American Journal of Food Science and Health
Vol. 3, No. 6, 2017, pp. 123-129
http://www.aiscience.org/journal/ajfsh
ISSN: 2381-7216 (Print); ISSN: 2381-7224 (Online)

Study of Yield and Yield Attributing Traits of Maize

Sanjay Kumar Raut[1], Surya Kant Ghimire[1], Raju Kharel[1], Chitra Bahadur Kuwar[2], Manoj Sapkota[3], Ujjawal Kumar Singh Kushwaha[4, *]

[1]Department of Genetics and Plant Breeding, Agriculture and Forestry University, Chitwan, Nepal
[2]National Maize Research Program, Nepal Agricultural Research Council, Rampur, Nepal
[3]Department of Genetics and Plant Breeding, Institute of Agriculture and Animal Science, Rampur, Nepal
[4]Agriculture Botany Division, Nepal Agricultural Research Council, Khumaltar, Lalitpur, Nepal

Abstract

A field experiment was conducted to evaluate the maize genotype for studying their genetic components and the traits of yield and their correlation in 2015/16. Fourteen genotypes were evaluated in randomized complete block design with three replications. Data were recorded for days to 50% tasselling, days to 50% silking, plant height, ear height, number of tassel branches per plant, length of ear, ear girth with kernels, number of rows per ear, number of kernels per row, thousand kernel weight and grain yield. Significant differences were found for days to 50% tasseling, days to 50% silking, tassel branch, plant height, ear height, ear diameter, ear length, number of leaf, grain rows per cob, grains per row, thousand kernel weight and grain yield. Based on quantitative traits, Arun-4 was considered best variety and Compoz-Nipb was best in terms of yield attributes. Genetic parameters study showed that genotypic coefficient of variation and phenotypic coefficient of variation were highest for tassel branch followed by grain yield. Correlation analysis revealed that grain rows per cob, grains per row, ear diameter and1000 kernel weight were most yield determining traits.

Keywords

Maize, Correlation, Regression, Variance, Yield

Received: February 21, 2017 / Accepted: April 7, 2017 / Published online: November 16, 2017

1. Introduction

Maize (*Zea mays* L.) is the mos timportan tcereal crops next to wheat and rice [25]. It is the second most important cereal crop in terms of area, production and productivity after rice in Nepal [17]. It is cultivated in 0.92 million hectares of lands with the production and productivity of 2.28 million metric tonne sand 2.458 ton/ha, respectively [17]. Maize occupies 30.04% of total cultivated agricultural land and shares about 23.87% of the total cereal production of Nepal [17]. It contributes 3.15% tonational GDP and 9.5% to agricultural GDP [17]. The proportion of maize area consists of 70% in mid hills followed by 22% in Terai and 8% in high hills [23].

Maize yield attributing traits namely number of cob plant^{-1}, number of kernel row^{-1}, number of kernel row ear^{-1} and thousand kernel weight have important role for yield [33]. Thus, indirect selection can be done through identifying improved yield components. Yield can be estimated knowing only components character, hence the contribution of each component is essential to know [12]. The time between sowing to flowering exhibit highly heritable traits, selection of those traits is important for selection of variety [4]. Through understanding the interrelationships existed between yield and its contributing components, we can improve the

* Corresponding author
E-mail address: kushujjwal@gmail.com (U. K. S. Kushwaha)

efficiency of maize breeding programmes [18].

This study was conducted to determine the genetic variability among different maize genotypes on phenological, agro-morphological, yield and its components. This study also aims to study the correlation between yield and yield attributing traits for grain yield and to estimate genetic components of yield and yield attributing traits.

2. Materials and Methods

There search was carried out at National Maize Research Programme (NMRP), Rampur, Chitwan, Nepal in 2015. The trial was 27°37'N latitude, 84°25'E longitude and at an altitude of 228 meter above sea level (Thapa & Dangol, 1990).

The material included v14 coordinated varietal trial genotypes including gone standard check (Arun-4) variety. Experimental design was Randomized Complete Block Design (RCBD) with three replications. The plot size was 5.0m×3.0m with 75cm×25cm between RR×PP. The Maize genotypes were obtained from NMRP for the experimentation.

