academicJournals

Vol. 8(37), pp. 4573-4579, 19 September, 2013
DOI:10.5897/AJAR11.1519
ISSN 1991-637X ©2013 Academic Journals
http://www.academicjournals.org/AJAR

African Journal of Agricultural Research

Full Length Research Paper

Identification and evaluation of sorghum (*Sorghum bicolor* (I.) moench) germplasm from Eastern Kenya

Catherine W. Muui[1]*, Reuben M. Muasya[2] and Duncan T. Kirubi[1]

[1]Department of Agricultural Science and Technology, Kenyatta University, P.O. Box 43844-00100, Nairobi, Kenya.
[2]South Eastern University College (Constituent College of Nairobi), P.O. Box 170-90200, Kitui, Kenya.

Accepted 8 August, 2013

Eastern Province is a major sorghum growing zone in Kenya. There exist different composites, landraces, open pollinated and wild relatives of sorghum that are not yet known. The landraces continue to be maintained by cultural preferences and traditional practices by the farmers. Germplasm collection of landraces was done in four regions; Mbeere, Makueni, Kitui and Mutomo in the eastern province of Kenya which are major sorghum growing zones. At time of collection information on traits preferred, seed source and variety type was recorded for each accession. The seed color and name of region collected were used to identify the different landraces. Forty four different landraces were collected from different farmers in the region. Mbeere region had the most landraces available with diverse colorations a clear indication of a possibility of sorghum complex in this particular region compared to Kitui, Mutomo and Makueni. The landraces are unique in their adaptation, food quality, grain yield, quality of harvested products, biotic stress resistance and post-harvest processing. These untapped resources could be useful in crop improvement programmes and in food security. The decline in use of the landraces may erode the genetic base and prevent use of distinctive traits in crop adaptation and improvement.

Key words: Crop improvement, diversity, food security, germplasm, landraces.

INTRODUCTION

Sorghum (*Sorghum bicolor* (L.) Moench) is one of the most important cereal crops in the semi-arid tropics (SAT) (Meeske et al., 1993). Since sorghum originated in Africa, it is uniquely adapted to Africa's climate, being both drought resistant and able to withstand periods of water-logging (Kimber, 2000; Meeske et al., 1993). Eastern Province is a major sorghum growing zone in Kenya (Jaetzold et al., 2006; Meeske et al., 1993). There exists different composites, landraces, open pollinated and wild relatives of sorghum that are not yet known. The sorghum landraces continue to be maintained by cultural preferences and traditional practices by the farmers. Sorghum is one of the underutilized crop species that could play an important role in the food security, income generation and food culture of the rural poor in Kenya. There is less attention paid to sorghum production especially the popular traditional varieties grown by farmers. Their potential value is under-estimated and under-exploited. It also places them in danger of continued genetic erosion and disappearance. The decline of use of these varieties may erode the genetic base and prevent the use of distinctive useful traits in crop adaptation and improvement.

Sorghum is an important subsistence cereal crop in semi arid areas for its diverse germplasm (Menz et al., 2004), adaptation to drought (Doggett, 1988) and its

*Corresponding author. E-mail: catherinemuui@gmail.com, muuicathy2006@yahoo.com. Tel: +254710 511221, +254733 436971.

close relationship in use to maize (Kellogg, 2001; Swigonova et al., 2004). Sorghum among others is an important traditional food crop in Eastern Kenya. However, the crop has been neglected due to the perception as food for the poor (Engle and Altoveros, 2000). These species of crops seemingly regarded to be of lower potential are actually an untapped natural resource that when properly harnessed can result in a decreased rate of degradation of environment. They may lead to sustainable production systems, provide diversity in diet and supply deficient micronutrients, provide extra income for farmers, and prevent the loss of genetic diversity (Javier and Foreward, 1993).

