Organic Exchange
Farmer Toolkit

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About the Farmer Toolkit

The OE Farmer Toolkit is a compilation of best practices - scientific research and farmers’ experiences - collected to provide crucial information on core organic cotton agricultural practices.

The information was compiled by the OE Farm Development team, and a list of sources and other publications on organic farming are available from Organic Exchange at www.organicexchange.org.

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We are thankful for the support of the ComMark Trust, ICCO, Nordstrom, C&A and Shell Foundation in the production of the Farmer Toolkit.
The Organic Exchange is a global non-profit organization whose mission is to catalyze market forces to expand organic fiber agriculture. Organic Cotton is a tool that allows greater visibility as well as concrete solutions for key issues that are impacting rural communities around the world: poverty, food security, and the need for greater bio-diversity. Organic cotton systems not only addresses environmental issues that are directly impacting our climate but also creating value chains that enable businesses and their partners to produce and deliver products and services that meet basic human needs in a sustainable way.

We have collected best practices in order to develop the Organic Exchange Farmer Toolkit as a resource to provide basic information on core organic cotton agricultural practices. The current components include: Soil Management, Intercrops and Crop Rotation, Seed Selection and Planting, Crop Nutrition, Pest & Disease Management and Harvest & Quality Control. Each component has a basic information sheet as well as a power point presentation that can be downloaded as well as posters that can be downloaded.

Successful organic cotton programs recognize that the farming and production of agricultural crops must be viewed as an integrated and holistic system. It is essential that the farm system include rotation crops to address soil fertility, bio-diversity and food security issues in rural communities. Diversification moves many agricultural crops away from a mono-crop production system to a multi-crop system that also has positive economic impacts.

What is organic?

The IFOAM basic standards state that ‘Organic agriculture [also known as “Biological” or “Ecological” agriculture or protected equivalent forms of these words (in other languages)] is a whole system approach based upon a set of processes resulting in a sustainable ecosystem, safe food, good nutrition, animal welfare and social justice. Organic production therefore is more than a system of production that includes or excludes certain inputs.’ (IFOAM 2008)

Strict laws and regulations governing organic production and food products have been enforced by the US Department of Agriculture since 2002. By definition, organic agricultural products are grown without the use of toxic and persistent pesticides or fertilizers, sewage sludge, irradiation or genetic engineering, and are certified by an accredited independent organization.

Organic cotton production currently takes place in 22 countries around the world, covering the same regions as conventional cotton. However, the vast majority (87%) of production takes place in just three countries: India, Turkey and Syria. The total land area globally is approximately 161,000 hectares with an estimated 177,678 farmers of which nearly 18% are women, located mostly in Africa. Organic cotton production in the 2007/8 season was an estimated 145,872 metric tons of lint. Total production recorded was 152% higher than in 2006/7, partly due to better data gathering and more reliable information, although 60% of the additional production is from increased production by existing known projects. (2008 Organic Exchange Farm & Fiber Report)

Recent growth in the organic fiber industry has led to questions and discussion over the meaning and definition of what an organic cotton system needs to be sustainable and over the integrity of organic cotton.

Special thanks to the sponsors and key supporters of the Organic Exchange Farm Development projects:
ComMark Foundation, ICCO, Martin Fabert Foundation, Nordstrom, C&A, and Shell Foundation
Organic by Design – Planning for Long Term Success. In looking at sustainability within the organic cotton system, we have used two main definitions of sustainable agriculture to inform our thinking:

Sustainable agriculture is:

- ‘the ability of an agroecosystem to maintain production through time, in the face of long-term ecological constraints and socio-economic pressures’ (Altieri, 1987)
- ‘involves a system for food and fibre production that can maintain high levels of production with minimal environmental impact and can support viable rural communities’ (Mellon et al., 1995)

Soil Management. Soil fertility is the foundation of sustainable and productive organic farming. When soil is well managed, pest pressure is reduced, water use is optimized and yields will improve for all crops grown in the rotation. To be sustainable and to enable organic cotton production to grow to meet demand, soil fertility has to be a priority for farmers and farming projects.

Intercrops & Crop Rotation. Biodiversity – a balanced agro-ecosystem helps reduce pest pressures and provides tools and ingredients for managing soil (green manures) and pests and diseases (botanical pesticide ingredients trap and refuge crops). Managing the rotation crops and other crops (farmed and wild) is also important to maximize the total returns from the farm as far as possible, both in cash terms and in terms of food security.

Seed Selection & Planting. Farmers need to have access to non-GMO varieties that are resistant or less susceptible to common pests and diseases and that also have the ability to meet the quality requirements of spinners. Timely planting with consideration of best management practices for the region also have to be considered.

Crop Nutrition. Crop nutrition should be appropriate for the type of soil, variety of cotton, environmental factors and the intensity of the attacks of pests and diseases. A plant with a balanced nutrition will have a greater chance of responding to adverse factors during their development.

Pest & Disease Management. Pests and diseases are important when generating economic damage. There are few pests that require control, and are used inputs or natural methods that do not contaminate the agro ecosystem.

Harvest & Quality Control. Good Quality fiber that is clean and free of non plant material contaminants is critical to produce high quality yarns which are needed for the organic fiber market. Measures taken to improve the quality of the fiber have direct and positive benefits for the farmer.

Certification & Internal Control Systems. Organic production systems have clearly defined standards which make the land and agricultural product produced to be marketed and sold as organic. Certification by an independent organization is required in most markets for agricultural products to be sold as organic.

Additional Resources:
Visit Organic Exchange (www.organicexchange.org) for more information including PowerPoints and Posters for farmer development and education.
Overview

Strict laws and regulations governing organic production and food products are enforced in local markets as well as other key markets like the EU, US or Japan. By definition, organic agricultural products are grown without the use of toxic and persistent pesticides or fertilizers, sewage sludge, irradiation or genetic engineering, and are certified by an accredited independent organization.

To be eligible to market their products as organic, farmers need to have their land and agricultural system audited, inspected and certified by a recognized 3rd party certifier. The farming operation must meet all of the production, record keeping, handling, storage and labeling requirements of the legal organic standard of the country where the product is grown and/or sold.

Key Steps to Certification

**Step 1. Convert to Organic Cultivation Practices**

Farmers begin the organic conversion process by deciding to adopt organic farming practices, which means eliminating the use of genetically modified seeds and synthetic pesticides and fertilizers on their fields and developing a farm plan. The farm plan shows the steps that the farmer will take to grow the crops organically, and will cover the following:

- list of expected crops
- map of areas to be farmed organically
- list of organic practices to be use such as buffer strips, rotational crops, and composting
- description of management system to track seeds and inputs
- plan to manage pests or crop diseases
- record keeping: maintain an audit trail that can provide information regarding the field where the product was grown, when the crop was harvested, where it was stored and when it was shipped.

Transitioning a field or farm to organic cultivation will typically take three years, depending on the standard. Most countries recognize the EU or USDA NOP standards. Farmers should be aware of their target market so that they know which standards to be certified against. The U.S. and EU require that the land is farmed following all of the organic principles for a full 36 months. Historically, transition or conversion crops attract a lower premium than certified organic crops. After the three-year transition period, and the successful completion of the organic certification process, the crops can be marketed as “organic”.

If crops are grown on virgin land (land not previously farmed) or land where an official body can testify that no synthetic chemicals have been used in recent years, the farmer may be eligible for organic certification within a year of adopting organic farming practices.
**Step 2. Decide on the Organic Production Standard(s) to Use in Your Farming Operations**

Farmers must decide which organic production standard(s) to follow in their farming operations. If they are growing organic crops that will be used in products sold in the United States, the farming operations must follow the USDA NOP rules for organic crop production. If the crops will be processed into products sold in Europe, the farming operations must follow the EC834/2007 standard or an accepted equivalent. If crops will be sold in Southern or Eastern Africa, the farming operations must also be consistent with the EC834/2007 standard.

Because organic cotton grown is used in products that may access multiple markets, we encourage farming projects to consider adopting practices that meet the requirements of more than one standard.

**Step 3. Choose a Certifier**

Farmers must select and hire an accredited certifier to review their farming plan, relevant business records, and farming practices. The certifier will also conduct an annual inspection of their fields. Note that a certification fee will be charged.

**Step 4. Undertake the Certification Process**

When the farm is ready for certification, the certifier will come to inspect the farming operations.

If the farming project includes many farmers, it may be worthwhile to seek group certification, which is more cost effective. Key elements required for group certification are discussed below.

When the certifier comes to inspect the farm, he or she will require a farm map and will want to see farm records of seed purchases, crop inputs, organic practices, etc.

The certifier will ask for yield estimates for organic crops that are in the ground and will compare these with actual yields obtained. The certifier will also inspect the fields and ask questions about the farming practices being used. They will do visual inspections of the crops and may take plant samples to determine if there is any contamination of the crop from the use of genetically modified seeds. They will also verify that appropriate buffer zones exist between organic and conventional fields, which may contain genetically modified seeds and/or use chemicals prohibited in organic farming. Buffer zones help prevent contamination of organic crops.

