Assessing production constraints, management and use of sorghum diversity in north-east Ghana: a diagnostic study

C.Y. Kudadjie[1,*], P.C. Struik[2], P. Richards[3] and S.K. Offei[4]

[1] Department of Agricultural Extension, University of Ghana, P.O. Box 68, Legon, Ghana
[2] Crop and Weed Ecology Group, Wageningen University, Wageningen, The Netherlands
[3] Technology and Agrarian Development Group, Wageningen University, Wageningen, The Netherlands
[4] Department of Crop Science, University of Ghana, Legon, Ghana
* Corresponding author (e-mail: comkudj@yahoo.com)

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Abstract

This paper reports on the results of a diagnostic study conducted to assess the problems and needs of sorghum farmers in north-east Ghana with the aim of determining the type of research that would be useful for them in their own context. The importance of the crop and its position within the cropping system are identified. Sorghum is still an integral part of the livelihoods of farmers. The crop is very versatile and not only contributes to food security but also plays a part in the socio-cultural, socio-economic, and religious aspects of the lives of farmers. Farmers have different uses for the varieties they grow, which depends on the morphological, agronomic and gastronomic traits of the crop. Sorghum varieties introduced from the research institutions have several problems including lodging, poor grain quality, bird damage and precocious germination. Farmers have developed management strategies for dealing with some of these problems. Nevertheless, further work is required by breeders to make the varieties more acceptable to users. Sorghum production constraints identified include poor soils, erratic rainfall and pest infestation of the grain during storage. The diagnostic study suggests that because farmers produce their own seed, enhancing their ability to improve the quality of their seed would be of benefit to them. The study further underscores the importance and value of diversity for farmers. It also highlights their understanding of diversity, and management and use of variation in their agronomic practices. Areas identified for further research together with farmers aim at enhancing farmers' knowledge towards strengthening their practices in diversity management and improving seed storage practices.

Additional keywords: farmers' knowledge, *Sorghum bicolor*, maize, seed management, biodiversity, variety

Introduction

Agricultural research has often failed to achieve the required impact for many resource-poor farmers especially in Africa (Chambers & Jiggins, 1987; Anon., 2001). So there is a pressing need to look beyond the conventional research approach to find more effective and sustainable ways of making agricultural research more relevant for small-scale farmers. The Convergence of Sciences Project (Anon., 2001) advocates interactive science by which the research agenda is set and implemented through the systematic participation of all stakeholders. Interactive science suggests the need for an approach that will make research more useful for farmers in their own local context. To this end a diagnostic study has been developed as one of the ways of anchoring research in the needs and conditions of farmers. Röling *et al.* (2004) argue that such an approach is just as important as embedding the research in the context of the international scientific literature.

Although the concept of a diagnostic study is not new, it is not yet a standard research tool. Here we approach the topic systematically, based on partnership between farmer groups and biological and social scientists. In this study the diagnostic study is not only used to assess and understand farmers' problems and needs but also as an entry point for a PhD research project that continues with the active participation of farmers in addressing the issues they consider relevant.

The diagnostic study reported here is within the confines of the sorghum (*Sorghum bicolor*) crop and the specific agronomic and socio-economic context in which it is grown. In Ghana, sorghum is a staple food and forms the basis of the farming systems for farmers in the savannah zones. It is a very versatile crop and a major source of income and employment for many. The choice of sorghum is based on the results of a technographic study (for a description of its methodology see Richards, 2001) conducted in Ghana between January and March 2002 (Offei *et al.*, 2002). The study revealed sorghum to be a 'grass roots' or traditional crop largely grown by subsistence farmers. Until recently, low priority has been given to the crop and it has received comparatively little attention from the national research institutions when compared with cereals like rice and maize. However, in the private sector there is interest in sorghum and this, in turn, provides opportunities to raise the research profile of the crop.

This paper first examines the importance of sorghum in relationship to other crops grown by farmers in the study area. It then outlines the importance of crop diversity by showing how it is used to meet different needs. The crop production constraints and problems associated with the varieties grown are also assessed. The paper then continues with an analysis of the knowledge and practices of farmers in diversity use and variety maintenance. Drawing on the above, the paper outlines the implications of the findings and the issues agreed and identified with farmers for further research. It concludes with reflections on the use of a diagnostic study to focus the research.

Materials and methods

The study area

First, exploratory visits were made to the Walewale District in the Northern Region and the Bawku East and West districts in the Upper East Region of Ghana. The choice of these districts was based on sorghum production data and yield statistics obtained from the Statistics, Research and Information Unit of the Ministry of Food and Agriculture (MoFA). The purpose of the exploration was to visit some villages, interact with local sorghum farmers and people working directly with these farmers and identify villages/communities where the study could be conducted. Being the lead producer in terms of cropped area and yield, the Bawku East district was selected for further studies. Located in the Sudan savannah zone of the north-eastern corner of Ghana, the basis of its traditional farming system has been the production of sorghum and millet. The rainfall pattern is mono-modal and the rainy season normally lasts from May to September/October.

The study villages

In the Bawku district two villages were selected using the following criteria (see also Figure 1):

1. Possible influences on the sorghum biodiversity as a result of introgression of genotypes from bordering countries like Burkina Faso and Togo.
2. Proximity to a peri-urban and rural sorghum and malt market.
3. The nearby location of an out-station of the Savannah Agricultural Research Institute.

Accessibility to the research station was considered necessary to facilitate future interaction between farmers and researchers during the experimentation phase of the research project. From a list of villages, using a list of dominant crops grown, both obtained from the MoFA office in the district, the villages Terago and Tesnatinga were selected. Inhabitants were predominantly Kusasi by tribe, but also included a mix of other ethnic groups such as Mossi, Busanga and Yanga.

