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Genetic variability, heritability and association analysis of morphological and yield components in maize hybrids

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ABSTRACT

The present investigation was conducted to evaluate the various parameters like genetic variability, nature and magnitude of association and also the direct and indirect effects of different morphological and yield traits on kernel yield in 13 different new maize hybrids at Research farm, ANGRAU-Agricultural Research station, Vijayarai (A.P.) during rabi season of 2019-20. The Analysis of variance revealed that highly significant differences exist among the maize hybrids for all the traits studied except for initial plant stand and final plant stand. It emphasize that the studied experimental material possesses sufficient variability for all the morphological and yield traits which can be beneficial for selection in different breeding programmes. High GCV and PCV values were obtained for kernel yield per plant (kg), kernel yield (kg ha^{-1}), plant height (cm), ear placement height (cm), number of kernels per cob, cob yield per plot (kg) and test weight (g). High heritability estimates coupled with genetic advance as percentage of mean was recorded for plant height, ear placement height, days to 50% pollen shed and test weight. Similarly, the traits kernel yield per plot, cob yield per plot, ear placement height, plant height and shelling percentage established. Highest significant positive association with kernel yield (kg ha^{-1}) and the trait kernel yield per plot also showed highest positive direct effects indicating that these traits are more effective and these traits directly and or indirectly will contribute for achieving higher kernel yields and selection based on these traits would be more effective in hybrid maize breeding programmes.

Key words: GCV, PCV, heritability, genetic advance, correlation, path analysis

INTRODUCTION

Maize (*Zea mays* L., 2n = 20) third most important cereal crop in world and in India due to its versatile use in different areas like food as raw material, poultry and cattle feed, as flour in different food ingredients, cosmetic and medicinal industries, dried plant and husk of the cob as fuel and other cottage industrial uses etc. India is the 4th place in area and 7th place in production among the maize grown areas in the world. During 2018-19, maize area reached to 9.2 million ha and production increased to 27.8 million MT in India due to its adaptability in different agro climatic conditions and also it replaces most of the rain-fed crops in India. Though the productivity in India is almost half of the Worlds average per day productivity of Indian maize is at par with many lead maize producing Countries (ICAR-IIMR-DACNET, 2020) (A.P.)

Since yield is main objective in any breeding programmes and crop improvement programmes it is essential to find out the variability parameters like genotypic and phenotypic variance and co-variance, heritability estimates and genetic advance in the studied material. The success of any crop improvement program is not only depend on the amount of genetic variability present in the population studied but also on the extent to which it is heritable, which sets the limit of progress that can be achieved through selection. Heritability alone provides no indication of the amount of genetic improvement that would result from selection of individual genotypes. Hence knowledge about genetic advance coupled with heritability is most useful to know about the inheritance of the trait which is useful in breeding programmes. Further, efficiency of selection in any crop improvement programmes mainly depends upon the knowledge of association of traits and also its direct and indirect effects of each trait as well as with yield parameter. The information on nature and magnitude of variation in population, association of different traits among themselves and with yield and the extent of environmental influence on the expression of

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these characters will give better analysis to achieve higher yields. Accordingly, the present investigation aimed to find out the genetic variability, heritability, genetic advance, to find out the association of different morphological and yield traits and also to analyse the nature and magnitude of the association of the studied traits using 13 different maize hybrids.

