

## 9-4 SORGHUM



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Ready for field testing

# IMPRINT

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

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# 9-4 SORGHUM



## FACTSHEET 4: SORGHUM

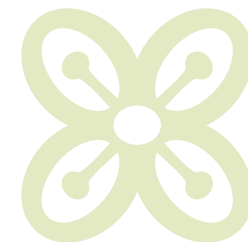
### Learning targets for farmers:

- › Know that, due to its drought tolerance, sorghum is especially suited for hot and dry conditions and thus can contribute to sustainable food security in such climates.
- › Recognise that considerable increases in yields are possible with improved management practices like variety selection, proper timing of the crop, diversification through crop rotation or intercropping, soil fertility management, proper management of pests and diseases and post-harvest management.
- › Understand that proper crop rotation is essential to prevent decrease of soil fertility and ensure control of the stemborer, the major pest, and the parasitic weed Striga.

## 1. Introduction and challenges

Sorghum (*Sorghum bicolor*) is an important cereal for food (mainly for subsistence) and fodder in tropical, semi-arid Africa. It is mainly grown in Sudan, Nigeria, Burkina Faso, Ethiopia, Mali and Egypt, but also in other African countries and contributes to the food security of the most food-insecure agro-ecological zones. The grains have also become an important feed for livestock, especially for pigs and poultry, due to an increasing demand for meat and dairy products. It is considered one of the best crops for silage to feed livestock, because of the high yields, high sugar content and the juiciness of the stalks. However, green sorghum grain and forage are not suitable for pasture, because they contain substances that are poisonous to livestock. Basically, there are five races of cultivated sorghum, namely *bicolor*, *guinea*, *caudatum*, *durra*, and *kafir*, each with specific characteristics.

Besides being grown for grain and fodder, specific sorghum types are grown as a raw material for industrial processes such as syrup, sugar, beer and fibre production or textile dyeing. In some countries the stems of sweet sorghum types are chewed like sugar cane and are sold along roadsides and on markets at rural development centres.



Sorghum is a vigorous, hardy and drought-tolerant crop, which grows up to 4 metres tall and has a high potential yield. It is a perennial grass, but is mostly cultivated as an annual crop. Sorghum has the ability to go into dormancy during drought conditions and to resume growth when the rains come, because it has a more efficient root system than most cereal crops (with the exception of millet) and rolls its leaves to reduce evapotranspiration.

Sorghum does well in hot climates that are too dry for maize. For early maturing cultivars 500 to 800 mm of rain are normally adequate, if they are evenly distributed over the cropping season. In some areas sorghum has been replaced by maize because it yields better under favourable conditions, is less liable to bird damage and easier to process. In less favourable environments this has repeatedly resulted in severe crop losses when drought occurred. Therefore, in hot and dry climates of Africa sorghum will remain an important food security crop. In the tropics sorghum can be grown at altitudes up to 2300 m, but temperatures below 12–15 °C during flowering may result in sterility. Still, sorghum is less susceptible to frost than maize. Although sorghum grows well on a wide range of soils, the best results are achieved on loams and sandy loams. Sorghum is adapted to poor soils and can produce grain on soils where many other crops would fail. In some areas of Africa with soils with high water content sorghum is sown in the early dry season and grows with residual moisture only.

### Challenges to sorghum production in Africa

Sorghum yields are generally low in Africa, ranging from 500 to 600 kg per hectare, which is far below the potential of the crop. The low yields may be attributed to a number of challenges, which include:

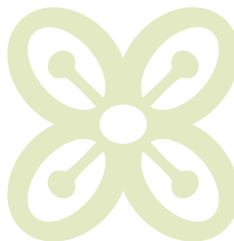
- › **Limited access to good quality seeds:** Most sorghum farmers typically grow traditional varieties. In most cases these landraces are well adapted to local conditions and have low nutrient requirements, but are low yielding. This is partly because farmers do not carefully select the sorghum seed, but instead pick seeds randomly from any remaining stock from the previous season.
- › **Decreasing soil fertility:** Most farmers grow sorghum as a mono-crop, season after season, without any added inputs for soil improvement. Due to the continuous loss of nutrients with every harvest, soil fertility continues to decline. In the long run, nutrients become deficient, thus affecting the ultimate sorghum yields. Farmers who use commercial fertilisers also experience declining soil fertility if they do not manage soil fertility sustainably.



### Discussion: Assessment of local sorghum production

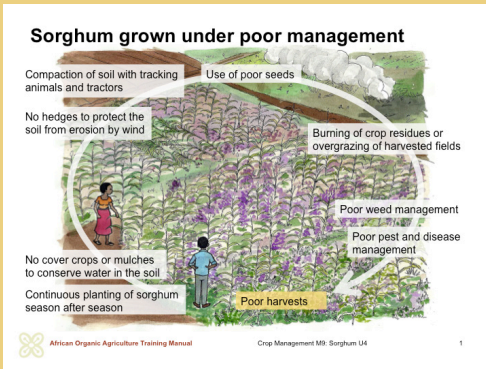
Inquire about the status of sorghum production in the area, using the following questions:

- › How important is sorghum in the area? What are its uses?
- › How is sorghum commonly grown? Which other crops are commonly grown with sorghum? What are the average yields?