The genotypes were Earlykatamani, Rajaharlocal, S97TEYGHAYB (3), POP-445/POP-446, COMPOZ-NIPB, R.C./POOL-17, SO3TEY/LN, ZM-621/POOL-15, EEYC1, SO3TEY-LN/PP, SO3TEY-PO-BM, Across-99402, FARMERSVARIETY and ARUN-4 (Standardcheck).

Ten guarded plants from the mid two row soft he plot were tagged randomly with coloured thread as indication for recording observations for each entry for all the quantitative characterstics. Different traits Plant height, ear height, Number of tassel branches per plant, Length of ear, Ear girth with kernels, Number of rows per ear, Number of kernels per row, Thousand kernel weight and Grain yield (ton/ha) at15% moisture except for 50% tasseling, 50% silking were recorded. The mean data was analyzed from Rstudio3.1.3 software, correlation from IBMSPSS21.0, Minitab15 was used for cluster study for important yield attributing traits.

3. Result

3.1. Mean Performance and Analysis of Variance

Mean value and significant levels of yield and yield attributing traits of fourteen maize genotypes are presented in Table 1. Significant results were observed for the traits grain yield hector^{-1}, thousand kernel weight, number of kernel row^{-1}, number of rows kernel per ear, earlength, eargirth, plant height, days to50% tassling, days to50% silking, leaf below cob, leaf above cob and tassel branches among the tested genotypes that indicate the presence of genotypic differences suggesting the importance of their genetic value in order to identify the best genetic make up for a particular condition.

3.2. Yield

The mean grain yield per hectare was 2.13 ton/ha. Highly significant differences (0.50) intested genotypes were found for grain yield per hectare (Table 1). COMPOZ-NIPB produced highest grain yield per hectare (2.82ton/ha) while POP-445/POP-446l produced lowest (1.57ton/ha). Genotypes COMPOZ-NIPB, SO3TEY-LN/PP and SO3TEY-PO-BM were higher in performance where as rest of the genotypes were lower in performance with respect to the check genotypes Arun-4 (2.49tonha^{-1}).

3.3. Yield Attributing Traits

The average 1000-kernel weigh to fourteen genotypes was 214.13g. Analysis of variance (ANOVA) revealed highly-significant difference (22.32) genotypes for this trait. COMPOZ-NIPB had the highest 1000-kernel weight (251.10g) while S97TEYGHAYB (3) had the lowest (184.73g).

The mean value number of kernels per row of the tested genotypes was 20.28 revealed highly significant differences (4.68) were observed among 14 genotypes for this trait EEYC1 showed the highest number of kernels per row (24.83) whereas RAJAHAR LOCAL showed the lowest number of kernels per row (14.87).

The mean value of number of kernel rows per ear for the experimented genotypes was 12.50 revealed highly significant differences were found among 14 genotypes for this trait COMPOZ-NIPB had the highest number of kernel rows per ear (14.20) while S97TEYGHAYB(3) had the lowest value (11.47).

The mean value ear girth of the tested genotypes was 3.99cm. There was highly significant difference (0.42) among 14 genotypes for ear girth. COMPOZ-NIPB had the highest ear girth (4.52cm) whereas S97TEYGHAYB (3) had the lowest (3.51cm).

The mean value ear girth of the tested genotypes was 12.89 cm. There was highly significant difference (1.80) among 14 genotypes for ear girth. COMPOZ-NIPB had the longest ear length (15.90cm) where as POP-445/POP-446 had the lowest (9.73cm).

3.4. Quantitative Traits

The mean value of plant height among experimented genotypes was 163.29cm. ANOVA revealed highly significant differences (19.16) among 14 genotypes R.C./POOL-17 had the highest plant height (181.75cm) while

POP-445/POP-446 had the lowest (143.91cm).

The mean value ear height of fourteen genotypes was 48.53cm. ANOVA revealed significant difference among 14 genotypes for this trait. FARMERS VARIETIES had the highest ear length (63.79cm) while POP-445/POP-446 had the lowest (29.79).

