

**Promoting fonio production in
West and Central Africa through
germplasm management and
improvement of post harvest
technology**

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By

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The crop



- Fonio (*Digitaria exilis* Kipp. Stapf and *Digitaria iburua* Stapf) are minor cereal crop species which are cultivated throughout West Africa from Senegal to Lake Chad.
- In this zone, fonio is either a staple food or food for hunger period. It supplies food to 3-4 million people
- It is also increasingly highly prized by nutritionists for its richness in methionine and cystine, two amino acids vital to human health but deficient major cereals such as wheat, rice, maize, sorghum or barley

The crop



Since 1974, Fonio is in the the USA Academy of Sciences priority list for underexploited African tropical plants with promising economic value in West and Central Africa.

Exploration and collection of germplasm of fonio (*Digitaria excilis*)

Countries visited: Benin, Guinea, Mali, Nigeria, Togo



- Grain of fonio





Husked grain of fonio

Unhusked grain of fonio



Project Description

- The overall **goal** of the project is to promote the production of fonio in West Africa.
- More specifically the project aims at improving the seed systems and on-farm germplasm management of fonio, to conserve the genetic diversity of the crop and to enhance its processing techniques

Project Description

The project has three major components:

- Collecting, characterization and evaluation of germplasm:

This component includes local germplasm collecting in Benin, Mali and Nigeria and their agro-morphological and biochemical characterization.

Project Description (Cont.)

- Post-harvest technology: This component includes assessment of fonio grain loss from harvest to threshing and testing of various threshing and hulling methods
- Traditional seed system: Farmers practices for fonio seed production and dissemination were assessed.

N.B: The project also facilitated the organization of national meetings of various actors involved in research, production, processing and trade of fonio to share views and to identify priority areas for research and/or development actions.

Outcomes: Germplasm collecting, charact/evaluation

- **Collecting germplasm**

- In Mali, 24 ecotypes/accessions have been collected in Bogoro, Diagani, Somo and Nongosso (San) and Bumbolo, Sokoro, Sadien and Kin (Tominian).

- There are very little differences among cultivars collected from one village to another. For example, the variety Wèlè wèlè is present in several villages.

Outcomes: Germplasm collecting, charact/evaluation

Collecting germplasm (Cont.)

It was observed that names given to cultivars by farmers are not very distinctive feature. Two distinct varieties could have the same name but are different for morphological and genetic traits. Farmers may also give different names to the same variety according to ethnic group and trait most valued by a given community.

NB: A threatened variety is identified in Somo: Ebe Ohoun which is a medium to long duration variety (100 days).

Outcomes: Germplasm collecting, charact/evaluation

Agro morphological characterization and evaluation

- In Nigeria, 62 accessions were characterized. Morphological traits used are growth cycle, grain colour, seed colour, leaf-tip shape, internodes, leaf pubescence, culm type etc.
- The results indicated that several cultivars could not be separated based on agro morphological characterization

Outcomes: Germplasm collecting, charact/evaluation

Cytogenetic studies

Ten accessions tested in Nigeria showed very little variation in chromosome numbers and are mostly euploids. Most of the accessions studied are hexaploid with chromosome number of $2n=54$, while few are diploid with chromosome number of $2n=30$ and $2n=34$

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Outcomes: Germplasm collecting, charact/evaluation

Cytogenetic studies (Cont.)

*In Benin three accessions of black fonio (*D. iburua*) from Togo and eighty eight (88) accessions of true fonio (*D. exilis*) from Benin, Guinea, Mali and Togo were evaluated.*

*Mean values of nuclear DNA content calculated for the different landraces of Benin and Togo showed that *D. exilis* and *D. iburua* have similar nuclear DNA content (about 2 pg).*

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Project Outcomes

Cytogenetic characterization (Cont.)