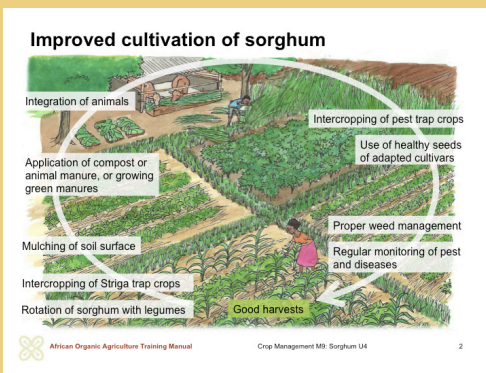




## CHALLENGES IN SORGHUM PRODUCTION IN AFRICA



## GOOD MANAGEMENT PRACTICES IN SORGHUM PRODUCTION



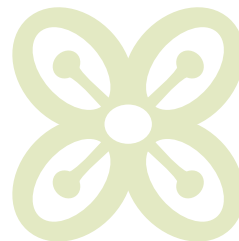
- › **Pest and disease problems:** Many pests and diseases are known to attack cultivated sorghum while others can cause considerable losses during storage. The main insect pests of sorghum include the shoot fly, stemborers, sorghum midge and head bugs. In the traditional farming context in Africa, direct control measures are rarely undertaken, as the crop is mostly cultivated under low input conditions. In situations where sorghum is grown continuously on the same fields without rotation, the risk of pests and diseases increases, especially where diseases like anthracnose, leaf blight, leaf spot and tar spot, downy mildew or rusts are prevalent. Other diseases include the honeydew disease or ergot, root and stalk rots. In many parts of Africa, birds are also common pests of ripening sorghum causing enormous losses before it is harvested.
- › **Water problems:** Due to its drought tolerance, most farmers in sub-Saharan Africa rely solely on rainfall during the entire growing period. However, prolonged drought favours pest attack by bugs and mites and delays maturity. Therefore, water conservation and, where possible, the additional supply of water through irrigation increases the yield potential of the crop.
- › **Weed problems:** Weeds are a big constraint to sorghum production, especially during periods with favourable growing conditions. When water is available, weeds can multiply very fast and outgrow the sorghum plants, if the farmer does not intervene in time. They will compete for space, nutrients and water, hence reducing the eventual yields obtained. Specifically, the parasitic Striga weed (*Striga hermontica*) causes significant yield losses in sorghum production and is widespread in Africa.

Organic production practices, which emphasise the sustainable utilisation of soil resources as well as other good agricultural practices, can improve sorghum yields in Africa. In some countries success has been achieved by using improved varieties and by improving soil fertility and water management. Therefore, this chapter discusses the importance of these strategies as well as other organic production practices to increase sorghum productivity and yields.



### Discussion: Local challenges facing sorghum production

Engage the farmers in a brainstorming session to highlight the key challenges to sorghum production under the local production situation. Find out whether the farmers have experienced any of the above or any other challenges and how they have tried to address them.





## SELECTION OF APPROPRIATE CULTIVARS

### Trying out a new cultivar



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## 2. Selection of appropriate varieties and good quality seeds

Many landraces of sorghum exist. All are adapted to specific growing conditions such as sandy or clayey soils, cold or hot season and different water conditions such as rain-fed cultivation, irrigation or drought. High-yielding improved cultivars and hybrids of sorghum are available in many African countries. But improved sorghum cultivars are not yet widely grown in Africa, because of the limited access to such seeds in many areas. Presently, improved varieties only account for about 10 percent of all seeds.

Improved varieties are characterised by higher grain yield, improved nutritional value of the grains and better processing quality, as well as resistances or tolerances to the major diseases and pests. Most improved cultivars combine high grain yield with high stover yields to provide animal feed from the residues. Striga-resistant cultivars are also available such as the Framida variety in Ghana and Burkina Faso. But compared to landraces the grain quality and hardness of improved varieties is generally lower.

### Recommendations to farmers for selecting good sorghum varieties:

When farmers use own seeds, they should ensure that they use carefully selected as well as pest and disease free seeds only.

Firstly, any variety should have been tested under local conditions by farmers or research stations before it is grown on a larger area. The selected variety must be adaptable to local climatic stresses, particularly in semi-arid and arid climates.

Secondly, the variety should not be highly susceptible to common insect pests and diseases.

Generally, early and uniform maturing varieties can be quickly harvested before pest and disease infestation increases. Under irrigation, however, varieties with longer maturity periods are preferable because they will produce higher yields.

Lodging is a common problem of sorghum. Tall varieties tend to be more sensitive to lodging than shorter varieties. Shorter varieties also have the advantage of facilitating harvest.

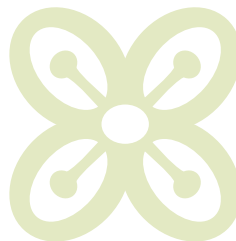
Some sorghum varieties are preferred for certain purposes. For example, red and brown grains are preferred for livestock feed as silage and for brewing purposes. There is also an increasing interest in sorghum varieties that produce



### Discussion: The local sorghum seed situation

Ask the farmers which varieties of sorghum are available locally and how selection of seeds is handled by asking the following questions:

- > What do you normally consider when selecting the sorghum varieties to grow?
- > Are improved varieties available? If yes, how have they performed locally?
- > How do you select and store seeds for the next season's crop?
- > Discuss the local approaches, taking note of any shortcomings, and then introduce the recommendations that follow.





## CRITERIA FOR VARIETY SELECTION

### Criteria for selecting sorghum cultivars



- › Type corresponding to the intended use
- › Adapted to local growing conditions
- › Tolerance to the main local pests and diseases like leaf diseases, green bugs, sorghum midge, stemborers, panicle feeding bugs
- › Early and uniform maturity
- › Dual purpose with good grain and good stover yields to provide fodder for livestock also
- › Grain quality that corresponds to processing requirements and consumer preferences



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good grain yields at uniform time and leave considerable amounts of leaves as animal feed (dual purpose sorghum).

Generally, using good agronomic practices can increase yields by at least 40 to 50 percent. In Uganda, for instance, yields of 800 kg per hectare have been recorded for well managed local varieties. Farmers should therefore contact the appropriate governmental organisations or extension agencies in their localities for the right choice of sorghum varieties.

### 3. Improving soil fertility

Most farmers in sub-Saharan Africa grow sorghum without any added fertilisers. Sorghum is much more tolerant to low soil phosphorus levels than most cereals. It can also tolerate some degree of salinity and poor drainage. However, in order to achieve full yield potential the crop requires appropriate nutrition.

#### a) Soil conservation

Soil conservation implies putting appropriate measures in place in order to protect the soil from being eroded by water and wind or being overheated by the sun. Most of the regions of Africa where sorghum is grown have sandy soils and are prone to both runoff and wind erosion. It is therefore necessary to ensure that the soil is protected from water and wind erosion. This can be done in a number of ways:

First, traditional methods such as ‘slash and burn’ and over-exposure of harvested lands to grazing animals should be discouraged to prevent exposure of the soil to erosion and loss of organic matter.

Secondly, in case of sloping land, there may be a need to construct terraces followed by planting across the slope.

Other practices like mulching of the soil with crop residues as well as intercropping with legumes like beans reduce exposure of the soil. Cover crops can also be used to cover the soil and smother weeds between sorghum growing seasons.

