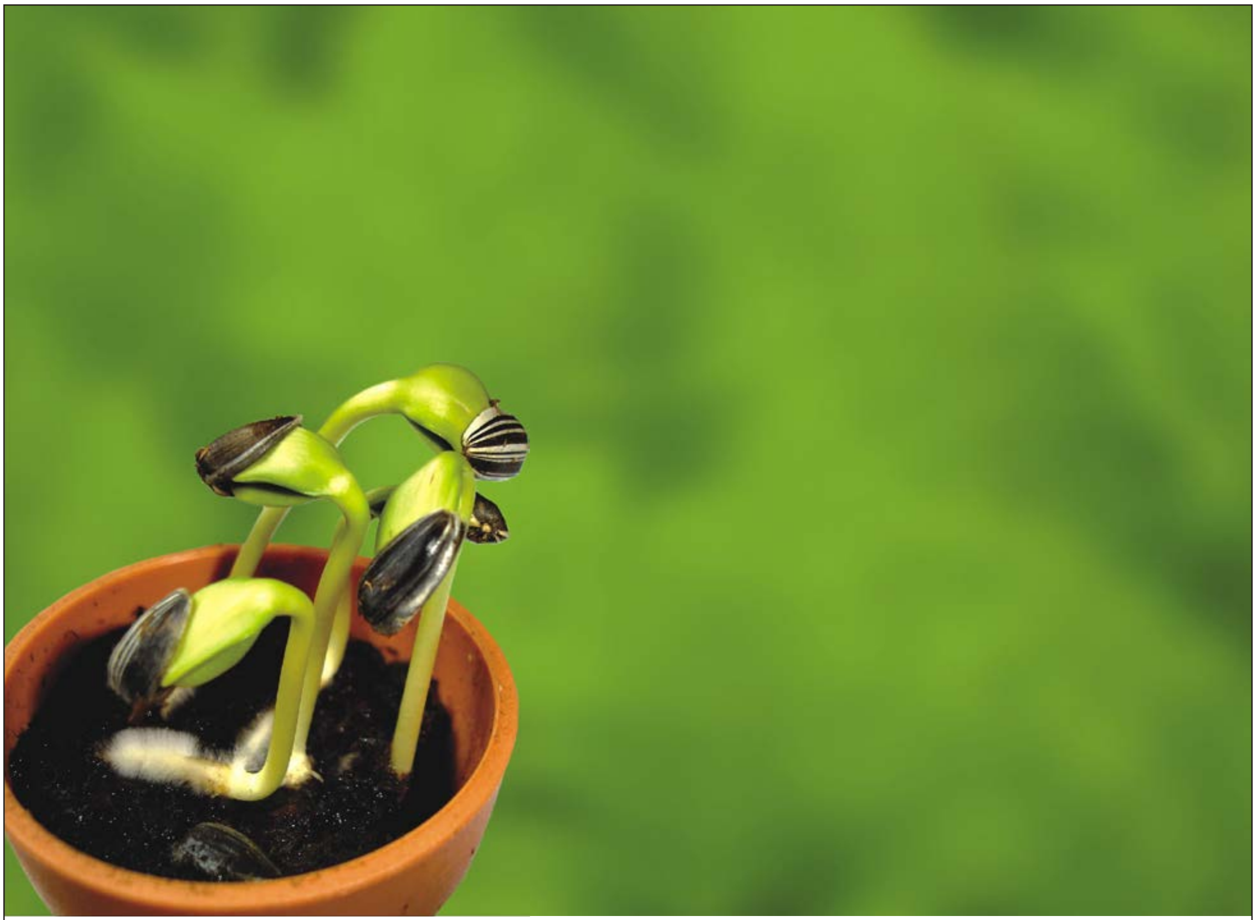

International Journal of
Plant Breeding and Genetics

ISSN 1819-3595

Academic
Journals Inc.

www.academicjournals.com

International Journal of Plant Breeding and Genetics 9 (4): 255-261, 2015
ISSN 1819-3595 / DOI: 10.3923/ijpbg.2015.255.261

Evaluation of Yield Performance and Variation on its Adaptation-Related Traits of Quality Protein Maize (QPM) (*Zea mays* L.) Varieties at Selected Woredas of Wolaita Zone, Ethiopia