The mean value tassel length of fourteen genotypes was 34.83cm. ANOVA revealed non-significant difference among 14 genotypes for this trait, the ARUN- 4 has largest tassel length (37.90cm) while COMPOZ-NIPB had the lowest (30.70cm).

The mean value tassel branch of fourteen genotypes was 12.47. ANOVA revealed highly significant difference (2.99) among 14 genotypes for this trait. COMPOZ-NIPB had the highest tassel branch (18.57) while POP-445/POP-446 had the lowest (7.73).

The mean value of day to 50% tasseling of 14 genotypes was 56.26 days. ANOVA revealed highly significant difference (2.00) for this trait. Arun-4 was the earliest tasseling genotype (52.67Days) whereas ACROSS-99402 was the latest teaselling (59Days) one.

The mean value of days to 50% silking among 14 genotypes was 61.07 Days. There were highly significant differences (2.60) among 14 genotypes for this trait (Table 2). Arun-4 was silked earlier (57.33Days) while ACROSS-99402 was the latest (64.33Days) one.

Table 1. Mean, EMS, LSD at 0.05 and CV of 16 characters of 14 maize genotypes.

Treatments	DTT	DTS	TBr	TL	PH (cm)	EH (cm)	ED (cm)	EL (cm)	GR/C	GperR	TKW (gm)	GY (ton/ha)
Across-99402	59.00	64.33	12.17	34.83	166.16	47.75	3.94	14.03	12.00	19.13	216.29	1.70
COMPOZ-NIPB	54.67	59.00	18.57	30.70	155.75	50.00	4.52	15.90	14.20	23.20	251.10	2.82
Early mid Katamani	54.67	58.66	17.13	34.97	168.00	51.14	4.01	14.13	13.00	23.07	198.58	2.10
EEYC1	58.00	62.33	14.20	34.13	164.54	49.54	3.96	13.86	12.73	24.83	210.77	2.29
FARMERSVARIETY	55.33	60.00	11.57	36.30	175.96	63.79	3.82	12.13	11.60	21.77	217.15	2.02
POP-445/POP-446	55.33	60.33	7.73	33.70	143.91	29.79	3.70	9.73	12.00	17.20	206.10	1.57
R.C./POOL-17	56.33	61.00	11.10	36.50	181.75	56.17	3.94	13.43	11.64	19.46	221.43	1.88
Rajahar Local	55.33	59.33	11.57	31.07	144.45	40.71	3.56	11.26	12.40	14.87	208.95	1.89
S97TEYGHAYB(3)	57.67	62.67	10.63	36.47	150.75	36.87	3.51	10.40	11.47	17.20	184.73	2.01
SO3TEY-LN/PP	58.33	64.00	11.37	39.40	172.25	52.83	4.33	13.06	13.40	22.20	222.85	2.57
SO3TEY-PO-BM	54.00	59.00	12.30	36.90	175.58	52.46	4.35	13.36	13.40	21.43	218.48	2.51
SO3TEY/LN	58.67	63.67	11.83	33.37	158.00	46.08	4.29	13.00	13.47	20.97	233.60	2.37
ZM-621/POOL-15	57.67	63.67	11.57	36.43	161.42	48.70	4.20	14.30	12.06	16.93	206.83	1.60
ARUN-4(StdChk)	52.67	57.33	12.90	37.90	167.58	53.70	3.79	11.90	11.67	21.67	205.10	2.49
Grand Mean	56.26	61.07	12.47	35.19	163.29	48.54	3.99	12.89	12.50	20.28	214.13	2.13
F-test	***	***	***	Ns	**	*	***	***	**	**	***	***
LSD	2.00	2.60	3.00		19.16	14.44	0.42	1.80	1.45	4.68	22.32	0.50
CV(%)	2.12	2.53	14.32	12.67	6.99	17.73	6.29	8.32	6.90	13.57	6.20	14.03

DG=days to germination, DTT=days to 50% tassling, DTS=days to 50% silking, TSI=tussling silking interval, TBr=tassel branch, TL=tassel length, PH=plant height, EH=ear height, LBC=leaf below ear, LAC=leaf above ear, TKW=1000-kernel weight, EL=ear length, ED=ear diameter, GR/C=number of kernel row per ear, Gper R=number of kernel per row, GY=grain yield

3.5. Correlation Coefficient Analysis

Based on correlation coefficient of selected traits and plot yield, grain row per ear (r=0.700**) and grain per row (r=0.709**) had positive and highly significant correlation with grain yield (Table 3). Similarly, tassel branch (r=0.586*), ear diameter (r=0.587*) and leaf below ear (r=0.546*) had positive and significant correlation with yield.

