Farmers' seed systems for sorghum in Mali:

An evaluation of farmers' variety characterization criteria

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Dedication: *To my wife Finda and the children Kumba, sia and the one to come.*

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Summary

Two villages, Gonsolo and Katibougou were selected in Mali to study farmers' seed systems of sorghum. The aim was to understand the criteria farmers use to evaluate their varieties using the Rapid Rural Appraisal approach. Gonsolo was the more traditional village with their seed systems held within family units, while Katibougou had metropolitan influences and an open seed system.

A total of 21 sorghum varieties were found to be growing in both villages. A variety group, *Kende* consisted of a number of sub-races and appeared to be the oldest set of landraces in both villages. The farmers neither remembered their origin nor the time they were first introduced to the villages.

Farmers 'variety characterization was based on adaptation, food quality, grain yield, resistance to biotic stresses and post-harvest processing. Variety classification was based on morphology, origin, purpose of cultivating variety and name of farmer that first had variety.

An attempt to answer the research questions developed during the evaluation with farmers was made by investigating two of the farmers' varieties in on-station trials. The aims were:

i. to investigate the similarity/difference in variation between varieties cultivated by different farmers,
ii. the similarity/difference in variation between different varieties believed to be the same by farmers.
iii. to investigate the effect of farmers' selection practices on variation within varieties;

A high level of variation was observed within all the populations evaluated for both development traits and the reproductive traits. CV was low for number of days to flowering, but relatively high for grain yield, panicle length, panicle weight, number of nodes and number of panicle branches at first node. Heritability that gave an indication of the effectiveness of selection was highest for number of days to flowering, and average for grain yield, panicle length, panicle weight, number of nodes and number of panicle branches at first node.

The t-test for the equality of means gave no strong indication of the similarity between the same varieties grown by different farmers, and the varieties that are believed to be the same by farmers. Similar relationship was realized when all pairs of means of the population s studied were compared.

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CHAPTER 1

Introduction

Sorghum (*Sorghum bicolor*) is one of the cereal crops grown mainly in the drier regions of West Africa. It accounts for about 37% of the total food grain production in the region, with small-holder farmers responsible for almost all the production. In Mali, sorghum is a subsistence crop for most of the population and the total harvested area is higher than that of rice and maize (Byth, 1993).

Sorghum breeding programs in Mali had in the past focussed on agronomic performance in order to increase food security for the majority of the population. The International Crops Research Institute for the Semi Arid Tropics in Mali (ICRISAT -Mali) has been conducting research to produce superior sorghum germplasm. These efforts are still continuing and new approaches are being exploited to meet farmers needs.

Institutional sorghum research in general terms has not been very successful in sub-Saharan Africa. This is because the universal insights of conventional plant breeders led to the concentration of efforts on grain yield and wide adaptability of cultivars (Sthapit *et al*., 1996, Ceccarelli, 1996). The researchers had always developed new varieties to meet these objectives without obtaining farmers input. Adapting a few varieties to wide agro-ecologies is a problem on its own, but most important also are farmers' variety preferences. Sorghum breeders largely overlook these farmer preferences. Moreover, the new varieties developed required high inputs, which the farmers cannot afford (Byerlee & Husain, 1993).

An important positive step for plant breeders nowadays has been to change strategy by including farmers at every step of the breeding process. The advantage of reaching out to farmers is that it helps researchers to understand farmers' criteria for evaluating new varieties. These criteria can then help the researcher to pick out germplasm with the traits farmers prefer and use them to develop new varieties. It also ensures that farmers make choices that adequately meet their needs and enhances breeders chances of producing varieties that farmers appreciate (Ashby, 1991).

The second change in the institutional breeders' strategy has been to adopt methodologies that could sufficiently enhance working with farmers. This is especially true when it comes to tapping farmers' traditional knowledge. Farmers are the custodians of the varieties they grow and the knowledge systems that uphold the diversity that exists within these crops. Here again conventional breeders used to evaluate farmers' varieties without understanding farmers' criteria. This was found out to be slow and expensive. The faster and inexpensive way is to give farmers first place in generating information about their varieties (Sperling *et al.,* 1993). The strategy brings together social scientists and plant breeders in developing comprehensive methods to work with farmers. Such methods, namely Participatory Rural Appraisal (PRA), Participatory Plant Breeding (PPB) and Participatory Variety Selection (PVS) are being widely tested and implemented.

Using these tools, Plant Breeders at the ICRISAT station in Mali have recently started involving farmers in the whole process of evaluating and selecting superior sorghum genotypes that can be advanced to meet farmers needs. The small farmers targeted generally grow a wide range of sorghum cultivars, mostly landraces. The fundamental interest is to develop cultivars that are better than the farmers' current ones, and at the same time meet the farmers' adoption criteria. For this it is important to characterize the varieties the farmers are growing, and to understand the system in which these varieties are maintained.

1.1 Focus of the Thesis Research

The main focus of this research is to use participatory methods as the first step in understanding farmers' seed systems. The research was designed to understand the manner in which traditional farmers manage their sorghum varieties. This being a broad subject, the work was divided into two phases:

1. Evaluating farmers' seed management of sorghum through the PRA approach. The research questions involved were:
   - i. What varieties are the farmers presently growing?
   - ii. What criteria are they using to evaluate and characterize these varieties?
   - iii. How do farmers obtain seed for planting?
   - iv. How do farmers produce seed?

During the course of the evaluations, further research questions were formulated to the basis of the second phase of this thesis work.

The objective for the first phase of the research has to understand the management systems of sorghum in Mali, and to formulate questions for further research work.

2. On-station trials involving farmers' varieties.

The questions formulated during evaluation of farmers' seed system supported the basis of this phase of the thesis.

This was meant to further investigate farmers' management systems by getting sufficient scientific understanding of the crops that they are growing. From working with farmers, it became clear that almost every farmer was selecting panicle yearly to produce seed for the next planting season. The research interest at this level was to investigate how such selection practices affect the genetic variation within the variety.

The second area of interest was whether a variety being grown by different farmers does maintained its genetic identity. In other words, do management practices of different farmers have any effect on the genetic identity of a variety?

Thirdly, during farmer evaluation, phenotypically different varieties were considered to be the same variety. Could there be any scientific basis for such consideration by farmers?

Research interests:

i. to investigate the effect of farmers' selection practices on variation within their varieties
ii. to investigate the similarity/differences in variation between varieties cultivated by different farmers, and
iii. to investigate the similarity/differences in variation between morphologically different varieties farmers believed to be the same.

The objective of the on-station trial was to investigate variation within and between sorghum varieties in the hands of farmers in order to answer the above questions.

1.2 The Research Area

1.2.1 Mali

The Republic of Mali is a landlocked country in West Africa, bounded on the north-east by Algeria, on the east by Niger, on the south by Burkina Faso, Cote d'Ivoire and Guinea, and on the west by Senegal and Mauritania. The capital is Bamako. It was a former French colony and it gained independence on June 20, 1960.

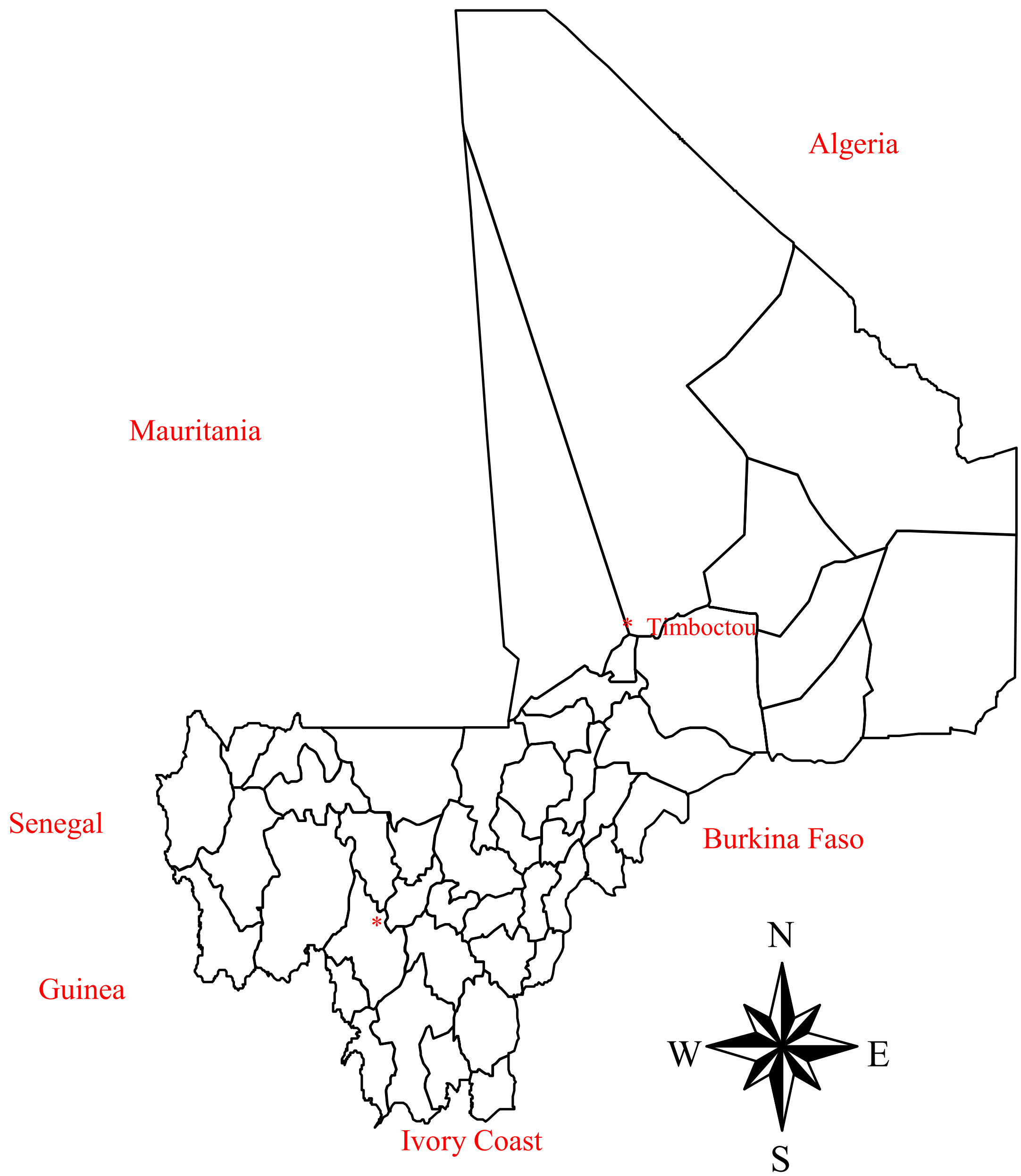
The total surface area of Mali is 1,240,192 km^2. Most of the country consists of low plains, broken occasionally by rocky hills. The river Niger cuts an arc of the country. The northern 1/3 of Mali lies in the Sahara desert and the western part falls within the Sahel, a semi-arid zone lying between the savanna in the south and the desert in the north.

The country is predominantly agricultural, and crop cultivation depends mostly on traditional cultivars. The climate of the southern and western parts of Mali is hot and dry, with average temperatures ranging from about 24^{o}C to 32^{o}C. Annual rainfall varies between 1,400 mm in the south to 1,120 mm around Bamako.

1.2.2 ICRISAT-Samanko

The ICRISAT-Mali center is situated at Samanko, 25 km from the capital Bamako. It covers a total land area of 124 ha, much of which is set aside for on-station variety trials. The latitude and longitude are 12^o 54" North and 8^o 4" West respectively. The average altitude is about 328 to 330 m above sea level. The climate is typically Sudanean, with a harsh dry periods stretching from March to May, and a rainy season from June to September.

Map of Mali showing research area



* - Bamako, National Capital

1.2.3 The research villages

The two villages Gonsolo and Katibougou chosen for the study are in the same climatic location as the ICRISAT Station. They are part of the Operation Haute-Valée du Niger agricultural zone that was producing tobacco after independence. Tobacco production ceased because of the poor quality of the product and in the mid 1990s the Compagnie Malienne pour le Development des Textiles (CMDT) introduced cotton, which has become the main cash crop. The villages share common features in their crop production systems. Sorghum is the staple food and has a larger share in the cultivated area compared to other subsistence crops. Other subsistence crops include maize, groundnuts, pearl millets and cowpea. Rice is grown in the low-laying basins in Gonsolo.

The traditional method of cultivating different crop types is by maintaining a well-planned rotational and inter-cropping system. Sorghum is mostly sown as a sole crop, although it is sometimes inter-cropped with cowpea, pearl millets, and groundnuts. Crop production on the rotational basis involves cotton, maize and sorghum in any one of the schemes: cotton - maize - sorghum; cotton - sorghum - cotton, cotton - maize - cotton and ground nut - sorghum - maize. NPK and urea fertilizers are applied on cotton and maize crops at the rate of 150kg complex/ha. Fertilization of sorghum fields depends on the use of animal wastes or wastes from dumps around the village.