Certifiers may also take soil and crop samples to check for chemical residue. The farmer should check with the certifier that farm inputs such as organic manures, fertilizers, natural pesticides and seed are allowed before using them. The certifier will also check that the correct soil management processes such as rotations are being followed.

Once an inspection has been carried out and the certifier is satisfied that the standards are being kept, a certificate will be issued allowing the farmer to market his or her products as organic to the given standard(s). There will then be annual inspections to ensure that the farmer stays in compliance with all relevant standards and records are in order.
Group Certification and Internal Control Systems

Group certification is a method allowing groups of farmers to be certified together and to share certification costs as a group. This can help make certification more affordable and efficient for small-scale farmers.

Some of the key steps for group certification include:

**Step 1. Form a Group**
Organic farmers join together to form a group to manage their own compliance with the organic standards.

**Step 2. Develop Internal Controls**
The group develops an internal control system and appoints an internal inspector, from the group or co-op, to inspect the farms. The outside certifier will also inspect this internal control system. Many groups appoint two people from the farmers’ group to support documentation and procedures: the people will typically work with the internal inspector or field agent appointed by the project.

**Step 3. Annual Inspections**
The internal inspector annually inspects all the documentation for the group and may also perform random inspections. They will do the same with several individual farms in the group (usually 15-20% of the total). They then write a report based on the inspection. When the outside certifier comes to inspect the fields, they look at the internal control system to make sure it’s functioning correctly, inspect the documents and records, then inspect their own random sample of the farms (again, usually about 15-20%), to see if the organic farm practices are being carried out correctly. An organic certificate is issued to the group, which demonstrates that the standard has been adhered to, and that certification will apply to all of the farms. Certification needs to be renewed annually.

**Step 4. Develop Disciplinary Procedures**
The internal control system needs to have disciplinary procedures in place for members who do not adhere to the organic standards. These procedures can have members temporarily or permanently removed from the group. An internal inspector should work with individuals to make sure that the group’s organic certification is not jeopardized. A training program is necessary for both the internal inspector and the individual members of the group for this system to function efficiently. Training should include proper organic procedures and practices and accurate documentation and record keeping.

Using this system allows small-scale farmers to become certified who would otherwise be unable to afford organic certification.

There are many organic farming projects that have developed excellent internal control systems and received group certification: Agrocel, bioRe India, Vesudha project, Chetna Organic, OBEPAB, KATC, bioRe Tanzania.

Organizations such as bioRe Tanzania, KATC in Zambia, Mavideniz in Turkey and OEBPAB in Benin have adopted practices such as the hiring of staff to manage the internal control system and develop manuals and farmer training programs to help increase farmer knowledge of and compliance with organic production standards.
Resources
Europe and the USA both have different Organic regulations and different certification procedures have to be followed to allow export to both. The National Organic Program (NOP) provides the standards for organic production and certification in the United States, and the EU Regulation 834/2007 provides the regulatory basis for becoming certified organic in Europe. Other country specific organic production standards also exist. IFOAM, (the International Federation of Organic Agriculture Movements) sets basic standards for certification for the industry and seeks harmonization between government standards.

IFOAM
Provides a common system of organic certification standards, and a list of IFOAM accredited certifiers for products to be sold in the European market.
www.ifoam.org

National Organic Program (NOP)
Provides the requirements and guidelines for becoming certified organic in the United States, and a list of accredited certifiers for products to be sold in the United States market.
http://www.ams.usda.gov/nop/indexIE.htm

European Certifiers

India Certifiers
http://www.apeda.com/organic/agencies.html

Additional Resources:
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<table>
<thead>
<tr>
<th>Date</th>
<th>Growth Week</th>
<th>Growth Stage</th>
<th>Field Work</th>
<th>Pests</th>
<th>Suggested Action</th>
<th>Interplant Rates per Hectare</th>
</tr>
</thead>
<tbody>
<tr>
<td>MID MAY TO MID AUGUST</td>
<td></td>
<td></td>
<td>Start making compost Remove cotton plant residue from old fields. Make basins or lines early but apply compost or manure one month to two weeks before planting (10t/ha) in lines or basins this would mean a quantity of approx 500-750kg in 0.25 ha. More could be added to soils depleted of organic matter.</td>
<td>Remember – do not bury cotton residues. It is estimated that 75% of all insect pests spend part of their life in the soil.</td>
<td>Cut, heap and burn cotton stalks as a pest control measure</td>
<td>Farmscaping – ensure permanent plantings for hedgerows are in place to attract beneficial insects. Important – ensure that you have nectar rich plants on your farm such as dill, coriander, mustard family and marigolds and other flowering plants all year round.</td>
</tr>
<tr>
<td>MID NOV TO MID DEC</td>
<td>1 to 3</td>
<td>0-2 cm</td>
<td>Planting – plant with first good rains or dry plant part of the field (10kg/ha of seed in high rainfall or irrigated 5kg/ha low rainfall) Weeding this should be carried out as soon as the weeds are about 4cm high. Weed competition at this stage can affect yield so do not hesitate to start weeding. Thinning and gapping should be carried out 10-14 days after emergence.</td>
<td>Thrips/Syagus, Termites, Cutworms, Grasshoppers, Aphids</td>
<td>Thrips/Syagus – practice conservation tillage to build organic matter, spot spray with neem extract Termites - apply ash or put trash along the lines to provide food for termites, mulch. Cutworms - drench with snake bean, papaya, tephrosia or pyrethrum leaf extracts, Grasshoppers – spot spray with papaya or neem extracts Aphids – spot spray with garlic, tephrosia or soap spray. General - set insect traps</td>
<td>Maize (traps aphids on tassels and bollworms)– 1kg at week 0 Sweet sorghum (traps bollworms and aphids) – 0.5kg at week 0 Marigold (flowers attract most beneficial insects, also a repellent) -0.25kg on nursery 2 weeks before transplanting Okra (attracts cotton stainer) - 0.25kg at week 0 Sunflower (moths to lay eggs and attractions most beneficial insects) - 5kg in hedgerows and borders at week 0 Sunnhemp (flowers attract beneficial insects) – 3kg around borders at week 0 Mustard (traps aphids and attracts beneficial insects) - 0.1kg on nursery 2 weeks before transplanting Dill (attracts beneficial insects) -0.1kg on nursery a month before transplanting or try planting direct Coriander (attracts beneficial insects)-0.1kg on nursery a month before transplanting or try planting direct</td>
</tr>
<tr>
<td>MID DEC TO EARLY JAN</td>
<td>3 to 6</td>
<td>50 cm 6-leaf</td>
<td>Souping (liquid manure application) – drench with Chicken manure/ cattle manure / compost/ compostfrey or other leaves soaked in a 200lt drum Diluted1:3 (approximately 800lt/ha) This should be carried out weekly from week 3 to 6 of planting). Weeding should continue until cotton is big enough to compete favorably.</td>
<td>Jassids, Whitefly, Aphid, Elegant grasshopper Leaf rollers Looping caterpillars Spiny bollworms Pink Bollworm</td>
<td>Jassids – spot spray with garlic, Aphids – spot spray with garlic, Grasshoppers-spot spray with garlic or neem extracts. Spot spray with snake beans Hand pick and crush Hand pick, crush and remove affected bolls Set traps</td>
<td>Maize- 0.5kg last week of December Sweet sorghum - 0.25kg 1st week January Cowpeas - 0.4kg 2nd week December Marigold - 0.1 kg on nursery 2 weeks before transplanting Okra - 0.125kg 1st week January Sunnhemp – 2kg in hedgerows 1st week January Mustard – 0.1kg on nursery 2 weeks before transplanting</td>
</tr>
</tbody>
</table>
### JANUARY

<table>
<thead>
<tr>
<th>Week</th>
<th>Height</th>
<th>Event</th>
<th>Source Material</th>
<th>Pest Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 to 9</td>
<td>70 cm</td>
<td>First buds</td>
<td>Souping (liquid manure application) – drench with manure/compost/comfrey tea soaked in a 200lt drum. Dilute 1:3 (approximately 800lt/ha). This should be carried out weekly from week 7 to 9.</td>
<td>Bollworms – hand pick crush and spray with mixture made with dead bollworms or spot spray with snake beans or neem extracts. Aphids - spot spray with soft soap when levels are high. Jassids - spot spray with soft soap when levels are high. Whitefly - set traps or apply a botanical spray as a last resort. Leaf rollers – apply a botanical spray as a last resort. Grasshoppers - apply a botanical spray as a last resort.</td>
</tr>
<tr>
<td>6 to 9</td>
<td>70 cm</td>
<td>First buds</td>
<td></td>
<td>Mustard - 0.1kg on nursery 2 weeks before transplanting. Marigold - 0.1 kg on nursery 2 weeks before transplanting. Cowpeas - 0.4kg 1st week January. Okra - 0.125kg 4th week January. Sunflower – 0.25kg 4th week January. Maize - 0.5kg 2nd week January. Dill – 0.1 kg on nursery 2 weeks before transplanting. Coriander –0.1 kg on nursery 2 weeks before transplanting. Or try direct planting</td>
</tr>
</tbody>
</table>

