Forage Res., **43** (1) : pp. 67-69 (2017) **http://forageresearch.in**
SHORT COMMUNICATION

VARIABILITY AND CHARACTER ASSOCIATION STUDIES IN FODDER MAIZE (*ZEA MAYS* L.) HYBRIDS

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(Received : 31 March 2017; Accepted : 3 May 2017)

SUMMARY

Twenty maize (*Zea mays* L.) hybrids were evaluated for character association study during **kharif** 2012 at Forage Research Farm, Punjab Agricultural University, Ludhiana. The genotypes were significantly different for all the characters, which indicated scope for further genetic studies. High heritability along with high genetic advance was recorded for all the traits except number of leaves per plant indicating the predominance of additive effects in the inheritance of these characters. The phenotypic coefficients of variation (PCV) estimates were invariably higher than their corresponding genotypic coefficient of variation (GCV) values thereby suggesting the environmental influence. High estimates of GCV and PCV were observed for plant height, leaf stem ratio, dry matter yield and green fodder yield, suggesting that selection based on these characters would facilitate successful isolation of desirable types. Traits like plant height, leaf length and dry matter yield had positive and significant correlation at genotypic as well as phenotypic level with green fodder yield and the selection based on these traits will result in improving the green fodder yield in maize. Most of the yield contributing traits like plant height, leaf length, stems girth, leaf : stem ratio and dry matter yield exhibited positive direct effect on green fodder yield.

Key words : Green fodder yield, fodder maize hybrids, heritability, correlation and path coefficient

The great challenge for forage maize breeders lies in identifying the genetic make-ups that are superior in green fodder yield. Green fodder yield is dependent on several other metric traits and it is the result of a number of complex morphological and physiological processes affecting each other and occurring in different growing stages. Therefore, the knowledge of association of this economically important character with other characters would be quite useful to select better genotypes having high green fodder yield with better nutrients and quality parameters.

To reach this goal, the basic requirements are to have adequate information on the extent of variability, heritability, expected genetic gain and degree of genetic association among the different characters. GCV together with heritability estimates would give reliable indication about the expected improvement of a trait under consideration. However, the importance of using selection strategies, chiefly for quantitative traits, in highly segregating populations. Intensifying artificial selection for low heritability traits of difficult gene action estimation must be practised in advanced generations with reduced frequency of heterozygosity. The indirect selection through less complex traits with larger heritability, however, results in larger genetic progress when compared to direct selection. Considerable significance has been devoted to studies involving correlation of traits in breeding programmes. The measurement and interpretation of these correlations can result in mistakes on selection strategies since a high correlation can be the result of a third trait or a group of traits affecting these traits. An attempt was, therefore, made to estimate the extent of variability for different yield contributing traits, magnitude and direction of association among different characters both at genotypic and phenotypic levels and to investigate the direct and indirect effects of yield components on green fodder yield in maize.

The experiment was conducted at Forage Research Farm, Punjab Agricultural University, Ludhiana. The plant material was comprised of a total of 20 hybrids (developed by both private and public sectors) along with two forage composite varieties African Tall and J-1006 as checks. The hybrids were grown in randomized complete block design (RBD); where each entry was accommodated in 18 m^2 plot size containing 10 rows of 6 m length with inter-row spacing of 30 cm with three replications. Recommended package of practices to raise a good crop were followed. Observations were recorded on five random plants selected from each entry on eight quantitative variables viz., plant height (PH), leaf length (LL), leaf width (LW), number of leaves per plant (NOL), stem girth (SG), leaf : stem ratio (LSR), dry matter yield (DMY) and green fodder yield (GFY).

The data were analyzed for variability, divergence, correlation and path coefficient.