1.2.3.1 Gonsolo

The entire village of Gonsolo consists of 6 clan groups (*Kabila*) based on common ancestors. The six *kabila* are:

1. Namomdouba
2. Serafimagana
3. Dombagala
4. Tagadimarila
5. Saribakodo
6. Banilaro

Each *kabila* has a *kabila* head (*chef de kabila*) responsible for the general affairs of the *kabila*. He is in charge of the distribution and utilization of the ancestral farmlands. Within each *kabila* there are sub-groups called *foroda* (exploitation). There are different numbers of *foroda* in any single *kabila*. Members of one *foroda* work together and eat together. They usually are composed of a family head with wife (wives), children and unmarried brothers. There are about 45 *foroda* in the village and each exploits a certain piece of land.

Within some of the *kabila* some *foroda* have formed harvest groups, who regularly exchange labor for harvesting. This is a mutual exchange of labor without payment structure.

Members of one *foroda* do not normally visit the fields of other *foroda*, even within the same *kabila*. This rule is maintained except if someone falls ill or needs support for some specific reason. In such a case, help is summoned from the *kabila* irrespective of *foroda* membership. Also, some *foroda*s (about 3) may come together to harvest their crop on individual fields.

There is abundant land for the inhabitants to cultivate in Gonsolo, though every piece of ancestral land is under *kabila* control and ownership. The *chef de kabila* controls the land belonging to the *kabila* and each *kabila* manages the allocation and to some extent the utilization of a particular piece of land.

There are some varieties that are grown only by one *kabila* - e.g., the variety *Namaramatenemaga* was named after (in honor of) one of the chef de *kabila* whose actual name was Namaramatenemaga. The restrictions on farm visits between members of different *foroda* makes it rather difficult for farmers to know about varieties grown by members of other *kabila*s.

1.2.3.2 Katibougou

The residents of Katibougou are strongly influenced by the proximity of the village to the city Bamako. Family units are not as strong as in Gonsolo and a large number of the population (more than 80%) are migrants from other parts of the country (personal communication, Baba Kumare). Many men and women of working age either move to the city in search of jobs, or they may stay in the village and take up part-time jobs such as that provided by the government forestry division.

Land ownership is a critical issue. During the colonial period (i.e. before independence in 1960) the entire terrain in and around the village was controlled by the central government. There was a vast field of a fibrous plant locally called *baga* (hence the region was called *baga furo* - *Baga* farm). This plant was exploited by an European company for the production of fiber. After independence, the company closed down but the land remained under government control. To encourage agriculture in the area, the government distributed the land to the few residents according to family size, and sold the remaining land to residents of Bamako. The landowners living in Bamako, however, allow the present residents to use their land without charge or payment.

This type of land ownership has literally led to the abandoning of shifting cultivation in the farming system, and some farmers in Katibougou have cultivated their pieces of land continuously for up to 30 years. The traditional bush fallow method, by which soil fertility was restored, has long been lost, and the continuously used soils are now predominantly sandy-loam and grayish in color, and presumably of low fertility.

Table 1.1 Summary of main differences between farmers in Gonsolo and Katibougou

Gonsolo	Katobougou
- More remotely situated: no metropolitan influence, littl market influence and little alternative jobs	- Close to Bamako: metropolitan influence, market forces, wider job opportunities.
- Farther away from the ICRISAT Research Station: littl casual researhc influence.	- Close to ICRISAT Research Station: accessibility to improved cultivars, research influences
- Farmers strongly held in family ties: traditional *kabila* an *foroda* households.	- Farmers are mainly migrants with diverse backgrounds
- Shifting cultivation practices	- Permanent cultivation of fields: poor soils
- No women sorghum farmers	- Women sorghum farmers.

Chapter 2

Literature Review

Over the past decade breeders have developed comprehensive approaches to study traditional knowledge of farmers in relation to farmers' seed management systems. This demonstrates the increasing interest in including farmers at every level of breeding programs. It is implicit that breeders' participatory research with farmers at every level has gained the terminology Participatory Plant Breeding (PPB). Included in PPB are aspects such as Participatory Variety Selection (PVS).

Moreover, the concepts of selection criteria and variety characterization are very similar and almost synonymous because the traits that farmers use to evaluate varieties are the same traits they use in selection procedure. These concepts form the background of this study.

Monyo *et al*. (1997) conducted Farmer Participatory Research studies in Namibia. Farmers and breeders were regarded as contemporaries that should work together to produce results that neither could produce working alone. From the results, it was concluded that in working with farmers, breeders get to know exactly what they need to focus on; i.e. which qualities and traits farmers consider most important. They also believe that inasmuch as breeders learn from the farmers, participatory research helps farmers to become better breeders, stating that 'quite clearly, two heads are better than one'.

Thiele *et al*. (1997) used the participatory rural appraisal as one of the tools to evaluate how farmers in Bolivia assess potato germplasm. Both the methodology used and the farmers' assessment criteria were evaluated. Some of the strengths of the methods were:

i. informal verbal evaluation was faster and more friendly for farmers,

ii. unstructured open evaluation made exploration of qualitative criteria possible.

Group evaluations generated in-depth discussions and stimulated farmers' participation. For the assessment of farmers' criteria, scientists' and farmers' choices coincided, although they were different at some points. They concluded that it would be more efficient to involve farmers later in the selection process so as to improve breeders' knowledge of farmers' criteria.

Defoer *et al*. (1997) studied farmers' assessment of local maize varieties in Southern Mali through participatory research methodologies. Open evaluation systems were used to assess the relative importance and specific characteristics of different local varieties. They found farmers selection criteria to be quite different from those of breeders; and the criteria differed between zones and per gender basis. They concluded that participatory research offers important tools to understand farmers' selection criteria. They therefore expressed the importance of including farmers' criteria early in selection programs so as to help breeders to produce varieties that have high chances of adoption. In another research, the same group suggested combining selection procedures of new varieties of corn with participatory tools (Kamara *et al*., 1996). This was in order to better understand and account for farmers' criteria for making variety choices.

Farmers have always been plant breeders, although formerly unrecognized at the institutional level. Sierra Leonean rice farmers are known to select superior panicles each year to produce seed for the next growing season (Jusu, 1999). Some farmers are, however, more experienced than others in the exercise. For this reason, while adopting a participatory research method to improve rice varieties in Nepal, Sthapit *et al.* (1996) realized that careful choice of farmers was important for the success of Participatory Plant Breeding. They found out that farmers' methods of plant selection varied with farmer's knowledge and circumstances. They also found that farmers have particular preferences for certain quality traits of rice.

Farmers in marginal environments do maintain genetic diversity of their crops, many of them landraces. This could be in the form of different crops or different cultivars of the same crop (Binswanger and Barah, 1980). There is an increasing concern, however, over the general sustenance of these genetic materials in the hands of the farmers and the threats that endangers biological diversity. Bellon (1996) argues that, to understand the loss of genetic diversity with farmers, it is important to link farmers' choices to the genetic materials they control. This is based on the fact that the size of farmers' germplasm base depends on their decision to maintain, incorporate or discard a variety. In their capacity as custodians of traditional seed stock, farmers maintain high interests in selecting, conserving and improving the genetic diversity of the crops they grow (Richards, 1985). Sorghum farmers in most parts of Africa are known to select panicles with superior characters at maturity for seed (Harlan, 1975).

It is on the basis of the complex seed management systems of local farmers in different parts of the world and under different circumstances, that Almekinders *et al*. (1994) conducted a literature survey. They concluded that "although no systematic information on informal seed supply (system) is available, there are many observations and reports in literature that confirm the importance and potential of local seed systems for a diverse, flexible and readily available seed supply for small farmers"

There are several approaches used by field researchers for the assessment of genetic variation in farmers' materials. The most commonly used approaches are directly linked to agronomic and morphological data, which are relatively easy to determine (Ceccarelli *et al*., 1987). The study of the seed systems and genetic variation of sorghum has been conducted using these conventional methods.

On-station participatory methods were used to evaluate the characteristics of pearl millets in western Niger by Baidu-Forson (1997). Farmers showed more concern for panicle, grain and growth cycle characteristics than for high grain yield. Researchers found out that farmer participation in variety evaluation provided a means of identifying a wide range of traits that were valued by farmers. This could provide guidance on farmers' demand for use in variety development.

While evaluating sorghum germplasm in India, Rao *et al*. (1996) measured several characteristics including grain color, grain type, 100-grain weight and grain covering. Juvenile pigmentation and midrib color were used to identify landraces; midrib color was strongly associated with stalk juiciness of sweet sorghum. Considerable diversity was observed between states and among seasons for all the characters, especially in the landraces. In a similar study, Teshome *et al*. (1997) used 14 characteristics to evaluate phenotypic similarities of 177 accessions of sorghum landraces grown by farmers in Ethiopia. The objective was to obtain taxonomic evidence on the resemblance between accessions. Farmers provided valuable information during germplasm collection. All the fourteen characters used were easy to sample and score. They included grain, inflorescence and seedling characters. The results indicated that landraces of the two regions clustered with nine characteristics. It also suggested that the names given by farmers to landraces in the two regions were consistent and represented the different types.

Elings (1991) evaluated phenotypic variation components for 10 characters of durum wheat landraces from Syria. Multivariate patterns of variation were established through principal component analysis in order to describe relationships between landrace groups and regions of collection. The results showed that variation among populations was high and amounted to 96% of the total variation. Variation among landrace groups was calculated as 9% of the total variation. Jaradat (1991) conducted a similar investigation on the phenotypic variation for developmental traits in landrace genotypes of Durum wheat from Jordan. He collected bulk samples from farmers' fields during harvest. These were grown for field evaluation in randomized complete block design. Data on number of days to booting, number of days to heading, number of days to anthesis, number of days to maturity and grain filling period were subjected to analysis of variance. The result of correlation analysis showed that grain yield was only positively and significantly correlated with number of days to anthesis and flowering period. It was also found out that genotypes with long flowering periods and medium to late heading gave the highest grain yield.

Chapter 3

Materials and Methods of farmer evaluation

3.1 Choice of Study villages

The two villages, Katibougou and Gonsolo, were selected on the basis of their strong background in the cultivation of sorghum, which is their main crop and staple food. Both villages were accessible by road; Katibougou being 30 km and Gonsolo 75 km from the city of Bamako. Katibougou is only 5 km from the research station and it served as base for frequent short visits by the research team. Farmers from both villages had close working relationship with researchers at ICRISAT. A selected number was conducting on-farm trials of advanced sorghum lines given to them by ICRISAT during the 1999 cropping season.

The closeness of Katibougou to Bamako gives the village a strong market influence in terms of buying manufactured goods and selling agricultural products. Gonsolo on the other hand was much more remotely situated, and the villagers have to travel several kilometers to reach the markets at the regional center, Bangumanaya.

Another important criterion considered for the selection of the villages was based on ethnicity and language. The language in the zone is Malinke. This was vital, because Malinke is sufficiently close in linguistic terms to Madingo and Kono, both of which form the language background of the researcher.

3.2 Choice of Farmers

Farmers conducting on-farm sorghum trials for ICRISAT were used as the main resource persons throughout the course of this research. Important criteria used by the ICRISAT team for selecting the farmers was high level of experience with sorghum and good ability to communicate and interact with researchers. This criterion fits well with the purpose of this research. Women were not among sorghum growers in Gonsolo but in Katibougou, women had their own sorghum farms both individually and as groups. They were, therefore, included in both the group and individual evaluations.

3.3 Organizing meetings

Village meetings were organized for the purpose of bringing together a group of sorghum farmers. This helped in using an open dialogue to discuss farmers' sorghum varieties. In Katibougou, Mr. Abdulaye Kamara (a social scientist in the research team) made arrangements for the meeting through Mr. Baba Kumare (a member of the farmer community). Mr. Kumare had a close interaction with both the research team and his farmer colleagues. All arrangements for subsequent visits were made through Mr. Kumare, who was able to bring his colleagues together at short notice. Women sorghum farmers got a special invitation because the village women considered open invitations predominantly men's affairs.

Because of the distance from the Research Station, visits to Gonsolo were organized through a field agent for an NGO (Adaf Galle) based in the region. In most cases, however, subsequent visits for group meetings were first discussed with the farmers and then communicated with the field agent. He then reminded the farmers as the date of the meeting approached.

3.4 Individual Evaluation

The second phase of the evaluation was done on an individual basis and farmers were visited either in their homes or in their fields. Frequent short visits were made to Katibougou for this purpose and longer discussions were held with the farmers. In Gonsolo, the first discussions with individual farmers were held in their fields during the time of crop maturity. Subsequent discussions were held in the evenings and at night.

3.5 Preparation and Schedule of visits

Due to the limitation in time for conducting the village visits, proper planning was done for each visit and a schedule was followed to achieve specific objectives. Planning included the preparation of forms for the ease of obtaining relevant information during the interviews. A clear objective was set for each visit, and when necessary, appointments were made beforehand. Table 3.1a and 3.1b gives details of the dates, names of the research team, the farmers visited and objectives of the visits.

