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VARIABILITY, HERITABILITY AND GENETIC ADVANCE OF MAIZE (*Zea mays* L.) GENOTYPES

Sampurna Bartaula[1*], Urbashi Panthi[1], Kiran Timilsena[2], Subarna Sharma Acharya[3] and Jiban Shrestha[4]

[1]Institute of Agriculture and Animal Science, Prithu Technical College, Tribhuvan University, Nepal; [2]Department of Plant Breeding, Tribhuvan University, Kirtipur, Nepal; [3]Institute of Agriculture and Animal Science, Lamjung Campus, Tribhuvan University, Nepal; [4]Nepal Agricultural Research Council, Agriculture Botany Division, Khumaltar, Lalitpur, Nepal.

***Corresponding author:** Sampurna Bartaula; E-mail: agsampurna@gmail.com

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The selection efficiency for certain traits in crops can be broadened using estimates of genetic parameters, which are fundamental for plant breeding. Ten maize genotypes were evaluated in randomized complete block design (RCBD) with three replications at the field of Lamahi Municipality, Dang district of Nepal to assess the magnitude of genetic variability, heritability and genetic advance for growth, yield and yield contributing traits during summer season (June to August), 2018. Analysis of variance revealed significant differences for all traits. The phenotypic coefficient of variation (PCV) was higher than genotypic coefficient of variation (GCV) recorded for all traits. The grain yield showed the highest PCV (50.78%) and GCV (51.24%) whereas the lowest PCV (4.51%) and GCV (4.50%) were recorded for test weight; test weight showed high heritability (0.99) with low genetic advance as a percent of mean (9.26). Grain yield showed positive and significant phenotypic correlation with test weight (r=0.960), kernel per row (r=0.924), kernel rows per cob (r=0.900) and cob length (r=0.840), respectively. Traits namely grain yield, number of kernels per cob and kernel rows per cob showed high GCV, PCV. Therefore these traits can be used further in crop improvement program.

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INTRODUCTION

Maize (*Zea mays* L.) is the most important cereal crops next to wheat and rice. It is the second most important cereal crop in terms of area, production and productivity after rice in Nepal. In Nepal, it is grown in 8,91,583 ha producing 2.2 million tons, with an average yield of 2.5 t/ha (MOAD, 2016). The trend of production is increasing due to its wide range of utilization. In Nepal, maize is cultivated throughout the country. Maize acreage and production have an increasing tendency with the introduction of hybrids due to its high yield potential. It possesses one of the most well studied genetic systems among cereals which have motivated a rich history of research into the genetics of various traits in maize**.** It offers tremendous scope for the plant breeders for genetic improvement.

Selection is the basic step of breeding program. Selection of the best suitable variety in accordance to the existing environment determines the performance of each genotype. The efficiency of selection depends on the direction and magnitude of association between yield and its components. The efficiency of selection can be using estimates of genetic parameters, which are fundamental in the plant breeding, since they allow identifying the nature of the action of genes involved in the control of quantitative traits and evaluate the efficiency of different breeding strategies to obtain genetic gains (Vashistha *et al.*, 2013). The estimates of genetic parameters as variances, coefficients of variation, heritability, genotypic, phenotypic and environmental correlations, allow knowing the magnitude of the genetic variability of a population, and the selection gains. A critical analysis of genetic variability present in the germplasm of a crop and its estimation is a pre-requisite for initiating any crop improvement programme as well as adopting appropriate selection techniques (Sravanti *et al.*, 2017). The knowledge of heritability enables the plant breeder to decide the course of selection procedure to be followed under a given situation (Li and Yang, 1985). The estimates of genetic parameters like heritability and genetic advance helps in predicting the gain under selection. Therefore, this study was undertaken to study the genetic variability, heritability and genetic advance among the maize genotypes for yield and yield contributing traits.

MATERIALS AND METHODS

Experimental site

This experiment was carried out in the field of Lamahi Municipality, Dang district in the Province number 5, inner Terai region of Nepal during the summer season, 2018. It was located at latitude of 28° 7' 0" N latitude, longitude of 82° 18' 0" E and 628 m altitude. The PH of the experimental site was slightly acidic and the texture of the soil was silt loam.

