

Full Length Research Paper

Genetic diversity and indigenous knowledge of fonio (*Digitaria exilis stapf*) produced in Burkina Faso

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Fonio (*Digitaria exilis* [Kippist] Stapf) species is from Africa. In Burkina Faso, the genetic diversity of fonio is little known. It is the same for its mode of management and the understanding of its culture. The objective of this study is to contribute to a better knowledge of fonio grown in Burkina Faso. Prospecting collects a permit to identify production areas and collect 60 accessions. The ethnobotanical survey made it possible to collect endogenous knowledge relating to the plant. Fourteen ethnic groups were encountered in 231 people surveyed. Both explained and unexplained vernacular names have been observed. Fonio is a plant of great importance for populations in terms of food and is part of the cultural identity of several ethnic groups. It is also a source of income for the local populations. A gradual abandonment (35.30% of respondents) of its cultivation has been observed because of the painful post-harvest transformation process. The endogenous knowledge collected within the local population will serve as a guide for the valuation of the species. The required accessions will be used for other studies such as agromorphological, biochemical and molecular genetic characterization to better identify its diversity, conserve it and better enhance the species.

Key words: Fonio, genetic diversity, indigenous knowledge, Burkina Faso, postharvest quality, shelf life.

INTRODUCTION

Fonio is a native species to Africa with food, sociocultural, therapeutic, and economic potentialities (Cruz and Béavogui, 2011). It is well adapted to local pedoclimatic conditions and tolerant to drought due to being with C4-type metabolism (Cruz and Béavogui, 2011). It also plays an important role, especially during the lean seasons (Blench, 2012). In addition, fonio is low

in gluten that could be indicated for diabetics because of being relatively low in glycemic index (Traore et al., 2009) compared to other grains such as rice. However, fonio has remained a minor crop to contribute to agricultural diversification though just like other neglected and underused crop species play a potential crucial role in food security and poverty alleviation. Nevertheless,

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agricultural diversification is highly promoted to minimize the negative impacts of climatic variations on agricultural production (Ward et al., 2014).

In Burkina Faso, there is scanty information on the variability, genetic diversity and extent of cultivation of fonio crop. The strategies and methods of conservation of fonio plant genetic resource are still the work of farmers in a global context of climate variations. This scenario suggests a need to develop a modern conservation strategy for sustainable management and enhancement of fonio in Burkina Faso. In addition, indigenous knowledge and know-how, generally transmitted from generation to generation, is an important source of information for understanding the evolution and characteristics of traditional varieties like fonio. Therefore, the objective of present study was to determine genetic diversity and indigenous knowledge of fonio crop cultivated in Burkina Faso. The findings obtained in the present study will be used for genetic characterization and development of modern conservation strategy for sustainable management and enhancement of fonio in Burkina Faso.

MATERIALS AND METHODS

Description of the study area

Prospecting-collection was carried out in three regions of Burkina Faso, namely the Hauts Bassins region, the Cascades region and the Boucle du Mouhoun region. Depending on the position of the isohyets, these regions fall into two climatic domains of Burkina Faso which are the the Sudano-Sahelian domain and the Sudanian domain (Thiombiano and Kampmann, 2010). The main characteristics of climatic domains are: The southern Sudanian domain located south of the 11th parallel roughly corresponds to isohyet 900 mm. This area, which occupies the entire south, is the wettest in the country with rainy season which lasts six months with maximums that can reach 1300 mm per year with average annual temperatures varying from 20 to 25°C.

The Sudano-Sahelian or northern Sudanian domain located between the 11th and the 14th parallel is between the 600 and 900 mm isohyets. This zone extends over the entire center and constitutes the largest climatic region of Burkina Faso (half the surface of the country) with a rainy season that lasts four to five months and temperatures between 20 and 30°C.

Selection of the study area

Based on the areas where fonio is produced, 31 localities spread over the three regions have been identified. Identification of villages where fonio is grown were made with the support of the provincial directors (DP) and Heads of Technical Animation Zones (ZAT) of the decentralized services of the Ministry of Agriculture and also in collaboration with the agents of the Institute of the Environment and Agricultural Research (INERA). In each locality the GPS coordinates were taken.

