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NARROW SENSE HERITABILITY, CORRELATION AND PATH ANALYSIS IN MAIZE (*Zea mays* L.)

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SUMMARY

An investigation was carried out to study the narrow sense heritability, correlation and path coefficient analysis for 11 characters on 45 maize hybrids, their 10 parents along with 2 standard checks during K*harif* 2011. Analysis of variance revealed that mean sum of squares due to genotypes showed significant differences for all the 11 characters studied. Magnitudes of genotypic correlations were found to be higher than phenotypic correlations. The results indicated that grain yield was positively and significantly associated with 100-seed weight, ear girth, number of kernels per row, ear length, plant height and ear height. Days to silking had largest direct effect on grain yield per plant followed by number of kernels per row, 100-seed weight and ear girth. High narrow sense heritability estimates were recorded in days to tasseling, days to silking, ear height, number of kernels per row, 100-seed weight, ear girth, days to maturity, ear length and grain yield per plant. Thus, these traits are predominantly under the control of additive gene action and hence these characters can be improved by selection.

Key words: Narrow sense heritability, correlation, path analysis, maize

Key findings: The results thus emphasized the need for selection based on plant with greater days to silking, number of kernels per row, 100-seed weight and ear girth, due to their strong association with grain yield. Hence, direct selection for these traits would be effective.

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INTRODUCTION

Maize (*Zea mays* L.) is the third most important cereal in India after rice and wheat. (Centre for Monitoring Indian Economy, 2015). It provides food, feed, fodder, fuel and severe as a source of basic raw material for a number of industrial products *viz*., starch, oil, protein, alcoholic beverages, food sweeteners, cosmetics and bio-fuel etc. Maize being a C_4 plant is physiologically more efficient, has higher grain yield and wider adaptation over wide range of environmental conditions.

Morphologically maize exhibits greater diversity of phenotypes than any other grain crop (Kuleshov, 1933) and is extensively grown in temperate, subtropical and tropical regions of the world. Yield of maize is considered as a complex inherited character and therefore, direct selection for yield *per se* may not be the most efficient method for its improvement, but indirect selection for other yield related characters with high heritability estimates will be more effective.

Diallel cross analysis for a fixed set of populations provides a basis for preliminary determination of heterotic groups. Thus the knowledge of the nature and magnitude of genotypic and phenotypic variability present in the crop species plays a vital role in formulating a successful breeding programme to evolve superior cultivars. The effect of environment on genotype is not practical important for the selection of elite genotype so that it was not included.

The selection criteria may be yield or one or more of the yield component characters. However, breeding for high yielding crops requires information on the nature and magnitude of variation in the available material, relationship of yield with other agronomic characters and the degree of environmental influence on the expression of these component characters. Since grain yield in maize is quantitative in nature and polygenically controlled, effective yield improvement and simultaneous improvement of yield components are imperative. To enhance the yield productivity, genetic parameters and correlation studies between yield and yield components are pre requisite to plan a meaningful breeding programme to develop high yielding inbreds and hybrids.

MATERIALS AND METHODS

Ten diverse inbred lines (CM 211, BML 2782, BML 5233-5, BML 2486, BML 6, BML 15, BML 7, BML 2910, BML 2 and BML 3044) of maize were crossed in diallel mating design (excluding reciprocals) during *kharif*, 2011. The resultant 45 hybrids along with 10 parents were evaluated during *rabi*, 2011-12 at College Farm, College of Agriculture, Rajendranagar, Hyderabad, India. Each genotype was sown in a single row of 4 m length having 75 cm x 20 cm spacing. The data were recorded from 5 random plants from each entry in all the 3 replications for days to tasseling, days to silking, days to maturity, plant height (cm), ear height (cm), ear girth (cm), ear length (cm), number of kernel rows per ear, number of kernels per row, 100- seed weight (g) and grain yield per plant (g). The mean values were used for statistical analysis.

Analysis of variance was done for partitioning the total variation due to treatments and replications according to procedure given by Panse and Sukhatme (1985). Correlation coefficients were determined as described by Singh and Chaudhary (1979). Data were analyzed using Indostat software (IndoStat Inc. Hyderabad, India).

RESULTS AND DISCUSSION

Grain yield is a complex character and is dependent on several contributing characters.Hence, character association was studied to assess the relationship among yield and its components for enhancing the usefulness of selection.

