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GENETICS AND PLANT BREEDING

Genetic Variability and Correlation Studies of Yield and Yield Component in Maize Hybrids (*Zea mays* L.) Under Kymore Plateau and Satpura Hill Region of Madhya Pradesh

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ABSTRACT

The study to estimate genetic parameters and to identify agronomic traits correlated with the grain yield of maize hybrids using an experiment was conducted at the Research Farm, JNKVV Jabalpur (MP) during the year 2012-13 consisting of seven newly developed maize hybrids and one composite variety. The experimental design was a randomized block design with three replications. Analysis of variance revealed high significant difference for all the twelve characters studied. Phenotypic coefficient of variation (PCV) was higher than genotype coefficient of variation (GCV) for all the characters indicating the little influence of environment on the characters. All the qualitative characters illustrated high estimates of heritability, which indicates preponderance of additive gene action in the inheritance of these characters. High to moderate degree of genetic advance was observed for grain yield and stover yield, which was followed by cob weight and grains /cob. The genotypic correlations were higher in magnitude than phenotypic correlation and in the same direction. Grain yield had a significant positive correlation at both genotypic and phenotypic level with stover yield, grains/ cob, grains/ row, shelling percentage, grain rows /cob, cob /plant, harvest index, cob weight, cob girth and seed index. Thus, these characters may serve as effective selection parameters during the breeding programme for crop improvement.

Highlights

- Crop yield had a significant positive correlation with grains/ cob, grains/row, shelling percentage, grain rows/ cob, cob/ plant, harvest index, cob weight, cob girth and seed index and stover yield at both genotypic and phenotypic level.
- Phenotypic coefficient of variation (PCV) was higher than genotype coefficient of variation (GCV) for all the characters studied.

Keywords: Genetic variability, heritability, maize, yield, GCV, PCV

Maize (*Zea mays* L.; 2n = 20) belongs to the family *poaceae* and is grown as a multipurpose crop in the world. It is considered as the queen of the cereal and is one of the most important cereal crops in the world next only to rice and wheat. The unique energy capturing capacity and efficient use of CO_2 as C_4 plant have made it capable of producing maximum grain yield per unit area when compared to all other cereal crops. At present, the yield level is much lower than the potential of our existing varieties. A main constraint to enhance maize productivity is the selection of unsuitable cultivars under a given set of environments.

The adoption of hybrids was the most important task in the cultivation of maize. The first commercial sale of hybrid seed was initiated in 1984. Increased production per unit area is the prime objective in many maize breeding programs. Of these, grain yield is the most important and complex trait with which the maize breeders work. Maize displays an orderly sequence of development of yield components namely number of cobs /plant, number of kernel rows per cob and kernel weight (Viola *et al.* 2003). Genetic variability, which is a heritable difference among cultivars is required in an appreciable level within a population to facilitate and sustain an effective long term plant breeding programme. Progress from selection has been reported to be directly related to the magnitude of genetic variance in the population (Tabanao and Bernardo, 2005). Genetic variation is an important agronomic trait, especially about the earliness to sufficiently justify the initiation of the selection programme (Abayi *et al.* 2004, Turi *et al.* 2007 and Salami *et al.* 2007). Breeders have developed thousands of hybrids of which one or more can flourish in almost any combination of soil and climate found in farming areas.

The appropriate knowledge of interrelations between grain yield and its contributing components can significantly improve the efficiency of breeding programs through the use of appropriate selection indices (Mohammadia *et al.* 2003). One of the goals of this study was to confirm correlation between grain yield and yield attributing traits. The present study also aimed to determine the genetic variability of yield and contributing traits in different maize hybrids and to formulate the genotypic and phenotypic correlations among the important traits of maize hybrids.