Table 3.1a Schedule of visits to Farmers in Gonsolo

Date of Visit	Team members	Objectives of the visit	Farmers that participated
28 - 29/10/99	Eva Weltzien-Rattunde Musa Diarra Robert Chakanda	To discuss and evaluate the advanced sorghum lines given to farmers for on-farm trials	Sayon Keita Sulaiman Keita Bakari Kamara Tamba Keita Namakan Keita Lansina Diakite Alasan Kamara
11 - 12/12/99	Eva Weltzien-Rattunde Boubakar Coulobali Abdoulaye Kamara Robert Chakanda	- To evaluate the advanced sorghum lines given to farmers; - To evaluate farmers' local varieties	Bakari Kamara Namakan Keita Sulaiman Keita Tamba Keita Lansina Diakite Sayon Camara Sina Keita
16 - 17/12/99	Eva Weltzien-Rattunde Boubakar Coulobali Abdoulaye Kamara Robert Chakanda	To verify information about farmers' varieties: - sources of varieties and naming systems; methods of obtaining new varieties - discuss social structure of the farmers	Bakari Kamara Namakan Keita Sulaiman keita Tamba Keita Lansina Diakite Sayon Camara Sina Keita Sayon keita Alhasan kamara

Table 3.1b Schedule of visits to Farmers in Katibougou.

Date of Visit	Team members	Objectives of the visit	Farmers that participated
26/11/99	Abdulaye Kamara Robert Chakanda	First meeting with farmer group to identify sorghum varieties grown by farmers in the village.	Salifu Kone (Village chief) Saidu Traoré Sanaba Sidibé Mohamed Diallo Diamako Coulobali Baba Kumaré Billi Traoré
30/11/99	Robert Chakanda Maolu Camara	To make appointment with farmers for future visits	Baba Kumare
2/12/99	Robert Chakanda Bouba Camara	Visit farmers individually on their farms to identify and characterise more varieties.	Yosouf Dumbuya Basiru Diakaté Soma Coulobali Bah Haidara Darami Traoré Nfaly Kone Bili Konate Zan Diarra
3/12/99	Robert Chakanda Maolu Camara	Visit farmers individually on their farms to identify and characterize more varieties. (More farmers were included in the evaluation)	Nasara Traoré Sanata Dambele Farima Traoré Naowe Traore Kalfa Traoré Yayah Traoré Bina Diarra Abdou Diarra
4/12/99	Robert Chakanda Maolu Camara	To visit farmers in their homes/farms and discuss their varieties	Diamako Coulobali
5/12/99	Robert Chakanda Bouba Camara	Further investigation about varieties - discuss seed origin of varieties, - methods of obtaining new varieties - selection procedure and history	Saidu Traoré Salifu Kone Sanaba Sidibe
6/ - 9/12/99	Robert Chakanda Maolu Camara	Further investigation about varieties - - discuss seed origin of varieties, - methods of obtaining new varieties - selection procedure and history - investigate abandoned varieties	Yayah Traoré Kalfa Traoré Naowe Traoré Bina Diarra Abdou Diarra
18/12/99	Robert Chakanda Bouba Camara	To clarify certain details about the varieties *Sakoyka* and Folomba	Nfaly Kone Billi Konaté
20/12/99	Robert Chakanda Mohamed Sangari	To clarify certain details about the varieties *Folomba* and *Sakoyka*, and other farmers' varieties	Zan Diarra
22/12/99	Robert Chakanda Maolu Camara	To discuss with key informant about the social structure and labour groups in the village Katibougou	Baba Kumaré
24/12/99	Robert Chakanda Maolu Camara	To discuss with key informant about the land ownership in the village; and to verify details about major varieties.	Baba Kumaré Saidu Traoré Yosouf Dumbuya Yayah Traoré Nfaly Kone

3.6 Evaluation Criteria

An open evaluation system as recommended by Quiros *et al*., (1991) and used by *Kamara et al.,* (1999) was adopted. Farmers were given the maximum opportunity to express their opinion without interruption, and the researcher suggested no variety evaluation criterion. Probing questions were only asked when there was need to clarify certain points from what the farmer had said.

3.7 Limitations of the study

This study has certain limitation, which could not be avoided:

- The language was a problem for the researcher to some extent. Although the Malinke was understood to a certain degree, the level was not strong enough for independent investigation, thus there was some dependence on interpreters.
- Time for the fieldwork (3 months) was very limiting considering the amount of information to be gathered.

3.8 Criteria for variety characterization used in Gonsolo

3.8.1 Number of farmers interviewed

The unique social structure described above for Gonsolo, warranted the use of *foroda* representatives for interviews. Because *foroda* as family units grow the same varieties, it was inappropriate to evaluate different individuals belonging to the same *foroda*. Few farmers that belonged to different *foroda* were evaluated.

3.8.2 Identification of varieties

During the visits, individual farmers were interviewed about the source of each of their varieties; the time each variety was acquired; the varieties grown before the present ones, and why varieties were abandoned. Selection criteria were investigated as to whether the farmer produces her/his own seed, how and when?

3.8.3 Variety characterization/description

In Gonsolo, farmers' criteria for describing varieties were evaluated by using sorghum varieties given to them for on-farm trials. Farmers evaluated the new varieties individually and drew comparisons with their local varieties. At the same time, their local varieties were evaluated as well, stating their advantages and disadvantages. This method was used to enhance our knowledge on what type of variety would be acceptable to farmers in accordance with what they know about their own varieties.

3.8.4 Verification of information

After the identification of the varieties grown in the village, a complete list of the varieties was compiled. A form was developed for each variety with a summary of all the information we had gathered about the variety in terms of characteristics, the origin and seed sources. This was to help complement already acquired information with what is left to be known, and to clarify points that were not clear during the previous sessions.

To get an in-depth knowledge about the varieties, a group meeting was organized with the farmers we had already interviewed. During this session, farmers discussed the sources of the varieties, the first people to acquire the varieties in the village, and their naming systems including synonyms. Also comparison in terms of productivity and duration was done for the three mostly grown varieties in the village.

3.8.5 Strengths and weaknesses of the research in Gonsolo

Strengths

- Visits were always done in company of professional researchers. The first couple of visits were in the company of Dr. Eva Weltzien, a Plant Breeder at ICRISAT, and her research assistant who is a native of Mali. During the last two visits, we were joined by two Malian Social Scientists. The Malian researchers gave us some background information before the visits, and also served as translators.
- There were already farmers to work with. Farmers were always willing to co-operate with the visiting team and provide information pertinent to the research.

Weakness

- The distance of Gonsolo from Bamako and the ICRISAT did not permit frequent visits, as was the case for Katibougou.

3.9 Criteria for variety cgaracterization used in Katibougou

3.9.1 Identification of varieties

During the group meeting, each farmer was asked to present her/his sorghum variety that s/he is presently growing. This was to identify the sorghum varieties the farmers were growing in the village. During the evaluation some farmers were not sure about the name of their varieties; the others helped in the identification. By doing so, a general overview was reached about who was growing which variety in the village.

3.9.2 Variety characterization

The next step was for the farmers to give reasons why they grew each of the varieties. Each farmer held his panicle in his hand and outlined both the advantages and disadvantages of the variety.

3.9.3 Variety description

After these preliminary sessions, next the researchers went to meet farmers individually in their homes or in their fields, as the case may be, and discuss their varieties. This open-ended evaluation was done to investigate the source of each variety; information about when the variety was first obtained. Farmers' previous varieties were also investigated, and reasons for which they were abandoned. Selection criteria used by the farmer to produce her/his own seed were investigated. For each stage of the interview, spontaneous comments made by farmers were relied upon.

3.9.4 Verification of information

After the first round of visits, two lists of varieties grown in Katibougou were prepared. One list contained the varieties currently grown and the second list contained the abandoned varieties. The next round of visits was made to individual farmers to discuss each variety, whether the farmer is growing it or not. During this session, the origin of varieties was discussed; the first people that brought varieties to the village, and the naming systems.

3.9.5 Strengths and weaknesses of the research in Katibougou

Strengths

- Katibougou was only five kilometers from the ICRISAT Research Station. This made it possible to make many short visits.
- There was already some background information about the varieties in Katibougou that was compiled during a workshop organized by breeders at ICRISAT (ICRISAT - WCASRN Workshop, 1998). The list of varieties in the booklet provided information whether farmers had presented all they had, or whether probing was needed.
- The farmers in Katibougou had long time experience with researcher and survey teams. This made it easier to communicate with them

Weakness

- After the first group meeting, it became difficult to get all the farmers for subsequent meetings. This was because most of them had busy travel schedules during the after-harvest rest period. Verification of information had to be conducted in small groups.

3.10 Data analysis

The information obtained from farmers was recorded, and later summarized under the following headings for analysis: Farmers' varieties cultivated, Criteria for characterization, Seed management. Farmers' comments were decoded and the SPSS statistical package was used to analyze the results. For most of the data, only means were obtained.

For the purpose of narrowing down farmers' criteria used in characterizing varieties, their favorite traits were summarized under six group headings (Table 3.2).

Table 3.2 Criteria for characterization and their grouping into six categories.

Criteria for characterization	Group
Yield	Yield
Adaptation to drought	Adaptation
Adaptation to long rains	
Adaptation to poor soils	
Growth duration	
Response when late sown	
Response to fertilizer	
Response as second crop	
Food (eating) quality	Food quality
Makes many food types	
For animal feed	
Grain quality	Quality of harvested products
Seed color	
Clean seed	
Panicle characteristics	
Less chaff	
Resistance to birds	Biotic resistance
Resistance to diseases	
Resistance to striga	
Storage ability	
Threshing ability	Post harvest processing
Decorticating	
Milling ability	

Chapter 4

Results of farmer-evaluation

4.1 Farmers' Germplasm base

4.1.1 Varieties grown in Gonsolo[1]

Nine farmers participated in the evaluation process in Gonsolo. Table 4.1 gives the list of the varieties of sorghum that were presented for evaluation. A total of 10 varieties were evaluated and they were classed according to the order of importance for production. *Tiemarifing* was the most popular variety and was reported by farmers that it is more productive than all the other varieties. It is a long duration variety, predominantly grown in the main farms (*chan de brousse*). The variety is believed to have been in the village for more than 20 years, according to Namaghan Keita, the key informant.

Table 4.1 Varieties in Gonsolo, percentage of farmers gtowing them, estimated number of years in the village and average duration of experience of farmers with variety

No.	Name of Variety	No. farmers (n=9)	Estimated number of years in village	Experience with variety (years)
1	Tiemarifing	5	>20	20
	(Bibagalawili)			
2	Kalosabani	6	-	34
	- Sibirinyoni			
	- Nyaka wuleni			
	- Trunkani			
3	Kende	2		13
	- Makononka		-	
4	Gadiaba (Sonyo)	1	-	
5	Fagotumate	3	12	12
	(Nyonifing)			
6	Trukanidjema	3	>30	30
7	Samanko	3	10	10
8	Timinkala(Mangala)	2	-	20
9	Seguetana	1	-	
10	Namaramatenemaga	1	-	

Note: (-) means: inherited from parents and farmer cannot remember when the variety arrived in the village.

Kalosabani is a composite name for a group of varieties, because three different morphological types were presented under the same group name. This grouping made by the farmers was based on growth duration. *Kalosaba* means three months, and *kalosabani* in this context means 'a variety of three months duration.' According to the farmers, all the varieties represented might have different backgrounds, but as long as they mature in three

[1] Most of the general information given here was obtained during the group meeting held on the 16th December when all participating farmers were present and from the key informant, Namaghan Keita

months, they are included in this classification. The farmers believed that each of the *kalosabani* varieties has a different origin and time of arrival in the village. From the farmers interviewed, the estimated number of years the varieties have been in the village was averaged to be 34. Most farmers grow *kalosabani* varieties close to the village (*chan de case*)

Kende is also a composite name for a group of varieties. The farmers admitted that it was difficult to trace these varieties because, although most farmers cultivated them, no one admits it. There was a myth about varieties belonging to the group, as they are believed to be a bad omen for the leadership of the village. Most farmers claimed that they had abandoned the variety altogether. Only two farmers out of the 9 interviewed presented one of their *kende* varieties, called *makononka*. Nobody remembered when *kende* was introduced to the village, and some farmers believe that it originated in the region.

The other varieties evaluated at Gonsolo included *gadiaba* (*sonyo*), which was grown for horses, *Fagotumate* (*Nyonifing*), *Trukanidjema, Samanko*, *Timinkala*(*Mangala*), *Seguetana* and *Namaramatenemaga*.

Seguetana is a variety known to be resistant to striga, a parasitic weed that destroys whole fields of sorghum. Not many farmers are growing *seguetana* because striga is not so much of a problem in Gonsolo.

During the course of the evaluation, abandoned varieties were also investigated as well as the reasons for which they were abandoned. The list of abandoned varieties is presented in Table 4.2.

Table 4.2 Abandoned varieties in Gonsolo

Variety	Reason
Drongonba	Very long duration
Kende - Futakan	Long duration
- Waranikende	Long duration
- Nyajan	Long duration

4.1.2 Varieties grown in Katibougou

22 Farmers participated in the evaluation process, and thirteen varieties were found to be growing in the village (Table 4.3). *Folomba* is the leading variety, grown by 18 out of the 22 farmers we talked to. This variety was believed to have been brought to the village 30 years ago and yields more than every other variety. Almost all the farmers growing *Folomba* related that it originated from Kita, a village in Western Mali. The story around its discovery in Kita is that a hunter went out on an expedition and found the plant growing at a watercourse (*folon*). The panicle looked good to him and it was already mature. The hunter then collected and later multiplied it, giving it the name *Folomba*.