Cytogenetic characterization

Benin:

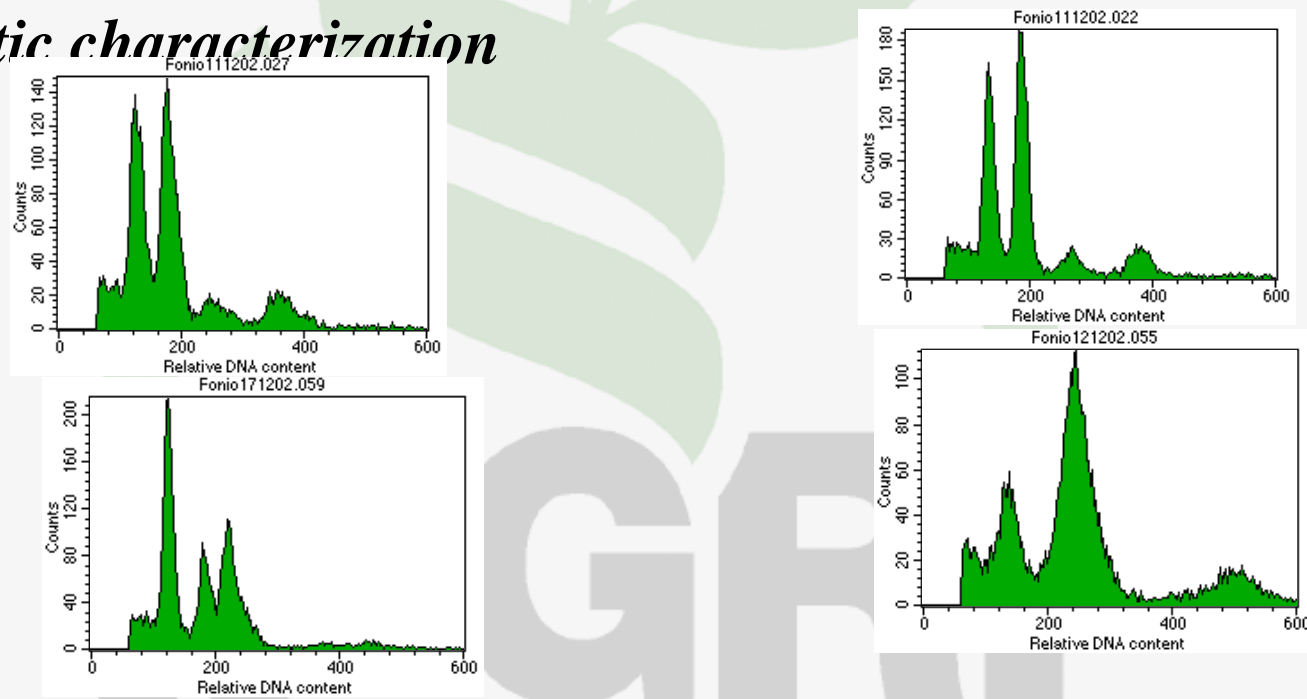


Figure 3: Histograms of relative nuclear DNA content obtained after analysis of nuclei isolated from young leaf tissues of *Raphanus* and *Digitaria*.

Outcomes: Germplasm collecting, charact/evaluation

Cytogenetic studies (Cont.)

