GENETIC VARIABILITY, HERITABILITY AND GENETIC ADVANCE ESTIMATES IN MAIZE (*ZEA MAYS* L.) GENOTYPES IN NEPAL

Bishnu Prasad Kandel[1*], Bijay Kumar Sharma[2], Subarna Sharma[2], Jiban Shrestha[3]
[1]Department of Plant Breeding, Post Graduate Program, Institute of Agriculture and Animal Science, Tribhuvan University, Kirtipur, Nepal; [2]Tribhuvan University, Institute of Agriculture and Animal Science, Lamjung Campus, Lamjung, Nepal; [3]Nepal Agricultural Research Council, National Commercial Agriculture Research Program, Pakhribas, Dhankuta, Nepal;
**Corresponding author:bkandel33@gmail.com*

Abstract. Eleven early maize and ten winter maize genotypes were evaluated in randomized complete block design (RCBD) with three replications at the research field of Regional Agricultural Research Station (RARS), Lumle, Kaski and National Maize Research Program (NMRP), Rampur, Chitwan, Nepal respectively to assess the magnitude of genetic variability, heritability and genetic advance for yield and yield contributing traits during summer (kharif) and winter (rabi) seasons of 2016-2017. Analysis of variance revealed significant differences for 10 characters studied among the genotypes. The phenotypic coefficient of variation (PCV) is higher than genotypic coefficient of variation (GCV) recorded for all traits. High GCV and PCV was recorded for grain yield, thousand kernel weight and ear height. Heritability was moderate to high except thousand kernel weight in kharif whereas number of kernel per ear showed lowest heritability in winter season. Genetic gain as percentage of mean (GAM) was greater for grain yield, thousand kernel weight, plant height and ear height. As grain yield had higher genetic advance along with high heritability in both the seasons that indicated the presence of large proportion of additive gene action for deciding this trait.

Keywords: Maize (*Zea mays* L.), variation, heritability, genetic advance

INTRODUCTION

Maize is popularly known as the ‘queen of cereals’ (Singh, 1998) because it’s has high yield potential as compared to other cereal crops. Maize is the second most important staple food crop after rice in terms of area and production in Nepal (MoALMC, 2016/17). The maize sown area in Nepal is 924,321 ha with a total production of 2,336,675 metric tonne and productivity of 2.53 tonne ha-^{1}. Maize is the only crop which is adaptive to across different agro-ecological zones because of its great diversity (Ferdu et al., 2002). Genotype-environment interaction (GEI) causes difference between genotypes and their yield stability. Hence, it is important to assess the importance of interactions in the selection of genotypes across several environments besides calculating the average performance of the genotypes under evaluation (Fehr, 1991).The genetic diversity of maize, being an out crossing crop, is very broad for conservation and utilization in breeding programs. Genetic variability among individuals in population offers effective selection. The understanding of genetic variability present in a given crop species for the traits under improvement is imperative for the success of any plant breeding program (Sankar et al., 2006). The parameters such as GCV and PCV are useful in detecting the amount of variability present in a given characteristic. The efficiency with which genotypic variability can be exploited by selection depends upon heritability and the genetic advance (GA) of individual trait (Bilgin et al., 2010). Genetic improvement of plants for quantitative traits requires reliable estimates of heritability in order to plan an efficient breeding program (Akinwale et al., 2011). Heritability provides information on the extent to which a particular morphogenetic character can be transmitted to successive generations (Bello et al., 2012). Heritability coupled with high GA would be more useful in predicting the resultant effect in the selection of the best genotypes for yield and its attributing traits (Singh et al., 2011).

The magnitude of genetic variability present in population is of paramount importance for the success of any plant breeding program. Therefore, this study was designed to assess the magnitude of genetic variability, heritability and genetic advance of traits in maize genotypes in different agro ecological region of Nepal.

MATERIALS AND METHODS

Field research on eleven early maize was conducted at research farm of RARS Lumle during kharif 2016. The station is situated at an altitude of 1740 meters above mean sea level in the south facing slopes at 28.297607° north and 83.816754° east coordinates. Ten winter maize genotypes were evaluated at NMRP, Chitwan from October, 2016 to April, 2017. The location is at 27°40' N latitude and 84°19' E longitude with an elevation of 228 meters above sea level. Both experiment were carried out in RCBD design with three replications. In first experiment each genotype received the plots of 9 m^2 (3m x 3m) area with the net plot area of 99 m^2 per block/replications, however in second experiment each genotypes received 10 m^2 (5m x 2m). Both kharif and rabi maize genotypes received the crop geometry of 25m x 75m.. The applied fertilizer dose is 120:60:40 NPK kg ha^{-1}. All cultural practiced were followed as per procedure of Nepal Agriculture Research Council (NARC). From five randomly selected plants of each plot for data collection. Data were statically analysis by MS-Excel, R-Package. GCV and PCV calculated by Using the formula given by Chaudhary and Prasad (1968) and categorized as suggested by Sivasubramanjan and Menon (1973) categoried the value of GCV and PCV as follows:

0 – 10 %: low
10 – 20 %: moderate
>20 %: high.

