Factsheet
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Productivity on ecological organic farms in the Tropics

Producing good yields using the ecological approach

Ecological organic farming provides many benefits for health, the environment and societal welfare, but is generally perceived as not productive enough to meet growing food demands. However, research has demonstrated that farm productivity on well-managed organic farms can match that of conventional – this requires active, holistic management practices, e.g., crop diversification via crop rotations, intercropping, agroforestry, effective pest and disease control, water management amoung other practices.

This factsheet discusses some best organic practices for good yields in ecological organic systems, the role of diversity, and highlights some opportunities and challenges with selected crops in organic production. The information is based on long-term experiments and on-farm research conducted in the scope of three projects across different countries in Africa, as well as Bolivia and India. Further products in the series, e.g., posters, videos and more, are linked in the 'Further information' section on the last page of this factsheet.

Key messages from the research

- Farm productivity in ecological organic systems can **match or exceed** those in conventional production systems. This is dependent on the type of crop, management practices and design of the system.
- In cacao production systems, research results show that **increasing the diversity** of the system (e.g., agroforestry) can **increase farm productivity**.
- Although cacao monocultures produce higher cocoa beans yields, agroforestry systems achieve higher total productivity as well as a higher diversity of products, e.g. fruit trees, like bananas, tuber crops, spices, herbs, etc.

Agricultural productivity is, simply speaking, the ratio of the agricultural yields (output) to inputs needed for production. In ecological organic systems, this definition goes beyond that to include the productivity of the whole farming system: the soil, crops, animals, labour and financial productivity.

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What to consider to have good yields in organic production?

» To have good yields in organic, it is not enough to just eliminate synthetic agrochemical inputs. The farmers' approach must consider the whole system, to use locally-available resources and engage in organic best practices, e.g., cropping systems diversification, intercropping and crop rotation, cover cropping, mulching, reduced tillage, integrated pest management, nutrient management, and water management.

Key finding from the research

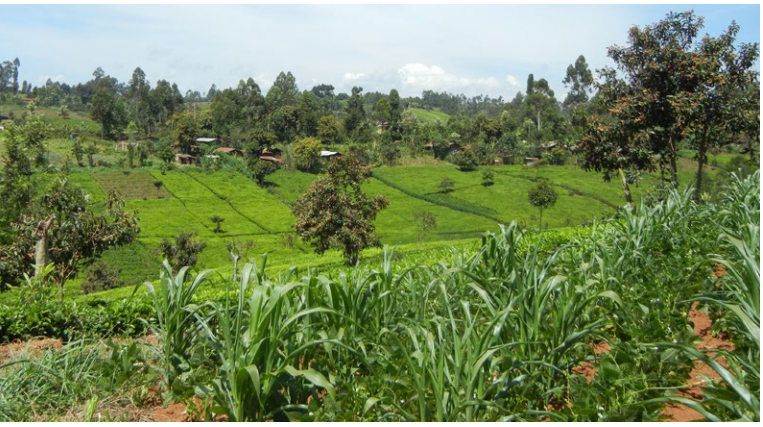
Yields in organic systems can match or exceed conventional systems. In organic systems, improved agronomic management through an active, ecological approach, can aid in improving yields and keeping yields consistent.

In the next section, some major factors to support good yields on organic farms are outlined.

Healthy soil, healthy crops

In ecological organic farming, the focus is on the long-term build up of soil fertility and health (organic matter and biological activity). This also has a positive impact on water infiltration and storage in the soil. Farmers can try these practices to support soil health:

- Produce high-quality organic inputs: The use of organic inputs in the correct amount and nutrient content at the right time is necessary to improve the yields of crops in organic system, e.g., plant tea extracts, green manure, decomposed animal manure.
- Plant nitrogen-fixing legumes and fast-growing plants for mulching or green manuring, i.e., herbaceous cover crops, shrubs or trees.