#### b) Introduction of leguminous crops to the sorghum cropping system

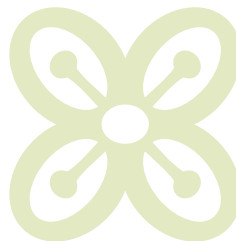
Sorghum thrives when planted after a legume crop. Therefore, planned rotation and intercropping of sorghum with legumes and other non-host crops is essen-



### Discussion: Improving soil fertility in sorghum production

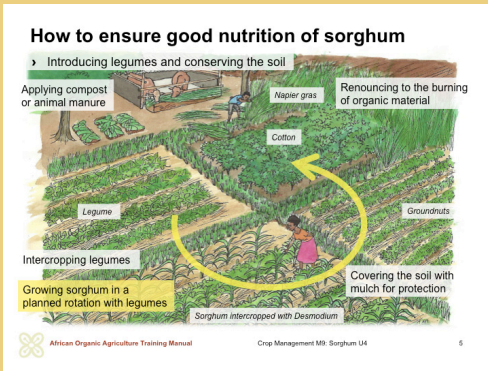
Inquire among the farmers whether any measures are taken locally to improve soil conditions for sorghum production by asking the following questions:

- › How do you protect and conserve the soil from erosion?
- › Which types of legumes grow well locally with sorghum?
- › Do you apply any fertilisers, organic materials or manures in sorghum fields?
- › Do you grow sorghum in rotation with green manures or intercropped with legumes?
- › Do you apply any method of reduced tillage to maintain soil fertility?





## NUTRIENT SUPPLY IN SORGHUM PRODUCTION



tial for maintenance of soil fertility and crop growth. Besides fixing nitrogen and improving soil organic matter, legumes also hinder the development of pest populations, diseases and weeds. Leguminous shrubs can act as windbreaks and help in recycling leached nutrients from the deeper layers of the soil. Leguminous crops like common beans, cowpea, pigeon pea, green gram and soybean, or green manure crops like jack beans, perennial peanut or mucuna fix nitrogen and produce large quantities of biomass that can be used to feed the soil and increase nitrogen availability.

Sorghum does not take as much water out of the soil as maize, sunflower or soybeans do, but it exhausts soil nutrients. To prevent depletion of the soil and prevent development of pests, diseases and Striga, sorghum should only be grown every 2 to 3 years in the same field. Furthermore, other plants in the grass family should not be planted in rotation with sorghum.

Recommended rotation partners are legumes, cotton, leafy vegetables or cassava. Recommended rotations may be groundnut – sorghum – pigeon pea/ cowpea; or field bean and amaranth – sorghum.

Intercropping of sorghum with cowpea, common bean, groundnut or Bambara groundnut is quite common. So, too, is intercropping with other grasses like maize or millet. Intercropping with sweet potatoes or cassava is also practised. Leguminous intercrops contribute more to improvement of soil fertility than other species. When grown for forage, sorghum can also be intercropped with legumes such as cowpea, as this improves the nutritional value of the forage.

When intercropped with pigeon pea, both crops are planted at the beginning of the rainy season. Sorghum is harvested after 100 days, while pigeon pea is left to use the remaining soil moisture and nutrients until harvesting after 160 days.

### c) Addition of organic fertilisers

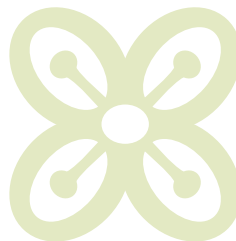
Smallholder farmers rarely apply commercial fertilisers. But application of farmyard manure or ash is quite common. Application of organic fertilisers like animal manures or compost to the field increases the water storage capacity of the soil and provides nutrients to the soil. Better availability of water and nutrients results in higher grain yields of sorghum.

The nutrient requirements of the crop are highest during rapid growth and early bloom. Requirements of the main nutrients nitrogen, phosphorus and potassium for an average yield of 7,500 kg per hectare are 185 kg N, 80 kg P<sub>2</sub>O<sub>5</sub> and 285 kg K<sub>2</sub>O. Without any provision of nutrients production depends on soil-



### Discussion: How can legumes contribute to nutrition of sorghum?

Discuss with the farmers possibilities of improving local crop rotations and/ or intercrops by introducing legumes. Are legumes best grown in rotation with sorghum, as intercrops, or in a combination of intercrop and rotation? Which legumes are commonly grown? Discuss advantages and constraints of common crop rotations and intercrops.





stored nutrients only, which in poor soils will give low yields. Grain sorghum responds well to a balanced supply of plant nutrients.

Nitrogen is best supplied by growing the crop after a legume crop or a leguminous green manure and/or through application of manure. In contrast, application of compost will supply balanced nutrients and improve soil properties. Animal manures and compost are best applied before land preparation by spreading them in the field and incorporating them into the soil before planting. If the land is prepared using a ripper only, which leaves the soil surface largely untouched, organic manures are best applied to the furrow and mixed with the soil into which sorghum will be planted. The standard farm wheelbarrow holds approximately 25 kg of dry manure or compost. For a low rate of fertilisation two wheelbarrows are enough for an area of 10 metres by 10 metres, making 200 wheelbarrows or 5 tons of manure or compost per hectare. For a high rate 400 wheelbarrows or 10 tons are to be applied per hectare.

#### 4. Proper establishment of the crop

Sorghum seeds prefer a fine bed for germination (if the soil is ploughed). In practice this is often not achieved. Most farmers sow the seeds directly into furrows, following a plough or a ripper. Seeds can also be broadcast and harrowed into the soil, but this hampers weeding and may result in irregular stands.

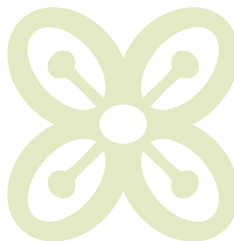
Soil cultivation and planting should take place before or at the onset of rains. When planted into dry soil, the planting depth should be 5 cm, but when planting in a moist soil use a planting depth of 2.5 to 4 cm.

Optimum plant spacing is determined by the availability of moisture, depending on rainfall and soil type. In low-rainfall areas a population of 20,000 plants per hectare is considered ideal, whereas in high-rainfall areas three times as many plants may be grown on the same area. Under favourable conditions, recommended spacing between rows can vary from 50 to 75 cm, and spacing in the row from 12 to 20 cm. This results in about 70,000 to 120,000 pockets per hectare. For drier or less fertile conditions a row distance of 90 cm to 1 metre and spacing between plants of 15 cm is appropriate. If another crop is planted between the rows of sorghum – depending on the climate and the intercropped species – every second row is planted with the intercrop, or the spacing between the rows is enlarged.



#### Discussion on field preparation and planting

Discuss with the farmers the relevance of proper seedbed preparation for crop development based on their experiences. Which conclusions can be drawn? Which plant spacing may be ideal under local conditions when sorghum is intercropped?