MATERIALS AND METHODS

The present experiment was laid out at Research Farm, JNKVV Jabalpur (MP) during *kharif*, 2012. The experimentation site lies between 23°91′ north latitude, 79°58′ east longitude with an altitude of 411.78 meters above the mean sea level, which comes under the agro-climatic zone classified as Kymore Plateau and Satpura Hill Zone of Madhya Pradesh, India. The soil of the experimental field was clayey and neutral (7.3) with neutral electrical conductivity (0.31 dSm^{-1}) and medium in available N (395 kg ha^{-1}), P (17.85 kg ha^{-1}) and organic carbon (0.64%) and high in available K (301 kg ha^{-1}). The seven newly developed maize hybrids viz., Proagro-Ly 620, Proagro SAMPPANN, Proagro 4644, Proagro 4640, Proagro 4558, Proagro 4794, Proagro 4212 and one composite HQPM 1 were tested as treatments T1, T2, T4, T5, T6, T7 and T8 respectively, in a randomized complete block design (RCBD) with three replications, having a net plot size of 4.0 m × 2.4 m. Sowing was done with the help of dibbler using the seed rate of 18 kg ha^{-1} with planting geometry 25 cm × 60 cm. The packages of recommended practices were adopted to maintain the crop. Data were recorded on five randomly selected competitive plants of each entries from each replication for twelve traits *viz.* Cobs/plant, Grain rows/cob, Grains/row, Grains/cob, Cob length(cm), Cob girth(cm), Cob weight (g), Seed index (g), Shelling percentage, Harvest index, Stover yield (q/ha) and Grain yield(q/ha). Phenotypic and genotypic coefficients of variation were estimated by following the procedure given by Burton (1952), heritability in broad sense (h^2) by Burton and De Vance (1953) and genetic advance *i.e.* the expected genetic gain by using the procedure given by Johnson *et al.* (1955). The genotypic correlation between yield and its component traits and among themselves was worked out as per the methods suggested by Al-Jibouri (1958). The significance was assessed at 5 and 1 per cent probability level, unless otherwise stated.

RESULT AND DISCUSSION

Plant breeding along with advances in agronomic and production practices has played a major role in the advanced grain yield per hectare over the past 50 years (Borlaug, 1983). The wider range of variation was revealed for all the yield and yield attributing traits (Table 1). It suggested the presence of enough variation for these traits to exploit the variability. Variability exploited in breeding programmes is desired from the naturally occurring variants and wild relative of main crop species as well as from strains and genetic stocks artificially developed by human efforts. Variability plays an important role in crop breeding.

An insight in to the magnitude of variability present in a crop species is of at most importance as it provides the basis for the selection of the total variation present in a population that arises due to genotypic and environmental effects. Presence of genetic variability in the breeding material is essential for a successful plant breeding programme. Through this study an attempt was made to assess

Table 1: Analysis of variance for grain yield and yield attributing traits of eight different maize hybrids

Traits	Sources				
	Replications	Treatments	Error	Coefficient variation (CV)	Critical difference (CD at 5%)
Degree of freedom (df)	2	7	14	-	-
Cobs per plant	0.002	0.07	0.019	13.60	0.24
Grain rows per cob	0.14	2.06	0.10	2.66	0.55
Grains per row	0.17	10.69	1.88	5.46	2.39
Grains per cob	25.49	5403.58	658.26	2.27	11.98
Cob length (cm)	1.89	6.77	0.86	6.26	1.62
Cob girth (cm)	0.001	0.248	0.003	1.37	0.10
Cob weight (g)	14.78	841.39	7.76	3.18	4.87
Seed index (g)	2.14	10.47	1.03	3.22	1.77
Shelling percentage	7.49	31.07	3.18	2.32	3.11
Harvest index	6.65	22.54	1.90	5.14	2.41
Stover yield (q/ha)	30.12	2773.09	22.35	4.53	8.26
Grain yield (q/ha)	93.13	725.91	15.67	10.06	6.92

**sign indicates the significant at probability 5% level of significant*

the mean performance and extent of variability in maize hybrids.

The 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 1). This indicated the presence of genetic variability in the material used and provided a good opportunity for yield improvement maize. Similar results were obtained in other studies with maize hybrids by Torres *et al.* (2013), Teodoro *et al.* (2014a), Teodoro *et al.* (2014b) and Ribeiro *et al.* (2015).

The estimates of phenotypic and genotypic variance, genotypic (GCV) and phenotypic coefficient of variation (PCV), heritability, genetic gain and genetic advance in percentage of mean (GA) for different characters have been presented in Table 2. The highest phenotypic and genotypic variance was found for grains/cob (1832.54 and 1785.52). This is in line with the previous results of Mutisya (1987). Lowest amount of phenotypic and genotypic variance was observed in cob/ plant (0.04 and 0.02). Phenotypic (PCV) coefficient of variability values ranged from 2.66% for grain rows/cob to 40.38 % for grain yield, whereas the genotypic (GCV) coefficient of variability ranged from 0.65 % for grain rows/ cob to 39.10% for grain yield. Similar results have also been reported by Ghimire and Timsina (2015).

The traits such as grain yield, stover yield, cob weight and cob/ plant exhibited high GCV and PCV (Table 2), which not only showed that selection can be effective for these traits but also indicated the existence of substantial variability ensuring ample scope for their improvement through selection. These results were consistent with the observations of earlier workers Bello *et al.* (2012) and Nzuve *et al.* (2014). The higher differences observed between phenotypic variance and genotypic variance for grains/cob, stover yield, grain yield, cob weight and shelling percentage (Table 2) reflects the influence of environment on the expression of traits. This was in accordance with the previous findings of Kumar *et al.* (2013). However, this gap was narrow for cob girth, cob/ plant, grain rows/ cob, cob length, seed index, grains/ row and harvest index, suggesting low environmental influence in expression of these traits and greater effectiveness of selection and improvement to be expected from these characters in the future breeding programme. The results obtained in Table 2 depicted that phenotypic variances and PCVs were higher than genetic variances and GCVs for all the traits, suggesting the influence of environment in the expression of these traits. Similar results have also been reported by Nelson and Somers (1992), Bello *et al.* (2012) and Patil *et al.* (2016).