MATERIALS AND METHODS

The experimental material comprising 13 elite maize hybrids *viz.,* PDMH-1810, PDMH-1540, DHM-117, PDMH-1449, PDMH-153227, PDMH-16921, PDMH-1829, P-3396, PDMH-1817, PDMH-1222, PDMH-1213,KAVERI-50 and Bharathi-99 studied at Research farm, ANGRAU-Agricultural Research station, Vijayarai during *rabi* season of 2019-20 following randomized block design with two replications. Each plot consisted with six rows of 5meter length row with spacing of 60cm × 25cm. The observational data collected from 10 randomly selected plants for fifteen important morphological and yield traits. The traits were initial plant stand, days to 50% pollen shed, days to 50% silking, final plant stand, plant height (cm), ear placement height (cm), cob length (cm), cob girth (cm), number of kernel rows per cob, number of kernels per cob, cob yield per plot (kg), kernel yield per plot (kg), shelling percentage (%), test weight (100-grain weight in grams) and kernel yield (kg ha^{-1}). Analysis of variance (ANOVA) for individual characters was carried out on the basis of mean value per entry per replication as suggested by Panse and Sukhatme (1967) for randomized block design, genotypic and phenotypic variance were estimated as per the formula given by Johnson *et al.,* (1955), heritability in broad sense was estimated as per the formula given by Johnson *et al.,* (1955) and Hanson (1953), genotypic and phenotypic coefficient of variations were estimated according to Burton (1952) and Singh and Choudhary (1985). Genetic advance was calculated following the formula given by Johnson *et al.,* (1955) and Allard (1960). Genetic advance as percent of mean was calculated by the formula of Johnson *et al.,* (1955). The Correlation coefficient analysis was estimated according to the formula given by Al-jibouri *et al.,* (1958) and the direct and indirect effects of path analysis was estimated as per the formula originally developed by Wright (1921) later described by Dewey and Lu (1959).

RESULTS AND DISCUSSION

Analysis of variance

The analysis of variance (ANOVA) revealed that significant differences among the genotypes for all the studied traits except for initial plant stand and final plant stand indicating that the studied genetic material was genetically divergent each other represents the presence of genetic variability in the studied experiment material (Table 1). The success of any crop improvement programme essentially depends upon the nature and magnitude of the genetic variability present in the crop. The similar results of existing genetic variability in studied population were also observed by Bhiusal *et al.,* (2017).

Table 1: Analysis of variance for yield and its attributing traits in maize hybrids

Source of variation	Replication (df = 1)	Genotypes (df = 12)	Error (df = 12)	CV (%)
Initial plant stand	5.53	17.80	10.12	4.31
Days to 50% pollen shed	0.15	6.93	0.24	0.86
Days to 50% silking	0.04	7.54**	0.71	1.42
Plant height (cm)	14.47	1131.75**	10.22	1.54
Ear placement height (cm)	2.59	170.65**	3.80	2.32
Final plant stand	246.15	31.25**	85.07	14.64
Cob length (cm)	0.71	3.51**	0.91	4.71
Cob girth (cm)	0.04	1.18**	0.33	3.49
Number of kernel rows per cob	1.63	2.23**	0.69	5.79
Number of kernels per cob	1938.63	8683.14**	3689.92	10.41
Cob yield per plot (kg)	0.28	4.10**	1.09	7.84
Kernel yield per plot (kg)	0.06	3.94**	0.73	7.76
Shelling percentage (%)	29.51	15.21**	4.55	2.58
Test weight (g)	1.72	31.05**	1.23	2.96
Kernel yield (kgha^{-1})	95469.36	4832834.55**	917459.24	7.76

*** Significant @ p = 0.01%*

Table 2 Estimates of range, mean and other genetic parameters for yield and its attributing traits in maize hybrids