Up to 10 seeds may be sown per pocket to compensate for poor seedbed or to allow for unfavourable moisture conditions. The seed rate varies from 3 kg in very dry areas to 10 kg, or 15 kg per hectare under irrigation. For broadcasting about 6 kg seed per hectare are needed.

Occasionally, sweet sorghum is transplanted from a nursery. Sorghum can also be propagated by splitting tillers from established plants and transplanting them. This practice is mostly used by smallholder farmers to fill gaps.

## 5. Proper weed management

The aim of weed management is to minimise competition with sorghum during its growth as well as to avoid dissemination of weed seeds. As sorghum does not compete well with weeds during early growth until four to five weeks after planting, the crop requires special attention during this phase.

Various measures can be implemented in the management of weeds in sorghum production, these include:

### a) Preventative and cultural measures

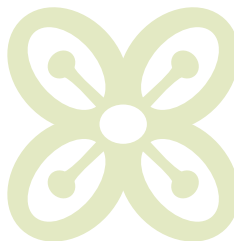
Prevention aims at restricting introduction and multiplication of weeds and ensuring good growing conditions for sorghum to limit competition for water, nutrients and light. Preventive measures include proper seedbed preparation (to ensure uniform stands), appropriate spacing (to ensure adequate plant populations), covering the soil surface with intercrops or cover crops and practising a proper crop rotation with densely growing legumes to regularly suppress weeds. To some extent sorghum plants can compensate for poor stands by building several tillers per plant, but tiller production depends on good growing conditions. A dense and uniform crop discourages weed growth.

As a general rule the fields should always be kept covered with green or dry plants. This prevents uncontrolled development and propagation of weeds. Frequent problems with weeds generally indicate an unfavourable crop rotation. A sequence of crops with diverse growth habits in terms of duration and extent of soil covering prevents propagation of specific weeds. Regular growing of green manures that build a dense soil cover and suffocate the weeds can be essential to control competitive weeds. Well-managed green manures like *Stylosanthes guianensis*, *Canavalia ensiformis* (Jack bean) or *Mucuna pruriens* grow aggres-



### Discussion: Weed management in sorghum production

Ask the farmers whether they experience any major weed problems. Identify the major weed species and note the local names. Identify the local weed control strategies that are being used in sorghum fields. Which measures have proven essential and effective? quis con conse illorunt



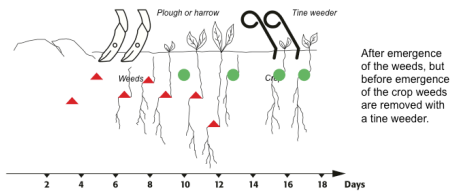


## BLIND HARROWING

### Blind harrowing

- Controlling weeds between sowing and crop emergence

In ploughed fields with bare soil weeds can be controlled using a tine weeder.



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sively and establish a thick biomass, which kills most weed growths underneath. The green manure biomass, combined with straw beddings, will provide good mulching material to protect the soil and contributes to soil improvement when ploughed or dug into the soil at land preparation.

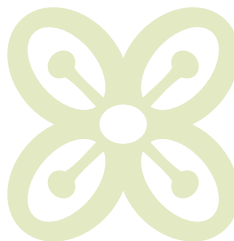
Growing an intercrop or a cover crop during growth of sorghum also contributes to the prevention of germination and development of weeds. Intercropping of Plumed cockscomb (*Celosia argentea*) has proved effective to control witchweed (Striga) in sorghum. To add an edible intercrop, beans (*Phaseolus vulgaris*) or another edible legume may be intercropped in addition to the catch crop. In arid climates growing a cover crop underneath the sorghum plants may result in competition for water and hinder growth of sorghum.

### b) Mechanical control

Giving sorghum plants necessary attention at the early growth stages enhances their ability to compete well with weeds in the later stages of growth. In early growth of sorghum mechanical weeding can be difficult, because sorghum plants look similar to grass seedlings. Mechanical weeding is also not recommended immediately after the emergence of sorghum until the plants have formed three leaves, as at this stage the sorghum plants are sensitive to injuries and may be uprooted.

Weeding is commonly done with a hoe, but animal-drawn or tractor-drawn cultivators can be used, too. In case a drawn cultivator is used for inter-row cultivation, the weeds within the rows are removed by hand. Hand weeding can be done at the same time as thinning is carried out, or it is done at intervals if the thinnings are used to feed livestock.

The most common mechanical device for weed control in sorghum is a tine-weeder (a harrow with spring steel tines). Tine-weeding is very effective between sowing and plant emergence, as well as when the sorghum plants have three to four leaves and the weeds are not taller than 1 cm, when they are easy to pull out. Tine-weeding is most efficient when the soil is neither too dry nor too moist. To avoid uprooting of the sorghum seeds when harrowing, the crop must be sown sufficiently deep, the tine-weeder must be pulled slowly and be well-adjusted to scratch only the soil surface. Tine weeding may not be very efficient against grass weeds. Broadcast sorghum can only be mechanically weeded using a tine-weeder. Tine-weeding between sowing and plant emergence is called blind harrowing.





## FALSE SEEDBED

**False seedbed**

1<sup>st</sup> round      2<sup>nd</sup> round

Plough or harrow      Tine weeder

Days: 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24

1. Prepare the seedbed early (2 to 4 weeks before seeding or planting).
2. Wait until the weeds have emerged.
3. Destroy the weeds at intervals of 7 to 10 days using a tine-weeder.

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In case of low weed pressure, a single cultivation with the harrow may be enough, while in case of higher weed pressure, up to three consecutive passages at two weekly intervals may be necessary. Where couch grass is a problem, even more frequent weeding is necessary.

In cases of high weed pressure, weeding before sowing is most appropriate in order to reduce the weed stock in the topsoil. For this the seedbed is prepared early and the weed seeds are left to germinate. After approximately seven days, the soil is cultivated superficially again to uproot the weeds before planting the sorghum seeds. Irrigation of the soil after soil cultivation, where possible, increases the effectiveness of this method. In some cases, the sorghum seeds may be sown at the same time when the germinating weeds are being uprooted by hand or when superficial hoeing is carried out. This method is called false seedbed.

## Management of Striga in sorghum production

The parasitic witchweed or Striga is a major constraint to sorghum production. The weed attaches itself onto the host's roots, where it draws nutrients and water. The infested host eventually becomes stunted, yellowish or wilted and gives poor yields. Crops grown in soil with poor fertility suffer greater damage than vigorously growing crops. The weed is dispersed by tiny seeds through wind, water, tools, animals and humans, and crop seeds. The parasitic weed can lead to total grain losses of sorghum.