Introduction to villages

The extension agent introduced the principal researcher to the chief of each village as a student who wanted to learn about sorghum production. The need to hold several discussions with farmers in order to know how best to work with them was explained. Subsequently an introductory meeting with farmers was scheduled in each village to explain the purpose of the research and pave the way for future contacts.

Data collection

Community members from each village were asked to suggest representatives to serve as key informants on the following subjects: type of crops grown, cropping patterns,

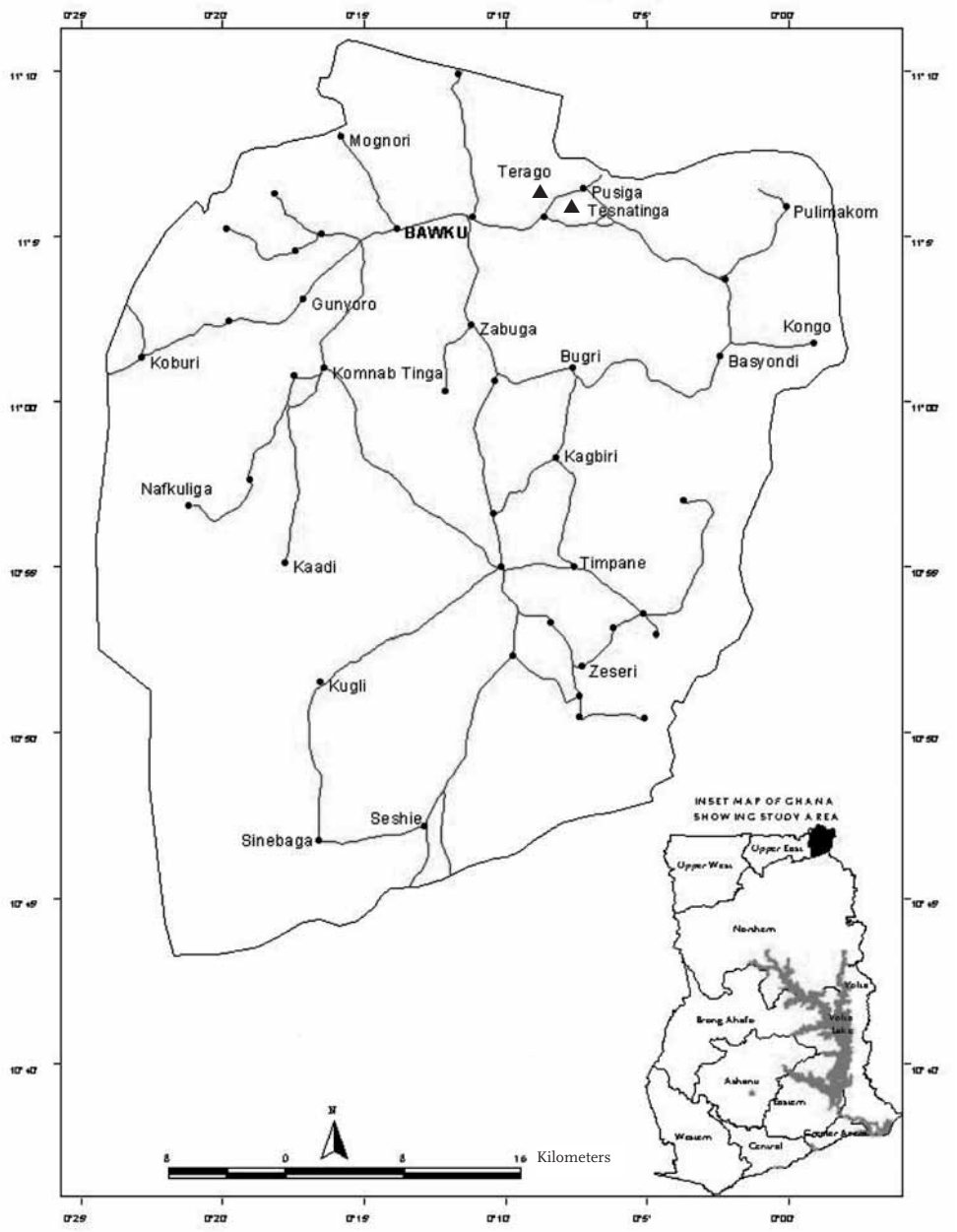

Figure 1. Map of Bawku East District, Ghana, with location of study villages (▲).

off-farm and income-generating activities, sorghum varieties grown and general information on the villages. The informants (8–10 per village) were required to have much knowledge about the village and the farming activities and included young and old as well as male and female farmers. The information obtained from these informants was cross-checked and confirmed using semi-structured interviews, farm visits and field observations with other farmers in the same villages.

Subsequent data collection was done through discussions with different groups of farmers depending on the focus of the discussions. Different participatory rural appraisal (PRA) tools were used as was deemed appropriate. Methods such as farmers' own classification of farmers and wealth ranking were used to understand the type of farmers living in the village. Using pair-wise ranking two different groups of farmers representing large and small-scale farmers (according to farmers' own categorization) were used to determine the importance of the crops grown. Information on source of varieties, names and their meanings, period of introduction and disappearance was obtained with the aid of a history line drawn by farmers. Problems and constraints in sorghum production were identified through brainstorming sessions with farmers, a process that was facilitated through the use of a problem pyramid. This visual tool helped farmers with little or no formal education to prioritize the problems identified and establish a hierarchy. The most important problem was represented by the longest rectangle and the least important by the shortest. The rectangles were then arranged to form a pyramid, starting with the longest at the bottom to the shortest at the top. Forty farmers from each village were individually interviewed on the main cereals they grew and on the functions of these cereals within their local household food security system. These farmers were also interviewed on the level and use of sorghum genetic diversity.