Regression analysis had shown grain per row, grain rows per ear, ear diameter and tassel branch have important role invariation in yield because they had contributed about 50.3%, 48.9%, 34.4 and 34.3% variation in grain yield respectively. Similarly, thousand kernel weight, ear length, ear height, leaf above ear, days to 50% silking, days to 50% tasseling, plant height, days to 50% germination and tassel length had contributed 28.3%, 15.5, 15.4%, 10.2%, 8.3%, 7.4%, 6%, 1.1% and 0.1% variation in grain yield respectively (Table 2).

Thousand kernel weight exhibited highly significant correlation with ear diameter (r=0.753**), and grain rows per ear (r=0.676**). Similarly, it shows positive significant correlation with ear length. It shows positive correlation with tassel branch, plant height, ear height and grain per row. However tassel length show negative correlation with thousand kernel weight. Ear length showed highly significant positive correlation with tassel branch (r=0.766**) and ear diameter (r=0.783**). Similarly, Ear height (r=0.545*) were found positive and significantly correlated. However, it showed positive correlation with days to tassling, days to silking, and plant height. Whereas, tassel length was found negatively correlated. Ear diameter was found to have positive correlation with days to tassling, days to silking, tassel branch, tassel length plant height (r=0.369) and ear height (r=0.398). Grain per row had significant and positive correlation with tassel branch (r=0.643*), plant height (r=0.544*), ear height (r=0.594*), ear diameter (r=0.546*) and ear length (r=0.560*). Similarly, it showed positive correlation with tassel length and grain rows per ear. However, there was negative correlation of days to tassling, and days to silking. Grain rows per ear exhibited positive and highly significant correlation with ear diameter (r=0.807**) similarly it shows positive and significant correlation with tassel branch (r=0.590*) and ear length (r=0.579*). Similarly, days to germination, and ear height were found positively correlated. However, it had negative correlation with days to tassling, days to silking, tassel length, and plant height. Ear heigh exhibited highly significant positive correlation with plant height (r=0.876**). Similarly, it had positive correlation with tassel branch (r=0.390), and tassel length (r=0.403). Plant height showed significant and positive correlation with tassel length (r=0.639*). Similarly, it had positive correlation with tassel branch. However, it showed negative correlation with days to tasseling and days to silking. Tassel length was found positively correlated with days to tasseling and days to silking. However, it showed negative correlation with tassel branch. Tassel branch was found to have negative correlation with days to tassling, days to silking. Days to silking exhibited highly significant and positive correlation with days to tussling (r=0.976**).

Table 2. Pearson's correlation coefficient among different yield and yield attributing traits of fourteen genotypes of maize in chitwan, Nepal, 2015/16.

	DTT	DTS	TBr	TL	PH	EH	ED	EL	GR/C	GperR	TKW	GY
DaystoTassling(DTT)	1											
Daystosilking(DTS)	.976**	1										
Tasselbranches(TBr)	-.259	-.345	1									
Tassellength(TL)	.052	.183	-.329	1								
Plantheight(PH)	-.061	-.018	.166	.639*	1							
Earheight(EH)	-.170	-.156	.390	.403	.876**	1						
Eardiameter(ED)	.090	.146	.487	.023	.369	.398	1					
Earlength(EL)	.114	.097	.766**	-.127	.442	.545*	.783**	1				
Grainrowperear(GR/C)	-.003	-.034	.590*	-.338	-.023	.074	.807**	.579*	1			
Grainsperrow(GperR)	-.120	-.166	.643*	.150	.544*	.594*	.546*	.560*	.504	1		
ThousandKernelWeight(TKW)	.029	.021	.381	-.349	.187	.349	.753**	.599*	.676**	.398	1	
GrainYield(GY)	-.272	-.289	.586*	.040	.245	.382	.587*	.393	.700**	.709**	.532	1