Estimates of Genetic Variability

It is evident from the range of mean values for different traits among the genotypes evaluated (Table 1) that these had diverse genetic background. The traits like plant height (94.6- 186.0 cm), leaf length (53.7-90.0 cm), leaf : stem ratio (0.38-1.20), dry matter yield (2.30-6.20 kg/plot) and green fodder yield (16.3-29.3 kg/plot) had wide range of mean values. Genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), broad sense heritability (h^2) and genetic advance as per cent of mean (GA %) (Table 1) revealed that GCV and PCV values were invariably higher for most of the traits except NOL indicating primarily the genetic control for these traits rather the environment effect alone. Also high estimates of GCV and PCV were observed for plant height, leaf : stem ratio, dry matter yield and green fodder yield, suggesting that selection based on these characters would facilitate successful isolation of desirable types. However, the genetic variability together with heritability estimates would give a better idea on the amount of GA expected from selection. Leaf width and number of leaves/plant had low GCV values indicating little scope for improvement in these traits in the material studied.

High h^2 along with high GA was recorded for plant height, leaf length and leaf : stem ratio. Heritability along with phenotypic variance and the severity of selection provide estimableness of genetic advance or responding to the selection which is very useful in the selection of promising lines (Rohman and Hussain, 2003). Traits having high h^2 and high GA are supposed to be under control of additive genes; hence, these can be improved by selection based on phenotypic performance (Singh *et al*., 2005). Dry matter yield had lowest h^2 (4.18) followed by number of green fodder yield (4.74), thus, was difficult to be improved by phenotype guided selection. Traits like number of leaves per plant, leaf width and stem girth had high h^2 but low values of GA suggesting the involvement of non-additive gene action in their inheritance. Traits like plant height, leaf length, stem girth and leaf : stem ratio exhibited high h^2 coupled with high PCV suggesting greater scope for selection of these traits on phenotypic basis.

TABLE 1

Estimates of genetic parameters for different traits in fodder maize hybrids

Characters	Range of mean values	h^2 (%)	GA (%)	PCV	GCV	GM
PH	94.6-186.0	92.93	41.11	21.48	20.70	144.57
LL	53.7-90.0	90.78	25.18	13.47	12.83	72.27
LW	6.9-10.1	67.27	16.41	11.84	9.71	8.45
SG	1.2-2.0	60.26	17.64	14.21	11.03	1.61
NOL	10.1-14.1	43.37	7.76	8.69	5.72	12.09
LSR	0.38-1.20	79.26	58.62	35.90	31.96	0.73
DMY	2.30-6.20	4.18	2.38	27.71	12.12	3.95
GFY	16.3-29.3	4.74	2.70	27.61	12.06	24.31

PH–Plant height (cm), LL–Leaf length (cm), LW–Leaf width (cm), SG–Stem girth (cm), LSR–Leaf stem ratio, DMY–Dry matter yield (q/ha), GFY–Green fodder yield (q/ha), h^2 (%)–Heritability (broad sense), GA (%)–Genetic advance as percentage of mean, PCV–Phenotypic coefficient of variability, GCV–Genotypic coefficient of variability and GM–Grand mean.

Genotypic and Phenotypic Correlation Coefficients

Results indicated that many yield contributing traits viz., plant height, leaf length and dry matter yield had positive and highly significant correlation at genotypic as well as phenotypic level with green fodder yield (Table 2) and the selection based on these traits will result in improving the green fodder yield in maize. It was reported by Kara *et al.* (1999) that the green forage yield in maize was positively correlated with stem diam-eter, ear diameter, and ear weight. Further perusal of the data revealed that none of the traits under study had a negative and significant correlation with green fodder yield and dry matter yield as well. Traits like plant height, leaf length, leaf width, stem girth and number of leaves/plant showed positive and highly significant correlation amongst each other. Highest value of positive and significant correlation was observed between green fodder yield and dry matter yield (0.75 and 0.94) closely followed by leaf width and stem girth (0.94 and 0.55) leaf length and leaf : stem ratio (-0.31 and -0.26) exhibited highest value of negative and significant correlation. The results reported by Iptas and Yavuz (2008) and Icoz and Kara (2009) also corroborated our results.