Plant genetic resources play an important role in generating new crop varieties with the high yield potential and resistance to biotic and abiotic stresses (Sajid et al., 2008). The germplasm of most crops collected from the local sources provides greater genetic variability and can furnish useful traits to broaden the genetic base of the under-utilized crop species. FAO (1996) recognises the need to conserve indigenous species of different crops. Most indigenous food crops are threatened by rapid adoption of highly improved crop varieties many of which are introduced and poorly adapted. Together with genetic resources, indigenous knowledge associated with the cultivation, utilisation and conservation of indigenous crops is also endangered. Unless something is done to conserve and re-popularise their use, this natural resource may be lost forever. Genetic erosion occurs mainly through cross pollination of plants from same variety, different varieties and wild relatives (Johnson et al., 2004; Hall et al., 2000). The purpose of this work was to identify different sorghum landraces still kept by farmers in Kitui, Makueni, Mbeere and Mutomo districts in eastern Kenya; establish traits preferred on the landraces, where the farmers obtain seed and whether the sorghum is local or a hybrid.

MATERIALS AND METHODS

Germplasm collection was done in 2010-2011 in four districts namely; Mbeere, Makueni, Kitui and Mutomo in the eastern province of Kenya which are major sorghum growing areas. The regions range from Zone IV (Semi Humid to Semi Arid) to Zone V (Semi Arid) (Jaetzold and Schmidt, 1983) (Figure 1). The Mbeere and Kitui sites are classified as Lower Midland (LM) with some regions in transitional zone towards Upper Midland (UM). Makueni and Mutomo sites are classified as Lower Midland (LM) (Jaetzold et al., 2006). Germplasm collection was done in different agro ecological zones in the region as follows; Mbeere in LM_3, LM_4; Makueni in LM_5, LM_6; Kitui in LM_3, LM_4, LM_5; and Mutomo in LM_4, LM_5 (Jaetzold et al., 2006). A total of forty four landraces were collected from different farmers in eastern Kenya region (Table 1) and put in sample bags separately. At time of collection information on traits preferred, seed source and variety type was recorded for each accession. Traits preferred by the farmers in landraces grown were high yields, high vigor, good taste, ease in cleaning, resistance to drought, early maturing, resistance to birds and other pests. Farmers obtain planting seed either from a previous harvest, borrow from neighbors or buy from the market; do not separate seed crop from the grain crop and harvest the crop together resulting to mixed crop stands. After collection, the color of the seeds was recorded using Munsel color chart for plant tissues (Anonymous, 1972). Data was analyzed using PROC GLIMMIX model of the Statistical Analysis Systems software (SAS Institute, 2005). Parameters studied were expressed as percentages; analysis of variance was performed, and least significant differences was used for separation of means at 0.05 level of confidence.

RESULTS

Traits preferred by the farmers in landraces grown were high yields, high vigor, good taste, ease in cleaning, resistance to drought, early maturing, resistance to birds and other pests. Percentage of farmers preferring drought resistance in sorghum planted was only reported in Mbeere with 30% (Table 4). Farmers preferring resistance to other pests were only in Mbeere with 30% while none were reported in the other three regions. Kitui had the highest percentage of farmers preferring resistance to birds with 27% followed by Mbeere with 3%. Percentage of farmers preferring early maturing sorghum varieties was highest in Kitui (33%). Most varieties take two to four months to maturity with only a few taking six to twelve months. Landraces with good taste were more preferred in Mbeere with 40%. High yielding varieties were preferred in the four regions with Mutomo having the highest percentage (73%). Varieties that show early vigorous growth were preferred by 20% of the respondents in Makueni while varieties that are easy to clean were preferred by only 7% of the respondents in Kitui (Table 4).

Kitui had the highest percentage (70%) of farmers who save own seed for planting next season while Mbeere had the highest percentage of farmers buying their seed from the market. Makueni and Kitui had the highest percentage of farmers borrowing seed from neighbours. The percentage of farmers that save seed for planting next season differed significantly ($P \leq 0.05$) between Makueni (13%) which had the lowest and Kitui (70%), Mbeere (60%) and Mutomo (47%) (Table 3). There was no significant difference ($P \leq 0.05$) in the percentage of farmers who bought seed from the market between the four regions. The percentage of farmers who borrowed seed for planting was highest in Makueni (37%) and lowest in Kitui (20%) and Mutomo (20%).