Heritability in broad sense for all characters was computed using the formula given by Falconer (1996) and categorized as suggested by Robinson et al. (1994).

0 – 30% : Low
30 – 60% : Moderate
> 60% : High

Genetic advances where for each character at 5% selection intensity was computed by the formula described by Johnson et al. (1955) and GAM was calculated by using the formula given by Falconer (1996) and categorized as suggested by Johnson et al. (1955).

0-10%= low,
10-20%=moderate,
>20 % =high

Grain yield (kg ha^{-1}) at 15% moisture content was calculated using fresh ear weight with the help of the below formula:

$$\text{Grain yield } \left(\frac{\text{kg}}{\text{ha}}\right) = \frac{\text{F.W.}\left(\frac{\text{kg}}{\text{plot}}\right) \times (100 - \text{HMP}) \times \text{S} \times 10000}{(100 - \text{DMP}) \times \text{NPA}}$$

Where,

F.W. = Fresh weight of ear in kg per plot at harvest

HMP = Grain moisture percentage at harvest
DMP = Desired moisture percentage, i.e. 15%
NPA = Net harvest plot area, m^2
S = Shelling coefficient, i.e. 0.8

This formula was also adopted by Carangal *et al.* (1971) and Shrestha *et al.* (2015) to adjust the grain yield (kg ha^{-1}) at 15% moisture content.

Table 1.

List of eleven genotypes used in research at genotypes used in research NMRP, Rampur, Chitwan during 2016

SN	Genotypes
1	EARLY MID KATAMARI
2	RAJAHAR LOCAL
3	S97TEYGHAYB(3)
4	POP-445/POP-446
5	COMPOZ-NIPB
6	R.C/POOL-17
7	SO3TEY/LN
8	ARUN-4(standard check)
9	MANAKAMANA-5 (local check)
10	ZM-621/POOL-15
11	EEYC1

Table 2.

List of ten rabi maize at RARS Lumle during 2016

SN	Genotypes
1	Across9942/Across9944,
2	ZM-627
3	Across9331RE
4	Rampur S10F20
5	Pool-15
6	KLY-POP
7	S03TEY FM(R)
8	Rampur S03F04
9	ZM-401
10	S99TLYQ-HGAB)

RESULTS AND DISCUSSION

The analysis of variance for all ten quantitative characters revealed that treatments differences were highly significant in both the seasons indicating the presence of inherent genetic differences in our experimental material (Table 3).This wide spectrum of variability for all characters provides greater opportunity for the isolation of best genotypes to be fitted in breeding program. 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., 2017).

Coefficient of variation. The values of PCV were higher than GCV values for all the characters in both seasons (Table 4). The large difference between the values of PCV and GCV of characters of thousand kernel weight and grain yield, days to fifty percentage silking, days to fifty percentage tasseling under each seasons, indicated that environmental factors significantly influenced the expression of these traits while other remaining traits were having the lower difference between of PCV and GCV, indicating the less influence of environment in expression of these traits.

In kharif season (Hill condition) highest PCV was obtained from grain yield followed by thousand kernel weight, and ear height, Similarly GCV was recorded on same pattern. Lowest PCV recorded for days to 50 % tasseling, followed by days to 50% silking,ear diameter and no. kernel row per ear. Similarly lowest GCV recorded for ear diameter followed by ear length and no. of kernel row per ear.In rabi maize (Terai condition) highest PCV was recorded from grain yield followed, thousand kernel weight and ear height. Similarly Highest GCV recorded from grain yield, followed by days to 50% silking,ear height, thousand kernel weight and days to 50% tasseling. Lowest PCV recorded for no. of kernel per row. Similarly lowest GCV recorded for no. of kernel per row followed by ear diameter, ear length and no. of kernel row per ear. In our experiment highest GCV and PCV recorded for traits like grain yield, thousand kernel weight and ear height. In kharif maize low GCV and PCV recorded for traits like days to 50% silking and days to 50% silking. Other remaining characters were having the fluctuating PCV and GCV values across the environments. Therefore, characters namely days to thousand kernel weight, ear height and grain yield might be considered as having the same exploitable genetic variability for crop improvement across both seasons. In hill condition Traits like days to 50% silking , days to 50% tasseling, thousand kernel weight ,ear height and grain yield used in crop improvement programs because these character were less influenced by environment.

Heritability. In kharif season (Hill condition) highest heritability recorded for traits like grain yield followed by ear diameter, days to 50% silking, ear length, ear height, days to 50% tasseling, plant height, no. of kernel weight per ear and no. of kernel per row. Thousand kernel weight showed lowest heritability in kharif condition. In rabi season (Terai condition) all studied traits showed high heritability except no. of kernel per row and days to 50 % silking. Traits like no. of kernel per row, thousand kernel weight, ear diameter, days to 50% silking significantly changed with seasons. This indicated that all characters except like no. of kernel per row, thousand kernel weight, ear diameter, days to 50% silking are less influenced by the environmental conditions and selection for such characters on the basis of phenotype will be effective. Similar findings of heritability for grain yield and other characters have also been reported by Abirami et al. (2005).

