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Evaluation and Selection of Improved Teff (Eragrostis teff) Varieties for Their Adaptability in Western Hararge Zone

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Abstract
An experiment was conducted in three districts of western Hararghe zone at Daro Lebu, Habro and Oda Bultum in 2016/2017 cropping season in order to identify and promote well adapted improved tef variety/s. The experiment was laid out in randomized complete block design with three replications. The most important data of the trial like days to50-% flowering, plant height, panicle length, maturity date, biomass harvest index and yield kg/ha were collected. The collected data was analyzed using Genstat statistical software and means were separated using least significance difference. Combined analysis of data revealed that, varieties varied significantly at ($P < 0.05$) for grain yield kg/ha and maturity date highly significance difference at ($P<0.01$) for plant height and days to 50% flowering and the rest parameters were showed no significance difference. Gimbichu and Boset were the two varieties showed relatively better yield with a value of 1794 and 1789 $kgha^{-1}$ respectively. Kena, Guduru and Dega tef were the least performing varieties interms of grain yield than standard checks kuncho having a value of 1271, 1576, 1573 and 1731$kgha^{-1}$ respectively. As a whole the performance of tef varieties were under their potential due to rain fall variability during the growth period. Generally, Gimbichu and Boset were the two varieties showed better performance with their mean yield and other measured traits. Therefore, these two varieties were recommended for further evaluation on farmer's field.
Keywords: Tef Variety, Grain yield, adaptation,

1. INTRODUCTION

Teff is the most important cereal in terms of both production and consumption in Ethiopia, and is grown as food grain in only one other country, Eritrea (FAO, 2015). Teff (*Eragrostis Teff*) is a nutritious small grained cereal, related to millet, which originates in Ethiopia and is thought to have been domesticated by Ethiopian farmers between 3 and 6 millennia ago (Samuel and Sharp, 2008). Teff is grown mainly in Amhara and Oromiya, which together accounted for 84 and 86% of the total cultivated area and production in 2011. East and West Gojam of Amhara and East and West Shoa of Oromiya are particularly known teff producing areas in the country (Demeke and Marcantonio, 2013).

Mostly, Teff is produced by small holder farmers at the central, eastern and northern highlands of the country on fragmented lands with rain fed conditions in both, *Meher* and *Belg*, seasons (Engdawork, 2009). Teff production has increased by 24.5% between 2003/2004 and 2012/2013 cropping years. This growth was achieved mainly due to 37% expansion in area under cultivation and 64% increase in yield levels per hectare (CSA, 2015). In 2015 cropping season the area under tef cultivation in Ethiopia is estimated to be 2,865,066.95 ha with a total production of 44,714,618.94 q/t.

Teff is one of the major cereal crops in Ethiopia which is mainly used for food consumption. The composition of Teff shows that it has good mineral content and generally higher amount of the essential amino acids (Engdawork, 2009). Its grain flour is mainly used for preparing *injera,* which is the favorite national dish of most Ethiopians. Injera produced from teff flour is of good odor, flavor, texture, and keeping quality. The grains give higher returns both in flour upon milling (i.e. 99 percent compared to 60-80 percent from that of wheat) and in *injera* upon baking. The flour is also used for the preparation of porridge and *kita* (non-fermented unleavened bread). Sometimes, the grain is also brewed into a native beer, *tella* and a traditional alcoholic liquor, *Katikalla* or local *arakie*. Alternative tef dishes such as tef breakfast cereal, tef waffles, tef banana bread and the like are appearing in the western world particularly in the USA (Teklu, nd). It is nutritionally rich with high levels of iron and calcium and has the highest amount of protein among cereals consumed in Ethiopia. It ranks low on the glycemic index (making it suitable for consumption by Type II diabetics), is gluten free and is high in fibre (FAO, 2015). Teff is the most nutritious of all grains grown in Ethiopia (Crymes, 2015). In term of caloric intake, cereals dominate the diets of Ethiopian households. Of the total calorie consumption, four major cereals (maize, teff, wheat, and sorghum) account for more than 60%, with maize and wheat representing 20% each. The low share of teff in calorie consumption often come as surprise to urban Ethiopians, as teff is the predominant staple in the of the middle- and high income households (Rashid, 2010). Similarly, FAO (2015) demonstrated that Teff is a major staple food for many Ethiopians. Most prefer teff to other grains but is in general more widely consumed by the economically better off urban residents than by rural households. Teff contributes up to 600 (28.5% of minimum requirement) kcal/day in urban areas, compared to only 200 (9.5% of minimum requirement) kcal/day in rural areas.