The number of farmers growing sorghum landraces was higher in Mbeere, Kitui and Mutomo than in Makueni (Table 3). In Makueni, the percentage of farmers growing sorghum hybrids was higher than in all the other districts and significantly ($P \leq 0.05$) differed with the other three districts where there were no farmers growing hybrids (Table 3). The percentage of farmers growing local varieties of sorghum in Makueni (84%) was low and differed significantly ($P \leq 0.05$) with Kitui, Mbeere and Mutomo which had 100% of the farmers growing landraces (Table 3).

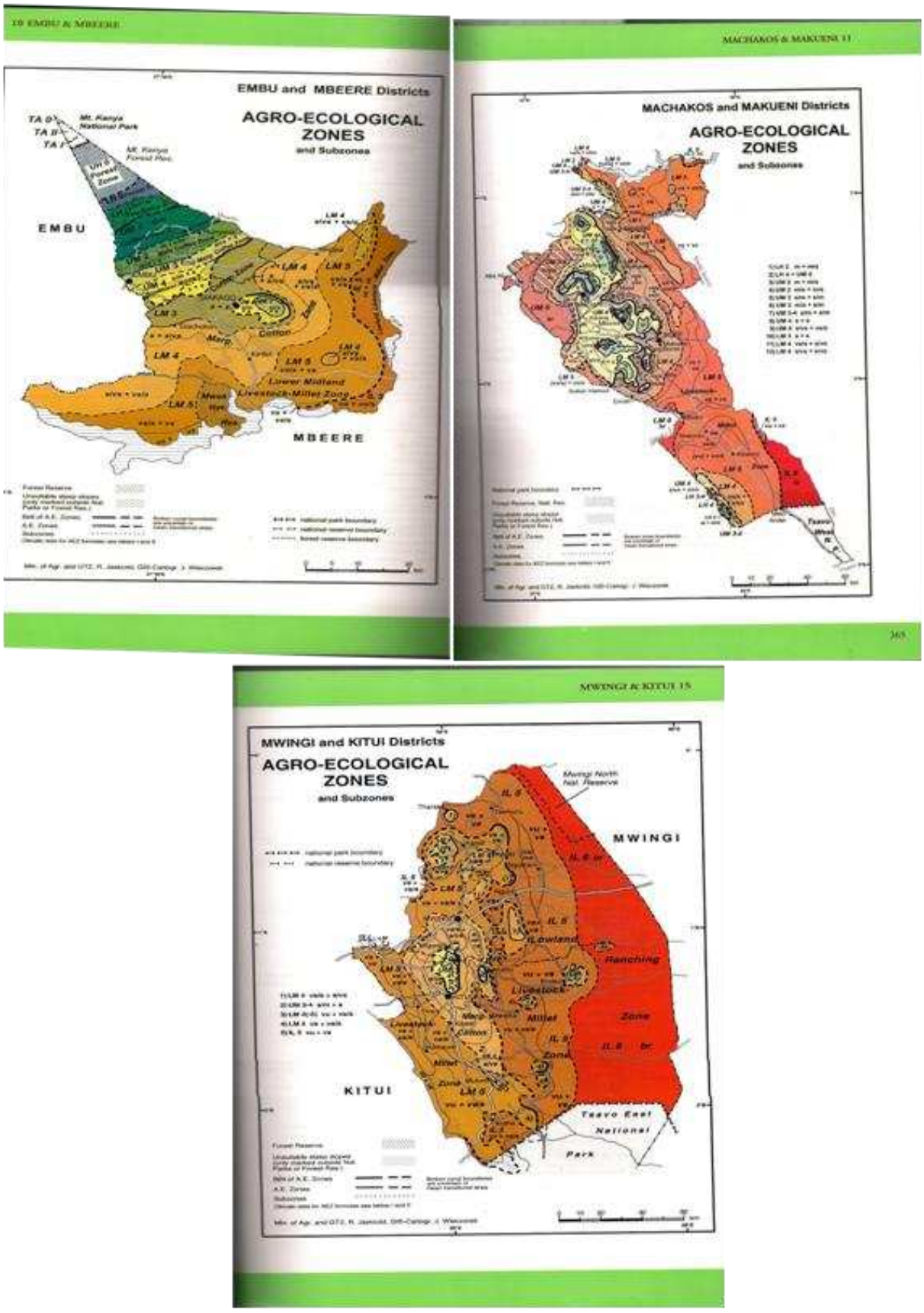


Figure 1. Agro ecological zones for Mbeere, Makueni, Kitui and Mutomo. Source: Jaetzold et al. (2006).

Table 1. Frequency occurrence based on color of different landraces collected from Kitui, Mutomo, Makueni and Mbeere districts in eastern Kenya.

Seed color	Seed color code	Kitui	Mutom	Makueni	Mbeere	Total
White	-	2	1	1	1	5
Dirty white	5RP 8/2	1	0	1	0	2
Brown white	2.5YR 7/4	0	1	0	0	5
	10R 7/4	1	0	0	0	
	7.5YR 7/4	0	0	1	0	
	2.5Y 8/4	0	0	1	0	
	5YR 6/6	1	0	0	0	
Brown	2.5YR 7/6	0	1	1	0	7
	5YR 7/4	2	0	1	0	
	5YR 6/6	1	0	0	0	
	7.5YR 8/4	0	0	1	0	
Dark brown	5YR 5/6	1	0	0	0	1
Brown red	5R 6/8;7/4	1	0	0	0	1
Red	5R 7/8	3	0	2	0	8
	2.5YR 7/8	0	0	1	0	
	5R 4/6	0	0	0	1	
	5R 5/6	0	0	0	1	
Black red	10R 3/4	0	1	0	0	1
Purple	5RP 5/2	0	1	0	1	4
	5RP 6/2	0	0	0	3	
Purple pink	5RP 5/2	0	0	0	1	4
	5RP 6/2	0	0	0	1	
	5R 6/4	0	0	0	1	