Climatic observation

The experimental site was situated in the sub-tropical climatic zone of Nepal. The area has sub- humid type of weather condition with cold winter, hot summer and distinct rainy season. There are three distinct seasons "namely rainy season (June-October), cool winter (November- February) and hot spring season (March- May).The climatic data was taken from meteorological station, Ghorahi, Dang. Data on maximum and minimum temperature and rainfall during cropping season were recorded (figure 1). Regarding to temperature, the average maximum and minimum temperature during cropping season ranged from 31.32^0c to 23.32^0c respectively. The highest maximum and minimum temperature was recorded in month of June 1st and 2nd week and June 3^{rd} week. The total rainfall 134.38 mm was recorded during crop growing period (June to September) 2018. Maximum rainfall was recorded during June 1st week and rainfall fewer weeks were Sep 2^{nd}, 3^{rd} and 4^{th} week and July 3^{rd} week.

Plant materials

Ten maize genotypes namely Rampur Composite, Deuti, ZM-401, Rampur-4, Manakamana-3, Arun-4, TLBR_507f16, Manakamana-7, Arun-2 and Farmer's variety as a Local check variety were used in the experiment. Except Farmer's Variety, all nine genotypes were received from National Maize Research Program, Rampur, Chitwan, Nepal

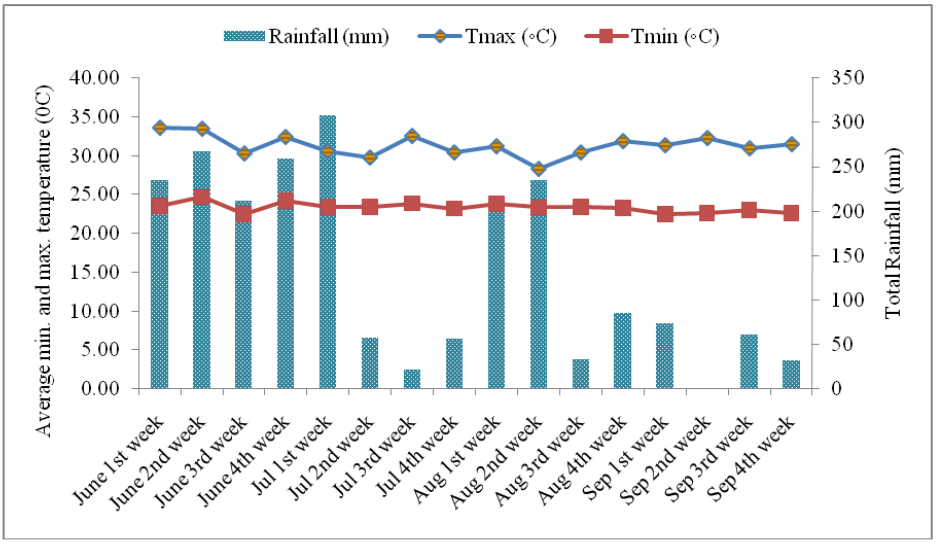

Figure1. Average weekly minimum and maximum temperature and total rainfall recorded at Ghorahi Meteorological station, Dang, Nepal from June to September, 2018.

Experimental design and crop management

The experiment was conducted in Randomized Complete Block Design (RCBD) with three replications. Each experimental plots were of size 6m^2 (2.4m x 2.5m) having 4 rows that were 60 cm apart. The seeds were sown on row 25 cm apart on June 03. The dose of chemical fertilizer applied was 120:60:40 kg NPK/ha. Fertilizer were applied prior to sowing at rate of 60 N kg/ha, 60 kg P and 40 kg K/ha and additional side dressing of 30 N kg/ha were applied at the two times in six leaves stage and knee high stage of maize. The irrigation was done three important stage, knee high stage, tasseling stage and milking stage. Recommended package of practices was followed as per recommendation of National Maize Research Program, Rampur, Chitwan, Nepal.

Data observation and analysis

Observations were taken on randomly selected 10 plants from each experimental plot for all the traits under consideration. Grain yield was calculated using formula adopted by Carangal *et al.* (1971) and Shrestha *et al.* (2018) by adjusting the grain moisture at 15% and converted to the grain yield per hectare basis. The data collected on all the characters were subjected to standard methods of analysis of variance (Panse and Sukhatme, 1985). Phenotypic and genotypic coefficient of variation was calculated as suggested by Falconer (1981). Heritability (broad sense) (Johnson *et al.*, 1955), genetic advance (Burton, 1952) and genetic advance as a percentof mean (Johnson *et al.*, 1955) were also estimated.

