Journal of Maize Research and Development (2016) 2 (1): 66-73
ISSN: 2467-9291 (Print), 2467-9305 (Online)
DOI: http://dx.doi.org/10.3126/jmrd.v2i1.16216

Genotype × environment interaction of quality protein maize grain yield in Nepal

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Received: September 2016; Revised: October 2016; Accepted: November 2016

ABSTRACT

In order to determine G × E interaction of quality protein maize grain yield, six maize genotypes were evaluated under different environments of three Terai (Chitwan, Surkhet and Doti) and four mid hill (Dhankuta, Lalitpur, Dolakha and Kaski) districts of Nepal during summer seasons of 2014 and 2015. The experiments were conducted using randomized complete block design along with three replications. The genotypes namely S99TLYQ-B, S99TLYQ-HG-AB and S03TLYQ-AB-01 were identified high yielding and better adapted genotypes for Terai environments with grain yield of 4199 kg ha^{-1}, 3715 kg ha^{-1}, and 3336 kg ha^{-1} respectively and S99TLYQ-B and S03TLYQ-AB-01 for mid hill environments with grain yield of 4547 kg ha^{-1} and 4365 kg ha^{-1} respectively. Therefore, these genotypes can be suggested for cultivation in their respective environments in the country.

Keywords: Evaluation, grain yield and quality protein maize

Correct citation: Shrestha, J., Kunwar, C.B., Upadhyaya, J., Giri, M., Katuwal, R.B., Acharya, R., Gurung, S.B., Adhikari, B.N., Paudel, A.P., & Paneru, R.B. (2016). Genotype × environment interaction of quality protein maize grain yield in Nepal. *Journal of Maize Research and Development, 2* (1): 66-73, doi: http://dx.doi.org/10.3126/jmrd.v2i1.16216

INTRODUCTION

The continuous evaluation and development of new varieties of maize is necessary to ensure food security in Nepal. In general, three types of hunger (calorie, protein, and micro nutrient deficiency) are facing by large portion of the people. Deployment of quality protein maize (QPM) is one of the good strategies to solve the problem of calorie and protein deficiency. In maize protein the most limiting amino acid are lycine and tryptophan (Kies et al., 1965). These amino acids are nearly double in QPM as compared to normal maize. FAO (1992) mentioned that about 80% is the

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biological value of QPM protein which is nearly double of normal maize. The QPM provides better quality feed and fodder to poultry, cattle and swine.

Maize has great diversity and is adaptive across various agro-ecological zones (Ferdu et al., 2002). Across the environments where the improved varieties are adapted would produce high and stable yields (CIMMYT, 1991). The preliminary step in varietal release is to evaluate the genotypes for yield potential and adaptation to the environments where it is cultivated. In most cases maize breeders look for a variety that has good mean performances over a large array of environments and years Gurmu et al. (2009). The continuous G × E study is necessary because with the changing environments, the performance of maize genotypes differs across the agro-ecologies. Under diverse agro ecologies in Nepal the information regarding the effect of genotype, environment and their interaction is not sufficient. Therefore, this study was done to evaluate the adaptability of six QPM maize genotypes in the Terai and Mid hill environments using AMMI model.

MATERIALS AND METHODS

Description of locations

These studies were conducted during summer seasons of 2014 and 2015 at 3 locations of terai and 4 locations of mid hill districts. The mid hill environments were Pakhribas (Dhankuta), Khumaltar (Lalitpur), Kabre (Dolakha) and Lumle (Kaski) and Terai environments were Bagyatada (Doti), Rampur (Chitwan), Madi (Chitwan) and Surkhet. The short description of these locations are given as below (Table 1).

