International Journal of Agriculture Innovations and Research
Volume 6, Issue 1, ISSN (Online) 2319-1473
Manuscript Processing Details (dd/mm/yyyy) :
Received : 05/04/2017 | Accepted on : 12/04/2017 | Published : 16/08/2017

Estimation of Genetic Parameters, Correlation and Path Coefficient Analysis of Different Genotypes of Maize (Zea Mays L.)

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***Abstract* – A field research was conducted to evaluate the maize genotypes for their genetic parameters, association among yield parameters and correlation and causation in alpha-lattice design with three replications at National Maize Research Program (NMRP) Rampur, Chitwan in 2012. Genotypic coefficient of variation was estimated high for number of kernels row^{-1} (24.3%) and ear height, moderate for plant height, 100-kernel weight, days to 50% silking, ear length, SPAD chlorophyll and leaf angle. Genetic advance as percentage of mean had high value for number of kernels row^{-1} (43.73%), ear height, plant height, days to 50% silking, SPAD chlorophyll and 100-kernel weight and moderate value for ear length, leaf angle, days to 50% tasseling and ear girth. High heritability was estimated for days to 50% tasseling (0.89), plant height, SPAD chlorophyll, days to 50% silking, number of kernels row^{-1}, leaf angle and ear length while, ear girt (0.56) while, 100-kernel weight, leaf number and number of kernel rows ear^{-1} showed moderate heritability. Number of kernels row^{-1} (0.94) had positive and highly significant correlation with grain yield plant^{-1} followed by ear length, 100-kernel weight, ear girth, SPAD chlorophyll, plant height and ear height while negative correlation was found for leaf angle, days to 50% silking and days to 50% tasseling. Number of kernels row^{-1}, ear length, 100-kernel weight and ear girth also had highly significant positive inter se association with all yield parameters except days to 50% tasseling, days to 50% silking and leaf angle. Path coefficient analysis showed that number of kernel row^{-1} (0.592) showed the highest, positive and high direct contribution on grain yield plant^{-1} followed by ear length, ear girth, 100-kernel weight and ear height while, Plant height and days to 50% tasseling showed negative, moderate and low direct effect on grain yield plant^{-1} respectively. Thus, selection for genotypes with more number of kernels row^{-1}, maximum ear length and ear girth and having more kernel weight is fruitful for improvement in grain yield plant^{-1}.**

***Keywords* – Maize, Heritability, Correlation, Path Analysis, Direct Effects, Grain Yield Plant^{-1}.**

I. Introduction

Maize is the second most important staple food crop both in terms of area and production after rice in Nepal. It is grown in 871387 hectare of land with an average yield of 2501.1 kg ha^{-1}. Maize occupies about 28.15 % of the total cultivated agricultural land and shares about 24.89 % of the total cereal production in Nepal. It shares about 9.5 % to Agricultural Gross Domestic Product and 3.15 % to gross domestic product. The terai and inner terai (below 900m), the mid-hills (900-1800) and the high-hills (above 1800m) are three distinct zones of maize production in Nepal. The proportion of maize area consists of about 70.89 % in mid-hills followed by 17.79 % in terai and 11.32 % in high-hills. About 86.7% of the total maize production is used for food, 12% for poultry, 0.4% for cattle and less than 1% for others (MoAD, 2012).

Maize grain yield is complicated trait, which can be affected by many factors, and usually as a result of insufficient yield heritability factor, direct selection of yield is not much effective; so, we would better use indirect selection for yield breeding (Khayat *et al*., 2012). Yield is the product of multiplicative interactions of a number of its component characters (Grafius, 1959), cannot be improved to a greater extent on its own. Therefore indirect selection for other yield related characters, which are closely associated with yield having high heritability estimates will be more effective instead of direct selection for grain yield *per se* for its improvement, the correlations between the traits are also of great importance for to achieve the goals in breeding programs. Analysis of correlation coefficient is the most widely used one among numerous methods (Yagdi and Sozen, 2009). Correlation indicates the extent of the observation having relation between two characters. Selection procedures could be varied depending on the relative contribution of each. The association among traits may be measured by correlation coefficient depending on the kinds of studied materials and the type of experimental design used (Sadek *et al.,* 2006).