Trait	Range	Mean ± SEd	σg^2	σp^2	GCV (%)	PCV (%)	h^2(bs) (%)	GA	GA as % of mean
Initial plant stand	67.56 – 77.00	73.16±2.16	3.83	13.96	2.65	5.06	27.50	2.11	2.87
Days to 50% pollen shed	54.55 – 60.00	56.61±0.33	3.34	3.58	3.23	3.34	93.38	3.64	6.43
Days to 50% silking	56.55 – 62.56	58.96±0.57	3.41	4.12	3.13	3.44	82.89	3.46	5.87
Plant height (cm)	172.56 – 237.47	207.60±2.17	560.76	570.98	11.40	11.50	98.21	48.34	23.28
Ear placement height (cm)	70.23 – 96.98	83.96±1.32	83.42	87.22	10.87	11.12	95.64	18.40	21.91
Final plant stand	57.00 – 70.76	63.00±6.26	-26.91	58.16	8.23	12.10	-46.27	-7.26	-11.53
Cob length (cm)	18.65 – 22.84	20.21±0.64	1.29	2.20	5.63	7.34	58.89	1.80	8.91
Cob girth (cm)	15.55 – 18.57	16.36±0.38	0.42	0.75	3.97	5.29	56.41	1.01	6.15
Number of kernel rows per cob	13.33 – 17.00	14.37±0.56	0.76	1.46	6.09	8.41	52.52	1.30	9.10
Number of kernels per cob	460.00 – 693.47	583.00±41.26	2496.61	6186.53	8.57	13.49	40.36	65.38	11.21
Cob yield per plot (kg)	11.22 – 16.133	13.35±0.71	1.50	2.60	9.17	12.07	57.78	1.91	14.36
Kernel yield per plot (kg)	9.11 – 13.86	11.04±0.58	1.60	2.34	11.47	13.85	68.61	2.16	19.58
Shelling percentage (%)	78.33 – 86.23	82.55±1.45	5.32	9.88	2.79	3.80	53.89	3.49	4.22
Test weight (g)	29.63 – 43.34	37.47±0.75	14.91	16.14	10.30	10.72	92.34	7.64	20.39
Kernel yield (kgha^{-1})	10082.51–15280.42	12269.41±650.72	1957687.65	2875146.90	11.40	13.81	68.09	2378.37	19.38

σg^2 = genotypic variance, GCV = Genotypic coefficient of variation, h^2(bs) = heritability in broadsense,
σp^2 = phenotypic variance, PCV = Phenotypic coefficient of variation, GA = Genetic Advance

Mean performance of Maize hybrids

Based on the per se performance of the studied population, all the traits showed a wide range of variation for most of the morphological and yield traits (Table 2). However, highest range of variation was noticed by kernel yield (10,082.51 to 15,280.42) followed by number of kernels per cob (460.00 to 697.47), test weight (29.63 g to 43.34 g), shelling percentage (78.33 to 86.23), plant height (172.56 cm to 237.47 cm), ear placement height (70.23 cm to 96.98 cm) an for final plant stand (57.00 to 70.76) indicating that the presence of sufficient variation in the studied population and in the traits studied. It provides good information about the selection for higher yields in maize by considering these traits are more effective.

Phenotypic and genotypic variance

The phenotypic and genotypic variances ranged from 0.75 to 2875146.90 and 0.42 to 1957687.65 for the traits studied respectively (Table 2). Comparatively higher phenotypic variance values of 2875146.90 for kernel yield followed by 6186.53 for number of kernels per cob, 70.98 for plant height were recorded in this study. Similarly higher genotypic variance values were observed for the same traits which have higher phenotypic variance indicated that genotype could be reflected by phenotype and the effectiveness of selection of genotype based on phenotypic performance of these traits.

Phenotypic coefficient of variance (PCV) values ranged from 3.34 for days to 50% pollen shed to 13.85 for kernel yield per plot whereas genotypic coefficient of variance (GCV) ranged from 2.65 for initial plant stand to 11.47 for kernel yield per plant (Table 2). As per the Deshmukh *et al.,* (1986) classification of PCV and GCV (>20% = high; 10-20% = medium and 10% = low) higher GCV & PCV values were recorded for kernel yield per plant, kernel yield, plant height, ear placement height, number of kernels per cob, cob yield per plot and test weight inferred that for development of any hybrid targeting higher yields is possible by selecting these traits in the study will be more effective. The traits like final plant stand (GCV = 8.23; PCV = 12.10), number of kernels per cob (GCV = 8.57; PCV = 13.49), cob yield per plot (GCV = 9.17; PCV = 12.07) expressed wide differences between GCV and PCV indicating that higher influence of environment played a role in expression of these traits and traits like these are less effective for selection of a genotypes for higher yields. The similar findings were also observed by Synrem *et al.* (2015) and Bhiusal *et al.* (2017).