Information sourced from other stakeholders such as seed growers was mainly obtained through semi-structured interviews, whereas group discussions combined with brainstorming sessions were used for the staff of MoFA.

Results and discussion

Importance of sorghum

Several crops are grown in the area, including cereals (millet, maize, sorghum and rice), legumes (groundnut and cowpea) root and tuber crops (sweet potato and *frafra* or Hausa potato (*Solenostemon rotundifolius*)), and exotic and indigenous vegetables. Generally, rice and sweet potato are grown for the market while the other cereals are grown for subsistence and form the main part of the diet. Table 1 shows how two groups of farmers (larger and small-scale farmers) in the villages ranked maize, millet and sorghum based on their importance for food and cash income. As the order of importance did not differ between the two groups, only the overall average is presented. The importance of these crops for food was negatively, but not significantly correlated ($R^2 = 0.25$; $n = 5$) with their importance for cash, and the rank correlation (Spearman's ρ) was also not statistically significant ($P > 0.05$).

Table 1. Millet, maize and sorghum ranked in order of their importance as food or cash crop, and functions of the crops as indicated by the farmers in the study area.

Crop	Importance[1]		Crop function[2] (response by farmers, %)			
	Food	Cash	Consumption	Market	Cons & market	Other
Early millet	1	4	67	3	30	0
Maize	2	2	54	14	31	1
Late millet	3	5	56	14	28	2
Late sorghum	4	3	49	3	5	43
Early Red sorghum	5	1	47	17	16	20

[1] Based on group discussion.

[2] Based on interviews with individual farmers.

Early millet ranked first in importance for food but was less important as a cash crop. It is considered a traditional crop that is grown for food by every household and only sold as the last resort in times of dire need. It is always the first crop to be harvested after the long dry season when many households are already running out of food. So it is regarded as a hunger breaker. According to the farmers, sorghum would have ranked second, but the introduction and adoption of maize about 10 years ago changed this considerably. Although few farmers in the region grew yellow maize before the early 1990s, it was not processed but eaten boiled or sold in its fresh state at the local market. During the same period both early-maturing sorghum varieties Naga white and Naga red grown by farmers were poor in terms of food quality and, in the case of Naga red, better suited for the production of local beer. The introduction of a short-cycle maize variety along with the provision of inorganic fertilizers supported by Sasakawa Global 2000 (SG 2000; a non-governmental organization) met with wide acceptance from farmers who found it suitable for preparing food. They also discovered that more flour was obtained from maize than from the same quantity of sorghum. The maize was early, high yielding and matured before their local sorghum, but a major drawback was the cost of fertilizer when the credit scheme through which the fertilizer was provided, ended.

The high ranking of maize for food and cash indicates that it fits farmers' needs for cash crops and for food security crops (Table 1). According to the farmers interviewed, maize and early millet are equally important as a crop grown for both home consumption and the market. Of the two traditional crops millet and sorghum, millet is more important for home consumption than sorghum, and so is maize. Home consumption includes food, drinks and any other dietary functions. Except for early red sorghum, which is mainly processed into a local alcoholic beverage (*pito*), all cereals are used as food. The late sorghum has a dual function and may be regarded as the subsistence crop par excellence for half the number of farmers interviewed.

So sorghum appears not to be a front-line food security crop nor a top-ranked cash crop. One major reason for this is the lack of early sorghum varieties that are suitable

for food. But in view of the fact that it still holds a consumption function for half the number of farmers interviewed it may be considered as a substitute food security crop. Furthermore, the relatively high ranking of the early red sorghum and late sorghum as cash crops suggests that sorghum still has a significant place on the local market. The diagnostic study indicates that sorghum is a salient crop, but after interaction with farmers, and with the benefit of hindsight, it is possible to argue that millet might have been an alternative or even better focus.

Naming, use and diversity of sorghum

Naming of sorghum varieties

The farmers listed several sorghum varieties that had been grown in the villages over the last 60 years. Varieties had been named after the source, the person through whom it was believed to have been introduced or its use. Names such as Eyadema (the then president of Togo) indicate the origin of the variety, and farmers explained that the seeds were first obtained from Togo. Kapaala (new sorghum) and Eyadema were used interchangeably by some farmers because they both are early maturing, have the same plant colour, panicle architecture and grain colour. There is reason to believe that Eyadema, like Kapaala, is an ICRISAT (International Crops Research Institute for the Semi-arid Tropics) variety known as ICSVIII, introduced into several West African countries some years ago.

Other names, like Widki (horses' millet) and Niyinrinchi (your eyes will not turn), explain how the varieties are used: while in the past Widki was fed to horses because it was considered to be of poor quality and unsuitable for human consumption, Niyinrinchi is valued for its medicinal value and used as an antidote for dizziness. Three early, red sorghum varieties (Kokosbog, Gurudu and Zula), similar in plant and seed colour were collectively known as *Naga* (meaning not known). The most commonly grown local, long-cycle varieties, collectively known as Belko (meaning not known), consisted of different types that were named after their grain colour and endosperm texture.

In Mali, Chakanda (2000) also found origin and function to be important elements in the naming of sorghum varieties. The second most frequently used criterion used by farmers in Mali in naming their sorghum varieties was the origin followed by the function of the variety grown.