Striga can be easily controlled by alternating sorghum with non-host or trap crops like groundnut, pigeon pea, Bambara bean, soybean, cowpea, cotton or sunflower. The trap crops induce germination of *Striga*, but do not serve as hosts. As a result the weed dies and the seed bank is reduced. Rotating sorghum with *Striga* trap crops (ideally with legumes to improve soil fertility) is an important preventive, as well as curative, control measure against *Striga*. Improved sorghum cultivars that are resistant or tolerant to Striga have been identified, but may not be available or affordable to farmers.

A successful trap intercrop in sorghum is Plumed cockscomb (*Celosia argentea*), while in maize intercropping of silverleaf (*Desmodium uncinatum*) has proved to be efficient. Plumed cockscomb planted between the sorghum rows can reduce Striga emergence by more than half in one season and can increase the yield of a susceptible sorghum variety in the field by more than one third compared to a sorghum monocrop. Some agroforestry species such as *Sesbania sesban* and *Leucaena diversifolia* have been shown to result in reduced striga



## Discussion: Mechanical control of weeds

Inquire among the farmers how common mechanical control of weeds is in the local context. If mechanical devices are used, discuss advantages and inconveniences of common practices and potential improvements.



## STRIGA CONTROL

**How to control Striga effectively**

Using clean crop seeds only

Intercropping trap crops

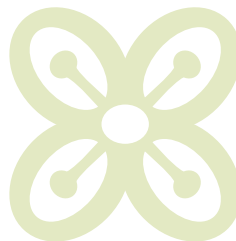
Rotating host and non-host crops

Improving soil fertility

Uprooting and burning Striga at the beginning of flowering

Avoiding dispersal of Striga seeds during crop harvest

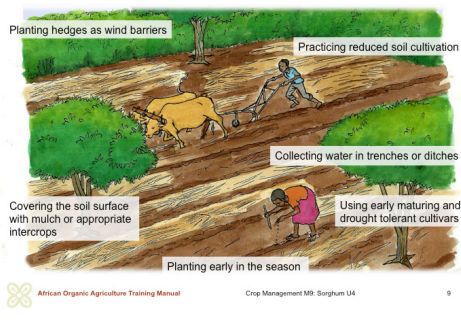
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## WATER CONSERVATION

### How to improve water supply of sorghum



infestations in fields. Where these trees can grow, they may act as false hosts to the weed and at the same time contribute to better soil fertility and serve as windbreaks or give partial shade. The trees are best grown in hedge rows.

Late sowing can also reduce Striga attack, but has a negative impact on yield. Therefore, a technique such as reduced tillage, which maintains a mulch soil cover and thus both allows early sowing and keeps soil temperature low, is a good option.

Sustainable control of Striga also includes preventive measures that limit distribution of the weed, such as using uncontaminated seeds, cleaning soil and plant debris off machinery, shoes, clothing and tools before entering the fields, and rigorous removal of Striga plants before they flower.

## 6. Proper water management

Sorghum's ability to extract water from great soil depth makes it better suited than most other cereal crops to growing in conditions where the water supply is limited. Although sorghum tolerates drought stress, significant increases in yields can be achieved through proper water management.

Proper water management in sorghum includes catching water with trenches or ditches on slopes, applying reduced tillage and keeping the soil surface covered with mulch, reducing evaporation of water by planting wind barriers, planting sorghum early in the season, and using drought tolerant and early maturing cultivars with a growth period of about 100 days. These measures help to reduce crop water needs and limit evaporation of water from the soil.

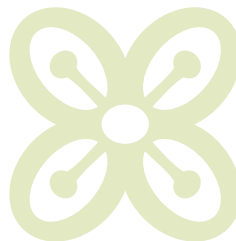
### Sorghum production in the parklands system

In the parklands system, which is common in the Sahel and Sudan zones of West Africa, trees that are considered important for various reasons are not cut when clearing land for cultivation. These tree species include *Faidherbia albida*, *Vitellaria paradoxa* and *Parkia biglobosa*. Annual crops like sorghum are then grown in association with these trees. Research has demonstrated that in low-fertility soils and in seasons when rainfall is limiting, sorghum grown under *Faidherbia albida* trees yields better than outside the tree canopies. This is due to the improved availability of soil nutrients and moisture under the trees. *Faidherbia albida* is leafless during the rainy season when sorghum grows and shades the soil



### Water management in sorghum production

Ask the farmers how they ensure good water availability for sorghum production. Have any farmers made experiences with reduced tillage and covering the soil with mulch? Have any other cultural measures proven to contribute to an efficient use of water?



during the dry season. Therefore, it can grow among field crops without shading them. The tree is highly drought resistant, fixes nitrogen from the air, its leaves are rich in nitrogen and can double yields of annual crops grown underneath the tree when added to the soil. Its flowers provide bee forage at the close of the rainy season, when most other local plants do not. The seed pods provide valuable feed for livestock and camel.

### Use of irrigation

In tropical Africa sorghum is mainly grown as a rain-fed crop. Irrigation is only practised on a small scale in areas with intensive crop management. In some areas sorghum is grown after fields have been flooded.

The total water requirements of sorghum for the entire growing season are similar to peanut and soybean. They range from 450 to 650 mm and are a bit lower than maize. Water requirements during early stages of growth are low. Thus, irrigation prior to planting is generally not useful, especially if there has been sufficient rainfall during that time. Irrigation should be planned for the later stages of growth.

Water supply should be increased in line with the development of the crop and reach a peak during the change from the vegetative to the reproductive phase. Adequate soil moisture during the peak period has the most positive effect on yields. In cases where water supply is limited, irrigation should focus on avoiding water deficits during flowering to avoid early grain formation. Application of small doses of water ensures most efficient use.

## 7. Effective pest management

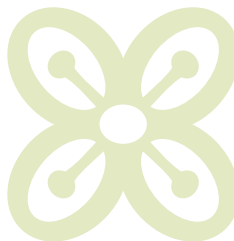
Sorghum is prone to damage by various insect pests and birds. Most insect species that infest sorghum occur widely and do not attack sorghum only, but several wild and cultivated grasses like maize, sugarcane or millet. Most insects appear at a specific stage of crop development: some feed on the leaves of seedlings, some bore into the stem causing a dead heart, many feed on the foliage during the vegetative stage, some suck the sap from leaves, some species damage the panicle at flowering, and some feed on the developing grain inside the glumes.