Selection of the participants

Producers or former producers of fonio were chosen randomly. A total of 231 people were surveyed.

Particular care was given to the sex ratio by interviewing as many

men as women per village.

Collection of accessions

Fonio accessions were collected in three regions of Burkina Faso from 2019 to 2020 to identify potential areas for cultivation, indigenous knowledge used management and accessions for further studies. Collection was carried out with the support of the provincial directors (DP) and the heads of the Zones Animation Technique (ZAT) and also in collaboration with the agents of the Institute of the Environment and Agricultural Research (INERA).

Procedure for data collection

An ethnobotanical survey was carried out in the different prospecting-collection areas. In each selected village, interviews were conducted using structured and semi-structured questionnaires on taxonomic, socio-cultural and economic aspects of the fonio, etc. They were organized in focus groups.

Statistical data analyses

Mapping of the fonio prospective areas, survey sites and accessions collection sites was made using ArcGIS software. The collected data was fed into the SPHINX plus V5 software. This software was used for data analysis. It was also used to calculate citation frequencies, construct graphs and tables.

RESULTS

Scope of fonio cultivation

Main areas cultivating in Burkina Faso are shown in Figure 1. The finding in the present study revealed that fonio was mainly produced in five provinces. Provinces identified for cultivation of fonio crop were Comoé and Léraba in the Cascades region; Houet and KénéDougou in the Hauts Bassins region; and Kossi in the Boucle du Mouhoun region (Figure 1). 60 accessions of fonio were collected and preserved in the germplasm of the Genetics and plant breeding team of the Biosciences Laboratory of University Joseph KI-ZERBO.

Socio-cultural characteristics of respondents

Distribution of respondents by province, sex and ethnical groups in Burkina Faso are shown in Table 1. The results showed that higher proportion of the respondents were men than women. Further, the results indicated that most of respondents were between 35 and 50 years of age followed by those who were aged above 50 years old while those who were aged between 20 and 35 years old were the minority. In addition, the results showed that respondent had belonged to 14 ethnic groups by which the majority were Turca followed by Senoufo and Toussian while other ethnic groups were the minorities in the present study. On the other hand, the study revealed that most of respondents (93%) were producing Fonio in

