

9-16 COTTON



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CONTENTS

1. Introduction	1
2. Potential of organic cotton production in Africa	2
3. Improving access to good quality seeds	4
4. Improving cotton yields	6
5. Improving postharvest handling	17
6. Improving returns from cotton production	18
7. Marketing and organic certification of cotton production	19

9-16 COTTON



FACTSHEET 16: COTTON

Learning targets for farmers:

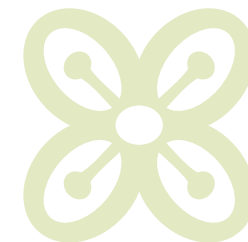
- › Understand the relevance of selecting appropriate cotton varieties and healthy seeds for successful cotton production
- › Understand the relevance of diversification within and around the field to encourage natural enemies for cotton pest control
- › Develop awareness of the importance of regular monitoring for management of cotton bollworms and other devastating caterpillars
- › Develop awareness of proper postharvest handling techniques
- › Learn about marketing and organic certification of cotton

1. Introduction

Cotton (*Gossypium* spp.) is a very important fibre crop and plays a major role in the economies of several Central and West African countries. Tanzania leads organic cotton production in sub-Saharan Africa, but only contributes about 2 % to the global organic cotton production. Other relevant African organic cotton countries are Uganda, Mali, Burkina Faso, Benin, Senegal, South Africa, Zambia, Togo, Kenya and recently in Ethiopia.

Organic cotton is grown on farms of a few acres to 50 or more acres in mostly diverse farm systems with often integrated animal husbandry and usually not more than half of the arable area under cotton.

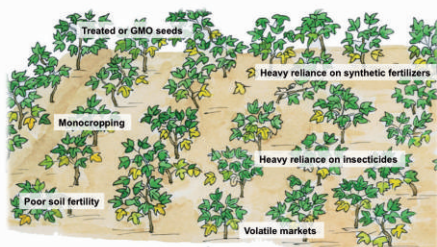
The African organic cotton sector is rather young, but has several initiatives by non-governmental organisations and by pioneers in the private sector searching for niche markets. This market has been assured by wealthier and environmentally conscious consumers from industrialized countries. Today demand is higher than supply. Shortage in supply is essentially caused by the complexity and the many risks and challenges that are related to the organic cotton production process.





COMMON SITUATION IN COTTON PRODUCTION

Common situation in cotton production



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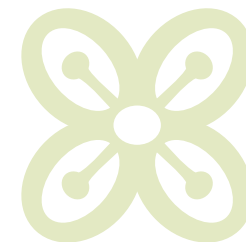
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Common challenges to cotton production in Africa

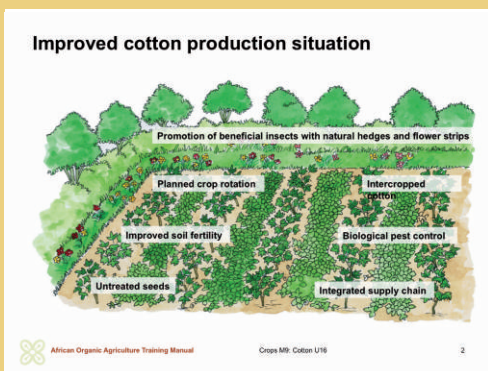
- › **Limited access to good quality seeds** - National cotton regulatory bodies ensure the distribution of cotton seeds, mostly hybrids, closely linked to seed companies which nearly control the entire cotton seed sector. The producers can hardly participate in the breeding process without having access to the parent lines. Breeding of varieties specifically suitable for sustainable agriculture remains a big challenge all over Africa.
- › **Heavy reliance on insecticides** - Cotton production is dominated by monocropping systems and consumes about 19 % of all insecticides used in agriculture worldwide. The pesticides are often provided within credit and extension schemes, where farmers are expected to pay back after harvest. Due to the complexities of cotton production, sometimes there is hardly enough harvest for the individual farmer to pay back for the inputs as well as meet personal needs. The high costs as well as the health risks, for example for pregnant women, are key arguments for farmers not to use synthetic insecticides.
- › **Decreasing soil fertility** - Many conventional cotton farmers in the South are in a crisis due to decreasing soil fertility. With prices for mineral fertilizers increasing and the continuous need to produce enough cereals for household consumption, a growing number of farmers started using the fertilizer designed for cotton on their food crop fields, therefore, fertilizer is no longer available for the cotton fields.
- › **Increasing production costs** - Costs for nitrogen fertilizers, chemical pesticides, irrigation and labour have all increased in the last years. If this factor is matched by low cotton prices on the markets, then the cotton producers hardly make any profit. Unstable cotton prices are very common, as they react to small changes on the global market.
- › **Volatile markets** - The high price fluctuations can lead to important economic losses, particularly if the market information is not available in a timely manner. In 2008, the oversupply of organic cotton led to very low prices for organic cotton. In 2011, the situation had reversed, leading to an increase in supply. The domestic market hardly exists in Africa, so most produce is exported.

In view of the prevalent challenges, an increasing number of farmers turn to organic cultivation in order to restore soil fertility, reduce production costs and/or to get a better price for their certified organic harvest. This chapter introduces





IMPROVED SITUATION



organic approaches to be adapted to local conditions in order to ensure a sustainable and profitable production of cotton.

2. Potential of organic cotton production in Africa

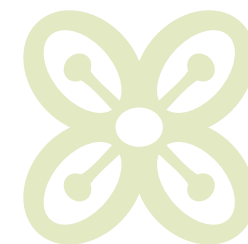
Most organic cotton farmers in Africa are small-holder farmers and grow less than 2 hectares of cotton on farms with a total size of less than 10 hectares. They compete with fully-industrialised production and processing systems in the USA, Brazil and elsewhere, which grow cotton on farms of more than 500 hectares. The African organic cotton industry, promoted mainly by civil society organizations and niche private sector operators, is still struggling with scaling-up and getting more support from national bodies. The small-scale projects are fighting with relatively high costs due to the lack of economies of scale and the limited research and extension services that would be needed to accelerate the expansion of proven best practices. However, the following strategies can help in the development of the organic cotton sector:

- › **Increasing the scale of production** - Larger scale projects and a better support by national services and policies will definitively contribute to bring down production costs, increase productivity and enhance the attractiveness of this young industry. The establishment of larger organic cotton areas providing more than 100 tons is necessary for success.
- › **Biological pest control** - The high susceptibility of cotton plants to pest attacks puts high demands on appropriate research and extension, especially regarding biological control options. Well organized set-ups, linking producers with researchers gives the required information for proper management of pests.
- › **Higher labour input** - Particularly the necessary weeding, manure applications and harvesting by hand increases the labour input for organic cotton producers. Through research and technology development (machinery and best practices), labour saving implements are needed for the different activities in order to improve efficiency and reduce costs associated with cotton production.
- › **Institutional development** - Research organisations and programs, cotton universities and producer organizations as well as properly designed government policies with appropriate budgets are indispensable in the long term to



Assessment of the local cotton production situation

Invite the farmers to a brief brainstorming session to understand their knowledge of cotton production and markets. Have they experienced any of the above or other challenges in growing and selling cotton? Note down the points in key words on a flip chart or board. Compare the aspects with those listed in transparency 1. Discuss which of the challenges are most important to them.





STRATEGIES TO DEVELOP ORGANIC COTTON

Strategies to develop organic cotton production

- › Increasing the scale of production
- › Biological pest control
- › Reducing labour input
- › Institutional development



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Crops M9: Cotton U16

3

remain competitive. Regional cooperation and networks of exchange could create synergies and enhance the knowledge base. Strong and committed leaders from within the producer community are indispensable to further develop the (organic) cotton industry in Africa.

3. Improving access to good quality seeds

Characteristics of variety and seed quality have a great influence on yields, plant health, climate change adaptation, nutrient uptake efficiency and adaptability to the soil, local climate conditions and lint quality. Access to good quality seed is, therefore, a prerequisite for successful cotton production.

Certified organic agriculture requires the use of seeds that have not been treated chemically, and that originate from multiplication on organic farms. The first requirement is usually met by organic cotton projects through the use of cotton seeds that have been exempted from chemical treatment. The second requirement – originating from organic production – cannot currently be met by most organic cotton projects in sub-Saharan Africa because of national legislation. However, certification bodies acknowledge these legal constraints and, therefore, accept by implication the use of conventionally but untreated seeds produced according to a well-established procedure.

3.1 The right variety for the right site

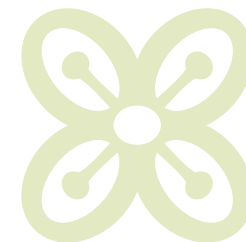
There are many different cotton varieties available on the seed market. Research stations and seed companies continuously release new varieties. Most of them are bred for producing high-yields with a high input of fertilizers, pesticides and irrigation. Organic farmers should, however, be more interested in robust varieties, which are resistant or tolerant to pests, diseases and droughts and produce satisfying yields of about 0.65 to 1 ton seed cotton per hectare, with medium manure supply.

To select the most suitable varieties, farmers need to consider the site conditions. This includes soil quality and availability of manure, availability of enough water from rain or irrigation as well as the prevalence of common pest and disease problems. Where irrigation is a constraint and rainfall is erratic, it is prefer-



Characterisation of available varieties

Inquire among the farmers about the locally available cotton varieties. What are their characteristics (e.g. yield potential, adaptability to local conditions, resistance to infection, lint quality)? Note the results on a table and agree with the farmers on the most suitable varieties for the local conditions.





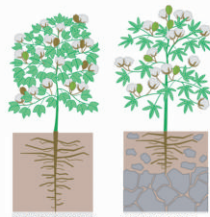
SELECTING THE RIGHT COTTON VARIETIES

Selecting the right cotton varieties

Many cotton varieties are bred for producing high-yields with a high input of fertilizers, pesticides and irrigation.

Selection criteria for organic cotton production:

- › Tolerant to pests, diseases and droughts
- › Satisfying yields with medium manure supply
- › Adapted to site conditions
- › Satisfying buyer's requirements



High yielding variety for high input production system

Medium yielding variety for low input production system

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Crops M9, Cotton U16

4

able to grow varieties, which require less water (meaning those making less leaf area). Lastly, the buyer's requirements concerning staple length and other fibre quality aspects need to be considered.

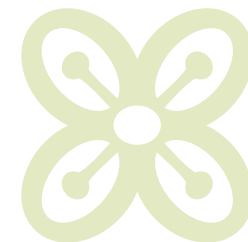
3.2 Multiplication and treatment of cotton seeds

Most seed companies do not provide untreated seeds anymore and large seed companies are no longer offering non-genetically modified varieties. Therefore, organic cotton projects normally have challenges of ensuring a reliable supply of untreated seed material with good yield potential. Traditional knowledge and know-how on seed production at the farm level is slowly 'drying' up. Research institutes have also hardly had the means to assist organic farmers in breeding and developing appropriate and locally adapted seed.

Alternative treatment of seeds can help to reduce damage by pests and diseases caused before and during germination. Some suggested methods are: dipping in cow urine, coating with clay and cow dung or treatment with a suspension of beneficial microorganisms (*Trichoderma* or *Bacillus subtilis*). To enhance the uptake of nutrients, some organic farmers treat the seeds with a suspension of *Azotobacter* and phosphorus solubilising bacteria (PSB).

In practical terms, involvement of a supporting organization as an intermediary between the farmers, the seed company and the associated national research body to manage organic cotton seed production is needed. Under supervision of a support organization the individual farmers can produce cotton seed for the production requirements. However, farmers will need a specific training to successfully accomplish this. At least every 5 years, seed varieties need to be replaced.

For a cotton field of 500 acres, 1 acre of seed production area is required. For 1 hectare it is advised to use 20 to 30 kilograms of seeds according to the germination capacity of seeds. The corresponding seed production area is 500 to 700 m².



GMO seeds are not allowed in organic agriculture

In organic agriculture, the use of genetically modified organisms (GMOs) is not allowed. Genetically engineered 'Bt cotton' seeds contain genes of the same microorganism *Bacillus thuringiensis* that is used in the biocontrol of many insect pests. The Bt cotton plant thus continuously produces an insecticide that prevents bollworms from feeding on it. However, success with Bt-cotton requires regular purchase of seeds and high inputs of fertilizers and pesticides. The other type of GMO cotton being promoted is tolerant against specific herbicides. So far, South Africa, Kenya and Burkina Faso have opted for GMO cotton production. In Burkina Faso, GM cotton is advancing very fast and has reached over 80 % in 2011. As seed procurement was traditionally organized by the cotton associations, the organic cotton producers set up their own breeding program in 2008 involving the national research program to assure untreated and non GM seed quality. This was only possible through the involvement of well-organized farmer organizations. In Burkina Faso, the UN-PCB—Union Nationale des Producteurs de Coton du Burkina—is supporting their organic cotton farmers in accessing appropriate seed.