### LATE JAN TO MID FEB

<table>
<thead>
<tr>
<th>Week</th>
<th>Height</th>
<th>Event</th>
<th>Source Material</th>
<th>Pest Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>9 to 12</td>
<td>90 cm</td>
<td>First Flowers</td>
<td>Souping (liquid manure application) - drench with /compost/comfrey tea soaked in a 200lt drum Dilute 1:3 (approximately 800lt/ha). This should be done weekly from week 10 to 12. Make sure all harvesting materials picking bags and wool packs are sourced early so as to be ready to start harvest in April.</td>
<td>Bollworms - hand pick crush and spray with mixture made with dead bollworms or spot spray with snake beans or neem extracts. Aphids - spot spray with soft soap when levels are high. Jassids - spot spray with soft soap when levels are high. Whitefly – set traps or apply a botanical spray as a last resort. Red spider mite – spray with botanical sprays especially African marigold and garlic as last resort.</td>
</tr>
</tbody>
</table>

### MID FEB TO MID MARCH

<table>
<thead>
<tr>
<th>Week</th>
<th>Height</th>
<th>Event</th>
<th>Source Material</th>
<th>Pest Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 to 15</td>
<td>120 cm</td>
<td>Green balls</td>
<td>Souping (application of liquid manure) drench with compost/comfrey tea soaked in a 200lt drum Dilute 1:3 (approximately 800lt/ha). This should be carried out weekly from week 13 to 15 Application of liquid manure may have to stop if the cotton grows too thick to prevent easy access.</td>
<td>Red spider mite – spray with botanical sprays especially African marigold and garlic as last resort. Handpick and crush. Aphids - spot spray with soft soap when levels are high. Jassids - spot spray with soft soap when levels are high. Bollworms - hand pick crush and spray with mixture made with dead bollworms or spot spray with snake beans or neem extracts.</td>
</tr>
</tbody>
</table>

### MID MARCH TO JUNE

<table>
<thead>
<tr>
<th>Week</th>
<th>Height</th>
<th>Event</th>
<th>Source Material</th>
<th>Pest Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 +</td>
<td>150 cm</td>
<td>Open bolls (first picking)</td>
<td>After completing harvesting all cotton plants should be cut down and removed from the field and burnt.</td>
<td>Red spider mites - Pick the cotton as soon as the bolls are ready. When 4-5 bolls per plant are open. Cotton Stainer-</td>
</tr>
</tbody>
</table>

This calendar is based on southern hemisphere planting in mid November. The timings can be moved one week or more weeks forward for crops planted later.

Special thanks to the KATC Project in Zambia, this calendar is based on information from the KATC Organic Cotton Manual.
Soil Fertility in Organic Farming Fact Sheet

**What is Soil?**
Soil is the layer of unconsolidated particles derived from weathered rock, organic material (*humus*), water and air that supports plant growth. The formation of soil depends on the parent material (i.e. the original material from which the soil is derived), the climate and topography of the area, the organisms present in the soil, and the time over which the soil has been developing.

**What is soil fertility?**
“Soil Fertility is the quality of a soil that enables it to provide essential chemical elements in quantities and proportions for the growth of specified plants.” (Brady and Well, 1999 - The Nature and Properties of Soils)
Soil fertility deals with the nutrient status or ability of soil to supply nutrients for plant growth under favorable environmental conditions such as light, temperature and physical conditions of soil.

Fertile soil contains sufficient nutrients to ensure plant growth and yield and is able to maintain appropriate moisture and components in the soil.

**What is Soil Fertility Management?**
Soil fertility management in organic farming is a long term strategy aimed at:
1) Reducing the loss of nutrients
2) Building soil fertility through the continuous nourishment of the soil. The aim is to minimize the need to bring in external inputs from outside the farm.

*There are a range of tools available to the organic farmer to improve and maintain soil fertility but the main focus in organic farming should be to maintain and improve the organic matter content of the soil.*

- A balanced crop rotation – crops with different nutrient demands and rooting depths are grown in the field. Legumes (which help nitrogen fixation) must be included to help.
- Cultivation methods such as minimum tillage chosen carefully to reduce soil erosion and compaction.
- Protecting the soil from strong sunlight and heavy rain by leaving a soil cover of crop residue, a cover crop or mulch.
- A nutrient management regime that supplies the crop with the appropriate nutrients at each growth stage and that does not over supply.
- Feeding the soil organisms by building and maintain the organic matter levels in the soil.
Why organic matter is so important

A loose and soft soil structure with a lot of cavities

Visible parts of organic matter act like tiny sponges

Many beneficial soil organisms such as earthworms feed on organic material

Good aeration and good infiltration of rain and irrigation water

Non-visible parts of organic matter act like a glue, sticking soil particles together

Soil organic matter provides a suitable environment for soil organisms

The Importance of Soil Organisms

In an active healthy soil, even a sample the size of a teaspoon will contain millions of soil organisms. These may be of both plant and animal origin, but all are important to the health of the soil and the crops that grow in it. They are classified according to size, the ones visible to the naked eye usually being referred to as soil organisms, and the ones only visible through a microscope being called micro-organisms. Some examples of common soil organisms are shown in the table below.

<table>
<thead>
<tr>
<th>Large Soil Organisms</th>
<th>Soil Micro-organisms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Earthworms</td>
<td>Bacteria</td>
</tr>
<tr>
<td>Spiders</td>
<td>Algae</td>
</tr>
<tr>
<td>Ants</td>
<td>Fungus</td>
</tr>
<tr>
<td>Termites</td>
<td>Protozoa</td>
</tr>
<tr>
<td>Slugs and Snails</td>
<td>Actinomycetes</td>
</tr>
<tr>
<td>Millipedes</td>
<td></td>
</tr>
<tr>
<td>Beatles and their larvae</td>
<td></td>
</tr>
<tr>
<td>Mites</td>
<td></td>
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</table>

Revision date: 01/2009
Soil Organisms are important for the following reasons:
1. They help decompose organic matter in the soil and produce humus.
2. They mix the organic matter with soil particles and build up stable soil crumbs.
3. They make tunnels in the soil opening up the soil to promote deeper rooting of the crop, and better aeration of the soil.
4. They help to release nutrients from mineral particles in the soil making them available to the crop.
5. They can help to control pest and disease organisms which may affect the roots of the crop.

Soil Fertility Inputs
The various soil fertility inputs used in organic farming worldwide are: Animal manure, humus (vermicompost), manure teas, Green manure, Compost, natural minerals and soil micro-organisms or bio-fertilizers. With the exception of liquid manure all these help increase organic matter in the soil; liquid manures feed the soil organisms and subsequently the crop. **Green Manures** are crops grown for the purpose of feeding the soil and soil organisms as opposed to be growing for human consumption. They are usually included in the annual rotation system and examples include Sunnhemp, Velvet beans, Cowpeas and Lablab beans.

Compost
Composting is the process of transforming organic material from plants or animals into high-value rich organic compost. Composting can be done in heaps or pits, which break down the organic materials faster because it heats up as part of the decomposition process. This results in a higher quality product with good nutrients and disease fighting micro-organisms. If the compost heap or pit is properly maintained, loss of nutrients (especially nitrogen) can be kept low. Compost provides the crop with well-balanced ‘food’ and helps to increase the soil organic matter content. Compost has both a long-term and a short-term effect on plant nutrition as nutrients are continuously released over a period of time.

Adding organic matter to the soil.
- Providing a balance of nutrients to the soil.
- Improving soil structure.
- Providing nutrients that are slowly released into the soil, so reducing the risk of these nutrients being leached away.
- There is evidence to suggest that micro-organisms in compost can help to suppress soil borne diseases.

Liquid Manures
These include manure teas, leaf teas and compost extract and compost teas these are useful to feed the crop at times of increased nutrient demand such as flowering or fruiting and allow the organic farmer opportunity to tailor a nutrition regime to a particular crop.

Humus (Vermicompost)
Vermicompost (also called Worm Compost, Vermicast, or Worm Manure or VermiCulture) is end product of the breakdown of organic matter by special varieties of earthworms. Vermicompost is a nutrient-rich, natural fertilizer and soil conditioner.

Crop Rotation
The farmer must practice a rotation to mix crops of different rooting depths and nutrient requirements. A legume or green manure crop must be include in the rotation ideally cotton should have two different crops between each cotton crop.
Cultivation Techniques
These should be tailored to the local climatic conditions but the farmer should always try and reduce soil erosion and loss of soil organic matter and nutrients. This means avoiding leaving fields bare and avoiding soil erosion through by cultivating across the slope. If possible minimum cultivation systems should be considered.

