Farmer Assessment, Conservation and Utilization of Endangered Sorghum Landraces in the Upper West Region of Ghana

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Abstract

Grain sorghum (*Sorghum bicolor* (L.) Moench) is an important staple food crop in the savanna zone of Ghana. Surveys to determine farmers' perception, crop management strategies and variety maintenance of neglected sorghum landraces were conducted in the Upper West Region of Ghana in 2004. Fifty-nine samples of the neglected landraces were collected from farmers and screened in an observation nursery in 2005 and 2006. Local landraces cultivated by subsistence farmers were 3–4.5 m tall and required 90–180 days to mature. Farmers classified them into three maturity groups: early medium and late-maturing varieties. Early maturing landraces were found in drier northwestern areas of the region and took about 90–115 days to mature. The intermediate ones matured in about 120–135 days. The late maturing landraces were found in the wetter south and are typically more than 4 m tall, requiring 140–180 days to mature. Most of the neglected sorghum landraces are either late maturing, have low yield potential, or are no longer adapted to the climatic and environmental conditions of the Region. The study showed a possible duplication among the landraces collected. Farmer preference criteria for local sorghum are based largely on food quality (overall ability to give good *tuo*), stable grain yield, brewing quality, earliness, grain quality and drought tolerance. Further improvement of sorghum must take these selection criteria and differences into account. It is clear that indigenous sorghum genetic material is being eroded and, therefore, measures must be taken to conserve existing landraces.

Introduction

Sorghum (*Sorghum bicolor* (L.) Moench) is an important staple food crop commonly grown by resource-poor farmers in the semi-arid tropics. In Ghana, it is largely grown as a rainfed crop by subsistence farmers in the northern savanna zones. Sorghum is a very versatile crop and its ability to perform in areas, where both rainfall and other conditions have proved hostile to other cereals, makes it an extremely important commodity in providing food for many people in northern Ghana.

Farmers mostly grow local landraces with loose, open panicles, which are chosen for their grain and stalk qualities, adaptation to low soil fertility and, most importantly, to match the length of the growing season. For a long time, farmers have continued to select sorghum based on desirability for human consumption and adaptation to their environments (Mann *et al*., 1983). Some indigenous landraces which were once widely cultivated are now grown only in some restricted areas. Landraces currently abandoned by farmers were once more popular and today neglected by users'

groups for a variety of agronomic, genetic, economic, social and cultural factors. Most of the landraces are an integral part of social, cultural and religious events of the people of the savanna zone. There is, however, very little knowledge about these neglected landraces, their potential for improvement and why and how they have been maintained.

The Northern Savanna Biodiversity Conservation Project (NSBCP), realizing the importance of agro-biodiversity conservation, and its importance in ensuring food security and developing a sustainable agriculture, initiated a programme with subsistence farmers in northern Ghana to create awareness about the rapid loss of useful local sorghum landraces and the concept of conservation of agro-biodiversity. Harlan (1972) best described the need for collection and preservation of germplasm as "Erosion of some of the most vital resources for human survival goes on with no notice from the public and very little attention from the scientific community, which should be better informed. The germplasm required for improvement of the basic food crops that feed the world are being rapidly destroyed. This destruction of genetic resources is caused primarily by the very success of modern plant breeding programs."

Thus, there is the need to promote the conservation and use of local sorghum landraces in order to contribute to achieving food security. The objective of the study was to document available indigenous knowledge on sorghum landraces that had previously been used by the local people and which, in the course of time, are gradually being neglected, with a view to using such knowledge to complement participatory selection and conservation of the landraces *in situ* and *ex situ*. The study also investigated farmers' existing production practices and perception of neglected sorghum landraces, as well as farmers' preferences and criteria for selection of the landraces to meet different needs.

Materials and methods

The study area

Sorghum is largely grown in northern Ghana which comprises Northern, Upper West and Upper East regions. Northern Ghana occupies about 40% of the total area of Ghana (239,000 km^2). The Upper West Region covers an area of 18,480 km^2, representing about 8% of the total land area of Ghana and is located in the north-western corner of Ghana, stretching from 9^O 35' N to 11^O N and from 01^O 25' E to 02^O 50' E (Fig. 1). The area falls within the Guinea savanna vegetation zone with Sudan savanna characteristics towards the extreme north-western fringes. The topography is generally flat with altitudes varying from 200 m above sea level along the Black Volta to 350 m for the ridge that stretches from Wa in the south to the Burkina Faso border in the north.

