Agroforestry coffee cultivation in combination with mulching, trenches and organic composting in Uganda

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Summary

This technology describes a combination of good practices for soil and water conservation that were introduced to coffee farmers in the central cattle corridor of Uganda, with aim to enhance their resilience to dry spells, pests and diseases, as part of the Global Climate Change Alliance (GCCA) project on Agriculture Adaptation to Climate Change in Uganda.

The concepts of mulching, trenches, organic compost and planting shade trees are briefly introduced. Additionally a cost-benefit analysis of the combination of the four good practices compared to normal practices are presented.

Description

1. Soil and water conservation practices

- Mulching is a low-cost practice that consists in covering the soil with locally available degradable plant materials to reduce water runoff and evapotranspiration.
- Contour trench digging for harvesting water during the rainy season while preserving soil quantity.
- Preparation and application of organic compost to improve soil fertility at low costs.
- Planting shade trees within the coffee plantation in order to provide shade and improve soil fertility.

1.1 Coffee cultivation

Temperature and rainfall conditions are two of the main determinants of coffee yield. According to a USAID vulnerability study published in 2013, the optimum temperature range for Arabica is somewhere between 18 °C and 23 °C. Higher temperatures have a negative impact on both yield and quality.

Above 23°C, the development and ripening of cherries are accelerated, often leading to loss of quality. Continuous exposure to daily temperatures as high as 30°C could result not only in reduced growth but also in abnormalities such as yellowing of leaves.

1.2 Mulching

Mulch is defined as any material applied to the soil surface as cover. Mulching is a low-cost practice that consists in covering the soil with locally available degradable plant materials to help the soil-crop system to reduce water runoff and evapotranspiration, as well as for the mineralization of organic matter, while counteracting the nutrient loss.

1.2.1 Socio economic benefits of mulching

- Conserve soil moisture, and therefore reduce effects of rainfall variabilities and droughts.
- Improve soil fertility and health.
- Help reduce direct raindrop impact and reduce soil erosion, for instance in case of intense rainfall.
- Slow water evaporation.
- Prevents weeds from emerging.
- Improve organic matter content and soil nutrient status
- Provide a beneficial environment for soil organisms, such as worms and millipedes that are important for biological tillage.
- Regulate the temperature during warmer and colder seasons.

1.2.2 Cost

Usually organic matter for mulching is available on the farm as it mostly consists of crop residues.

Mulching therefore only involves some labour to cut and bring the crop residues to the soil, but no additional costs to buy the mulch itself.

1.2.3 Side effects

Organic mulches decompose over time, improving soil structure and quality, and returning nutrients to the soil. Increased amounts of organic matter will improve soil tilth and drainage; increase soil moisture retention; reduce soil compaction and attract earthworms.

Since organic mulches decompose, they need to be replaced. Depending on the type of mulch used, replacement intervals vary from one to four years.

1.2.4 Major Barriers

Organic mulching requires access to some crop residues, compost, grass, animal manure or leaves.

1.2.5 General Recommendations

The general recommendation is to have a mulching depth of two to four inches (5 to 10 cm). Mulch should be kept at a minimum of 20 cm away from the trunk of the plant.

This space will allow for air circulation around the base of the plant and help avoid potential disease problems that can arise from excessive moisture against the trunk.

1.2.6 Synergies with other good practices are:

- cover crops;
- minimum tillage;
- improved varieties; and
- organic fertilizers.

1.3 Trenches

Trenches are dug along the contours of the plantation, with the aim of harvesting water during the rainy season. By keeping harvested water around the agricultural land infiltration and soil moisture are enhanced.

In addition trenches slow down rainwater runoff and as a consequence soil moisture is improved and soil quality is preserved. This technique is particularly useful in areas where rainfall is spars, and their applicability fits all kinds of soils and rain conditions.

1.3.1 Socio - economic benefits of trenches are:

- harvested water;
- prevention of soil degradation and erosion, hence,

preserving soil quality; and
- enhanced surface water infiltration

Figure 1. Trenches along a coffee plantation

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1.3.2 Cost

This technique only involves labour (depending on the soil conditions) to dig the trenches along the contours of the plantation. This could be the most expensive input in addition to the cost of basic construction materials for digging the trenches.

1.3.3 Side effects

No side effects were identified regarding the use the trenches.

1.3.4 Major barriers are that:

- work is required from farmers to dig and maintain the trenches;
- and less land might be available for cultivation.

1.3.5 General Recommendations

Sediments should be removed from the trenches and reapplied to the field.

1.3.6 Synergies with other good practices are:

- mulching;
- cover crops;
- minimum tillage;
- improved varieties;
- organic fertilizers; and
- agroforestry.