Statistical analysis

All agronomic data from trials were analyzed by ANOVA using a split split-plot design. The experimental data were processed using Excel 2010 and analyzed by using Genestat software. Least significant difference (LSD $p \leq 0.05$) test was used for mean comparison to identify the significant components of the treatment means (Jan *et al.*, 2009; Sharma *et al.*, 2016; Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Genetic Variability

The analysis of variance revealed the existence of significant differences among the genotypes for all the traits (Table 1), indicating the presence of considerable genetic variability among the experimental material under study. Thus, there is plenty of area and scope for improvement of different quantitative and qualitative traits through selection. Similar finding on presence of significant variability for various characters in the maize genotypes was also reported by many researchers in their study (Kumar *et al.*, 2015; Kandel *et al.*, 2018)

The mean values, genotypic and phenotypic coefficient of variation, heritability, genetic advance and genetic advance as percent of mean (Table 2) of all ten genotypes were calculated for yield and yield attributes. For all the characters under study except no. of leaves and cob length, phenotypic coefficient of variation values are slightly higher than the genotypic coefficient of variation values indicating that the characters were less influenced by the environment. Therefore, response to direct selection may be effective in improving these traits. In contrast to other traits, no. of leaves and cob length the difference between phenotypic coefficient of variation and genotypic coefficient of variation was higher indicating that the characters were more influenced by the environment. The characters studied in the present investigation exhibited low (less than 10%), moderate (10-20%) and high (more than 20%) phenotypic and genotypic coefficients of variation. The estimates of phenotypic variation (50.78%) and genotypic variation (51.24%) were found to be high for grain yield (kg/ha). This findings was similar to the results were reported by Bhusal *et al.* (2017) and Sharma *et al.* (2018).

ASI (29.79%, 27/11%) and Kernel per cob (29.47%, 28.88%) reported high phenotypic and genotypic coefficients of variations. Results were supported by Kharel *et al.* (2017) who reported higher variability for kernel per cob and higher variability for ASI was reported by (Sharma *et al.*, 2018). Plant height at harvest (14.69%, 14.62%), ear height (14.53%, 14.51%), kernel row per cob (16.88%, 15.70%) and kernel per row (13.84%, 13.59%) had moderate phenotypic and genotypic coefficients variations. These results were in conformity with the findings of Choudhary and Choudhary (2002) and Singh *et al.* (2003). Phenotypic and genotypic coefficients of variation were low for test weight (4.51%, 4.50%). While traits namely No. of leaves (11.19%, 6.31%) and Cob length (12.05%, 8.82%) expressed moderate PCV values coupled with low GCV values indicating high influence of environment on these characters.

Heritability and genetic advance

Seven characters under investigation viz., plant height at harvest (0.99), ASI (0.82), ear height (0.99), kernel row per cob (0.86) showed high estimates of heritability in broad sense. High heritability for these characters indicates the scope of genetic improvement of these characters through selection, which revealed that these characters are less influenced by environment and there could be greater correspondence between phenotypic and breeding values. Cob length (0.53) and no. of leaves (0.31) have moderate heritability. Ghimire and Timsina (2015) also reported higher heritability for ear height and grain yield.

Genetic advance as a percent of mean is classified as low (less than 10 %), moderate (10-20 %) and high (more than 20 %). Among the characters under study, no. of leaves (7.33%) and test weight (9.26%) exhibited low genetic advance as a percent of mean. Trait namely cob length (13.29%) showed moderate genetic advance as a percent of mean. All other traits plant height (29.98%, ASI (50.84%), ear height (29.85%), kernel row per cob (30.10%), kernel per row (27.49%), kernel per cob (58.32%) and grain yield (103.67%) showed high estimates of genetic advance as a percent of mean.

Among all the characters studied, test weight exhibited high heritability coupled with low genetic advance as a percent of mean suggesting expression of the trait is under the control of non-additive type of gene action, and its response to selection would be poor. In such case hybridization programme is rewarded. No. of leaves showed lower heritability as well as genetic advance suggesting the trait governance by non-additive gene action and direct selection would not be effective for the trait. All other traits under consideration expressed high heritability coupled with high genetic advance, which indicated the preponderance of additive gene action in controlling the traits. Hence direct selection of such characters would be effective in improving the yield.

Table 1. Mean square comparison for different traits of ten maize genotypes at Lamahi, Dang, Nepal (2018)

Parameters	Mean Square of Squares		
	Replication (df = 2)	Genotypes (df = 9)	Error (df = 18)
Plant height at harvest (cm)	29	1055***	10
No. of leaves	4.93	1.04	1.3
ASI (days)	0.3	1.737***	0.337
Ear height (cm)	0.1	301.9***	0.9
Cob length (cm)	0.555	2.566	1.728
Kernel row per cob	1.6	4.8***	0.71
Kernel per row	0.53	18.37***	0.68
Kernel per cob	2460	15541***	627
Test weight (g)	0	125.2***	0.5
Grain yield (kg/ha)	35433	2833539***	51542