Table 4.3: Varieties in Katibougou, percentage of farmers growing them, estimated number of years in the village and average duration of experience of farmers with variety.

	Name of Variety	Number of farmers growing it (n =22)	Estimated number of years in village	Average experience with variety (years)
1	Folomba	18	30	11
2	Kende			
	- Kendebleni	7	>100	10
	- Kendefini			
	- Kendegema			
3	*Sakoyka*	5	45	4
4	Gadiaba	3	-	1
5	Sobaku	3	-	1
6	Timinkala (Mangala)	2	-	2
7	Waradjè	1	-	1
8	Tiemarifing	1	1	1
9	Tenekuka	1	-	2
10	Bimbiri	1	-	5
11	Serakoilaka	1	-	5

Note: (-) means no information available

Kende is a composite name representing a set of 3 varieties that can be distinguished by glume colour. In Katibougou also, the *kende* set of varieties had some mythical significance though not as strongly as in Gonsolo. Most farmers reject some of the food types prepared from it in order to avoid the omen associated with such dishes. Farmers believed that the varieties belonging to this group have been in the region for more than a hundred years, and no one remembers when they were brought to the village.

Sakoyka was at the time of the evaluation the third most widely grown variety in Katibougou. From the glume color, two types of *Sakoyka* were presented in mixed panicles. One panicle type was with red glume and the other was black-glumed. All the farmers cultivating this variety however believed that these two types were the same variety. They reported that it is the nature of the crop, that if you plant pure black *Sakoyka*, the red one appears on the field and vice versa.

Sakoyka is reported to have been in the village for more than 45 years. During colonial rule, it was the most popular variety, and the native chief requested only *Sakoyka* from his subjects (personal communication, Bah Haidara). For the past decade however, the production of this variety has dropped drastically. The farmers reported that the reduction in yield in *Sakoyka* was because of low soil fertility as a result of continuous land use. Because of this, the farmers are gradually replacing *Sakoyka* with *Folomba*, as the latter was giving high yield in the impoverished soils.

The less frequently grown varieties included *, Gadiaba, Sobaku, Timinkala, Waradje, Tiemarifing, Tenekuka, Bimbiri* and *Serakiolaka*.

Two farmers, Saidu Traore and Nfaly Koné had bought varieties from the market and gave them names of varieties in the village. The varieties bought were *'Tiemarifing'* and '*Sakoyka'* respectively.

It was observed that certain varieties in the possession of farmers were not regarded by them as varieties and were not presented for evaluation. These included *Timinkala* (sweet sorghum) and *Gadiaba*. They are minor varieties. The farmers say that they are only maintained for special purposes, e.g., *Timinkala* for its sweet stalk, and *Gadiaba* is grown for animals.

It was apparent that a good number of varieties were abandoned in Katibougou, but the farmers could not remember them all. The ones they remembered and the reasons they gave for abandoning them are listed in Table 4.4

Table 4.4. Abandoned and threatened varieties in Katibougou

Variety	status	Reason
Drongonba	Abandoned	Very long duration
Nyagafima	Abandoned	Long duration
Driblini	Abandoned	Low yielding
Bimbiriba	Threatened	Long duration and needed high fertilization
Waradje	Threatened	Needs high fertilization
Serakoilaka	Threatened	Needs high fertilization and is low yielding.

4.2 Characterization of local sorghum varieties

The traits farmers used to characterize each of their varieties are given in Table 4.5 for Gonsolo, and in Table 4.6 for Katibougou. Farmers describing their varieties in spontaneous comments did the characterization. It was much easier to get farmers to talk about their varieties in Katibougou. Although description of varieties was done at the individual level in Gonsolo, most of the responses were obtained during a group discussion.

Table 4.5 Farmers' varieties and the traits farmers used to evaluate them in Gonsolo

No.	Name of Variety	Positive Characteristics	Negative characters
1	**Tiemarifing (Bibagalawili)**	– high yielding, bold grains, good germination, open glume at maturity	– *long duration*
2	**Kalosabani** **- Sibirinyoni** **- Nyaka wuleni** **- Trunkani**	– short duration, high yielding, can do well in both chan de case and chan de brousse	
3	**Kende** **- Makononka**	– good food quality as 'kini - (rice)'	– *long duration*
4	**Gadiaba (Sonyo)**	– white grains, bold grains, grains good for animal consumption	
5	**Fagotumate (Nyonifing)**	– medium duration, high yielding, responds well to fertilizers, easy to decorticate, does well on chan de case	
6	**Trukanidjema (Samanko)[2]**	– short panicles, can be stored for long, high yielding, white grain.	– *low test weight* – *long duration*
7	**Timinkala**	– sweet stalk	
8	**Seguetana**	– resistant to striga	
9	**Namaramatenemaga**	– Short duration	

[2] For classification, Trukanidjema and Samanko were characterised as the same (see section 5.4, on variety naming)

Table 4.6 Farmers' varieties and the traits farmers used to evaluate them in Katibougou.

	Name of Variety	Positive traits	Negative traits
1	**Folomba**	– adapted to poor soils, good food quality & gives many food types, high yielding, does well as second crop, many grains on panicle, high grain density, adapted to drought and long rains, good seed quality (not much chaff), good seed color, easy to thresh, not susceptible to birds, good panicle type, responds well to fertilizer, resistant to striga and diseases, conserves for a long time, rapid germination	– *difficult to de-hull and mill.* – *destroyed by storage insects* – *does not do well in standing water*
2	**Kende** **- Kendebleni** **- Kendefini** **- Kengema**	– resistant to birds, heavy grains, good eating quality, does well on poor soils, high yielding, can be harvested twice, early duration,	– *difficult to pound* – *not good for t🌧* – *a taboo to many people*
3	**Sakoyka**	– does well on poor soils, gives good food quality, high yielding, easy to thresh	– *susceptible to striga* – *needs fertile soils*
4	**Gadiaba**	– very early maturity, responds well to fertilizer, chaff good for animal feed	
5	**Sobaku**	– very long panicles, early duration, good food quality	
6	**Timinkala**	– sweet straw, grains good as food also, good yield	
7	**Waradjè**	– white grain color, very bold grains, long panicles	
8	**Tiemarifing**		– *the t🌧 goes black*
9	**Tenekuka**	– responds well to Katibougou soils, good eating quality, difficult to pound	– difficult to decorticate
10	**Bimbiri**	– good food quality, good yield, good seed/grain quality, medium duration	
11	**Serakoilaka**	– good yield, good panicle type, can be prepared into many food types, good eating quality, conserves for long, good grain type, heavy grains, vary long duration	

4.3 Seed source

In Gonsolo, most varieties were inherited through the generations. In addition to this, farmers generally obtain new varieties from close relatives, normally at *foroda* level. As a rule, farm visits and group harvesting are restricted to *foroda* membership. The general principle of obtaining a new variety from another member is by exchange of material. The exchange can take different forms: variety for variety; variety for grain; or seed of sorghum for the seed of a different crop, e.g. maize.

This system of obtaining seed is not in the strict sense restricted only to *foroda* members. Starting farmers who have no seed can obtain seed from a neighbor for free. Afterwards, she/he is expected to produce own seed. Subsequent request from the same farmer is fulfilled by exchange. In special cases, if the request for seed comes from only one farmer, the donor may give seed freely, but if the request comes from more farmers, it is considered a loss to the donor if he has to honor the requests. The different sources from which farmers obtained their current seed in both Gonsolo and Katibougou are given in Table 4.7.

Table 4.7 Sources from which farmers obtained seed in Gonsolo & Katibougou

	Seed Source					
Village	Neighbor	Relative	Inherited	ICRISAT	Market	Another Village
Gonsolo (n=14)	0	5	7	1	1	0
Katibougou (n=47)	31	7	0	1	3	5

n = the number of times seed presently grown was obtained

In Katibougou, the principal manner by which farmers find out about, and obtain, new varieties is during the time of communal harvest on each others farms. The farmers themselves refer to this relationship as 'receiving from a neighbor'. Group harvesting is done on a general invitation basis, and invited farmers interested in a variety are allowed to select panicles freely for seed.

In addition to getting seed from a neighbor's farm, news about varieties is usually brought by visiting farmers from other villages. Moreover, some farmers admitted going out to seek information about new varieties. There is also a common practice by which farmers went to settle in distant villages for up to three years in search of better fields, thereby leaving their fields in Katibougou to fallow. These farmers normally return with new varieties.

4.4 Naming of varieties.

Table 4.8 gives the criteria farmers used to name varieties. Descriptive terminology was used to name most of the varieties. This included adjectives describing glume color, seed color, panicle size and sometimes the nature of the variety during its development.

Table 4.8 Variety names and their meanings in both Gonsolo and Katibougou .

Name of variety	Group name	Acronym (A)/ Synonym (S)	Meaning of name
Folomba	-	-	Obtain from water course (folon)
Sakoyka		-	Coming from Sakoy village
Makononka	**Kende**		Obtained from Makonon village
Kendebleni		-	Red kende
Kendefini			Black kende
Kendejema			White kende
Tiemarifing	-	Bibagalawili (S)	Bibagalawili - Savior: someone that holds you to prevent you from falling.
Sobaku	-	-	Tail of a big horse (soba - big horse; ku - tail)
Tinekuka	-	-	-
Waradjé	-	-	Wild (vigorous) variety (Wara - wild animal)
Gadiaba	-	Sonyo (S)	Sorghum for horses (so - horse, Nyo - sorghum)
Timinkala	-	-	Something that is sweet
Serakoilaka		-	-
Bimbiri		-	-
	Kalosabani	Nyotelini (S)	Three months duration; quick sorghum
	(Race**)**		Red glumed sorghum
Niaka wuleni			Simbiri's (someone's name) sorghum
Sibirinyoni			Truna's sorghum
Trunkani			
Fagotumate	-	Nyonifing (S)	Fagotumate - does not do well without fertile soils Nyonifing - black-glumed sorghum
Trukanidjema	-	Samanko (A)	White seed of the Trukas
Samanko	-	Trunkanidjema (A)	-
		-	
Seguetena	-		Taboo to striga
Namaramatenemaga	-	-	Tenemaga, son of mother Marama (name of the man that brought the variety)

The naming criteria are summarized in Table 4.9.

Table 4.9 Summary of farmers' naming criteria for varieties

Criterion	% varieties named (n=22)
Description of variety	36
Origin of variety	23
Purpose of cultivating the variety	18
Name of farmer who first introduced	14

variety	
Description + purpose of cultivation	5
Trivial names	5

Descriptive terminology was used to name 36% of the varieties. This included the adjectives for glume color, seed color, panicle size and sometimes the nature of the variety during its development. The second most frequently used criterion was the origin of the variety. For this, 23% of the varieties were named after the village of origin. The purpose of cultivating particular varieties was also a naming criterion for which 18% of the varieties were given names such as "sorghum for horses", "sweet sorghum", "fertilizer dependent", etc.' Fourteen percent of the varieties were named after the person who first brought them to the village. Varieties also had combined names: purpose for cultivating + description (5% of the varieties), and 5% of the varieties had names that seemed to be trivial.

There were two cases in which farmers considered a group of varieties by a composite name. These were:

i. *Kende* which included *Makononka* in Gonsolo and *Kendebleni, Kendefini* and *Kendejema* in Katibougou.

ii. *Kalosabani* in Gonsolo which included *Niaka wuleni, Sibirinyoni* and *Trunkani*.

The name *kende* in both Gonsolo and Katibougou had no specific meaning. It was the individual varieties that bore names that were either descriptive or stated origin. In the case of *kalosabani,* the category included all varieties that were of short duration.

4.5 Seed Production

In both Gonsolo and Katibougou, farmers conduct their sorghum seed production practices in a very similar manner. The usual practice is that at maturity, the best panicles that were free of diseases were selected and tied into bundles called *gerbes*. The number of *gerbes* maintained for seed is always in excess of the farmer's need for the following year. Selection history for individual farmers starts in the first year the variety was obtained and this continues year after year. Only male farmers carry out seed selection in Gonsolo.

All the farmers evaluated produce and store seed separate from grain. Seed on the *gerbes* are transported to town and hung either on rafters or on veranda posts. Farmers believe that sorghum seeds can remain viable in this manner for up to 7 years.

Chapter 5

Discussion

5.1 Farmers' germplasm base

The results indicate that farmers in both Gonsolo and Katibougou maintain considerable diversity of sorghum. This practice is extensive with farmers living in and producing a crop in difficult environments. They do this as a form of security against changing environmental and social conditions (Dennis, 1987). Richards (1985) found farmers in Sierra Leone growing 60 rice varieties in one village and suggested that the farmers maintain diversity of a crop for the additional purpose of improving local cultivars of that crop.