	5RP 7/2	0	0	0	1	
Cream pink	5RP 8/2	0	0	0	1	1
Pink brown	10R 6/4	0	0	0	1	2
	2.5YR 6/4	0	0	0	1	
Mixture of purple, pink, white	5R 6/2	0	0	0	1	2
	5RP 7/2	0	0	0	1	
Mixture of purple, pink, white, brown	5R 6/2;7/2	0	0	0	1	1
Total	12	4		11	17	44

The color of the landraces varied considerably between and within the germplasm (Table 1). The landraces which were white in color occurred in the four districts while dirty white (5RP 8/2) occurred only in Kitui and Makueni. Brown and brown white types were available in Kitui, Mutomo and Makueni while dark brown and brown red types occurred in Kitui only. However, the brown germplasm had four different types based on the color while brown white had five different types (Table 1). Brown red found at Kitui occurred as a mixer of two color codes (5R 6/8 and 7/4) (Table 1). The red type was present in all districts except Mutomo which had a unique black red type. The red germplasm had four different color codes. Purple, purple pink, cream pink, pink brown, mixture of purple, pink, white, and mixture of purple, pink, white, brown occurred only in Mbeere. The purple germplasm had two different color codes while purple pink germplasm had four different codes. Pink brown germplasm had two codes while the mixed germplasm with purple, pink and white had two different codes (Table

Table 2. Percentage landraces collected from Kitui, Mutomo, Makueni and Mbeere districts in eastern Kenya.