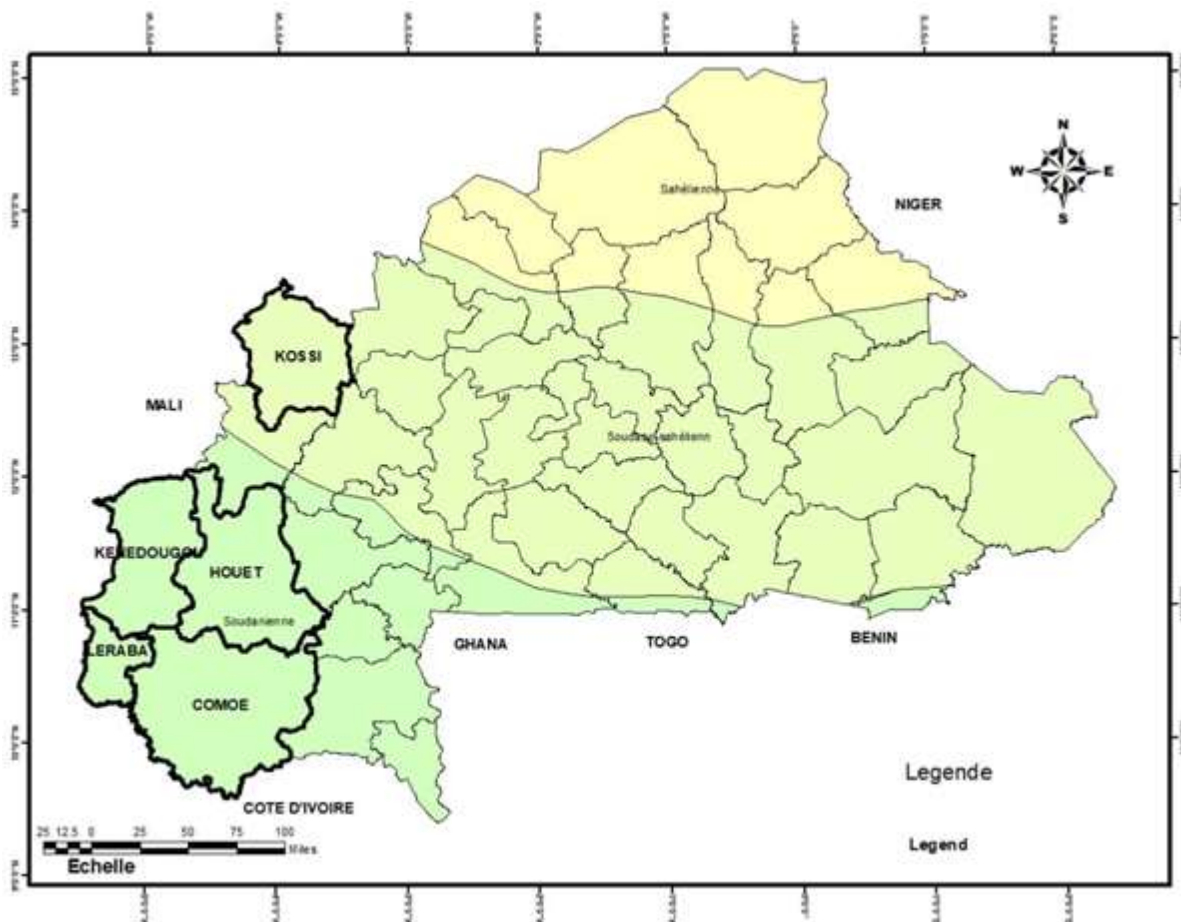


Figure 1. Main areas cultivating fonio in Burkina Faso.
Source: Authors

Table 1. Distribution of respondents by province, sex and ethnical groups in Burkina Faso.

Province	Age classes (years)			Sex		Ethnical groups
	20-34	35-50	> 50	Men	Women	
Comoe	17	11	23	38	13	Turca, Senoufo, Samo, Toussian, Forgeron
Houet	13	19	15	29	18	Forgeron, Toussian, Bobo, Turca,
Kenedougou	11	15	08	22	12	Senoufo, Toussian, Siamou, Mossi, Peulh, Sambla
Kossi	17	28	17	42	19	Bwaba, Kado, Mossi, Dafing
Leraba	11	16	10	23	15	Turca, Senoufo, Samo,
Total	69	89	73	154	77	14

Source: Authors

monoculture whereas only few (6%) of them were integrating with other crops particularly sorrels (*Hibiscus sabdariffa*).

Status of fonio cultivation

Status of fonio production in the surveyed areas is shown

in Figure 2. The findings in the present study revealed that some respondents (25%) had abandoned fonio production whereas some respondents (35.5%) highlighted that fonio cultivation has been declining during the past five years in some studied areas. Highest (80%) rate for abandonment of fonio cultivation was noted in Leraba province followed by Comoé (53%). However, the findings in the present study showed that