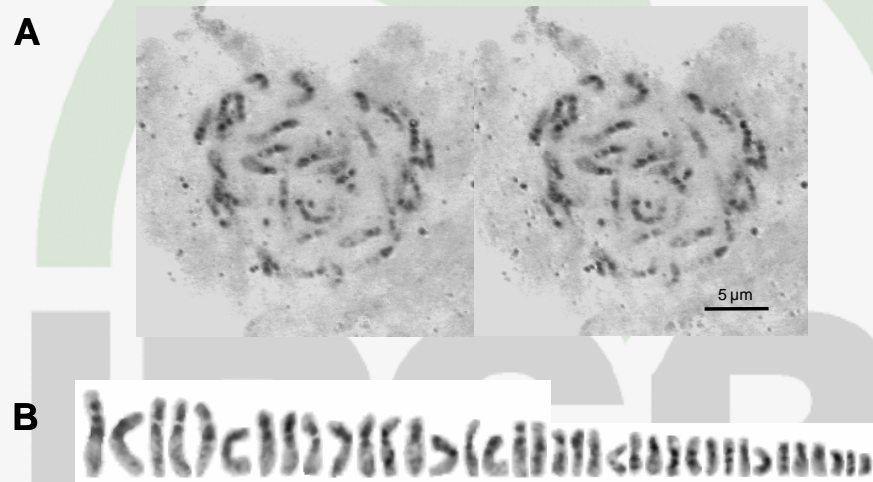


Figure 4 : *Digitaria exilis* chromosomes ($2n=36$) accession from Ben2. (A) :Spatial somatic metaphase cell (stereo pair can be observed with prism glasses or without glasses at a distance of about 30 cm);(B): Karyogram established from the same cell

Outcomes: Germplasm collecting, charact/evaluation

Cytogenetic studies (Cont.)

*Synthesis of results obtained from the two countries revealed that the chromosome number for *D. exilis* varies from $2n = 34$, to $2n = 54$ and $2n = 30$ to $2n = 34$ for *D. iburua*. These are indications that more are needed on the crop DNA nuclear content and ploidy in order to determine accurately factors influencing its genetic diversity.*

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Outcomes: Seed Systems

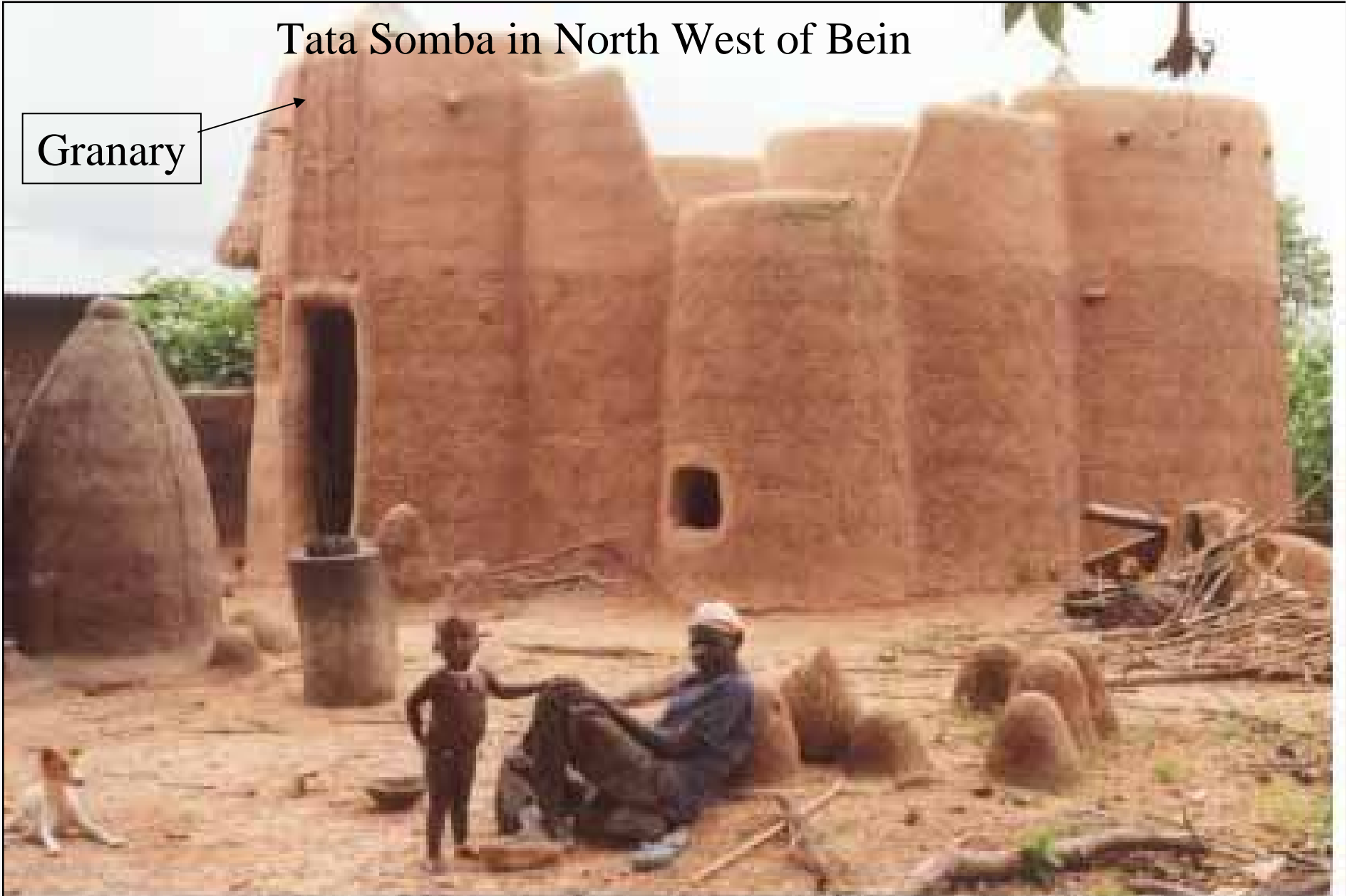
The community seed system was assessed in all 4 countries.