Estimates of heritability in broad sense and expected genetic advance as percent of mean

The present investigation revealed that the estimates of heritability (broad sense) ranged from27.50% (initial plant stand) to 98.21% (plant height) (Table 2). According to Pramoda and Gangaprasad (2007) the values for estimates of heritability (broad sense) were, 40% for low, 40% - 59% for medium, 60% -79% for high and ≥80% for very high. Similarly, the genetic advance as percentage of mean was classified as low (<10%), medium (10% - 20%) and high (>20%). The results showed that high heritability estimates in coupled with genetic advance as percentage of mean was recorded for plant height, ear placement height, days to 50% pollen shed and test weight reveled that these traits possess additive type of gene action and selection can be more effective to improvement of yield of maize hybrids. Sumathi *et al.,* (2005) also report on similar trend of results. Moderate values of heritability estimates coupled with genetic advance as percentage of mean was recorded by kernel yield per plot, kernel yield, cob yield per plot and number of kernels per cob indicating the presence of both additive and non-additive type of gene action in the inheritance of these traits hence, selection based on these traits are moderately effective due to lower influence of environment in expression of these traits. Low heritability in coupled with lower genetic advance as percentage of mean was recorded for number of seed rows per cob, cob length, days to 50% pollen shed, cob girth, days to 50% silking, shelling percentage and initial plant stand reveled that the role of non-additive gene action and more influence of environment in expression of these traits explained the high range of selection pressure in breeding programmes.

Table 3: Genotypic and Phenotypic Correlation among yield and its attributing traits in maize hybrids

		IPS	DFPS	DFS	PH	EPH	FPS	CL	CG	NKRPC	NKPC	CYPP	KYPP	SP	TW	KY
IPS	G	1.0000	0.6815	0.7159	0.3114	0.3746	-0.1480	0.5977	-0.1290	-0.4333	-0.4734	0.3677	0.3281	0.1118	0.8357	0.3468
	P	1.0000	0.3403	0.3312	0.1358	0.1921	0.6537	0.1569	-0.0401	-0.1380	-0.1761	0.2331	0.2073	0.0276	0.3977	0.2172
DFPS	G		1.0000	0.9067	-0.0459	-0.0743	-0.919	-0.0087	0.4029	0.0945	-0.2874	0.0388	-0.0733	-0.3995	0.4538	-0.0620**
	P		1.0000	0.9708	-0.0450	-0.0708	0.2420	-0.0026	0.2887	0.0861	-0.1493	0.0160	-0.0371	-0.1671	0.4198	-0.0280**
DFS	G			1.0000	-0.1058	-0.1231	-0.9010	-0.0581	0.2849	0.0136	-0.3728	0.0084	-0.1122	-0.4509	0.4683	-0.1001**
	P			1.0000	-0.0893	-0.1051	0.1828	0.0316	0.2748	0.0683	-0.1368	-0.1113	-0.1396	-0.1259	0.3991	-0.1299
PH	G				1.0000	0.9766	-0.9147	0.0744	-0.1512	-0.0577	0.3795	0.1026	0.1118	0.8292	-0.0708	0.9117**
	P				1.0000	0.9560	0.1071	0.0500	-0.1345	-0.0850	0.1942	0.7517	0.8264	0.5977	-0.0755	0.8235**
EPH	G					1.0000	-0.9150	0.1201	-0.3223	-0.2621	0.2736	0.9589	0.9519	0.7304	-0.0801	0.9534**
	P					1.0000	0.0875	0.0558	-0.2108	-0.1929	0.1596	0.6641	0.7435	0.5697	-0.0918	0.7416
FPS	G						1.0000	-0.9214	-0.9014	-0.9312	-0.9415	-0.9147	-0.9514	-0.9112	-0.9332	-0.9571
	P						1.0000	-0.0462	-0.2900	-0.1112	-0.0678	0.4544	0.3820	-0.0220	0.0392	0.3906
CL	G							1.0000	0.3662	0.1452	0.5279	-0.1147	0.0466	0.5187	0.5773	0.0423*
	P							1.0000	0.3922	0.2835	0.5406	-0.1596	-0.0489	0.3394	0.4003	-0.0503
CG	G								1.0000	0.7149	0.2197	0.1406	0.1153	-0.0058	0.5805	0.1132*
	P								1.0000	0.6861	0.4679	-0.1875	-0.1805	-0.0617	0.4017	-0.1846
NKRPC	G									1.0000	0.4948	0.1989	0.2392	0.3129	0.0640	0.2355**
	P									1.0000	0.6835	-0.0896	-0.0159	0.2062	-0.0168	-0.0213
NKPC	G										1.0000	0.4091	0.6308	0.9178	-0.3059	0.6241**
	P										1.0000	0.0419	0.1884	0.5375	-0.2586	0.1830
CYPP	G											1.0000	0.9862	0.6909	-0.1332	0.9871**
	P											1.0000	0.9636	0.3190	-0.0383	0.9646**
KYPP	G												1.0000	0.8021	-0.1949	0.9999**
	P												1.0000	0.5593	-0.1071	0.9998**
SP	G													1.0000	-0.3307	0.7988**
	P													1.0000	-0.2352	0.5559**
TW	G														1.0000	-0.1901**
	P														1.0000	-0.1046**

