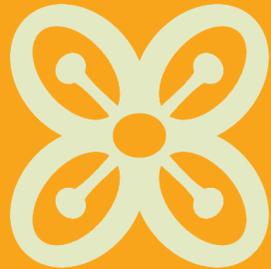


9-5 FONIO



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Ready for field testing

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This is an interim version. Comments and recommendations for improvement are welcome.

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9-5 GROWING FONIO THE ORGANIC WAY



SET OF TRANSPARENCIES



FLYER 5: FONIO

Learning targets for farmers:

- › Know that fonio is suited for hot and dry conditions and thus can contribute to sustainable food security in such climates.
- › Understand that increases in fonio yields are possible with improved management of soil, crop and harvest.
- › Realise potential improvements through mechanisation of post-harvest processing.

1. Introduction

White Fonio (*Digitaria exilis*), also known as ‘acha’ or ‘fundu’, is a minor cereal crop cultivated throughout West Africa from Senegal to Lake Chad. It is a common staple food as well as a prestige food and a gourmet item. The plants, reaching a size of 30 to 80 cm, produce tiny grains of 1.0 to 1.5 mm length which have excellent nutritional quality and are also a valuable, easily digested feed for poultry. The straw and the chaff are excellent fodder and are often sold in West African markets. The straw is also chopped and mixed with clay to build walls of houses, or used as fuel for cooking or to produce ash for potash.

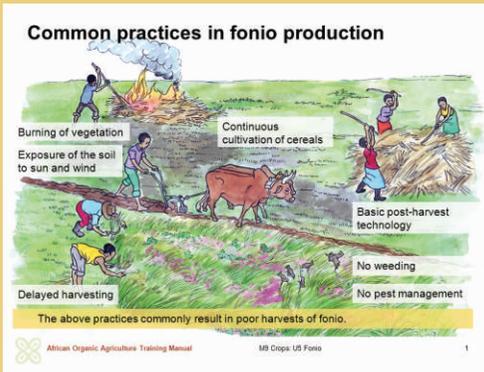
Fonio is a source of food for several million people when other food resources are scarce, making an essential contribution to food security. Due to its short growth cycle of 70 to 150 days, farmers can sow the crop two times within one year, if conditions allow. If farmers grow cultivars with a very short cycle, fonio enables them to cover the critical season before the major food crops are harvested.

Fonio grows on very poor soils, where other cereals do not succeed. But its low yielding capacity and very laborious traditional processing have hindered its development.

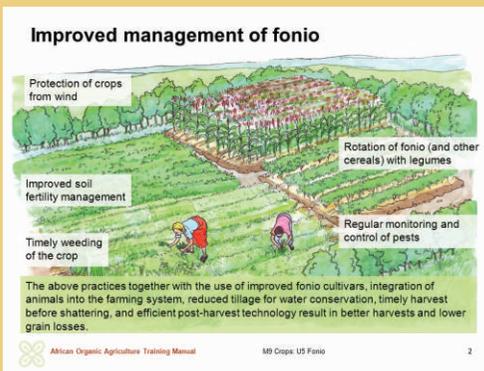




TYPICAL PRODUCTION SITUATION



IMPROVED PRODUCTION SITUATION



Fonio production faces several challenges:

- › **Poor soil fertility:** One reason for low yields, which have been attributed to the crop, is that fonio is mostly grown on poor sandy soils that are considered too infertile for other cereals. Fonio has a very low nutrient demand, and therefore generally occupies the last place in rotation systems before a fallow of several years. Provision of nutrients and water is usually not thought to be relevant by the farmers. For soil preparation many farmers burn the fallow vegetation and spread the ashes. This procedure destroys soil organic matter in the topsoil, which is essential for soil fertility and soil moisture conservation.
- › **Use of low-yielding cultivars:** Fonio cultivation relies mainly on traditional landraces. Thus, farmers use seeds from the previous harvest to grow the new crop. Traditional landraces are often less productive than the few existing improved varieties, despite their good adaptation to marginal growing conditions.
- › **Inadequate weeding:** Due to fonio's ability to establish quickly, farmers normally do not weed the fields. This leaves the crop to compete with weeds, which can reduce its ability to yield well.
- › **Pests and diseases:** Susceptibility of fonio to pests and diseases is low. Nevertheless, some fungi can affect the growing crop. Grain moulds are also common. The parasitic *Striga* weed, particularly *Striga rowlandi* which is known to occur abundantly in West Africa, can cause serious damage to the crop. Insect pests can also cause significant losses; birds feed on the maturing grains.
- › **High harvest losses and laborious post-harvest management:** Lodging and shattering of seeds result in high grain losses. Lodging of fonio is common because of the fragile nature of its shoots. Shattering of seeds in mature crops is another problem. In delayed harvests grain losses can reach 25 percent. Threshing and husking are a labour-intensive task and are difficult to perform. They are traditionally performed manually by beating or trampling on the fonio sheaves, often on unpaved flat ground or rocks, which results in contamination of the product with sand.
- › **Low socio-economic appraisal:** Fonio has a low ranking in regional cereal production due to its low yields and rather low commercial value. This makes it less competitive than other cereals like pearl millet, sorghum or maize and hampers its improvement. So far, plant breeders have contributed little to provide improved cultivars.



Discussion: Assessment of the fonio production situation

Inquire about the status of fonio production in the area, using the following questions:

- › Is fonio a common crop in the area?
- › Under what conditions is it commonly grown?
- › What are the average yields?
- › Which attention is given to the crop?
- › Which are considered to be the main constraints to good fonio yields?



Discussion on potential improvements in fonio production

Discuss with the farmers potential improvements in fonio production based on prevailing challenges:

- › How can crop growth and yields be improved?
- › How can harvest and post-harvest losses be reduced?
- › How can processing be simplified?





SELECTION OF SUITABLE CULTIVARS

Criteria for selecting fonio cultivars



- › High adaptability to local conditions
- › Appropriate length of growth cycle
- › Tolerance to local pests and diseases
- › Resistance to lodging and shattering
- › High yield potential



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Despite all the constraints, total fonio production in West Africa has increased steadily since 1980, mainly due to an increase of the harvested area. However, considerable potential for improvement remains in both production and processing. Further improvement depends on better cultivars, improved crop management, and less laborious processing methods.

2. Selection of suitable cultivars

For good results farmers should select the most suitable cultivars, as this determines, to some extent, the yield that can be obtained from the crop. Cultivars should be selected according to the length of the local growing period, their resistance to lodging, pests, diseases and shattering, as well as their yield potential.

In the last years, first improved cultivars have been released in West African countries, including five cultivars in the Benin Republic with an early to medium growing period and good yield potentials. Further breeding efforts and proper plant seed selection may result in improved stability of tillers to prevent lodging, provide reduced photoperiod-sensitivity and larger grain size.

Factors to consider when selecting suitable cultivars for cultivation include:

- › **Length of the growing period:** Fonio plants reach maturity and are ready for harvesting from 8 weeks upwards after sowing. Ideally, the growing period of the selected cultivars must match the length of the rainy season. Usually cultivars with a short to medium growing period are preferred, as they can still perform during rainfall.
- › **Adaptability:** Selected cultivars should not only grow well under local growing conditions, but be easy to process, also when processing is done mechanically, and satisfy consumers' preferences.
- › **Resistance to lodging and shattering:** Lodging is a challenge in fonio cultivation due to the fragility of the plant shoots. It therefore is imperative for farmers to grow cultivars that are resistant to lodging, in order to avoid yield losses. It is also necessary to select cultivars that are, as much as possible, resistant to shattering.
- › **Resistance to pests and diseases:** Ideally the selected cultivars would exhibit high resistance to common pests and diseases like the leaf spot disease, rust, or birds.



Discussion on cultivar selection

Invite the farmers to share their experiences with fonio cultivars, using the following questions:

- › Which criteria do you consider when selecting seeds to grow fonio?
- › Have you tried out different local cultivars?
- › Have you made any experiences with improved fonio cultivars?





PROPER FIELD ESTABLISHMENT

Different ways of sowing fonio

Broadcasting

- › Easy to apply
- › Requires more seeds
- › Results in uneven stands
- › Allows weeding by hand only

Sowing in rows

Manually



Mechanically



Manually



Mechanically



- › Done manually or better mechanically
- › Requires less seeds than broadcasting
- › Results in more even stands
- › Allows mechanical weeding between the rows



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Yield potential: Low yields are one of the major challenges to fonio production. It is therefore necessary to select improved cultivars, where they are available, that have the ability to give higher yields. To fulfill their potential such cultivars depend on improved soil fertility and management.