- Implement soil conservation measures, like keeping the soil covered by living plants (cover crops) or organic matter (mulch), reducing tillage or no till, vegetative strips, terracing, alley cropping.
- Integrate livestock into your cropping systems to help cycle nutrients. Utilise livestock for farm labour and the manure and urine for compost and biogas production.
- Read more into the topic in the 'Soil fertility and health' factsheet > Link

Make nutrients available to crops

Certain nutrients are less available in organic systems because they are applied in forms that are less available to plants or are released more slowly. Missing nutrients at key crop stages can limit yields in organic systems. These challenges were seen in nitrogen (N) in cotton and wheat in India, and with phosphorus (P) in Kenya. In such instances one can:

- Adjust the quality and type of organic inputs (compost, manure, compost tea, etc.) and the timing of their application.
- Incorporate more legumes into cropping systems: some legumes take N from the air and transfer it into the soil in a plant-available form, for the next proceeding crops in the rotation.
- Intercropping can sometimes address N deficiencies: for example, when maize was intercropped with beans in Kenya, the yields of the organic and conventional systems were similar.
- Short-term N availability at critical crop growth stages is essential and can be governed by the application of high-quality organic inputs at the right moment – like flower or fruit formation, depending on the species of crop, as well as mulching fast decomposing shrub material or hoeing at the critical crop stages, like fruit setting.

Local seeds and plants are better adapted

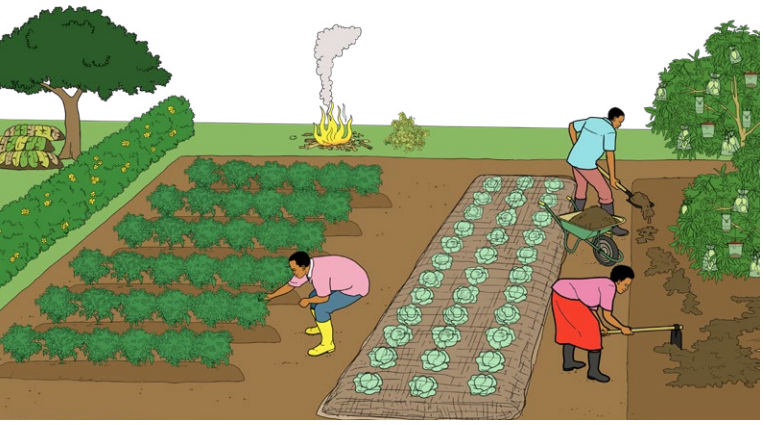
Seeds contain the instructions for how the plant will grow and reproduce (genetic information). This information is constantly adapting. When plants adapt to the local environment they pass on their learnings, via their seeds, to the next generation.

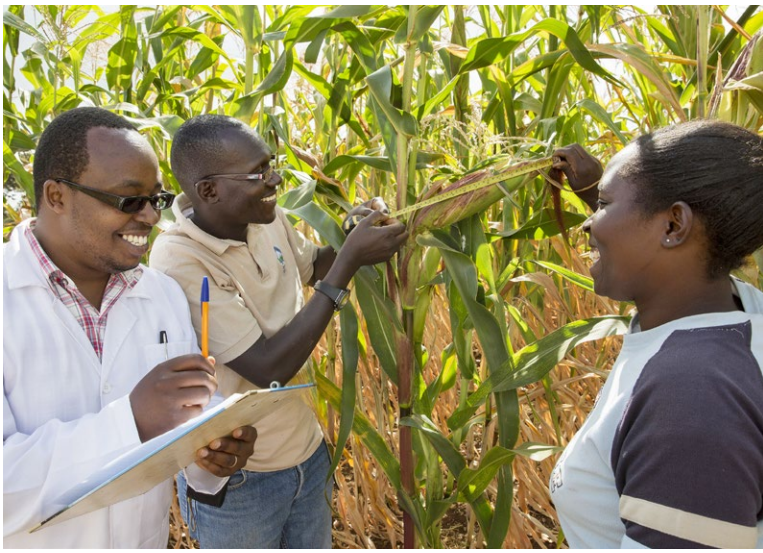
Example from India: desi cotton species, *Gossypium arboreum*, was found to be a better choice for organic farming as it is known for higher genetic diversity than *G. hirsutum*. It is also better adapted to low fertile and rain-fed conditions, drought and has higher pest and disease resistance, and salt tolerance. The only challenge with *G. arboreum* was the short fibre length compared to *G. hirsutum*, which has now been overcome using a participatory plant breeding approach. Here are a few ways to take advantage of plants' diversity on-farm:

- Use healthy, locally adapted seeds and crop varieties, ideally organically produced, as they are better suited for the environmental conditions on an organic farm.
- Select mature, good quality seeds and store in ideal conditions to maintain viability.

Prevent pest and disease attacks

Integrating pest and disease management into your system is key to reducing yield and quality loss. Some practices include: scouting plants early, planting pest repelling (push) and pest attracting (pull) non-crop plants (to trap the pests), using physical barriers to keep pests out, removing host plants and properly disposing infected plants, i.e., by burning them. The organic approach to pest and disease management is outlined in the 'Pest and disease' factsheet > Link





Plan, learn and experiment

It is important to plan your farm to include: plants with complementary nutrient use, legumes in the crop rotation, pest and disease prevention, e.g., plants that repel pests and attract beneficial organisms into your field. Here are a few things to keep in mind:

- Establish a flexible plan that allows for experiments – try new techniques, crops and their combination on your farm. This will help to maintain and promote productivity throughout the year.
- Test and adapt farming practices gradually.
- Never stop learning – from other farmers, trainers and online. When farmers are well trained and knowledgeable, they practice organic agriculture actively and have higher yields.
- Stay open to feedback from other farmers, your family, organic agricultural trainers, your community and consumers. In sharing experiences about organic farming with fellow farmers and others, one can also recieve a lot in return.

Cultivate a diversity of crops

Although some monoculture crops can achieve higher yields, more diverse farming systems, like intercropping, agroforestry, etc., can achieve higher total productivity as well as higher diversity of products. In addition, farmers and their environment benefit in many ways. This topic is explained in detail in the following chapter.

What role does crop diversity play in productivity?

Cultivating many crops, and many varieties within each crop, can **increase the overall farm productivity and contribute to improved nutrition and higher incomes**. Higher crop diversity lessens the risk potential of crop loss and damage, i.e., if one crop fails due to drought or is attacked by pests, another may thrive. In this way, higher crop diversity can mean less economic risks for farmers, spreading the risks amongst multiple crops while also distributing the income and harvest over the year.

Additional advantages of a more diverse farm include a healthier, more balanced farming ecosystem, more beneficial organisms that help to manage pest and disease pressures, as well as improved soil health and fertility. By growing a high diversity of crops and not using herbicides and pesticides, farmers can support a more balanced community of beneficial organisms, both above and below ground. This can help reduce pest and disease damage, increasing the quality and quantity of marketable goods.

In the following section, some practices which increase crop diversity are highlighted.

Intercropping systems

Intercropping is growing two or more crops at the same time in the same field, plot, etc. Often there is one main crop with more economic or production importance paired with a 'minor crop'. This can produce a higher yield on a given piece of land by making use of resources (nutrients, water, sunlight) that would otherwise not be utilised by a single crop.

Plants in the legume family promote growth in nearby plants with their ability to fix nitrogen and make it available for plants. Other plant combinations suppress common pests or weeds – crop combinations should be practised in order to maximise benefits and minimise negative interactions.

Push-pull is an intercropping technique that acts to control pests by using 'push' plants, which repel pests, and 'pull' plants which trap them. Examples from the research which showed reduced pest infestation, include:

1) **Coriander and cabbage:** Coriander is a 'push' plant, repelling problem cabbage pests, while attracting beneficials and pushing out weeds.
2) **Desmodium and maize:** Desmodium is a legume and a 'push' plant, when planted in between the rows of maize it repels pests, e.g., stemborer. As a ground cover, it reduces weeds, while fixing nitrogen in the soil for the maize. Desmodium can also be used as fodder.