Table 2: Estimates of genetic variability for grain yield and yield attributing traits of eight different maize hybrids

Traits	Range		Mean	Variance			Coefficient of Variance (%)			Herita -bility (%)	Genetic gain as % of mean	Genetic advance as % of mean
	Min.	Max.		Pheno-typic	Geno-typic	Environ-mental	Pheno typic	Geno typic	Environ-mental			
Cobs per plant	0.80	1.20	1.01	0.04	0.02	0.02	18.80	12.98	13.60	0.48	0.19	18.47
Grain rows per cob	10.60	13.33	11.93	0.75	0.65	0.10	7.28	6.78	2.66	0.87	1.55	13.00
Grains per row	22.13	28.53	25.12	4.81	2.94	1.88	8.74	6.82	6.82	0.61	2.76	10.97
Grains per cob	234.81	380.73	301.82	1832.54	1785.52	47.02	14.18	14.00	2.27	0.97	85.92	28.47
Cob length (cm)	13.09	16.97	14.81	2.83	1.97	0.86	11.36	9.48	6.26	0.70	2.41	16.29
Cob girth (cm)	3.59	4.51	4.16	0.08	0.08	0.00	7.00	6.87	1.37	0.96	0.58	13.88
Cob weight (g)	48.51	99.86	87.51	285.63	277.88	7.76	19.31	19.05	3.18	0.97	33.87	38.71
Seed index (g)	27.93	33.29	31.48	4.17	3.15	1.03	6.49	5.63	3.22	0.75	3.17	10.08
Shelling percentage	70.47	81.75	76.78	12.47	9.30	3.18	4.60	3.97	2.32	0.75	5.42	7.06
Harvest index	30.13	23.13	26.81	8.78	6.88	1.90	11.05	9.78	5.14	0.78	4.78	17.85
Stover yield (q/ha)	53.43	152.51	104.45	939.26	916.91	22.35	29.34	28.99	4.53	0.98	61.63	59.01
Grain yield (q/ha)	19.44	65.69	39.35	252.42	236.75	15.67	40.38	39.10	10.06	0.94	30.70	78.01

Estimates of heritability in broad sense (h^2) ranged from 48% for cobs per plant to 98% for stover yield (Table 2). Heritability estimate were high for stover yield, grains/ cob, cob weight, grain yield and grain rows/ cob (Grzesiak 2001; Nelson and Somers 1992; Kalla *et al.* 2001) and Rafique *et al.* 2004). This suggested that heritability is due to additive genetic effects and selection could be effective in early segregating generations for these traits. It also suggested the possibility of improving maize grain yield through direct selection (mass selection) for grain yield related traits.

A perusal of genetic advance at 5% selection intensity revealed that it was high for grain yield (78.01%) and stover yield (59.01%), which was followed by cob weight (38.71%) and grains/cob (28.47%). It was minimum for shelling percentage (7.06%), seed index (10.08%), grains/ row (10.97%), grain rows/ cob (13.0%), cob girth (13.88%), cob length (16.29%), harvest index (17.87%) and cobs/ plant (18.47%). High heritability estimate along with high genetic advance was recorded for stover yield, grains per cob, cob weight, and grain yield, indicating that heritability is due to additive gene effects, which is only fixable in subsequent generations. This also provides the evidence that larger proportion of phenotypic variance has been attributed to genotypic variance, and reliable selection could be made for these traits on the basis of phenotypic expression. Hence pedigree method of breeding will be a rewarding one to improve the traits under investigation. These results find support from the earlier studies of Kumar *et al.* (2014). The present study also reveals high heritability with low estimates of genetic advance as % of mean recorded for some traits, which may be attributed to non-additive gene action governing these traits, and these characters could be improved through the use of hybridization and hybrid vigour. High heritability accompanied with low genetic advance as % of mean had earlier been reported by Bello *et al.* (2012).