Oxford Dictionary of Biology
http://www.ikisan.com/links/ap_soils.shtml#Soil

Additional Resources:
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Establishing the Cotton Crop

**Step 1: Methods of increasing yield**

At this stage it is best to introduce the concept of maximizing yield in the cotton crop, as cotton is a low value cotton crop, maximum returns are achieved by producing maximum yields. The following have been identified as means of achieving this.

2. Early planting
3. Adequate plant population
4. Correctly timed weeding
5. Good pest management (referenced in the pest management fact sheet)

**Step 2: Land preparation and Field Design**

The first decision the farmer has to make is to which system of cultivation should be used, in organic farming minimum cultivation systems are recommended but where conventional plowing is carried out this should be carried out in a way were the soil is left bare for the minimum period to reduce losses of organic matter and reduce any chance of soil erosion.

Minimum tillage can be either planting in a ripper line or hand hoe basins, if the crop is dry-land the cultivation should be carried out after harvesting the preceding crop to make use of residual soil moisture to ease cultivation. Manure or compost should be applied to the field at least two weeks prior to planting (the crop nutrition fact sheet gives the amounts that should be applied).

Marking out the field prior to carrying out this operation is also important as the farmer will have to decide on the spacing of the cotton plants and the spacing of inter-plants growing in the field. A sample field design is shown below.

The spacing used in the field design is 1m between cotton rows and within the rows is 0.15m (0.3m for dry-land cotton) this will allow the farmer to obtain the optimum plant population. The farmer must remember that the field layout should allow for the contours of the land. Crop rows should always go across the slope to prevent erosion.

<table>
<thead>
<tr>
<th>Sunhemp Borders</th>
<th>Interplants</th>
<th>14 Rows Cotton</th>
<th>Interplants</th>
<th>14 Rows Cotton</th>
<th>Interplants</th>
<th>14 Rows Cotton</th>
<th>Sunhemp Borders</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interplants</td>
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<td>14 Rows Cotton</td>
<td>Interplants</td>
<td>14 Rows Cotton</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Sample field design
**Step 3: Sowing**

**Time of Planting.** Timing of planting is critical in achieving maximum yields. It is recommended that the farmer plant with the first good rains at least 28 mm of rain should have fallen for dry land planting. The ideal planting time varies from region to region (reference the “Growing Calendar” for your specific growing region). Alternatively, the farmer may dry plant a small portion of the field if he or she is confident that he or she can replant the area if there is a prolonged dry spell. Dry planting the whole field would be too much of a gamble.

**Spacing.** The ideal spacing is a row spacing of 1m and a plant spacing of 15cm-30cm depending if the crop is irrigated or rain fed. In higher rainfall countries the irrigated spacing of 15cm can be used for rain fed crops.

**Using the basin system.** Farmers using the hand hoe system will be limited in their spacing by the basins but seeds should be planted in groups of 4-6 seeds at each end of the basin. Basin length will be 30cm and the basins will be 40cm apart.

**Using ripper lines.** The seed should be planted in groups of 4-6 seeds 15-30cm apart along the ripper line. In both cases the initial compost or manure will have been applied to the ripper line or basin 2 to 4 weeks prior to sowing the seed.

**Sow the cottonseeds at a depth of 1-2cm and cover them with fine soil.** This protects the germinating seed so it won’t dry out. Depending on the seed quality, 4 to 6 seeds are sown per spot. Seed should be re-sown in gaps where the seeds did not germinate or the seedlings have been destroyed, within 2 weeks after emergence of the young cotton plants. Seeds sown later will not produce much as they are shaded out by neighboring plants. Therefore, it is better to fill these later gaps with trap crops such as sunflower, maize or okra.

**Step 4: Thinning**

Seven to fourteen days after emergence, remove weaker seedlings so that there are only one plant in each spot. If thinning is done too early, the seedlings could still die off; if it is done too late there is competition among plants and chance of root damage when the seedlings are pulled out.

**Step 5: Sowing**

The importance of timely weeding cannot be overemphasized, as weed competition is one of the major contributory factors in yield loss. In dry years yield loss due to weed competition can be 3% per day or 21% in one week. (Source CFU Zambia).

Timely weeding has a higher impact on increasing cotton yield than fertilization or pest control. Most important for successful weed management in cotton are proper crop rotation and timely soil cultivation. However, this does not mean that the cotton fields need to be kept free of weeds throughout the season. In the initial stage of crop growth, weeds take up nutrients which otherwise would be lost through leaching. These nutrients are returned to the soil and made available to the cotton crop when the weeds are cut and decompose. 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, detracting pests from the cotton plant. Careful observation of weed populations and the use of shallow soil cultivation (hoes, weeder), combined with selective hand weeding, usually allow the experienced organic cotton farmer to ‘keep on good terms’ with weeds. To prevent the spreading of weed seeds through compost, it is important that composts containing weed seeds go through a heat phase, which destroys the seeds. It is recommended that the farmer should first remove the weeds within the row, that is, the weeds growing between the plants. At the first weeding this might have to be done by hand as well as with a hoe to avoid damaging the young cotton plants. Weeds can then be removed in the rows using an animal drawn cultivator, hand weeder or a hoe. Using this system the farmer will achieve much faster and efficient weed removal.

The timing of the first weeding is most critical in achieving a good cotton crop for if it is left too late the weeds will benefit from the basal dressing of manure or compost and will prevent the young cotton plants from establishing properly. For this reason it is important that the first weeding is carried when weeds reach 4-5cm in height and not left any later. If weeding is delayed it will make the job harder as weeds will be stronger and bigger and will be difficult to remove. The job will take longer and if any hired labour is used it will cost the farmer more money, further reducing profits as well as reducing potential yield.

The number of times a farmer has to weed cannot be stated as this will depend on the weed population in a particular field and type of weed (whether perennial or annual) and also the previous cropping and weather conditions in the growing season. Generally the farmer will have to weed 3 times before the cotton plants become big enough to compete favourably with the weeds. As mentioned earlier on, the farmer in an organic system does not have to remove all the weeds if they are not posing a threat to the crop. If weeds are not competing for nutrients and are not harbouring pests they pose no threat. It must also be remembered the cut weeds will act as a mulch and when decomposing will return some nutrients back to the soil further assisting the crop. Some weeds such as stoloniferous grasses and weeds with seeds should be removed from the field if possible to prevent growth but this material should not be wasted but used for compost making.

**Additional Resources:**
Visit Organic Exchange (www.organicexchange.org) for more information including PowerPoints and Posters for farmer development and education.
Intercrops are crops of a different species to the main crop grown in the same field to assist in the pest and disease management and in some cases to fertilize the main crop.

**Effects of intercropping on diseases.**
With few exceptions, crops that are grown with intercrops suffer fewer diseases than a pure crop with the same over-all density and stand. This is because the densities of susceptible plants are lower hence the amounts of potential disease causing organisms are also lower.

**Effects of intercropping on weeds.**
Time spent on weeding is often a main factor that significantly reduces the yields. Most crop combinations suppress growth by providing an early ground cover.

**Decoy Crops and Trap Crops.**
These are plants that can be sown or planted in the field alongside the cotton, which can attract pests’ away form the cotton. Pests will gather on them and they can be more easily controlled. Beneficial insects will build up on the pests and will also be attracted by certain flowering plants for nectar on which many adult beneficial insects depend for food.

Decoy crops are crops that will activate the adult to lay eggs but the larvae, when hatched, will have difficulty finding food. An example could be sesame if intercropped with cotton. The moth of the pink bollworm will lay eggs on sesame but the larva will find no food and eventually will die from hunger. Another example is sorghum planted amid cotton this can be cut down when bollworms infest it.

Some cotton pests prefer crops like maize, sweet sorghum, sunflower, pigeon pea, and okra to cotton. These crops can be grown along with cotton as trap crops, so that the cotton crop is spared. Experience from Tanzania and Zambia shows that sunflower is an efficient trap crop for the American bollworm, the bollworms being attracted to the flower heads. The sunflower is sown together or shortly after the cotton so that it starts flowering when the American bollworm attack begins. The flowering plant attracts a number of beneficial insects and birds. The sunflower seeds provide additional income to the farmers, and the plants can be used as fodder.

Using sunflower as a trap crop for American bollworm has the following advantages compared to maize and sorghum:
- Attractive to the moths for a long period, especially varieties which produce several flowers;
- Attracts beneficial insects when flowering;
- The productivity of the sunflower is hardly affected by the bollworms.
- Birds are attracted to the seed heads and some of these also predate on bollworm and other caterpillars.