From the results obtained in both Gonsolo and Katibougou, the varietal diversity can be classed into four groups:

a) The obvious leading varieties in terms of the number of farmers cultivating them. These were *Tiemarifing* in Gonsolo, *Folomba* and *Sakoyka* in Katibougou.

Research question 1[3]. Do the varieties in this category maintain their genetic identity while grown by different farmers?
Research question 2. There were two distinct phenotypes of Sakoyka. Are they really the same variety?

b) The group of varieties under a single identity. These include the *kalosabani* set of varieties in Gonsolo whose grouping depended only on their short growth duration.

c) The *kende* varieties. The definition given by Cleveland (1999) qualifies the *kende* set of varieties as a sub-race of the super-race *guinea*. This is because a group of related varieties, sharing specific constant traits, are represented. Farmers in both Gonsolo and Katibougou believe that the *kende* set of varieties originated in the region. Most farmers interviewed believe that *kende* has been in the villages for more that 100 years, and no one remembers the origin. On this evidence, the *kende* varieties might be further regarded as the oldest landrace in the region. According to Rumker (1908), a landrace is a variety that has been growing in a particular region since time immemorial. Harlan (1975) relates that landraces are genetically diverse and consist of a mixture of genotypes, all of which are reasonably well adapted in the region.

d) The minor varieties, including *Fagotumate* (*Nyonifing*), *Trukanidjema* (*Samanko*), *Timinkala*(*Mangala*), *Seguetana* and *Namaramatenemaga* in Gonsolo and *Sobaku, Gadiaba, Timinkala, Tiemarifing, Tenekuka, Waradje, Bimbiri* and *Serakiolaka* in Katibougou.

The gradual process of one variety replacing another was in progress in Katibougou between the varieties *Folomba* and *Sakoyka. Sakoyka* was introduced into Katibougou during the colonial era (1950s) and was the most popular variety then. In recent years however, obtaining reasonable harvest from this variety depended largely on the use of organic fertilizers. The introduction of *Folomba* seemed to be a production relief in dealing with the continuously exploited fields in the village.

Farmers replaced varieties when they failed to be productive and do not meet the needs that they are grown for. Varieties that are of extraordinary long duration were easily replaced by varieties that mature early enough to meet food needs during hungry periods. The process of replacing a variety is gradual, and continues until such a time that enough confidence is built in the new variety. This is evident in the relationship between *Folomba* and *Sakoyka* in Katibougou. What makes it easier for farmers to adopt *Folomba* in the place of *Sakoyka* is, that the two varieties are very much similar in plant type and growth cycle. It is for the same reason of confidence building that the farmers just starting with *Folomba* are still growing *Sakoyka.* On account of the similarity between the two varieties, farmers without sufficient reason to drop *Sakoyka* find no reason for adopting *Folomba.*

Drongonba was a variety grown in both villages but has long been abandoned. The most obvious reasons for abandoning varieties was because of their long duration, followed by the decrease in yield and the high need for fertilization. It is clear from Tables 4.2 and 4.4 that more varieties were abandoned in Katibougou than in Gonsolo. This may be due to the fact that the farmers are responding continuously to the gradual degradation of their fields by using different variety options within their reach.

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[3] The research questions form the basis for the on-station field trials.

5.2 Characterization of local sorghum varieties

In order to understand farmers' interests in broad terms, a list of the desired traits was compiled (Table 5.1).

Table 5.1 Pooled desired traits - Gonsolo and Katibougou

Pooled Traits	Frequency	No. of varieties cited (n=21)	No. of farmers citing (n=31)
Adaptation	44	15	30
Food quality	44	19	22
Yield	28	10	23
Quality of harvested product	15	14	12
Resistance to biotic factors	18	11	11
Post-harvest processing	11	5	9
Total	**160**		

The general interest of farmers in both Katibougou and Gonsolo was in variety adaptation to general environmental conditions and food quality. Each was mentioned 44 times out of 160. Moreover, for adaptation and food quality, more varieties were considered (15 and 19 out of 18 varieties, respectively) and more farmers (30 and 22 out of 31 farmers, respectively) used the criteria in evaluating their varieties. Yield was next, mentioned 28 times (out of 160). The quality of grain and seed and the resistance to different biotic stresses were mentioned 15 and 18 times respectively. Processing of harvested products was least frequently mentioned (11 times out of 160). All mentions came from farmers. Women are in charge of post-harvest processing of harvested products and they particularly mentioned the difficulty of post harvest processing. This factor might have figured much higher if we had taken a quota sample of the gender.

The large number of traits farmers use to characterize their varieties demonstrates that their interests cannot be encapsulated into a single criterion (Farrington, 1988 cited in Baidu-Forson, 1997). Primary traits were described as components of adaptation to stresses found in their fields. It is the ability of a variety to survive within these stresses that determines its productivity. Adaptation in this case can be further broken down into (a) agronomic terms e.g. soil fertility and (b) the seasonal trends that determine how growth duration of the variety fits into the duration of rainfall. The importance of the adaptive ability explains why farmers are in the habit of trying unfamiliar varieties in the worst niches of their fields (Sthapit *et al.*, 1996). The practice is regarded as a risk control strategy. It therefore suggests that to these farmers yield comes in second place to adaptability.

Although maximum production to meet the food needs remains at the top of farmers' minds, the quality of the variety to be used as food largely determines its acceptability. Grain and seed qualities were important criteria for considering the quality of a variety. Adaptation to biotic stresses determines survival of the variety both on the field and in storage. This essentially is the characteristic of well-adapted varieties such as landraces. It might also seem reasonable to group the product quality trait with that of resistance to biotic resistance because seed and grain quality actually depend on the degree of resistance the variety shows to biotic pests, e.g. grain mould, anthracnose and covered smut.

The male farmers gave post-harvest processing little consideration. This may be due to the fact that this is something they left to the women. Women were responsible for the threshing, de-hulling and milling of sorghum. On the other hand, it may be due to the fact that the processing of sorghum is a difficult task, regardless of the variety.

5.3 Seed source

The role of neighbors and relatives in traditional seed systems is not a new phenomenon in itself. It involves farmer-to-farmer seed exchange, seed donations and other transfer methods to meet social obligations (Cromwell, 1992). Cromwell and Zambezi (1990) reported that up to two-thirds of farmers' bean seed in Malawi comes from neighbors, relatives and other local sources. In Ethiopia, most seed transactions take place between neighbors and relatives because farmers prefer to see the crop stand in a neighbors' farm before deciding on obtaining the variety (Singh, 1990).

From what we have learnt about Gonsolo, the system of exchange for the acquisition of new varieties supports the value given to seed as a family asset. A farmer may stand to lose a lot if he continues to lose his seed and go into certain forms of exchange to get them back. Thus, farmers tend to maintain their varieties with great care and interest. This in turn accounts for the number of years farmers have acquired/inherited their varieties. Experience with varieties per family is traced back over long periods, and the general trend is the handing down of the variety from father to son.

The open system of farmers getting varieties in Katibougou appears to be more dynamic in terms of seed being obtained on a frequent and free basis. The majority of farmers gave great value to the influence of neighbors when it came to obtaining seed. A close study of the system revealed that it was rather the insecure nature of the seed system in the village that upholds the dynamism of the flow of varieties in the community. Because farmers lose seed readily, they make frequent requests to neighbors. The time-scale of individual farmer's experience with varieties suggests that seed is easily obtained and lost, and then obtained again (see table 4.3). The form of acquiring seed is not necessarily replacing an old variety with a new one, but replacing a lost variety with the same type, or another known variety. In the process, new varieties can be obtained, but on a less frequent basis.

5.4 Naming of varieties

The system of naming varieties by farmers suggests that there is a strong need to keep track of varieties. The criteria can be explained in simple terms:

i. Descriptive: Descriptive names distinguish one variety from the other if there happen to be similarities. A farmer obtaining seed will know exactly what he is getting even if it is not apparent in the seed.
ii. Purpose: This explains the aspect for which the variety is important.
iii. Origin: Naming varieties after their origin is important to keep a record of where the variety came from. In the case of loss, it is easy to look for it if desired.
iv. Farmer Name: Similarly, the name of the farmer who first brought the variety to the village gives a clue about the origin of the variety.
v. Trivial names: The name of some varieties seems to be meaningless. This may happen when a variety was brought from a different culture with a name that seems meaningless to the village. In such cases, the origin of the variety can easily be lost or forgotten as in the case of the varieties *Tinekuka,* and *Bimbiri* in Katibougou.

The naming system also included synonyms and acronyms. Varieties with more than one name had a first name that is apparently trivial. The second names are often meant to explain the meaning of the first name, sources, or a descriptive word to explain the characteristics of the variety. E.g. *Bibagalawili* is a phrase explaining the productive nature of the variety *Tiemarifing*, and *Sonyo* is the name that explains that *Gadiaba* is cultivated to produce food for horses. *Nyotelini* explains the 'quick' maturing nature of *Kalosabani* varieties, while *Nyonifing* is a word describing the black glume of *Fagotumate*.

Trukanidjema and *Samanko* are acronyms of two different varieties but because of their similarity, the names are interchangeable between the varieties. The farmers can easily establish their differences, particularly on the basis of origin, but the similarity lies in the phenotypic aspect of farmer classification and growth cycle.

Farmers were also of the habit of naming unknown varieties in accordance with phenotypic resemblance to known varieties. This was true for at least two farmers (Saidu Traoré, his variety *Tiemarifing*, and Nfale Koné with vareity *Sakoyka*) interviewed in Katibougou who had bought varieties from the market and gave them the name of existing varieties.

5.5 Seed Production

The seed production and storage practices in both Katibougou and Gonsolo ensures maximum seed security at the time of planting. Immediately before sowing, the *gerbes* are loosened and the panicles threshed. There were reported cases of germination failure due to poor seed quality and heavy rains. In such cases farmers can employ any of the following methods of obtaining seed for replanting:

i. by obtaining left-over seed from friends, relatives or neighbors
ii. buying seed from the market, especially in Katibougou and
iii. thinning seedlings on a neighbor's field to gap-fill the failed field.

Farmers may have seed left over and with no need to replant. In such a case the excess seed is either given to another farmer in need or included with the grain for consumption.

Research question 3: What is the effect of continuous farmers selection on the variation within a variety?

Conclusion

From this first part of the study, the following conclusion were drawn:

1. The farmers in the two villages maintained a diversity of sorghum varieties.
2. Farmers' variety characterization was based (in order) on adaptation, food quality, grain yield, quality of harvested products, biotic stress resistance and post-harvest processing.
3. Farmers' classification was based (in order) on morphology, origin of variety, purpose of cultivation and name of farmer that first had variety.

Questions for further research

Although numerous research questions could be formulated from farmers understanding about their varieties, the three questions that form the basis of the second phase of this thesis research are:

1. Do varieties maintain their genetic identity while grown by different farmers?
2. Phenotypically different varieties were considered to be the same by farmers. Is there a scientific basis for this consideration?
3. What is the effect of continuous farmers' selection on the variation within a variety?

The on-station research that forms the second part of this study gives some clues to answering the above questions.

Part two

On-Station Evaluation

CHAPTER 6

Materials and Methods of the on-station trial

6.1 Varieties used[4]

The study to determine the genetic variation within and between two local sorghum varieties was conducted as an on-station evaluation of farmers' selections. The varieties used were *Folomba* and *Sakoyka* and they were obtained from 4 farmers in Katibougou. *Folomba* is presently the most widely grown variety in Katibougou and it was characterized by farmers as being adapted to poor soils and is high yielding. It was introduced into the village more than 20 years ago from another village called Kita in Mali. *Sakoyka* is an old variety and was obtained in the village since the years of colonial rule (before 1960), and was widely cultivated. The farmers believe that *Folomba* is replacing *Sakoyka*. Below is the profile of the varieties with each farmer from whom they were obtained:

Folomba 1 (glume color red): This variety was obtained from Zan Diarra of Katibougou. He had obtained 1 bundle (*gerb*) of the variety while harvesting on a neighbor's farm 15 years ago and has been cultivating it since. Before getting *Folomba*, he was growing *Sakoyka*. The first year he obtained *Folomba*, he grew both varieties in separate farms. He abandoned *Sakoyka* the following year because *Folomba* was better yielding and had larger grains. Mr Diarra selects good panicles for seed (6 - 7 *gerbs*, sometimes up to 10 *gerbes*) just before harvest every year.

Folomba 2 (glume color red): This variety was obtained from Billi Konaté. Mr. Konaté obtained 2 *gerbs* of the variety from his uncle, Kita Issa, during a collective harvest on Issa's farm. He had been growing the variety now for 7 years. He selects superior panicles at harvest each year to produce seed for the following year.

Sakoyka 1 (glume color, black): This variety was obtained from Nfaly Koné. He has been growing *Folomba* for about 5 years which he obtained from a neighbor Bobo. Bobo in turn had obtained it from a civil servant that brought it from a village called Kita. In 1997 he selected less than 10 panicles of the variety for seed because he had planned to grow maize the following year. At the start of the 1998 growing season, he lost both his maize and sorghum due to drought. He did not have sorghum seed to replant his field. He then sent his children to purchase sorghum seed from a grain merchant in the Katibougou market. The merchant had come from Bamako, but Mr. Koné speculated that the merchant had bought his ware from another village, Niono. Mr. Koné called this variety *Sakoyka*, because it resembled seed his parents grew by the same name.