Benin: Fifty farmers were surveyed in 11 villages. The results indicated that the main seed sources are from farmers' stores. Seeds are obtained through exchange among farmers. seeds are well conserved in clay granaries for one to two years maximum after which a decrease in viability is observed. Women farmers are queen in seed conservation, but distribution is done by men.

- **Guinea:** Among 295 people surveyed, 112 said they produced their own seeds. Most of them answered that the major seed source is from previous harvests. Seed is also acquired as gifts from colleagues (83 respondents) and by exchange (74 respondents) . Very few farmers buy fonio seed from markets (22 respondents only).

Tata Somba in North West of Bein

Granary







Outcomes: Testing threshing and milling techniques in Benin

The experiment was conducted in Boukombé, north west Benin. The investigation took place in three households. In each household three threshing methods and three husking methods were tested. The threshing methods were: threshing on paved soil, threshing on non paved soil and threshing on canvas sheet. For the husking, three technologies are used: husking with mortar, husking in a hole in the ground and husking with Sanoussi Diakité's machine

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Outcomes: Testing threshing and milling techniques in Benin Cont.)

Threshing on canvas sheet method and husking with the Sanoussi machine are new technologies developed by research and agricultural services. While the other methods of threshing or husking are traditional

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Fonio: A treasure for West Africa

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Introduction

Fonio, one of the oldest and richest cereals of West Africa, is unknown to many people and neglected by research and extension services. Adapted to poor soils and limited water supply, fonio is an excellent dry areas crop which grows and produces where other crops fail.

Origin and distribution

- West Africa is home to three unique millets: *Digitaria exilis* (white fonio), *Digitaria iburua* (black fonio) and *Bracharia deflexa* (guinea millet/fonio)
- Fonio is the oldest cereal of West Africa and is widely grown from Senegal to Lake Chad, on the Fouta Djallon in Guinea, the Bauchi-Plateau in Nigeria and in north-west Benin and scattered elsewhere.

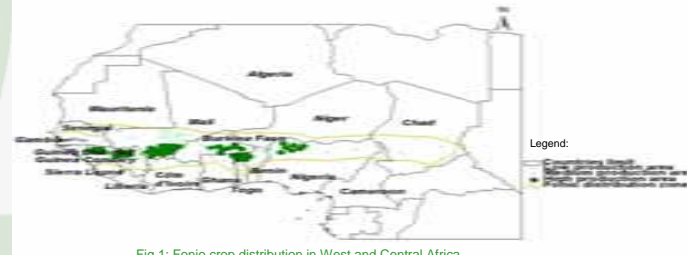


Fig 1: Fonio crop distribution in West and Central Africa



Fig 2: Harvested fonio (at the left) and woman selling fonio in a local market in Togo (at the right)