The use of collective names sometimes indicates a farmers' system of classification based on some agronomic or morphological characteristics. For instance, studies by Abidin (2004) on sweet potato varieties in north-eastern Uganda revealed that some vernacular names used by farmers provided important information on maturity period, yield performance and other yield-related information.

It has been suggested by McGuire (2002) that the names Ethiopian farmers assigned to sorghum types described variants within groups or distinguished a subtype or local population. A comprehensive understanding of the farmers' system of classification using their naming system and descriptions would be useful in explaining local concepts and perceptions of a variety, and is a subject for further investigation.

Sorghum varieties grown

The farmers in the two study villages grew early-maturing and late-maturing sorghum varieties. The main early varieties were Naga white, Naga red and Eyadema/Kapaala; the main late varieties all belonged to the Belko type. Thirty-five percent of the farmers grew improved varieties introduced from research institutions, i.e., Naga white and Eyadema/Kapaala whereas 55 and 74% grew Naga red and the Belko types, respectively. Reasons given by farmers for not growing Naga white included poor taste and food quality, poor storage and its requirement of fertile soils, while reasons for not growing Kapaala were its requirement of additional inputs (such as fertilizers), lack of seeds and insufficient land. Not growing Belko was mainly due to its low yield and late maturing. Some farmers perceived that the rainfall pattern had changed to the extent that late-maturing varieties are no longer adapted to the prevailing conditions. Farmers who did not grow Naga red attributed this to insufficient land. Such farmers hired farmland at high costs. They therefore preferred to grow crops like groundnut, because compared with Naga red these fetch almost twice the amount of money on the market.

Use of sorghum varieties

Table 2 shows how the different sorghum varieties are used. The value of these varieties was linked to social, economic, cultural, traditional, religious, food security, nutritional and health aspects of the farmers' lives. Varieties like Naga red and the Belko group have several uses, which explains why many farmers grow them. Being the raw material for the local beer it is impossible to separate sorghum from the social, cultural and religious events that help to maintain and create new social bonds. Farmers mentioned that some varieties have been lost as a result of famine or calamities. They also complained that other varieties (Kerig, Gibrok and Niyirinchi) are low yielding, late maturing and not well suited for the changing environmental conditions. Nevertheless conscious efforts are still made to grow them year after year in very small plots, in an attempt to preserve them. This is not surprising considering their importance for particular needs such as feeding lactating mothers, curing illnesses and providing delicacies for guests.

Diversity of sorghum varieties

Diversity in growth period, plant architecture, palatability of grain and leaves for humans or animals were all found to determine the value placed on the different sorghum varieties. The fact that farmers are still holding and using these varieties implies that they recognize the need to maintain this diversity and that they have developed strategies and skills for adapting their germplasm to the changing environmental conditions and their own specific household needs. These skills need to be built upon, and establishing links between formal and local crop development may be one way of doing so. Clearly, these skills, when developed or enhanced will be indispensable for improving the livelihood of the farmers.

The culture, tradition, customs and religion of these farmers had strong ties with these varieties. Belko, for example, is believed to have originated from the ancestors and is entrusted to each new generation for passing it on to the next. Failure to do so

Table 2. Uses and plant parts used of sorghum varieties grown by the farmers in the study area.

Use	Plant part used	Commonly used varieties
Beverage	Grain	Gurudu (Naga red)
		Belko (Nwuago)
Building/fencing material	Stalks	Belko (all types)
		Naga red
Cash income	Grain	Kapaala
		Naga red
		Belko (Piele)
Culture (festivals, marriages, celebrations, traditional ceremonies/rituals)	Grain and stalks	Belko (all types)
Famine/hunger crop	Grain	Naga red
		Naga white/Widki
Animal feed	Leaves and stalks	All available varieties
Food	Grain	Amenyeaw
		Abiemlad
		Akpaa
		Belko (Piele, Zia, Nwuago)
		Gibrok
		Kapaala/Eyadema
		Kerig
		Torok
Fuel	Stalks	Belko
		Naga red
Medicine (cure for diarrhoea, antidote for dizziness)	Grain	Naga red
		Niyirinchi
Religion (sacrifices to pacify gods)	Grain	Belko
Special foods (desserts, food for lactating mothers)	Grain	Gibrok
		Amenyeaw

will incur the displeasure of these ancestors, who are held in high esteem and considered the source of blessing and prosperity. Similarly, all ceremonies, celebrations and rituals that require the preparation of food or the pouring of libation to invoke their blessing must of necessity use this variety. All natives of the land must ensure that it is grown each year for such purposes. By this practice such varieties are not likely to become extinct, as farmers will continue to conserve and adapt them to their changing conditions.

Millar *et al.* (1999) draw attention to the relationship between spirituality and agriculture among small farmers in northern Ghana. They found that in northern Ghana the worship of the ancestors is paramount in the worldview of the rural people. The traditional crops sorghum and millet were received from the ancestors. The spirits of the ancestors are owners of humankind and responsible for their well-being. So rituals

are associated with such traditional crops but far less to crops introduced from outside.

Farmers' production constraints

Table 3 lists the problems encountered by farmers in growing sorghum.

Table 3. Sorghum problems in the study area, ranked by the farmers in order of importance.