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ABSTRACT

This study was conducted with the aim of evaluating the performance of released quality protein maize varieties in the lowlands of Wolaita Zone, southern Ethiopia in 2014. As treatment, four varieties; BH540, MelkassaQ4, MelkassaQ6 and MHQ138 was planted in the complete randomized block design with three replications in two locations including Humbo and Badessa. In the 2014, growing season there was shortage and uneven distribution of rainfall compared to the relative normal distribution of rainfall in the lowlands of study area. Analysis of variance and mean comparison results prevailed the presence of significant difference ($p<0.05$) for some of the studied traits. These traits are plant height, root height, grain yield, biomass and kernels per ear. Plant height was negatively ($r = -0.18$ and $r = -0.12$) correlated with ear height and root height respectively and positively with low value correlated ($r = 0.042$) with grain yield. Similarly root height was strongly correlated with grain yield and biomass ($r = 0.24$ and $r = 0.35$) in the positive direction. Regarding the yield performance, from three QPM varieties, MHQ138 performed better than that of others and the check BH540.

Key words: Quality protein maize (QPM), yields and adaptation related traits, root

INTRODUCTION

Maize (*Zea mays* L.) is the third most important cereal crop in the world. In Ethiopia, maize grows in all agro ecologies from highland to lowlands (Mulatu *et al*., 1993) and it covers 1.3 million hectare from this, the share of quality protein Maize is 7283 ha (Krivanek *et al*., 2007). The total annual production and productivity exceeds all other cereal crops except teff in area coverage. It is one of the most important cereal crop consumed by many small scale farmers in Wolaita zone in the rural areas. Currently, because of the high price of teff which is consumed as injera, the Ethiopian traditional food, even urban people now a days are also consuming normal maize as a staple food as injera or Kitta (local food from maize). However, the normal maize is very poor in nutritional quality due to lack of two amino acids (FAO., 1992). The two amino acids absent in normal maize are lysine and tryptophan, which can be only obtained from meat, milk and egg (Lauderdale, 2000). In contrast quality protein maize is very rich in essential amino acids. Research on QPM is of the recent history in Ethiopia and variety BHQ542 was the first to be released in 2001 as the best alternative to be used by the farmers for its cooking qualities and making injera instead of normal maize (De Groote *et al*., 2010).

Africa is the only region, where both the proportion and the number of underweight children are increasing because of malnutrition (Rosegrant *et al*., 2001; De Onis *et al*., 2004). Moreover, lack of access to nutritious food is an underlying and major cause of child mortality (Caulfield *et al*., 2004). In rural areas, household diets are dominated by staples such as cereals and tubers, mostly produced at the homestead, while consumption of other foods that would improve dietary quality, such as legumes, vegetables, fruits and animal source foods, is limited by availability and prices (De Groote *et al*., 2010).

Many research work related with QPM has been done in different regions in the world and now a days there are different varieties of QPM under production (EIAR., 2001).

Taking the importance of QPM into account, Ethiopian Institute of Agricultural Research initiated a research to convert normal maize into Quality Protein Maize (QPM) whereby now five varieties were released for different agro-ecologies (Worku *et al*., 2012).

Wolaita Zone is densely populated with serious shortage of farmable land per each household. Indeed, increasing the productivity per hectare and increasing the nutritional quality of produce in this area is seems to be the best alternative for food security. Regarding the performance, of released QPM maize yielded comparable amount as normal maize (Bjarnason *et al*., 1988). In the study of QPM materials in 1995 and 1996 in Ethiopia, the QPM materials (hybrids), produced better and were comparable in agronomic performance with the check BH140. Tulu *et al*. (2001) reported that QPM hybrids had 20 and 42% yield advantage over the checks BH140 and Beletech, respectively.

Correlation studies prevails the existing relationship among character of studied genotypes, which are useful in most breeding programs. In the breeding program correlation can be used for direct selection and indirect selection of traits. It gives the chance of considering qualitative traits, as part of selection (in selection, most of the time, only quantitative traits are considered). Both phenotypic and genotypic correlations are very important in the breeding program for selecting better performing parents. Genetic diversity is important for selecting parents to recover transgressive segregates.

Hence, this study was initiated with the objectives of investigating the adaptability, variation of adaptation-related traits and correlation of yield and yield related traits of QPM varieties.