Table 1. Description of experimental locations

Environments	Altitude, (m) (m.a.s.l)	Annual rainfall (mm)	Global Position	
			Longitude	Latitude
Hills				
Pakhribas (Dhankuta)	1315-2025	1500-1600	$87^0$17'61'E	$27^0$02'96'N
Khumaltar(Lalitpur)	1368		$85^0$20'E	$27^0$40’N
Kabre (Dolakha)	1600-1740	2466.2	$86^0$80'E	$27^0$38'N
Lumle (Kaski)	848	3172.85	$83^0$58'27.72"E	$28^0$13'6.8"N
Terai				
Bagyatada (Doti)	610	Not exceed 1000	$80^0$55'E	$29^0$15'N
Rampur (Chitwan)	228	Over 1500	$84^0$19'E	$27^0$40'N
Madi (Chitwan)	110	1500	$84^0$43’E	$27^0$40’N
Surkhet	580	1550	$81^0$47"E	$28^0$30"N

Genetic materials

Six maize genotypes were evaluated in mid hills and Terai environments of Nepal during summer seasons of 2014 and 15. The genotypes were SO3TLYQ-AB-01, SOTLYQ-AB-02, S99TLYQ-HG-AB, S99TLYQ-B, Poshilo Makai-1 and Farmer’s variety. Farmer’s variety was Rampur Composite.

Experimental design and cultural practices

The experiments were carried out using randomized complete block design along with three replications. The individual plot was 13.5 m^2 (4.5 m × 3 m) . The spacing was

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0.75 m for row to row and 0.25 m for plant to plant. Fertilizer was applied @ 120:60:40 N, P_2O_5, K_2O kg ha^{-1}. The full dose of P_2O_5 and K_2O along with half of N were used as basal dose. The half of the N was used into two times; at knee-high and pre-tasseling/silking stages. Rest of agronomic practices was done as per recommendation of National Maize Research Program, Rampur, Chitwan, Nepal.

Table 2. Description of genotypes with their characteristics

SN	Genotype	Parentage	Origin	General description
1	SO3TLYQ-AB-01	Formed using inbreds from heterotic group A and B	CIMMYT, Mexico	This is open pollinated, prerelease and yellow variety for Terai
2	SOTLYQ-AB-02	Formed using inbreds from heterotic group A and B	CIMMYT, Mexico	This is open pollinated, prerelease yellow variety for Terai
3	S99TLYQ-B	Formed using inbreds derived from heterotic group B	CIMMYT, Mexico	This genotype is open pollinated , prerelease, yellow variety for terai and mid hills
4	S99TLYQ-HG-AB	Formed using inbreds from heterotic group A and B	CIMMYT, Mexico	This is open pollinated, prerelease yellow variety for Terai
5	Poshilo Makai-1	Formed using inbreds derived from heterotic group A and B	CIMMYT, Mexico	This is open pollinated white variety released in 2008. It is recommended for Terai and mid hills
6	Rampur Composite (Farmer's Variety)	Formed from Thai composite-1 × Suwan-1	Thailand	This is open pollinated , full season yellow variety released in 1975. It is recommended for Terai and mid hills regions of Nepal

(Source: Shrestha and Tripathi, 2014)

Data recording

Grain yields were adjusted to 80% shelling recovery. Grain yield was estimated using formula adopted by Carangal et al. (1971) and Shrestha et al. (2015) by adjusting the grain moisture at 15% and converted to the grain yield kg per hectare.

Statistical analysis

The combined ANOVA for all locations was done to estimate the variations in the genotypes under study and partitioning of G × E interaction. Data were analyzed through GENSTAT packages applying 5% significance level.

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RESULTS AND DISCUSSION

The pooled analysis of genotypes over terai locations showed that the highest grain yield was given by S99TLYQ-B (4199 kg ha^{-1}) followed by S99TLYQ-HG-AB (3715 kg ha^{-1}), S03TLYQ-AB-01 (3336 kg ha^{-1}) excluding Farmer's Variety. The non-significant effects were found for genotypes, location and genotype × environment interaction (Table 3).

Table 3.Combined analysis of QPM genotypes for grain yield (kg ha^{-1}) at Doti, Rampur, Madi and Surkhet during summer seasons of 2014 and 2015

SN	Genotypes	Doti	Rampur	Madi	Surkhet	Combined
1	SO3TLYQ-AB-01	1258c	2162b	4539	5080b	3336
2	SOTLYQ-AB-02	1467c	3392ab	4781	3956ab	2937
3	S99TLYQ-B	1572bc	3241ab	5737	3383ab	4199
4	S99TLYQ-HG-AB	1664bc	2959ab	4014	4182ab	3715
5	Poshilo Makai-1	1979b	3390ab	4594	1905a	3250
6	Farmer's Variety	2563a	4167a	4053	3967ab	4490
	F-test	**	*	ns	*	0.577
	Env					0.062
	Gen × Env					0.926
	CV,%	13.2	30	20.30	30.38	31.96
	LSD0.05	421.9	1756.3	2122.2	2574.6	4996 (loc × gen)