Analysis of variance revealed significant differences for all of the 11 quantitative traits studied which was presented in Table 1. Genotypic coefficient of variation (GCV) was the highest in case of grain yield per plant (37.0) followed by number of kernels per row (22.3), ear height (21.4), 100-seed weight (18.4), ear length (17.9) and plant height (14.9) (Table 2). Phenotypic coefficient of variation (PCV) was the highest in case of grain yield per plant (37.5) followed by number of kernels per row (23.5), ear height (22.4), ear length (18.6), 100-seed weight (18.6) and plant height (18.1).The range of mean values for all the traits was relatively high and treatment mean squares (TMS) were significant suggesting sufficient variability and offers scope for selection. Similar results of PCV and GCV values for grain yield and other traits were reported by Zahid Mahmood *et al.* (2004); Abirami *et al*. (2005).

Heritability narrow sense is the proportion of total additive variance of the phenotypic variance. It plays a very important role in selection process in plant breeding. It is estimated from additive genetic variance and plays a very important role in the selection of elite genotypes from the segregating populations. Narrow sense heritability estimates along with genetic advance are normally more helpful in predicting the gain under selection than heritability estimates alone. For a practical breeder dominance variance cannot be predicted and it does not affect the mean or variance of the offspring of a selection cross in a systematic fashion. Thus, only additive genetic variance is useful.

High narrow sense heritability estimates were recorded for days to tasseling (42.0%) followed by days to silking (39.0%), ear height (32.0%), number of kernels per row (21.0%), 100-seed weight (20.0%), ear girth (20.0%), maturity (17.0%), ear length (16.0%), grain yield per plant (11.0%) and plant height (10.0%). Similar results were reported by

Table 1. Analysis of variance for yield and yield components in maize.

Source of variation	d.f.	Days to tasseling	Days to silking	Days to maturity	Plant height (cm)	Ear height (cm)	Ear girth (cm)	Ear length (cm)	Number of kernel rows per ear	Number of kernels per row	100-seed weight (g)	Grain yield per plant (g)
Replications	2	2.81	1.26	2.21	230.60	87.21	0.64	0.39	0.66	21.73*	0.15	59.53
Treatments	56	51.82**	51.24**	84.58**	2850.8**	1032.33**	7.26**	23.54**	4.66**	145.88**	66.27**	4606.29**
Error	112	4.11	4.26	2.4	152.7	32.67	0.44	0.62	0.53	5.27	0.55	45.85

** Significant at 5 percent level; ** significant at 1 percent level*

Table 2. Genetic parameters for yield and yield components in maize.

Character	Days to tasseling	Days to silking	Days to maturity	Plant height (cm)	Ear height (cm)	Ear girth (cm)	Ear length (cm)	Number of kernel rows per ear	Number of kernels per row	100-seed weight (g)	Grain yield per plant (g)
GCV	5.7	5.4	4.9	14.9	21.4	11.5	17.9	8.1	22.3	18.4	37.0
PCV	6.4	6.1	5.1	16.1	22.4	12.6	18.6	9.6	23.5	18.6	37.5
h^2_{ns} (%)	42.0	39.0	17.0	10.0	32.0	20.0	16.0	7.0	21.0	20.0	11.0
GAM	10.5	9.9	9.7	28.4	42.1	21.7	35.5	14.3	43.5	37.4	75.1
Mean	69.4	72.6	106.3	200.7	85.1	13.0	15.4	14.3	30.6	25.4	105.3

PCV= Phenotypic coefficient of variation, GCV= Genotypic coefficient of variation, h^2_{ns}= narrow sense heritability, GAM= genetic advance as percent of mean at 5 percent level.

Yadav *et al.* (2002); Muhammad Rafique *et al.* (2004); Seanski *et al.* (2005); Mohammad Akbar *et al.* (2006); Ali *et al.* (2010); Abdel Moneam *et al.* (2014); Sudika *et al.* (2015).

The results of narrow sense heritability estimates emphasized the portion of additive genetic variance for all the studied traits and suggest the importance of choosing suitable segregating generations for exhibiting the best expression of genes of different characters and also for improving such traits.

Genotypic correlations reveal the existence of real associations, whereas phenotypic correlations may occur by chance. Significant phenotypic correlations without significant genotypic associations are of no value. If the genotypic correlation is significant and phenotypic is not, it means that the existing real association is masked by environmental effect. In general, genotypic correlations were of higher magnitude than the corresponding phenotypic values and hence only the genotypic correlations are discussed.