Among the most important insect pests are the shoot fly and stemborers. The larvae of the shoot fly attack the shoots of seedlings and tillers, and cause dead



### Sharing experiences with sorghum production systems

Ask the farmers to discuss their experiences with different sorghum production systems – without trees, and including trees like the parklands approach. For the parklands approach ask the farmer to discuss any differences among different parkland systems (based on the dominating trees in the parkland).*quis con conse illorunt*





## COMMON SORGHUM PESTS AND THEIR CONTROL

### Control of major pests of sorghum

Pests	Preventive and cultural measures	Direct control
<b>Shoot fly</b>	<ul style="list-style-type: none"> <li>Use of tolerant cultivars (for late planting mainly)</li> <li>Early, uniform sowing at high seeding rates</li> <li>Intercropping of legumes (non-host plants)</li> <li>Removal of wild grass species</li> <li>Incorporation of crop residues into the soil</li> </ul>	<ul style="list-style-type: none"> <li>Removal and destruction of infested plants</li> <li>Spraying of <i>Bacillus thuringiensis</i> against larvae</li> <li>Spraying of Neem solution against larvae</li> </ul>
<b>Stemborer</b>	<ul style="list-style-type: none"> <li>Early sowing</li> <li>Intercropping of repelling plants</li> <li>Promotion of natural enemies</li> <li>Planting of Napier grass as a trap crop</li> <li>Destruction of infected crop residues after the harvest</li> </ul>	<ul style="list-style-type: none"> <li>Application of a Neem- or a fish bean plant extract sawdust/clay mixture into the funnel of young plants</li> </ul>
<b>Sorghum midge</b>	<ul style="list-style-type: none"> <li>Early and uniform sowing with high densities</li> <li>Use of resistant cultivars</li> <li>Crop rotation and intercropping with pulses</li> <li>Removal of host weed species</li> <li>Incorporation of crop residues after harvest</li> </ul>	<ul style="list-style-type: none"> <li>Spraying of pyrethrum extract</li> </ul>



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hearts, whereas stemborers cause damage in all crop stages. The leaves are attacked by army worms (*Spodoptera* and *Mythimna* spp.). Larvae of the sorghum midge feed on the young grains in the panicle. Head bugs suck on the developing grains, which results in yield loss, grain deformation and discolouration, and infection by moulds. Among the birds, especially *Quelea quelea* can cause important yield losses.

Regular monitoring and proper pest management are necessary to avoid yield losses in sorghum. In Africa the focus of pest management in sorghum is on proper application of preventative and cultural measures. Direct control of pests is not common. Pest management measures include the use of early-maturing cultivars, early planting and rotation of sorghum with non-host crops. Early sowing is particularly important, as it helps to avoid large insect populations at times when plants are most susceptible to damage. Cultivars with a good resistance are available for sorghum midge only. But cultivars with low levels of resistance to other pests exist.

Sorghum is also very susceptible to damage by storage pests like weevil (*Sitophilus oryzae*), flour beetle (*Tribolium castaneum*) and grain moth (*Sitotroga cerealella*).

### Management of the common pests in Africa:

**Shoot fly (*Atherigona soccata*):** The larvae destroy the growing points and stems of young sorghum plants, which results in dead hearts. When temperatures are moderate and humidity is high during the rainy season the population of the shoot flies increases rapidly. Therefore, infestations are high after the rainy season. Between seasons, the flies hide on the tillers of remaining sorghum plants and alternative grass hosts.

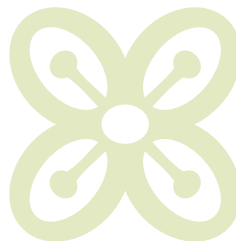
The carry-over of the pest from one season to the next is reduced by mixing the crop residues into the ground after harvest, and by maintaining a proper crop rotation or ensuring sufficient fallow periods.

The use of tolerant cultivars, where available, or the inoculation of sorghum seeds with the bacteria *Azospirillum* and *Pseudomonas* considerably reduces shoot fly damage. Cultural control measures that reduce shoot fly damage also include early, non-staggered planting, establishing a high plant density, intercropping of sorghum with legumes or especially garlic, ensuring the availability of sufficient moisture and nutrients in the soil, delayed thinning, and removal of wild grass species which can serve as hosts. Plants with shoot fly damage should



### Working group/ field visit: Pest management in sorghum production

Organise a field visit to selected sorghum fields, and identify together with the farmers any observable signs of pest problems. Ask the farmers whether they are familiar with those signs of pests and whether they have monitored to see when the pests attack. Discuss possible preventative and cultural measures to manage the pests





### Controlling stemborer with the push-pull method

1. Make plots of 10 to 50 m size.
2. Sow 2 to 3 rows of Napier grass around the plots.
3. Plant healthy Napier before the rain season at 75 cm between rows and 50 cm within rows.
4. Sow repellent intercrops together with sorghum.
5. Weed intercrops repeatedly.



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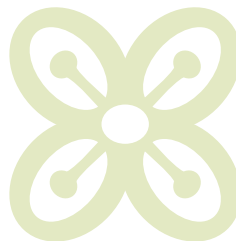
be removed during thinning and destroyed. In cases where plants are attacked and at high risk of damage, it is possible to spray with *Bacillus thuringiensis* or Neem extract.

**Stemborers** (particularly *Busseola fusca*, *Chilo partellus* and *Sesamia calamistis*): These insects prefer sorghum, but also attack other cereals and grasses like sugarcane and maize. The larvae feed on the growing points, leaves and stems of the plants at different growth stages. Attack can result in major losses. The symptoms are similar to those of shoot fly, but occur later in crop development. Other symptoms are rolled leaves in the vegetative stage and tunnelled stems in later stages of crop growth. Late attack in the generative phase may result in chaffy heads and, in severe cases, the peduncles may snap. Stemborers pupate in the stems or between the stem and the leaf sheath. The insects can survive from one season to the next as fully grown larvae in stems.

Cultural practices to reduce stemborer attacks include early, non-staggered sowing of sorghum, promotion of natural enemies, intercropping with millet (as adults do not lay eggs on millet stems) and destroying the residues after harvest to kill the caterpillars. Repeated application of Neem kernel powder or the leguminous Fish bean plant (*Tephrosia* spp.), mixed with sawdust or clay and placed into the funnel of young plants can be used to control stemborers if major damage is expected.