When more than two variables are involved, the correlations *per se* may not provide a clear picture of the importance of each component in determining grain yield as correlation coefficient measures the mutual association only between a pair of variables. Correlation analysis itself does not provide a true knowledge of the amount of contribution made by each of the yield attributes (Ojomo, 1977, Fakorede and Opeke, 1985). Path coefficient analysis provides more information among variables than do correlation coefficients since this method provides the direct effects of specific yield parameters on yield, and indirect effects via other yield parameters (Garcia del Moral *et al.,* 2003).

The path coefficient analysis unfolds whether the association of grain yield with its component characters is due to the direct effects of component characters on grain yield or is consequence of its indirect effect via some other traits. Therefore, in order to improve grain yield, effective selection can be practiced for the characters having high direct effects and for the characters through which indirect effects are mainly exerted on grain yield.

II. Materials and Methods

Twenty seven maize genotypes were evaluated in a field experiment at NMRP, Rampur in alpha-lattice design with three replications during 2012. There were three blocks within replication and nine genotypes within block. The genotypes were allotted randomly to the 27 plots in each replication. The plot size was 3.0 m × 1.5 m with inter and intra row spacing of 75 and 25 cm, respectively. Every genotype was being sown in two consecutive rows. The standard maize growing technique was practiced as recommended by NMRP, Rampur.

Five plants were tagged randomly for recording observations for each entry for all traits except for days to 50 percent tasseling and silking and average values were taken for analysis. Observation were taken for quantitative traits, viz., leaf number, SPAD chlorophyll, leaf angle, plant height, ear height, days to 50% tasseling and days to 50% silking, for yield attributing traits, viz., ear length, ear girth, number of kernels row^{-1}, number of kernel rows ear^{-1} and 100-kernel weight and for grain yield plant^{-1} and plot yield.

Analysis of variance was done for alpha-lattice design as given by *Andreas et al.* (2007). The genotypic and phenotypic coefficient of variation was computed according to Burton and Devane (1953). The extent of genetic advance as percentage of mean to be expected by selecting 5% of the superior progeny was calculated by using the following formula given by Robinson *et al*., (1949). Heritability in broad sense was estimated as the ratio of genotypic variance to the phenotypic variance (Hanson *et al*., 1956). Simple correlation coefficients were calculated for each pairs of the parameters using the formula by Steel and Torrie (1980) and t-test was applied for testing significance of correlation coefficients. Standardized partial regression coefficients (path coefficients) were calculated according to the method of the inverse symmetric correlation matrix (Edwars, 1997).

III. Results and Discussion

The analysis of variance (Table I) revealed significant differences among genotypes for all the traits under consideration. The difference between GCV and PCV ranged from 0.52 to 6.25 were lower for all traits studied. This showed that the environmental effects are minimum in these parameters. Higher broad sense heritability (Table II) of all traits revealed that larger portion of variations is heritable to offspring. Genetic advance as percentage of mean showed that these parameters were under control of additive genes.

Table I. Analysis of variance for yield and yield parameters in maize

Source of Variation	DF	Seq SS	Adj SS	Adj MS	F	P
Ear length	26	287.111	287.111	11.043	5.83**	0.000
Ear girth	26	102.493	102.493	3.9421	4.89**	0.000
Ear Weight (g)	26	195821.8	195821.8	7531.6	8.53**	0.000
Number of kernel row Ear^{-1}	26	68.8951	68.8951	2.6498	4.56**	0.000
Number of Kernels Row^{-1}	26	3702.61	3702.61	142.41	10.69 **	0.000
100-Kernels Weight	26	1287.40	1287.40	49.52	4.63**	0.000
Plant Height	26	85945.5	85945.5	3305.6	18.97 **	0.000
Ear Height	26	29897.03	29897.03	1149.89	13.19**	0.000
SPAD Chlorophyll	26	2320.169	2320.169	89.237	15.83**	0.000
Days to 50% Tasseling	26	1597.275	1597.275	61.434	24.97**	0.000
Days to 50% silking	26	4097.73	4097.73	157.60	15.72**	0.000
Leaf Angle	26	719.33	2719.33	104.59	8.43**	0.000
Leaf Number	26	82.0018	82.0018	3.1539	4.63**	0.000
Grain Yield Plant^{-1}	26	82214.3	82214.3	3162.1	9.11**	0.000
** Significant at 99% level of confidence.						