A multipurpose crop for West African people

- Food security:** Fonio is a staple food in dry areas of many West African countries (Guinea, Gambia, Mali, Burkina Faso, Benin, Senegal, Togo). It is crucial to food security particularly in hungry seasons and critical periods when food reserves in the household is low.
- Nutrition and healing properties:** the seed is rich in two vital amino acids for humans: methionine and cystine. The richness in these amino acids makes it an excellent complement to legumes. Fonio is also regarded as a grain with medicinal and healing properties; it is recommended for lactating women and diabetic people and is often used in diets of sick people.
- Income generation and economic values:** Fonio is a small scale farmers' crop and provides important income to the household; the price of a kg of cleaned fonio is about 1.5 to 2 times that of rice. The straw is also used to feed animals or mixed with clay to build houses.
- Cultural values:** Fonio is considered a sacred crop in some areas and plays a central role in social events and celebrations. It is used for the reception of important and prestigious personalities and is an important part of dowry in many Sahelian communities.
- Environmentally safe crop:** Fonio requires very little input in its cultivation (no fertilizer, no pesticide) and is highly adapted to drought and low-fertility soils.

Important crop, but neglected

For a long time, research activities in the region have been oriented towards major cereals such as maize, rice and sorghum. The interest in fonio is relatively recent. The crop has been neglected by research and extension services. Factors that contribute to its low yield and that need to be the focus of research are:

- its tiny grain: 1000 grains weigh about 0.44g
- its shattering characteristic: fonio easily shatters at maturity and grain losses of 10 to 30% occur if the harvest is delayed (fig 3).
- inappropriate harvesting technique: local tools and traditional harvesting methods lead to significant loss between the cutting and threshing areas.

The strenuousness of traditional threshing and husking methods used, which generally result in poor quality of the final product, are additional reasons for the neglect of the crop (Fig. 4).

Extension and research approaches

Research efforts at national and regional levels focus on:

Genetic diversity and production: germplasm of fonio is collected, characterized and conserved. Promising cultivars are selected and released to farmers.

Improvement of threshing and husking methods: a new husking machine is developed (SANOUSI's husker). New threshing and husking practices are being tested.

Improvement of the product quality: techniques and methods to produce sandless fonio (**premium fonio**) are being developed.

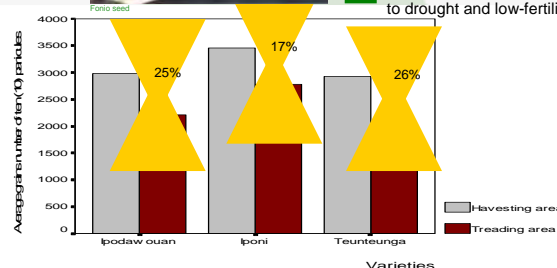


Fig 3: Average grain number of fonio panicle and losses level (in %) from harvest to threshing



Fig 4: Fonio threshing area (a woman holding the threshing pestle)



Fig 5: Sanoussi husker: a small machine for a big task

Results

National/International research institutes and development organizations in the sub region are now devoting more attention to the crop. The following results have been achieved:

Through participatory approach, major limiting factors to the promotion of the crop was identified by farmers, processing units and research institutes.

Five cultivars of early to medium growing cycle and with good yielding potential are released to farmers.

A husking machine is locally developed and adopted. Other tools introduced are being tested.

Post harvest technologies to reduce grain losses are being experimented.

Conclusion

More people are now interested in fonio for its qualities. To satisfy an ever increasing demand, farmers and processing units expressed concerns about existing cropping and processing systems. Research efforts in recent years are yielding promising results and should be encouraged and supported at national and international levels.

Outcomes: Testing threshing and milling techniques in Benin (Cont.)

- The results indicated that the use of canvas has not significantly contributed to increase threshing yield (45% vs 42.5% without canvas). However, the farmers witnessed that when canvas is used, there is very little sand in the final product and there is gain of time and in water used to clean the product.
- It was clearly demonstrated that the combined use of canvas and Sanoussi's machine is the most efficient processing method. It improved the quality of the final product and contributed to a savings of time, labour and water.

Outcomes: Testing threshing and milling techniques in Benin (Cont.)

