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Evaluation of early maize genotypes for grain yield and agromorphological traits

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ABSTRACT

The purpose of this study was to assess the variation on agro-morphological traits and grain yield. A set of 14 early maize genotypes were studied at research field of Regional Agricultural Research Station (RARS), Doti, Nepal in summer seasons of 2015 and 2016. The experiment was carried out in Randomized Complete Block Design (RCBD) with three replications in each year. The variation among genotypes was observed for grain yield and flowering. The genotype SO3TEY-PO-BM produced the highest grain yield (4.33 t/ha) in 2015 whereas Rajahar Local Variety produced the highest grain yield (2.52 t/ha) in 2016. The combined analysis over years showed that Farmer's variety was found earlier in tasseling (36 days) and silking (39 days), followed by S97TEYGHAYB(3) in tasseling (45 days) and by S97TEYGHAYB(3) and Arun-4 in silking (48 days). EEYC1 produced the highest grain yield (3.17 t/ha), followed by COMPOL-NIBP (3.09 t/ha), SO3TEY-PO-BM (2.90 t/ha), S97TEYGHAYB(3) (2.78 t/ha) and Rajahar Local variety (2.77 t/ha), respectively. The information on variation for the agro-morphological traits among studied early maize genotypes will be helpful to plant breeders in constructing their breeding materials and implementing selection strategies.

Keywords: Early maize genotypes, grain yield, agromorphological traits.

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INTRODUCTION

Maize (*Zea mays* L.) ranks the second to rice in important cereal crop in Nepal. It is used as food, feed, fodder and raw materials for industries. It is cultivated in 891,583 hectares of land (MoAD, 2017). The production of maize in the country is 2,231,517 t with the productivity of 2.5 t/ha (MoAD, 2017). It is the major food crop in the hills of Nepal (Upadhyay et al., 2009), and accounts about 71% of maize production of the country (MoAD, 2017). Furthermore, the share of cereal crops to AGDP is about 49%, and maize alone contributes about 7% to AGDP (MoAD, 2015). It is a traditional crop and is mostly grown in the sloping *bari* land (rainfed upland) in the hills. Maize cultivation is a lifestyle for majority of the farmers in the hilly region of Nepal (Adhikari, 2000). It is cultivated in a very diverse environment in Nepal (NPC, 1994). Hills and mountain districts of far western development region are characterized by remote, inaccessible, food deficit and drought prone areas of the country. Like other crops, maize productivity in far-western development region is also low (2.0 t/ha) with respect to national average (MoAD, 2017). In many developing countries, several biotic and abiotic stresses are underpinning to confine the maize yield (Prasana, 2012). Further, the adoption rate of improved maize genotypes is 30% lower than eastern and western mid-hills (Gurung, 1999). It might be due to longer duration of improved maize genotypes which could not fit in the cropping pattern. Moreover, early maturing genotypes, which better fit in existing cropping system, are preferred by hilly farmers of far-western development region. Lack of high yielding genotypes suitable for agro-climatic condition, inadequate variety in the existing system, lack of improved seeds and lack of agricultural inputs like irrigation, fertilizers etc. have always been associated with low productivity of maize in far-western development region. Up to now, there are limited options for the high yielding early maize genotypes for the farmers which could fit in the different cropping patterns (Kunwar et al., 2014). Thus, the improved maize genotypes, with high yielding and early maturing that better fit in existing cropping system, could increase and stabilize maize yield in this food deficit region. Therefore, this study was done to identify high yielding and early maturing maize genotypes, which can be cultivated in Far-Western Development Region of Nepal.

MATERIALS AND METHODS

Description of experimental site

In coordination with National Maize Research Program (NMRP), Rampur, Chitwan, a field experiment as Coordinated Varietal Trial (CVT) of early maize genotypes were tested for two consecutive maize growing seasons i.e. 2015 and 2016 summer at research field of Regional Agricultural Research Station (RARS), Doti (610 masl). RARS, Doti is situated at 29°15' north latitude and 85°55' east longitude. It represents the river basin agro-environment of far-western hills (RARS, 2012). The soil of the experiment plots was light texture sandy loam, slightly acidic (pH 5.5-6), low in organic matter content (1-2%), nitrogen is only 0.6% (RARS, 2016). The average annual rainfall received by experimental site is about 1000 mm and generally doesn't exceed it (RARS, 2016).