Table 2. Variability, heritability and genetic advance for growth, yield and yield attributing traits of ten maize genotypes at Lamahi, Dang, Nepal (2018)

Traits	σ^2_g	σ^2_p	σ^2_e	Mean	GCV (%)	PCV (%)	Hbs	GA (%)	GAM
Plant height at harvest (cm)	1051.67	10	1061.67	221.77	14.62	14.69	0.99	66.48	29.98
No. of leaves	0.60	1.30	1.90667	12.333	6.31	11.19	0.31	0.90	7.33
ASI (days)	1.62	0.33	1.96167	4.7	27.11	29.79	0.82	2.38	50.84
Ear height (cm)	301.60	0.90	302.5	119.64	14.51	14.53	0.99	35.72	29.85
Cob length (cm)	1.99	1.72	3.718	15.989	8.82	12.05	0.53	2.12	13.29
Kernel row per cob	4.56	0.71	5.27333	13.6	15.70	16.88	0.86	4.09	30.10
Kernel per row	18.14	0.68	18.8233	31.333	13.59	13.84	0.96	8.61	27.49
Kernel per cob	15332	627	15959	428.67	28.88	29.47	0.96	250.01	58.32
Test weight (g)	125.03	0.5	125.533	248.03	4.50	4.51	0.99	22.98	9.26
GY (kg/ha)	2816358	51542	2867900	3304.4	50.78	51.24	0.98	3425.89	103.67

σ^2_g = Genotypic variance, σ^2_p = Phenotypic variance and σ^2_e = Environmental variance, Hbs= Heritability broad sense, GCV= Genotypic coefficient of variation, PCV= Phenotypic coefficient of variation, GA= Genetic advance, GAM= Genetic advance as percent of mean.

Phenotypic correlation coefficients

Estimates of phenotypic correlation of grain yield and other yield related traits are shown in Table 3. Grain yield showed positive and significant phenotypic correlation with test weight (r=0.960), kernel per row (r=0.924), kernel rows per cob (r=0.900) and cob length (r=0.840). Anthesis Silking interval showed highly significant negative correlation with yield (r=-0.717) and Plant height showed moderately significant negative correlation (r=-0.443) with grain yield. Correlations of grain yield with other traits considered were not significant. The most yield determinative traits were test weight followed by number of kernels per row and hence, simultaneous selection for these traits might bring an improvement in grain yield. Similar results were also obtained by Alvi *et al.* (2003), Prakash *et al.* (2006), Sreckov *et al.* (2010), Chinnadurai and Nagarajan (2011) and Kharel *et al.* (2017).

Table 3. Phenotypic correlation coefficient among different growth, yield and yield attributing traits of ten maize genotypes at Lamahi, Dang, Nepal (2018)

Parameters	PH	No. of leaves	ASI (days)	EH	CL	RPC	KPR	KPC	TW	GY
PH	1	0.129	0.430*	0.726**	-0.434*	-0.445*	-0.463**	-0.27	-0.492**	-0.443*
No. of leaves		1	-0.097	0.251	0.119	0.134	0.135	0.256	0.044	0.078
ASI (days)			1	0.131	-0.650**	-0.681**	-0.709**	-0.181	-0.719**	-0.717**
EH				1	-0.223	-0.248	-0.24	-0.166	-0.308	-0.325
CL					1	0.739**	0.950**	0.193	0.826**	0.840**
RPC						1	0.911**	0.075	0.924**	0.900**
KPR							1	0.159	0.926**	0.924**
KPC								1	0.021	0.118
TW									1	0.960**
GY										1

**Correlation is significant at the 0.01 level *. Correlation is significant at the 0.05 level. PH- Plant height at harvest (cm), ASI- Anthesis Silking Interval, EH- Ear height (cm), CL-Cob length (cm), RPC-Rows per cob, KPR-Kernel per row, KPC-Kernel per cob, TW-Test weight (gm) GY-Grain yield (kg/ha)

CONCLUSION

All the studied traits were significant, indicating that presence of genetic variability which can be exploited in crop improvement program. PCV is higher than GCV in all studied traits; it does indicate that there is no environmental influence. Traits namely grain yield, number of kernels per cob and kernel rows per cob having high GCV, PCV, heritability along with high genetic advance as percentage of mean were used in selection process of crop improvement program. As test weight, number of kernels per row and number of rows per cob were positively and highly correlated with grain yield hence, selection for these traits might bring an improvement in grain yield.

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CONFLICT OF INTESEST

The authors declare that there is no conflict of interest.

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