Sakoyka 2: This variety was obtained from Mr. Bah Haidara who first moved to Katibougou in 1972. He has been growing only *Sakoyka* for the past 7 years. He had obtained 2 *gerbes* of the variety from his neighbor, Zan Diarra, during collective harvest on the latter's field. He selects good panicles each year at harvest to produce seed for the following year.

The farmers themselves selected one hundred panicles of each of the two varieties just before harvest in 1998. These were labeled and kept in paper envelopes for use as seed for the on-station trial. Table 6.1 gives the farmers names and number of panicles selected.

Table 6.1 Population and names of varieties used for on-station evaluation

Sample	Population	Variety Name	No. of panicles	Name of farmer
1	1	*Folomba*	100	Zan Diarra
2	2	*Folomba*	100	Billi Konaté
3	1	*Sakoyka*	100	Nfaly Koné
4	2	*Sakoyka*	100	Bah Haidara

6.1.1 Field layout[5]

The soils at the ICRISAT trial sites at Samanko which were used for the trial, had been left fallow for 3 years. They were of the tropical ferocious type, brownish yellow in color and with the pH ranging from 5.0 to 5.5. Organic matter content was low (6 to 8%) and Cation Exchange Capacity (CEC) was between 2.0 and 3.0%. These soils need high fertilization for crop establishment.

A tractor was used to plough on the 15th of June 1999. Basal fertilizer (NPK SB complex type 14 - 22 - 12 - 7 - 1) was applied by a mechanical applicator at the rate of 300 kg/ha. This was thoroughly mixed with the soil on the 25th of June.

[4] The choice of materials, field layout and planting were carried out by ICRISAT Plant Breeding staff .

A tractor traced plot rows on the 26th of June. A plot constituted a single ridge row of 5 m long and 0.75 m between the plots. This gave a net plot size of 3.75 m^2.
Each replication covered an area of 474.4 m^2, giving the total area used for all 12 trials as 5692.5m^2.

Each population was treated a separate experiment. The experimental design used was the lattice 10 x 10 design with each experiment replicated 3 times. Total number of plots was 110 per replication, including 10 plots of check varieties. The check varieties were CSM 335 and CSM 660.

The four populations were evaluated in experiments adjacent to each other. The experiments were planted on the 27th of June 1999. Five to six seeds were sown per hill at a distance of 0.5 m apart. This gave a total of 10 hills per row plot. The two checks were alternated after every ten rows in each replication.

The first weeding was done on the 13th and 14th day after seeding. Immediately after the weeding, thinning was done to 2 seedlings per hill. The second fertilizer application was done 27 days after seeding. The fertilizer used was urea (46 - 0 - 0) at the rate of 50 kg/ha (2 g per hill) in a ring form around every hill. The third fertilizer (urea) application was done 40 days after seeding, at the dose of 50 kg/ha (23 kg N/ha or 2 g N/hill).

Harvesting of the trials started on the 1st of November and each of the 12 trials was harvested in a single day. Immediately before the harvest of any trial, the farmer that had donated the variety was invited to conduct a tour through the trial and comment on his variety. The farmer's comments were noted.

Harvesting was done by breaking the stalk at about 1 m above ground level for the ease of reaching the panicles. Each panicle was cut about 3 cm below the last node with a sharp knife. The panicles were then laid adjacent to their respective plots and the farmer and the breeders did further evaluations.

6.1.2 Data collection

The following traits were observed in each plot:

i. Seedling vigour

Seedling vigour was determined visually at 2 weeks after sowing. A 0 - 9 scale was used, 0 representing a very weak seedling vigour, and 9 representing an excellent seedling vigor.

ii. Development vigor

Development vigor was assessed visually 5 weeks after sowing. A 0 - 9 scale was used, 0 representing a very weak plant vigor, and 9 representing excellent plant vigor.

iii. Number of days to 3 plants heading

The number of days to 3 plants flowering was recorded as the number of days from seeding to the day when 3 plants flowered.

iv. Number of days to 50% heading

The number of days to 50% heading was recorded as the number of days from seeding to the day when 50% of plants in the plot flowered.

v. Plant height (cm)

The heights of 3 random plants were measured in centimeters from the ground level to the tip of the tallest panicle. A long ruler graduated from 0 to 600 cm was used for this measurement. Plant height was calculated as the average of the three plants measured.

vi. Number of plants

The total number of plants harvested was recorded.

vii. Number of panicles

The number of harvested panicles, including sterile panicles, was counted.

viii. Panicle weight (kg)

Panicle weight was determined by weighing (in kg) the harvested panicles. Because the panicles were collected in a cloth bag, the average weight of a bag was first obtained and it was subtracted from the total weight of bag + panicle. An electric laboratory scale was used to weigh the samples.

ix. Grain yield (kg)

After obtaining the panicle weight, threshing was done. Grain yield was determined by weighing (in kg) the total amount of grain.

x. Anthracnose susceptibility

Anthracnose is a disease caused by *Colletotrichum graminicolum,* that attacks during the vegetative growth stage and continues up to the maturity stage of the plant. The disease symptoms can be found on leaves and at maturity, on the panicle rachis or branches and on the grains. The severity of the symptoms was scored visually at harvest (for grain symptoms). The scale used was as follows:

Score	Trace of anthracnose on the grains
1	0%
2	1 -5%
3	6-10%
4	11-20%
5	21-30%
6	31-40%
7	41-50%
8	51-60%
9 -.	More than 75%

xi. Senescence

Senescence was assessed visually at maturity. It was determined by quantifying the amount of chlorophyll still present in the leaves of the plant at maturity. It was scored by using the 0 - 9 scale: 0 representing no plant part is green, 1 representing 10% of plant still green, and 9 representing more than 90% of the plant green.

xii. Sterility

This was obtained at harvesting. Panicles that were completely sterile were counted and recorded.

The following panicle characteristics were included in the data when it was discovered, during farmer evaluations that farmers were very much interested in number of nodes, and number of panicle branches.

xiii. Panicle length (cm)

Panicle length was measured in cm. This was done for two randomly selected panicles, which were measured from the first productive node to the tip of the panicle. Panicle length was calculated as the average of the two panicles measured.

xiv. Number of nodes per panicle

Number of nodes per panicles was obtained by counting the average number of productive nodes of two randomly selected panicles. Sterile panicles and panicles that were damaged were not included. A node is characterized by a complete ring around the rachis.

Shifted nodes were counted as one and this was the same for nodes with scattered nodal branches. Panicle branches appearing at inter-nodes were not counted, except if such a spot holds at least two branches and portrays some nodal characteristics such as a budge or a partial ring. The last node was characterized by multiple branches close to the tip of the panicle.

xv. Number of panicle branches at the first productive node

This trait was observed for the same two randomly selected panicles (see xiii). The branches at the first productive node were counted. The first node was chosen as it appeared to have the largest number of branches and showed some variation with regard to the number of branches. If malformation at the first node was observed, the branches at the second node were counted.

6.1.3 Data Analysis

The SPSS statistical package was used to analyze the data obtained from the experiment. The initial analysis consisted calculating across all 100 entries range, means and standard deviation (SD) for each trait measured. Univariate analysis of variance per trait was then carried out to determine for which traits the variation within populations was significant. The coefficient of error variation (CV) was calculated simultaneously.

After obtaining the software output, the heritability in the wide sense (h^2_w) was calculated as follows:

$h^2_w = \sigma^2_g / \sigma^2_p$ where

$\sigma^2_g = (MS_t - MS_e)/2.27$ where

2.727 approaches number of replications

$\sigma^2_p = \sigma^2_g + \sigma^2_e/r$

r = number of replications = 3

σ^2_g = genetic variance

σ^2_p= phenotypic variance

σ^2_e = error variance

MS_t = treatment mean square

MS_e = error mean square

Character association was studied through the calculation of coefficients of correlation between all pairs of traits. Particular attention was given to developmental traits and reproductive traits. Development traits were seedling vigour, development vigour, number of days to flowering of 3 plants, number of days to 50% flowering and plant height. Reproductive traits were grain yield, panicle length, panicle weight, number of nodes per panicle and number of branches at first panicle node.

The standard t-test was done to determine the equality of means between *Folomba* 1 and *Folomba* 2; *Sakoyka* 1 and *Sakoyka* 2.

For each trait, the null hypothesis was:

$\mu 1 = \mu 2$, where

$\mu 1$ = mean of one population of one variety for a particular trait

$\mu 2$ = mean of the other population of the same variety for the same trait.

The null hypothesis was rejected if the 2-tailed significance was <0.05; otherwise it was not rejected.

The correlation coefficient for each pair of traits was calculated across the 100 genotypes by the computer software.

Table 6.2 Traits, summary names, and abbreviations used in the text were as follows (All measurements are per plot).

Trait	Summary name	Abbreviation
Seedling vigor	Seedling vigor	Sdl.vg
Development vigor	Development vigor	DV
Number of days to 3 plants flowering	3 plants flowering	Fl.3 plts
Number of days to 50% flowering	50% flowering	Fl.50%
Plant height	Plant height	Plt.ht
Number of plants	No. of plants	No.plt.
Number of panicles	No. of panicles	No.pan.
Panicle weight (g)	Panicle weight	Pan.wt.
Grain yield (g)	Grain yield	Gr.yld.
Anthracnose susceptibility	Anthractnose	Anth.
Senescence	Senescence	Sene
Sterility	Sterility	Ster.
Panicle length (cm)	Panicle length	Pan.ln
Number of nodes per panicle	No. of nodes	Nod.
No. of branches at 1st node of panicle	No. of branches	Bran.

Chapter 7

Results of the on-station trial

Folomba 1

The range, mean and standard deviation of the morphological traits measured for *Folomba* 1 is given in table 7.1. A high significant variance among the 100 entries was observed for all the traits, except for seedling vigor, number of plants and number of panicles per plot. The average number of days to 3 plants flowering and 50% flowering were 91 and 95 days, respectively. Plant height ranged from 398 to 557 cm, with the average of 492 cm. The average panicle weight and grain yield were 1123 and 772 g per plot respectively. Panicle length was 38.81 cm on average, and the average number of nodes was 11

The coefficient of error variation (CV) was lowest for number of days to 3 plants flowering and 50% flowering, each with a value of 0.3% (Table 7.2). These two traits, however, had the highest values for heritability in the wide sense ($h^2_w = 0.89$ for each one). Traits with high CV were seedling vigour, development vigor, panicle weight and grain yield. These traits had high heritability in the wide sense, except seedling vigor. Sterility had the highest CV (134%), and a low heritability in the wide sense ($h^2_w = 0.38$).

The correlation coefficients between the traits under study for *Folomba 1* are given in Table 7.3. Correlation coefficients between development traits and reproductive traits albeit significant at $P< 0.01$ were generally low, with values less than 0.4. Number of days to both 3 plants and 50% flowering were negatively correlated with number of nodes, panicle length, grain yield, panicle weight, number of plants and number of panicles. Plant height was positively correlated with panicle length, grain yield, panicle weight and number of panicles. The results also show that yield had a strong and positive correlation with panicle weight and number of panicles. Yield had a very low (less than 0.20) correlation with panicle length and number of nodes. Panicle length correlated significantly ($P < 0.01$) and in the positive direction (0.35) with number of nodes.

Folomba 2

There was no significant difference between the 100 entries with regard to development vigour, and sterility in *Folomba* 2 (Table 7.1). All other traits gave high significant differences (P < 0.01), except for seedling vigor and number of panicles that were significant only at P < 0.05. Number of days to 3 plants and 50% flowering were 92 and 93, respectively. Plant height ranged from 301 to 527 cm respectively, with an average of 475 cm. Average panicle weight and grain yield was 972 and 635 g per plot respectively. The average panicle length was 40 cm, and the average number of nodes was 12.

The coefficient of error variation was lowest for number of days to 3 plants and 50% flowering (Table 7.2). Each had a CV of 0.45%, and they had however, the highest values for the heritability in the wide sense. CV was high for seedling vigor, panicle weight and grain yield, and heritability in the wide sense was low for seedling vigor, average for panicle weight and high for grain yield. Sterility had the highest CV (93.2%), and a low value for heritability in the wide sense ($h^2_w = 0.02$).