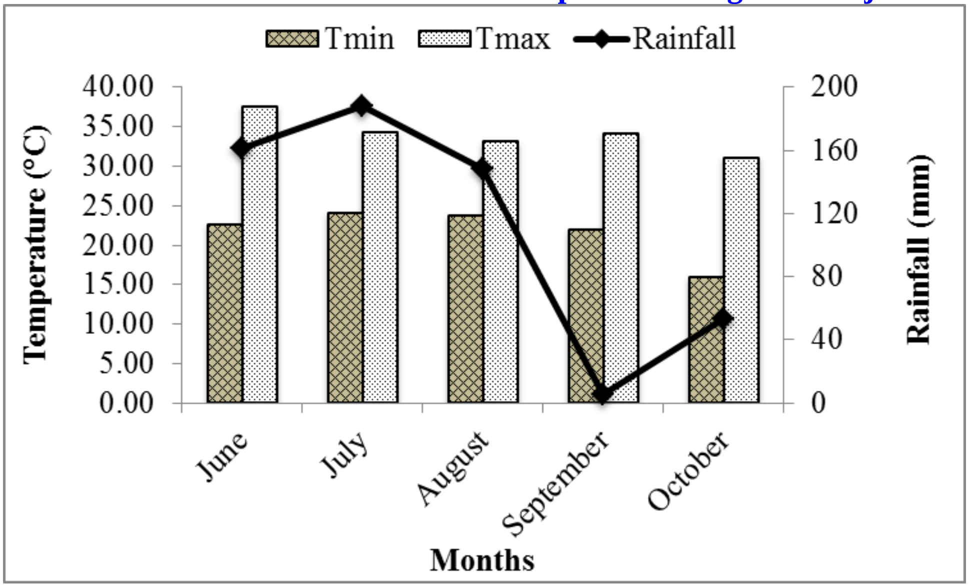

Figure 1: Weather data of experimental site at RARS, Doti during 2015 growing season

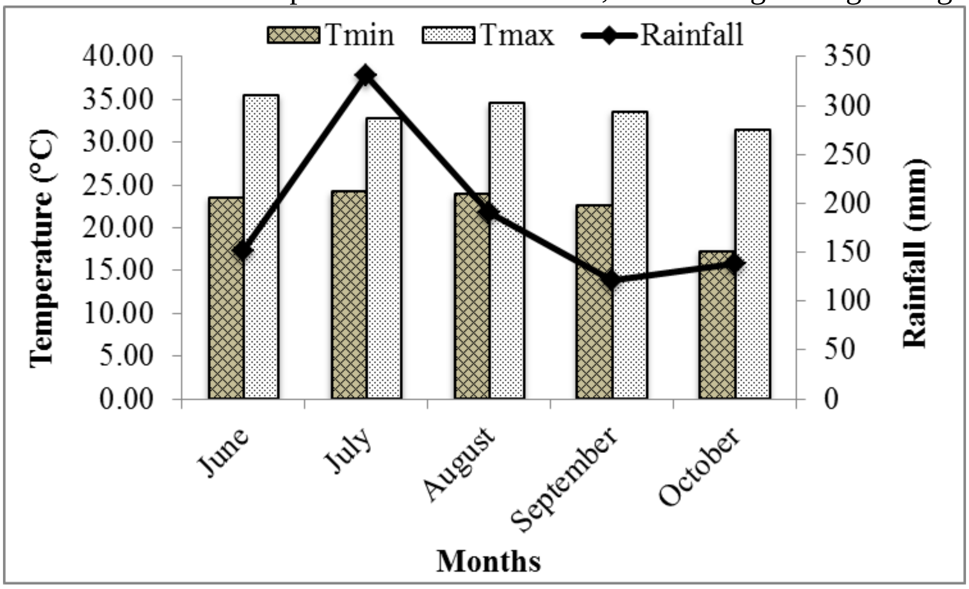

Figure 2: Weather data of experimental site at RARS, Doti during 2016 growing season

Genotypes

The experiment was carried out with fourteen different early maize genotypes in both years. The genotype were: Earlymid Katamani, Rajahar Local Variety, S97TEYGHAYB(3), POP-445/POP-446, COMPOL-NIBP, RC/POOL-17, S03TEY/LM, Arun-4, Farmers' Variety, ZM621/POOL-15, EEYC1, SO3TEY-LN/PP, SO3TEY-PO-BM and Across-99402. Among fourteen genotypes, two genotypes were check genotypes viz. Farmer's Variety as local check and Arun-4 as standard check.