Though tef is relatively resistant to many biotic and abiotic stresses and can be grown under different agro-ecological conditions, ranging from lowland to highland areas (FAO, 2015).The national average yield of tef is very low which is 1.3t/ha (CSA, 2016).Several factor were mentioned in different studies regarding the low production of tef of these constraints lack of improved varieties adaptable to wider environment, limited access to improved crop variety, uneven and erratic distribution rainfall & poor agronomic management practices were considered as a major one. However, many research efforts have been made by many agricultural research centers to solve these problems by developing tef varieties adaptable to specific agro climatic conditions. In west Hararghe there are potential districts well recognized by tef production but the production and productivity of this crop is very low due dominant use of local varieties and poor agronomic management practices. As result testing tef genotypes with different potential interims of yield increment and adaptability to our environment is assumed to be one of the options in which our farmers could improve the livelihood of their family through increasing production and productivity this crop as a zone in particular as a national in general.

Therefore this activity was initiated with objective of evaluating and selecting the best adapted tef variety/s in western Hararghe zone and similar areas

2. Material and Methods

2.1. Description of the study area

The field experiment was conducted at Mechara Agricultural Research Center (MeARC) during the 2009/10 cropping season. McARC is found in altitude 1700 a.m.l and (40^o 19' N latitude and 08^o 35' E longitude). It is located 434 km east of Addis Ababa in West Hararghe, Eastern Ethiopia. The major soil type of the Center is sandy loam with reddish color (McARC, 2010). McARC is found Daro Lebu, which is one of the districts of West Hararghe zone. The ambient temperature of the district ranges from 14 to 26°C with average of 16°C with average annual rainfall of 963 mm/year. Oda Bultum is located at 08054, 3180N, 0400; 0210E.The annual rain fall is 900 mm-1100 mm). It has a mean maximum and mean minimum temperature of 28°C and 25°C; respectively. The maximum rainfall and minimum rainfall is 1200mm and 900 mm. The district is characterized reddish sandy loam in color .Habro district is found in West Hararghe zone of Oromia region with mean annual rainfall of 1010 mm and the annual temperature ranges from 25-32oC (HDoANRO, 2016) .The soil type of the district is characterized by black clay loam .

2.2. Experimental Material and Design

Six improved tef varieties including one standard check were brought from Debre Zeit (**Boset Gimbichu, Dega-Tef)** and Bako Agricultural research center (**kora, Guduru and kena)** and tested in randomized complete block design with three replication on plot area of $2.4m^2$ with a plot length ,width of 2 m x1.2m at row spacing of 0.2m and 0.5m,1m between plot & block respectively.

2.3. Experimental Management

Land preparation was done using animal drawn conventional tillage implements 2-3 times was inverted and break down in to fine tilth to create suitable soil condition for uniform emergence of the seedlings and moisture conservation. Planting of tef was done in the mid of august when the rain fall was well established and drilling method of planting was used at row spacing of 20cm with recommended seed rate of 25kg/ha each varieties were consisted of six rows in each plot and block respectively.100/100 kg/ha NPS and Urea were applied and 2-3 times hand weeding and other management practices were applied to enhance the plant growth and development.

2.4. Data collected

The important data of the trial including days to 50% emergence, grain yield, and days to 50% heading, maturity date, plant height, panicle length & straw yield as well as harvest index were collected.

2.5. Data Analysis

The collected data were subjected and analyzed by Gens tat software version 13. Mean separation was carried out using LSD test at 5% probability level.