Temperatures are generally high, between 26 and 30 ^{o}C with little variation throughout the year. Rainfall pattern is characterized by a short, single peak rainy season from April to September, followed by a long dry season. The total annual rainfall and the rainfall distribution are highly variable, and crop production is, to a great extent, dominated by small-scale or resource poor farmers. The annual rainfall increases from north to south, with a long term average of 1100 mm for Wa. Soils in the study area vary from those with shallow sandy loam,

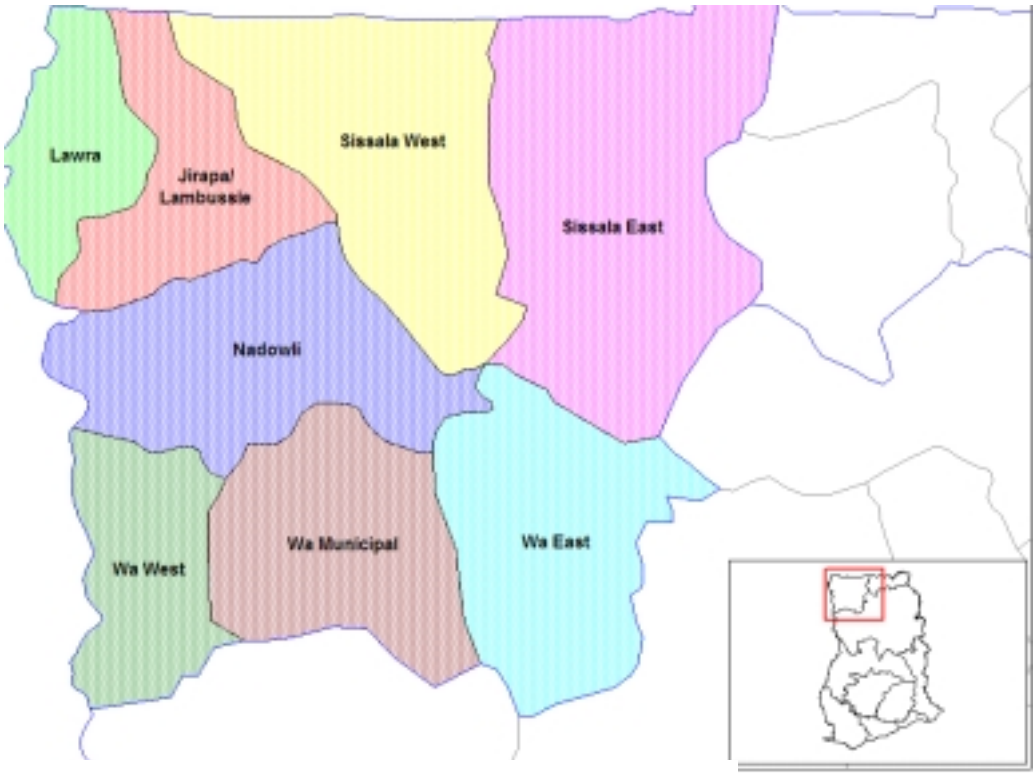

Fig.1. Map of the Upper West Region showing the various districts

having medium and course quartz stones and iron-pan boulders on the surface (Dystric Leptosol), to those having deep, poorly drained alluvial clays (Vertic Cambisol) in valley bottoms. The texture of the soils is mainly loamy sand and sandy loam.

Inventory survey and observation nursery

The study was carried out in two phases. Phase 1: Surveys on neglected landraces were conducted in 2004 in four (Wa municipal, Sissala, Lawra and Jirapa/ Lambussie districts) out of the then five administrative districts in the Upper West region, using focused group discussions, matrix ranking and individual interviews. Different participatory rural appraisal (PRA) tools were used as was deemed appropriate. The Region now has nine administrative districts with the Wa municipal being split into three. Sissala and Jirapa/Lambussie have been split into two each. The districts and the communities within the districts were selected on the basis of the importance of sorghum and for their range of agro-ecological and socio-economic conditions, ethnic and cultural multiplicity. Additionally, the research team was guided by some prior knowledge of the distribution of sorghum diversity in those districts and communities. Surveys were not carried out in the Nadowli

District because it has agro-ecological and socio-economic conditions similar to Wa municipality.

The random sampling procedure was used to select 120 farmers, 30 from each of the four districts. The selection was made from a compilation of farmers who were believed to possess more indigenous knowledge about sorghum. This criterion was met with the help of field extension workers and the village chiefs who were more familiar with farmers in the study sites. The farmer sample consisted of 97% males and 3% females with age range of 33-75 years. The mean age of farmers, who were still growing the neglected landraces on less than 0.4 ha per variety was 57 years. Information about the landraces that had previously been used by the local people and which, in the course of time, are gradually being neglected were collected randomly through individual, household and group interviews, with some of the interviews conducted on the field. In addition, information on source of varieties, names and their meanings, current status and any possible threats was obtained from the farmers.

Farmers were individually interviewed on the indigenous sorghum varieties they grew and on the functions of these varieties within their local household food security system. Where possible, small quantities of seed samples of the neglected landraces were obtained from farmers in areas where they were still grown. The participatory inventory exercise in the Region helped to identify 59 landraces that are gradually being neglected in the Region. Through farmer networks, local farmers who still had seed of the neglected landraces were encouraged and supported financially by NSBCP to continue *in situ* conservation of the indigenous varieties. The farmers were to increase the seed of the indigenous varieties so as to provide a source of seed for local communities. This "conservation through use" approach is particularly refreshing and a much needed innovation.