We can learn from this case in West Africa that only a well-organized multi-stakeholder approach, involving cotton producers, the support agency (e.g. farmer organization, NGO, state, private seed, ginning or marketing organization) can bring satisfactory and practical solutions to the seed challenge. However, the key players remain the ginners, input suppliers (fertilizers, pesticides) together with government bodies.

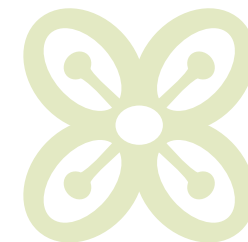


Group discussions on possibilities for improvement of cotton yields

Form small groups of 3 or more farmers and let them suggest the different ways to improve cotton yields. Let them note down their contributions on paper for discussion with the rest of the group in a plenum.

4. Improving cotton yields

Cotton yields are mainly determined, apart from the farmers' skills, by climatic factors such as temperature, sunlight, and availability of water, the soil qualities (structure, texture, nutrients and biological life), the seed variety as well the situation regarding pests, diseases and weeds. Under good conditions the cotton plant may produce 1 to 2 tonnes of seed cotton per hectare in tropical Africa. However, if only one of the favourable conditions is lacking, yields are drastically reduced. If the unfavourable conditions are only short term (few weeks), the cotton plant may recover through compensation.





ESTABLISHING A COTTON GARDEN

Establishing a cotton garden

1. Proper land preparation



2. Incorporate animal manure or green manure



3. Plant at the beginning of the rainy season



4. Thin and leave two plants per hole



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Crops M9: Cotton U18

5

4.1 Establishing a cotton garden

Cotton is highly sensitive to excess water and water logging, which causes a reduction in yields through boll shedding, even when the plant appears to be unaffected. Cotton plants prefer deep, well-drained soils with good nutrient content. Ideal soils are clay-rich, vertisols (also called 'black cotton soils'). This ensures that the tap roots of cotton plants can penetrate up to 3 meters in such soils and hence are able to sustain short periods of drought. However, cotton is also grown on less ideal sites with shallow, sandy soils, both under irrigated and rainfed conditions. This will, however, require well-adapted varieties and solid management practices.

Land preparation should be done early while incorporating green manure or animal manure before planting. Land preparation should also ensure that weeds are substantially removed to prevent an excessive growth of weeds during the early growth phases of the cotton crop. Planting should be done as soon as the rain season begins to ensure that the planted seeds get adequate moisture for germination and growth. Cotton is either planted on flat rows or ridges. Ridges are used in soils that are difficult to drain, and in regions with little rainfall, as this helps to conserve water under dry conditions and aid drainage under wet conditions.

In small-holder cotton production, cotton planting is done by hand and about 3 to 4 seeds are planted per hole in flat rows or ridges. Thinning is done when the plants are 6 to 10 cm high, leaving the strongest two plants per hill. The optimum spacing depends on the size and fruitfulness of the plant permitted by local conditions. The optimum spacing ranges from 20 to 50 cm within rows and 60 to 90 cm between rows, with one or two plants per hill.

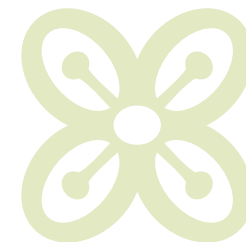
4.2 Diversification in cotton production

Cotton is by nature a perennial crop, but it is commonly grown as an annual crop. Contrary to most cereal and leguminous crops, cotton is deep rooting. Its vertical tap root gives the plant access to water and nutrients in lower soil layers. This makes it a good rotational crop, and one that is relatively tolerant to drought and variable rainfall.



Group activity on diversification in cotton fields

Ask the farmers which crops are commonly grown together or in rotation with cotton. Summarize the results of the discussion and discuss the advantages and disadvantages of the suggested options, based on the experience of the farmers. At the end of the discussion, try to agree with the farmers on the most suitable crop rotation and intercropping patterns for local conditions.



a. Crop rotation

Cotton must be grown in rotation with other crops to maintain fertility of the soil, break the development cycles of soil-borne pathogens and prevent the spreading of weeds. Cotton should not be grown after cotton in the same field. Instead another crop should be grown at least for one, but preferably for two seasons, before the next cotton crop.

Cotton rotations should include legume crops such as mung bean, cow pea or chick pea for harvesting or a green manure crop such as sun hemp or cow pea, to be cut and ploughed back into the soil before flowering. Pulses like mung beans, soybean, chickpea, pigeon pea and groundnuts increase the nitrogen content in the soil by fixing nitrogen from the air. But they can also be marketed to increase farm income. Suitable crop rotation patterns with cotton depend on the climatic conditions, market requirements and availability of land.

b. Green manures and intercropping

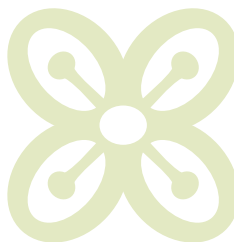
When cotton is intercropped with maize, sorghum, beans or peanuts, pests find it more difficult to move from one host plant to another, and they are controlled by a number of beneficial insects hosted by the intercrops. Some examples are:

- > Maize planted in every 2 rows of cotton attracts the African bollworm.
- > Sunflower or cowpea sown in every 5 rows of cotton attracts moths when planted as trap crops.
- > Castor bean (*Ricinus communis*) also attracts caterpillars.
- > Rice when rotated with mung bean and cotton disrupts the life cycle of pests attacking these crops.

For best distracting effect, planting of intercrops, trap crops and border crops should be timed such that they flower at the same time with cotton. Intercrops are usually allowed to mature and are cut and used as mulching material after the seeds are harvested.