Maize, sweet sorghum and okra can also be used as trap crops. Marigold also attracts beneficial insects and helps to control nematodes. Cowpeas are used as a trap crop to attract aphids away from the cotton crop, as they are more attractive than the cotton. Also the predators of aphids will be attracted and so help control the population. Cowpeas also have the benefit of fixing nitrogen and also attract ants to the field, which will predate on bollworms.
Table of useful inter-plants:

<table>
<thead>
<tr>
<th>Inter-plants</th>
<th>Main Action</th>
<th>Secondary Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize</td>
<td>Attracts American bollworm</td>
<td>Red bollworm</td>
</tr>
<tr>
<td>Sweet sorghum</td>
<td>Attracts bollworm</td>
<td></td>
</tr>
<tr>
<td>Sunflower</td>
<td>Attracts beneficial insects e.g. Parasitic wasps</td>
<td>Attracts birds for controlling caterpillars and bees for pollination</td>
</tr>
<tr>
<td></td>
<td>Attracts bollworm to flower heads</td>
<td></td>
</tr>
<tr>
<td>Okra</td>
<td>Attracts cotton stainer</td>
<td>Same family as cotton so attracts many similar pests</td>
</tr>
<tr>
<td>Mustard</td>
<td>Attracts beneficial insects</td>
<td>Attracts flea beetles</td>
</tr>
<tr>
<td>Lucerne</td>
<td>Attracts Lygus Bug</td>
<td>Flowers attract beneficial insects</td>
</tr>
<tr>
<td>Cowpeas</td>
<td>Attracts aphids</td>
<td>Attracts looping caterpillar adults to lay eggs, attracts ants.</td>
</tr>
<tr>
<td>Marigold</td>
<td>Attracts aphids and repels nematodes</td>
<td>Flowers attract beneficial insects and some varieties repel aphids.</td>
</tr>
<tr>
<td>Sesame</td>
<td>Attracts pink bollworm</td>
<td></td>
</tr>
<tr>
<td>Coriander</td>
<td>Flowers attract beneficial insects</td>
<td>Aroma can act as a repellent</td>
</tr>
<tr>
<td>Dill</td>
<td>Flowers attract beneficial insects</td>
<td>Aroma can act as a repellent</td>
</tr>
<tr>
<td>Fennel</td>
<td>Flowers attract beneficial insects</td>
<td>Aroma can act as a repellent</td>
</tr>
</tbody>
</table>

This is a critical aspect of growing organic cotton, as the inter-plants have to be at the correct growth stage in relation to the growth stage of the cotton to achieve the full benefit from them. Successful pest and disease control will be reliant on this aspect. A suggestion is to plant with the cotton leave spaces and plant four weeks later and four weeks later again.

Inter-plants will also provide a small income for the farmer from the same cotton field so the area planted to inter-plants will not be unproductive. In any case, the inter-plants will be a critical part of the success of the cotton crop.

Additional Resources:
Visit Organic Exchange (www.organicexchange.org) for more information including PowerPoints and Posters for farmer development and education.
Soil Nutrient requirements of Cotton
Crop rotation and intercropping with legumes, recycling of crop residues and the application of farm-produced organic manure (kraal manure and compost) need to form the basis of nutrient management in organic cotton farming. Organic farmers should not try to copy conventional fertilizer application schemes by substituting NPK-fertilizers with organic manures. It is very important that above all they preserve the nutrients that are already available in the soil and on the farm: prevent soil erosion, use all available crop residues and organic wastes, and do not burn crop residues or cow dung.

Like other crops, cotton requires the full range of nutrients in a well-balanced composition. The cotton plant requires two-thirds (2/3) of these nutrients during the first two months of its growth. To ensure sufficient nutrient supply (especially of nitrogen) during this phase, it is recommended that a basal dose of well-decomposed compost or manure be applied at the start of the growing season. This is equivalent to 10 tonnes of compost or manure per Ha. This is complemented with applications of manure or compost or leaf teas, which should be applied weekly, until the crop becomes too dense to prevent access. Change to leaf and compost teas after buds form to provide more potassium for better yields.

In cotton, Nitrogen (N) is needed for overall growth. Adequate amounts are needed to obtain desired yields. A harvest of 1000 kg seed cotton extracts approximately 72kg nitrogen (N), 28 kg phosphate (P2O5) and 30 kg potassium (K2O equivalents) (FiBL cotton production Manual). Parts of these nutrients may be replaced through nitrogen fixation by legumes (N) and through weathering of minerals (P and K). Potassium is the element in great demand by the cotton plant during boll formation. Yield and fibre quality are determined by potassium. The critical period for potassium uptake is during flowering, about two to three months after planting. This is why application of compost and comfrey tea is important prior to and during this time, as these liquid manures will have a higher concentration of potassium than plain manure tea.

Uptake of Nutrients
In organically managed soils, the crops mainly depend on the nutrients supplied by minerals and by the organic matter in the soil. These take up, store and release nutrients (through exchange, weathering, and decomposition). Soil organisms play a vital role in this process and should be supported through careful soil cultivation and regular application of organic matter. Measures to improve overall soil fertility (microbial activity, structure, moisture retention) are more likely to result in increased yields than merely applying fertilizers.

The most widespread nutrient deficiencies in tropical cotton fields are in nitrogen, phosphorus, sulphur, zinc and boron. The availability of nutrients to the crop, however, depends on a number of factors such as the activity of soil microorganisms, the root system of the crop, and the water content in the soil. Nutrient uptake can be hindered by water-logging, (the roots then lack air) and dryness (there is no nutrient uptake without water). Excess nitrogen, phosphorus and potassium also disturb the uptake of certain other nutrients like calcium, magnesium and micronutrients. In the case of a cotton crop showing deficiency symptoms (yellow or light green leaves), it is not always necessary to apply additional manure or fertilizers. It may be more efficient to stimulate microbial activity and to overcome the inhibiting factors, e.g. through soil cultivation, irrigation, and incorporation of biomass and application of manure/leaf teas or compost extract.

Application of manures and fertilizers
Suitable application doses of nutrients in organic cotton depend on the soil condition, the previous crop, and the expected yield. Table 1 shows the nutrient quantities recommended for organic cotton for cotton soils of average fertility cultivated with high-yield varieties. A considerable portion of the required nutrients, however, can be supplied through decomposing residues of the previous crop and through nitrogen fixation by leguminous crops.
Table 1: Recommended nutrient doses in average organic cotton fields, to be adapted to local conditions.

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Required Amount</th>
<th>Possible sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen (N)</td>
<td>100–120 kg/ha</td>
<td>Residues from previous crop, nitrogen fixation through pulses, compost, kraal manure, liquid manures, teas</td>
</tr>
<tr>
<td>Phosphorous (P2O5)</td>
<td>50–60 kg/ha</td>
<td>Residues from previous crop, compost, kraal manure, rock phosphate, wood ash, teas.</td>
</tr>
<tr>
<td>Potassium (K2O)</td>
<td>40–50 kg/ha</td>
<td>Residues from previous crop, compost, kraal manure, wood ash, teas especially comfrey and compost.</td>
</tr>
</tbody>
</table>

Organic manures such as compost and straw rich cattle dung contain the full range of nutrients including micronutrients in a balanced composition. Thus, where organic manures are applied in sufficient quantity, usually there is no deficiency of micronutrients.

Farmers can achieve the desired nutrient input through the following steps (in order of priority):
1. Practice crop rotation, and grow leguminous crops (e.g. pulses) as intercrops or as green manures;
2. Use all biomass available on the farm (do not burn crop residues or cow dung!); mix wood ash into the compost heap;
3. Use whatever biomass is cheaply available nearby (e.g. weeds, leaves, agricultural processing wastes);

Table 2: Recommended nutrient management plan for organic cotton.

<table>
<thead>
<tr>
<th>Manure or measure</th>
<th>Recommended quantity (per ha)</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crop rotation</td>
<td>Preferably grow cotton on plots where the previous crop was a legume or green manure.</td>
<td>The cotton crop benefits from the high nutrient level of the previous crop.</td>
</tr>
<tr>
<td>Green manure / intercrop</td>
<td>If possible, grow leguminous crops (e.g. pulses) as intercrop or as a green manure.</td>
<td>Leguminous crops increase the nitrogen content in the soil by fixing it from the air.</td>
</tr>
<tr>
<td>Compost, cow dung or compost</td>
<td>Initial application: 10-tons/ha cow dung, or 10-tons/ha compost. (Applying to basins or rip lines 3.5 tonnes would be used.) Top dressing (decomposed compost, 3 weeks after sowing: 1.5 - 2.5 tons per ha.</td>
<td>Compost and cow dung should be well decomposed. The quantity can be reduced if the previous crop was pulse or a horticulture crop, or if pulses are grown as green manure or an intercrop.</td>
</tr>
<tr>
<td>Rock phosphate</td>
<td>50–70 kg per ha, application together with the compost.</td>
<td>Mix into the compost when setting up the heap; do not apply it directly to the soil. Increase the quantity to 100 kg in case of P-deficiency (soil test).</td>
</tr>
<tr>
<td>Leaf/manure teas</td>
<td>Start 1 week after germination and continue weekly until mid January. Change from manure tea to compost tea or comfrey tea after 1 month. 800l/ha</td>
<td>Drench on plant and soil. Only apply after rains and do not dry drench. Changing tea type is to ensure the plant does not receive too much nitrogen. Avoid leaves when drenching with chicken manure.</td>
</tr>
</tbody>
</table>

Caution: A too-high supply of nitrogen-rich manures can cause:
- Strong vegetative growth of cotton (many leaves instead of bolls);
- Increased shedding of square buds;
- Plants to become more attractive to sucking pests like aphids, whitefly and jassids;
- Potentially lower yields!
Compost
Composting is the process of transforming organic material of plant or animal origin into high-value organic manure in heaps or pits. Farmers need to prepare quantities of compost in advance of the growing season to make sure it is ready prior to planting. Organic farmers should be already doing this, as application of compost is critical to increasing soil organic matter levels.