Phase 2: Participatory variety selection was applied to select diversified sorghum landraces that possess farmer-preferred plant and grain traits. Thus, the 59 landraces, which were collected from farmers, were sown during the 2005 and 2006 cropping seasons in an observation nursery, established in the NSBCP garden at Poyentanga near Wa (10^{O} 04' N latitude; 02^{O} 30' W longitude; about 323 m altitude). The objective was to evaluate the agronomic performance and morphological diversity of the collected landraces and also get a feedback on what quality criteria farmers use for selecting sorghum varieties. In addition, the nursery was to give other farmers access to the diversity of sorghum landraces present in the Region, train farmers in seed selection and management techniques, and teach principles to help them maintain the characteristics of landraces they valued. These interventions were available to anybody who wanted to participate, and open invitations and publicity encouraged farmers to participate.

During each cropping season, visits were made at various stages of plant growth to fields of the farmers who were supported financially by NSBCP to continue *in situ* conservation of the landraces. This was to observe farmers' production practices, as well as growth and development of the landraces under real farm situation. Observations revealed the presence of off-types and poor-quality grain of non-uniform size for most of the landraces. This showed

that current storage and seed selection practices were not meeting farmers' needs, and that training would play an important role in modifying farmers' current practices. Thus, the training offered in the garden was based on understanding farmers' knowledge about issues of storage and seed selection, and trying to provide general principles that farmers themselves could use.

Three training sessions were offered in the garden, starting with a discussion of farmers' knowledge about sorghum reproduction and perceptions of sorghum improvement. Additional sessions taught basic principles of sorghum reproduction, principles of seed selection in the field and in the household, including hands-on exercises in the field, and principles and techniques for storing seed and grain. The training activities showed that participating farmers often did not understand certain aspects of sorghum reproduction, but, once this knowledge was provided, at least some of them were keen to try new management techniques.

Each landrace was planted on three-row plots of 10 m in length. Rows were spaced 0.75 m apart, and interplant spacings were 0.20, 0.25 and 0.30 m for early, medium and late-maturing varieties, respectively. Planting was done on 25th June and 17th July in 2005 and 2006, respectively. No insecticide or mineral fertilizer was applied, but moderate amount of manure (3.0 t/ha) was applied in 2006 only. The observation nursery was managed by both the research team and farmers. The performance of the landraces in the nursery was judged both visually and quantitatively by a group of farmers including the NSBCP-supported farmers. The farmers themselves made the final judgment and ranking of landraces. A field day was held when the plants reached physiological maturity.

Farmers were invited to see the landraces and to "vote" for the ones they liked. The farmers walked through the trial and recorded the numbers of all of the plots containing the landraces they liked. Farmers were also asked to give their quality criteria for a maximum of 10 varieties, through pair-wise comparisons of landraces, explaining which criteria contributed to the preference for a given landrace. The pair-wise comparison enabled farmers' criteria for making preferences to be obtained. These preference criteria reflected farmers' priorities with regard to objectives of production, crop management, processing, consumption and marketing. Organoleptic qualities of the landraces were obtained from farmers who grew and utilized the landraces. Basically, descriptive statistics were used to summarize the data collected, and these formed the basis of the results of this study.

Results and discussion

Genetic diversity of sorghum in the region

In northern Ghana, subsistence farmers generally place a high premium on their landraces because of the specific and distinct roles these landraces play in socio-cultural, economic and religious aspects of their lives. Javis *et al.* (2004) observed that many of the crop varieties maintained and used by farmers (largely local) meet several different needs of small farmers and represent a valuable resource for farmers and mankind, in general. Nevertheless, some of the landraces are steadily being neglected in the region.

Fifty-nine neglected sorghum landraces, consisting of 19 early, 20 intermediate and 20 late-maturing varieties, based on farmers'

names and not on any genetic or molecular characterization, were obtained from farmers in four districts in the region after the harvest in March 2004 (Tables 1–3). Although the collection of local landraces encompassed many different sorghum types, farmers actually planted only a mean of two varieties per household, indicating that farmers wanted access to more than one sorghum variety. Farmers mostly planted one neglected landrace on a limited scale alongside other sorghum varieties from which they can obtain higher yields. This is because the neglected landraces are perceived to have low yield potential.

Some of the local sorghum landraces are common to several ethnic groups. The naming of the endangered landraces was mainly based on their maturity period, grain colour or their use. It was evident that similar cultivars had different names due to differences in ethnicity and locality. Thus, there were duplications within the collections made. Additionally, a high variation for seed colour existed in the collection probably because of human selection. Names like *Kapiela* (white sorghum) and *Kazie* (red sorghum) described the grain colour. *Konton-nii* describes dwarf sorghum whereas *Nyonso* describes a sorghum landrace with high water requiremnets. Moreover, it was evident that farmers sometimes used collective names for sorghum landraces.

On average, the diversity of sorghum increased along a south-north gradient and was related to the importance of sorghum in the staple diet. The higher varietal diversity in the drier north-western fridges of the region (i.e. Lawra District) could be explained by the higher suitability of the area for sorghum production compared to maize, the farmers' preference for sorghum compared to other cereals, and the fact that the area under sorghum cultivation was larger in that area. In the absence of truly drought tolerant maize varieties, farmers in drier areas prefer to plant more sorghum than maize, as the former is perceived to have better tolerance to drought. The local landraces commonly grown by subsistence farmers in the region are 3–4.5 m tall and require 90–180 days to mature. The landraces could be grouped according to three maturity periods; early, intermediate and late varieties. Early maturing cultivars require 90–115 days to reach maturity. The intermediate maturing landraces have a maturity classification of 120–135 days. The late maturing photosensitive ones are typically tall (more than 4 m tall), requiring 140–180 days to mature and flowered towards the end of the rains.