**=Correlation is significant at the 0.01 level (two-tailed),*=Correlation is significantat the 0.05level (two-tailed), ns=correlation is non-significant., DTT=days to 50% tassling, DTS=days to 50% silking, TBr=tassel branch, TL=tassel length, PH=plant height, EH=ear height, LBC=leaf below ear, LAC=leaf above ear, TKW=1000-kernel weight, EL=ear length, ED=ear diameter, GR/C=number of kernel row per ear, G perR=number of kernel per row, GY=grain yield

3.6. Genetic Parameters

There was remarkable difference in Phenotypic Coefficient of Variation (PCV) and Genotyping Coefficient of Variance (PCV) of the considerd traits. Among the studied traits, the high value for both PCV and GCV was estimated for tassel branch. Similarly, other trait ear height, leaf above ear, grain per ear and ear length showed moderate PCV and GCV. In the same way low PCV and GCV were found in days to tassling, days to silking, plant height, leaf below ear, grain rows per ear, thousand kernel weights, ear diameter. The difference between GCV and PCV ranged from 0.22 to 3.36.

The considerable differences in heritability value for different characters were observed. Among characters under study, leaf below ear (89%) had highest value of heritability followed by days to tussling (87%), ear length (86%), tassel branch (85%), Days to silking (84%), grain yield (80%), ear diameter (78%), thousand kernel weight (76%), grain per ear (68%), grain rows per ear (67%), plant height (67%) and ear height (65%) high heritability estimates.

Table 3. Genetic parameters of traits of 14 maize genotypes.

Variables	GCV	PCV	hbs2	GA	GAM
DTT	3.27	3.49	0.87	2.56	4.56
DTS	3.45	3.75	0.84	2.95	4.83
TBr	19.8	21.49	0.85	3.45	27.66
PH	5.86	7.12	0.67	13.41	8.21
EH	13.94	17.3	0.65	9.47	19.52
GRperC	5.67	6.92	0.67	0.99	7.94
GperC	11.79	14.2	0.68	3.31	16.36
EL	11.93	12.87	0.86	2.15	16.71
ED	6.86	7.76	0.78	0.38	9.6
TKW	6.44	7.37	0.76	19.29	9.00
GY	16.33	18.215	0.80	0.485	21.50

The genetic advance as percentage of mean at 5% selection intensity revealed remarkable differences among the traits under study. Tassel branch showed the highest genetic advances as percentage of mean (27.66%) among the entire trait. Exhibited high genetic advance as per centage of mean followed by grain yield (21.50%), Likewise, genetic advance as per centage of mean was found to be moderate for ear height (19.52%), leaf above ear (17.19%), ear length (16.71%) and grain rows per ear (16.36). Genetic advance as percentage of mean was found to be lowest for ear diameter (9.6%) followed by, thousand kernel weight (9.00%), plant height (8.21%), leaf below ear (8.2%), grain rows per ear (7.94%), days to silking (4.83%) and days to tussling (4.56%) (Table 3).

4. Discussion

4.1. Mean Performance and Analysis of Variance

Grain yield is the out of yield attributing factors. Variation in grain yield was reported by number of researcher which fit with present result. Badu-Apraku and Hussein [3, 9] evaluated and identified high yield in maize varies among different genotypes tested. Highly significant differences for the yield components were reported while comparing original and selected maize populations for grain yield traits very low and negative association was observed between grain yield and days to 50% tasseling and days to 50% silking [20]. Gaire [7] found that there were highly significant differences among genotypes for grain yield and yield contributing traits which strongly support the present finding. Malik [14] observed highly significant variation in grain yield while comparing thirty maize genotypes.

The genetic potential of particular genotypes can be judged by the thousand kernel weight. Kernel weight has a direct effect on the kernel yield of maize; also it has a remarkable role in increasing kernel yield in relation with other yield related components. Gair [7] found that there was significant different among the genotypes for thousand kernels weight which strongly support the present finding. Hanif (2010) observed highly significant variation in 100 grain weight while comparing thirty maize genotypes.