1.4 Organic Composting

Compost is decomposed organic matter, such as crop residues and/or animal manure. Composting contributes to soil fertility and soil structure in the long term due to the increase of organic matter content of the soil. Adding compost to sandy soils increases the water retention capacity. This means that water remains longer in the soil and thus remains available to plants for a longer time in periods of drought.

Compost is an organic fertilizer that can be made on the farm at very low cost, since most of its ingredients (natural materials of either plant or animal origin, including livestock manure, green manures, crop residues, household waste and woodland litter) can be easily found around the farm, being the farmer's labour the most important input.

1.4.1 Socio-economic benefits of organic composting

Continued use of organic fertilizers results in increased soil organic matter, reduced erosion, better water infiltration and aeration, higher soil biological activity as the materials decompose in soil, and increased yields after the year of application. Crops with fertilizer application perform better (better yields) than the plots with inorganic fertilizers. During production of compost manure, large amounts of vegetation such as crop remains, garden weeds, kitchen and household waste, hedge cuttings, and garbage are put to good use.

1.4.2 Benefits

- When properly made, compost is immediately available as plant food.
- Compost does not cause excessive weed growth.
- Good crop yields can be obtained without the need for extra chemical inputs.
- All farmers regardless of their financial abilities, can make and use compost.
- Compost manure can be used in all soils with low fertility.
- Compost manure is especially good in areas that receive low rainfall. In such areas, artificial fertilizers cannot be used effectively because of limited moisture. In addition, compost will maintain soil moisture, which artificial fertilizers do not do.
- Compost manure is also useful in sandy soils which have poor water holding capacity.

1.4.3 Cost

Compost is made or bought by farmers. They are usually available on or near the farm at very little or no cost other than labour costs of handling, transportation, or opportunity costs of land used for their production.

Estimating the cost of the technology can be difficult because most of the necessary resources are found within the farm. Labour for constructing compost pits is the most expensive input. Depending on the size, it can be estimated to be equivalent to one person working for a day. Collecting organic material and then applying the compost constitute the additional costs.

1.4.4 Side effects

No side effects were identified regarding the use organic fertilizers.

1.4.5 Major Barriers

It requires work from farmers to create their own compost, prior to its application to the field.

1.4.6 Organic composting limitations

- Composting is labour intensive and requires a lot of organic materials. Some have to be gotten outside the farm.
- The outputs of using compost are not immediate, results appear only after some seasons and it requires some labour. Farmers see immediate results with inorganic fertilizers, but these have adverse impacts at the difference of organic ones. The challenge is to teach farmers to be patient and consistently use compost for six years without switching if they don’t see immediate results. The challenge is to teach farmers to be patient and consistently use compost for six years without switching if they don’t see immediate results.

1.4.7 General recommendations

- If the quantity of organic fertilizer is limited, it may be banded along furrows or spot applied, but the seed needs to be placed away from the fertilizer.
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1.4.8 Synergies with other good practices are:

- improved varieties;
- mulching;

- minimum tillage; and
- cover crops.

1.5 Agroforestry

Agroforestry is the mixture of trees and crops in cultivated parcels. It increases land productivity and offers at the same time many environmental services. According to some studies, agroforestry induces a significant increase in productivity, far better than any other innovation introduced by agronomists in the recent past.

One adaptation measure consists of producing coffee under agroforestry systems or shade grown systems. In Uganda, the typical agroforestry systems developed is the intercropping with banana trees. Agroforestry species such as *Ficus natelensis*, *Ficus sur* and *Maesopsis eminii* may also be used with Arabica coffee in Uganda to provide shade and improve soil fertility.

Current agricultural development programs in Uganda support access to fertilizers and pesticides, which can have beneficial effects on crops yields and productivity in the short term but contribute to soil degradation in the long term. Agroforestry on the contrary not only increases yields but can also restore soil fertility though the use of nitrogen fixing species.

1.5.1 Socio-economic benefits of agroforestry

Agroforestry systems offer many advantages (economic and ecological benefits):

- Fewer inputs required.
- Timber and firewood production improve coffee farmers' income when agroforestry is practiced with the use of nitrogen fixing trees.
- The trees can also provide fodder for livestock and bark cloth which can be used domestically or sold to supplement household income. By spreading income over several crops, these systems are economically less risky than coffee monocultures.
- The erosion of fragile mountain soils is reduced (i.e. the canopy intercepts raindrops, reducing the erosive impact on the soil below).
- Trees act as wind breaks.
- Exploitation of natural forest reserves is limited.
- Shade trees create a microclimate propitious to quality coffee production.
- A smaller crop on coffee trees and an extension of the cherry ripening period are propitious to better quality coffee.