Farmers generally planted landraces suited to the existing rainfall pattern in their localities. As presented in Table 1, short-season landraces were mostly found in the more arid and degraded north-western parts of the region (i.e. Lawra District). This could be an opportunity for the promotion of early-maturing sorghum varieties in that area. However, given farmers' low preference for early-maturing high yielding improved varieties like *Naga White, Framida, Kapaala and Dorado* because of grain quality problems and high fertility requirement, earliness alone cannot be sufficient for selecting suitable sorghum varieties for extension in the area. *Dorado and Kapaala* have semi-compact panicle and are prune to head bugs attack, which predisposes the grain to mould infection,

TABLE 1
Early maturing indigenous sorghum varieties planted at Poyentanga in 2004 and 2005

Accession number	*Local name*	*Community*	*District/Municipal*	*Plant height (m)*
ES1	Dawel-kale	Bekyinteng	Lawra	2.64
ES2	Zikedire	Bekyinteng	Lawra	2.79
ES3	Dire-ber	Bekyinteng	Lawra	3.16
ES4	Zele	Kokoligu	Lawra	2.25
ES5	Dawelle	Zambo-Hayieu	Lawra	2.53
ES6	Alozious	Betaglu	Lawra	3.03
ES7	Beluru (cream)	Tempelle	Lawra	2.87
ES8	Nyinguo	Brifoh-Naayir	Lawra	2.63
ES9	Dawelle	Billaw	Jirapa/Lambussie	2.92
ES10	Dawelle	Nyago	Jirapa/Lambussie	2.75
ES11	Kadaga	Taffiasi	Sissala	2.67
ES12	Kadaa Kufeng	Chinchang	Sissala	2.72
ES13	Kadaa Kufeng	Chinchang	Sissala	2.80
ES14	Kadaa fermu	Sorbelle	Sissala	2.65
ES15	Kadaa fermu	Sorbelle	Sissala	2.79
ES16	Dawele-zie	Liero	Sissala	2.50
ES17	Kapiela	Jambusi	Wa	2.75
ES18	Cheri	Jambusi	Wa	2.74
ES19	Chekpuri	Jambusi	Wa	2.80

TABLE 2
Medium maturing indigenous sorghum varieties planted at Poyentanga in 2004 and 2005

Accession number	*Local name*	*Community*	*District/Municipal*	*Plant height (m)*
MS1	Gyibaraa	Yagha	Jirapa/Lambussie	3.08
MS2	Balur	Zambo/Badi	Lawra	2.74
MS3	Beluru (red)	Tempelle	Lawra	2.74
MS4	Kaza Kpulekpule	Jambusi	Wa	3.18
MS5	Gberre	Jambusi	Wa	3.03
MS6	Nyonso	Pulima	Sissala	3.33
MS7	Nyonso	Djimanjan	Sissala	3.17
MS8	Nyonso	Tarsor	Sissala	3.38
MS9	Nyonso	Taffiasi	Sissala	3.05
MS10	Cheteh	Nanchala	Sissala	2.54
MS11	Zele	Gaapari	Sissala	2.87
MS12	Zelfieme	Nimoro	Sissala	3.15
MS13	Kpalfieme	Lilixsie	Sissala	3.19
MS14	Delfieme	Borsubelle	Sissala	2.92
MS15	Gbaffullo	Nanchala	Sissala	3.14
MS16	Kadaa pula	Sorbelle	Sissala	3.35
MS17	Kadaa pula	Sorbelle	Sissala	2.91
MS18	Kadaa pula	Sorbelle	Sissala	3.35
MS19	Konton-nii	Bujan	Sissala	2.20
MS20	Mifiame	Bujan	Sissala	3.23

TABLE 3
Late maturing indigenous sorghum varieties planted at Poyentanga in 2004 and 2005

Accession number	*Local name*	*Community*	*District/Municipal*	*Plant height (m)*
LS1	Ollu-bile	Sagu	Wa	3.25
LS2	Ollu-bile	Sagu	Wa	3.54
LS3	Kazu	Jambusi	Wa	3.05
LS4	Kabile	Paase	Wa	2.75
LS5	Kazie	Paase	Wa	2.96
LS6	Kazie	Jambusi	Wa	2.87
LS7	Donboro Oluu	Charia	Wa	3.43
LS8	Donbora	Paase	Wa	3.15
LS9	Pogkuori latuori	Sagu	Wa	3.17
LS10	Murapai	Biakanayiri	Wa	2.96
LS11	Dafaalo	Chaggu	Wa	3.11
LS12	Cheteh	Nankpawie	Sissala	2.95
LS13	Mempeh	Tarsor	Sissala	2.88
LS14	Mempeh	Gowi/Jeffisi	Sissala	3.12
LS15	Mempeh	Lilixsie	Sissala	3.17
LS16	Cheteri	Dimanjan	Sissala	2.95
LS17	Pogkuori latuori	Tampaala	Jirapa/Lambussie	3.06
LS18	Gber	Gyengvuuri	Jirapa/lambussie	3.16
LS19	Latour	Gyengvuuri	Jirapa/lambussie	3.05
LS20	Kunkyebile	Kuncheni	Jirapa/Lambussie	2.44

thereby, reducing the quality of the harvested grains. These two varieties are also susceptible to bird damage.