Path Coefficient Analysis

Partitioning of the total correlation coefficient into direct and indirect effects for green fodder yield showed a positive direct effect of many yield contributing traits viz., plant height, leaf length, stem girth, leaf : stem ratio and dry matter yield (Table 3). Kumar and Singh (2004) reported that the dry forage yield/plant was significantly and positively associated with green fodder yield and yield components such as plant height, number of leaves/plant, and stem diam-eter. Thus, the improvements in characters such as plant height, leaf length, and stem girth will help improve fodder yield both directly and indirectly. Negative direct effect contributed by traits like leaf width and number of leaves per plant, however, deluded the positive and direct effect of earlier traits on green fodder yield.

The positive indirect effects were contributed through most of the traits except leaf length, leaf width and number of leaves per plant (Table 3). Icoz and Kara (2009) reported that ear weight, leaf number, and stem diameter had the greatest direct effects on plant weight at the lowest and the highest plant densities. Positive and significant genotypic correlation values of traits viz., plant height (0.26), leaf length (0.68) and dry matter yield (0.75) with green fodder yield and their positive direct effect values on green fodder yield i. e. 0.013, 0.0087 and 0.9966, respectively, indicated a true picture of association between these traits. Iptas and Yavuz (2008) reported that plant height and stem diameter were not related to dry matter yield. However, Kumar and Singh (2004) demonstrated that plant height and stem diameter were related to dry matter yield.

Selection for taller plants with more number of broader and longer leaves will be significant for the improvement of green fodder yield in the material

TABLE 2

Genotypic and phenotypic correlation coefficients among various traits of fodder maize hybrids

Characters		PH	LL	LW	SG	NOL	LSR	DMY
LL	G	0.67**						
	P	0.62**						
LW	G	0.69**	0.39**					
	P	0.58**	0.29*					
SG	G	0.62**	0.78**	0.94**				
	P	0.49**	0.55**	0.55**				
NOL	G	0.75**	0.77**	0.64**	0.79**			
	P	0.53**	0.47**	0.35**	0.48**			
LSR	G	0.14	-0.31*	0.17	-0.24	-0.23		
	P	0.11	-0.26*	0.87**	-0.14	-0.12		
DMY	G	0.16	0.71**	0.10	0.02	0.01	0.04	
	P	0.18	0.18	0.12	0.20	0.28**	-0.11	
GFY	G	0.32*	0.68**	0.09	0.03	0.01	0.05	0.75**
	P	0.26*	0.32**	0.12	0.22	0.29**	-0.12	0.94**

*Critical value of 'r' at 5% = 0.26, **Critical value of 'r' at 1% = 0.34; G= genotypic correlation coefficient; P=Phenotypic correlation coefficient. Characters details are given in Table 1.

TABLE 3

Path coefficient analysis for direct (bold) and indirect effects on green fodder yield (kg/plot) in fodder maize hybrids

Characters	PH	LL	LW	SG	NOL	LSR	DMY	Genotypic correlation with GFY
PH	**0.013**	-0.0054	-0.0098	0.0094	-0.0018	-0.0010	0.1791	0.26*
LL	0.0079	**0.0087**	-0.0048	0.0106	-0.0016	0.0022	0.1833	0.68**
LW	0.0074	-0.0025	**-0.0169**	0.0104	-0.0012	-0.0008	0.1170	0.09
SG	0.0063	-0.0048	-0.0092	**0.0191**	-0.0016	0.0013	0.2062	0.03
NOL	0.0069	-0.0041	-0.0059	0.0093	**0.0033**	0.0010	0.2746	0.01
LSR	0.0014	0.0021	-0.0015	-0.0028	-0.0004	**-0.008**8	-0.1118	0.05
DMY	0.0023	-0.0016	-0.0020	0.0040	-0.0009	0.0010	**0.9966**	0.75**

*,**Significant at P=0.05 and P=0.01 levels, respectively.
Character details are given in Table 1.

under study. At the same time, progress in breeding for enhanced green fodder yield may be adversely affected by selection for traits like number of leaves per plant and leaf : stem ratio due to a strong negative association of these traits with green fodder yield.

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