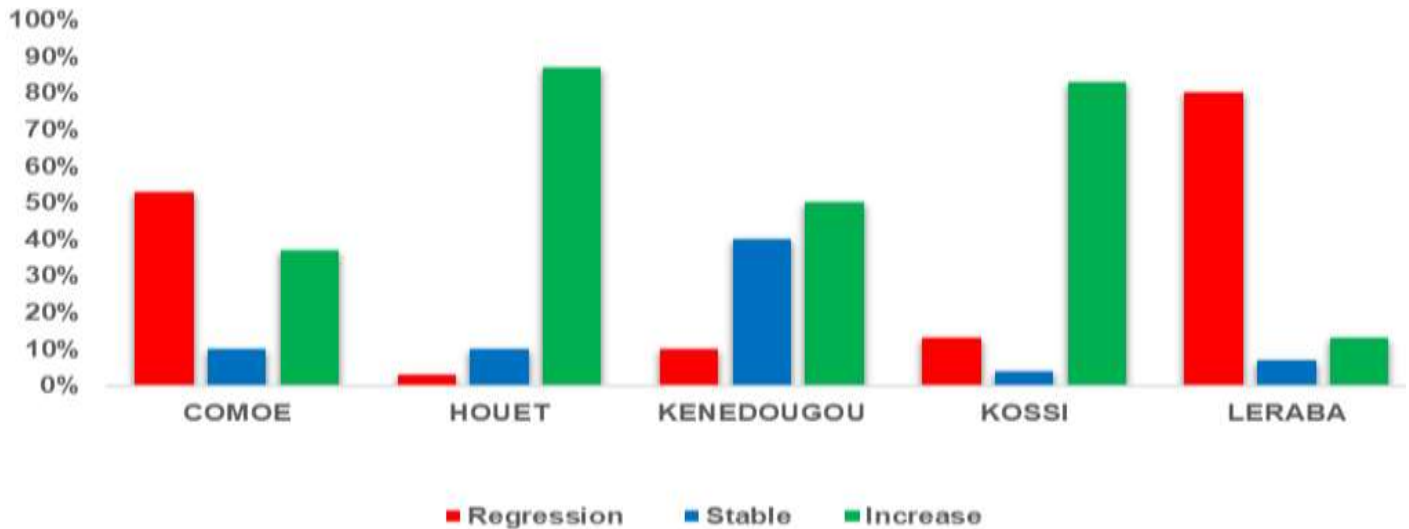


Figure 2. Status of fonio (*Digitaria exilis*) cultivation in the five surveyed provinces in Burkina Faso. Source: Authors

the rate of fonio cultivation was increasing in the provinces of Houet (87%) and Kossi (83%) as shown in (Figure 2).

Ethnobotanical nomenclature of fonio crop (*Digitaria exilis*)

The findings in the present study showed that most of fonio crop producers were using morphological traits to identify different fonio cultivars. Most of traits used to identify different fonio crop cultivars were plant growth cycle (87%) followed by the stem size (76%) and rarely grain characteristics (6%). Based on the traits fonio cultivars were classified into two major groups which were cultivars with [early growth cycle + small stem and small sized grain] and those with [late growth cycle + large stem and coarse grains].

On the other hand, fonio crop was known by several names among different ethnical groups in the study area. The names of fonio variety varied from two to nine within the same ethnic group (Table 2). These were often explained or unexplained appellations which generally reflected to types of varieties.

Sources and storage of fonio seeds

Different modes of sourcing fonio seeds are shown in Figure 3. The findings in the present study showed that fonio seeds were sourced through three different modes in the study area. Majority of the respondents had sourced fonio seeds through heritage followed by those who sourced seeds through donations. However, the least proportion of respondents were sourcing fonio seeds

through purchase. Moreover, fonio seeds were conserved by harvesting grains from ears in bulk after threshing without any selection pressure. Thereafter, fonio grains were mainly packaged in bags or rarely kept in canaries to keep it safe from insects and rodents.

Socio-economic and cultural importance of fonio crop

The findings in the study revealed that fonio crop had socio-economic and cultural importance in the study area. Most (51%) of the respondents highlighted that fonio had nutritional role followed by those (33%) who pointed its economic importance whereas the least (16%) highlighted that fonio had cultural value. Fonio flour was used in the preparation of the various dishes in the form of couscous, dough commonly known as fat fonio and porridge. In all studied areas, fonio flour was considered as food that strengthened health due to its digestibility and slimming properties. The majority (87%) of the respondents in the present study, showed that consumption of fonio dough provides health, relieves people with diabetes and was more advised for pregnant women.

In traditional medicine, fonio porridge was used by the respondents (33%) for the treatment of chickenpox while other respondents (20%) were using powder of roasted fonio grains for healing wounds. In addition, some respondents (32%) were using fonio grains in poultry feeds. Furthermore, fonio was a source of income for different households in the study area. Fonio products were marketed by women (8%) in local markets either in form (55%) of paddy or in shelled form (45%) at various prices. Tomato box of 2.2 kg (Figure 4) filled with

Table 2. Ethno-taxonomy of fonio by ethnic group.