Plant height is of major concern to plant breeders since yield has positive correlation with plant height [27]. Significant variation in ear height and plant height of forty four genotypes of maize were reported by Gurung (2010) of maize genotypes for high temperature tolerance in terai region of Nepal. Prasai [23] found highly significant differences among 14 genotypes in early maize genotypes for plant height which strongly support this result.

Significant variation in ear height and plant height of forty four genotypes of maize were reported by Gurung et al. of maize genotypes for high temperature tolerance in terai region of Nepal. The finding is in accordance with Anwar [13] who also reported the presence of variability in ear height among different maize populations.

The number of days it takes a genotype to reach 50% tasseling and silking from the date of planting determines whether the genotype is early maturing or late maturing. This observed variation may be attributed to differences at their genotypic level and may be utilized for further manipulation. This variability may be attributed to their differential genetic constitution. Shah et al [29] have also reported similar results for different maturity traits among maize populations.

Highly significant variation in grain rows per ear and grain per rows was observed [14]. Anwar and Mohmmadi [13] reported significant variability for number of kernels per row of different genotypes which support the finding of kernel per row is in accordance with the report whereas number of kernel row per ear contradicts with the report.

4.2. Correlation Coefficient

Correlation analysis measures the mutual association between a pair of variables independent of other variables under consideration [21]. The correlations between the traits are also of great importance for to achieve the goals inbreeding programs. Analysis of correlation coefficient is the most widely used one among numerous methods [34].

Grain yield was positively and highly significantly correlated with other traits viz., grain row per ear and grain per row. Positive and significant correlation of yield with tassel branch, ear diameter and leaf below ear were found. Similarly, tassel length, plant height, ear height, ear length, leaf above ear and thousand kernel weights had positive correlation with plot yield. Positive correlation coefficient among traits shows that the changes of two variables are in the same direction i.e. high value of one variable is associated with high value of other and vice versa. However, the most yield determinative traits were ear diameter followed by number of kernels per row, ear height and plant height and hence, simultaneous selection for these traits might bring an improvement in grain yield per plant. Similar results were also reported [2, 12, 15, 28, 30].

You [35] revealed positive and significant correlations between grain yield and number of rows ear^{-1}, number of grains row^{1} which was similar result to research finding. Similar results of direct positive effect of 1000-kernels weight on grain yield was reported by Reddy et al. [26] who found positive direct effect of 100-kernels weight on grain yield.

Contrarily, grain yield per plant had highly significant negative correlation with days to 50% tasseling and days to 50% silking, indicating thats election for early tasseling and silking is desirable to increase yield per plant. Kumar [12], reported similar results for these two traits

Thousand kernel weights found highly significant positive correlation with ear diameter and grain per row. Similar result report had come from Alaei [1].

Indeed highly significant and positive correlation between row number per ear with ear diameter was noted. These results are in agreement with those of other researchers by

Mohan [19]. Grain rows per ear are highly and significantly correlated to thousand kernel weight was found [1].

4.3. Genetic Parameter

The total variability among the genotype in terms was done by ANOVA. However, the assessment of heritable and non-heritable components in the total variability observed is necessary as it is the key component of breeding programmers for broadening the gene pool of crops. This variation is very important for the plant breeders and selection is effective when magnitude of variability in the breeding population is too enough.

The GCV was less than its corresponding estimates of Phenotypic Coefficient of Variation PCV for all the traits which indicated significant role of environment in the expression of these traits [26]. The high value of GCV and PCV for grain yield was supported [5, 16, 22]. Similarly, the Mani et al. [5] reported the moderate value of PCV and GCV for ear height and 1000 kernels weight which is also supports our result.

Plant height and 1000 kernels weight revealed higher heritability which is in conformity with the search result [6, 10, 13, 24, 31].

The high value of GAM coupled with high value of heritability for grain yield was also found in the experimental result [11, 16] which is also suggested by the four experimentation.

