to 50% silking	Anthesis silking interval	Plant height (cm)	Ear height (cm)	Leaves plant^{-1}	Ear length (cm)	Ear diameter (cm)	Kernel rows ear^{-1}	100-kernel weight (g)	Harvest index (%)	Stover yield plant^{-1} (g)	Correlation with grain yield plant^{-1}
Days to 50% tasseling	0.44	-0.49	0.05	0.01	-0.00	-0.01	0.00	-0.01	-0.00	0.01	-0.02	-0.01	-0.03
Days to 50% silking	0.44	-0.49	0.05	0.01	-0.00	-0.01	0.00	-0.01	-0.00	0.01	-0.02	-0.01	-0.04
Anthesis silking interval	0.26	-0.32	0.08	-0.01	-0.00	-0.00	0.00	-0.01	-0.00	0.00	-0.08	-0.02	-0.10
Plant height (cm)	-0.02	0.02	0.00	-0.12	0.06	0.03	-0.00	0.01	0.00	-0.01	0.52	0.12	0.61**
Ear height (cm)	-0.02	0.02	-0.00	-0.09	0.09	0.01	0.00	-0.00	-0.00	-0.00	0.12	0.01	0.13
Leaves plant^{-1}	-0.08	0.09	-0.01	-0.09	0.03	0.04	-0.01	0.03	0.01	-0.02	0.57	0.11	0.68**
Ear length (cm)	-0.01	0.01	-0.00	-0.01	-0.01	0.02	-0.02	0.04	0.02	-0.02	0.43	0.06	0.51**
Ear diameter (cm)	-0.06	0.06	-0.01	-0.02	-0.01	0.03	-0.01	0.05	0.02	-0.03	0.56	0.06	0.65**
Kernel rows ear^{-1}	-0.09	0.10	-0.01	-0.01	-0.01	0.03	-0.01	0.05	0.02	-0.03	0.43	0.07	0.53**
100-kernel weight (g)	-0.07	0.07	-0.01	-0.02	0.01	0.02	-0.01	0.04	0.01	-0.04	0.40	0.11	0.53**
Harvest index (%)	-0.01	0.01	-0.01	-0.08	0.01	0.03	-0.01	0.03	0.01	-0.02	0.86	0.14	0.98**
Stover yield plant^{-1} (g)	-0.02	0.02	-0.01	-0.06	0.00	0.02	-0.00	0.01	0.01	-0.02	0.44	0.27	0.67**
Residual Effect	0.0409												

**and ** significant at P = 0.05 and 0.01, respectively* diameter, stover yield plant^{-1}, ear length, kernel rows ear^{-1} and ear height showed positive indirect effects via. harvest index. Days to 50 per cent tasseling and anthesis silking interval exhibited desirable indirect effects on grain yield plant^{-1} via. days to 50 per cent silking, indicating perfect relationship among these characters. It may therefore, be argued that if other factors are held constant, an increase in these characters individually would be reflected an increase in grain yield.

From the results of present study, it is concluded that considerable amount of variation exists in the genotypes for all these traits. The effective selection for superior genotypes is possible considering the characters such as harvest index, leaves plant^{-1}, stover yield plant^{-1}, ear diameter, plant height, kernel rows ear^{-1}, 100-kernel weight and ear length. Therefore, due emphasis should be given to these characters in selection programme to develop superior genotypes in maize.

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