Intermediate and long duration neglected landraces dominated the collections made in the region (Tables 2 and 3). The late maturing ones are not suitable for production in the drier areas of the region. They are mostly grown in the wetter southern parts, especially in Wa municipality at the beginning of the rainy season (late May to early June) when conditions are favourable, especially moisture. This period also ensures that the crop is ahead of shootfly development, which damages sorghum seedlings. Additionally, the long duration sorghum landraces flower towards the end of the rains, thereby, helping the grains escape fungi and sucking bugs, which are prevalent while the rains persist but disappear during the months that follow.

Most (76%) project participating farmers often matched sorghum varieties with soil types. Landraces that require fertile soils to perform well are planted either closest to homesteads where a lot of mineral and organic amendments are applied on other fields considered fertile.

The present farming practices are based on indigenious knowledge inherited from generation to generation, and these practices, along with the seed, are gradually disappearing. Several farmers (74%) were uncertain about the origin of the local varieties. According to the farmers, the landraces have been reverently handed down from generation to generation.

Main purpose of sorghum cultivation

The endangered landraces are mainly grown for both home consumption and the

market. However, majority (92%) of the farmers cultivated the landraces on a small scale for home consumption only, and less than 1% of the respondents cultivate them for the market only (Table 4). About 8% of the farmers, however, produce the neglected landraces mainly for household subsistence and only sell relatively smaller quantities as sorghum required a longer cooking time and had much firmer texture than rice. Sorghum stems can also be chewed, especially the juicy, sweet stem variety (*kakanuo*). The rusty-coloured leaf sheaths provide pigment (dye) that is traditionally used to colour food. Cooked rice and beans (*wakye*) gets its brilliant red hues this way.

TABLE 4
Frequencies of main purpose for growing local sorghum varieties

Purpose for growing sorghum	*Frequency (n = 120)*	*Percent*
Mainly for food	110	91.7
Mainly for cash	1	0.8
For both food and cash	9	7.5
Total	120	100.0

Source: Field survey data, January 2005.

the last resort in times of dire need. Sorghum grain is used primarily in the home to prepare local foods such as thick porridge (*tuo*) and thin porridge (*koko*) and any other dietary functions. White-grained sorghum generally is preferred for food because they give the desired colour while red and brown grains are preferred for brewing a local beer called *pito* (Demuyakor & Ohta, 1991). In the wetter southern parts of the region, maize is relatively more important for home consumption than sorghum. Sorghum is, however, an important cash and food security crop in the extreme north-western fringes of the region, where it is used in most traditional festivities.

Grain of the neglected landrace g*baffulo* is boiled and eaten like rice in the Sisaala District. Similarly, sorghum is substituted for rice in many areas (Murty & Kumar, 1995). The distinct grains separate easily when properly cooked. Farmers revealed that

Maintenance of biodiversity

In the survey, majority of sorghum farmers in the region were no longer cultivating the neglected sorghum varieties on a large scale. Among the farmers interviewed, very few (about 10%) still grow the endangered sorghum varieties in very small plots annually. Farmers said they cultivated the neglected landraces less than in the past because they are no longer competitive with improved varieties that have come to dominate the world food supply and that are supported by seed supply systems, production and post-harvest technologies and extension services. The indications are that indigenous sorghum genetic material is being eroded and measures must, therefore, be taken to conserve existing landraces.

Main reasons cited by the farmers for increasingly neglecting the sorghum landraces included low productivity (56%),

moisture stress (27%), varietal growth characteristics (10%) and poor soils (Table 5). Majority (94%) of the farmers perceive that declining soil fertility, coupled with unpredictable climatic conditions, makes the cultivation of long duration varieties very risky. Under such circumstances only early maturing crop varieties can be grown. Such a situation could gradually lead to a loss in biodiversity. Farmers' perception about diminishing rainfall may be due to the distribution of rainfall rather than the total amount of rainfall received. Soils in the region have a sandy texture and poor soil organic matter and, therefore, low moisture retention capacity. Moreover, mean annual rainfall in the region is normally sufficient for sorghum production despite intermittent drought in some years. National sorghum yield is low; in the Upper West Region, it is estimated at 0.92 t/ha (SRID, 2007) although yields of about 3.0–4.0 t/ha are achievable for improved sorghum varieties.

Table 5
Main reasons for loss of indigenous sorghum varieties

Reasons for loss	*Percent*
Low productivity	56.0
Varietal growth characteristics	10.0
Moisture stress	27.0
Poor soils	5.0
Food quality problems	2.0
Total number of farmers	120

Source: Field survey data, January 2005

For 89% of the farmers, the advent of high yielding, early-maturing maize and sorghum varieties may result in the underutilization of local late-maturing landraces and, or those with low yield potential. Sixty-four per cent of farmers perceived their soils were of adequate fertility for sorghum production, hence, they do not use any fertilizers in the production of local sorghum. Again, farmers were very clear in their perception that local sorghum cultivars are not responsive to fertilizer additions and would produce some grain even without fertilizer additions. Even then, because of scarcity and high cost, most smallholder farmers in northern Ghana rarely use inorganic fertilizers on food crops including sorghum. Subsistence farming in the country is, thus, characterized by low external input, low crop yield, food insecurity, nutrient mining and environmental degradation (Rhodes, 1995).