Seed color	Kitui	Mutomo	Makueni	Mbeere	Total	LSD (*P*=0.05)
White	6.8[a]	2.3[b]	2.3[b]	2.3[b]	13.6	4.0
Dirty white	0.0[a]	0.0[a]	2.3[b]	0.0[a]	2.3	1.5
Brown white	4.5[a]	2.3[b]	4.5[a]	0.0c	11.4	2.0
Brown	6.8[a]	2.3[b]	9.1[a]	0.0[b]	18.2	3.6
Dark brown	2.3[a]	0.0[b]	0.0[b]	0.0[b]	2.3	2.0
Brown red	2.3[a]	0.0[b]	0.0[b]	0.0[b]	2.3	1.7
Red	4.5[a]	0.0[b]	6.8[b]	4.5[a]	11.4	2.1
Black red	0.0[a]	2.3[a]	0.0[a]	0.0[a]	2.3	1.7
Purple	0.0[a]	0.0[a]	0.0[a]	9.1[b]	9.1	1.0
Purple pink	0.0[a]	0.0[a]	0.0[a]	9.1[b]	9.1	2.8
Cream pink	0.0[a]	0.0[a]	0.0[a]	2.3[b]	2.3	1.5
Pink brown	0.0[a]	0.0[a]	0.0[a]	4.5[b]	4.5	3.9
Mixture of purple, pink, white	0.0[a]	0.0[a]	0.0[a]	4.5[b]	4.5	2.3
Mixture of purple, pink, white, brown	0.0[a]	0.0[a]	2.3[b]	2.3	1.1	
Total	27.3	9.1	25.0	38.6	100%	

*Any two means having a common letter within a row are not significantly different at 5% level of significance according to the LSD test.

Table 3. Percentage means of farmers growing local and hybrid sorghum varieties obtained from different source in Kitui, Mbeere, Makueni and Mutomo districts of eastern Kenya

Site	Percentage of farmers				
	Varieties		Seed Source		
	Local	Hybrid	Saved	Market	Borrow
Kitui	100[a]	0[a]	70[a]	10[a]	20[a]
Mbeere	100[a]	0[a]	60[a]	10[a]	30[b]
Makueni	84[b]	16[b]	13[b]	33[a]	37[c]
Mutomo	100[a]	0[a]	47[a]	33[a]	20[a]
LSD (*P*=0.05)	15	11	28	28	5

*Any two means having a common letter within a column are not significantly different at 5% level of significance according to the LSD test.

1). Mbeere region had the highest percentage number of landraces with 38.6%, followed by Kitui with 27.3%, Makueni with 25% while Mutomo had the lowest percentage of 9.1% (Table 2). The results showed that landraces with brown color schemes were more with 18.2%, followed by white color schemes with 13.6%, brown white and red color schemes with 11.4%. Purple and purple pink had a percentage of 9.1% respectively, followed by pink brown and mixture of purple, pink, white with 4.5% and finally dirty white, dark brown, brown red, black red, cream pink and mixture of purple, pink, white, brown with 2.3% (Table 2).

DISCUSSION

Traits preferred by farmers in landraces grown were high yields, high vigor, good taste, ease in cleaning, resistance to drought, early maturing, resistance to pests and diseases as shown in Table 4. In India farmers planted sorghum varieties that were high yielding, good in quality of both grain and fodder, and resistance to biotic and abiotic stresses (Rana et al., 2000). In Mali general interest of farmers was in variety adaptation to general environmental conditions, eating quality, yield and resistance to different biotic stresses (Baidu-Forson, 1997; Sthapit et al., 1999). The quality of a variety to be used as food largely determines its acceptability by the farmers while adaptation to biotic stresses determines the survival in the field and in storage. Other studies conducted by Maundu et al. (1999), Schippers (2000) and Simiyu et al. (2003) revealed that sources of seed for most indigenous crops are obtained from local markets, farm saved or borrowed from neighbors and relatives. The role of neighbors and relatives in traditional seed systems is not new; and involves farmer-to-farmer seed

Table 4. Percentage means of preferred traits in sorghum varieties grown by farmers at Kitui, Mbeere, Makueni and Mutomo districts of eastern Kenya.

