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Research Article

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Performance and variation in phenotypic characters of maize genotypes in Mid-Western Region of Nepal

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Abstract

An experiment was conducted to evaluate the morphological characters of maize genotypes at Horticultural Research Station, Dailekh in two consecutive years (2016 and 2017). Altogether, seven genotypes consisting of BGBY POP, BLSPRSO7, Across 9942/9944, Across 9331/RE, TLBRSO7 along with check varieties (Deuti and Local) were experimented. The trial was laid out in Randomized Complete Block Design with three replicates. Data on morphological parameters and yield attributing traits were recorded. The results over the years of experiment revealed significant differences for days to maturity, plant height, ear height, number of kernel per row and grain yield. Furthermore, highest grain yield was recorded in Across 9944/9942 (7.24 tha^{-1}) followed by BLSPRSO7 (6.73 tha^{-1}). Similarly, number of kernel per row was maximum in Across 9942/9944 (37.6) followed by Deuti (37.1). The significant variation in ear height was observed which ranged from 125.4 cm (Across 9944/9942) to 146 cm (local variety). It showed local variety to be early maturing (114 Days After Sowing); however, Across 9942/9944 was late maturing (119 DAS). Correlation analysis revealed that ear population, plant population and plant height were yield determinative and simultaneous selection for these traits might bring an improvement in grain yield. This study revealed that Across9931/RE can be a potential genotype for yield and for further maize breeding program.

Keywords: Correlation, Genotypes, Maize, Phenotype, Yield

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Introduction

Maize (*Zea mays* L.) is the world's widely grown cereal and primary staple food in many developing countries (Shrestha, 2015). In Nepal, it is the second most important staple food crop both in terms of area and production after rice. It is grown in 891,583 hectare of land with total production of 2,231,517 mt and yield of 2.5 t/ha^{-1} (ABPSD, 2016). It shares about 7% to Agricultural Gross Domestic Product (MOAD, 2015). It has higher yield potential than any other cereals and thus is popularly known as the 'queen of cereal'. It is a traditional crop cultivated as food, feed and fodder on sloping uplands in the hills. Maize is grown under rain-fed condition during the summer (April-August) as a sole crop, relayed with millet later in the season (Paudyal et al., 2001). About 80% of the rainfall occurs in Nepal during June to September. However, the mid-western and western regions are relatively dry in comparison to other regions, which affects on the yield of crops in those dry areas. Thus, development of new crop varieties to such areas is essential.

Maize is one of the five cereal crops meeting the food requirement, which contributes approximately 22.6% of the total requirement. It contributes to food security in the hills, while in the accessible areas it is gradually becoming a commercial commodity due to increasing demand of nutrients in poultry and animal feed (Pathik, 2002). In Nepal, improved seeds are produced in 841596 ha whereas local are produced in 49987 ha (ABPSD, 2016). The second most important agricultural land area is the mid-hills where 15% of land is cultivated (Paudyal et.al., 2001). In mid-western region, maize is produced in 8394 ha with production of 12030 ton and yield of 1.4 t/ha-1 whereas in Dailekh it is produced in 20150 ha with production of 35292 ton and yield of 1.7 t/ha-1. The overall demand for maize has been estimated to grow up by 6-8% per annum for the next two decades because of the increased demand for food in the hills as population increases and for livestock feed in accessible areas in the Terai and inner-Terai as the demand for milk, meat, and meat products is increasing (Pathik, 2002).

Several production factors are responsible for the yield reduction of maize such as; declining soil fertility, low adoption of high yielding varieties, meager availability of the essential inputs and partly due to the management practices of the crop (Kaini, 2004). Further, many farmers of Dailekh district are dependent on their local variety of maize which is less yielding , susceptible to disease, pest and in-tolerance to changing climatic condition. The performance of maize crop isn't satisfactory in mid-hills due to unavailability of improved varieties. Thus, the selection of maize genotypes is an importance for propagation of desirable traits and development of new varieties. The need of new variety for farmers is realized for ensuring food security by developing new varieties appealing characteristics like higher yield, disease resistant, drought tolerant or regionally adapted to different environments and growing conditions. Hence, to address these issues, replace

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the local variety with new varieties, and strengthen the farmers with superior maize cultivars an experiment was conducted at HRS, Dailekh during 2016 and 2017 and the performance of promising maize genotypes was studied under Mid-Western condition of Nepal.