The study revealed that despite the low yield potential of the neglected landraces compared to improved early-maturing varieties of sorghum and maize, conscious efforts are still made by some few farmers to grow them annually in very small plots, in an attempt to maintain biodiversity probably because of the socio-cultural and nutritional roles the indigenous landraces play in their communities. The landraces are also passed on from generation to generation.

Sorghum seed selection practices

Sorghum is grown from seeds. The initial sources of seed for planting included on-farm seed selection, use of planting material saved from previous crop harvest and, to a lesser extent, through loans and exchanges among farmers. Most (96%) farmers had never bought seed and, therefore, used their own seed saved from previous crop harvest. Other sources of seed were neighbours, relatives and friends. Similar seed selection procedures have been reported in northern Ghana (Jatoe *et al.*, 2005) and Malawi

(Nkongolo *et al.*, 2008). Because these neglected landraces are grown on limited scale, their seed are rarely found in the market.

Farmers control seed quality by sorting and selecting at physiological maturity. This method is cheap and relies on indigenous knowledge of seed production, quality control and processing. Farmers base their seed selection creteria on the panicle size, grain size, maturity and grain health. Farmers mostly selected well-matured, good looking bigger panicles that are free from disease but have clean seeds that looked exactly like what they had planted. Majority of the farmers (86%) selected seed of the neglected landraces based on multiple criteria during harvesting. Seed selection is mostly done by men (82%) and, in some cases, both men and women did the selection (15%). Very few women (2%) selected seed alone for planting.

The panicles are mostly selected at harvest and tied together, kept in a safe place and preserved from weevil attack. Often, selected panicles are stored separately from the rest of the plant and threshed as and when seed is needed. Most farmers (72%) hang the selected panicles from the roofs of storage barns, made from grass or mud, in the open or close to the kitchen smoke so that the soot preserves the seed from pest attack, and also to maintain the seed viability. Other farmers, mostly men, threshed the panicles and stored the seed in polythene or nylon bags. Several farmers (87%) do not treat their seed with any chemicals in storage. Other farmers (12%) treat seed with either ash or herbs. Majority of the respondents (97%) claimed they acquired the techniques for seed selection from their ancestors.

Assessment of the local landraces in the observation nursery

Farmers in the region valued many characteristics in their sorghum landraces, especially characteristics related to consumption. The field day, which showed the diversity of sorghum collected in the region, drew much attention and participation from farmers, and the selection exercise suggested that there was no best variety as no single landrace had all the characteristics farmers desired. Instead, farmers seemed to want a range of varieties (i.e. a range of diversity). Farmers' preference criteria for local landraces were based on food quality, stable grain yield, earliness, brewing qualities, drought tolerance and grain quality (Table 6). Likewise, Jatoe *et al*. (2005) reported that farmers in north-western Ghana considered their varieties better than improved varieties with regard to taste, suitability for their local food and resistance to drought, pests and diseases.

Organoleptic quality (food quality) was the most frequently indicated preference criteria by both men and women followed by productivity and earliness. This implied that most farmers in the region considered the capacity of the sorghum to give good quality *tuo* an important characteristic, and, perhaps, more so than any other criterion. The keeping quality, processing characteristics and taste of *tuo, koko* and the traditional sorghum-based foods are paramount; more important than the absolute level of yield. The keeping quality of *tuo* is of major importance because the *tuo* is stored overnight, reheated and consumed. For example, Naga White, a high yielding, early maturing improved variety has been rejected by farmers because its grain with soft

TABLE 6
Varietal preferences criteria for local sorghum varieties (percentage of farmers interviewed)

Preference criteria	*Early varieties*	*Medium - Late varieties*
Organoleptic quality	81.7	76.7
Productivity (yield)	70.8	65.0
Early maturity	60.0	54.2
Suitability for brewing	49.2	52.5
Drought tolerance	47.5	39.2
Good grain quality	29.2	25.0
Adaptation to poor soils	16.7	15.1
Pest resistance	13.3	10.8
Resistant to lodging	6.7	5.1

endosperm texture produces *tuo* with a sticky, less firm texture that deteriorates rapidly during storage (i.e. the starch gel collapsed overnight). Farmer participation in the breeding of crop varieties for low-resource farmers is regarded by some as necessary to help ensure acceptance and eventual adoption (Gyawali *et al.,* 2007; Mekbib, 2006).

White-grained sorghum is preferred for food, but they are mostly subject to bird damage in the field because they lack the bitter taste of pigmented sorghum. The bitter taste acts to repel birds. Among non-Moslem women, it seemed productivity was not as important as the suitability of the variety for brewing native beer or *pito* which has become a small-scale commercial enterprise in Ghana (Demuyakor & Ohta, 1991). All farmers agreed that the preferred attributes of brown sorghum landraces were suitability for brewing and resistance to bird damage. The dark brown grains with high diastatic power (high level of amylase activity) are considered best for brewing and impart a dark colour to the *pito* which is desirable (Demuyakor & Ohta, 1993). Red or brown grains (e.g. *Kadaga*) may be relatively high in tannin, but high-tannin types are used frequently for food where bird pressure is high. People using high-tannin grain for food may have learnt how to detoxify the negative dietary effects of tannin.