What is crop diversity?

This term refers to the diversity of:

- different crops on the same plot, field or farm: e.g., planting beans, bananas, cotton, maize, carrots, tomatoes, lettuce, etc.
- different varieties of one crop: e.g., planting many types of beans.

As well as:

- in space: e.g., intercropping, different crops on different plots of land.
- in time: e.g., crop rotations.

Cacao-based agroforestry systems

Complex agroforestry systems combine many different plants. For example, in the SysCom Bolivia plots, cacao is combined with fruit and timber trees, as well as local palm trees and other crops in the under-storey. This combination is more efficient in both energy use and total productivity.

The prunings from shade trees provide biomass to feed the soil and wood for the household and other purposes. In the long-term, additional income can be generated from timber trees – if the legal situation for timber harvesting in your region allows.

Although monocultures produce higher cocoa yields, the total system yields of all harvested products were three to four times higher in agroforestry systems compared to monocultures (this includes the main cocoa crop but also bananas, other fruits, coffee and tubers). With good management, including regular pruning of shade trees, cocoa yields in mature organic agroforestry systems in Bolivia reached 800–900 kg/ha of dry cocoa beans, even with a very high density of shade trees (300–800/ha).

Opportunities and challenges with selected crops in organic production

If an active, system-oriented ecological approach is taken, organic best practices are used and site-specific characteristics are taken into consideration, i.e. soil type, rainfall, season, etc., organic yields can match or exceed those seen on conventional farms.

In the research projects we observed some crop and seasonal yield differences. In annual crops, productivity in organic systems was primarily limited by nutrient availability and pest and disease pressure compared to conventional crops within the same region. Therefore, the biggest factor for success was taking an active, systems approach which uses sufficient amounts of high-quality, organic inputs, e.g., compost, and prevents pest and disease attacks before they exceed a critical threshold.

Here, some examples are provided of crops studied in the two projects and what was learned, highlighting trends found regarding yields, production challenges and successes.

Legumes

Legumes (e.g., soybeans, common beans, peas) often achieve similar yields in organic farming systems compared to conventional. This is due to their root nodules which enable them to convert nitrogen from the air into a form used by plants. These crops do not depend much on external nitrogen and receive other important nutrients, e.g., phosphorus and potassium, from manures.

Some examples of leguminous crops that performed well include: soybeans, common beans, pigeon pea and cowpea. The bean yield dependent on the variety used: dry beans (harvested when fully mature) were able to achieve similar yields, whereas green beans (harvested when the pods are still green) yielded 40% lower in organic, due to pest and disease pressure – this yield gap was reduced to near zero with the system approach.

Cereals

Cereals (e.g., maize, wheat) yields can be negatively affected when the nutrient availability does not meet the crop demand at crucial growth stages. Application of correct amounts of organic inputs at the right time is necessary to improve organic crop yields – this needs experimentation. It is also important to ensure that soils are well managed to improve and/or maintain good fertility and overall health, as this helps to assure good cereal crop growth, yield and quality.

SysCom India showed that wheat yields in a cotton-cereal rotation were, on average, 20% lower in organic systems. This yield gap in wheat can be explained by the fact that modern high-yielding varieties have high nitrogen demands during certain crucial crop growth stages. Yield gaps are, therefore, associated with insufficient nitrogen supply from organic manures at key crop growth stages. Such deficiencies can be partially addressed by intercropping and well-planned crop rotations. A successful intercropping example from Kenya in organic cereal production: combining maize and beans (harvested when fully mature). This system showed a total yield advantage compared to conventionally produced, sole-cropped maize.

However, return on investment calculations revealed that in monetary terms, every unit invested in organic wheat earned much higher returns than in conventional, without organic price premium. The main reason was the lower cost of production in organic systems compared to conventional.

In SysCom India, chickpea, a leguminous plant, was later chosen as a replacement for wheat in the crop rotation, as it has a higher market value and lower nitrogen demand.