Ranking	Problem
1	Insufficient rainfall
2	Delayed rainfall
3	Infertile land
4	No bullocks for ploughing
5	Insufficient seed
6	Termites attack grain in storage
7	*Striga* infestation
8	Black ants

Rainfall

The erratic nature of rainfall is a major problem for farmers since their agriculture is typically rain-fed. Farmers held the view that the amount of rainfall has decreased and is insufficient. However, it appears that the problem stems from the lack of appropriate sorghum varieties that fit the current rainfall regime rather than the rainfall regime itself. Findings from a study conducted by ICRA in the Upper East Region (Anon., 2000) showed that there has been no significant decrease in the average monthly rainfall for Bawku during the period 1976–1999. Comparing the periods 1946–1986 and 1976–1999 for the average annual rainfall in Bawku even indicates an increase over the latter period. These findings suggest that the farmers' perception about diminishing rainfall may be due to a reduced water-holding capacity of their soils, related to loss of soil organic matter.

Farmers also explained that a delay in the onset of the rains delays planting so that their local varieties, which are late maturing, run the risk of failure. Under such circumstances only short-cycle varieties and crops can be grown. Such a situation could gradually lead to a loss in diversity.

Soil quality

Poor soils were a source of worry to all farmers. Although few use inorganic fertilizers for growing sorghum it is common for farmers to improve their soils with organic or farmyard manure, depending on the possession of livestock. Apart from the rich who possess large numbers of cattle, for most households the available quantities of farmyard manure are small and have to be shared with all male members of the household

who own farmland. A common feature of the local farming system is that a continuously cultivated farmyard surrounds each compound. In addition to this, most farmers also cultivate one or more bush farms within easy reach (i.e., between 1–3 km from their compound). The farmyards are used for growing food crops for home consumption and are controlled by the male head and his married sons. Farmyard manure is applied on a rotational basis so that different portions of land receive inputs each year. But it are the soils around the compound and the land cultivated to crops such as maize and millet that receive most attention. Farmyard manure is hardly used on bush farms. So women, who are often allocated portions of the bush farms, are always in a disadvantageous position. Farmers attribute the low fertility of their soils to population pressure, land fragmentation, land scarcity, and continuous cropping. They feel that not much can be done except try and avoid practices such as ploughing along the slope, and reduce the destruction of organic material resulting from burning during the dry season.

Lack of bullocks and seed

Lack of bullocks delayed planting, particularly for farmers who could not afford to hire them. They could only borrow bullocks after their owners had finished using them. This means that the first few rains, which are important for land preparation and sowing, would be missed and that crops/varieties that require early planting cannot be grown.

Shortage of seed usually occurred when farmers were forced to consume grain reserved for planting. Pest infestation of stored seeds also led to shortage of planting material. Farmers without adequate seeds for planting solicit for seeds from friends or family members, buy from the market or provide labour to other farmers in exchange of seeds. Farmers acknowledged that seed from the market was not always of good quality but that they had to use it because there was no alternative source of supply.

Pests

Stored early millet and Naga red sorghum were reported to be very susceptible to weevils because of their softer grains, whereas sorghum varieties of the Belko group have harder and more resistant grains. To combat termites some used chemicals bought on the market or wood ash to protect their seed while few grew plants believed to be repellents to pests, around their storage barns.

The farmers in the study area did not consider *Striga* as a very important pest as clearly indicated by its position in Table 3. It was not considered to be a problem in early-maturing crops and was controlled by weeding or hand pulling. Farmers explained that the problem of *Striga* was only severe where a long-cycle sorghum variety such as Belko was grown without weeding consistently.

In the event of a long dry spell, insects such as black ants tend to remove seeds from the soil immediately after sowing and infilling becomes necessary, which is an added cost to the farmer. Farmers have tried to prevent this problem by seed treatment but this has often proved to be detrimental because fowls pick up the treated seeds and are poisoned.

Impact on farmers' choices

Problems with rainfall and soil fertility are likely to influence farmers' choices between the sorghum varieties to be grown and so affect diversity. Depending on the rainfall regime in a particular year less or more early or late-maturing varieties will be grown. Similarly, the fertility status of the farmer's soil will determine how much land is allocated to each variety.

Apart from the problems outlined above, problems more specific to the sorghum varieties used by farmers were reported. These included poor adaptation to the soils, lodging, bird damage, poor taste and grain quality and precocious germination. Farmers have developed some management strategies to deal with these problems.

Varieties susceptible to lodging are fortified when they start booting by reshaping the ridges to give support to their roots. Varieties prone to precocious germination are harvested immediately when they are ripe and dry (to avoid being re-wetted by the rain). Varieties with poor grain quality may be grown in small areas or not at all. Their grain is often mixed with larger quantities of better quality grain for food preparation. Where a variety requires a very fertile soil, farmers apply farmyard manure or compost. But in the absence of such inputs they are not grown at all. Farmers plant varieties that are susceptible to bird damage close to their compounds or resort to bird scaring if they are planted further away. Farmers who have enough land cultivate large areas and ensure that their planting dates coincide with those of other farmers in order to reduce the damage caused to a single, isolated farm. The development of such strategies indicates the willingness and innovative capacities of farmers to manage their varieties.

Farmers' knowledge and practices relating to biodiversity, seed management and variety maintenance

Variation and diversity management

Discussions with farmers and observations in farmers' fields during seed selection learned that farmers have knowledge about diversity and seed management. On their fields farmers appreciated diversity, using characteristics such as plant height, panicle shape, panicle length and compactness, tillering and seed colour as descriptors or markers. While some were keenly aware of variation within populations others were not or did not consider it to be important. In a discussion with 23 farmers from the study villages over 50% of them confirmed that they sometimes observed differences within fields sown from the same seed lot, while others maintained that differences do not occur. Farmers also showed some knowledge about the predominantly self-pollinating nature of sorghum by comparing it with maize. They explained that little cross pollination was seen in sorghum, whereas maize fields close to each other consisted of several mixtures, which they attributed to "the wind blowing flowers from plants in one field to the other".