3. RESULT AND DISCUSSION

Table.1 Mean effect of tef varieties on grain yield and yield components in each districts of western Hararghe Zone in 2009/2010 cropping season

	Daro Lebu (Mechara on station)						Habro (Bareda on FTC)						Oda Bultum (Oda baso on FTC)					
Varieties	Gy kg/ha	Stray kg/ha	Plan height (Cm	Panicle length (cm	Md	Df	Gy kg/ha	Stray kg/ha	Plan Height (cm	Panicle length(cm)	Md	Df	Gy kg/ha	Stray kg/ha	Plan height (cm	Panicle length(cm)	Md	Df
Boset	1281	4058	19.26	19.26	89	41	2222	1764	30.47	30.47	64	43	1864	5420	71.83	27.13	75	37
Dega-Tef	1340	3449	20.93	20.93	84	45	1687	2572	32.2	32.2	68	40	1693	4592	80.93	30.4	82	36
Kora	1367	3525	22.2	22.2	95	51	1986	5183	37.1	37.1	73	45	1909	4289	86.23	33.63	78	41
Gimbichu	1354	4305	20.14	20.14	86	27	2306	4682	28.27	28.27	81	46	1722	4588	77.33	30.3	84	41
Guduru	1319	4317	22.97	22.97	87	45	1764	4481	36.33	36.33	68	41	1645	4118	82.6	32.2	84	40
Kena	1076	2688	22.77	22.77	96	53	1069	3320	28.57	28.57	82	44	1666	3973	78.47	30.03	84	40
Kuncho (check)	1444	3484	21.63	21.63	91	49	2132	3224	31.47	31.47	69	42	1618	4331	80.43	28.67	76	37
LSD 5%	406	1894	6.59	4.40	13	11.7	686	3318	13.1	11.2	15.8	4.48	820.8	2179.	10.1	7.59	5.1	6.7
CV	17.4	10.5	5.8	11.6	8.3	14.8	20.5	51.8	9.4	19.8	12.3	5.8	26.7	27.4	7.1	14	4	9.7
P.value	NS	NS	*	NS	NS	*	*	NS	NS	NS	NS	NS	NS	NS	NS	NS	*	NS

* Significant at 0.05 level LSD= Least significance difference NS = not significant CV= Coefficient variation Gy = grain yield Df= days 50% flowering Md= days to maturity Stra= straw yield

Table 2. Combined Mean effect of location and tef varieties on yield and yield components at Daro Lebu, Habro and Oda Bultum Districts in 2009/10 cropping season

Varieties	Grain yield kg/h	Straw yield kg/ha	Plant height(cm	Panicle length cm	Maturity date	lodging	Days 50% flowering	Disease (1-5)	Above Ground Biomass	Harvest index
Boset	1789	3747	66.67	25.62	76	1.5	40	1.2	5058	0.315
Dega-Tef	1573	3538	75.24	27.84	78	1.6	40	1.3	4958	0.341
Kora	1754	4332	79.77	30.98	82	1.3	46	1.6	5525	0.286
Gimbichu	1794	4525	69.47	26.24	84	2.1	38	1.3	5759	0.296
Guduru	1576	4306	78.89	30.5	80	2.1	42	1.3	5384	0.259
Kena	1271	3327	74.2	27.12	88	2.1	46	1.4	4792	0.352
kuncho(ch)	1731	3680	75.13	27.26	79	1.4	43	1.4	4935	0.301
LSD	423.2	1187	9.593	7.495	11.4	1	7.4	0.67	5058	0.1486
CV	22.3	37.1	7.8	16.3	8.6	35	10.6	29.2	23.5	29.3
P.Value	*	NS	**	NS	*	*	*	NS	NS	NS
						Location	Mean			
Locations	Grain yield kg/h	Straw yield kg/ha	Plant height(cm	Panicle length cm	Maturity date	lodging	Days 50% flowering	Disease (1-5)	Above Ground Biomass	Harvest index
Daro Lebu	1312	3690	64.18	21.41	72.1	2.143	44.4	1.21	4905	0.2917
Habro	1881	3604	78.72	32.06	80.62	1.238	43	1.81	4960	0.3256
Oda bultum	1731	4473	79.69	30.34	89.76	1.857	38.9	2.381	5740	0.3041
LSD %	228.7	907	3.36	2.83	4.3	0.38	2.8	0.25	763.6	0.05
P value	NS	NS	**	***	***	**	***	**	*	NS

Table 3. Analysis of variance table from AMMI model showing the effect of variety, environments and their interaction on grain yield performance of teff varieties and interaction principal components in 2017 at three locations of West Hararghe, Ethiopia

Source	D.F	S.S.	M.S.	% Explained	F.cal	F prob.
Total	62	13230146	213389			
Treatments	20	7364394	368220	55.6	2.67	0.0051**
Genotypes	6	1908450	318075		2.30	0.0552
Environments	2	3658685	1829342		12.24	<0.001**
Block	6	896569	149428		1.08	0.3912
Interactions	12	1797259	149772	13.6	1.09	0.4008
IPCA 1	7	1611818	230260	89.5	1.67	0.1482
IPCA 2	5	185441	37088	10.4	0.27	0.9273
Residuals	0	0				
Error	36	4969184	138033			