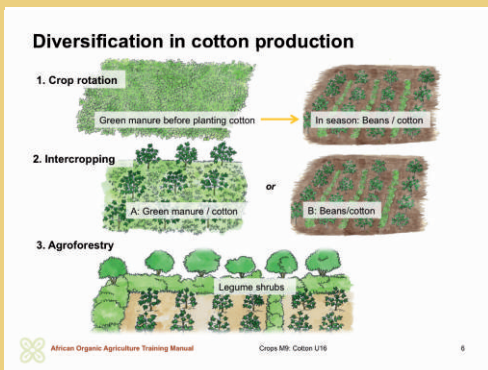
Diversification of crops furthermore reduces vulnerability to crop failure and to fluctuating prices. It also helps to prevent shortage of labour in peak seasons, as labour requirements are more evenly distributed throughout the year.

Green manures improve soil fertility and can act as trap crops. Green manure crops like sun hemp (*Crotalaria juncea*), jack bean (*Canavalia ensiformis*), Lablab (*Lablab purpureus*) or velvet beans (*Mucuna pruriens*) are usually sown between the rows after cotton seedlings emerge. They are cut before or at the time of





DIVERSIFICATION IN COTTON FIELDS



flowering, and are either used as mulch or incorporated into the soil.

Both green manure and intercrops have the following benefits:

- › They distract pests from the cotton crop (especially sucking pests), attract and host beneficial insects.
- › They take up nutrients from the soil and buildup organic matter, which would otherwise be lost through leaching. The added organic matter builds better soil structure, water retention and overall fertility.
- › Leguminous green manure crops and intercrops fix nitrogen from the air and make nutrients available to the cotton crop.
- › They suppress weed growth and protect the soil from soil erosion through rain or wind.
- › They provide additional yields or fodder for livestock.
- › On the other hand, green manure and intercrops do compete with the cotton crop for water, light and nutrients. Thus, appropriate timing of the sowing and cutting is very important in order to get maximum benefit with minimum competition.

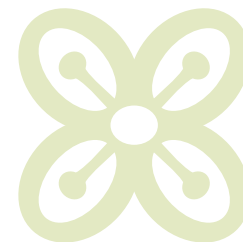
c. Agroforestry

In areas with heavy wind and frost, agroforestry with wind breaks should be considered. Different trees are needed to break the wind, protect from strong rains, and provide shade, mulch and fodder. Useful species are *Leucena leucocephala*, *Moringa oleifera*, *Faidherbia albidia*, Neem and other adapted trees, which do not consume too much water and ideally provide additional food and fodder as well as serving as mulch. However, the trees need regular pruning because the cotton plants do not tolerate much shade.

4.3 Improvement of water availability

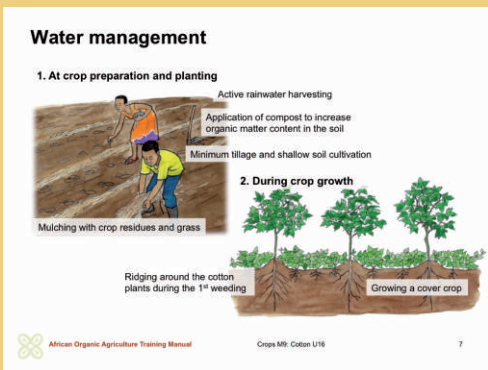
Cotton has high water requirements for boll setting and renewed growth, but dry conditions are also needed for ripening and harvest. In rainfed cotton production, major emphasis should be given to increasing the infiltration of rainwater into the soil and to its conservation. The following measures contribute to increased availability of water:

- › Application of compost and organic manures helps increase organic matter content in the soil, which is known to improve soil structure, hence increas-





WATER MANAGEMENT



ing water infiltration and water retention.

- › Minimum tillage and shallow soil cultivation (hoeing) reduces water evaporation from the soil. Ridging around the growing plants is also a common practice to conserve water.
- › Covering the soil with mulching materials helps to preserve humidity in the soil and to prevent water loss, while enhancing increased biological life in the upper-parts of the soil.
- › Active rainwater harvesting through pits or trenches leading to wells can help to recharge groundwater levels and thus to improve the availability of irrigation water.

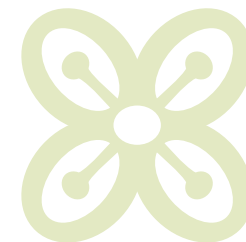
Where little irrigation water is available, alternate furrow irrigation can still help irrigate the crop. If rain fails after the seedlings have germinated, it can even be worth saving them through bucket irrigation, plant by plant.

Virtually all cotton cultivation in sub-Saharan Africa is rainfed. Irrigated cotton would technically be possible in some areas in very dry regions with less than 600 mm of rain per year. The resulting extra yield from irrigation covers the cost of irrigation.

4.4 Optimizing weed management

Weed management strategies in cotton include proper crop rotation, timely soil cultivation, proper sowing density and ploughing techniques to remove the weeds. Weeds are important in cotton fields during certain parts of the growing season:

- › In the initial stage of plant growth, weeds catch nutrients which otherwise would be lost through wash out. These nutrients are returned to the soil and made available to the cotton crop when the weeds are cut. Once the cotton crop has developed a dense stand, weeds usually will remain below a level where they significantly compete with the main crop.
- › Some weeds are important hosts for beneficial insects, or act as trap crops distracting pests from the cotton plant. Careful observation of weed populations and the use of shallow soil cultivation combined with selective hand weeding usually is enough to keep the weeds under control.



Weeds should be controlled well during land preparation before sowing. In about 6 weeks after sowing, all emerging weeds that emerge should be removed. This helps to reduce later weeding requirements and reduces weed competition with the young cotton plants. Ridging is normally done once the cotton plants are about 0.5 to 1 meter high and this can be combined with a last weeding session. A positive side effect of ridging is the reduction of water evaporation.

4.5 Soil fertility improvement

The right strategy to improve and maintain soil fertility in cotton depends first and foremost on the soil types present in a farm.

Light or shallow soils usually have a lower water retention capacity and lower nutrient exchange capacity than deep or heavy soils. The application of compost or other measures in increasing soil fertility is important to increase water holding and nutrient supply and to improve the structure of the soil. Intercropping of more drought resistant crops like sorghum, sunflower, sesame or castor can help to reduce the risk of crop failure. Soil cultivation should be shallow and kept to a minimum in order to avoid soil erosion and enhance buildup of organic matter. In deep or heavy soils such as black cotton soil, an intensive production system can be established with sufficient inputs of organic manures, intensive crop rotation and green manuring. Frequent shallow soil cultivation helps to improve soil aeration and nutrient supply. It also reduces evaporation and suppresses weeds. When the cotton crop is well established after 6 to 9 weeks, it is recommended to apply additional organic manure such as vermi-compost or oil cakes and to earth up ridges in order to accelerate decomposition and to bury weeds.