3. Proper field establishment

Fonio is grown in traditional rain-fed farming systems in areas with annual rainfall of 700 to 1000 mm. In areas with very low rainfall the crop is grown in valleys that benefit from run-off water. From sea level up to an altitude of 1500 metres white fonio is cultivated, while in upland regions mostly black fonio is grown. Although considered to be quite drought resistant, fonio is not as drought resistant as pearl millet. However, the fast-maturing landraces, due to their short growing period, are suited to areas with short and unreliable rains. Fonio grows on various soil conditions including poor, shallow, sandy, degraded or acidic soils, but heavy and saline soils are less suitable.

Fonio is usually sown at the beginning of the rainy season. Instead of preparing the soil the traditional way by burning the fallow vegetation and ploughing, the remaining vegetation may be slashed and left as a mulch on the soil surface to protect it from erosion and drying out. Then reduced soil cultivation may be applied, for example by ripping the soil in rows only. Although not common, such a method may have its advantages. For germination fonio only requires a superficially loosened soil, because of its small seeds. Loose topsoil with a fine tilth provides good conditions for germination.

Sowing is commonly done by broadcasting. For this, the small seeds are best mixed with an equal quantity of sand to best spread the seed. After sowing the seeds are covered with soil by a light hoeing or brushing with tree branches. The seed rates range from 10 to 30 kg per hectare, depending on soil fertility and growing conditions. Seed rates from 50 to 70 kg per hectare result in denser stands and reducing competition from weeds. Broadcasting can result in bunches of fonio plants, which then develop poorly.

Although not common yet in fonio production, sowing in rows provides a number of advantages: it requires less seeds, results in more uniform stands and – when sown at a row distance of 15 to 20 cm – allows mechanical weeding with a hoe or a tine or blade weeder, if the soil is not covered by dry mulch.



Discussion on the most appropriate

sowing technique

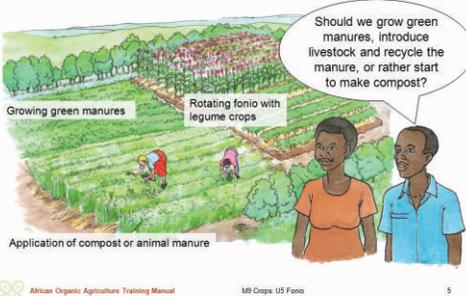
Ask the farmers, whether any of them have experience sowing fonio in rows. Discuss possible advantages and inconveniences of sowing in rows compared to broadcasting. Which requirements must sowing equipment fulfill?





SOIL FERTILITY MANAGEMENT

How to further improve soil fertility



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4. Improving soil fertility

Fonio is seen as a very hardy crop that grows well on poor soils. Due to this claim farmers usually plant fonio on very poor soils without considering any efforts to improve soil fertility or fertilise the crop. Although little is known about the nutrient requirements of fonio, the crop will most probably give better yields in a fertile soil.

Soil fertility management first serves an entire production system or an entire crop rotation, and only in second priority an individual crop. So, even if fonio does not require high soil fertility, improvement in soil fertility will improve growth of all crops.

Soil fertility management should start from preserving the soil from erosion and degradation, and include practices that feed the soil with organic matter.

Practices that can contribute to soil fertility improvement in fonio production:

a) Soil conservation. When the soil is left bare, it is exposed to wind and water erosion, and to high sun intensities. Therefore, where wind is frequent, wind-breaking hedges around the fields are necessary to prevent wind erosion and reduce the otherwise high evaporation and evapotranspiration of water from crops and soil. They also help prevent strong winds carrying away the small seeds after sowing.