Cultivar preferences were area-specific with farmers in more productive and wetter southern parts of the region showing high preference for tall, late-maturing varieties, while those in the more arid and degraded northern parts of the region preferred drought tolerance ahead of high yield, suggesting that they are prepared to trade off high yielding variety for a drought tolerant cultivar. Productivity in terms of stable grain yields per unit area (i.e. ability to produce some grain even in bad years) and earliness were particularly more important to farmers in the more arid parts of the region. Farmers reported that early varieties helped to bridge the hunger gap. Farmers' preference for early maturing varieties was consistent with previous reports that farmers would prefer these cultivars because they can escape late season drought, provide food when stores become depleted and command higher market price when sold (Banziger & de Meyer, 2002).

Given the less favourable conditions of the drier parts of the region, 84% of the farmers particularly cited characteristics related to agro-ecological conditions, especially yield stability over the years and under different soil conditions and drought resistance as their preference criteria. Maximum yield is usually not the primary requirements for the subsistence farmers who deal with a variable environment and have multiple production objectives that will affect their choice of crops and selection of genotypes. Furthermore, sorghum farmers in Zimbabwe do not perceive yield as an important selection criterion (Van Oosterhout, 1993). Likewise, de Groote *et al*. (2000) reported that farmers in eastern Kenya preferred early maturity maize ahead of yield, followed by yield related traits, namely cob size, grain size and drought tolerance. However, Lando & Mak (1994) found that rice farmers cited yields as the most frequent reason to plant a variety.

In the wetter parts of the region where the tall, late-maturing varieties represented the majority, factors cited by majority (77%) of the farmers to explain their preferences were good grain and *tuo* quality, good brewing qualities, strong stalks and less disease and insect susceptibility. Lateness in itself did not appear to be an important criterion to the farmers, but the characteristics they were looking for were often, but not always, found in the late maturing landraces. Taller stalks are preferred over shorter types as tall sorghum stalks are resources vital for fencing, thatching and firewood.

Head smut and midge were the only disease that farmers identified in the observation nursery and on their farms. The late-maturing landraces were highly susceptible to midge damage in the nursery. However, the late maturing landrace, *Pogkuori latuori*, owes its resistance to midge to its closed, tight glumes. Consequently, farmers observed that this attribute makes the threshing of its panicles difficult. In general, a series of flowerings (as a result of planting sorghum of different growth cycles close to each other) results in midge build-up, which was observed in the sorghum nursery. Timing the planting of sorghum so that flowering occurs simultaneously is important to minimize midge damage. Other pests that attack sorghum in the field and mentioned by farmers included birds especially on white grain sorghum, Striga (*Striga hermonthica)*, stem borer, cutworm, grubs, aphids and weevils, green grasshoppers and termites. Farmers have, perhaps, developed management strategies for dealing with some of these problems.

Labour and gender roles

Farmers relied mainly on manual methods of labour for sorghum cultivation supplied mostly by family labour. Nonetheless, a combination of family, hired and communal labour was mostly adopted for sorghum production. Hired and communal labour was commonly used for land preparation while family labour was used for planting, weeding and harvesting. The study showed that both men and women were involved in sorghum production in the region. Women helped in planting, weeding, harvesting, threshing, carting, cooking and dominated the marketing activities of the crop. Women often thresh and winnow sorghum, while making of hoe handles and construction of storage sheds are activities solely for men. Gender division of labor is not only related to the work done

by men and women but also recognizing that men and women do different work and, hence, possess different types of indigenous knowledge. Women have more knowledge of cooking, food processing, preservation and storage. Tiruneh (2001) reported that rural women are often found to be key players in post-harvest processing and saving seed in Ethiopia. On the other hand, men seemed more knowledgeable about site selection, land preparation techniques and pest and disease control.

Men and women play different roles and responsibilities within the household, in farming, and in society, yet the operational implications are often obscured, not least by gender bias, however, unwitting, on the part of plant breeders (Franworth & Jiggins 2003). The analysis of differentiated gender roles and responsibilities along the food chain and in gene flow management, can help plant breeders to avoid bias and accommodate diversity, and, thereby, make their work more relevant and effective.

Women mainly controlled the *pito* and sorghum malt industry, and sales of the commodities are an important source of household income. Brown or red sorghum types are in particular demand, and diversity is enhanced when these preferences are taken into account. The pito brewing is the largest consumer of sorghum grain in Ghana and the crop has become synonymous with the pito industry. Farmers estimated the proportion of sorghum grain used for local beer production in the region to be between 60 and 80% because of the numerous domestic breweries managed by women. In general, the whole socio-cultural economic and religious events of the people of northern Ghana (except in areas where Islam is practiced strictly) are inextricably linked up with this popular local beer. Clearly, this explains the dominance (85%) of red and brown landraces in the collection as they are mostly used for brewing.