Variation within populations was attributed to rainfall, land and nature. This may be interpreted as genotype × environment interaction. Though farmers could discuss some of the factors that influence variation, their explanations suggested that they did

not fully comprehend how it occurred, or what the sources were of this variation. For example, differences in seed colour of plants from the same parent were attributed to insufficient washing of panicles by rainwater during seed ripening. As explained by Van Dusseldorp & Box (1993) the worldview of cultivators, which is often different from that of scientists, leads to differences in causal explanations of what happens in the environment.

Usually, varieties are not planted in mixtures. However, some farmers plant sole crops of a single variety with another variety just along the borders. These border plants tended to be varieties reserved for medicinal or other specific purposes for which no large quantities of grain are required. Roguing was not practised although off-types were observed in some fields at maturity before harvesting. Few farmers attempted to maintain the purity of their seeds at the time of harvesting by selecting panicles with grains that looked exactly like what they had planted. Others were not interested in purity but in yield and therefore only selected panicles from high-yielding plants even though they did not look like the original, hoping that the subsequent crop will portray the same character, i.e., good yield. These are different selection practices that could give different results, but what farmers were unaware of is how these different practices could contribute to or influence the variation in their fields.

Varieties and soil type

In deciding where to plant sorghum, farmers matched varieties with soil types. Information from farmers revealed that the varieties Naga white and Kapaala require fertile soils to do well, and therefore they are planted either close to the compound where a lot of organic manure is applied or at other places considered fertile. Belko is planted on less fertile soils although it is common to see small plots of it planted close to the compound. The Naga red types have different soil requirements; although Gurudu and Zula can be grown on different types of soils they perform better on valley bottoms or soils with a high moisture content. On the other hand, Kokosbog requires well-drained soils and is therefore planted on upland soils and not on valley bottoms. Although these claims have not been tested to ascertain their validity, they still indicate that farmers believe that even varieties of the same crop may have different soil requirements and therefore must be managed differently.

Seed management

Seed material was collected by selecting panicles in the field immediately after harvesting (cutting down stalks). Such panicles must be large and have large grains free from disease. Panicles with small grains are rejected. Poor germination was associated with insect-infestation and mouldy or diseased grains. The practice of winnowing before planting was believed to rid the seed lot of seeds that would not germinate. Storage methods included hanging the selected panicles from the roofs of storage barns made from grass or mud, in the open or close to the kitchen smoke. Other farmers threshed the panicles and stored the seed in polythene or nylon bags. Though farmers believed that these storage methods were quite effective in maintaining seed viability, the number of seeds sown per planting hole (6–8) suggests otherwise. When questioned, they explained that not all seeds germinate and since it is difficult to determine this

before sowing it is necessary to sow many seeds and later thin to the required number of plants. Farmers lacked knowledge about the use of simple tests to determine the germination capacity of their seed lot. The diagnostic study thus suggests that because farmers produce and use their own seed, enhancing the knowledge and ability to improve the quality of their seed would be of benefit to them.

Pest and disease management

Pests and diseases did not seem to be of much importance to the farmers. In several cases where attention was drawn to insects such as mould-causing mirid head bugs (*Eurystylus immaculatus*) seen on panicles in the fields, farmers insisted that "they do not affect the crop". Diseases like smut were believed to be caused by rainwater entering flowers when they open in the afternoon. Because its mode of transmission was unknown to farmers, proper measures (like roguing in an early stage) were not taken. Bellon (2001) observed that in farming areas where certain phenomena are difficult to observe, or that have interacting causal factors, farmers' knowledge may be less precise or even non-existent.

Farmers' perceptions about technology development and its products

The major responsibility of introducing, promoting and disseminating technology lies with the Extension Services of the Ministry of Food and Agriculture (MoFA). Agricultural Extension Agents (AEAs) are directly involved in introducing technology from research institutions to farmers and serve as links between researchers and farmers. The technology on sorghum that has been extended to farmers has mainly been in the form of improved varieties. Before the release of such varieties, these agents conduct adaptive trials with farmers and send feedback to and from research. Few researchers interact directly with farmers during this adaptive stage and most farmers have more contact with these AEAs than with researchers. It is for this reason that the views of both agricultural extension agents and farmers were considered important in this diagnostic study. The perceptions of seed growers are also considered.

In the Upper East Region, which includes Bawku East district, three varieties from the Savannah Agricultural Research Institute (SARI) were introduced to farmers through MoFA. Naga white was introduced in 1988, Framida in 1990 and Kapaala in 2000. As the introduction of Naga white was supported by supplies of fertilizers, its cultivation took off quite well and yields obtained were very high, but the poor quality of the grain for food and the absence of a market for the crop soon discouraged farmers from growing it. Framida, an early maturing, red-grained variety had the problem of shattering during harvest and also suffered from poor seed set due to its susceptibility to the sorghum midge. It is reported to have lost popularity very quickly. Although the variety Kapaala was released in 1996, it was formally introduced by MoFA in 2000 in the Bawku East district.

During discussions with AEAs on their role in transferring sorghum technology to farmers they expressed their concern about the technology development system. The agents felt that farmer adoption of varieties was slow and low and that the weak linkage between farmers and researchers was partly responsible for this. They were of the

opinion that the problems associated with the varieties, like poor demand and lack of market, discouraged farmers and seed growers, which contributed to the poor adoption. So they acknowledged that it was not just enough to provide technology (improved varieties) but that there also is a need to include other support systems like market outlets for such products. This is echoed by Röling *et al*. (2004), when they point out that there is a limit to which technology development becomes important for farmers if the opportunities provided by marketing, service and input delivery and financial institutions are not created.