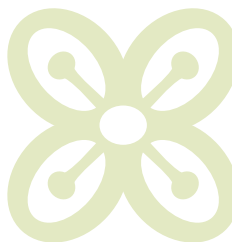
Attention must be paid that the soil is not prone to water erosion. In case of the risk of eroding contour lines or terraces, other soil conservation measures are highly recommended as the basis of improving soil fertility.

Manure or compost should also be applied before soil cultivation such that during ploughing, the organic materials are brought into soil. Well composted manure or other organic fertilizer can replace the extracted nutrients and contribute to maintenance of soil fertility. Availability of nutrients to the crop, however, depends on other factors as well, such as sufficient soil organic matter and active soil organisms, deep rooting of the crop and humid soil conditions. Cotton's nutrient requirements are highest between first flowering and boll forma-



Discussion on local soil types

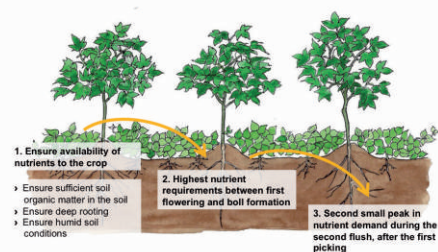
Share with the farmers their experiences with the prevalent soil types in the region and try to agree on characteristics of these soils and their reaction to approaches to improve their fertility.





TIMING NUTRIENT SUPPLY IN COTTON

Timing nutrient supply in cotton



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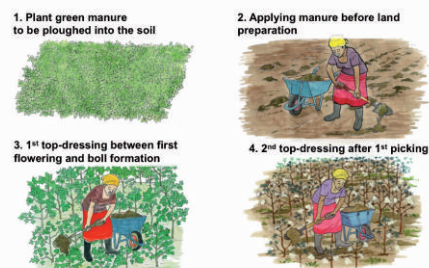
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8



SOIL FERTILITY IMPROVEMENT IN COTTON PRODUCTION

Soil fertility improvement



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Crops M9: Cotton U16

9

tion. A second small peak in nutrient demand is during the second flush, after the first picking. A top-dressing of organic manure during this critical growing period contributes to increasing yields.

4.6 Pest and disease management

Cotton has a wide range of pests that can lead to 50 to 90 % yield losses. In most of the semi-arid tropical regions diseases are not a big problem in well-managed organic cotton fields.

Early observation, combined with the required knowledge of the ecology of the insects and the tools for monitoring (pegboard, biopesticides and advice) as well as a professional support from scientifically trained experts will be required in order to manage the risks effectively.

Cotton research has done a great deal to identify the insects that ‘threaten’ the cotton production system. Researchers in almost all sub-Saharan African countries can claim that the list of important cotton pests consists of:

- › **Early-season pests:** Aphids (*Aphis* spp.), Whiteflies (*Bemisia* spp.), Cotton leaf-roller (*Sylepta*), Lygus bugs (*Lygus*), etc.
- › **Mid-season pests:** Cotton bollworm (*Helicoverpa armigera*), Spiny bollworm (*Earias* spp.), Cotton leafeater (*Spodoptera* spp.), Red or Sudan bollworms (*Diparopsis* spp.), and/or depending on the region Pink bollworm (*Pectinophora gossypiella*) and False codling moth (*Cryptophlebia leucotreta*).
- › **Late-season pests:** Aphids (*Aphis* spp.), Whiteflies (*Bemisia* spp.), Cotton strainers (*Dysdercus* spp.), etc.

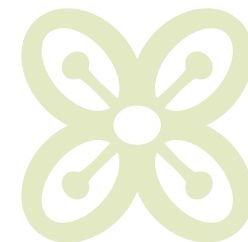
Selected examples of important cotton pests:

American bollworms (*Heliothis (or Helicoverpa) armigera*) - The young larvae feed on tender leaves, buds, flowers and later bore into the bolls. While feeding, its head and part of the body are inside the boll. They deposit faeces at the base of the entrance hole. Eggs are pinhead-size and yellowish-green in colour. They are found singly laid on the surface of the leaves. Larvae vary in colour from bright green, pink and brown, to black, with lighter undersides. Alternating light and dark bands run lengthwise along their bodies, the heads are yellow and the legs are almost black. Mature larvae drop to the ground to burrow into the soil to pupate. Pupae are yellowish-green and turn brown as they mature. Adult moths



Discussion on suitable on-farm and off-farm manures

Ask the farmers, which manures and fertilizers are available on their farms, and which are available from nearby. Discuss with them, how nutrient supply can be further improved and which alternative sources of nutrients could be used.





IMPORTANT COTTON PESTS

Management of important cotton pests (1)

Pest	Preventive measures	Direct control measures
Bollworms (<i>Helicoverpa</i> and others)	• Trap crops: sunflower, okra, castor • Hand-pick damaged capsules • Encourage natural enemies • Remove cotton stalks • Cattle grazing after picking is over	• Bt-spray, NPV spray • Neem, botanical preparations • Buttermilk spray • Pheromone traps, light traps • Trichogramma cards
Aphids, jassids, thrips, whitefly (<i>Bemisia</i>)	• Intercrop of moong, cow pea, etc. • Avoid high manure application • Avoid waterlogging and water shortage • Promote natural enemies by growing flowering plants	• Neem, botanical preparations (chilli, sweet flag, turmeric etc.) • Soft soap spray • Cow urine spray • Potato starch spray • Yellow sticky traps



African Organic Agriculture Training Manual

Crops M9: Cotton U18

10

are grey to brown in colour and have dark spots on the front wings. They are active at night and hide in vegetation during the day. The total development period from egg to adult is about 34 to 45 days.

Cutworms (*Agrotis* spp.) - The larvae cut seedlings often at ground level. They can be found in the soil down to a depth of about 5 cm near the host plant. Cutworms always curl up when disturbed. They feed only at night. Eggs are tiny, pearl-white, round and have a ridged surface. The full-grown larva is brown or brownish-black with a tinge of orange. The pupa is black or brown in colour. The adult has dark brown forewings with distinctive black spots and white and yellow wavy stripes.