Materials and Methods

To study the performance of different genotypes of maize in mid-hills region of Nepal, an experiment was conducted at research blocks of Horticultural Research Station, Dailekh (28°85'N, 81°72'E, 1300 m asl) during summer season in two consecutive years: 2016 and 2017. Five genotypes of maize (BGBYPOP, BLSPRSO7, ACROSS 9942/9944, ACROSS 9331/RE and TLBRSO7) procured from NMRRP, Rampur including one released variety Deuti, and a local variety (Standard Check) were used in the experiment. The experiment was laid out in Randomized Complete Block Design (RCBD) with seven genotypes as treatments and was replicated thrice. Each plotconsisted 4 rows of 3 m long with spacing of 75cm x 25cm and the plot size was maintained at 3m x 3m. The recommended dose of fertilizers and manure were applied at the rate of 120:60:40 kg NPK/ha and 6 t/ha-1 FYM respectively. 50% (60 kg per ha urea) of the recommended dose of Nitrogen and full dose of Phosphorous and Potassium were applied during the land preparation and remaining 50% dose of Nitrogen, in the form of urea, was applied in two split doses: 25% during the knee height stage and 25% during the silking stage.

The parameters were taken with frequent field supervision. Days to tasseling and days to silking were recorded with regular field observation after 60 days of sowing, at which emergence of 50% of tassel followed by silking started to be observed in the early genotypes. Similarly, the days to maturity was noted with the observation of matured cob color and dryness. And the remaining parameters were taken during the time of harvest.

Five sample plants of each plots based on the genotypes were taken for measurement of plant height, ear height, number of kernels row per year, and number of kernels per row and eventually averaged. Plant height was measured from the ground level (soil surface) to the base of tassel at the time of harvest. Similarly, the measure of ear height was taken from the soil surface to the base of the ear at the harvesting time. Further, the maize and ear population was counted at the standing crops stage during the time of harvesting the maize. Cobs were harvested, husks were removed and five sample cobs of each genotype were weighted and averaged and the final grain yield was calculated.

Similarly, the correlation coefficients among different traits were carried out using the formula given by Steel and Torrie (1980) by using SPSS program.

$$\text{Correlation coefficient (r)} = \frac{\sum XY-(\sum X)(\sum Y)/N}{[\{\sum X^2-(\sum X)^2\}\{(\sum Y^2)-(\sum Y)^2/N\}]^{1/2}}$$

Where,

r= correlation coefficient

$\sum XY$ = Sum of product of two variables X and Y

$\sum X^2$ =Sum of squares of variables X

$\sum Y^2$ = Sum of squares of variables Y

N = Number of pairs of observations X and Y

Results and Discussion

The analysis of variance revealed significant differences for days to maturity (DM), plant height (PH), ear height (EH), number of kernel per row (NKPR) and grain yield among the tested genotypes whereas, days to tasseling (DT), days to silking (DS), plant population (PP), ear population (EP), ear length (EL), number of kernel row per ear (NKRE) and five hundred kernel weight (FKW) showed non-significant differences (Table 1, 2 and 3).

The effect of genotypes was non-significant for days to tasseling and days to silking over the years of experiment. However, both the parameters were varied significantly between genotypes in the year of 2017. Despite of significant effect of genotypes in days to maturity during 2017, the overall data revealed the variation with non-significant differences in maturing days. The local variety was found to be early maturing (114 DAS), which was statistically similar with Across 9331/RE (115 DAS), BLSPRSO7 (115 DAS) and TLBRSO7 (116 DAS). Contrastingly, Across 9942/9944 was observed to be late maturing (119 DAS) among the tested genotypes.

Statistical analysis for plant height and ear height revealed significant difference among tested genotypes over the years (Table 2). Local variety was significantly tallest (256.7 cm) with maximum ear height (146 cm). However, shortest plant height (225.5 cm) and ear height (125.4 cm) was recorded in TLBRSO7 and Across 9942/9944 respectively. Genotypes Deuti (252.8 cm) and BLSPRSO7 (241.3 cm) were statistically at par with local variety of maize in terms of plant height. Similarly, the maximum ear height in local variety was considerably followed by Deuti (135.2 cm) and TLBRSO7 (132.0 cm), whereas, the minimum ear height was measured in Across 9942/9944 (125.4 cm).

Plant population and ear population varied insignificantly among the genotypes. However, highly significant difference was observed among the tested genotypes for ear population during 2017, where the plots of TLBRSO7 were counted with maximum number of ears per plot (45) among the tested genotypes.

The number of kernel row per ear revealed non-significant differences among tested genotypes over the experimental years (Table 3). However, highly significant difference was recorded during year of 2017 among the tested genotypes and BGBY POP was collectively recorded to have maximum number of kernel row per ear (15.3). Further, the number of kernel per row varied significantly. Maximum number of kernel per row (37.6) was counted in Across 9942/9944, which was insignificantly followed by other tested genotypes except BGBY POP and BLSPRSO7. BLSPRSO7 was noted with the minimum number of kernel per row (32.7).