MATERIALS AND METHODS

Site description: Field trail were conducted during 2014 cropping season at Humbo and Damot woyde(Badessa) of Wolaita Zone, which is found in the southern part of the county at a distance of 383 km from the capital of Ethiopia on the way to Arbaminch. Humbo and Damotwoyde represent lowland. The Woredas (districts) were selected purposefully, because of their potential for maize production (personal communication with Wolaita Zone Bureau of agriculture, Wolaita Zone). The two districts; Humbo and Damotwoyde are located at the latitude and longitude of 6°40'N and 37°50'E and 6°50'N 38°00'E, respectively.

Treatments: The treatments are the quality protein maize varieties which were released from Melkassa Agricultural research center. They are MelkassaQ4, Melkasa6Q, MHQ138 and BH540.

Methods or experimental design: The proposed treatments was planted and tested for evaluating its performance in the selected maize growing areas in Wolaita Zone. The experiment was laid out following the RCBD design with three replications. Farmers managed all cultural practice and applied recommended fertilizer rate of DAP and Urea. The spacing between plants and between rows were 25 and 75 cm, respectively. Plot size was (2.5×3 m) = 7.5 m^2 and consisted of four rows. Two seeds were planted per hole and later thinned to recommended plant population per hectare at the age of knee height.

Data collection and analysis: The data collected were Plant height, ear height, root (main root) height, grain yield, biomass, thousand seed weight, number of rows per ear and number of kernel per ear. The data were subjected to analysis by using SAS version 9 and mean comparison was done using LSD at 5% level for significance.

RESULTS

Quality Protein Maize (QPM) varieties which were released for different agro-ecologies were tested in the lowlands of Wolaita Zone namely in Humbo and Badesa. To evaluate their performance randomized completed block design was used. The selected districts were the potential areas for maize production under the varying rain conditions in the zone. The rain distribution of 2014, was very erratic especially in the lowlands. However, some varieties were performed very well though the rain fall was low as compared to the related normal distribution in the lowlands.

The ANOVA was carried out for the traits studied and the results were presented (Appendix 1, Table 1). ANOVA has showed significant difference ($p<0.05$) for five of the traits such as plant height, root height grain yield, biomass and kernel per ear. From the five traits, which showed significant difference, three of them are related to yield, which is the ultimate goal of crop

Appendix 1: Mean square values for crop phonology and growth parameters of quality protein maize at Humbo and Badessa, in 2014 cropping season

Source	df	Plant height (cm)	Ear height (cm)	Root height (cm)	Grain yield	Biomass	1000 weight	Row/ear	Kern/row	Kern/ear
Replication	2	397.18^{ns}	2.34^{ns}	13.48^{ns}	0.038^{ns}	0.019	186.6^{ns}	0.042^{ns}	13.63^{ns}	406.79^{ns}
Variety	3	1249.67*	0.45^{ns}	81.34*	0.22*	0.243**	3548.78^{ns}	0.71^{ns}	3.38^{ns}	7890.15*
Location	1	105.84^{ns}	13.20^{ns}	161.94*	0.11^{ns}	3.28**	4474.47^{ns}	18.37**	1.50^{ns}	5735.04^{ns}
Error	6	378.38	3.69	19.09	0.0416	0.484	3450.55	2.76	11.94	3074.49
CV (%)		7.97	9.16	20.31	15.60	13.50	17.69	9.39	11.06	11.83

*: 5% and **: 1% level of significance, CV: Coefficient of variation, DF: Degree of freedom, cm: Centi-meter and kern: Kernel, ns: Not significant