Aphids (*Aphis gossypii* and others) - Aphids are important pests in fields with low populations of natural enemies, high manure application, or where crops suffer water stress. Heavy infestations cause crinkling and cupping of leaves, defoliation, square and boll shedding and stunted growth. If the infestation is not too high, the plant can compensate for the damage. Honeydew excretion causes sticky cotton lint and thus problems in spinning. Aphids produce large amounts of a sugary liquid waste called honeydew. A fungus, called sooty mould, grows on this honeydew, turning leaves and branches black. The eggs are very tiny, shiny black and are found in the crevices of bud, stems and bark of the plant. Winged adults are produced only when it is necessary for the colony to migrate.

Cotton stainers (*Dysdercus* spp.) - Cotton stainers suck sap from flowers, buds and bolls of cotton. In case of high infestation, the bolls open insufficiently and the lint quality is reduced due to stains resulting from fungal infections. When sucking on immature seeds, cotton stainers transmit fungus on the immature lint and seed, which later stains the lint with typical yellow colour, hence the name 'cotton stainers'. Heavy infestations on the seeds affect the crop mass, oil content, germination capacity of the seed and marketability of the crop. Cotton stainers are, however, usually not a major problem in organic fields.

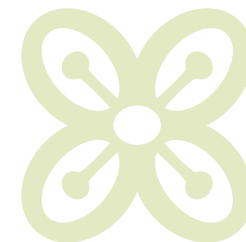
Cotton stainers lay their eggs into the soil or under plant debris. Nymphs look similar to their adult counterparts, but have no wings, meaning that they can only attack seeds in open bolls. The adult cotton stainers are true bugs with piercing and sucking mouthparts. They can even suck on seeds in closed bolls. Their colour varies from bright red to yellow to orange, depending on the species.



Discussion: Pest management in cotton production

In order to understand the local pest situation and to be able to recommend suitable measures, ask the farmers the following questions:

- › What are the most important cotton pests in their area?
- › Which preventive and direct methods are used to keep the pests below the economic threshold level?
- › What are the advantages and disadvantages of each method? Are there new methods to be tested in field trials?





KEEPING COTTON PLANTS HEALTHY

Management of important cotton pests (2)

Pest	Preventive measures	Direct control measures
Cotton stainers (<i>Dysdercus</i>) 	• Frequent soil cultivation to destroy the eggs (also along field borders) • Encourage birds (turmeric-coloured rice, bird perches, trees) • Avoid stand-over of cotton	• Pyrethrum spray • Botanical sprays (neem, custard apple, garlic bulb, sweet flag, sweet basil, Derris species) • Grazing of chickens
Cutworms (<i>Agrotis</i> and other species) 	• Early soil cultivation • Remove weeds in and around fields • Encourage birds, spiders etc. (bird perches, trees, hedges)	• Apply neem cake into the soil • Pyrethrum, Derris or thyme spray • Cutworm baits • Hand picking or BT-spray at night



African Organic Agriculture Training Manual

Crops M9: Cotton U18

11

a. Keeping your cotton crop healthy

Healthy cotton plants have some means of defence. They compensate for affected shoots and leaves through additional growth. They also produce substances such as gossypol that deter insects from eating them. Organic cotton farmers, therefore, enhance plant health and natural regulation of pest populations by applying the following practices:

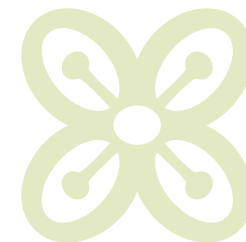
- › Varieties with hairy leaves and higher gossypol content are less susceptible to pest attacks and are thus recommended.
- › Fertile soil and a balanced nutrition based on applying compost and organic manures enhance plant health. Shallow soil cultivation and careful irrigation avoiding dryness as well as water logging contribute to establishing favourable soil conditions.
- › Diverse cropping systems and natural habitats around the fields enhance development of natural enemy populations like birds and beneficial insects, which help to control pests. Crop rotation, intercropping and trap crops are very effective measures to prevent pests in cotton. Intercrops like pulses, flowering plants and trap crops like sunflower or maize distract pests from the cotton plants. Experience from Tanzania shows that the sunflower is an efficient trap crop for the American bollworm, as the pest prefers sunflowers to cotton. It is even reported that on sunflower plants, bollworms attack each other (cannibalism). It is, therefore, recommended to sow one row of sunflowers every 15 meters at the same time as the cotton crop. In Africa it was observed that beneficial ants visit the sunflower plants and efficiently control bollworms.

If preventive measures are properly implemented, pest problems in organic cotton are minor. A certain level of pest attack will not significantly reduce the cotton yield. Below the economic threshold, the cost and effort to control the pest is higher than the damage it causes.

Diseases are normally not an issue in organic cotton systems, as they are prevented with appropriate crop rotation and using healthy seed and adapted varieties.

b. Threshold levels and monitoring through observation

Regular monitoring of pest levels in the cotton fields during the critical growth period beginning approximately 4 weeks after sowing and lasting until the sec-



ond harvest is a key to successful pest management in organic cotton. Monitoring helps to find out when a pest population reaches the economic threshold and thus direct control measures become necessary. The indicated threshold levels of the major cotton pests in following table may need to be verified and adapted for use under local conditions.

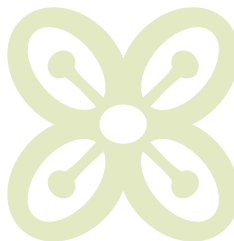
Pest	Threshold level (according to US practices)
American bollworm (<i>Helicoverpa</i>)	1 larva per 5 plants, 5–10% damage to bolls or 15 flared squares with a hole on 30 plants
Pink bollworm (<i>Pectinophora</i>)	5% rosetted flowers
Spotted bollworm (<i>Earias</i>)	1 larva per 5 plants, 5–10 % damaged shoots or bolls
Cotton leafworm, tobacco caterpillars (<i>Spodoptera</i>)	2 larvae per 10 plants or 3 skeletonized leaves with young larvae
Cotton stainer	2–3 individuals per leaf
Aphids	20% infested plants
Jassids	5–10 insects per plant
Thrips	5–10 nymphs/adults per leaf
Mites	5% infested plants
Whitefly	5–10 nymphs/adults per leaf

(Source: adopted from Aventis and Avena; University of Nebraska)

For monitoring American bollworm populations, farmers in some African cotton projects are using simple pegboards for scouting.