Ethnicity	Vernacular names	Meaning	Morphotypes	Meaning	
Turca	<i>Fomou</i>	Food	<i>Sampin</i>	Late (cycle)	
	<i>Fom</i>		<i>Kenekene</i>	Early (cycle)	
			<i>Fomdebiri</i>	Late (cycle)	
	<i>Himbiiga</i>	Which looks like grass	<i>Lahla</i>	Early (cycle)	
		<i>Fombemou</i>	Early, Red Fonio (grain)		
		<i>foompoupla</i>	White Fonio (grain)		
Samos	<i>Pi</i>	Unrecognized			
	<i>Fonni</i>				
Senoufo	<i>Foo</i>	Unrecognized	Fonio of 3 months (name unknown)	Description: Small grains	
	<i>Fiinin</i>				
	<i>Fiiningui</i>				
	<i>Foue</i>		Fonio of 4 months (name unknown)	Description: Coarse Grains	
Forgeron	<i>Fii</i>	Unrecognized	Unrecognized		
	<i>Wourd</i>	Small grain food	<i>Wolontono</i>	Very early, (cycle)	
<i>Wourdè</i>			<i>Ouan</i>	Early (cycle)	
Toussian		Unrecognized	<i>Wisse</i>	Late (cycle)	
	<i>wril waki</i>			<i>Tchemiche</i>	Early (cycle)
		Small grain food	<i>maanoussa</i>	Late (cycle)	
				<i>Weweke</i>	Late (cycle)
	<i>Wourou</i>			<i>Fiitan</i>	Early (cycle)
		<i>tingouinguin</i>	Late (cycle), very large (size)		
		<i>wourdwagrin</i>	Early (cycle)		
Siamou	<i>Foum</i>	Unrecognized	<i>Awoukokro</i>	Coarse grains (grain)	
				<i>hunglegnecar</i>	Medium-sized grain (grain)
				<i>kungledoua</i>	Small grains (grain)
Bwaba	<i>Peri</i>	Unrecognized	Unrecognized		
Kado	<i>Houngou</i>	Unrecognized	Unrecognized		
Sambla	<i>Foo</i>	Unrecognized			
	<i>Foosii</i>				
Mossi	<i>Tchiou</i>	Which resembles millet			
Peul	<i>Paggouri</i>	Unrecognized			
Bobos	<i>Fiin</i>	Unrecognized	<i>Quinprin</i>	Early (cycle)	
				<i>Fiisa</i>	Late (cycle)
				<i>fonisoumani</i>	Early (cycle)
Dioula	<i>Foni</i>	Unrecognized	<i>Fonidiona</i>	Early (cycle)	
				<i>Foniba</i>	Late (cycle)
				<i>Fonimicin</i>	Early (cycle)
				<i>Foniguani</i>	Very early (cycle)
				<i>fonibakoin</i>	Early (cycle)
Tiefo	<i>Foni</i>	Unrecognized	<i>Kolosaba</i>	3 months; Early (cycle)	
				<i>fonibakuani</i>	Late (cycle)

Source: Authors

unshelled fonio grains was costing 300F (€0.45) whereas shelled fonio grains was costing 900F (€1.37).

Culturally, producers had considered fonio crop as a lucky plant and was perceived to protect people against

evil spirits. Furthermore, fonio was used during traditional ceremonies, Majority (45%) of respondents highlighted that fonio were used during wedding ceremonies followed by some (23%) who were using it during funeral or