Organic manures
Crop rotation with legumes, organic manures and the recycling of organic matter must form the basis of nutrient management in organic cotton production. Compost and farmyard manure are important to improve and maintain soil fertility and to provide a base supply of nutrients to the crop. However, during flowering and boll formation cotton has a particularly high nutrient demand that usually cannot be fully satisfied with the available amounts of compost and kraal manure. Thus it is recommended that additional organic manures be provided during this phase, like poultry manure, goat and sheep manure, bone meal, food processing wastes, etc. However, note that manures from intensive rearing (e.g. chicken rearing) are not permitted unless composted according to organic standards.

Cattle grazing on fields after harvest
The transportation and application of farmyard manure or compost to the fields involves quite a lot of labour. An easy way to apply manure to a field is to allow cattle to graze on it after the harvesting is over. The cattle feed on the crop residues, and at the same time fertilize the field with their dung. This also helps to kill pests like stem borers and bollworm living in stalks and unpicked pods.

Liquid fertilizers
Liquid manures like cow urine, manure teas, compost extract, leaf teas and leaf juices can provide part of the nutrients needed in the later growth stages of the crop. They are drenched on the soil. Liquid manures have the advantage that the nutrients are available almost instantly. Thus they can be used to fine-tune nutrient supply. Table 3 provides some examples of liquid manures used by organic cotton farmers.

**Table 3**

<table>
<thead>
<tr>
<th>Liquid manure</th>
<th>Preparation</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manure tea</td>
<td>Take 15-20 kg manure, tie it in a piece of cloth or a sack and suspend it in a drum of 210 litres water for 10–15 days, open drum and stir every 2 days.</td>
<td>Dilute 1:3 and apply a total of approx 800lt/ha. Dilution may vary depending on type of manure e.g. poultry manure may need more water to avoid scorching the plants. Apply weekly during growing season.</td>
</tr>
<tr>
<td>Compost extract</td>
<td>Take 15-20 kg of compost in a sack tie the sack and suspend in a 210litre drum for 10-15 days.</td>
<td>Dilute 1:3 and apply a total of approx 800lt/ha. Dilution may vary depending on quality of compost but application rate will remain the same.</td>
</tr>
<tr>
<td>Comfrey or other leaf teas</td>
<td>10-15 kg of Comfrey or other plant leaves are placed in a sack as above this is left suspended in a 210 litres drum for 10-15 days</td>
<td>Dilute 1:3 and apply a total of approx 800lt/ha. Dilution may vary depending on the leaf material.</td>
</tr>
<tr>
<td>Comfrey or other leaf juice</td>
<td>The juice can be extracted by squeezing the leaves and any leaf residue is used for compost making.</td>
<td>Dilute 1:5 as this is a more concentrated solution to strong an application may scorch the plant. Apply a total of approx 800lt/ha.</td>
</tr>
</tbody>
</table>

Additional Resources:
Visit Organic Exchange (www.organicexchange.org) for more information including PowerPoints and Posters for farmer development and education.
Good soil fertility and balanced nutrition (through compost and other organic manures) support plant health which reduces pest and disease pressure on the crop. Farmers can optimize soil conditions through shallow soil cultivation and increasing soil organic matter. Diverse cropping systems and natural habitats enhance control of pest populations by means of natural enemies, like birds and beneficial insects. Intercrops of pulses and trap crops like sunflower or maize distract pests from the cotton plants. Some pests multiply faster if the same crop is grown on the same field year after year. It is therefore important to rotate the different crops within the farm and not grow cotton in fields that had cotton in the previous season.

Poor control of pest and diseases drastically reduces yields. It is a critical point to which we should pay much attention to in cotton production, otherwise work carried out earlier in establishing the crop will go to waste.

### Diseases
The estimated crop losses due to diseases could range between 15-25%. The cotton diseases are caused by pathogens, which may be fungi, bacteria, or virus. In most of the semi-arid tropical regions, diseases are not a big problem in organic cotton. Diseases that occasionally occur are given below:

1. **Damping-off**
   Several pathogens cause damping-off whose symptoms are seed rot during germination, root rot and collar rot of the young seedlings.

   **Control**
   Buying seed certified seed from a reputable seed company. Crop rotation - normally cotton should follow crops that are not susceptible to damping-off. This can be treated by applying compost and or spraying with concentrated ash solution.

2. **Black arm**
   It can be identified by (canker) black/brown lesions on cotton plant followed by desiccation of the top part from the area of infestation.

   **Control**
   Planting of new fresh seed. Using baking soda (mix 150g in 1l of water put in 16l knapsack sprayer and dilute). Spraying of contracted ash solution. Remove infested plants/bolls to reduce pathogen dispersal to other cotton plants.

3. **Fusarium wilt**
   This is general wilting of the plant, it occurs at any time during the cotton cycle. Fusarium wilt is often related with root-knot nematodes and application of fresh manure without decomposing it.

   **Control**
   Planting of new and fresh seeds. Improve the water drainage. Crops rotate with green manures that leave large volume of biomass to improve soil fertility. Remove the diseased plants. Rotation with Sunnhemp can reduce soil nematodes.
**Pest Control**

A large number of pests feed on cotton: caterpillars (e.g. bollworms), beetles, bugs, aphids, jassids, whitefly, thrips, mites etc. The healthy cotton plant has some means of defense. It compensates for affected shoots and leaves through additional growth, and produces substances that deter insects from eating them (e.g. gossypol). In conventional farming, cotton is considered a crop that is highly sensitive to pest attack. Large quantities of chemical pesticides like organophosphates and pyrethroids are sprayed to keep them under control. This, however, eventually results in the pest problem increasing, as the natural enemies of many pests are decimated. First and foremost, organic cotton farming tries to prevent pests from even becoming a problem. The best way to do this is to establish a diverse and balanced farm ecosystem.

Sucking pests (aphids, whitefly and mites) and some other small pests (especially thrips and jassids) usually attack plants that are stressed. Stress can be caused by unbalanced nutrition (too many or too few nutrients, especially nitrogen). Water shortage or water logging can also cause stress. Just like humans or animals, plants also have a kind of immune system, which usually enables them to fight an attack of sucking pests. In stress situations, this immune system works less effectively. Therefore it is important to avoid stress situations for the plant. This primarily means:

- Neither too little nor too much manure (no ‘overfeeding’).
- Shallow cultivation of the soil, (cultural operations) to encourage soil aeration and decomposition of organic matter.

With these preventive measures properly implemented, the pest problem in organic cotton is surprisingly 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. In this regard, one should take into account both the cost of the pesticide and the labor for fetching water and for spraying.

As long as pest infestations remain below the threshold levels, farmers should wait and see whether the natural enemies are able to control the pests, which would result in negligible damage to the crop.

### Important cotton pests and their management:

<table>
<thead>
<tr>
<th>Pest</th>
<th>Part of the plant attacked</th>
<th>Trap crop</th>
<th>Other control</th>
</tr>
</thead>
<tbody>
<tr>
<td>American bollworm</td>
<td>Flowers, buds and bolls</td>
<td>Sweet sorghum, sunflower, maize, okra.</td>
<td>Hand picking, NPV spray, neem spray, Encouraging predators.</td>
</tr>
<tr>
<td>Red bollworm</td>
<td>Flowers, buds and bolls</td>
<td>Sweet sorghum, sunflower, maize, sesame, okra.</td>
<td>Hand picking, NPV spray, neem spray, Encouraging predators.</td>
</tr>
<tr>
<td>Spiny bollworm</td>
<td>Flower, buds and bolls</td>
<td>Sweet sorghum, sunflower, maize, okra.</td>
<td>Hand picking, NPV spray, neem spray, Encouraging predators.</td>
</tr>
<tr>
<td>Cut worm</td>
<td>The seedling cotton plant.</td>
<td>Coriander (repellent)</td>
<td>Using ash round the plant, anti-feeding sprays such as chilli.</td>
</tr>
<tr>
<td>Aphid</td>
<td>Seedling, leaves, buds and growing tips and sooty mould damage to the open boll. Can vector viruses.</td>
<td>Cowpeas, marigold (repellent), mustard, sorghum.</td>
<td>Soap spray, encouraging natural enemies.</td>
</tr>
<tr>
<td>Jassids</td>
<td>Leaves and growing tips.</td>
<td>Cowpeas, mustard, flowering plants.</td>
<td>Soap spray, encouraging natural enemies.</td>
</tr>
<tr>
<td>Whitefly</td>
<td>Leaves and growing tips can cause lint to be sticky and of low value.</td>
<td>Flowering tobacco (nicotiana).</td>
<td>Soap spray, neem spray, lantana spray, yellow sticky traps.</td>
</tr>
<tr>
<td>Thrips</td>
<td>Leaves, growing tips, flowers.</td>
<td>Sunflower, mustard</td>
<td>Ash, neem spray, garlic spray, encourage natural enemies</td>
</tr>
<tr>
<td>Cotton Stainer</td>
<td>Bolls</td>
<td>Okra,</td>
<td>Neem spray, hand picking encouraging natural enemies.</td>
</tr>
<tr>
<td>Red Spider Mite</td>
<td>Leaves,</td>
<td>Flowering plants to encourage predators.</td>
<td>Soap spray, encourage natural enemies.</td>
</tr>
<tr>
<td>Grasshopper</td>
<td>Seedlings</td>
<td></td>
<td>Neem spray, or ash or salt around the plants.</td>
</tr>
</tbody>
</table>
**A Table of Beneficial Insects**