Unlike ploughing, where the entire soil surface is returned and exposed to sun and wind, soil disturbance is minimized in reduced soil cultivation, which essentially contributes to conservation of soil water. Especially in case of ploughing, sowing should be done immediately after soil preparation. On sloping land, land preparation must be done across the slope to minimise run-off water with supporting suitable structures which stabilise and hold the soil, and trap erosion.

b) Crop rotation and intercropping. Fonio is often grown in rotation with other cereals like sorghum and millet. In some areas it is grown after rain-fed rice as a short-cycle crop before another (cereal) crop is sown in the same season. Continuous cultivation of cereals, particularly with poor soil fertility management practices, decreases soil fertility and encourages build-up of soil-borne diseases, pests and weeds. To improve soil fertility fonio should be grown in a planned rotation with nitrogen-fixing leguminous crops like beans, cowpeas, groundnuts or leguminous green manure crops and other



Discussion on soil fertility management

Ask the farmers to describe, how they manage fertility of their soils.

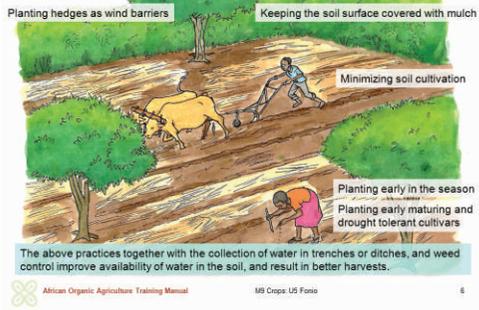
- › Do they prevent soil erosion by wind and water? If so, how?
- › Do they grow crops that also feed the soil? If so, which ones? Discuss, how they do it.
- › Do they recycle plant materials and animal manures? Which challenges do they meet with this?
- › Are any manures or compost applied? If yes, which challenges do they meet with compost production?





WATER MANAGEMENT

How to improve water use efficiency of fonio



appropriate crops. Besides fixing nitrogen in the soil for subsequent crops, legumes interrupt the lifecycles of soil-borne pests and diseases, which are hosted by grass crops. Conversely, growing fonio before peanuts, cowpeas or sesame can reduce development of *Macrophomina phaseolina*, a fungus that causes charcoal rot on these and many other plant species.

- c) **Addition of organic materials.** Application of compost, animal manure or biomass from green manure crops to the soil provides essential organic material for maintenance of soil fertility. While green plant materials and animal manures provide food for soil organisms and nutrients to plants, compost mainly improves soil properties like soil structure and soil water holding capacity. Planned cultivation of leguminous green manures like mucuna during the off-season, if sufficient water is available, protects the soil from erosion, fixes nitrogen from the air, and supplies great amounts of biomass for soil organic matter management.
- d) **Recycling crop residues on the field.** In order to minimise loss of nutrients from the field, crop residues should be returned to the piece of land where they were harvested. If the residues are fed to livestock, the dung of the animals should be returned to the fields and mixed into the soil, or composted together with plant materials to improve the quality before application. Burning of the crop residues is not recommended, as this results in loss of valuable organic matter.
- e) **Use of mineral fertilizers.** In principle application of selected mineral P and K fertilizers is allowed in organic farming, whereas the use of mineral N fertilizers is not allowed. Use of such fertilizers should only be the last option in soil fertility management and is only recommended in case of heavy deficiency. Use of commercial fertilizers may hardly be economic in fonio production. Nevertheless, before using mineral fertilizers certified organic farmers should check prevailing regulations.

5. Proper water management

Fonio is well adapted to annual rainfall of 700 to 1000 mm. However, towards the Sahelian zone annual rainfall drops lower. Effective management of water is therefore essential in traditional rain-fed fonio production and is now becoming even more important due to the increasing occurrence and severity of droughts.



Discussion on integration of improved soil fertility management practices

Discuss with the farmers, how practices of improved soil fertility management can be introduced into their farming systems.



Assessment of water availability

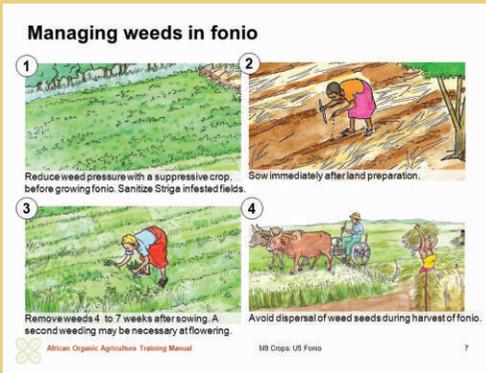
Assess the situation regarding the availability of water for fonio production:

- > Are there water stress problems in fonio production?
- > Are the farmers growing any early maturing cultivars to limit water needs and escape droughts?
- > What are the farmers currently doing to harvest water in the field and make it more available?