The 'push-pull' strategy, which was originally developed for maize-based farming systems in Eastern and Southern Africa, is also effective against stemborers in sorghum (see under weed management). To attract and kill the stemborers, some rows of Napier or Sudan grass are planted around the sorghum field acting as trap crops (pull). Additionally, repelling crops such as *Desmodium* spp. and *Melinis minutiflora* are sown between the rows of sorghum. These companion crops all have the added advantage of being useful fodder plants and *Desmodium* also supplies nitrogen to the soil and suppresses the parasitic Striga weed. Biological control of stemborers is possible with the wasp *Cotesia flaviceps*.

**Sorghum midge** (*Contarinia sorghicola*) is a very destructive pest of grain sorghum and occurs wherever the crop is grown. The adult is a tiny orange fly, whose larvae feed on the developing seeds, making the panicles appear blasted. Infections are common during the rainy season, among low density plant populations, or when there is a prolonged flowering due to staggered sowings and/or cultivation of varieties with different maturities, and the presence of alternative hosts. Late-flowering varieties often coincide with high midge population hence caus-







## COMMON SORGHUM DISEASES AND THEIR CONTROL

### Control of major diseases of sorghum

Diseases	Symptoms	Control measures
<b>Stalk rot</b>	<ul style="list-style-type: none"> <li>Rotting of roots and premature death</li> <li>Infected stalk tissue turns dark red</li> <li>Lodging of plants</li> </ul>	<ul style="list-style-type: none"> <li>Crop rotation</li> <li>Use resistant cultivars</li> <li>Proper spacing</li> </ul>
<b>Anthracnose</b>	<ul style="list-style-type: none"> <li>Orange, red- or blackish purple leaves</li> <li>Small leaves with circular or elliptical shape</li> </ul>	<ul style="list-style-type: none"> <li>Use resistant cultivars (hybrids)</li> <li>Rotation with pulses</li> <li>Encourage decomposition of crop residues after harvest</li> </ul>
<b>Smuts</b>	<ul style="list-style-type: none"> <li>Sorghum kernels are replaced by a cone-shaped gall (Covered kernel smut)</li> <li>Long and pointed galls formed by loose kernels (Loose kernel smut)</li> <li>Large, dark-brown smut galls emerging in place of the panicle (Head smut)</li> </ul>	<ul style="list-style-type: none"> <li>Use resistant cultivars or certified disease-free seeds</li> <li>Hot water treatment of seeds</li> <li>Crop rotation with non-cereals</li> <li>Removal of infected panicles</li> </ul>
<b>Downy mildew</b>	<ul style="list-style-type: none"> <li>Vivid green and white stripes on the leaves and heads</li> <li>Heads partially or completely sterile</li> </ul>	<ul style="list-style-type: none"> <li>At least 3 years between two sorghum or maize crops</li> <li>Use of resistant cultivars</li> <li>Use of clean, properly dried seeds</li> <li>Proper plant spacing</li> </ul>



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ing severe yield losses. High or very low temperatures and very dry conditions or high rainfall during flowering hinder the development of the pest.

If sorghum is sown early in the growing season using early-maturing cultivars and avoiding staggered planting, it usually escapes infestation. The use of resistant cultivars considerably reduces damage. Cultural practices such as appropriate rotation with non-host crops, and the intercropping of sorghum help to reduce pest damage. Infected crop residues should be destroyed by being fed to cattle, incorporated into the soil or burnt. Spraying of natural pyrethrum may be used, but is costly, difficult to apply, must be well timed to coincide with the flight of the adult insects and is less effective than other measures. After harvest the crop residues should be incorporated into the ground.

**Head bugs** (*Calocoris angustatus* and *Eurystylus oldi*) puncture and suck juice from the developing kernels, making them shrivelled, stunted and discoloured. The damaged kernels become infected with secondary pathogens, which further deteriorate the quality. Head bugs can be successfully controlled by growing tolerant cultivars. Guinea type sorghum is generally less affected by head bugs. Also, early maturing varieties are less susceptible.

**Birds:** Losses due to bird attack during grain-filling are widespread. Keeping birds away from ripening grains and harvesting in time are essential to limit losses. The cultivation of varieties with grains that have a purple seed undercoat containing tannin is another efficient control measure, as the birds ignore the bitter tasting seeds.

## 8. Effective disease management

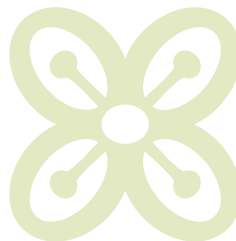
Disease attack by fungi, bacteria, viruses and nematodes is one of the causes of low yields in sorghum production. The four economically most damaging diseases of sorghum include stalk rots, anthracnose, smuts and downy mildew.

**Stalk rot** (*Fusarium* spp.) causes the premature death of plants and rotting of roots. Infected stalk tissue turns dark red. This disease is favoured by physiological stress, abundant moisture and moderate temperatures during the grain-filling period. The stalk-rotting fungi quickly invade plants and digest the remaining stalk structure, which eventually results in lodging of the plants. Use of resistant cultivars, proper crop rotation and proper plant spacing are effective in controlling stalk rot.



### Working group/ field visit: Disease management in sorghum pro- duction

Organise a field visit to selected sorghum fields, and identify together with the farmers any observable signs of disease problems. Ask the farmers whether they are familiar with the signs of disease infections and whether they have monitored to see when the diseases attack. Discuss possibilities of managing the diseases.

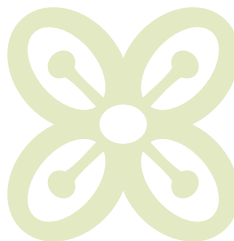


**Anthracnose** (*Colletotrichum graminicola*) causes orange, red or blackish-purple discolorations on leaves, which are small, circular or elliptical in shape. The disease is common in hot and humid climates and is prevalent in areas where high humidity alternates with relatively dry periods. The disease can be controlled using resistant varieties (hybrids), growing sorghum in rotation with non-cereals, preferably pulses, and by encouraging rapid decomposition of crop residues after harvest.

**Smut** (*Sporisorium sorghi*): Diseased plants show individual grains that are replaced by whitish to grey or brown smut sori. Heavily contaminated seed may turn greyish-black, especially in white-seeded sorghums. The fungus rarely survives in the soil between cropping seasons, therefore proper rotation can effectively control smut. Sorghum can only be infested by smut when the seeds are infested by airborne spores at harvest or in the soil before the seedlings emerge. Treatment of seeds with hot water successfully reduces the disease. Tolerant sorghum cultivars are less susceptible. Cultural control measures include proper crop rotation and removal of infected panicles.