**Significant @ p = 0.05%, ** Significant @ p = 0.01%; IPS: Initial Plant Stand, DFPS: Days to 50% pollen shed, DFS: Days to 50%silking, DM: Days to maturity, PH: Plant Height (cm), EPH: Ear placement height (cm), FPS: Final Plant Stand, CL: Cob length(cm), CG: Cob girth(cm), NKRPC: Number of kernel rows per cob, NSPC: Number of seeds per cob, CYPP: Cob yield per plot (kg), KYPP: Kernel yield per plot (kg), TW: Test weight (g), sp: Shelling percentage (%) & KY: Kernel yield (kg ha^{-1})*

Table 4: Path analysis among yield and its attributing traits in maize hybrids

	IPS	DFPS	DFS	PH	EPH	FPS	CL	CG	NKRPC	NKPC	CYPP	KYPP	SP	TW	KY
IPS	**0.0022**	-0.0911	0.0988	-0.0141	-0.0031	0.0037	-0.0079	0.0011	0.0071	-0.0129	-0.0112	0.3602	-0.0028	0.0168	0.3468
DFPS	0.0015	**-0.1336**	0.1390	0.0021	0.0006	0.0035	0.0001	-0.0035	-0.0016	-0.0078	-0.0012	-0.0805	0.0102	0.0091	-0.0620**
DFS	0.0015	-0.1345	**0.1380**	0.0048	0.0010	0.0037	0.0008	-0.0025	-0.0002	-0.0101	-0.0003	-0.1232	0.0115	0.0094	-0.1001**
PH	0.0007	0.0061	-0.0146	**-0.0454**	-0.0082	0.0036	-0.0010	0.0013	0.0009	0.0103	-0.0306	0.9110	-0.0211	-0.0014	0.9112**
EPH	0.0008	0.0099	-0.0170	-0.0443	**-0.0084**	0.0037	-0.0016	0.0028	0.0043	0.0074	-0.0292	0.9105	-0.0186	-0.0016	0.9534**
FPS	-0.0022	0.1336	-0.1380	0.0454	0.0084	**0.0034**	0.0132	0.0088	0.0164	-0.0272	0.0305	-0.9098	0.0254	-0.0201	-0.9571
CL	0.0013	0.0012	-0.0080	-0.0034	-0.0010	0.0036	**-0.0132**	-0.0032	-0.0024	90.0143	0.0035	0.0511	-0.0132	0.0116	0.0423*
CG	-0.0003	-0.0538	0.0393	0.0069	0.0027	0.0034	-0.0048	**-0.0088**	-0.0117	0.0060	-0.0043	0.1266	0.0001	0.0117	0.1132*
NKRPC	-0.0009	-0.0126	0.0019	0.0026	0.0022	0.0037	-0.0019	-0.0063	**-0.0164**	0.0134	-0.0061	0.2626	-0.0080	0.0013	0.2355**
NKPC	-0.0010	0.0384	-0.0515	-0.0172	-0.0023	0.0036	-0.0070	-0.0019	-0.0081	**0.0272**	-0.0125	0.6925	-0.0300	-0.0061	0.6241**
CYPP	0.0008	-0.0052	0.0012	-0.0455	-0.0080	0.0035	0.0015	-0.0012	-0.0033	0.0111	**-0.0305**	0.9083	-0.0176	-0.0027	0.9871**
KYPP	0.0007	0.0098	-0.0155	-0.0459	-0.0080	0.0035	-0.0006	-0.0010	-0.0039	0.0171	-0.0301	**0.9098**	-0.0204	-0.0039	0.9999**
SP	0.0002	0.0534	-0.0622	-0.0377	-0.0061	0.0036	-0.0068	0.0001	-0.0051	0.0320	-0.0211	0.8806	**-0.0254**	-0.0066	0.7988**
TW	0.0018	-0.0606	0.0646	0.0032	0.0007	0.0036	-0.0076	-0.0051	-0.0011	-0.0083	0.0041	-0.2140	0.0084	**0.0201**	-0.1901**