The results indicated that grain yield was positively and significantly associated with 100 seed weight, ear girth, number of kernels per row, ear length, plant height and ear height (Table 3). These observations are in consistent with the findings of others for 100-seed weight (Kumar *et al.* 2006), ear girth (Pavan *et al.* 2011), number of kernels per row (Sadek *et al.* 2006), ear length (Choudhary and Chaudhary, 2002), plant height (Jayakumar *et al.* 2007, Zahra Amini *et al.* 2013 and Aminu *et al.* 2014) and ear height (Sofi and Rather (2007); Raghu *et al.* (2011); Ram Reddy *et al.* (2012); Ravi *et al.* (2012); Khodadad *et al.* (2013); Mahesh *et al.* (2013); Aminu *et al.* (2014); Sudika *et al.* (2015). The characters days to tasseling, days to silking and days to maturity were negatively correlated with grain yield per plant and are similar to the results reported by Umakanth and Sunil (2000).

Table 3. Phenotypic (P) and Genotypic (G) correlations for yield and yield contributing characters in maize.

Source		Days to tasseling	Days to silking	Days to maturity	Plant height (cm)	Ear height (cm)	Ear girth (cm)	Ear length (cm)	Number of kernel rows per ear	Number of kernels per row	100-seed weight (g)	Grain yield per plant (g)
Days to 50% tasseling	P	1.0000	0.8012**	0.6166**	0.0436	0.2238**	-0.1462	-0.3373**	-0.1649*	-0.3258**	-0.1049	-0.2209**
	G	1.0000	0.9986**	0.7210**	0.0413	0.2520**	-0.1231	-0.3964**	-0.2376**	-0.3497**	-0.1250	-0.2413**
Days to 50% silking	P		1.0000	0.6675**	0.0386	0.1537*	-0.1819*	-0.3051**	-0.2589**	-0.2898**	-0.1010	-0.2361**
	G		1.0000	0.7557**	0.0520	0.1927*	-0.1775*	-0.3435**	-0.3269**	-0.3252**	-0.1187	-0.2754**
Days to maturity	P			1.0000	-0.2217**	-0.1272	-0.3030**	-0.5432**	-0.2550**	-0.4614**	-0.1259**	-0.3734**
	G			1.0000	-0.2117**	-0.1393	-0.3625**	-0.5580**	-0.3217**	-0.4888**	-0.1398	-0.3909**
Plant height (cm)	P				1.0000	0.6648**	0.4560**	0.4476**	0.0168	0.4742**	0.3330**	0.5177**
	G				1.0000	0.7710**	0.5787**	0.5033**	0.0343	0.5265**	0.3706**	0.5601**
Ear height (cm)	P					1.0000	0.4154**	0.2182**	0.0446	0.2480**	0.0982	0.2714**
	G					1.0000	0.4822**	0.2483**	0.0087	0.2791**	0.1083	0.3042**
Ear girth (cm)	P						1.0000	0.5781**	0.1603*	0.4465**	0.5803**	0.6113**
	G						1.0000	0.6471**	0.2320**	0.5161**	0.6473**	0.6728**
Ear length (cm)	P							1.0000	0.0768	0.7783**	0.3896**	0.6006**
	G							1.0000	0.0938	0.8553**	0.4106**	0.6292**
Number of kernel rows per ear	P								1.0000	0.0088	-0.0635	-0.0240
	G								1.0000	-0.0102	-0.0764	0.0058
Number of kernels per row	P									1.0000	0.3401**	0.6085**
	G									1.0000	0.3610**	0.6531**
100 seed weight (g)	P										1.0000	0.7147**
	G										1.0000	0.7251**
Grain yield per plant (g)	P											1.0000
	G											1.0000

** Significant at 5 percent level; ** significant at 1 percent level*

In selecting high yielding genotypes, correlation studies provide reliable information on the nature, extent and direction of selection. The knowledge of correlation between different yield attributes helps to find out the nature and magnitude of the association between these traits which are mostly used to attain better yield of the crop.

The path coefficient analysis was conducted to obtain further information on interrelationships among traits and their effects on grain yield (Table 4). Path coefficient analysis at genotypic level revealed that the days to silking had largest direct effect on grain yield per plant followed by number of kernels per row, 100-seed weight and ear girth. These observations are in confirmation with the findings of Netaji (2000); Devi *et al.* (2001); Venugopal *et al.* (2003); Kumar *et al.* (2006); Pavan *et al.* (2011); Raghu *et al.* (2011); Ram Reddy *et al.* (2012); Sudika *et al.* (2015).