Correlation coefficients between all traits measured for *Folomba* 2 are given in Table 7.4. Correlation coefficients were significant (P < 0.01) but low between developmental traits and the reproductive traits. Number of days to both 3 plants and 50% flowering were negatively correlated with number of nodes, grain yield, panicle weight, number of panicles, and number of plants. Yield had a significant and high positive correlation with panicle weight and number of panicles, but a significant negative correlation with number of days to 3 plants and 50% flowering, development vigor and seedling vigor. Panicle length and number of nodes per panicle correlated significantly and positively (0.24)

Table 7.1 Range, means and standard deviation (SD) for traits of Folomba 1 and 2

	Folomba 1			Folomba 2		
Trait	**Range**	**Mean**	**SD**	**Range**	**Mean**	**SD**
Seedling vigor	1 - 3	1.37ns	0.52	1 - 4	1.62*	0.71
Development vigor	1 - 6	2.64**	1.07	1 - 7	2.99ns	1.28
Flowering, 3 plants (days)	86 - 98	91.0**	1.77	84 - 101	92.0**	2.77
Flowering, 50% (days)	90 - 101	95.0**	1.76	86 - 103	93.0**	2.86
Plant height (cm)	398.3 -556.7	492.0**	28.83	301.3 -526.7	475.2**	27.2
No. of plants harvested	9 - 10	9.99ns	0.099	6 - 10	9.94**	0.36
No. of panicles harvested	12 - 39	23.09ns	4.09	11 - 51	23.25*	4.80
Panicle weight (g) per plot	585 - 172.5	1123.0**	250.0	304 - 1749	971.5**	240.96
Grain yield (g) per plot	228 - 1254	771.63**	219.58	106 - 1153	635.4**	204.53
Sterility	. 0 - 3	0.81**	1.22	0 - 4	1.48ns	1.49
Panicle length (cm)	31.5 - 47	38.81**	2.91	29.5 - 50.5	39.8**	3.12
No. of nodes	8 - 15	11.47**	1.04	9 - 15	11.88**	1.11
No. of branches at 1^{st} node	4.5 - 10.5	7.28**	1.14	4.5 - 9.5	7.25**	1.03

Note: ns and ** refer to the test for differences among the 100 entries of each variety
** Significant variation at the 0.01 level
* Significant variation at the 0.05 level
ns = not significant

Table 7.2 Coefficients of error variation (CV) and heritability in the wide sense (h^2_w) of Folomba 1 and 2

Trait	Folomba 1		Folomba 2	
	CV(%)	h^2_w	CV(%)	h^2_w
Seedling vigor	29.3	0.06	29.9	0.28
Development vigor	16.5	0.51	14.9	0.19
Flowering, 3 plants (days)	0.3	0.89	0.45	0.95
Flowering, 50% (days)	0.3	0.89	0.45	0.93
Plant height (cm)	3.2	0.46	4.0	0.59
No. of plants	1.0	-	3.1	-
No. of panicles	14.1	0.06	16.5	0.34
Panicle weight (g) per plot	15.2	0.57	16.7	0.55
Grain yield (g) per plot	19.8	0.50	18.7	0.70
Sterility	134.0	0.38	93.2	0.023
Panicle length (cm)	6.2	0.54	5.8	0.69
No. of nodes	7.4	0.57	6.8	0.70
No. of branches at 1st node	12.6	0.59	11.8	0.55

(-) = data not available

Table 7.3 Coefficients of correlation between traits of *Folomba 1*

	Ster	Bran	Nod	Pan.ln	Gr.yld	Pan.wt	No.pan	No.Pl	plt.ht	Fl.50%	Fl.3 plts	DV
Bran	0.01											
Nod	-0.04	-0.01										
Pan.ln	0.02	-0.02	0.35**									
Gr.yld	-0.19**	0.18**	0.12*	0.19**								
Pan.wt	-0.18**	0.08	0.08	0.19**	0.90**							
No.Pan	-0.04	0.04	0.03	0.02	0.48**	0.56**						
No.Plt	-0.1	-0.01	-0.05	-0.06	0.06	0.08	0.04					
Plt.ht	0	0.11	-0.02	0.17**	0.49**	0.49**	0.33**	0.01				
Fl.50%	0.23**	0.07	-0.17**	-0.22**	-0.30**	-0.3**	-0.17**	-0.06	-0.04			
Fl.3 plts	0.25**	0.09	-0.18**	-0.23**	-0.26**	-0.27**	-0.17**	-0.09	-0.05	0.87**		
DV	0.03	-0.13*	-0.1	-0.12*	-0.59**	-0.62**	-0.43**	-0.07	-0.64**	0.3**	0.3**	
Sdl.vg.	0.02	-0.08	-0.1	-0.07	-0.20**	-0.28**	-0.18**	-0.06	-0.13*	0.24**	0.22**	0.29**

** Correlation is significant at the 0.01 level (2-tailed)
* Correlation is significant at the 0.05 level (2-tailed)

Table 7.4 Coefficients of Correlation between traits of *Folomba 2*

	Ster	Bran	Nod	Pan.ln	Gr.yld	Pan.wt	No.pan	No.plt	Plt.ht	Fl.50%	Fl.3 plts	DV
Bran	-0.11											
Nod	0.17	-0.09										
Pan.ln	0.14*	-0.14*	0.24**									
Gr.yld	-0.36**	0.1	0.09	-0.13*								
Pan.wt	-0.29**	0.07	0.1	-0.1	0.93**							
No.Pan	-0.09	-0.03	-0.05	-0.13*	0.42**	0.48**						
No.Plt	0	0.03	0.11	0.07	0.09	0.11*	0.12*					
Plt.ht	0.04	-0.06	0.05	0.03	-0.01	0.03	-0.08	0.04				
Fl50%	0.3**	-0.12*	-0.16**	0.05	-0.3**	-0.23**	-0.14*	-0.18**	0.26**			
Fl.3 pts	0.3**	-0.11	-0.19**	0.02	-0.32**	-0.25**	-0.12*	-0.17**	0.26**	0.89**		
DV	0.22**	-0.13*	-0.05	-0.01	-0.52**	-0.54**	-0.4**	-0.17**	0.07	0.32**	0.36**	
Sdl.vg.	0.22**	-0.07	-0.08	-0.02	-0.36**	-0.4**	-0.32**	-0.08	-0.17**	0.19**	0.24**	0.6**

** Correlation is significant at the 0.01 level (2-tailed)
* Correlation is significant at the 0.05 level (2-tailed)

Sakoyka 1

Variation among the 100 *Sakoyka* 1 entries was not significant for seedling vigour, development vigor, number of plants, anthracnose, sterility and number of branches at the first node (Table 7.2). There was a high significant variation ($P < 0.01$) for the other traits. The number of days to 3 plants and 50% flowering were 90 and 92 respectively. Plant height ranged from 398 to 540 cm, with an average of 497 cm. Panicle weight and grain yield had average values of 1088 g and 801 g respectively.

The coefficients of error variation were lowest for number of days to 3 plants and 50% flowering (Table 7.6). Each had a CV of 0.4%, and they gave highest values for heritability in the wide sense. High CV values were obtained for seedling vigor, development vigor, panicle weight, grain yield, susceptibility to anthracnose and senescence. Heritability in the wide sense was considerably low for seedling vigour and development vigor. The highest CV value was obtained for sterility (184%), which had the lowest value for heritability in the wide sense ($h^2_w = 0.1$). CV was low for panicle length and number of nodes per panicle, with a moderate and low heritability in the wide sense respectively.

Correlation coefficients between development traits and reproductive traits were generally low, with values less than 0.4 for *Sakoyka* 1 (Table 7.7). Number of days to both 3 plants and 50% flowering were negatively correlated with grain yield and panicle weight at $P < 0.01$, and with number of panicles at $P < 0.05$. Plant height was significantly correlated with number of nodes, senescence, grain yield and panicle weight. Grain yield gave a reasonably high correlation value with panicle weight, number of panicles and plant height. Panicle length and number of nodes per panicle correlated significantly.

Sakoyka 2

No significant differences between the 100 entries were observed for the development vigour, number of plants and number of panicles (Table 7.6). There was also no significant difference for senescence and sterility. A high significant difference ($P < 0.01$) was, however, observed for number of days to 3 plants and 50% flowering, which had average values of 90 and 92 days respectively. Panicle and grain weights gave averages of 1105 and 777 g per plot respectively, and plant height ranged from 383 to 523 cm, with an average of 473 cm.

Coefficients of error variation were very low for number of days to 3 plants and 50% flowering (Table 7.4), and their heritability in the wide sense were the highest. CV was also low for panicle length and number of nodes per panicle, and they also had reasonably high heritability values. CV was high for seedling vigor, development vigor, panicle weight, grain yield and senescence. Sterility had the highest CV value (185.6%) and the lowest heritability in the wide sense ($h^2_{w=}$ 0.09).

Correlation coefficients between the traits of *Sakoyka* 2 are presented in Table 7.8. Correlation coefficients between development traits and reproductive traits were significant but generally low, with values less than 0.4. Number of days to both 3 plants and 50% flowering were negatively correlated with number of nodes, grain yield, panicle weight and number of panicles and positively correlated with development vigor. Plant height was significantly but negatively correlated with sterility, development vigor and seedling vigor. Grain yield had a significant and positive correlation with panicle weight, number of panicles, and plant height. Yield had a rather high negative correlation with development vigor (-0.46) and seedling *vigor* (-0.40).

Results of the t-test for the equality of the means of *Folomba 1* and *2* are presented in Table 7.9. From the results, no significant difference was found between the means of the two varieties for the number of panicles. For all the other traits, the test failed to establish similarity between the means of the two varieties. All differences were significant at P = 0.01.

Table 7.5 Range, means and standard deviation (SD) for traits of Sakoyka 1 and 2.

Trait	Sakoyka 1			Sakoyka 2		
	Range	Mean	SD	Range	Mean	SD
Seedling vigor	1 - 3	1.57ns	0.68	1 - 4	1.94**	0.72
Development vigor	1 - 5	2.73ns	0.79	1 - 5	3.17ns	0.79
Flowering, 3 plants (days)	84 - 98	90.0**	2.49	85 - 96	90.0**	1.90
Flowering, 50% (days)	86 - 101	92.0**	2.60	86 - 101	92.0**	1.99
Plant height (cm)	398 - 540	496.9**	21.213	383.3 - 523.3	473.2*	26.79
No. of plants	9 - 10	9.97ns	0.17	9 - 10	9.98ns	0.13
No. of panicles	15 - 40	22.87**	4.41	11 - 42	23.89ns	4.88
Panicle weight (g) per plot	518 - 1639	1088.0**	211.5	378 - 1939	1105.0**	271.96
Grain yield (g) per plot	342 - 1265	800.8**	173.8	185 - 1487	776.7**	238.28
Anthracnose	1.21 - 2.23	1.75ns	0.83	1 - 3	1.69**	0.32
Senescence	1 - 4	2.92**	0.75	1 - 5	2.49ns	0.92
Sterility	0 - 4	0.39ns	0.73	0 - 10	0.69ns	1.38
Panicle length (cm)	29 - 66	37.41**	3.42	30.5 - 48.5	39.15**	3.51
No. of nodes	10 - 16	12.67**	1.19	7 - 18	12.97**	1.39
No. of branches at 1st node	5.5 - 10.5	7.58ns	1.101	4.5 - 11	7.052 **	1.03

Note: ns and ** refer to the test for differences among the 100 entries of each variety
** Significant variation at the 0.01 level
* Significant variation at the 0.05 level
ns = not significant

Table 7.6 Coefficients of error variation (CV) and heritability in the wide sense (h^2_w) of Sakoyka 1 and 2

Trait	Sakoyka 1		Sakoyka 2	
	CV(%)	h^2_w	CV(%)	h^2_w
Seedling vigor	29.0	0.17	21.2	0.38
Developmentvigor	19.	0.14	15.	0.1
Flowering, 3 plants (days)	0.4	0.92	0.4	0.83
Flowering, 50% (days)	0.4	0.94	0.4	0.90
Plant height (cm)	3.0	0.57	3.4	0.34
No. of plants	1.7	-	1.3	-
No. of panicles	12.0	0.64	14.9	0.25
Panicle weight (g) per plot	13.9	0.55	16.4	0.51
Grain yield (g) per plot	14.9	0.65	18.6	0.61
Anthracnose	86.0	0.59	12.9	0.74
Senescence	19.3	0.39	30.5	0.21
Sterility	184.0	0.1	185.6	0.09
Panicle length (cm)	7.6	0.56	6.0	0.76
No. of nodes	8.1	0.41	8.7	0.61
No. of branches at 1st node	12.7	0.18	11.6	0.62

(-) = data not available

Table 7. 7 Coefficients of Correlation between traits of *Sakoyka 1*

	Anth	Ster	Bran	Nod	Pan.ln	Sene	Gr.yld	Pan.wt	No.pan	No.Plt	Plt.ht	Fl.50%	Fl.3 pts	DV
Strer	0.05													
Bran	0.02	0												
Nod	-0.02	0	-0.01											
Pan.ln	-0.07	0.08	0.11	0.22**										
Sene	0.12*	0.05	0.02	-0.04	0.01									
Gr.yld	-0.05	-0.07	0.1	0.06	0.05	0.17**								
Pan.wt	-0.03	-0.07	0.11	0.05	0.08	0.17	0.97**							
No.Pan	0.05	-0.07	0.14*	0.04	0.03	0.1**	0.62**	0.68**						
No.Plt	0.04	0.04	0.06	-0.01	-0.03	-0.1	0.07	0.07	0.05					
Plt.ht	0.07	0	0.09	0.15**	0.02	0.21**	0.2**	0.18**	0.05	0.11*				
Fl50%	0.12*	0.08	0.03	-0.04	-0.11	0.18**	-0.29**	-0.22**	-0.12*	-0.04	0.1			
Fl.3 Pts	0.15*	0.09	0.01	-0.06	-0.11	0.21**	-0.28**	-0.21**	-0.12*	-0.06	0.08	0.95**		
DV	-0.05	0.05	-0.11	-0.1	-0.06	-0.17**	-0.49**	-0.49**	-0.44**	-0.04	-0.35**	0.18**	0.18	
Sdl.vg.	-0.06	0.02	-0.19**	-0.08	-0.02	-0.17**	-0.37**	-0.38**	-0.38**	-0.02	-0.36**	0.07	0.07**	0.63**