Conclusion

Farmer knowledge regarding local landraces constitutes an important element in the knowledge and management of genetic resources. This is particularly true of sorghum with its very long history of cultivation, to which research still offers few alternatives. Sorghum not only contributes to household food security but also plays a part in the socio-cultural, economic, and religious aspects of the lives of people in northern Ghana. There is a wide genetic diversity among the sorghum collection and also there is duplications within the collections made. There is, therefore, the need to further characterize sorghum germplasm both morphologically and genetically. Most local landraces are selected by farmers on the basis of good food quality (mostly *tuo* quality), stable grain yields, brewing quality, earliness in maturity, pests and drought tolerance. Further improvement of sorghum must take these selection criteria into account.

To the subsistence sorghum farmer, ability of the crop to produce some grain even in bad years is paramount; more important than absolute level of yield. It is evident that most of the local landraces are gradually being eroded genetically within the growing areas, so the necessary steps must be taken to conserve and maintain the existing landraces, both *in situ* and *ex situ*. A detailed socioeconomic study may identify reasons why most of the local landraces are gradually

being neglected. This might provide avenues to promote the production and utilization of the indigenous landraces.

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References

Banziger M. and **de Meyer J.** (2002). Collaborative maize variety development for stress-prone environments in southern Africa. In *Farmers, Scientists and Plant Breeding*. (D. A. Cleveland and D. Soleri, eds), pp 269–296. CAB International.

De Groote H., Siambi M., Friesen D. and **Diallo A.** (2000). *Identifying farmers' preferences for new maize varieties in Eastern Africa*, CIMMYT, Nairobi, Kenya.

Demuyakor B. and **Ohta Y.** (1991). Characteristics of pito yeast from Ghana. *Fd Microbiol.* **8**: 183–193.

Demuyakor B. and **Ohta Y.** (1993). Characteristics of single and mixed culture fermentation of pito beer. *J. Sci. Fd Agric.* 6**2**: 401–408.

Franworth C. R. and **Jiggins J.** (2003). Participatory Breeding and Gender Analysis. CGIAR Systemwide program on participatory research and gender analysis for technology development and institutional innovation. *PPB monograph No.4. International Center for Tropical Agriculture (CIAT).* pp. 116.

Gyawali S., Sunwar S., Subedi M., Tripathi M., Joshi K. D. and **Wilcombe J. R.** (2007). Collaborative breeding with farmers can be effective. *Fld Crop Res.* **1001**: 88–95.

Harlan J. R. (1972). Genetic resources in sorghum. In *Sorghum in the seventies.* (N. G. P. Rao and L. R. House, eds). Oxford & IBH, New Delhi, India. pp. 1–13.

Jarvis D. I., Zoes V. and **Hodgkin T.** (2004). On-farm management of crop genetic diversity and the convention on biological diversity programme of work on agricultural biodiversity. *Pl. Gen. Res. Newsl.* **138**: 5–17.

Jatoe J. D. B. Alhassan R. M. and **Abatania L. N.** (2005). Factors affecting the adoption of improved sorghum varieties among farming households in north-west Ghana: A probit analysis. *Ghana J. Dev. Stud.* **2**: 37–50.

Lando R. P. and **Mak S.** (1994). Cambodian farmers decision making in the choice of traditional rainfed lowland rice varieties. *IRRI Research Paper Series* **154**. IIRI, Los Baòos.

Mann J. A. Kimber C. T. and **Miller F. R.** (1983). The origin and early cultivation of sorghums in Africa. *Bull. Texas Agric. exp. Stn*. **1454**

Mekbib F. (2006). Farmer and formal breeding of sorghum (*Sorghum bicolor* (L.) Moench) and the implications for integrated plant breeding. *Euphytic*a **152**: 163–176.

Murty D. S. and **Kumar K. A.** (1995). Traditional uses of sorghum and millets. In *Sorghum and Millets: Chemistry and Technology*. (D. A. V. Dendy, ed.), pp. 185–221. American Association of Cereal Chemists, St. Paul, MN.

Nkongolo K. K., Chinthu K. K. L., Malusi M. and **Vokhiwa Z.** (2008). Participatory variety selection and characterization of sorghum (*Sorghum bicolor* (L.) Moench) elite accessions from Malawian gene pool using farmer and breeder knowledge. *Afr. J. agric. Res.* **3**: 273–283.

Rhodes E. R. (1995). Nutrient depletion by food crops in Ghana and soil organic nitrogen management. *Agric. Syst*. **48**: 101–118. DOI: 10.1016/0308-521X(95)93648-W

SRID (2007). *Facts and figures.* Statistics, Research and Information Department of Ministry of food and Agriculture, Ghana.

Tiruneh A. (2001). *Socioeconomic and gender issues in the selection, consrvation and utilization of sorghum landraces in Ethiopia.* Online document. http://www.idrc.ca/uploads/user-S/10928613081 gender.doc. Accessed [21-08-09].

Van Oosterhout S. (1993). Sorghum genetic resources of small scale farmers in Zimbabwe. In *Cultivating knowledge: Genetic diversity, farmer experimentation and crop research.* (W. De Boef, K. Amanor, K. Wellard and A. Bebbington eds), pp. 89–95. Intermediate Technology Publications, London.