The meta analysis indicated that variety Gimbichu (17.94 Qut ha^{-1}) was highest grain yielder than other varieties while the lowest grain yielder was recorded in Kena variety (12.31 Qut ha^{-1}). The principal component (PC1) explained 89.5% of the total variation; while the principal component (PC2) explained 10.4%. Finally, these two principal components summed up to 99.9% which accounted for the total variation in grain yield. The AMMI analysis of variance for grain yield of variety tested in three environments showed that the main effect of V and E account for 13.6% (Table 4). The analysis revealed that variance due to environment was highly significant and variety was significant while VxE interaction was not significant. Large difference among environment means causing most of the variation in grain yield, which is in line with the findings of (Molla *et.al*., 2013; Maqsood and Ali, 2007; Mahto *et.al.,* 2006) in finger millet production.

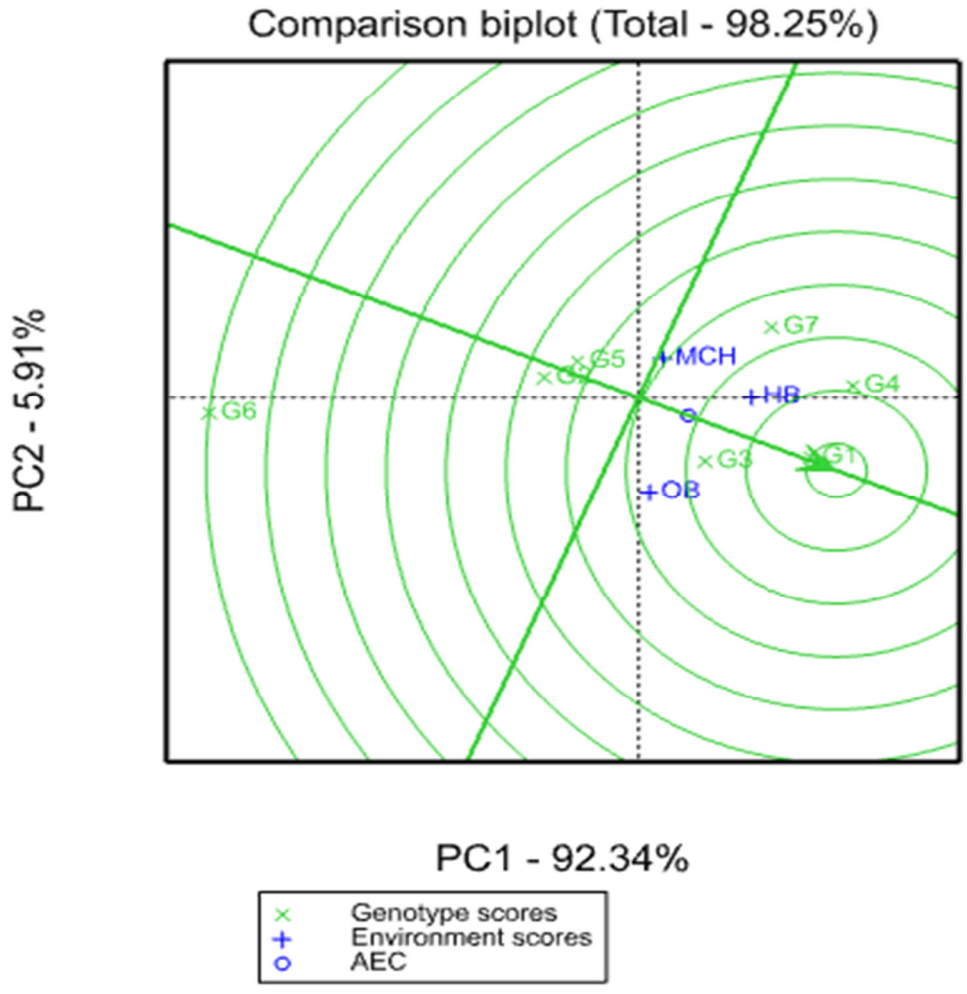

Figure 1. GGE Biplot for which won where pattern of variety by environment in grain yield of teff varieties in West Hararghe

Genotype 1 (G1)/ Boset and genotype 4 (G4) Gimbichu was the winning genotype in all locations .This

pattern suggests that G1 and G4 being the winning genotype , it would be selected for further demonstration and promotion in teff growing areas of West Hararghe zone. However, genotype 6 (Kena) was less responsive than Gimbichu. (Figure 1).