5. Conclusion

In order to improve late maturing varieties or to develop early maturing varieties, it is very important to know the genetic parameter which give the estimate of traits which are more effective for selection for breeding purpose. Based on quantitative traits ARUN-4 was considered best varieties because of earliness in days to 50% tussling and days to 50% silking. Regarding the yield attributes, COMPOZ-NIPB had the highest ear length, ear diameter, grain rows per cob, grain per rows, thousand grain yield and grain yield per hector. It was found that GCV and PCV were highest for tassel branch followed by grain yield. Correlation analysis revealed grain rows per cob, grains par row, ear diameter and 1000 kernel weight were most yield determining traits. Hence simultaneous selection of traits might be improved with improvement of grain yield.

References

[1] Alaei, Y. (2012). Correlation analysis of corn Genotypes morphological traits. *International research journal of applied and basic sciences*, *3*, 2355-2357.)

[2] Alvi, M. B., Rafique, M., Tariq, M. S., Hussain, A., Mahmood, T., & Sarwar, M. (2003). Character association and path coefficient analysis of grain yield and yield components maize (*Zeamays*L.). *Pak. J. Biol. Sci*, *6*(2), 136-138.

[3] Badu-Apraku, B., Abamu, F. J., Menkir, A., Fakorede, M. A. B., & Obeng-Antwi, K. C. (2003). Genotype by environment interactions in the regional early variety trials in Westand Central Africa. *Maydica*, *48*(2), 93-104.

[4] Banziger, M., & Diallo, A. O. (2004). Progress in developing drought and N stress tolerant maize cultivars for eastern and southern Africa. In *Integrated approaches to higher maize productivity in the new millennium. Proceedings of the 7th eastern and southern Africa regional maize conference, CIMMYT/KARI, Nairobi, Kenya* (pp. 189-194).

[5] Choudhary, A. K. and L. B. Choudhary. (2002). Genetic studies in some crosses of maize (*Zeamays* L.). Journal Research of BAU 14 (1):87-90.

[6] EI-Hosary, A. A. (1987). Genetic studies in synthetic variety of maize. An Egyptian Journal of Agronomy (1-2):57-64.

[7] Gaire, T. L. (2013). Morpho agronomic characterization and evaluation of maize genotypes in Rampur, Chitwan, Nepal. IAAS. T. U. P:31-45.

[8] Golam, F., Farhana, N., Zain, M. F., Majid, N. A., Rahman, M. M., Rahman, M. M., & Kadir, M. A. (2011). Grain yield and associated traits of maize (*Zeamays* L.) genotypes in Malaysian tropical environment. *African Journal of Agricultural Research*, *6*(28), 6147-6154.

[9] Hussain, N. (2011). Screening of maize varieties for grain yield at Dera Ismai lKhan. *Animal and Plant Sci*, *21*(3), 626-628.

[10] Johnson, G. R. 1981. Genetic variability and relationships of physical grain quality traits in BSSS maize. Dissertation Abstract. University of agricultural Sciences Dharwad.42:12-62.

[11] Kumar, S., Shahi, J. P., Singh, J., & Singh, S. P. (2006). Correlation and Path Analyis in Early Generation Inbreds of Maize (*Zeamays* L.). *Crop Improvement*, *33*(2), 156-160.

[12] Kumar, T. S., Reddy, D. M., Reddy, K. H., & Sudhakar, P. (2011). Targeting of traits through assessment of interrelationship and path analysis between yield and yield components for grain yield improvement in single cross hybrids of maize (*Zeamays* L.).

[13] Mahmoud, I. M., M. A. Rashed, E. M. Fashmy and M. H. Abodheaf. (1990). Heterosis combining ability and types of gene action in a 6x6 diallel of maize. Annual Agricultural Science pp.307-317.

[14] Malik, H. N., Ara, I., Naeem, M., Hussain, M., & Hanif, M. (2010). Comparison of open pollinated varieties and newly developed hybrids for yield and yield contributing traits in maize. *Pakistan J. Agric. Res. Vol*, *23* (1-2).

[15] Mani, V. P. (1999). Variability and path coefficient study in indigenous maize (*Zeamays* L.) germplasm. *Environment and Ecology*, *17* (3), 650-653.

[16] Mani, V. P. and G. S. Bisht. (1996). Genetic Variability in local maize (*Zea mays* L.) germplasm of Uttar Pradesh hills. Journal of Hill Research 9(1): 131-134.