Use of a pegboard in scouting for American bollworms:

- › Scouting is started 8 weeks after germination and is repeated weekly until the bolls open.
- › At scouting, the plants are checked by crossing the cotton field on two diagonals, starting 5 steps inside the field from one corner.
- › Every 5 to 10 steps on a cotton plant, all newly opened flared squares (those





MONITORING COTTON PESTS

Keeping cotton crops healthy

1. Applying manure or compost



2. Promoting natural enemies



3. Improving water management



4. Crop rotation, intercropping



African Organic Agriculture Training Manual

Crops M9: Cotton U15

12

with changed shape due to bollworm attack; not dropped squares) are counted. For each flared square, the marker on the pegboard on the right part of the pegboard is forwarded 1 hole.

- › After finishing with a plant, the marker in the left part of the pegboard is forwarded 1 hole.
- › On each diagonal, 15 plants are examined, moving the markers forward accordingly. After inspection of plants on the first diagonal, plants on the second diagonal are inspected.
- › The procedure is continued until 30 plants have been inspected or until 15 flared squares have been found. When the stick for the flared squares reaches the red zone, the economic threshold is reached and spraying of a natural pesticide is recommended for the same day. No spraying is recommended, when less than 15 flared squares were found.

c. Direct control of major cotton pests

Direct measures such as spraying botanicals such as neem or Derris, or microbial sprays containing Bt or NPV should be used only when the preventive measures prove insufficient to keep pests below the economic threshold.

The best time for spraying is in the morning hours between 8 and 11 AM. Spraying after it rains or when the plants are still wet is not recommended because effectiveness is reduced.

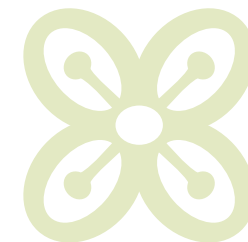
Major pests in tropical cotton cultivation are **bollworms** (*Helicoverpa*, *Pectinophora* and *Earias* species). If bollworm populations reach the economic threshold, different direct control methods are available. Microbial preparations Bt and NPV can be used against American bollworm (*Helicoverpa armigera*). Pheromone traps and dispensers attract the adult moths and thus prevent the laying of eggs. Spraying of neem formulations and locally prepared botanical extracts is a cheap method to control bollworms and other pests. In India, organic farmers use diluted cow urine and buttermilk sprays with good success. However, most of these sprays also affect beneficial insect populations and thus should be used only when necessary.

Aphids (*Aphis* spp.) and **whiteflies** (*Bemisia* spp.) are typical secondary pests. They have a wide range of natural enemies under natural growing conditions. Where no synthetic insecticide sprays are used, aphids and whiteflies normally maintain lower numbers. However, if organic cotton fields are small and scattered around a conventional cotton growing area, the fields may come to act as refuges for aphids and whiteflies from nearby sprayed conventional fields.



Field demonstration: Monitoring bollworm with the help of the pegboard

Explain the concept of monitoring and the use of the pegboard with the help of Transparency 12. If possible, visit a nearby cotton field and demonstrate the use of the pegboard for monitoring American bollworms or other insects.

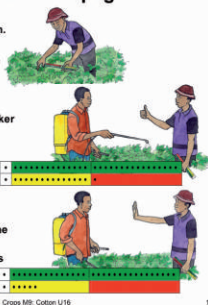




MANAGEMENT OF MAJOR COTTON PESTS

Monitoring of cotton pests with a pegboard

- Start scouting 8 weeks after germination.
- Repeat it weekly until the bolls open.
- Check the plants by crossing the cotton field.
- Every 5 to 10 steps, count all newly opened flared squares.
- For each flared square, forward the marker on the pegboard by 1 hole.
- Continue the procedure until you have inspected 30 plants, or until you have found 15 flared squares.
- When the stick for the flared squares reaches the red zone, the economic threshold is reached and spraying of a natural pesticide is recommended for the same day.
- No spraying is recommended, when less than 15 flared squares are found.



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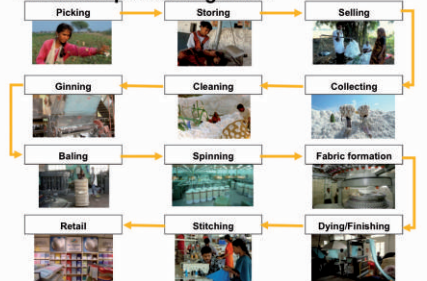
Crops MB: Cotton U16

13



COTTON PROCESSING CHAIN

The cotton processing chain



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Crops MB: Cotton U16

14

5. Improving postharvest handling

The price of cotton depends on its quality. The cleaner and the longer the fibres are, the higher their price. Markets prefer clean, white fibres with long staple length, good strength, non-stickiness, low amounts of short fibres, and fine, rather than coarse lint. Therefore, cotton handling should be given sufficient attention at all stages.

Picking, grading and storage

Cotton picking should be done with care, avoiding leaves and damaged or immature cotton. Grading of cotton can easily be done with the help of a second, smaller picking bag for the inferior quality. In order to fetch a better price, only ripe cotton should be picked.

If farmers store the harvested cotton before selling it, they must avoid any contamination through dust or chemicals. The storage place must be clean and dry. Damp conditions can lead to moulds with significant loss of cotton quality. Where the organic harvest is stored in the same facilities together with conventional cotton (for example in ginneries), mixing of organic and non-organic produce must be avoided. Appropriate storage conditions contribute to about a fourth to maintaining cotton quality. Storage should be done off the ground and protected from rain or standing water. To avoid mixing, the store personnel must be instructed accordingly, incoming and dispatched organic lots must be documented and different cotton qualities should be marked with sign boards, for example using colour codes.

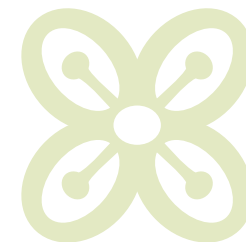
Processing

Throughout the entire organic cotton processing chain, contamination with GMO cotton and synthetic residues must be avoided. Therefore, organic cotton needs to be treated separately from conventional cotton. Where spinning mills and processing entities process organic and conventional cotton on the same machinery, clear separation and cleaning of the equipment is necessary before processing an organic lot. Some labels and brands also have certain restrictions on which dyes can be used.