Table 1: Mean comparison analysis of parameters at each location

Locations and treatment	Plant height (cm)	Ear height (cm)	Root height (cm)	Grain yield (kg $plot^{-1}$)	Biomass (kg $plot^{-1}$)	1000 weight	Row/ear	Kernel/ row	Kernel/ ear
Humbo									
Varieties	241.84^{ns}	21.71^{ns}	24.10^{ns}	2.40*	2.80**	345.62^{ns}	15.33^{ns}	31.00^{ns}	484.16^{ns}
BH540	265.40^{a}	20.66	21.65	0.67^{b}	2.30^{bc}	374.53	14.66	30.00	440.33
MekasaQ4	235.53^{a}	21.26	23.48	0.82^{b}	2.66^{b}	339.67	15.66	32.00	498.00
MelkasaQ6	231.47^{a}	21.93	22.04	0.86^{b}	2.13^{c}	322.43	15.66	30.33	473.67
MHQ138	234.97^{a}	23.00	29.23	1.22^{a}	4.12^{a}	345.87	15.33	31.66	524.67
LSD 5%	42.11	3.32	9.01	0.31	0.48	129.79	3.43	8.55	116.33
CV (%)	9.24	8.12	19.86	18.16	9.18	19.94	11.90	14.66	12.76
Badessa									
Varieties	246.04^{ns}	20.23^{ns}	18.9**	0.76^{ns}	2.06**	318.31^{ns}	13.58^{ns}	31.50^{ns}	453.25**
BH540	265.00	21.53	17.00^{ab}	0.83	1.94^{b}	360.93	13.33	33.66	452.33^{ab}
MekasaQ4	230.67	20.53	16.16^{b}	0.61	1.42^{b}	294.60	14.00	31.33	437.67^{b}
MelkasaQ6	244.50	19.33	17.66^{ab}	0.63	1.62^{b}	309.97	13.33	30.00	407.33^{b}
MHQ138	244.00	19.53	24.80^{a}	0.98	3.26^{a}	307.77	13.66	31.00	515.67^{a}
LSD 5%	37.59	2.68	8.39	0.45	0.52	91.12	1.33	4.95	76.53
CV (%)	8.12	7.04	23.58	13.57	13.61	15.20	5.20	8.34	8.96

*: 5% and **: 1% level of significance, LSD: Least significant difference, CV: Coefficient of variation, cm: Centi-meter and kern: Kernel, ns: Not significant, superscript letters are significantly different

Table 2: Crop phenology and growth parameters of quality protein maize as affected by varieties combined over locations (Humbo and Badessa) in 2014

Treatments	Plant height (cm)	Ear height (cm)	Root height (cm)	Grain yield (t ha^{-1})	Biomass (t ha^{-1})	Kernel/ear
Varieties	243.94*	20.98^{ns}	21.51*	2.37*	6.48**	468.70*
BH540	265.90^{a}	21.10^{a}	19.33^{b}	2.28^{b}	5.65^{b}	446.33^{b}
Melkassa 4	233.10^{b}	20.90^{a}	19.83^{b}	1.91^{b}	5.44^{b}	467.83^{ab}
MelkassaQ6	237.98^{b}	20.63^{a}	19.85^{b}	1.84^{b}	4.99^{b}	440.50^{b}
MHQ138	239.48^{b}	21.26^{a}	27.02^{a}	3.48^{a}	9.84^{a}	520.17^{a}
LSD 0.05	23.60	2.33	5.32	0.245	0.67	67.23
CV (%)	7.97	9.16	20.31	15.60	13.50	11.83

*: 5% and **: 1% level of significance, LSD: Least significant difference, CV: Coefficient of variation, cm: Centi meter and kern: Kernel, ns: Not significant, superscript letters are significantly different

Table 3: Analysis of correlation of crop phenological and growth parameters of released QPM varieties

Correlation parameters	Plant height (cm)	Ear height (cm)	Root height (cm)	Grain yield (t ha^{-1})	Biomass (t ha^{-1})	1000 weight (g)	Row/ear	Kernel/row	Kernel/ear
Plant height		-0.18	-0.12	0.042	0.019	-0.15	0.074	0.11	0.09
Ear height			0.49*	0.276	0.304	0.496*	0.021	0.593*	0.327
Root height				0.237	0.354	0.535*	0.15	0.244	0.155
Grain yield					0.66*	0.146	0.109	-0.224	0.264
Biomass						0.014	0.30	0.086	0.64*
1000 weight							-0.38	0.342	-0.174
Row/ear								-0.198	0.56*
Kernel/row									0.449*
Kernel/ear									-

improvement program. One of the traits which showed significant difference is related to the adaptation which is assumed due to adaptation gene released during the stress conditions. The remaining traits such as ear height, 1000 seed weight, rows per ear and kernels per row were non-significant. The better performance of those significant varieties in the moisture stress condition can be considered as a good indication for indirect selection of best performing variety.

For those traits, which showed significant differences ($p<0.05$) according to ANOVA, mean comparison analysis was carried out to detect the magnitude of differences which was contributed from each varieties (treatments) at LSD 5% (Table 2). In the table, the yield and yield related parameters, such as; yield, biomass and kernel per ear of treatment 4 (MHQ137) exhibited differences in the mean comparison analysis as compared to the remaining three (treatments) varieties.

Furthermore, correlation analysis was conducted to detect the prevailing relationship among those parameters which showed performance differences in the preliminary ANOVA (Table 3). The adaptation related trait such root height showed positive correlation with the yield and yield related traits (Table 3).