Experimental design and cultural practices

The experiment was carried out in Randomized Complete Block Design (RCBD) and replicated thrice in each year. Maize genotypes and protocols were followed as provided by NMRP, Rampur, Chitwan. The trial was planted on 2nd week of June in each year. In addition

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to 10 FYM t/ha, chemical fertilizers were applied at the rate of 60:60:40 N P_2O_5 K_2O kg/ha during final land preparation. Remaining 60 kg N/ha was top dressed in two splits, i.e. 30 kg N/ha at knee high stage and 30 kg N/ha at tasseling stage. The plot size was maintained by 3m × 3m (4 rows of 3m long) and yield and other data were taken from middle 2 rows. The crop geometry was maintained as 75 cm × 25 cm and two seeds per hill were sown. Thinning was done to maintain plant population after 3 weeks of germination. Furadan 3% was applied @ 3-4 granules/plant to control stem borer.

Field measurements

Plant height, ear height, days to tasseling and silking, number of plants per hectare, number of ears per hectare and grain yield were recorded. Grain yield (kg/ha) was adjusted at 15% moisture content 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) at 15% moisture content. This adjusted grain yield (kg/ha) was again converted to grain yield (t/ha).

Statistical analysis

A computer software, MSTATC version 1.3 (Freed, 1994), was used for statistical analysis of datas, applying 5% level of significance.

RESULTS AND DISCUSSION

Plant and ear height

Plant height and ear height were significantly influenced by genotypes during both growing seasons (Table 1). During 2015 growing season, Rajahar Local Variety was the tallest genotype in plant height (287 cm) and ear height (126 cm). Farmers' variety and S97TEYGHAYB(3) were identified as dwarf genotypes for plant height and ear height. Prasai et al. (2014), Prasai et al. (2015), Adhikari et al. (2016) also found the genotypic differences in plant height and ear height among the tested genotypes. Similarly, during 2016 growing season, Rajahar Local Variety was the tallest genotype in plant height (250 cm) and ear height (147 cm). POP-445/POP-446 and COMPOL-NIBP were identified as dwarf genotypes for plant height and ear height. Combine analysis over years revealed that Rajahar Local Variety was the tallest genotype in plant height (269 cm) and ear height (137 cm), whereas Farmers' variety (190 cm) and POP-445/POP-446 (196 cm) were identified as dwarf

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genotypes for plant height. Genotypes POP-445/POP-446 and COMPOL-NIBP were identified as dwarf genotypes for ear height. Prasai et al. (2014), Kunwar et al. (2014) and Prasai et al. (2015) also concluded the similar findings in their experiments. The mean plant height of 2016 growing season was shorter than 2015 growing season. It is highly possible that continuous rain for about 3 weeks after maize seeding might have affected the plant growth. Zaidi et al. (2004) also supported that the excessive moisture stress during early vegetative stage severely affects the growth. The detail of data on plant height and ear height is presented in Table 1.

Table 1: Plant height and ear height of early maize genotypes evaluated at RARS, Doti during summer seasons of 2015 and 2016

SN	Genotype	Plant height (cm)			Ear height (cm)		
		2015	2016	Combined	2015	2016	Combined
1	Earlymid Katamani	250	214	232	100	115	108
2	Rajahar Local Variety	287	250	269	126	147	137
3	S97TEYGHAYB(3)	211	240	225	75	127	101
4	POP-445/POP-446	222	169	196	78	65	72
5	COMPOL-NIBP	232	178	205	77	87	82
6	RC/POOL-17	251	211	231	111	112	111
7	S03TEY/LM	256	232	244	107	100	103
8	Arun-4	245	232	238	106	125	116
9	Farmers' Variety	195	184	190	75	91	83
10	ZM621/POOL-15	241	199	220	97	93	95
11	EEYC1	271	221	246	101	113	107
12	SO3TEY-LN/PP	253	207	230	96	106	101
13	SO3TEY-PO-BM	273	203	238	102	99	100
14	Across-99402	233	204	219	90	103	96
	Mean	244	210	227	96	106	101
	F test						
	Genotypes (G)	**	**	**	**	**	**
	Year (Y)			**			**
	G × Y			*			ns
	$LSD_{(0.05)}$						
	Genotypes (G)	20.48	37.49	22.140	22.90	30.41	19.560
	Year (Y)			8.370			7.390
	G × Y			31.320			
	CV (%)	5.0	10.6	8.4	14.2	17.1	16.8

(Note: ns = non-significant at 5% level of significance, *=Significant at 5% level of significance, **= significant at 1% level of significance)