WEED MANAGEMENT



Recommended practices to improve water use efficiency in fonio production include:

- > **Early planting in the season.** Early sowing can be advisable in order to optimise the use of rainwater, particularly if weather forecasts depict a short rainfall period.
- > **Early maturing cultivars.** In areas with limited rainfall amounts, or when planting is done close to the end of the rainy season, early maturing cultivars are preferable.
- > **Mulching.** Using the previously harvested crop residue to mulch the field can reduce the rate of evaporation of water from the soil.
- > **Reduced tillage.** Reduced or no tillage strongly reduces loss of soil water through evaporation compared to ploughing of an entire field.
- > **Proper weed control.** Removal of weeds reduces the rate at which they compete with fonio for water, leaving more moisture to the crop.
- > **Reducing plant population.** This is an important consideration in arid regions where rains are brief and unreliable, and where there is no irrigation.

6. Proper weed management

Fonio seeds germinate rapidly. But despite its quick establishment, fonio is sensitive to competition from other plants for light, water and nutrients, as it does not grow tall and does not build a dense soil cover to prevent other seeds from germinating. Without weeding, this can result in high competition of the crop by weeds, and of contamination of the harvest by weed seeds.

Therefore, fonio should not be grown on fields where weed pressure is high without applying preventive and cultural measures that help to manage the weeds. During growth usually one or two hoeing rounds are necessary to control weeds and obtain reasonable yields.

Fonio is also host of the parasitic weed Striga and should not be grown on fields where Striga occurs without proper practices to control the Striga.

Recommended weed control measures in fonio production:

- > **Proper crop rotation:** Rotation of fonio with other crops, which cover the soil well and suppress weeds, limits propagation of weeds on a field and thus reduces weed pressure.



Discussion on weed management in fonio production

Ask the farmers whether they experience any major weed problems in fonio. Discuss, which weeds are predominant and which control strategies are being used in local fonio production.



- › **Planting immediately after land preparation:** The earlier fonio is sown after land preparation, the better it allows germination of the crop before other seeds improving its competitiveness during the early stages of growth.
- › **Weeding:** In most cases a first weeding 4 to 7 weeks after sowing reduces competition from weeds and has a very positive impact on yield. A second weeding may be necessary at flowering.
- › **Control of Striga:** To prevent introduction of Striga seeds to the field, only clean fonio seeds should be used. Rotation and intercropping of fonio with Striga trap crops like plumed cockscomb (*Celosia argentea*) and cotton limit development of the parasitic weed (for further information on Striga control see module 9.4 on sorghum).

7. Effective pest and disease management

Although pests and diseases can reduce the growth and performance of fonio, they are in most cases a minor problem. The most common diseases that affect fonio are caused by the fungi *Phyllachora sphearosperma* and *Helminthosporium* spp. and rust caused by *Puccinia oahuensis*. Occasionally some insect pests cause significant seed losses. Birds like to feed on freshly sown seeds and on ripening grains. To avoid major losses after sowing and in the last days before harvest, bird scaring is recommended.

Control of fonio diseases

Diseases are best controlled by planting tolerant or resistant cultivars, if available, and by employing cultural measures like proper crop rotation, sowing early in the season and removing infected ears at harvest. The effectiveness of these control measures is however minimal if the measures are applied individually. Seed treatment with natural fungicides such as ashes and botanicals like neem and castor leaves can hinder development of fungal diseases that are transmitted on seeds.



Field visit on pest and disease management

Visit different fonio fields, and identify together with the farmers any observable signs of pest and disease problems. Ask the farmers, whether they are familiar with those signs and whether they have monitored to see, when the pests and diseases attack, and how both can be controlled.





HARVEST

Harvesting fonio

Harvest as soon as the grains are ripe to avoid shattering of grains



Try out mechanical harvest for higher efficiency.

Pre-dry the fonio sheaves on well-aerated heaps until the straw is dry. Control heaps regularly for heat.