- In Guinea the imported machine GMBF 02 gives very interesting husking, milling and winnowing results:
 - Husking: up to 130Kg/h with an average husking index of 75%.
 - Milling: 200Kg/hour with 90% milling yield

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Outcomes: Testing threshing methods in Guinea

Three threshing methods were compared: 1) threshing machine "Type ASSI"; 2) threshing with stick; 3) foot threshing

- The mechanical threshing assured good quality product and reduced labour and time needed to clean the product.; the rate of non threshed panicle is only 2% against 8% for foot threshing and 10.5% for the stick. Threshing with machine requires 70% less time than manual threshing.

Outcomes: Assessing grain loss in Guinea

The grain losses recorded at maturity, harvest and during transportation to the threshing surface were evaluated.

Losses are evaluated at four stages: 1) before maturity; 2) at maturity; 3) at harvest; 4) and during transportation to threshing area.

The results revealed that the average number of grains of 10 panicles decreased from 1280 to 799 grains from pre maturity (phase 1) to the threshing area (phase 4) with an overall loss of 35.5%.

Outcomes: Assessing grain loss in Guinea

*The assessment of the losses during the post harvest operations is very important as it indicates the great portion of grain lost due to mismanagement. Any improvement of the technology at that stage will substantially improve the total grain yield by **20 to 30%** and make the crop more attractive to farmers.*

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Outcomes: Biochemical characterization in Mali

- **Eleven varieties of *D. exilis* from Guinea, Mali and Benin were tested.**
- **The results showed that the protein content varied according to varieties between 7.86 and 16.97 g/100g. The variety Wélé wélé showed the highest protein content (16.97 g/100g). This is very important as protein contents for cereals reported in the same area range from 9 to 12 %.**
- **All tested varieties have similar carbohydrate content (77.9 - 80.25 g/100g) except for accession Wélé Wélé which showed the lowest carbohydrate content (70.85 g/100g).**

Outcomes: Biochemical characterization in Mali

- **The lipid content is also similar for all varieties (3.12 -4.06 g/100g). With regards to the mineral contents, the results revealed that, phosphorus and potassium are the major. This is similar for other cereals such as sorghum or maize.**

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Le Fonio: un regain d'intérêt en Afrique de l'Ouest

L

Le fonio (*Digitaria exilis*) est certainement la plus ancienne céréale cultivée en Afrique de l'Ouest. A cause des difficultés de transformation surtout du décortiquage, il est resté longtemps à l'état de céréale marginale

La mécanisation des opérations post-récoltes a ouvert de nouvelles perspectives pour mieux valoriser le fonio sur le marché urbain où il est bien apprécié. Le fonio qui a été longtemps considéré comme une céréale mineure, la « céréale du pauvre » connaît de nos jours un regain d'intérêt en zone urbaine en raison des qualités gustatives et nutritionnelles que lui reconnaissent, les consommateurs.

Spontanément et avec l'appui des autorités locales et de diverses organisations non gouvernementales, de nouveaux produits à base de cette céréale et de nouveaux circuits de commercialisation émergent.

Le fonio, une céréale de bonnes qualités nutritionnelles

N°	Céréales	Energi (Kcal)/100	Hydra carb	Protéine	Vit B1 (mg)	Vit B3 (mg)	Ca (mg)	Fer (mg)
1	Mil	341	71,6	9,4	0,3	1,7	22,0	20,7
2	Sorgho	340	74,0	9,4	0,25	3,7	45,0	8,8
3	Maïs	357	73,6	9,4	0,33	2,2	16,6	3,6
4	Riz décortiqué	346	79,8	7,0	0,17	5,4	6,0	2,4
5	Blé	322	69,5	11,6	0,32	4,5	35,0	3,1
6	Fonio	332	74,4	7,1	0,24	1,9	40,0	8,5

Le fonio, une céréale consommée sous plusieurs formes

Trois principales formes de préparation du fonio sont largement répandues dans la sous-région :

- Le couscous indique un mode de cuisson des grains à la vapeur. Celui-ci peut être accompagné d'une sauce salée ou de lait et de sucre.
- Le fonio "au gras" est le mode de cuisson des grains directement dans une sauce grasse avec des légumes et de la viande ou du poisson.
- La bouillie indique un mode de cuisson dans l'eau. Elle peut être légère, plus ou moins épaisse jusqu'à former une pâte consistante (tô de fonio).
- Les farcis, les croquettes sont de nouvelles formes qui viennent varier le plat du quotidien.