Days to tasseling and silking

During 2015 growing season, both days to tasseling and days to silking were significantly influenced by genotypes. Genotype farmers' variety was early in both tasseling (37 days) and silking (40 days), followed by Arun-4 and S97TEYGHAYB(3), simultaneously. Similarly, in 2016 growing season, farmers' variety was early in both tasseling (35 days) and silking (38 days), followed by S97TEYGHAYB(3) in tasseling (45 days) and by S97TEYGHAYB(3) and Arun-4 in silking (48 days) (Table 2). The significant difference in days to tasseling and

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silking among the genotypes might be attributed to genotypic composition of genotypes. Difference in days to tasseling and silking among early maize genotypes were also observed by Prasai et al. (2014) and Kunwar et al. (2014). Result of combined analysis over year showed that there was highly significant influence of genotypes on days to tasseling and days to silking. Genotype farmers' variety was early in both tasseling (36 days) and silking (39 days), followed by S97TEYGHAYB(3) in tasseling (45 days) and by S97TEYGHAYB(3) and Arun-4 in silking (48 days) (Table 2). Similar result was also observed by Prasai et al. (2015).

Table 2: Days to tasseling and silking of early maize genotypes evaluated at RARS, Doti during summer seasons of 2015 and 2016

SN	Genotype	Days to tasseling			Days to silking		
		2015	2016	Combined	2015	2016	Combined
1	Earlymid Katamani	50	47	49	52	51	51
2	Rajahar Local Variety	48	49	49	50	53	52
3	S97TEYGHAYB(3)	45	45	45	48	48	48
4	POP-445/POP-446	46	50	48	49	53	51
5	COMPOL-NIBP	50	50	50	53	54	53
6	RC/POOL-17	47	48	48	50	52	51
7	S03TEY/LM	51	50	50	53	54	54
8	Arun-4	45	46	46	48	48	48
9	Farmers' Variety	37	35	36	40	38	39
10	ZM621/POOL-15	48	50	49	51	54	53
11	EEYC1	45	46	46	48	50	49
12	SO3TEY-LN/PP	49	51	50	52	55	53
13	SO3TEY-PO-BM	49	50	49	52	53	52
14	Across-99402	49	51	50	51	55	53
	Mean	47	48	47	50	51	51
	F test						
	Genotypes (G)	**	**	**	**	**	**
	Year (Y)			ns			**
	G × Y			*			ns
	$LSD_{(0.05)}$						
	Genotypes (G)	2.41	2.19	1.667	2.56	3.11	1.999
	Year (Y)						0.755
	G × Y			2.358			
	CV (%)	3.0	2.7	3.0	3.1	3.6	3.4

(Note: ns = non-significant at 5% level of significance, *=Significant at 5% level of significance, **= significant at 1% level of significance)

Number of plants and ears per hectare of land

The number of plants/ha and number of ears/ha were significantly influenced by genotypes in both growing seasons. During 2015 growing season, S97TEYGHAYB(3) recorded the highest number of plants/ha, followed by EEYC1. The highest number of ears/ha was recorded in SO3TEY-LN/PP, followed by EEYC1, Across-99402 and COMPOL-NIBP, simultaneously (Table 3). Similarly, during 2016 growing season, ZM621/POOL-15 recorded

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the highest number of plants/ha, followed by Rajahar Local Variety. The highest number of ears/ha was recorded in Rajahar Local Variety, followed by SO3TEY/LM. Combined analysis over years showed that Rajahar Local Variety, ZM621/POOL-15 and Across-99402 had the highest number of plants/ha simultaneously, whereas Rajahar Local Variety had the highest number of ears/ha, followed by SO3TEY/LM. The number of plants/ha was low as compared to the standard number of plants/ha in both growing seasons. This was mainly due to low germination of seeds in the experimental field. Besides this, continuous rain for 3 weeks after maize seeding further reduced the plant population in 2016 growing season as compared to the 2015 growing season. The reduced plant growth and vigor during 2016 growing season might have resulted in low translocation of photosynthates from source, causing low number of cobs/ha. The detail data is presented in Table 3.

Table 3: Number of plants and ears per hectare of early maize genotypes evaluated at RARS, Doti during summer seasons of 2015 and 2016