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8. Reducing harvest and post-harvest losses

Harvesting of fonio is often staggered to suit the immediate needs of the farmer's family. But late harvesting can result in important grain losses due to birds, shattering and moulding. Manual harvesting is time consuming and the processing of fonio is lengthy and complex and subject to sand contamination and to heavy grain losses mainly due to the tiny size of the grains.

Many farmers abandoned fonio production because of the time consuming harvest and post-harvest processing. The efficiency of harvesting and processing determines to a great extent the profit a farmer makes. Measures to reduce grain losses include timely harvest, proper drying of the grains and application of improved methods of post-harvest handling. Measures to reduce labour costs include mechanised harvesting and post-harvest processing.

Harvesting

Fonio today is still all harvested by hand. This is done by cutting the dried plants with a knife or a sickle and gathering them into sheaves. Manual harvesting is very time consuming. Mechanisation of harvest could contribute to a more efficient harvest, but is challenged by lodging of fonio plants at harvest and limited cash of farmers.

To avoid major grain losses due to shattering before and during harvest the grains should be harvested as soon as they get ripe and before the dry season has fully established and air humidity has declined. At harvesting with the sickle the height of the cut varies depending on whether the straw is to be used as animal feed or not.

Grain yields of fonio commonly range from 200 kg per hectare on marginal land to 600 kg or more under good management.

8.1 Post-harvest handling

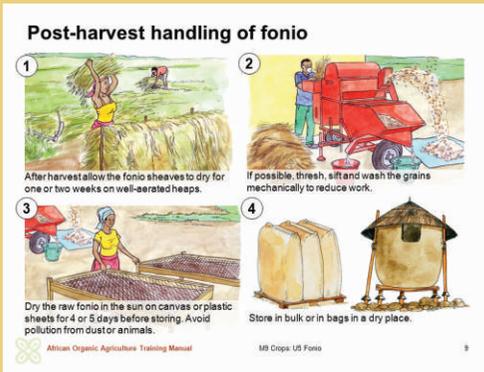
Pre-drying

After harvesting, the fonio sheaves are dried for about one or two weeks (or more), before being threshed. Well-dried straw is relevant for mechanical threshing. For drying, the sheaves are piled to round or oblong heaps on the edge of the field, built on simple wooden structures to improve aeration. In humid con-





POST-HARVEST MANAGEMENT



ditions such as heaps may develop heat due to insufficient aeration and decomposition processes, or may encourage development of moulds. Both reduce the quality of the grains and can result in grain losses. Therefore, such heaps must be controlled regularly and must be disassembled as soon as they develop heat inside.

Threshing and sifting

Traditionally, threshing is done by hand, which is very laborious. Also, traditional threshing on non-paved soil results in high rates of sand contamination, whereas threshing on a paved surface is somewhat better. Threshing on a canvas is considered being best when threshing manually.

For mechanical threshing rice threshing machines were adapted to be used for fonio, processing 250 to 300 kg of grains per hour. Shifting from manual to mechanical processing can give farmers benefits, which are much higher than the investments. Mechanising the processing proves essential to reduce work and improve the quality and availability of marketed fonio. However, the relatively high costs to buy a threshing machine may be a constraint to some farmers. To reduce the costs, farmers should form groups to buy machines at village level, or threshing services should be provided to the farmers by the private sector.

Sifting of the grains after threshing removes part of the sand, which otherwise would wear down machines in further processing and would need to be removed for food production anyhow.

Drying

Threshed fonio, which is also called ‘fonio paddy’ or ‘raw fonio’, needs further drying for 4 to 5 days, as the hulls still remain on the grains. Fonio paddy is usually dried on traditional mats or on canvas or plastic sheets in the sun. The grains are sufficiently dry, when they run easily through the fingers (moisture content lower than 11 %).