** Correlation is significant at the 0.01 level (2-tailed)
* Correlation is significant at the 0.05 level (2-tailed)

Table 7.8 Coefficients of correlation between traits of *Sakoyka 2*

	Anth	Bran	Nod	Ster	Pan.ln	Sene	Gr.yld	Pan.wt	No.pan	No.Plt	Plt.ht	Fl.50%	Fl.3 pts	DV
Bran	-0.06													
Nod	-0.05	-0.24**												
Ster	0.06	0.07	-0.09											
Pan.ln	0.16**	0.23**	-0.02	0.07										
Sene	0.06	-0.05	-0.01	0.01	0.05									
Gr.yld	-0.21**	-0.02	0.13*	-0.24**	-0.02	-0.24**								
Pan.wt	-0.22**	0	0.1	-0.24**	0	-0.24**	0.98**							
No.Pan	0.03	-0.11	0.02	-0.13*	-0.02	-0.13**	0.7**	0.7**						
No.Plt	-0.05	0.04	0.07	0.05	-0.05	0.05	0.1	0.11	0.09					
Plt.ht	-0.03	0.05	-0.08	-0.17**	0.12*	-0.17	0.48**	0.5**	0.5**	0				
Fl50%	0.09	0.14*	-0.21**	0.1	0.08	0.1	-0.23**	-0.2**	-0.2**	-0.05	0.06			
Fl.3 plt	-0.08	0.1	-0.21**	0.09	0.07	0.09	-0.23**	-0.2**	-0.15**	-0.3	0.08	0.91**		
DV	0.09	-0.05	-0.09	0.08	0.06	0.08	-0.46**	-0.44**	-0.35**	-0.07	-0.33**	0.23**	0.22**	
Sdl.vg.	0.02	-0.1	-0.01	0.08	-0.08	0.08	-0.4**	-0.39**	-0.26**	-0.08	-0.27**	0.07	0.07	0.52**

** Correlation is significant at the 0.01 level (2-tailed)
* Correlation is significant at the 0.05 level (2-tailed)

Table 7.9 Results of the T-test for testing equality of means of *Folomba 1* and *2*

Trait	Mean Difference
Seedling vigor	-0.25**
Development vigor	-0.35**
Flowering, 3 plants (days)	1.22**
Flowering, 50% (days)	1.31**
Plant height (cm)	16.8**
No. of plants	0.05**
No. of panicles	-0.16ns
Panicle weight (g)	151.3**
Grain yield (g)	136.27**
Sterility	-0.67**
Panicle length (cm)	-0.99**
No. of nodes	-0.41**
No. of branches at 1st node	0.02**

Note: The null hypothesis is that the means of the two varieties are equal
** = reject null hypothesis at 1% significance.
ns= Accept null hypothesis.

In the case of *Sakoyka 1* and *2* the t-test gave no significant difference between the means with regard to number of plants harvested, panicle weight and grain yield. The results however showed that for all the other traits, the t-test rejected similarity of the means of the varieties. All these differences between means were significant at P = 0.01.

Table 7.10: Results of the T-test for the equality of means of *Sakoyka 1* and *2*

Trait	Mean Difference
Seedling vigor	-0.37**
Development vigor	-0.44**
Flowering, 3 plants (days)	-0.91**
Flowering, 50% (days)	-0.75**
Plant height (cm)	23.76**
No. of plants	-0.013ns
No. of panicles	-1.01**
Panicle weight (g)	-16.93ns
Grain yield (g)	24.08ns
Senescence	0.43**
Panicle length (cm)	-1.74**
No. of nodes	-0.30**
No. of branches at 1st node	0.52**

Note: The null hypothesis is that the means of the two varieties are equal
** = reject null hypothesis at 1% Probability.
ns= Accept null hypothesis.

T-tests for the equality of means was also done for comparing means of *Folomba 1* and *Sakoyka 1, Folomba 1* and *Sakoyka 2*, *Folomba 2* and *Sakoyka 1* and *Folomba 2* and *Sakoyka 2*. These are given in Tables 7.11, 7.12, 7.13 and 7.14 respectively.

Table 7.11 Results of the T-test for testing equality of means of *Folomba 1* and *Sakoyka 1*

Trait	Mean Difference
Seedling vigor	-0.21**
Development vigor	-0.09ns
Flowering, 3 plants (days)	3.22**
Flowering, 50% (days)	3.06**
Plant height (cm)	-4.88**
No. of plants	0.02ns
No. of panicles	0.12ns
Panicle weight (g)	35.05ns
Grain yield (g)	-29.19ns
Panicle length (cm)	1.39**
No. of nodes	-1.19**
No. of branches at 1st node	-0.29**

Note: The null hypothesis is that the means of the two varieties are equal
** = reject null hypothesis at 1% Probability.
ns= Accept null hypothesis.

Table 7.12: Results of the T-test for the equality of means of *Folomba 1* and *Sakoyka 2*

Trait	Mean Difference
Seedling vigor	-0.57**
Development vigor	-0.53**
Flowering, 3 plants (days)	2.32**
Flowering, 50% (days)	2.32**
Plant height (cm)	18.87**
No. of plants	0.01ns
No. of panicles	-0.89**
Panicle weight (g)	18.12ns
Grain yield (g)	-5.11ns
Panicle length (cm)	-0.34ns
No. of nodes	-1.49**
No. of branches at 1st node	0.22*

Table 7.13 Results of the T-test for testing equality of means of *Folomba 2* and *Sakoyka 1*

Trait	Mean Difference
Seedling vigor	0.04ns
Development vigor	0.25**
Flowering, 3 plants (days)	2.00**
Flowering, 50% (days)	1.76**
Plant height (cm)	-21.76**
No. of plants	-0.03ns
No. of panicles	0.37ns
Panicle weight (g)	-116.67**
Grain yield (g)	-165.47**
Panicle length (cm)	2.38**
No. of nodes	-0.79**
No. of branches at 1st node	-0.33**

Note: The null hypothesis is that the means of the two varieties are equal
** = reject null hypothesis at 1% Probability.
ns= Accept null hypothesis.

Table 7.14: Results of the T-test for the equality of means of *Folomba 2* and *Sakoyka 2*

Trait	Mean Difference
Seedling vigor	-0.32**
Development vigor	-0.18**
Flowering, 3 plants (days)	1.09**
Flowering, 50% (days)	1.01**
Plant height (cm)	2.00ns
No. of plants	-0.05ns
No. of panicles	-0.64ns
Panicle weight (g)	-133.61**
Grain yield (g)	-141.39**
Panicle length (cm)	0.65ns
No. of nodes	-1.08**
No. of branches per 1st node	0.19ns

Chapter 8

DISCUSSION

The high degree of variability for the developmental traits (number of days to 3 plants and 50% flowering and plant height) and the reproductive traits (panicle length, number of nodes per panicle, number of branches at the 1st node, and yield) was consistent for all the 4 populations studied. This could be due to the wide variation for the traits measured within the populations studied. These variations seem to be a general characteristic of landraces, which enables them to remain stable in marginal environmental conditions (Harlan, 1975a).

The number of days to 3 plants and 50% flowering was observed to get and idea of the earliness of the varieties. Sorghum landraces are generally known to have a short-day photoperiodic response, and flowering traits are controlled by day-length distribution. Rao *et al*. (1996) found that flowering time varied considerably for the same cultivars when grown in different regions in India with different day-length conditions. The number of days to flowering may not be a very important issue to sorghum cultivation in Mali, due to an almost constant day-length. It is still an important consideration for plant breeders because it enables them to synchronize plant flowering periods for hybridization purposes. Since there is a positive significant correlation between number of days to flowering of 3 plants and 50% flowering for all populations studied (between 0.87 - 0.95), there is no need to obtain both data for this crop.

One of the main characteristic features of traditional sorghum is its tallness. Maximum plant height given by House (Undated) for sorghum is 400 cm, but heights reaching 655 cm were reported by Rao *et al*. (1996). Mean plant height obtained in this study was above 470 cm for all 4 populations, with maximum heights exceeding 500 cm. During harvest of the trials, farmers commented that the station plants were taller than those on their own fields of the same varieties. The excess in plant height may be attributed to the high amount of fertilizer that was applied on the trial fields. Farmers in Mali tend to appreciate taller plants for the purpose of using the stalk to construct fences. The dry matter is also a principal raw material for organic manure, which is obtained by first feeding animals with the straw and collecting animal dung which is used on the farm for crop production.

The level of variation obtained for panicle characteristics from the trials confirmed farmers' interest in the trait. The farmers tend to know that these variations existed and used them as criteria for selecting new varieties. The normal habit for farmers is to consider such traits while selecting between different varieties. However, it also gives reason why farmers look for superior panicle types at crop maturity to produce seed for the coming season (Richards, 1985; Harlan, 1975b).

The coefficients of error variation are a function of the error variance of the trait and the mean, thus expressing the level of residual variation for a trait in each population. A high degree of consistency of the CV was observed from the results presented for the 4 varieties studied. It showed that CV was low for most of the traits that gave significant levels of variation from the analysis of variance. This can be explained by the fact that experimental error was low for the traits with low CV. The figures given in the CV table improves our understanding about the error variability existing within each population for a particular trait.

It is understandable why the variation for the days to flowering could have resulted to the variability in the other traits. The variation in flowering time gave ample possibility for exchange of pollen between different varieties, which might have ensured exchange of genetic material, hence the higher variation for the reproductive and other traits as well.

Heritability in the wide sense was calculated because sorghum is to a large extent, a self-pollinating crop. The results indicate differences in efficiency of selection for the traits studied. The relationship between the CV and h^2_w from these results showed that traits with high CV tend to have a low efficiency of selection, as indicated by their low value of h^2_w. It gave an indication that morphological variation tends to increase in the latter stages of crop development, which increases efficiency of selection. This suggests that selection can be more effective for traits expressed at later stages of development than for traits expressed at earlier stages. This is supported by similar conclusions by Jaradat (1991).

The number of days to 3 plant and 50% flowering were either negatively correlated or have a very low correlation with almost all the reproductive traits. This could be due to the fact that the more a plant invests in morphological development, the less it invests in grain yield. In other words, investing in the morphological development by the plant is done at the expense of grain yield. This suggests that early maturing plant types may give better yield returns and can be selected for (Jaradat, 1991). Yield in this research was considered from the breeders' point of view. Farmers in Mali, however, consider production in a broader sense, which includes grain yield (for food), straw (for construction and animal feed) and leaves (for animal feed). In this study, however, we did not take the biomass yield into consideration. This could be necessary for future research, wherein farmers' production requirements are taken into consideration. The adoption of most research materials, developed with the breeders' view, is low because of such differences in view between breeders and farmers.

The high degree of mean differences as indicated by the t-tests for each pair of varieties suggested that:

i. farmers are growing different varieties but are calling them by the same name. This was evident from the two *Sakoyka* varieties obtained from two different farmers. The two varieties were distinctly differentiated by glume color: *Sakoyka* 1 is black glumed, while *Sakoyka* 2 is red glumed. However due to the visual resemblance in all other traits, the farmers believe that the varieties are the same.

ii. different farmers in possession of the same variety could have different management practices that determine how pure the variety is maintained. The management of fields and varieties determines the extent to which farmers go to maintain genetic purity or encourage genetic variation by exchange of genes between different varieties (Bellon *et al*., 1997). Coincidences in flowering dates of different varieties combined with variety proximity are factors that influence gene flows. Deliberate or accidental direct mixture of varieties is another major way of introducing variation within a particular variety (Dennis, 1987).

Conclusion

It has been demonstrated that a high level of variation for the traits studied exists within farmers varieties, despite the effectiveness of annual selection of panicles for seed production. It was evident that the variation for days to flowering traits resulted to high variation in reproductive traits.

The correlation relationships between traits of farmers' varieties signify the features that are common for these varieties, especially landraces. Their low yielding ability could be attributed to the high level of investment by the plant in morphological development.

It was also demonstrated that the same varieties that are cultivated by different farmers are likely to lose their identity for certain traits. The management of fields and varieties by such farmers (field distances between different varieties), are potential causes of variation between otherwise similar or identical varieties.

It also became clear that two phenotypically different varieties that are considered the same by farmers can prove to be dissimilar by several characteristics. On the other hand, the varieties do share certain characteristics that make farmers consider them as the same variety. It is unclear whether the latter does influence farmers' decision. The only conclusion that could be drawn from this research in this case is that more participatory work is required between farmers and breeders to understand each others' perception about varieties.

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