Des variétés en étude à l'IRAG

Le fonio: une céréale de grande diversité génétique

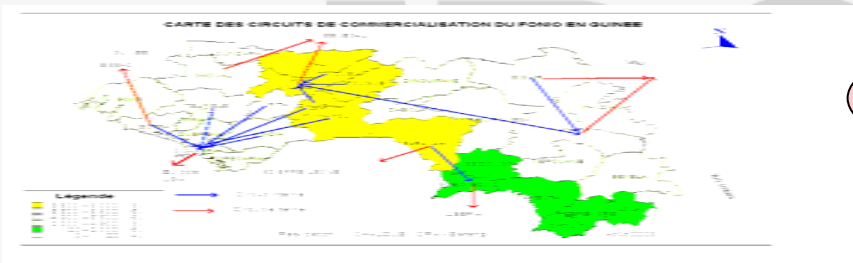
46 variétés ont été identifiées en Guinée:

- 16 variétés extra précoces (70 –85 jours et 500 – 1 000 kg/ha) ;
- 15 variétés précoces (85 –100 jours et 800 – 1 500 kg/ha) ;
- 15 variétés semi-tardives (100 –120 jours et 1500 – 2 500 kg/ha).



Aubergine farcie de fonio

Le Fonio, une spéculation de rente en Guinée



La Guinée exporte environ par an :

- 400 tonnes (2002) vers le Sénégal
- 203 tonnes (2002) vers le Mali
- 175 tonnes (2003) vers la Guinée Bissau
- 10 à 20 tonnes de fonio précuit en sachet et 25 tonnes de fonio blanchi lavé vers l'Amérique et l'Europe.

Des équipements pour fournir en quantité aux consommateurs un produit de qualité

Les études techniques réalisées dans le cadre du projet sous-régional CFC – Fonio, ont abouti à l'adaptation d'une batteuse et à la mise au point d'un décortiqueur blanchisseur GMBF de type « engelberg » et de plusieurs équipements de nettoyage : canal de vannage, cribles rotatifs, dessableur. Certains de ces équipements ont été installés en zone rurale et dans de petites entreprises, à Bamako au Mali, à Labé en Guinée, à Bobo Dioulasso au Burkina.



Le décortiqueur GMBF (130 – 200 kg/h)

Des efforts restent à fournir pour mettre à la disposition des utilisateurs, les technologies mises au point

Conclusions and perspectives

- Characterization of germplasms of fonio collected in Benin, Guinea, Mali and Nigeria revealed limited intra specific diversity, but more studies are needed to confirm interactions genotype/environment and interactions between morphological traits and amino acid content of grains.
- Grain loss at harvest heavily affects the crop yield and therefore compromises farmers' production efforts. In-depth studies of factors controlling the shattering habit of fonio will be beneficial for improving the crop yield.

Conclusions and perspectives

- Existing threshing and milling methods generally yield poor quality final product (high percent of sand, stone and other scraps). Using threshing and husking or milling machines improves the quality of the product and increase its market value. The high cost of the modern equipment made it unaffordable to individual farmers. While waiting for private sectors or Government support to make this material available at local communities levels, adoption of intermediate technologies (Combination of canvas and mortar) is proposed.

Conclusions and perspectives

- A second phase of the project is needed for more investigations in the following areas:
 - Testing and selection of varieties with good yield potential, low shattering habit, rich in favourable amino acids,
 - Facilitating farmers' access to improve seeds
 - Developing and testing in collaboration with farmers appropriate cropping systems
 - Creating and testing locally reproducible threshing, husking and milling equipment
 - Exploring new markets for fonio products.



THANK YOU

JE VOUS REMERCIE