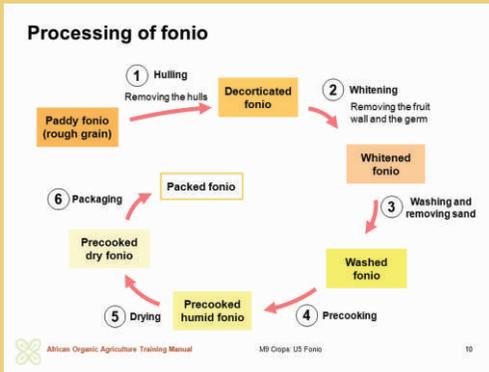
Storage

Well-dried fonio grains store well and can be kept for many months or even years. They are not liable to damage by storage pests. For storage the grains are usually filled in bulk into traditional clay granaries. Or the product is stored in jute or in woven polypropylene bags for selling.





PROCESSING



Hulling and whitening

The dried grains are further processed by removing the hulls from the grains (called hulling) and removing the fruit wall and the germ (called whitening). Hulling and whitening require 4 to 5 beatings with pestle and mortar, alternated with winnowing, when done by hand. For mechanical hulling and whitening the GMBF (Guinea-Mali-Burkina-France)-huller was developed by CIRAD, with an output of about 100 kg of grains per hour.

After whitening, the fonio grains must be cleaned to remove the bran and foreign bodies such as sand. Cleaning is traditionally done by repeated washing, which is an extremely time-consuming and tedious operation.

9. Marketing and organic certification of fonio

Traditionally, fonio is grown for home consumption, especially to provide food during the period of the year before other crops are ready for harvest. So, traditionally only a small percentage of fonio is marketed. In recent years though, the percentage of marketed fonio has increased. Today fonio is sold on many local markets and is traded within West Africa. A very small percentage is traded outside West Africa, some of it being sold as luxury product to Europe and the United States. Locally marketed fonio is mostly sold as hulled fonio. For export mostly precooked fonio is required. Thanks to improvements in post-harvest processing and new market opportunities, the crop has gained new interest among farmers.

Most farmers grow fonio on plots under 1 hectare. In order to meet market requirements and improve profits, farmers have to produce larger quantities. This applies especially to the marketing of certified organic fonio.

Cleanliness, an ideal milling degree and a light colour are quality requirements considered to be essential by consumers, and thus strongly determine the price of fonio. These requirements need to be kept in mind when processing fonio. Precooked fonio is becoming increasingly common and gives higher prices.

Other considerations for organic certification (similar to production of other cereals) include:

- > Farmers should have sizeable land to produce commercial volumes and to be able to cover the extra costs of certification. To be encouraged to invest in soil fertility management and long-term organic management, the land



Discussion on marketing and organic certification

Engage the farmers in a brainstorming session in order to understand the market situation for fonio, using the following questions:

- > Is fonio widely consumed in the area or neighbouring urban centres? Who are the main buyers?
- > Are any farmers producing fonio on a commercial scale?
- > Are there any markets that may require certified organic fonio?



should be owned by the producers, or they should have an assured long-term lease on the land.

- › Farmers of the same village with adjacent fields can form an organic producer organisation to minimise the risks of contamination of their crops from application of pesticides in neighbouring fields.
- › The producers should have access to at least one processing facility (especially for milling and packing), where they can negotiate for preferential treatment of their harvests to minimise contamination with non-organic cereals. During processing, any contamination of the organic fonio from conventionally grown fonio and chemical substances should be avoided. Eventually, as volumes increase, they can acquire their own processing facilities.
- › All post-harvest equipment used for handling conventional fonio should be adequately cleaned before being used for organic fonio. It is also very important to use clean bags or containers that have not been used for synthetic fertilisers or any chemicals. Any other reusable bags or containers must be sufficiently washed before using them for harvested produce.

10. Further reading

Publications:

- › Le fonio, une cereale africaine. Jean-François Cruz et al. Editions Quae. France. 2011. ISBN: 9782759210398. www.quae.com/en/r810-le-fonio-une-cereale-africaine.html
- › «GMBF» fonio huller. Leaflet. CIRAD. Download under <http://fonio.cirad.fr/>
- › Manual rotating sieve CRMC. Leaflet. CIRAD. Download under <http://fonio.cirad.fr/>
- › NRC (National Research Council), 1996. Lost crops of Africa, Vol.1: grains. Board on Science and Technology for International Development, National Academy Press, Washington D.C., 59-75.

Useful weblinks:

- › www.cropsforthefuture.org
- › The Fonio Network: http://fonio.cirad.fr/en/fonio_network