The genotypes being close to each other produce similar response and those close to environment indicate their better adaptation to that particular environment. SO3TLYQ-AB-01 and S99TLYQ-B showed similar performance for grain yield. The genotypes Poshilo Makai-1 and Farmer's Variety were similar in their grain yield performance and they were suitable for Doti and Rampur where as SO3TLYQ-AB-01 and S99TLYQ-B were suitable for Surkhet environment (Figure 1). This finding was very similar to findings of Anley et al. (2013).

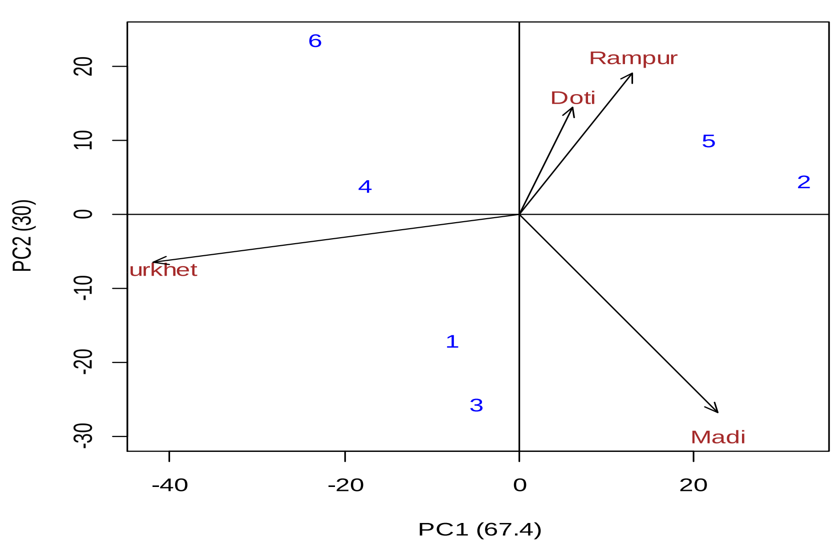

Figure 1.Stability of QPM genotypes across the tested Terai locations (Doti, Rampur, Madi and Surkhet) during summer seasons of 2014 and 2015.

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The combined analysis of variance for grain yield (Table 4) revealed that there was non significant interaction for replication within environment. Similarly non significant effect for genotype and genotype × environment interaction and highly significant effect for environment were observed. This clearly showed that effect of environment had more influential effect on grain yield.

Table 4. Analysis of variance derived from AMMI analysis across the terai locations

Source	DF	SS	MSS	F value	Pr(>F)
ENV	3	34162654	11387551	607000	0.000943***
REP(ENV)	1	19	19	0.000	0.997749
GEN	5	8889211	1777842	0.834	0.57668
ENV:GEN	15	12576434	838429	0.393	0.926219
Error	5	10662756	2132551		

Significance Codes: '***' 0.001 '**' 0.01 '*' 0.05

Across the mid hill locations pooled analysis of genotypes (Table 5) showed that the highest grain yield was given by S99TLYQ-B (4547 kg ha^{-1}) followed by S03TLYQ-AB-01 (4365 kg ha^{-1}) excluding Posilo Makai-1 and Farmer's Variety. The genotypes were significant. There was significant effect for genotype × location for grain yield. This finding was similar to findings of Carson et al. (2002). The significantly different G × E interactions was recorded for grain yield in maize (Makumbi, 2005; Menkir & Ayodele, 2005).

Table 5. Combined analysis of QPM genotypes for grain yield (kg ha^{-1}) at Pakhribas, Khumaltar, Kabre and Lumle during summer seasons of 2014 and 2015.