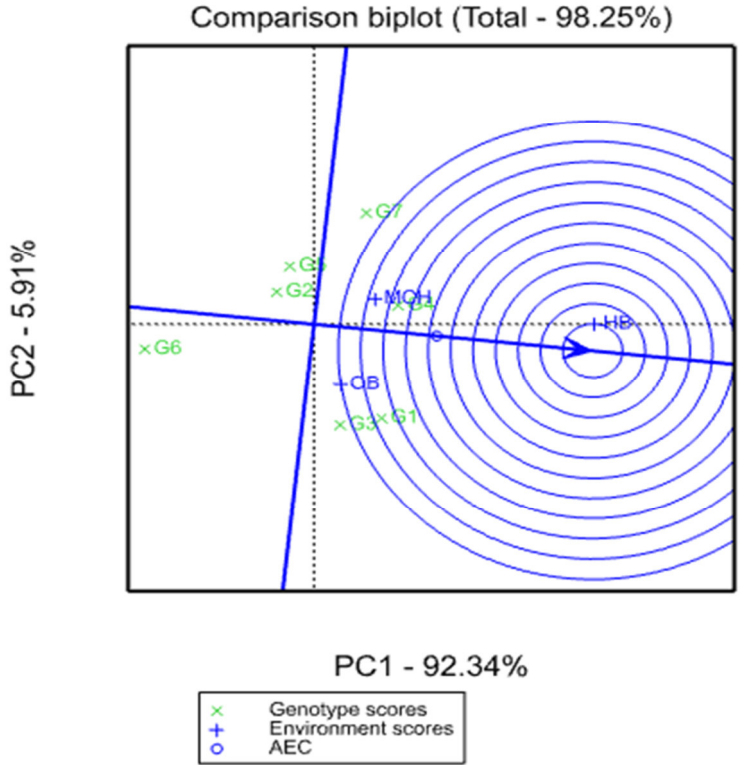

Figure 2. GGE Biplot of the relationship among three environments in grain yield of teff in West Hararghe.

HB (Habro) was best locations for genotype 1 and 4 than MCH (Mechara) and OB (Odaa Bultum). Environments were positively correlated with one another. The result clearly indicated that Gimbichu and Boset were the stable genotypes than other varieties at all locations (Figure 2).

Grain yield: The individual location result of data analysis reveals no significance difference for grain yield at (P>0.05) Table.1 for Daro Lebu and Oda bultum but at Habro there is a significance difference between treatment. Combined analysis variance for treatment means effect of location interaction was showed significance difference on grain yield kg/ha Table 2. However, in combined analysis mean effect within location for were highly significant at (P<0.001) table 2.The highest yield (1794 kg/ha) was recorded for variety **Gimbichu** lowest for Kena (1271 kg/ha)

Straw yield kg/ha: Statistical data of the result analysis o f variance show no significant difference among individual location for straw yield Table .1 and the result of combined analysis indicates variety and location interaction effect was not significant for this traits Table 2. Variety Gimbichu and Kena were showed the better 4525 kg/ha and 3327kg/ha lower straw yield respectively

Plant height: In Daro Lebu district the plant height was statistically significant at P<0.05 and not significance difference were observed in the rest location for this trait .The combined mean effect of plant height within variety and location showed highly significant difference at P<0.001 (Table 2). As a whole kora tef variety was recorded the highest plant height of (79.77cm) and Boset was recorded the lowest (66.67cm)

Panicle length:-Tef varieties were not showed a significance difference for panicle length at each location as well as combined mean effect of varieties for this trait, but there is significance within location for the measured trait in combined analysis of variance in (table 2). Kora tef variety was recorded the highest panicle length of (30.98cm) and the lowest panicle length was also recorded for Boset (25.62cm) table 2.