The observation in grain yield varied significantly among the tested genotypes over the year of experimentation. Across 9944/9942 has recorded to have maximum grain yield of 7.2 tha^{-1}, which is statistically at par with BLSPRSO7 (6.7 t/ha-1), Local (6.1 t/ha-1), Deuti (6.1 t/ha-1) and BGBYPOP (5.8 t/ha-1). Despite of local check having the highest plant population per plot, Across 9942/9944 was recorded to have the maximum grain yield due to the maximum plant population per plot and highest number of kernel per row, which is in partial conformity with the finding of Abuzar et al. (2011), in which the higher grain yield was found from the plot with higher number of ears per plant and number of grains row per ear. Similarly, Emam (2001) verified that kernels per ear and kernel row per ear is the most important yield adjusting components in response to plant population density in maize. The genotype Across 9331/RE, however, produced minimum grain yield (4.1 t/ha-1).

Correlation coefficient among the phenotypic variables is given in Table 4. Days to tasseling was strongly, positively correlated with days to silking which is similar to the observations of Noor et al. (2010). Plant height had significantly positive association with ear height (0.59**), and plant population per plot (0.57**). The similar result is in conformity with Jhakar et al. (2017). Further, the plant height is observed to be positively and significantly associated with the grain yield (0.31*). This positive and statistically significant relationship between plant height and grain yield found in our research is also supported by Sadek et al. (2006); Halidu et al. (2015); Jhakar et al. (2017), under different experimental conditions. Further, Silva et al. (2016) is in partial agreement with our findings as they found negative correlation between the plant height and grain yield. However, the negative correlation existed between ear length and grain yield in our research is supported by their results which recorded negative phenotypic relation between those traits. Also, the positive and significant correlation between plant population and grain yield is corroborated by Emam (2001), who described that the grain yield increased at the higher population densities of maize plant.

Moreover, highly significant and positive correlation existed between ear population and plant population (0.57^{**}). Days to maturity had highly negative significant correlation with plant height (-0.45^{**}). The plant population demonstrated the significant and positive correlation with plant height and ear height. Many research showed that increasing crop density increases PH and EH (Sharifi et al., 2009; Shafi et al., 2012; Silva et al., 2014; Mandic et al., 2016).

Ear length was found to have the negatively significant correlation with plant height (-0.40^{**}). The observation of Noor et al. (2010), however contradicts this finding as they noted positive and significant correlation between ear length and plant height. Ear length exhibited positive and highly significant correlation with days to maturity (0.73**). NKPR showed positive and highly significant correlation with days to maturity (0.42^{**}) and ear length (0.60*). This result is in partial conformity with Dar et al. (2015) as they observed the negative correlation of no. of kernels per row (NKPR) with days to maturity and highly positive correlation between NKPR and ear length.

Conclusion

The variation in phenotypic characters is observed among the maize genotypes. The genotype Across 9944/9942 was found to be superior in terms of grain yield producing 18.7% more grain yield than the standard check along with the highest ear population. Plant height, plant population, and ear Population are highly and significantly associated with yield and are needed to be considered for selection. Thus, we could recommend to the farmers of this area (mid-hills) to select the genotype Across 9944/9942 in order to improve overall performance and yield of the crop.

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Table 1. Performance of different genotypes of maize in terms of growth parameters during 2016/17 in research block of HRS, Dailekh

Maize Genotypes	Days to Tasseling			Days to Silking			Days to Maturity		
	2016	2017	Mean	2016	2017	Mean	2016	2017	Mean
BGBY POP	68	68	68	70	71	71	122	114	118
BLSPRS07	62	67	65	64	70	67	119	112	115
Across 9942/9944	67	69	68	69	72	71	120	118	119
Across 9331/RE	60	68	64	64	70	67	117	112	115
TLBRSO7	65	68	67	67	70	69	118	114	116
Deuti (Check)	67	72	70	69	74	72	120	115	118
Local (Check)	69	62	66	71	64	68	119	108	114
Grand Mean (GM)	66	68	67	68	70	69	120	113	116
LSD $_{(0.05)}$	NS	3.8*	NS	NS	3.6*	NS	NS	4.7*	3.5*
CV (%)	7.5	3.1	6.5	7.4	2.9	6.1	2.5	2.3	2.6

Note: NS and * indicate non-significant and significant at P<0.05 respectively.