Table 3: Genotypic and phenotypic correlation coefficients between grain yield and related traits of maize hybrids

Traits		X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11
X2	r_g	0.993**										
	r_p	0.727**										
X3	r_g	0.971**	0.982**									
	r_p	0.553**	0.805**									
X4	r_g	0.987**	0.993**	0.990**								
	r_p	0.708**	0.935**	0.843**								
X5	r_g	-0.005^{NS}	0.168^{NS}	0.093^{NS}	0.149^{NS}							
	r_p	-0.051^{NS}	0.187^{NS}	0.087^{NS}	0.124^{NS}							
X6	r_g	0.653**	0.574**	0.634**	0.554**	-0.200^{NS}						
	r_p	0.411*	0.534**	0.495*	0.539**	-0.175^{NS}						
X7	r_g	0.865**	0.822**	0.877**	0.791**	0.317^{NS}	0.818**					
	r_p	0.587**	0.747**	0.693**	0.773**	0.215^{NS}	0.808**					
X8	r_g	0.754**	0.693**	0.648**	0.624**	0.289^{NS}	0.118^{NS}	0.306^{NS}				
	r_p	0.490*	0.532**	0.286^{NS}	0.546**	0.112^{NS}	0.112^{NS}	0.269^{NS}				
X9	r_g	0.956**	0.938**	0.988**	0.998**	0.064^{NS}	0.769**	0.923**	0.485*			
	r_p	0.623**	0.753**	0.680**	0.810**	0.120^{NS}	0.646**	0.764**	0.412*			
X10	r_g	0.906**	0.584**	0.757**	0.631**	-0.692**	0.397^{NS}	0.314^{NS}	0.177^{NS}	0.609**		
	r_p	0.411*	0.442*	0.521**	0.541**	-0.483*	0.360^{NS}	0.230^{NS}	0.147^{NS}	0.428*		
X11	r_g	0.814**	0.981**	0.990**	0.982**	0.090^{NS}	0.593**	0.842**	0.543**	0.976**	0.644**	
	r_p	0.727**	0.885**	0.843**	0.956**	0.075^{NS}	0.579**	0.825**	0.425*	0.841**	0.543**	
X12	r_g	0.910**	0.935**	0.970**	0.971**	-0.148^{NS}	0.582**	0.736**	0.505*	0.939**	0.810**	0.976**
	r_p	0.718**	0.854**	0.829**	0.911**	-0.095^{NS}	0.533**	0.677**	0.421*	0.807**	0.765**	0.940**

Legends: *X1=Cobs per plant, X2=Grain rows per cob, X3=Grains per row, X4=Grains per cob, X5=Cob length (cm), X6=Cob girth (cm), X7=Cob weight (g), X8=Seed index (g), X9=Shelling percentage, X10=Harvest index, X11=Stover yield (q/ha), X12=Grain yield (q/ha).*

** and ** sign indicates significant at 0.05 and 0.01 level of significance respectively*

The genotypic and phenotypic correlations between all possible combinations of twelve traits are presented in Table 3. In general, it was seen that genotypic correlations were higher in magnitude than phenotypic correlation and in the same direction. This revealed a strong inherent relationship among the traits studied and also showed that association may be largely due to genetic reason (Sharma 1988). This result is in harmony with those obtained by Duvick (2001). Grain yield quintal per hectare showed significant positive correlation at both genotypic and phenotypic level with stover yield, grains/ cob, grains/ row, shelling percentage, grain rows/ cob, cob/ plant, harvest index, cob weight, cob girth, seed index, however, negative non-significant correlation was with cob length. Similar associations were also reported by Parh *et al.* (1986), Khanday and Thakur (1990) and Singh *et al.* (1995). Among the pair of characters, cob/ plant, grain rows/ cob, grains/ row and grains/ cob had a significant positive correlation at both genotypic and phenotypic levels with all the traits under study except for cob length. Cob length had a significant negative correlation with harvest index only and all the other traits had a non-significant correlation at both genotypic and phenotypic levels under the study. Similar observations were reported by Bhole and Patil (1984). Cob girth and cob weight had a significant positive correlation at both genotypic and phenotypic levels with all the traits under study except for seed index and harvest index. Seed index had a significant positive correlation at both levels with all the traits under study except for harvest index. In the present investigation, positive correlation coefficient between any two characters suggested that they can be improved simultaneously and improvement in one will automatically cause correlated response in the other. However, such simultaneous improvement is not possible for those traits that are negatively correlated. Therefore, correlated traits can be improved by indirect selection.

CONCLUSION

It was concluded from the present study that the different hybrids observed significant difference among themselves for all the traits studied. The genetic advance as percent of mean was high for majority of yield contributing traits indicating predominance of additive gene action and selection will be effective for the improvement of these traits. Grain yield had a significant positive correlation at both genotypic and phenotypic level with stover yield, grains/ cob, grains/row, shelling percentage, grain rows/ cob, cob/ plant, harvest index, cob weight, cob girth and seed index. Thus, these characters may serve as effective selection parameters during the breeding programme for crop improvement.

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