DISCUSSION

The main aim of this study was to evaluate the performance of released QPM varieties, such Melkasa Q4, Melkassa Q6 and MHQ138 with the standard check BH540 in maize growing areas of Wolaita Zone. As it is observed in the preliminary ANOVA and mean comparison analysis (Appendix 1 and Table 1 and 2), the variation was significant for the following traits such as plant height, root height, grain yield, biomass and kernels per ear. These differences are similar with the findings of Sorsa *et al*. (2014). The mean of plant height was 243.94 cm and the highest plant height was 265.9 cm. This finding is in line with work of Yusuf (2010) and Bello *et al*. (2012), where plant height of QPM genotypes showed significant variation. In the correlation analysis plant height was negatively correlated with ear height, root height and thousand seed weight (Table 3). However, in contradictory to Yusuf (2010) finding in which plant height highly correlated with ear height, plant and ear height in this research showed negative correlation which is believed might be due to the stress conditions (low rain fall), as compared to the previous growing seasons. This plant height correlation with the yield and yield related parameters is in the positive direction almost approaching to zero values. The other phenological parameter, which showed significant difference and which was considered as one of the adaptation trait was root height. The mean of root height was 21.51 cm and the highest one was 27.02 cm, which is from Variety MHQ138. The root height correlation of this variety with plant height is negative but with other yield related traits is positive and relatively strong which is similar with the findings of (Royo *et al*., 2005). This root height performance and its positive correlation with yield performance in the stress environment of Humbo and Badessa in 2014 main growing season can be considered as one of the best indicator for selecting of varieties. Many physiologists are undertaking research work on adaptation to abiotic stress factors to incorporate the output in a breeding program but some of the adaptation traits are not available in well adapted genotypes and their validation frequently requires the development of appropriate breeding material, which is costly and time consuming (Royo *et al*., 2005). However, the indication of available adaptation trait, in the case of this study, root height can be one of the selection entry for breeding program of maize varieties for lowland (moisture stress environment).

The performance of yield and yield related traits of the varieties in this experiment was similar to many of previous works (Sorsa *et al*., 2014; Bello *et al*., 2012; Tulu *et al*., 2001; Hussain *et al*., 2006). In similar way, Martins *et al*. (2010) reported that QPM is best in nutritional aspect as well as in its high yielding ability compared to the normal maize. In the correlation analysis, grain yield is strongly correlated with biomass and kernel per ear. Among all correlation of parameters, the strongest one was the correlation of root height with grain yield and the correlation of grain yield with that of biomass. In general, when we are connecting the main objectives of this study, that was evaluation of yield performance and correlation of agronomic and yield related parameters with yield, the performance of yield and yield related traits and that of adaptation traits prevailed significant differences, as well as correlations. Especially, the correlation of root height with that of all other traits studied in the existing stress situation indicates much attention should be given to this trait during the breeding program, if the target area is lowland similar to the environment, where this research was conducted. Rather than evaluating the released varieties of lowlands in places other than its place of release, it is advisable to start the breeding program in the target place. Because in the place of release the varieties have expressed their adaptation potential and at that time some of the important traits of adaptation to other places would be dominated and probably it could be drifted (lost).

CONCLUSION

In conclusion quality protein Maize varieties are the new alternatives to people who consume maize as a staple food where they can easily get essential nutrients, which otherwise can be obtained from meat, milk and egg which is not affordable to small scale farmers. From African country, Ethiopia, in generally and from south nations and nationalities people, Wolaita in particularly consume maize, as a staple food, since long time. The performances of released varieties were checked at Wolaita Zone in the two locations. According to ANOVA and the mean comparison analysis, five of the traits showed significant difference and in the correlation analysis root height is highly correlated with the yield and yield related traits. Location showed significant difference for traits of root height, biomass and number of rows per ear. In this experiment the variety MHQ138 performed better than that of other varieties studied including BH540 as a check. As the result of this study Variety MHQ138 is recommended for Humbo and Badessa lowlands.

ACKNOWLEDGMENTS

I would like to acknowledge Wolaita Sodo University for all financial support and timely release of budget allotted for this research in 2014. I want to take this opportunity to thank the research coordination office of college of agriculture and the department of plant Science as well. Thanks to Zagros Bioidea Co., Razi University Incubator for all supports. Lastly, I would like to express my great thanks to Technical assistant namely Simon Yohannes for all his contribution in planting and data collection.

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