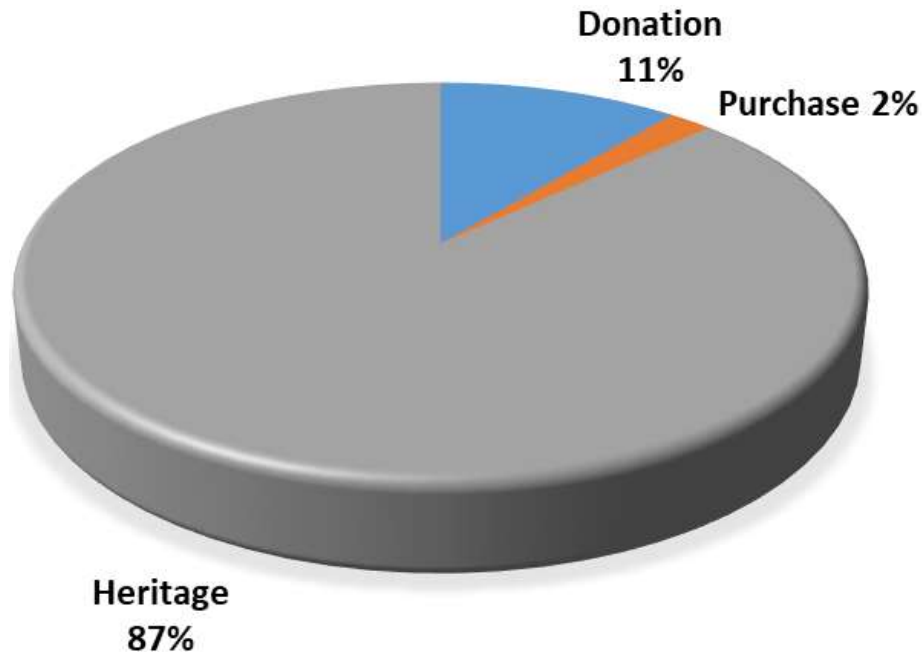


Figure 3. Different modes of sourcing fonio seeds.
Source: Authors



Figure 4. Display of fonio products for sale at the Moussodougou market (A: Unshelled Fonio; B: Fonio shelled)
Source: Authors

initiation rites, others (17%) who were using it during other cultural activities and others (5%) were using during baptisms ceremonies. These findings revealed that among the Toussian ethnical group, was using fonio in every wedding ceremony. The post-harvest treatment of fonio was a moment of social cohesion because it brought together almost all the living forces of the village.

Cultural practices for cultivation of fonio

Sowing of fonio seeds

Findings in the present study revealed that fonio sowing was done between May and July depending on agro-ecological zone, variety and period of starting of the rainy

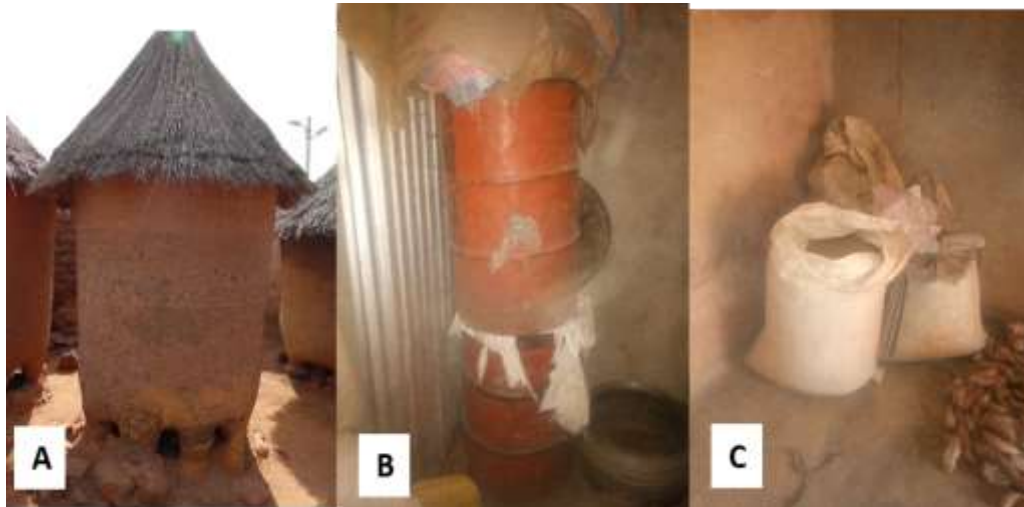


Figure 5. Storage mode of fonio (A: Attics; B: Barrels; C: Bags)
Source: Authors

season. The study further revealed that generally, fonio seeds were not treated prior being sowed. However, most (96%) of producers were sowing fonio through broadcasting of seeds whereas minority (4%) of trained producers were sowing fonio seeds through mixing of fonio seeds equally with sand or ash to allow homogeneous distribution of seeds during broadcasting.

Field maintenance

The findings in present study indicated that fonio was cultivated without manure or any kind of fertilizer but probably was benefiting nutrients from the back effects of the previously cultivated crop because majority (96%) was included it in a rotation plan. The majority (98%) of producers had maintained fonio field maintenance through manual uprooting or and on-demand weeding. Diseases were essentially prevented by choosing healthy seeds for cultivation, rotation or cultural association with other crops, uprooting and destruction of diseased plants to avoid infections or secondary infestation.