The use of this method allows farmers to create more suitable areas to grow Arabica coffee. The effects of the agroforestry, by providing shade for instance, can reduce temperature variation and can be an adequate option to reduce vulnerability to expected climate change, as shade trees can reduce temperatures in the coffee canopy by 2 to 3°C and can even buffer high and low temperature extremes by up to 5°C.

Coffee also requires adequate moisture in terms of both rainfall and relative humidity. Shade from the trees helps reduce potential evapotranspiration by modifying solar radiation, which increases potential suitable land for Arabica coffee.

1.5.2 Cost

The economists from World Agroforestry Centre have estimated the cost of training and equipping one farm family to practice agroforestry to be about USD 2.5.

The costs associated to the production of Arabica coffee are as follows:

- Producers grow the SL14, SL35 and KP28 Arabica varieties.
- Purchase of shade tree seedlings.
- Each coffee seedling costs around UGX 300 and households plant at an average density of about 500 trees per acre.
- Coffee is sold between UGX 2 200 and UGX 5 500 per kg.

1.5.3 Side effects

Under good management, modest shading (<40 percent) does not appear to have any negative impact on yield.

1.5.4 Major Barriers

One barrier to upscaling agroforestry lies in the lack of tree seed supply for nitrogen fixing trees. Even though there is a demand for seeds from farmers, they are often unable to obtain them because of costs or inadequate supply.

This barrier reduces the potential expansion of agroforestry systems. A reliable seed supply and distribution system on a much greater scale is required to increase adoption of agroforestry practices.

1.5.5 General recommendations

- Agroforestry can be potentiated with the use of improved crop varieties and intercropping.
- Demonstration of agroforestry's effects is particularly important to show this method to potential farmers.

1.5.6 Synergies with other good practices are:

- mulching;
- trenches;
- organic composting; and
- intercropping.

2. Benefits

2.1 Climate change adaptation related benefits

The combination of mulching, trenches, organic composting and shade trees can reduce the negative impact of prolonged dry periods on coffee production.

Therefore, the production of a vulnerable crop, such as Arabica coffee, would be better adapted to climate change effects after the adoption of this set of good practices.

2.2 Economical benefits

Cost-Benefit Analyses were conducted based on quantitative data collected during the monitoring period in the 2016 dry season (June to August).

The monitoring was done in farms that have been implementing mulching, trenches, organic composting and shade trees since two to seven years. Annual coffee production is considered, including two harvests of coffee per year. Data collected from good practice plots were compared with data collected from control plots within the same farms.

Figure 2 shows that, in dry spell conditions, coffee cultivation with mulching, trenches, organic composting and shade trees brings returns 14 percent higher than coffee cultivation without any soil and water conservation (SWC) practice. The benefit-cost ratio of the local practice is higher than the BCR of the good practice.

This is due to the higher capital and running costs involved with the implementation of the good practice. In particular, the good practice requires additional labour and capital costs (i.e. purchase of shade tree seedlings and materials for digging trenches). However, when considering the absolute value of net benefits, the good practice shows a better performance.

Figure 2. “Cumulative Net Benefits and Benefit Cost Ratios of Good Practice and Local Practice ($ per acre per year) 2016 Dry Season (June-August)”

Source: FAO 2017

3. Validation of the practice

3.1 Geographical area of practice validation

Twenty three farms in Kiboga (3), Mubende (1) and Sembabule (19) districts in the central cattle corridor of Uganda.

3.2 Context of implementation

3.2.1 Environmental and climatic context

During the 2016 dry season (June to August), the performance of this good practice package was monitored in 23 farms in Kiboga (3), Mubende (1) and Sembabule (19) districts. All the farms were affected by a dry spell during the monitoring period.

Few farms also experienced strong winds, heavy rains, pests and diseases. Dry spell was the main hazard: rainfall was between 50 to 100 percent below normal in August, and land surface temperatures were 3°C to 7°C above average, causing a reduction in water availability.

3.2.2 Economic (Livelihood strategy) and Social (target group) context

Coffee producers of the central cattle corridor of Uganda.

4. Further reading

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5. Agro-ecological zones

- Tropics, warm

6. Objectives fulfilled by the project

6.1 Resource use efficiency

This technology encourages the use of mulch which can be any locally available degradable plant materials that are otherwise wasted.

6.2 Pro-poor technology

Estimating the cost of the technology can be difficult because most of the necessary resources are found within the farm. For example mulch material is usually available on the farm and does not involve any costs.

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