Agroforestry products

Agroforestry systems have higher total yields of all harvested products (e.g., cocoa, plantain, banana, other fruits, cereals, tuber crops, etc.) compared to monocultures, resulting in a substantially higher nutritional output.

Cacao pest and disease management consists of removing infested pods regularly at harvest and every 15 days in both organic and conventional systems. In mature systems weeds are reduced to a minimum by shade and litter and no direct control biorationals are used. The cocoa and by-crops production in agroforestry systems does not seem to rely on external fertiliser, as yields of all crops were equal in conventional and organic systems, even when organic fertilisation was reduced. This is due to the high recycling of nutrients from the prunings of shade trees.

Although cocoa is the main cash crop in SysCom Bolivia, the seasonal availability of diverse, nutritious food products is crucial for local nutrition and food security and can add to the family income depending on the market situation.

In a ProEcoAfrica case study in Kirinyaga, Kenya, coffee and macadamia nuts yielded higher on organically-managed farms than those under conventional management.

Vegetables

Vegetables in the Brassica family (e.g., cabbages, kales, broccoli) and potatoes have high nutrient demands and yields can be negatively affected when the nutrient availability does not meet the crop demand at crucial growth stages, or if pests are not efficiently prevented or controlled.

These crops showed 40 to 60% lower yields in organically managed systems compared to conventional. This yield gap is also because the recommended dosage for most biorationals, e.g., organic pesticides, on the market was not effective in preventing high pests and diseases incidences.

Pests and diseases can severely reduce yields in organic systems (e.g., in vegetables) especially if organic systems try to mimic conventional methods and only substitute conventional pesticides with biorationals.

Mitigating losses and damages from pest and disease pressure in these crops is crucial. Read more about integrated pest and disease management and practices which prevent these outbreaks in the 'Pest and disease' factsheet > Link.

In the SysCom project in Kenya, innovative ways to control the pests and diseases, and assure good plant nutrition, are now being applied and are resulting in higher cabbage and potato yields, thereby reducing the yield gap between organic and conventional. The innovations include the use of resistant varieties, companion cropping, use of sticky traps, applications of biorationals, like botanicals, at the right amount and time, adequate amount and right time of nutrient application.

Baby corn

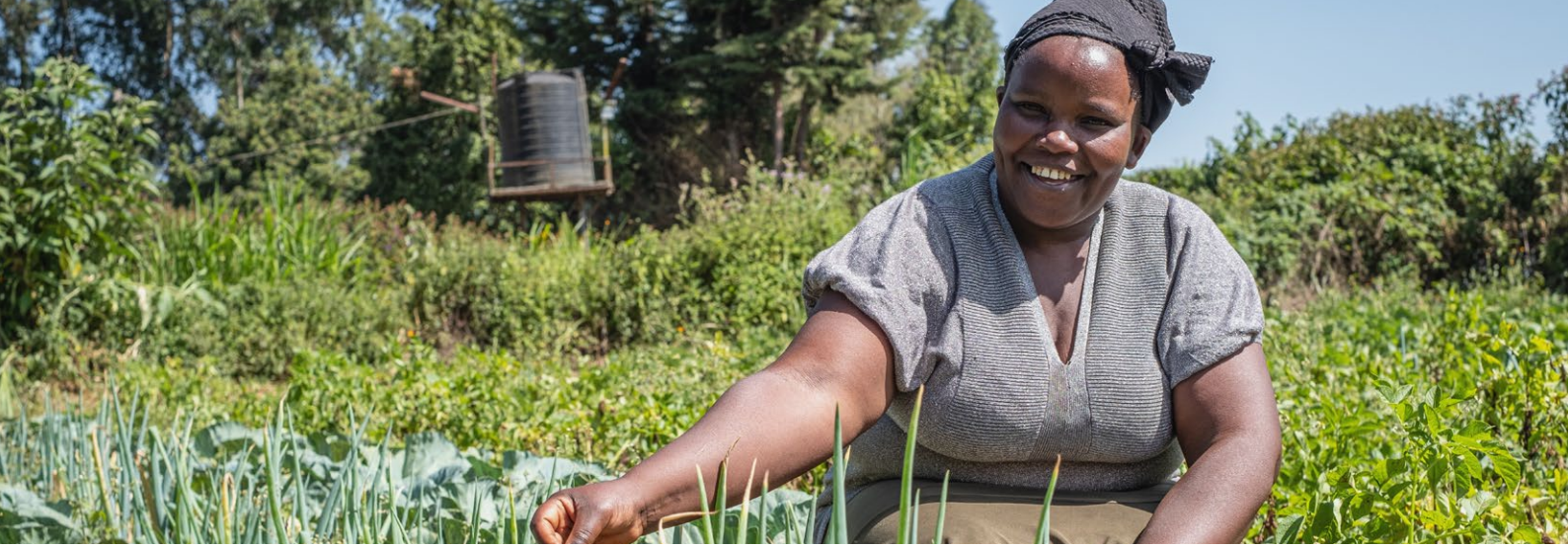
From the SysCom trails in Kenya, six years of comparative cultivation at two sites found similar yields of baby corn in organic and conventional.