SN	Genotype	No. of plants/ha			No. of ears/ha		
		2015	2016	Combined	2015	2016	Combined
1	Earlymid Katamani	30370	32593	31481	35556	29630	32593
2	Rajahar Local Variety	38519	39259	38889	38519	42963	40741
3	S97TEYGHAYB(3)	42222	29630	35926	37778	25926	31852
4	POP-445/POP-446	24444	32593	28519	28889	14815	21852
5	COMPOL-NIBP	31852	22222	27037	39259	26667	32963
6	RC/POOL-17	32593	28148	30370	34815	25926	30370
7	S03TEY/LM	20000	31852	25926	37037	40000	38519
8	Arun-4	33333	35556	34444	31111	29630	30370
9	Farmers' Variety	21481	15556	18519	24444	14074	19259
10	ZM621/POOL-15	31852	45926	38889	25185	35556	30370
11	EEYC1	40741	34815	37778	39259	30370	34815
12	SO3TEY-LN/PP	30370	28148	29259	40000	28148	34074
13	SO3TEY-PO-BM	31111	25926	28519	37037	22963	30000
14	Across-99402	40000	37778	38889	39259	25926	32593
	Mean	32063	31429	31746	34868	28042	31455
	F test						
	Genotypes (G)	**	**	**	**	**	**
	Year (Y)			ns			**
	G × Y			**			**
	LSD $_{(0.05)}$						
	Genotypes (G)	6184	7650	4843	5792	5481	4147
	Year (Y)						1567
	G × Y			6849			5865
	CV (%)	11.5	14.5	13.2	9.9	11.6	11.4

(Note: ns = non-significant at 5% level of significance, *=Significant at 5% level of significance, **= significant at 1% level of significance)

Grain yield

The grain yield was significantly influenced by genotypes during both growing season (Table 4). During 2015 growing season, SO3TEY-PO-BM had the highest grain yield (4.33 t/ha), followed by COMPOL-NIBP (4.18 t/ha). Similarly, during 2016 growing season, Rajahar Local Variety had the highest grain yield (2.52 t/ha), followed by EEYC1 (2.46 t/ha). The higher grain yield in these genotypes might be attributed to higher number of ear harvested. The significant differences in grain yield of early maize genotypes were also recorded by Kunwar et al. (2014) and Prasai et al. (2014). The mean grain yield of 2016 growing season was lower than 2015 growing season. This was due to the continuous rainfall for 3 weeks after maize seeding, which affected the plant growth, vigor and yield. Excessive moisture stress during early vegetative stage severely affects the growth, anthesis and silking, and eventually results in poor kernel development and yield (Zaidi et al., 2004). Over the combined analysis, the highest grain yield was recorded in EEYC1 (3.17 t/ha), followed by COMPOL-NIBP (3.09 t/ha). Further, there was highly significant G × Y interaction for grain yield (Table 4).

Table 4: Grain yield of early maize genotypes evaluated at RARS, Doti during summer seasons of 2015 and 2016

SN	Genotype	Grain yield (t/ha)		
		2015	2016	Combined
1	Earlymid Katamani	2.95	1.65	2.30
2	Rajahar Local Variety	3.01	2.52	2.77
3	S97TEYGHAYB(3)	3.11	2.45	2.78
4	POP-445/POP-446	2.23	1.07	1.65
5	COMPOL-NIBP	4.18	1.99	3.09
6	RC/POOL-17	2.3	1.71	2.00
7	S03TEY/LM	3.41	1.78	2.60
8	Arun-4	2.83	2.33	2.58
9	Farmers' Variety	1.41	0.78	1.09
10	ZM621/POOL-15	2.39	2.06	2.22
11	EEYC1	3.88	2.46	3.17
12	SO3TEY-LN/PP	3.52	1.50	2.51
13	SO3TEY-PO-BM	4.33	1.46	2.90
14	Across-99402	3.98	1.26	2.62
	Mean	3.11	1.79	2.45
	F test			
	Genotypes (G)	**	**	**
	Year (Y)			**
	G × Y			**
	$LSD_{(0.05)}$			
	Genotypes (G)	0.75	0.44	0.478
	Year (Y)			0.181
	G × Y			0.675
	CV (%)	14.3	14.7	16.9

ns = non-significant at 5% level of significance, *=Significant at 5% level of significance, **= significant at 1% level of significance.

The highly significant G × Y interactions indicated that the genotypes performance differs across the testing years, which might be due to difference in climatic condition of study area during crop growth period. Prasai et al. (2015) also concluded the similar findings from their earlier research.

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CONCLUSION

Evaluation of maize genotypes is important task for maize development program. The Early maize genotypes showed considerable variation in grain yield. The genotypes, EEYC1, COMPOL-NIBP, SO3TEY-PO-BM and S97TEYGHAYB(3) were superior early maize genotypes for river basin agro-environment of Far-Western Nepal.

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AUTHOR CONTRIBUTIONS

B.P.J. performed the experiments and collected data; B. D. analyzed the data and wrote the paper, and K.P.S. and J. S. revised the article for the final approval of the version to be published.

CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.

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