Discussion on post-harvest handling of cotton

Ask the farmers to describe common handling of cotton after harvest, as it is practiced in the area. Together, identify gaps and discuss appropriate improvements.





STRATEGIES TO IMPROVE INCOME

How to improve income in cotton production

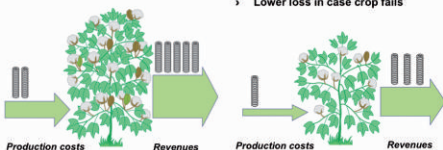
Strategy I: Intensive organic:

- › High yields, but relatively high production costs
- › High loss in case crop fails

high

Strategy II: Low input, low risk:

- › Smaller yields, but also lower production costs, thus still good income
- › Lower loss in case crop fails



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Crops Mlt: Cotton U16

Source: IFPRI Training Manual

19

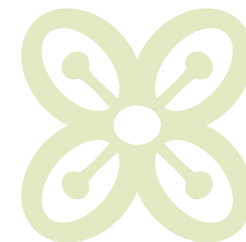
6. Improving returns from cotton production

Cotton under organic production is always included in a diversification strategy and monoculture production is never considered. To get a better income, farmers can attempt to increase crop yields to reduce costs of production (inputs and labour) and to achieve a better price for their produce. Intensive organic farming aims to achieve high yields through optimum nutrient supply and crop care. Especially in marginal conditions and where sufficient family labour is available, it can be equally efficient to focus on reducing costs of production (low input strategy). This can be achieved by avoiding commercial organic manures and pest control materials, using only on-farm means instead. The low input strategy can also help to reduce risk in areas of frequent crop loss due to drought, hailstorms or other calamities, as farmers need to invest less money into the crop.

Cotton is grown in rotation with a number of food crops, which also need to be managed organically and can be sold for more income. Organic cotton farmers can get additional benefit (and reduce their dependency on cotton prices), when they can find a market with a better price also for the rotation crops. In Tanzania, mung beans are successfully promoted as a rotation crop.

With a diversified crop production strategy, the organic cotton growers thus contribute to better food security in the region. Therefore, organic cotton projects should also cover the rotation crops as a way of diversifying and increasing incomes to the cotton farmers.

Close collaboration between the farmers, spinners and other partners, allows establishing an environmentally and socially sound supply-chain. Ideally, the value added in processing is realised locally. The outcome of a good business relationship between the organized cotton farmers and the lint producer and exporter, whether it is private like in Tanzania or private-public like in West Africa, has better chances to steadily improve competitiveness of the cotton value chain and at the same time to respond to needs of society and the environment. Cotton itself is also a classic dual purpose crop (lint, oil) with many uses. A harvest yielding 1,000 kg of seed cotton per hectare provides 320 to 420 kg of fibre (raw cotton), 200 to 250 kg of seed cakes or flour, 100 to 150 kg of oil, 200 kg of shells, 20 kg of retained seeds and 40 kg of dirt.



7. Marketing and organic certification of cotton production

Major markets for organic cotton are in industrialized countries. Consumers buy organic cotton because it is produced and processed without using agro-chemicals and thus is known to cause less skin irritation and allergies. Such consumers also care about nature conservation and supporting farmers in the tropics in achieving a sustainable livelihood. Originally, most organic cotton production was processed into garments containing 100% organic cotton fibre. Today there is a trend to blending a certain percentage (usually 5–10%) of organic fibres with conventional ones.

Cotton is a rather complex value chain inside the textile sector. It needs well-organized partners in order to be successful for the producers of seed cotton. State policies and normally direct services in research, extension, ginning and/or marketing and regulation are required. The relation between these state services and institutions, the private sector and the organized farmer community are crucial for a successful and sustainable business.

Conversion of small-holder farms in the tropics to organic cotton is usually facilitated by companies or NGOs, which provide extension and inputs and organize for the certification, processing and marketing of the produce. Marketing and organic certification needs to be discussed within the producer organization and with the business partners along the value chain (lint producer, exporter, retailer, etc.). A particular challenge is the 'contamination' with GMO cotton, which is rapidly expanding. Buffer zones are normally sufficient with 25% of the field size (if the neighbouring field is 100 m large, the distance should be at least 50 meters), but if GMO cotton is planted in the same village or district, then consequences must be anticipated and considered.

General requirements for certification of organic cotton production are:

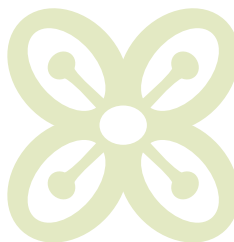
- › During production of cotton, no use of synthetic pesticides including herbicides and fertilizers or genetically modified planting materials is allowed. Any pesticide contamination from neighbouring conventional cotton fields through soil erosion or wind drift should also be avoided. Machines and equipment used in conventional application of pesticides and fertilizers need to be cleaned well before handling organic cotton.
- › During postharvest handling, clear separation of the ginning, grading and storage of organic cotton is necessary to avoid cross-contamination from conventional cotton. Ideally organic cotton farmers identify a facility, where



Assessment of the local situation on marketing and organic certification of cotton

Assess with the farmers present market situation in organic cotton and discuss with them the potential for development and for organic certification. You may start by asking the following questions:

- › Who are the main buyers of cotton in the area?
- › Are there any certified organic cotton farmers in the area?
- › Are there any companies that require certified organic cotton?
- › What are their requirements in terms of quantity and quality?



their cotton is handled. The farmers sign an agreement with the facility owner in order to guarantee preferential treatment of the organic cotton.

Specific national or international organic standards may define additional requirements for production and postharvest handling of organic cotton. Farmers should, therefore, consult the national organic movement or organic certification body operating within the region or country.

Recommended further readings

- > FiBL, Organic cotton crop guide. A manual for practitioners in the tropics. 2005. www.fibl.org
- > Helvetas, Guide de production du coton biologique et équitable. Un manuel de référence pour l'Afrique de l'Ouest. www.organicandfair.org
- > PAN, Organic cotton production in sub-Saharan Africa: the need for scaling-up. Pesticides, Poverty and Livelihoods project. 2002. www.organicexchange.org
- > Naturland, Organic Farming in the Tropics and Subtropics. Exemplary Description of 20 Crops Cotton. 2004. www.naturland.de
- > Infonet- biovision. www.infonet-biovision.org > Crops > Cotton