**Downy mildew** (*Peronosclerospora sorghi*): The disease can cause serious yield losses in sorghum (and maize). It affects the plant at nearly all stages. Infection results in vivid green and white stripes on the leaves and heads that are partially or completely sterile. The major sources for infection are spores that survive in the soil and airborne spores coming from infected plants. High plant density and rainfall after planting encourages development of the disease. The disease is not transmitted by seeds, provided that they are properly dried and stored. Proper crop rotation is an effective cultural measure, but requires a break of at least 3 years between cultivating two sorghum or maize crops to prevent new spores being added to the soil. Resistant cultivars exist. Natural fungicide applied as seed treatment or preventive foliar spray provides further effective control.

## 9. Minimising losses at harvest and in storage



Proper harvest and post-harvest handling of sorghum aims at minimising losses and maintaining grain quality. Timely harvest and adequate drying of the grains before storage considerably reduce storage losses. Cultivars with hard grain suffer less damage at storage.

### Timely harvesting

Prompt harvesting of mature grains is important to avoid major losses, mainly those caused by birds. Rain-fed sorghum crops are harvested at the end of the rainy season when the grain has become hard. Most farmers in the tropics harvest sorghum manually by either cutting the heads or removing the whole plant. Where short cultivars are grown, the plants can be harvested mechanically using a combine harvester.

Sorghum grain yields under traditional farming practices in Africa are as low as 0.5 to 0.9 tons per hectare. If conditions are favourable and improved cultivars are used, yields of 3 tons and more per hectare are possible.

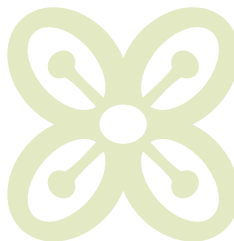
As a general rule, sorghum stalks and re-growth should be dug or ploughed into the soil, grazed or destroyed soon after harvest to prevent further development of insect pests. Burning of the residues is not recommended in organic farming, as it destroys valuable soil organic matter in the top soil and kills soil organisms. Sorghum forage is often dried and stacked along the field as trash lines or made into silage. Drying and ensilage of sorghum forage avoids animal poisoning from prussic acid. In case of pasture use, re-growth of sorghum plants is best, if stubbles with no less than 10 to 15 cm length are left. Forage sorghum is usually only cut once after flowering under rain-fed conditions. Under conditions of sufficient water and nutrients forage sorghums can be harvested multiple times.

In some areas with a climate that allows two subsequent crops of sorghum, ratooning of sorghum is common. The practice aims at getting more than one harvest from a single sowing. Immediately after the first harvest the plants are ratooned. Compared to a newly sown crop a ratoon crop develops faster because of its established root system which utilises the available water in the soil early in the season, matures earlier and therefore can avoid losses by migratory quelea birds. Ratooning also saves on labour for ploughing and planting. Where the parasitic *Striga* weed or soil borne pests and diseases prevail, two subsequent crops of sorghum are not recommended. To achieve good yields, the crop is thinned to 2 to 3 tillers per hill. Weeding and other management practices are done as for a



### Discussion: Post-harvest handling of sorghum

Ask the farmers to describe how they handle sorghum between harvesting and storage. Identify any shortcomings of their methods and recommend appropriate modifications with respect to the principles of organic agriculture.



newly sown crop.

### **Proper drying**

Traditionally, the harvested panicles are properly dried in the sun for about 2 weeks. Drying is ideally done by spreading the grains on a mat or tarpaulin to minimise ground contamination and fencing-in the area to keep out domestic animals. Furthermore, grains should be protected from rain, as rain can delay drying and lead to the development of mould.

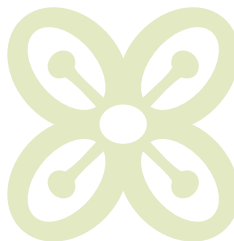
### **Threshing and winnowing**

Threshing is done to separate the grains from the panicles. As in wheat, the seeds separate easily from the floral brackets when threshed. Traditionally, the dried panicles are filled in sacks and the sacks are hit gently with a stick to loosen the seeds off the panicles. With this method, care should be taken not to damage the seeds. After threshing, grains are winnowed to remove any foreign matter.

### **Proper storage**

For storage, grains should be filled into bags made of jute or sisal that allow good aeration. This reduces infestation with storage pests and moulds. To further reduce infestation by fungi and insects, a layer of neem leaves can be laid out on the bottom of the granary. Rat-guards should be used to prevent entry of rats into the granaries. Stored grain can further be brought out periodically and exposed to the sun in order to reduce the build-up of high humidity conditions, which is a precursor for mould development. Attention should be paid not to use bags or containers which contain traces of pesticides or other chemical products, in order to avoid any contamination of the grains.

## **10. Requirements for organic certification of sorghum production**



Organic certification is only economically reasonable if the market demands it. Demand for organic sorghum grains for food may be still low, but may increase continuously with the growing worldwide demand for organic food.

Certification requires that the entire farm complies with organic rules. This includes abstaining from synthetic pesticides and fertilisers and chemically treated and genetically modified seeds for all crops.

Farmers should have sizeable land to produce commercial sorghum volumes beyond the household requirement in order to be able to cover the extra costs of certification. The land should be owned by the farmers or they should have assured, long-term leasehold.

Ideally farmers of the same village or area with adjacent fields form an organic producer organisation to minimise the risk of contamination from neighbouring fields and negotiate for preferential treatment of their harvests and good prices. Establishment of an internal control system helps to minimise the costs of organic certification. Eventually, as volumes increase, a producer organisation can acquire its own processing facilities.

To avoid contamination clean sacks only should be used for storing sorghum. These should not have been used for synthetic fertilisers or any chemicals.

## 11. Recommended further reading

- > [www.infonet-biovision.org](http://www.infonet-biovision.org). Further information on pests and diseases.
- > International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). [www.icrisat.org](http://www.icrisat.org). Information on pests, diseases and crop production.
- > [www.pushpull.net](http://www.pushpull.net). Training Manual on Striga control and push-pull strategy against stem borers.



### Discussion: Organic certification in sorghum production

Discuss with the farmers the market requirements for sorghum. Is organic certification needed? Is there an organic market for the other crops of the sorghum rotation, too? Would it be worth creating an organic producer organisation?