Harvesting and threshing

The findings in present study revealed that fonio after maturity; their stems were mowed in a tuft bundled in the form of a sheaf of 2 to 3 kg and thereafter were sun dried. Threshing or crushing was done by separating the grains from the panicles using a substantial labour force. Majority (37%) of farmers were using family labour force followed by those (36%) who were using communal labour force while the least (27%) of farmers were using employed labour force for threshing and crushing fonio. Communal labour force entailed informing people,

particularly men, on the day and place where threshing or crushing work was performed. The communal labourers were served the local drink made from sorghum (*Sorghum bicolor*) to serve as a refreshment and / or were served food (sorghum paste and meat) by the owner. The employed labourers were provided with wages by the owner according to a standard specific to each village.

Storage and conservation

Storage and conservation structures of Fonio paddy are shown in Figure 5. Results in present study showed that fonio grain after being harvested, dried and threshed was stored in the attics, barrels or in bags, mainly without being shelled. Regular grooming of these storage and conservation structures was done by the elders. The study revealed that there were no chemicals and or organic products used for the preservation of fonio. The shelf life of fonio paddy in the attics was estimated to be about 10 years. However, according to the respondents, fonio paddy was not affected by the insects while stored in the attics.

Shelling of fonio

Shelling process of fonio paddy are shown in Figure 6. Results in the present study revealed that there were two methods commonly used by the people in shelling fonio paddy into fonio grain. Looting was the most traditional and widely used method by the majority (93%) of people in shelling fonio paddy in the study area. However, the other method used by minority (7%) in shelling fonio paddy was use of modern milling machines.



Figure 6. Shelling of fonio (A: Mortar containing fonio; B: Looting; C: Fonio shelled and washed)
Source: Authors

Production constraints of fonio

Most (69%) of the producers of fonio had highlighted arduousness of post-harvest treatment followed by those (53%) who pointed a lack of interest among young people to cultivate in favour of more productive species such as cashew plantations as the most critical production constraints of fonio in the study area. Further, emergence of other alternative activities such as millet (*Pennisetum americanum*) or sorghum and gold mining were highlighted by (47%) as respondents as one of the major production constraints of fonio in the study area. Other production constrains of fonio noted in present study were lack of means of production (12%), maintenance and harvesting (12%), presence of diseases and pests (3%), low yield (1%) and mode of disposal (3%).

DISCUSSION

Burkina Faso was identified by Portères (1976) as a fonio cultivation area just like Mali, Guinea, Côte d'Ivoire and Senegal. However, unlike other cereals such as sorghum, millet, rice and maize, fonio has been a minor crop that is not widespread throughout the country. Moreover, its cultivation has been declining in many areas. However, fonio cultivation has been maintained in the 3 regions due to cultural values attached to fonio by different ethnic groups found in the respective regions. For example, all tradition ceremonies such as wedding among the Toussian ethnical group cannot take place without fonio. Therefore, maintenance of fonio in those respective areas could be justified by the traditional beliefs and perceptions attached around the respective crop. According to Baskar-Rajan (2005) and Kahane et

al. (2005), traditional knowledge and know-how such as the maintenance of traditional cuisine represents a socio-economic, but also strategic and ecological challenge in the conservation of genetic diversity.

Results in present study showed that cultivation of fonio was mostly practiced by adult men. These findings were in agreement with a study done by Salami (2015) who reported that in Benin, fonio was mainly cultivated by adults because of their long experience in the field. The number of years spent in production was an asset allowing producers to have effective indigenous knowledge about this speculation. The findings in the present study revealed that most of households were using family and communal labour force for cultivation of fonio. Therefore, these findings reflect a good dynamism between the producers and socio-cultural character of the fonio in the studied areas. Mutual assistance reduces production costs and circumvent the difficulties associated with arduousness of the work and the lack of manpower.