Days to 50% flowering:-Statistical analysis of variance for days flowering were showed significant difference at P<0.05 at Daro Lebu but at Oda bultum and Habro no significance were observed regarding individual location (table.1). The performance of varieties for days of flowering in combined analysis among varieties and within location were showed a highly significance difference at (P<0.001) in table.2 this trait. In this the longest days of flowering were recorded by kena tef variety which is (46) and the shortest day was recorded by Gimbichu (38) variety. In this case Gimbichu is considered as earliest flowering genotype & kena was considered much more days requiring genotype for days to 50% flowering as compared to all varieties tested together

Maturity date: Analysis of variance shows that the individual location data for days of maturity was not

significant difference for mean effect varieties except at Daro Lebu district table 1, but the combined mean effects of varieties & within location result were showed a highly significant difference at P<0.001 for days to maturity (table .2).The interaction of location and varieties were showed no significance. However, overall days of maturity recorded for almost all varieties were very closer to each other as this trait is a very determinant character for selection one variety/s from the other hoping that it could help in escaping short rainy seasons of the recent farmer's basic issue of straggle made to survive. As a general, the longest days of maturity in combined mean effect of varieties were recorded by Kena tef genotype which is (88) and shorter by Boset tef genotype which is (76) days to attain its full physiological maturity.

Above ground biomass: -It is another important trait for this crop as it is economically a highly demanded plant parts for many purposes including animal feed and mud house plastering services for low income earning lower level social classes at anywhere in the country. It is mostly used to measure the productive potential of the variety/s with regard to the ratio of whole above ground plant part to the ratio of economically important part that is grain. Some crop shows proportional advantage with increasing biomass and increasing grain yield. Statistical analysis of variance showed that no significant difference were observed for mean effect of varieties for biomass yield in combined analysis but within location there is a significant for this trait and of these tef varieties the highest above ground biomass of 5759 kg/ha was recorded by Gimbichu tef variety and lowest which is 4792 kg/ha by Kena tef.

4. CONCLUSION AND RECOMMENDATION

The result of the experiment showed tef varieties were showed a lower performance than their potential .Genotypes were highly affected by environments which show the selective adaptation to specific location favoring their production. The mean performance of genotype at Oda bultum and Habro are relatively good and this shows the potential area for this crop. Generally, Gimbichu and Boset were one of the best genotypes showed the highest mean grain yield .Therefore; these two varieties of tef were recommended for further evaluation on farmer's field.

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5. REFERENCE

CSA (Central Statistical Agency), 2015. Agricultural sample survey report on Area and production of major Crops (private peasant holdings, meher season 2014 / 2015; Addis Ababa Ethiopia, the FDRE statistical bulletin, Volume I.

CSA (Belg report 2016 or 2008) Report on area, production and farm management practice of belg season crops for private peasant holdings.

Crymes, A, R. 2015. The International Footprint of Teff: Resurgence of an Ancient Ethiopian Grain. A thesis presented to the Graduate School of Arts and Sciences of Washington university in partial fulfillment of the requirements for the degree of Master of Arts.

Demeke, M and Marcantonio, F., 2013. Analysis of incentives and disincentives for teff in Ethiopia. Technical notes series, FAO, Rome.

Engdawork, T., 2009. Understanding Teff: A Review of Supply and Marketing Issues .Ethiopia Commodity Exchange Authority.

FAO, 2015. Analysis of price incentives for Teff in Ethiopia. Technical notes series, MAFAP, by Assefa B. Demeke M., Lanos B, Rome.

Mahto, R.N., Karmaker, S and Haider, Z.A. (2006). Genotype x Environment interaction study in finger millet.Zonal Research Station, Darisai, Birsa Agricultural University, Barakhursi, Singhbhum (East) 832304 India.

Maqsood, M. and Ali ,S.N. (2007). Effect of environmental stress on Growth, Radiation use efficiency and yield of finger millet. *Pakistan Journal Botany*, 39(2): 463-474.

Molla F, Alemayehu A, Ketema B (2013). AMMI Analysis of Yield Performance and stability of finger millet genotype Across Different Environments. *World Journal of Agricultural Science* 9 (3): 231-237: ISSN 1817-3047.

Rashid,S, 2010.Variation in staple food prices: Causes, consequence, and policy options. Maputo, Mozambique, 25 - 26 January 2010 under the African Agricultural Marketing Project (AAMP)

Samuel, G and Sharp, K., 2008.Commercialization of Smallholder Agriculture in Selected Tef-growing Areas of Ethiopia.