The problems associated with the varieties as mentioned by AEAs, farmers and seed growers are shown in Table 4. Although their views were obtained separately, several problems outlined for Naga white and Kapaala were commonly expressed by extension agents and farmers. These problems were: precocious germination, bird damage, high soil fertility requirement and lodging. It is not surprising that fewer problems were mentioned by farmers than by extension agents since the agents interact with a wider group of farmers than those contacted in this study. Farmers are more likely to mention only those problems that they consider important. However this is not conclusive since the set of problems listed by extension agents were not presented to farmers for their comments. The variety Framida was not mentioned by farmers at all. Problems mentioned by seed growers only applied to Kapaala because it is currently the only sorghum variety the seed of which is produced by seed growers.

These growers belong to the Northern Sector Seed Grower's Association (NOSGA)

Table 4. Problems with sorghum varieties introduced by research institutions, as expressed by extension agents (A), farmers (F) and seed growers (S).

Problem	Variety		
	Naga white	Framida	Kapaala
Susceptible to bird damage	A, F		F, S
Precocious germination	A, F		A, F, S
Susceptible to mould	A, F		F
Poor grain quality and taste	A, F		
Low suitability for preparing *pito*[1]	A, F		
Non-uniform ripening	A		
Stover of poor fuel quality	A		
Poor storability	A		A
Susceptible to lodging	A		A, F, S
Seed shattering		A	
Poor seed set (sorghum midge)		A	
Sweet stalks prone to stealing			A, F, S
Requiring fertile soils			A, F, S
Lack of market/poor demand			S

[1] *Pito* = local beer.

that forms part of the formal seed sector, which still is in its developmental stages. Seed growers started producing seed during the past 2–7 years. Their major problem was marketing. The demand for Kapaala seed was low and in the past, growers had to find their own ways of selling the seed. Even though the recent interest of a brewing company (Guinness Ghana Ltd) in the variety Kapaala was seen by growers as a likely solution to their marketing problems, they pointed out that this market could only be assured if farmers would be willing to produce the grain. Yet, in the first year that the brewery contracted farmers in the Northern Region, only 10–12% of the target was achieved. This was attributed to head bug infestation of the grain, associated moulds and poor drying, all of which reduced grain quality and therefore most of the grain was rejected. According to seed growers the prices offered to the farmers were too low, and in view of the cost incurred for cleaning and transporting the grain it was considered better to sell on the local market. Growers were of the view that for this initiative to take off successfully, farmers would require support to offset the high cost of production.

The perceptions of farmers, seed growers and extension agents of the varieties introduced from SARI clearly indicate that further work by breeders is needed to address these problems and make the varieties more acceptable to all users of the crop.

Further research and agreements with farmers

The issues arising from the diagnostic study point to the need for developing appropriate research and development strategies that are based on the capacities of farmers to experiment with their crops and on the knowledge they have acquired in managing their diversity. The proposal for research with farmers is aimed at linking scientific knowledge to farmers' knowledge (De Boef *et al.*, 1993; Reij & Waters-Bayer, 2001). For such a linkage to be developed and sustained between the two knowledge systems, dialogue is needed in which both farmers and scientist are willing to listen to each other and learn from each other as equal partners in agricultural change. The form of dialogue that paves the way for learning and interaction from different knowledge systems is the approach that has been adopted in determining the way forward for experimental work with farmers in the subsequent phases of the research.

The diagnostic study has led to the identification of an area of research that is not only based on what farmers know but also on what they do not know. The knowledge of farmers in managing diversity and variety maintenance became apparent during the several exchanges of views with farmers on their practices. Evidence of varietal mixtures and the presence of off-types in farmers' fields pointed to the need to understand farmers' appreciation and use of variation. The importance of variation for farmers, and the human and natural elements that contribute to the creation or maintenance of variation is currently under discussion with farmers. Table 5 summarizes the different phenomena (genetic, environmental and temporal sources of variation) discussed with farmers. It provides a qualitative assessment of farmers' knowledge, understanding, use and management of each phenomenon in their agronomic

Table 5. Farmers' knowledge, understanding, use and management of variation, and the plans for further research on these aspects.

Source of variation	Farmers' knowledge				Research plans		
	Knowledge	Understanding	Use	Management	Identification	Investigation	Creating learning experience
Genetic							
-Inter-varietal variation	++[1]	++	++	++	+[2]	+	+
Intra-varietal variation	+	±[3]	–[4]	–	+	+	+
Environmental							
Soil	++	++	+	+	–	–	–
Weather	++	++	–	–	+	–	–
Site specific	++	+	±	–	–	–	–
Plant to plant/ random	±	±	±	–	+	+	+
Genotype × environment	+	±	±	±	+	+	–
Temporal							
Outcrossing	++	+	–	–	+	–	–
Selection	++	+	+	+	+	+	–
Single panicle descent	±	–	–	–	+	+	+

[1] ++ = farmers know or understand the phenomenon in detail and make use of it and manage it extensively in their agronomic practices; the research project identifies the phenomenon extensively, investigates it in detail and creates an intensive joint learning exercise on it.

[2] + = most farmers are aware of the phenomenon, understand it to some extent, make use of it and manage it to some extent; the research project pays attention to the phenomenon, investigates it to some extent and includes it in the joint learning exercises.

[3] ± = some farmers, but not the majority, are aware of the phenomenon, understand it to some extent, make use of it and manage it to some extent.