Numerous vernacular names observed on fonio in the present study could testify to the varietal variability of fonio. In addition, the diversity of vernacular names could also be an indicator of the importance of a plant (Blench, 2012). Similar studies of fonio in other countries had reported several vernacular names for fonio plant in Senegal, Togo and Benin (Dansie et al., 2010; Diop, 2018). The naming of local morphotypes on the basis of criteria related to the plant cycle, morphology and grain characteristics could be justified by the empirical selection method, which is based essentially on generally visible and easily observable phenotypic characteristics. These results were consistent with the results of Bambara et al. (2011) on several cultivated plants and Kiébré (2015) on *Cleome gynandra* in Burkina Faso. The

plant cycle mostly used as criterion in the naming of cultivars would stipulate that the cycle is one of the most important traits of interest of fonio. In addition, Diop (2018) in Senegal, Adoukonou-Sagbadja et al. (2006) in Togo and Dansi et al. (2010) in Benin who reported that producers describe or give designations to fonio varieties based on criteria related to the growth cycle and grain size.

The methods of sourcing fonio seeds observed in the present study were in agreement with those reported in other African countries such as Senegal, Côte d'Ivoire, Ghana, Tanzania, etc. who reported that seeds were commonly exchanged through heritage, donation or purchase. These practices have been reported by Abukutsa-Onyango and Onyango (2005), Nguni and Mwila (2007) and Missihoun et al. (2012) who showed that seed exchanges between crop producers can take place at the local level or between countries. In all the ethnic groups encountered in the study area, the inheritance of fonio seeds was the most frequent. These findings suggest that fonio had vital roles to different ethnic groups for generations in the studied area.

Despite its marginal position among other cereals, fonio is giving rise to an increasingly important trade in most of countries where it is cultivated. It therefore generates a significant source of income and is therefore considered a strategic cereal among the crops of future. In addition to its importance in food, it is also part of the cultural identity of several ethnic groups in Burkina Faso. This could be explained by the fact that fonio was the most important crop used during initiation, baptism and customary wedding in most of the ethnical groups observed in the studied area. Other studies on fonio have also highlighted similar roles in most ethnic groups that cultivate fonio in West Africa (Adoukonou-Sagbadja et al., 2006).

The gradual abandonment of fonio cultivation observed in the present study in some studied provinces such as Comoé, could be due to the lack of means of production, the arduousness of post-harvest work and also the low crop yield compared to other crops such as maize and cashew. Also, cultivation and shelling techniques of fonio have remained traditional. Thus, a mechanization of the system could allow producers to increase the cultivated areas and production. These findings concur with other studies in other countries such as Benin and Senegal. Salami (2015), found that in Benin the traditional cultivation practices were characterized by the arduousness of operations, low yields and the various processing used were painful and slow. Therefore, gradual decrease in the cultivation of fonio in production areas could lead to the reduction of diversity or even the disappearance of the species given the narrowness of its cultivation area.

However, the present study showed that fonio had socio-economic and cultural importance whilst was highly valued from a nutritional point of view by the local population. These findings implied that the cultivation of

fonio could be benefited by being popularized in order to curb all of the potentialities of the crop to the entire population. Similarly, in a context of valorization of local dishes and in view of the nutritional potential of the plant, the cultivation of fonio could generate reasonable income to producers.

Conclusion

The study made it possible to highlight the regions where fonio is grown in Burkina Faso. It also revealed the existence of numerous endogenous knowledge relating to the species within the local population. This knowledge points them from one ethnicity to another and guides them in the nomenclature, classification and use of this species. Endogenous knowledge will serve as a guide for the valuation of the species. The local nomenclature of species in the study area varied from one ethnic group to another, and sometimes even within the same ethnic group. In this local nomenclature, phenomena of synonymy, the use of the same name by two or more ethnic groups and the case of unexplained names have been observed. For meaningful names, nomenclature was based on nomenclature elements such as plant cycle, morphology, and natural habitat. For all the ethnic groups encountered, fonio is used for both food and socio-cultural purposes. It is also a source of income for the local population. A gradual abandonment of fonio cultivation has been observed in some areas for several reasons, while its cultivation is increasing in other regions. It is necessary to understand the social and biological factors of abandonment and also to seek mechanization to remove the constraints. The collection brought together sixty fonio accessions. Required in different agro-ecological zones under different biotic and abiotic factors, these accessions will form the basis of knowledge of the genetic diversity of species in Burkina Faso. Hence the interest of other studies such as agromorphological characterization, physico-chemical characterization and molecular genetic characterization in order to better understand its diversity, conserve it and enhance the species.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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