[17] MoAD. (2015). Statistical information on Nepalese agriculture 2014/2015. *Hariharvawan, Kathmandu, Nepal.*

[18] Mohammadi, S. A., Prasanna, B. M., & Singh, N. N. (2003). Sequential path model for determining interrelationships among grain yield and related characters in maize. *Crop science*, *43*(5), 1690-1697.

[19] Mohan, Y. C., D. K. Singh and N. V. Rao. 2002. Path coefficient analysis for oil and grain yield in maize (*Zea mays* L.) genotypes. National Journal of Plant Improvement 4:75-76.

[20] Netaji, S. V. S. R. K., Satyanarayana, E. and Suneetha, V. (2000). Heterosis studies for yield and yield component characters in maize (*Zea mays* L.). The Andhra Agricultural Journal 47:39-42.

[21] Owen, E., & Jones, F. (1977). Statistics 3^{rd} (eds.). Renold Publishing Company, NewYork.30p.

[22] Prakash, O., Shanthi, P., Satyanarayana, E., & Kumar, R. S. (2006). Studies on interrelationship and path analysis for yield improvement in sweet corn genotypes (*Zeamays* L.). *NEW BOTANIST-International Journal of Plant Science Research*, *33* (1and4), 91-98.

[23] Prasai H. K., Kushwaha U. K. S., Joshi B. P. & Shrestha J. (2015). Performance evaluation of early maize genotypes in farwestern hills of Nepal. *Journal of Maize Research and Development* 1(1):106-111

[24] Radovic, G. (1979). Heterosis and heritability of important components of yield in F maize hybrids. Arh Poljornauke 32:17-32.

[25] Rawal, R., & Kuligod, V. (2014). Influence of graded doses of nitrogen on nutrient uptake and grain yield of maize (*Zea mays* L.) under varying levels of soil salinity. *Karnataka Journal of Agricultural Sciences*, *27*(1).

[26] Reddy, V. R., Jabeen, F., Sudarshan, M. R., & Rao, A. S. (2013). Studies on genetic variability, heritability, correlation and path analysis in maize (*Zea mays* L.) over locations.

[27] Rupak, K., Verma and T. P. Singh. (1979). Interrelations among certain quantitative traits in pop corn. Mysore Journal of Agriculture Science 13: 1-17.

[28] Satyanarayana, E., Saikumar, R., & Koteswar, R. (1990). Character association or grain yield with some yield components in maize (*Zea mays* L.). *Madras Agriculture Journal*, *77*, 514-516.

[29] Shah, R. A., B. Ahmed, M. Shafi and B. Jehan (2000). Maturity Studies in 336 hybrid and open pollinated cultivars of maize. Pak. J. Biol. Sci., 3(10): 1624-1626

[30] Sreckov, Z., Bokanski, J., Nastasic, A., AlovicI., & Vukosavljev, M. (2010). Correlation and path coefficient analysis of morphological traits of maize (*Zea mays* L.). *Research Journal of Agricultural Science* 42(2):292-296.

[31] Swamy Rao, T., Ramamurthy, A., Patil, S. J., Aradhya, R. S. and Kajjari N. B., (1970). Evaluation of new maize introductions in Mysore State. Adaption and genotypic and phenotypic variability in four environments. Genetica Agraria 22(4):362-371.

[32] Thapa, R. B., & Dangol, D. R. (1990). A preliminary survey of bee flora at IAAS and its vicinity. *IAAS Research Reports 1985-1991*, 59-65.

[33] Voila, G., M. G., Reddy, S. S., & Kumar, C. V. (2004). Study on heritability and genetic advance in elite baby corn (Zea mays L.) lines. Progressive Agriculture, 3(2), 127-128.

[34] Yagdi, K. O. K. S. A. L., & Sozen, E. (2009). Heritability, variance components and correlations of yield and quality traits in durum wheat (Triticum durum Desf.). *Pak. J. Bot*, *41*(2), 753-759.

[35] You, L. J., Dong, J. P., Gu, Y. Z., Ma, L. L., & Zhao, S. (1998). Target characteristics to develop for improved seed production in maize hybrids, J. *Henan Agric. Sci*, *10*, 3-4.