In East Africa, the incidence of plant-parasitic nematodes (PPN) and other soil pathogens is high, which consequently affects crop productivity on smallholder farms. Our findings demonstrated that abundance of PPN was significantly reduced in the organic system where the ecological system-approach was implemented, e.g., using organic best practices and neem cake powder as a control measure. The findings demonstrated the resilience of organic production systems against PPN at the farm level.

Cotton

Cotton has high nutrient demands and high pest pressure from bollworms. The on-station long-term trials in India showed on average 20% lower yield in organic cotton compared to conventional. Bollworms can also be a challenge for farmers causing substantial damage to cotton yields in organic production – 'best bet practices' and biorationals for holistic pest management are being tested. Refer to the leaflet series: 'Preparation and Application of self-made organic pest control products' > Link for more detailed information on biorational preparation.

However, similar to wheat, return on investment calculations revealed that in monetary terms, every unit invested in organic cotton earned much higher returns than in conventional systems – with the organic price premium.



Further information

- Complimentary knowledge products, e.g., a poster, powerpoint, video about farm productivity on ecological organic farms > Link
- Further knowledge products, e.g., posters, videos and more, in the series cover topics such as: the ecological approach, pest and disease, soil, profitability and biodiversity > Link
- Leaflet series: 'Preparation and Application of self-made organic pest control products' Mandloi, L. et al. 2014 > Link
- African Organic Agriculture Training Manual Module 9: Crop Management, written by various authors according to crop (2011): The materials provide specific information on the management of selected crops, describe crop-specific measures related to plant nutrition, pest, and disease and weed management, harvesting and storage. Some materials were developed for specific African countries > Link
- What is the contribution of organic agriculture to sustainable development?, Bhullar (2021): A synthesis of twelve years (2007–2019) of the 'long-term farming systems comparisons in the tropics (SysCom)' The SysCom team published a first report which synthesises the scientific findings of SysCom. The report is presented in a form that is easy to understand for an 'educated non-expert' audience > Link
- Infonet Biovision: What is Organic Agriculture: 6. Organic agriculture and food security. This webpage explains the key benefits of organic agriculture in relation to food security > Link
- Infonet Biovision: Intercropping and Push-Pull This webpage contains various types of intercropping as well as push pull innovation > Link
- Living in abundance – encounters with agroforestry video: different actors share their experiences from the Alto Beni region and demonstrate that agroforestry systems are a real alternative to conventional agriculture with the use of agrochemicals > Link

Imprint

This factsheet is a part of a series of knowledge products created within the KCOA project, analysing the outcomes of the SysCom and ProEcoAfrica projects. For further information on these projects refer to the corresponding project brief > Link

The purpose of this series is to educate African farmers and advisors on research results related to organic farming

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