Site	Percentage of farmers								
	Drought resistance	Pest resistance	Bird resistance	Early maturity	Good taste	High yield	Vigor	Ease of cleaning	All traits
1	0^{a}	0^{a}	27^{a}	33^{a}	10^{a}	20^{a}	0^{a}	7^{a}	20^{a}
2	30^{b}	3^{b}	3^{b}	30^{a}	40^{b}	20^{a}	0^{a}	0^{b}	7^{b}
3	0^{a}	0^{a}	0^{b}	0^{b}	0c	63^{b}	20^{b}	0^{b}	0^{b}
4	0^{a}	0^{a}	0^{b}	0^{b}	7^{a}	73^{b}	0^{a}	0^{b}	20^{a}
LSD (*P*=0.05)	1	11	7	15	24	3	2	**5**	

*Any two means having a common letter within a column are not significantly different at 5% level of significance according to the LSD test. 1, Kitui site; 2, Mbeere site; 3, Makueni site; 4, Mutomo site.

exchange, seed donations and other transfer methods to meet social obligations (Cormwell et al., 1992). Cormwell (1990) reported that up to two-thirds of farmers' in Malawi obtains bean seed from neighbors, relatives and other local sources. A study by Singh (1990) in Ethiopia indicated that, most seed transactions take place between neighbors and relatives because farmers prefer to see the crop stand in a neighbors' farm before deciding on obtaining the variety.

Majority of the farmers in this region grow sorghum landraces due to the variable traits preferred by farmers except a few in Makueni who grow hybrids (Muui et al., 2011). An earlier study conducted by KFSSG (2008) showed that, only 10% of farmers use certified seed for other crops while 90% relied on locally selected seeds. The landraces are kept by farmers based on preference selection ensuring the crop diversity is maintained for decades. The landraces are unique in their adaptation, food quality, grain yield, quality of harvested products, biotic stress resistance and post-harvest processing. Most families in eastern part of Kenya grow sorghum landraces which are used for making fermented and un-fermented porridge, ugali (thick porridge) and other traditional dishes (Ministry of Agriculture, 2010).

Results presented in Table 1 show that there is a diverse sorghum germplasm in lower eastern Kenya region which is highly variable between and within accessions. The fact that Mbeere district had the most landraces available with diverse colorations is a clear indication of a possibility of early existence of sorghum–wild–weed complex in this particular region compared to Kitui, Mutomo and Makueni. In earlier studies, wild sorghums with diverse morpho-types have been reported in many of the sorghum growing regions of Africa, often as indistinct races of *S. bicolor* that form a crop–wild–weed complex (Ejeta and Grenier, 2005; de Wet, 1978). The variation in coloration within accessions indicated mixtures of materials planted by the farmers. A study conducted by Muui et al. (2011), indicated that farmers obtain planting seed either from a previous harvest, borrow from neighbors or buy from the market; do not separate seed crop from the grain crop and harvest the crop together resulting in mixed crop stands.

The sorghum germplasm identified in the lower eastern Kenya is an untapped resource which is useful in crop improvement programmes and in food security. The region contains a rich diversity of sorghum as shown in Table 1. The germplasm of most crops collected from the region provides greater genetic variability and can furnish useful traits to broaden the genetic base of the under-utilized crop species. FAO (1996) recognises the need to conserve indigenous species of different crops. Most indigenous food crops are threatened by rapid adoption of highly improved crop varieties many of which are introduced and poorly adapted. Together with genetic resources, indigenous knowledge associated with the cultivation, utilisation and conservation of indigenous crops is also endangered. Unless something is done to conserve and re-popularise their use, this natural resource may be lost forever.

Conclusion

From this study, it's clear that farmers in eastern region of Kenya maintain a diversity of sorghum landraces by cultural preferences and traditional practices. Farmers maintain landraces that are unique in their adaptation, food quality, grain yield, quality of harvested products, biotic stress resistance and in post-harvest processing. The rich germplasm could be exploited for use in crop improvement programs. And since the region has a high agricultural potential, productivity for better food security could be improved by use of locally available germplasm adapted to this particular environment.

ACKNOWLEDGEMENT

We acknowledge farmers from eastern Kenya region for willing to share with us germplasm and information; and the Ministry of Agriculture office in Embu for allowing us access to the region. This study was funded by the National Council of Science and Technology (NCST),

Kenya.

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