<table>
<thead>
<tr>
<th>Farmers Friend</th>
<th>Useful Stage</th>
<th>Pest Preyed Upon</th>
<th>Predator or Parasitoid</th>
<th>Inter-plants to Attract Farmers Friend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lady Bird Beetle</td>
<td>Adult &amp; Larvae</td>
<td>Aphid</td>
<td>Predator</td>
<td>Flowering plants and trap crops such as cowpeas</td>
</tr>
<tr>
<td>Lacewing</td>
<td>Larvae</td>
<td>Aphid/bollworm</td>
<td>Predator</td>
<td>Flowering Plants, Mustard, Fennel, Coriander</td>
</tr>
<tr>
<td>Hover-fly</td>
<td>Larvae</td>
<td>Aphid</td>
<td>Predator</td>
<td>Flowering Plants, Mustard, Coriander, Marigold</td>
</tr>
<tr>
<td>Assassin Bug</td>
<td>Adult</td>
<td>Cotton Stainer</td>
<td>Predator</td>
<td>Trap Crops, Okra</td>
</tr>
<tr>
<td>Predatory Mites</td>
<td>Adult &amp; Nymph</td>
<td>Red Spider Mite</td>
<td>Predator</td>
<td>Trap crops &amp; the main Crop</td>
</tr>
<tr>
<td>Parasitic Wasps</td>
<td>Adult &amp; Larvae</td>
<td>Aphids, Bollworms, White-fly</td>
<td>Parasitoid</td>
<td>Flowering plants, Fennel, Coriander, Marigold</td>
</tr>
<tr>
<td>Praying Mantis</td>
<td>Adult</td>
<td>All insect pests</td>
<td>Predator</td>
<td>Trap crops and the main crop</td>
</tr>
<tr>
<td>Spiders</td>
<td>Adult</td>
<td>All insect Pests</td>
<td>Predator</td>
<td>Trap crops and the main crop</td>
</tr>
<tr>
<td>Red Ants</td>
<td>Adult</td>
<td>Boll worms</td>
<td>Predator</td>
<td>Trap crops such as cow peas</td>
</tr>
</tbody>
</table>

**Preventing pests from becoming a problem**

As mentioned previously, the first step in organic pest management is to support healthy growth of the cotton crop. The second step is to prevent pest populations from building up and becoming a problem. The preventive measures described below can help in this.

**Promotion of natural enemies**

In a diverse field not treated with pesticides, natural enemies help the farmer keep pest attacks within tolerable levels. Natural enemy populations can be increased in the field by providing suitable habitats: intercropping of flowering plants, applying mulch, setting up bird perches etc.

Generally speaking, the more different plants growing in a field, the higher the number of different natural enemies. Intercropping of pulses or other crops in cotton is therefore an effective preventive pest-management strategy.

**Removing crop residues**

Some cotton pests can survive in cotton stalks and seeds. Therefore it is important that cotton be uprooted after the end of the harvest, and removed from the field or buried by ploughing the field. In a large number of cotton growing regions destruction of plant residue to avoid disease and reduction of pest habitats. In Southern African countries this must be done by September and it is a legal requirement that this is carried out. Cattle grazing the field after the picking is over destroy the remaining pests in the unpicked bolls and leaves.

**Direct pest management methods**

Only when the first two steps of organic pest management – strengthening the crop and preventive measures – are not sufficient to keep pest populations below the economic threshold, direct control methods should be used. The methods described below are recommended in organic cotton production.
Biological control

Biological control uses living organisms or germs to affect the pests. By promoting the natural enemies of the pests through the planting of intercrops the farmer can perform some form of biological control by collecting “farmer’s friends” and releasing them into the field. In Uganda, organic cotton farmers rear and promote ants of the Acantholepis family for controlling a number of pests.

Other bio-control methods involve microbes and viruses attacking the pests:

- **Bt spray**: Bt (Bacillus thuringiensis) is a microbe that is effective against leaf feeding caterpillars. Therefore, it is only effective against bollworm in its early stage, before it enters the bolls. Night-time spraying increases exposure to Bt, since sunlight breaks it down. NPV: This virus (nuclear polyhedrosis virus) attacks American bollworm and causes its death. To multiply the NPV preparation locally, spray NPV on a cotton field, collect caterpillars affected by NPV, grind them and dilute with water. Commercially available fungal sprays can also control bollworm.

Natural Pesticides

There are a number of natural pesticides that can be used in organic cotton cultivation, and organic farmers continuously try out new ones. But little scientific research has been done on the efficiency of most of the locally prepared formulations. Therefore, farmers are encouraged to do their own experiments and trials to find out which natural pesticides are most suitable for their farms. Below we list some of the natural pesticides used by farmers in India and Africa.

<table>
<thead>
<tr>
<th>Neem spray (Azadirachta indica)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ingredients</strong>: Neem kernel extract, containing azadirachtin</td>
</tr>
<tr>
<td><strong>Target pests</strong>: Sucking pests, jassids, bollworms, thrips</td>
</tr>
<tr>
<td><strong>Preparation</strong>: Farm-made: Pound 30 g neem kernels (that is the seed from which the seed coat has been removed) and mix in 1 litre of water. Leave overnight. The next morning, filter the solution through a fine cloth and use immediately for spraying. It should not be further diluted. Commercial formulations like Bio Neem EcoNeem, NeemCare etc.: as per package description.</td>
</tr>
<tr>
<td><strong>Remarks</strong>: Sprays from neem seed or leaf extract do not kill the insects directly but reduce their normal activities like feeding, moving and multiplying. Therefore the effect is not noticeable until after few days. The main advantage of using neem is that it is not harmful to most beneficial insects. To a limited extent, neem’s active substance is also absorbed by the plants and thus affects the pest when they feed on the crop.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pyrethrum</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ingredients</strong>: Powdered flower heads or liquid extracts of a daisy-like chrysanthemum (commercially available).</td>
</tr>
<tr>
<td><strong>Target pests</strong>: Red cotton bug, cutworms, grasshoppers</td>
</tr>
<tr>
<td><strong>Preparation</strong>: Commercial preparations: as per package instructions.</td>
</tr>
<tr>
<td><strong>Remarks</strong>: Pyrethrum causes immediate paralysis or death to most insects, but also affects beneficial insects. The active substance in the pyrethrum extract is quickly destroyed when exposed to sunlight.</td>
</tr>
</tbody>
</table>

Caution: Many natural pesticides also affect beneficial insect populations and thus should be used only when really necessary. Some plant extracts are also toxic to humans and animals and should be used with care. It should also be noted that any botanical insecticides and release of biological control (parasites, predators and microbial pesticides), require prior approval of the certification organization in order to maintain certification eligibility.
**Garlic-onion-chilli repellent**

**Ingredients:** 2.5 kg garlic, 2.5 kg onion, 7.5 kg green chilli. 10 litres water.

**Target pests:** Bollworm, sucking pests

**Preparation:** Crush the ingredients and mix in 4 litres water to prepare a stock solution. Add 500 litres of water to this stock solution for spraying 1 ha.

**Remarks:** This repellent does not kill the insects but deters pests from the crop.

**Remarks:** Repelling effect.

**Coriander seed spray (Coriandrum sativum)**

**Ingredients:** 200g coriander seeds, water

**Target pests:** Spider mites

**Preparation:** Boil the crushed coriander seeds for 10 minutes in 1 litre water. Dilute with 2 litres of water. Spray early in the morning.