Genetic Advances. In kharif season highest GA and GAM recorded for traits like grain yield, plant height, thousand kernel weight. In rabi season (Terai condition) all studied traits showed highest GAM except no. of kernel per ear and ear diameter. High genetic advance along with high heritability arises due to additive type of gene action, while, high heritability estimates with low genetic advance indicates that heritability of these characters is due to non-additive gene effects, *viz.,* dominance, over dominance and epitasis gene action. High expected genetic advance at 5% selection intensity and as per cent of mean coupled with high heritability for most important economic trait i.e. grain yield indicated that genotypic variation present in the genetic material studied might be due to additive genetic variance in both the seasons. High heritability coupled with high GAM for traits grain yield obtained, similar findings with some deviations of(Mahmood et al., 2004; Nagabhusan et al., 2011, Badawy, 2012 and Bekele and Rao, 2014).

Table 3.

Analysis of variance for important characters in maize across kharif and rabi seasons

SOV	Df	Environment	DTT	DTS	PH (cm)	EH (cm)	EL (cm)	ED (cm)	TKW (g)	NKPR	NKRPE	GY kg ha^{-1}
Replication	2	Kharif	14.75	0.75	527.5 .	82.5	1.31	0.01	223.3*	0.51	0.16	0.83
	2	Rabi	10.03.	24.63***	551.1*	463.2*	3.27**	0.01	0.001	11.55˙	0.33	4.27**
Genotypes	10	Kharif	18.15*	20.08***	1191.0***	566.7**	6.26**	0.12***	184.4**	10.83 .	1.29*	3.20***
	9	Rabi	174.43***	217.22***	534.6**	355.2*	1.24*	0.12˙	0.005**	1.53	2.18.	1.50.
Error	20	Kharif	6.15	3.45	178.9	140.5	1.49	0.02	50.6	5.09	0.51	0.52
	18	Rabi	3.11	2.04	104.1	122.7	0.48	0.06	0.001	3.56	1.001	0.67

Sig. codes: *** significant at 0.001, ** significant at 0.01 level, * significant at 0.05 level PH= plant height, EH= ear height, DTT= days to 50% tasseling, DTS= days to 50% silking, EL= ear length, ED= ear diameter, NKPR= number of kernel rows per ear, NKPRE= number of kernel row per row, TKW= 1000 grain weight and GY=grain yield.

Table 4.

Heritability, genetic advance, genotypic and phenotypic coefficient of variation for important characters in maize across kharif and rabi seasons

Genetic Parameter	Season	DTT	DTS	PH (cm)	EH (cm)	EL (cm)	ED (cm)	TKW (g)	NKPR	NKRPE	GY kg ha^{-1}
GCV	Kharif	5.24	5.18	18.17	24.91	15.80	8.51	41.22	11.71	7.96	36230.75
	Rabi	19.87	16.96	13.03	19.52	8.33	6.52	18.69	2.21	9.62	29.44
PCV	Kharif	6.16	6.32	19.55	28.04	17.73	9.28	71.66	14.62	9.61	39268.55
	Rabi	20.05	26.81	14.32	23.02	10.02	10.31	20.58	7.47	11.96	36.34
H	Kharif	0.72	0.84	0.68	0.78	0.79	0.84	0.33	0.64	0.68	0.85
	Rabi	0.98	0.40	0.83	0.72	0.69	0.40	0.82	0.09	0.65	0.66
GA	Kharif	7.03	8.24	64.38	41.68	4.40	0.65	41.47	4.98	1.80	3305.35
	Rabi	26.89	15.68	41.90	30.97	1.78	0.37	0.14	0.36	2.25	1.89
GAM	Kharif	9.19	11.02	34.78	45.54	29.03	16.09	48.85	19.33	13.58	68861.6
	Rabi	40.57	22.09	24.42	34.10	14.26	8.50	34.96	1.35	15.96	49.11

PH= plant height, EH= ear height, DTT= days to 50% tasseling, DTS= days to 50% silking, EL= ear length, ED= ear diameter, NKPR= number of kernel rows per ear, NKPRE= number of kernel row per row, TKW= 1000 grain weight, GY=grain yield.PCV=phenotypic coefficient of variation ,GCV=Genotypic coefficient of variation ,H= heritability ,GA= genetic advance and GAM= genetic advance as percentage of mean.

CONCLUSION

All the studied traits were significant, indicating that presence of genetic varaiability which can be exploited in crop improvement program. PCV is higher than PCV in all studied traits, it's indicate that there is no environmental influence. Traits having high GCV, PCV, heritability along with high genetic advance as percentage of mean were used in selection process of crop improvement program. In our study traits like plant height ,ear height

,thousand kernel weight and grain yield have moderate to high GCV, PCV, heritability and GAM in both environment so there traits used in selection program.

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