Table 4. Phenotypic (P) and Genotypic (G) path coefficients for yield and yield contributing characters in maize.

Source		Days to tasseling	Days to silking	Days to maturity	Plant height (cm)	Ear height (cm)	Ear girth (cm)	Ear length (cm)	Number of kernel rows per ear	Number of kernels per row	100-seed weight (g)	Grain yield per plant (g)
Days to 50% tasseling	P	0.0423	-0.0542	-0.0705	0.0069	0.0001	-0.0141	-0.0101	0.0091	-0.0787	-0.0516	-0.2209**
	G	-1.1162	1.1355	-0.1520	0.0010	0.0230	-0.0326	0.1544	-0.0142	-0.1803	-0.0599	-0.2413**
Days to 50% silking	P	0.0339	-0.0676	-0.0763	0.0061	0.0000	-0.0176	-0.0092	0.0143	-0.0700	-0.0497	-0.2361**
	G	-1.1146	1.1370	-0.1593	0.0012	0.0176	-0.0470	0.1339	-0.0195	-0.1676	-0.0569	-0.2754**
Days to maturity	P	0.0261	-0.0451	-0.1143	-0.0350	0.0000	-0.0293	-0.0163	0.0140	-0.1115	-0.0619	-0.3734**
	G	-0.8048	0.8593	-0.2108	-0.0051	-0.0127	-0.0961	0.2174	-0.0192	-0.2519	-0.0670	-0.3909**
Plant height (cm)	P	0.0018	-0.0026	0.0253	0.1581	0.0002	0.0440	0.0135	-0.0009	0.1145	0.1638	0.5177**
	G	-0.0461	0.0591	0.0446	0.0239	0.0703	0.1534	-0.1961	0.0020	0.2714	0.1776	0.5601**
Ear height (cm)	P	0.0095	-0.0104	0.0145	0.1051	0.0003	0.0401	0.0066	-0.0025	0.0599	0.0483	0.2714**
	G	-0.2813	0.2191	0.0294	0.0184	0.0912	0.1278	-0.0967	0.0005	0.1439	0.0519	0.3042**
Ear girth (cm)	P	-0.0062	0.0123	0.0347	0.0721	0.0001	0.0966	0.0174	-0.0088	0.1079	0.2854	0.6113**
	G	0.1374	-0.2018	0.0764	0.0138	0.0440	0.2650	-0.2521	0.0139	0.2660	0.3102	0.6728**
Ear length (cm)	P	-0.0143	0.0206	0.0621	0.0707	0.0001	0.0558	0.0301	-0.0042	0.1880	0.1916	0.6006**
	G	0.4424	-0.3906	0.1176	0.0120	0.0227	0.1715	-0.3896	0.0056	0.4409	0.1968	0.6292**
Number of kernel rows per ear	P	-0.0070	0.0175	0.0292	0.0027	0.0000	0.0155	0.0023	-0.0551	0.0021	-0.0312	-0.0240
	G	0.2652	-0.3716	0.0678	0.0008	0.0008	0.0615	-0.0365	0.0597	-0.0052	-0.0366	0.0058
Number of kernels per row	P	-0.0138	0.0196	0.0528	0.0749	0.0001	0.0431	0.0234	-0.0005	0.2416	0.1673	0.6085**
	G	0.3903	-0.3697	0.1030	0.0126	0.0255	0.1368	-0.3333	-0.0006	0.5155	0.1730	0.6531**
100 seed weight (g)	P	-0.0044	0.0068	0.0144	0.0526	0.0000	0.0561	0.0117	0.0035	0.0822	0.4919	0.7147**
	G	0.1395	-0.1350	0.0295	0.0089	0.0099	0.1715	-0.1600	-0.0046	0.1861	0.4792	0.7251**

Bold values are direct effects; Phenotypic residual effect = 0.5402; Genotypic residual effect = 0.5501

CONCLUSION

The estimates of narrow sense heritability emphasized for all the studied traits and suggest that importance of selection of elite genotype form segregating generations. The high direct effects of these traits appeared to be the main reason for their strong association with grain yield. Hence, direct selection for these traits would be effective. Days to tasseling and days to maturity exhibited negative direct effect on grain yield and indicated that selection for high yield can be done by indirect selection through yield components. The results thus emphasized the need for selection based on plant with greater days to silking, number of kernels per row, 100-seed weight and ear girth.

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