**Remarks:** Repelling effect.

**Flour spray**

**Ingredients:** 2 cups of fine white flour; half cup of soap (sticker), water

**Target pests:** Aphids, spider mites, thrips, whitefly

**Preparation:** Stir the flour into the water. Add the soap and stir again before spraying.

**Remarks:** Repelling effect.

**Soft soap spray**

**Ingredients:** Soft soap, water

**Target pests:** Aphids, jassids, whitefly, thrips

**Preparation:** Stir 15 g soft soap into 15 litres water.

**Remarks:** Soft soap sprays also affect beneficial insects and should only be used as the last resort.

**Mass trapping**

Traps can help reduce the population of certain pests, especially of moths (the adults of caterpillars). If used at an early stage, they can prevent mass multiplication. There are several types of traps:

- Light traps attract night-active flying pest insects.
- Sticky traps of yellow color.
- Pheromone traps attract the male moths that get stuck in the trap.
**Constructed traps**

Various kinds of traps can be constructed to catch insects, rodents or other creatures, which will threaten cotton crop. The most common ones are:

1. **Light traps.** To catch night-flying insects. Electric or kerosene lamps can be used. The tripod stand can be used. The tripod stand is anchored on the ground and the light source is hung on the middle of three poles and a shallow bowl (dish) filled with water is placed underneath. Cooking oil is then added to water so that when the moth falls in, after being attracted, the oil will stick to wings preventing it flying away. Lamps can be set at different heights above the ground preferably 1m and above so that moths can see them more easily even from a long the distance.

2. **Sticky traps.** There are numerous ways of making and using sticky traps. Yellow sticky trap. Yellow is one of the colors liked by insects and it can be seen from a distance (it’s easily identified). Stick traps have sticking stuff- (glue) so that when insects are trapped, the glue will hold them. Blue traps can be used to attract thrips.

**Hand Picking**

This is another method of pest control that can be practised by the small-scale farmer. This literally involves walking through the field and collecting the pests that are found. This can be done in conjunction with preparing an NPV spray for bollworm. In the case of cotton this method of control is only really applicable to bollworm control. It should not however be dismissed as it can be effective in controlling infestations without harming the natural balance of pests and predators in the field, unlike using a natural pesticide and is a preferred method of control.

**Monitoring pests (scouting)**

A key to successful pest management in cotton is a careful and continuous monitoring of pest levels in the cotton fields during the critical growth period (approx. 4 weeks after sowing up to the second harvest). Monitoring helps to determine when a pest population reaches the economic threshold and, therefore, when direct control measures need to be implemented. For monitoring, farmers randomly inspect a number of cotton plants while crossing the field in diagonals.

**Pest to Predator ratios**

This is simply the number of pest found on a plant related to the number of predators or beneficial insects found when inspecting the crop. This is another factor to consider before the farmer decides to spray a natural remedy. The ratio is simply calculated by counting the number of pests and the number of predators or beneficial insects found on the plant and dividing one number by the other. The acceptable ratios for this vary between predators and pests. Some examples are shown in the table below.

<table>
<thead>
<tr>
<th>Predator or sign of predator</th>
<th>Pest</th>
<th>Acceptable ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lady bird beetle/ larvae</td>
<td>Aphid/Jassid</td>
<td>1:40</td>
</tr>
<tr>
<td>Lacewing egg/ larvae</td>
<td>Aphid/Jassid</td>
<td>1:30</td>
</tr>
<tr>
<td>Assassin bug</td>
<td>Cotton Stainer</td>
<td>1:10</td>
</tr>
</tbody>
</table>

Other ratios could be worked out by the farmer after several years experience; the farmer should always wait before spraying if any natural enemies are found. Careful observation of the situation may show that the natural enemy is controlling the problem and spraying may unbalance the situation and make the problem worse in the long term. Alternative methods of control like hand picking could also be considered.

**Additional Resources:**

Visit Organic Exchange (www.organicexchange.org) for more information including PowerPoints and Posters for farmer development and education.
Protecting and preserving the quality of cotton lint throughout the growing, harvesting, ginning and manufacturing processes is a critical element of textile production. Small, but strategic investments in quality management at the farm and manufacturing levels can help protect the quality of the fiber and result in the production of high quality products that command good prices in the retail market.

Manufacturers are typically looking for clean, white lint with good staple length and strength, no stickiness, low amounts of short fibers and minimal trash and leaf content.

If the buyers know that they can obtain quality lint from a known farmer they will be more ready to pay a higher price for the seed cotton. On the other hand, if producers supply poor quality cotton, they are likely to get a lower price for their cotton. Poor quality cotton can also reduce the quality of the end product, resulting in lower economic returns for all parties in the value chain.

**Key Steps for Managing and Improving Quality**

**Step 1. Implement Quality Management Practices at the Farm Level**

Quality lint starts with excellent management at farm level. The farmer can to a very large extent determine the quality of the lint by producing quality cotton at his or her farm. A cotton plant that is continuously growing well during the growing season will more likely have longer and stronger fibers, be free of Neps (knots in the lint), and have a fineness in appearance. A plant will grow well if it is weed free and has sufficient nutrients. Addressing soil fertility and crop nutrition like good compost and manure teas at the correct time will help the farmer attain a quality seed cotton and lint.

<table>
<thead>
<tr>
<th>Quality Procedure</th>
<th>Quality Controls</th>
</tr>
</thead>
<tbody>
<tr>
<td>Timely and correct land preparation.</td>
<td></td>
</tr>
<tr>
<td>Timely and correct application of manure/compost.</td>
<td></td>
</tr>
<tr>
<td>Achieving a good plant population of between 63,000-74,000 plants per ha.</td>
<td>Early and continuous weeding when necessary.</td>
</tr>
<tr>
<td>Correctly times planting of interplants throughout the growing season.</td>
<td>Early gapping and thinning to ensure correct plant population.</td>
</tr>
<tr>
<td>Correctly times application of liquid feeds, top dressing.</td>
<td></td>
</tr>
<tr>
<td>Adequate pest and disease control during growing season.</td>
<td>Physical or chemical (natural pesticide) control of pests if a threshold level is reached in a part of the field.</td>
</tr>
<tr>
<td>Harvesting as soon as 4-5 bolls per plant have opened and continue to harvest as soon as cotton is ready.</td>
<td></td>
</tr>
<tr>
<td>Grade cotton at harvest time by using two picking bags.</td>
<td></td>
</tr>
<tr>
<td>Clean and secure storage of cotton on farm to avoid contamination from non organic products. As this could cause the cotton to lose its organic status.</td>
<td>Check grades again when packing bales. Should be no mixing of grades in bales.</td>
</tr>
<tr>
<td>Comply with the organic regulations at all stages of the growing, harvesting, storing and transporting processes.</td>
<td></td>
</tr>
</tbody>
</table>
**Step 2. Maintain a Strong Focus on Quality During Harvest and Post-Harvest Operations – Hand Harvesting**

The quality of the cotton harvest depends on the length of the fibre (staple length), on the degree of contamination with non-fiber material such as leaves or dust, and on the portion of fiber damaged by pest or disease infestation.

Good-quality raw material helps to produce yarns and garments of high quality, and thus eventually contributes to the market success of the organic cotton project. When cotton buyers fix prices, they usually take into consideration the quality of the seed cotton. Measures taken to improve the quality of the harvest therefore directly pay off for the farmers.

Some key quality measures include:

- Allow the cotton bolls to fully ripen and open. It is important that no unripe cotton is picked, as it will not absorb the dye well enough and thus is priced lower.
- Pick the cotton after the morning dews have dried up, so that the cotton is dry and less prone to fungus when being stored.
- Pick the cotton into cotton bags or polythene bags supplied by the cotton company, never into nylon or polypropylene sacks (old mealie-meal sacks)
- Remove leaves, capsules and damaged bolls from the cotton harvest.

Picking delays can cause reduction of fiber quality, as the opened bolls are exposed to dew, dust and honeydew from insects longer. For cotton being hand harvested, here are some steps farmers can take to help improve the efficiency of picking include:

- Use a long sack so that the weight rests on the ground.
- Keep the sack permanently open with a ring of flexible wood.
- Pick two rows at a time.
- Use two bags and keep cotton of lesser quality separate with the help of a second, smaller picking bag.

**Step 3. Store and Pack Cotton Properly to Prevent Contamination**

The cotton should be packed into the bales provide by the cotton company, grades should not be mixed in the bale. A bale should weigh approximately 75-80kg when correctly packed. Once the bale is full it should be stitched up and the farmer should mark it so that it can be easily identified as originating from his farm and to which grade it contains.

If farmers store the harvested cotton before selling it, they should take care to prevent contamination from dust or chemicals, especially fertilizers, pesticides, and petroleum. Items or containers that have been utilized for pest control should never be utilized for storing harvested cotton! The storage place needs to be clean and dry. Damp conditions can lead to the growth of fungus, with significant loss of cotton quality. When organic harvest is stored in the same facilities with conventional cotton (e.g. in ginneries), care must be taken to clearly separate the organic, in-conversion and non-organic produce, and to avoid any mixing.

**Resources**

Contamination: Meaning, Causes, Impacts and Solutions. Maral Overseas Limited & M&S. Organic Exchange. Africa Regional Meeting 2007. Cape Town, South Africa. This power point presentation describes the vulnerability of organic cotton to contamination in farming, picking and ginning and storing, and provides examples of preventative practices than can be followed.

**Additional Resources:**

Visit Organic Exchange (www.organicexchange.org) for more information including PowerPoints and Posters for farmer development and education.