Table II. Estimation of genetic parameters (heritability, GAM, PCV AND GCV)

	Heritability	GAM	PCV	GCV
EL	0.62	19.76	15.55	12.21
EG	0.56	11.72	10.08	7.57
NKRE^{-1}	0.54	9.47	8.48	6.24
NKR^{-1}	0.76	43.73	27.80	24.30
100-KW	0.55	21.01	18.63	13.78
PH	0.86	35.61	20.17	18.68
EH	0.80	37.19	22.49	20.15
SPAD	0.83	22.90	13.37	12.19
DTT	0.89	16.72	9.13	8.61
DTS	0.83	23.51	13.74	12.52
LAN	0.71	19.75	13.46	11.36
LN	0.55	7.17	6.36	4.70
YP-1	0.73	61.33	40.79	34.85

GAM = genetic advance as percentage of mean, PCV = phenotypic coefficient of variation GCV = genotypic coefficient of variation, EL = ear length, EG = ear girth, NKRE^{-1} = number of kernel row ear^{-1}, NKR^{-1} = number of kernel row $^{-1}$, 100-KW = 100-kernel weight, PH = plant height, EH = ear height, SPAD = soil and plant analyzer development, DTT = days to 50% tasseling, DTS = days to 50% silking, LAN = leaf angle, LN = leaf number and YP^{-1} = grain yield plant^{-1}.

GCV was the highest in case of grain yield plant $^{-1}$ followed by number of kernels row^{-1}, ear height and plant height. Heritability was also higher than 70% for all traits showing high heritable variation among genotypes. Genetic advance as percentage of mean for these traits were also higher and more than 35% showing that these traits were under control of additive genes. Similar findings were reported by Alvi *et al.* (2003), Annapurna *et al.* (1998), You *et al.* (1998).

Wannows *et al.* (2010) reported high heritability for number of kernels row^{-1}, plant height, ear height and ear length which is in partially agreement with this result. This result was also supported for 100 - kernel weight and leaf number with moderate heritability.

Grain yield plant^{-1} and ear height had better genotypic variability, better broad sense heritability along with better genetic advance which considered the good estimates for effective selection of a trait. This depicted that visual selection based on these traits among the genotypes would be used for improvement of grain yield (Shakoor *et al.*, 2007).

Grain yield plant^{-1} was positively and highly significantly correlated (Table III) with seven traits viz., number of kernels row $^{-1}$, ear length, 100 - kernels weight, ear girth, SPAD readings, plant height and ear height and positively and significantly correlated with leaf number. Positive correlation coefficient shows that the changes of two variables are in the same direction, i.e. high value of one variables are associated with high values of other and vice versa. However, the most yield determinative traits were number of kernels row^{-1} followed by ear length, 100 - kernel weight and ear girth and hence, simultaneous selection for these traits might bring an improvement in yield plant^{-1}. Similar results were obtained by Sandeep *et.al. (2011)*, Alvi *et.al.* (2003), Prakash *et.al.* (2006), Sreckov *et.al.* (2010), Manivannam (1998), Chinnadurai and Nagarajan (2011) and satyanarayana *et.al.* (1990).

Grain yield plant^{-1} had significant negative correlation with leaf angle while non-significant negative correlation with two traits viz., days to 50% silking and days to 50% tasseling, indicating that selection for early tasseling and silking is desirable to increase yield plant^{-1}. Sandeep *et.al. (2011)* reported similar results for later two traits but relation was significant.