*Residual effect = - 0.0093, * Significant @ p = 0.05%, ** Significant @ p = 0.01%,*

Genotypic and phenotypic correlation

The results of phenotypic and genotypic correlation coefficient analysis revealed that almost all the traits showed higher genotypic correlation values than the phenotypic correlation values indicating the strong intrinsic association are reduced at phenotypic levels due to significant levels of environment influence (Table 3). Mahesh *et al.,* (2013) and Bhiusal *et al.,* (2017) too noticed the similar results. Highest significant positive association of kernel yield was established with kernel yield per plot, cob yield per plot, ear placement height, plant height and shelling percentage revealed that the strong correlation of these traits will be the major contributors to achieve higher kernel yields. The similar findings were also noticed by Munawar *et al.,* (2013). The traits, final plant stand, test weight, days to 50% pollen shed and days to 50% silking had significant negative association with kernel yields revealed that the negative association of these traits for improvement of kernel yield. These findings are in correlation with the findings of Knife and Tsehaya, (2015) and Bhiusal *et al.,* (2017).

Similarly, the higher significant association between the traits will indirectly impact in the development of higher yields. The results revealed that the traits cob yield per plot with kernel yield per plot (0.9862), plant height with ear placement height (0.9766), ear placement height with cob yield per plot (0.9589), ear placement height with kernel yield per plot (0.9559), number of kernels per cob with shelling percentage (0.9178) and days to 50% pollen shed with days to 50% silking (0.9067) expressed significantly higher correlation revealed that the direct association of these traits will indirectly the reason for obtaining higher kernel yields. The similar trends were also registered by Brown and Caligari (2008) and Bhiusal *et al.,* (2017).

Path coefficient analysis

Path analysis contributes the clear view about the association of different traits studied by direct and indirectly towards contribution towards achieving higher yields. It also allows separating direct and indirect effects of different traits which in-turn assist breeder to find-out the traits that could be used as selection criteria in maize breeding programmes (Wright, 1921). Path analysis depicted the strength of all independent variables under study on kernel yield (Table 4). The results obtained from path coefficient analysis revealed that the trait, kernel yield per plant (0.9098) showed highest positive direct effect followed by days to 50% silking (0.1380) indicated that improvement of these traits will indirectly the reason for obtaining higher yields. Similarly, the trait days to 50% pollen shed recorded highest negative direct effect (-0.1336) indicated that this trait has least influence in achieving the higher yields. The indirect effects of different traits like ear placement height, plant height, cob yield per plot and shelling percentage showed higher positive effects with kernel yield per plot which indicating the indirect contribution of these traits for obtaining higher kernel yields. Similar findings were obtained earlier by Rafiq *et al.* (2010) and Bello *et al.* (2010).

The studied experimental material possesses sufficient variability for all the morphological and yield traits which can be beneficial for selection in different breeding programmes. High GCV & PCV values were obtained for kernel yield per plant, kernel yield, plant height, ear placement height, number of kernels per cob, cob yield per plot and test weight. High heritability estimates coupled with genetic advance as percentage of mean was recorded for plant height, ear placement height, days to 50% pollen shed and test weight. Similarly, the traits kernel yield per plot, cob yield per plot, ear placement height, plant height and shelling percentage established Highest significant positive association with kernel yield and the trait kernel yield per plot also showed highest positive direct effects indicating that these traits are more effective and these traits directly and or indirectly will contribute for achieving higher kernel yields.

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