[4] – = farmers are not aware of the phenomenon, do not understand it, and are definitely not capable of using or managing it; the research plan is not dealing with it.

practices. Based on this assessment a learning exercise on the phenomenon identified has been created with farmers, which will be part of the rest of the research. On the learning plot designed with farmers different panicles of sorghum varieties selected by farmers will be grown on a head-to-row basis. The exchanges between farmers and researchers will be aimed at augmenting farmers' knowledge on variation. It is expected that the farmers will use the knowledge gained to strengthen their skills in managing their sorghum genetic resources. Through field observations and practical demonstrations in the field, researchers and farmers will also be engaged in learning about the morphological traits used by farmers to distinguish between varieties in order to understand farmers' concept of variety.

Following the diagnostic study continued dialogue with farmers on their seed management and storage practices showed that the different treatments by farmers to store their seed were all geared to one main objective: to produce good quality seed that will germinate at planting time. However, a lot of attention appeared to have been paid to preventing diseases and pests that destroy the seeds in storage and thus good germination was directly linked to pest- and disease-free seed. Farmers were also aware that there were other aspects, such as seed moisture content, aeration and temperature, that influenced the physiological seed quality and that these were important during storage. Over the years many farmers have changed from one treatment to another in an attempt to obtain good quality seed but not much attention was paid to the storage method. This was the case for both sorghum and millet. It was therefore agreed with farmers to test and compare the effect of (1) treatments, and (2) storage methods on seed quality. The use of germination capacity as a test of quality was proposed and accepted by farmers as a measure of effectiveness.

Another important issue that emerged from the diagnostic study was the lack of appropriate, improved sorghum varieties. This view was shared not only by farmers and extensionists but also by seed growers. During the validation of the results of the diagnostic study with researchers, breeders, farmers, extensionists, seed growers and other relevant stakeholders it became evident that the problems with the varieties were being addressed. The breeders revealed that a hybridization programme to improve the qualities of the most recently introduced variety was already underway. Out of this programme some promising breeding lines had already been selected for further testing. These lines will be evaluated on-farm with farmers in different locations during the growing season. It is hoped that feedback obtained from farmers involved in the evaluation will provide useful information to shape breeders' efforts in making varieties more acceptable.

Reflections on the use of diagnostic study

Reflecting on the process of the diagnostic study, the researcher agrees that making certain pre-analytic choices like choosing a specific crop is necessary to help delineate boundaries for the investigation and have an entry point for the research. During the investigation, however, these choices must not become limiting and/or reduce the scope of the diagnosis when it becomes necessary to broaden the scope. It should also

be pointed out that studies of this nature demand adequate time at the disposal of the researcher to ensure that sufficient attention is paid to all issues that appear relevant. So if this approach is used for 'academic' research its full benefits may not always be realized. Perhaps the approach may be more useful in research for development, where time is not so limited as it is in a PhD programme.

In this study not all the problems identified with the farmers could be channelled into the field research. The use of the diagnostic study as a precursor to PhD work, however, did not compel the researcher to address all issues that came to light once there were other ways of addressing them. A specific case was the problem of low soil fertility expressed by farmers, which was ranked very high in importance. During validation of the findings with other stakeholders it became clear that methods for assisting farmers to address this problem existed, but had either not been available to, or were not used by this group of farmers. Subsequently, extension agents from MoFA contacted farmers interested and willing and arrangements for training in compost making are currently underway.

The initial stages of the data collection process of the study were very slow. This was due to the inability of the researcher to speak the local language and to the lack of experience in riding a motorcycle, the main means of transportation in the area. For the first three months during which efforts were made to find a translator, an extension agent assisted with translation. The good services of the same agent had to be relied upon for transportation to and from the villages on motorbike. This meant that visits had to be planned outside his field schedule and at his convenience until such a time that the researcher gained enough confidence to ride. During this period very little time was spent with farmers in the communities outside the scheduled meetings. It is felt that otherwise much more information could have been gathered more quickly. This experience again confirms that lack of familiarity with the culture and language of the people poses barriers to working effectively with them. Agricultural science for farmers in multi-ethnic communities will require either scientists from the area or some linguistic preparation by the anthropologists and other social science field workers.

Conclusions

Although sorghum has been known for many years as one of the most important and widely grown cereals for the people of Northern Ghana, the diagnostic study revealed that its position might be changing for the farmers of Terago and Tesnatinga villages of the Bawku East district. Sorghum is still important and may be considered as a substitute food and cash crop. But the emergence of maize – which after millet has the advantage of being a short-duration crop contributing to coping with seasonal hunger in the area – is seen as one of the factors responsible for this shift in importance. Late-maturing crops are becoming less reliable and no longer adapted to changing and uncertain rainfall patterns. For some farmers, therefore, solutions to food security lie in early-maturing crops, both for consumption and the market. Although this greatly increases the opportunity for formal research to develop high-yielding and

early-maturing sorghum varieties to fill this gap, the inappropriateness of such varieties developed in the past has limited their impact.

This generates the question as to whether technological emphasis on sorghum towards the development of improved varieties should be pursued. Perhaps research efforts on promoting sorghum as a food crop may go nowhere, while research for industrial use and commercial purposes may stand a better chance. However, answering this question goes beyond the scope of the present study. What the study did establish, however, is that despite environmental change sorghum continues to hold importance for many farmers beyond considerations of either food security or cash income. Sorghum is still very much an integral part of a local culture in which the ancestors continue to play a part. As for that, the diagnostic study brought to light the importance and value of genetic biodiversity. This appeared part of the motivation for farmers to join in a research effort intended to support and build on their own efforts and skills in biodiversity and variety maintenance. This sets the agenda for the experimental phase of the research.

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