To select only those character which are favorably associated among themselves as well as with grain yield *inter se* association studies also provide an opportunity besides the correlation studies. Studies on *inter se* association among yield parameter showed that the trait number of kernels row^{-1} exhibited highly significant positive association with seven traits viz., ear length, 100-kernel weight, SPAD chlorophyll, plant height, ear girth and ear height and significant positive association with leaf number besides highly significant positive correlation with grain yield plant^{-1} in this experiment,. This result was supported by Sandeep *et.al.* (2011).

Likely, ear length, 100-kernels weight and ear girth showed highly significant association with seven traits besides highly significant positive correlation with grain yield plant^{-1}. It was interesting to noticed that, the traits number of kernels row^{-1}, ear length, 100-kernel weight and ear girth did not exhibit negative association with any of the other yield parameters except days to 50% tasseling, days to 50% silking and leaf angle and hence, these traits could be utilized for the improvement of grain yield along with earliness using the present materials. Highly significant favourable correlation among yield attributes indicates that, the unit increase in one trait will cause a unit increase in the associated traits, which in turn will cause in increase in the grain yield (Sandeep *et.al.* 2011).

Path analysis using grain yield plant^{-1} as dependent variable revealed that, number of kernels row^{-1} exerted maximum positive direct effects on grain yield plant^{-1} followed by ear length, days to 50% silking, ear girth, 100-kernel weight, ear height and leaf number (Table IV). Hence, these traits except days to 50% silking could be relied upon for selection of genotypes to improve genetic yield potential of maize. Days to 50% silking had non-significant negative correlation with grain yield plant^{-1} and also had negative indirect effects on grain yield via number of kernels row^{-1}, ear length, ear girth and 100-kernel weight indicating relatively less importance in yield improvement.

Differently, some of the characters viz., plant height, days to 50% tasseling, SPAD chlorophyll and leaf angle exerted negative direct effects on grain yield per plant. Sandeep *et al.* (2011) found similar result for SPAD chlorophyll. However, the negative direct effects of SPAD chlorophyll and plant height were nullified by their indirect positive effects through other component traits, which ultimately resulted in to highly significant positive correlation with grain yield plant^{-1}. Hence, indirect selection through other component characters with which these two traits exhibited positive indirect effects can be recommended so as to bring improvement in grain yield. Further, it was evident that 96.88% of the yield contributing characters was utilized in this analysis as amount of model remainder effect was 0.0312 in the present study (3.12% of yield variations are controlled by unknown factors).

In this study, by and large, the trait number of kernels row^{-1} influnce grain yield plant^{-1} directly and predominantly followed by ear length, ear girth and 100-kernel weight. This result is in agreement with Alvi *et.al.* (2003), Sreckov *et.al.* (2010), Sofi and Rather (2007), Wannows *et.al.* (2010), Mohan *et.al.* (2002) and Venugopal *et.al.* (2003). Further, the association of these traits with grain yield plant^{-1} was also positively and highly significant, indicating traits, number of kernels row^{-1}, ear length, ear girth and 100-kernel weight also influence grain yield plant^{-1} indirectly in a substantial magnitude through most of other yield parameters.

IV. Conclusion

As direct selection for yield improvement in maize is quite difficult, breeding action towards maize yield improvement need to focus on indirect selection of secondary traits. Maize breeders are suggested to consider secondary trait for yield improvement research. Thus, selection for genotypes with higher number of kernels row-1, maximum ear length and ear girth and having high kernel weight is fruitful for getting improvement in grain yield plant-1.

Table III. Simple correlation coefficient of yield parameters and grain yield plant^{-1} and inter se association of yield parameters

	EL	EG	NKR^{-1}	HKW	PH	EH	SPAD	DTT	DTS	LAN	LN	YP-1
EL	1											
EG	0.750**	1										
NKR^{-1}	0.907**	0.774**	1									
HKW	0.770**	0.710**	0.824**	1								
PH	0.684**	0.692**	0.787**	0.710**	1							
EH	0.603**	0.652**	0.671**	0.606**	0.948**	1						
SPAD	0.682**	0.659**	0.804**	0.695**	0.845**	0.765**	1					
DTT	-0.341^{ns}	-0.280^{ns}	-0.453*	-0.228^{ns}	-0.671**	-0.650**	-0.582**	1				
DTS	-0.430*	-0.330^{ns}	-0.507**	-0.268^{ns}	-0.744**	-0.733**	-0.612**	0.934**	1			
LAN	-0.454*	-0.661**	-0.460*	-0.319^{ns}	-0.580**	-0.656**	-0.572**	0.629**	0.599**	1		
LN	0.305^{ns}	0.386*	0.409*	0.413*	0.619**	0.625**	0.484*	-0.116^{ns}	-0.287^{ns}	-0.146^{ns}	1	
YP-1	0.922**	0.839**	0.945**	0.858**	0.695**	0.605**	0.715**	-0.276^{ns}	-0.329^{ns}	-0.458*	0.386*	1