SN	Genotypes	Pakhribas	Khumaltar	Kabre	Lumle	Combined
1	SO3TLYQ-AB-01	4441	2979ab	3101c	5594d	4365
2	SOTLYQ-AB-02	3866	1987b	2305c	6013cd	4026
3	S99TLYQ-B	4569	2927ab	4683c	4975ab	4547
4	S99TLYQ-HG-AB	4208	3304ab	2343b	4669abc	3847
5	Poshilo Makai-1	5454	3989a	5629ab	5482ab	5340
6	Farmers Variety	4196	3980a	6389a	3865a	4549
	F-test	ns	*	**	**	0.032
	Env					<0.001
	Gen × Env					0.011
	CV%	26.9	23.7	10.8	8.8	20.71
	$LSD_{0.05}$	2176.8	1378.5	1189.4	820.3	1950(env x gen)

The Figure 2 indicated that the performance of SO3TLYQ-AB-01 seemed better for Pakhribas. Similarly, SOTLYQ-AB-02 was better for Lumle and Poshilo Makai-1 and S99TLYQ-B for Kabre condition. In hill environments the genotype by environment interaction for grain yield was highly significant this may be due to differences among the sites in soil fertility, relative humidity and temperature, all factors which affect performance. The results showed that the genotypes responded differently to different environmental conditions. Similar findings were observed by Butron et al. (2002). Ogunbodede et al. (2001) reported that the genotypes should be partially released for locations where the performance was most favorable.

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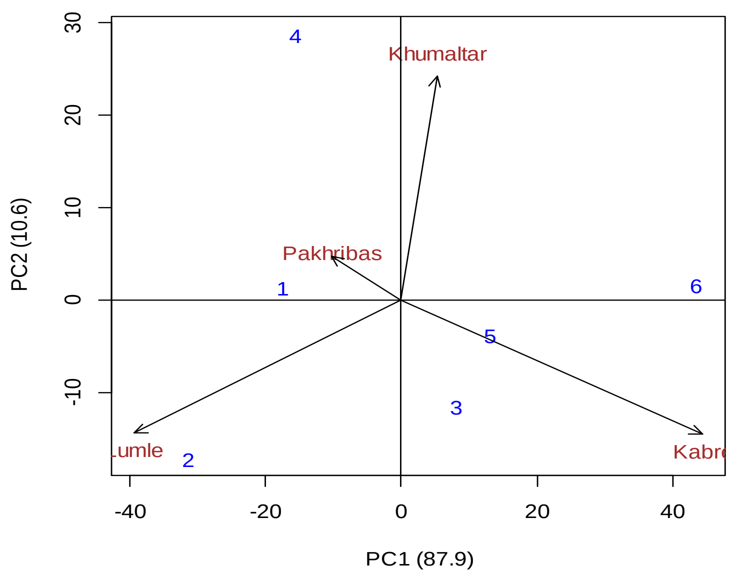

Figure 2. Stability of QPM genotypes across the hills locations. (Pakhribas, Khumaltar, Kabre and Lumle) during summer seasons of 2014 and 2015.

The combined analysis of variance for grain yield (Table 6) revealed non significant effect for replication within environment. For grain yield the effect of genotype was significant, genotype × environment effect was highly significant and environment was significant.

Table 6. Analysis of variance derived from AMMI analysis across mid hill locations

Source	DF	SS	MSS	F value	Pr(>F)
ENV	3	18749637	6249879	3.495	0.10576
REP(ENV)	5	8941208	1788242	2.5662	0.05253
GEN	5	12247819	2449564	3.5152	0.015257*
ENV:GEN	15	34329473	2288632	3.2843	0.004211**
Error	25	17421184	696847		

CONCLUSION

The better genotypes with respect to grain yield and location were Poshilo Makai-1 and Farmer's Variety for Doti and Rampur where as SO3TLYQ-AB-01 and S99TLYQ-B for Surkhet. Similarly SO3TLYQ-AB-01 was better for Pakhribas, SOTLYQ-AB-02 for Lumle and Poshilo Makai-1 and S99TLYQ-B for Kabre condition. Therefore these varieties with respect to their specific adaptation can be recommended for general cultivation.

ACKNOWLEDGEMENTS

The authors were grateful to National Maize Research Program, Rampur, Chitwan for financial and technical support. They were thankful to collaborative staffs from RARS Doti, ARS Pakhribas, ARS Surkhet, RARS Lumle, ADB Khumaltar and HCRP Kabre for their cooperation in the implementation of project activities. The authors acknowledged all the participating farmers for cultivating maize in the field trials.

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