Table 2. Phenotypic characters of maize genotypes tested at HRS, Dailekh during 2016 and 2017

Maize Genotypes	Plant Height (cm)			Ear Height (cm)			Plant Population/Plot			Ear population/Plot		
	2016	2017	Mean	2016	2017	Mean	2016	2017	Mean	2016	2017	Mean
BGBY POP	219.3	243.1	231.2	125.0	128.5	126.8	30	36	33	35	36	36
BLSPRS07	233.0	249.5	241.3	128.7	127.9	128.3	31	35	33	34	43	38
Across 9942/9944	230.0	248.1	239.1	121.7	129.2	125.4	28	37	33	32	44	38
Across 9331/RE	229.0	225.3	227.2	137.3	122.9	130.1	29	29	29	30	28	29
TLBRSO7	217.3	233.6	225.5	125.3	138.6	132.0	26	31	28	29	45	37
Deuti (Check)	242.7	262.9	252.8	134.5	135.9	135.2	33	36	35	32	37	35
Local (Check)	244.0	269.4	256.7	141.0	151.1	146.0	34	37	36	31	36	33
GM	230.8	247.4	239.1	130.5	133.4	132.0	30	34	32	32	38	35
LSD $_{(0.05)}$	NS	NS	16.28*	10.8*	13.93*	9.44*	NS	NS	NS	NS	5.5**	NS
CV (%)	4.8	6.8	5.8	4.7	5.9	6.1	11.6	18.9	15.3	17.5	8.1	15.1

Note: NS, * and ** indicate non-significant, significant and highly significant at P<0.05 and. P<0.01 respectively.

Table 3. Performance of different genotypes of maize in terms of yield and yield attributing during 2016/17 in research block of HRS, Dailekh.

Maize Genotypes	No. of kernel row/ear			No. of kernel per row			FKW (g)			Yield (t/ha-1)		
	2016	2017	Mean	2016	2017	Mean	2016	2017	Mean	2016	2017	Mean
BGBY POP	14.8	15.9	15.3	36.1	31.6	33.9	223.3	235.0	229.2	6.0	5.7	5.8
BLSPRS07	13.3	15.1	14.2	33.2	32.2	32.7	226.7	240.0	233.3	5.3	8.2	6.7
Across 9942/9944	13.3	14.8	14.0	39.3	35.9	37.6	216.7	223.3	220.0	8.2	6.6	7.2
Across 9331/RE	14.5	13.1	13.8	37.7	34.7	36.2	213.3	243.3	228.3	4.9	3.4	4.1
TLBRSO7	13.9	13.7	13.8	36.6	35.2	35.9	213.3	260.0	236.7	4.4	6.5	5.4
Deuti	13.1	13.9	13.5	39.3	34.9	37.1	220.0	220.0	220.0	6.1	6.1	6.1
Local (Check)	13.7	13.5	13.6	37.7	32.6	35.2	243.3	253.3	248.3	6.1	6.0	6.1
Grand Mean	13.8	14.3	14.1	37.1	33.9	35.5	222.4	239.3	230.8	5.8	6.1	5.9
$LSD_{(0.05)}$	NS	1.2**	NS	3.5*	NS	2.9*	NS	NS	NS	2.1*	2.3*	1.7*
CV (%)	10	4.5	8.1	5.3	9.1	7	15.2	18	15.5	20.1	21.6	24

Note: FKW, NS, * and ** indicate Field Kernel Weight, Non-Significant, significant and highly significant at $P<0.05$ and. $P<0.01$ respectively.

Table 4. Correlation coefficient among different yield and yield attributing traits of seven genotypes of maize experimented at HRS, Dailekh, Nepal during 2016/17.

	DT	DS	PH	EH	PP plot^{-1}	EP plot^{-1}	DM	EL	NKRE	NKPR	FKW	Yield
DT	1	0.97**	0.07	-0.13	0.10	0.09	0.14	-0.15	0.20	0.05	-0.08	0.14
DS		1	0.08	-0.12	0.04	0.04	0.15	-0.16	0.17	0.08	-0.04	0.13
PH			1	0.59**	0.57**	0.35*	-0.45**	-0.40**	0.01	-0.27	0.24	0.31*
EH				1	0.36*	0.18	-0.33*	-0.12	0.02	-0.13	0.13	0.07
PP plot^{-1}					1	0.57**	-0.27	-0.23	0.17	-0.15	0.10	0.33*
EP plot^{-1}						1	-0.12	-0.34*	0.25	-0.18	0.16	0.60**
DM							1	0.73**	-0.07	0.42**	-0.25	0.06
EL								1	-0.16	0.60**	-0.27	-0.01
NKRE									1	-0.23	-0.16	0.11
NKPR										1	-0.19	0.05
FKW											1	0.23
Yield												1

Note: PP plot^{-1}= Plant Population per Plot, EP plot^{-1}= Ear Population per Plot. * and ** indicate significant at $P<0.05$ and. $P<0.01$ respectively.

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