** = correlation is significant at the 0.01 level (two-tailed), * = correlation is significant at the 0.05 level (two-tailed) and ns = correlation is non-significant. EL = ear length, EG = ear girth, NKR-1 = number of kernels row-1, HKW = 100-kernel weight, PH = plant height, EH = ear height, SPAD = SPAD chlorophyll, DTT = days to 50% tasseling, DTS = days to 50% silking, LAN = leaf angle, LN = leaf number and YP-1 = grain yield plant-1.

Table IV. Direct effects (bold) and indirect effects of yield parameters on grain yield plant^{-1} in 27 maize genotypes

	EL	*EG*	*NKR^{-1}*	*HKW*	*PH*	*EH*	*SPAD*	*DTT*	*DTS*	*LAN*	*LN*
Via EL	***0.274***	*0.206*	*0.249*	*0.211*	*0.188*	*0.166*	*0.187*	*-0.094*	*-0.118*	*-0.125*	*0.084*
Via EG	*0.130*	***0.173***	*0.134*	*0.123*	*0.120*	*0.113*	*0.114*	*-0.049*	*-0.057*	*-0.114*	*0.067*
Via NKR^{-1}	*0.537*	*0.459*	***0.592***	*0.488*	*0.466*	*0.397*	*0.476*	*-0.268*	*-0.300*	*-0.272*	*0.242*
Via HKW	*0.133*	*0.123*	*0.142*	***0.173***	*0.123*	*0.105*	*0.120*	*-0.039*	*-0.046*	*-0.055*	*0.071*
Via PH	*-0.182*	*-0.184*	*-0.209*	*-0.189*	***-0.266***	*-0.252*	*-0.225*	*0.179*	*0.198*	*0.154*	*-0.165*
Via EH	*0.067*	*0.073*	*0.075*	*0.068*	*0.106*	***0.112***	*0.086*	*-0.073*	*-0.082*	*-0.073*	*0.070*
Via SPAD	*-0.031*	*-0.030*	*-0.037*	*-0.032*	*-0.039*	*-0.035*	***-0.046***	*0.027*	*0.028*	*0.026*	*-0.022*
Via DTT	*0.036*	*0.029*	*0.047*	*0.024*	*0.070*	*0.068*	*0.061*	***-0.104***	*-0.098*	*-0.066*	*0.012*
Via DTS	*-0.082*	*-0.063*	*-0.097*	*-0.051*	*-0.142*	*-0.139*	*-0.116*	*0.178*	***0.190***	*0.114*	*-0.055*
Via LAN	*0.016*	*0.024*	*0.017*	*0.011*	*0.021*	*0.024*	*0.021*	*-0.023*	*-0.022*	***-0.036***	*0.005*
Via LN	*0.023*	*0.029*	*0.031*	*0.032*	*0.047*	*0.048*	*0.037*	*-0.009*	*-0.022*	*-0.011*	***0.076***
Total	*0.922***	*0.839***	*0.945***	*0.858***	*0.695***	*0.605***	*0.715***	*-0.276*	*-0.329*	*-0.458**	*0.386**

(Residual value = 0.0312) EL = ear length, EG = ear girth, NKR-1 = number of kernels row-1, HKW = 100-kernel weight, PH = plant height, EH = ear height, SPAD = SPAD chlorophyll, DTT = days to 50% tasseling, DTS = days to 50% silking, LAN = leaf angle, LN = leaf number and YP-1 = grain yield plant-1.

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