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

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 the 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 combination of good practices include: (a) mulching, a low cost practice that consists in covering the soil with locally available degradable plant materials to reduce water runoff and evapotranspiration; (b) digging contour trenches for harvesting water during the rainy season while preserving soil quality; (c) preparation and application of organic compost to improve soil fertility at low costs; and (d) planting shade trees within the coffee plantation in order to provide shade and improve soil fertility.

KEYWORDS:
Coffee [1]
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CATEGORY:
Climate change and disaster risk reduction [7]
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COUNTRIES:
Uganda

DESCRIPTION:

1. Description of the application of the technology/practice
This technology describe 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 combination of good practices include:

a) mulching, a low cost practice that consists in covering the soil with locally available degradable plant materials to reduce water runoff and evapotranspiration;

b) digging contour trenches for harvesting water during the rainy season while preserving soil quantity;

c) preparation and application of organic compost to improve soil fertility at low costs; and

d) planting shade trees within the coffee plantation in order to provide shade and improve soil fertility.

This technology briefly introduces the concepts of mulching, trenches, organic compost and planting shade trees and presents a cost-benefit analysis of the combination of the 4 good practices compared to normal practices.

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

Mulching allows to:
(a) Conserve soil moisture, and therefore reduce effects of rainfall variabilities and droughts;
(b) Improve soil fertility and health
(c) Help reduce direct raindrop impact and reduce soil erosion, for instance in case of intense rainfall
(d) Slow water evaporation
(e) Prevents weeds from emerging
(f) Improve organic matter content and soil nutrient status
(g) Provide a beneficial environment for soil organisms, such as worms and millipedes, that are important for biological tillage; and
(h) Regulate the temperature during warmer and colder seasons.

1.2.2 Cost

Usually, organic matters for mulching are available on the farm as they mostly consist in crop residues. Mulching therefore only involves some labor to cut and bring the crop residues on 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. Because 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 2 to 4 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.

1.2.6Synergies with other good practices

(a) Cover crops
(b) Minimum tillage
(c) Improved varieties
(d) Organic fertilizers

1.3 Trenches

Trenches are dug along the contours of the plantation, with the aim of harvesting water during the rainy season and by keeping it 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 sparse, and their applicability fits all kinds of soils and rain conditions.

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Picture1: "Trenches along a coffee plantation"

1.3.1 Socio-economic benefits of trenches

Trenches allow to:
(a) Harvest water
(b) Prevent soil degradation and erosion, hence, preserving soil quality
(c) Enhance surface water infiltration

1.3.2 Cost

This technique only involves labor (depending on the soil conditions) to dig the trenches along the contours of the plantation, which 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

(a) It requires work from farmers to dig and maintain the trenches.
(b) 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

(a) Mulching
(b) Cover crops
(c) Minimum tillage
(d) Improved varieties
(e) Organic fertilizers
(f) 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 labor 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.

Benefits include:
(a) When properly made, compost is immediately available as plant food;
(b) Compost does not cause excessive weed growth;
(c) Good crop yields can be obtained without the need for extra chemical inputs;
(d) All farmers regardless of their financial abilities, can make and use compost;
(e) Compost manure can be used in all soils with low fertility;
(f) 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;
(g) Compost manure is also useful in sandy soils which have poor water holding capacity.

1.4.2 Cost

Compost is made by farmers or bought. They are usually available on or near the farm at very little or no cost other than labor 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. Labor 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.

1.4.3 Side effects

No side effects were identified regarding the use organic fertilizers.

1.4.4 Major Barriers

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

Organic composting limitations are:
(a) Composting is labor intensive and requires a lot of organic materials. Some have to be gotten outside the farm;
(b) The outputs of using compost are not immediate, results appear only after some seasons and it requires some labor. 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.

1.4.5 General Recommendations

(a) 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.

(b) The outputs of using compost are not immediate, results appear only after some seasons and it requires some labor. 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.

1.4.6 Synergies with other good practices

- Improved varieties
- Mulching
- Minimum tillage
- 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.

The actual 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; and
- 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?3°C and can even buffer high and low temperature extremes by up to 5°C (Vaast & van Kanten, 2006).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 US$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 300UGX and households plant at an average density of about 500 trees/acre
- Coffee is sold between 2,200 and 5,500UGX/kg.

1.5.3 Side effects

Under good management, modest shading (<40%) 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 considerably 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 recommendation

- 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

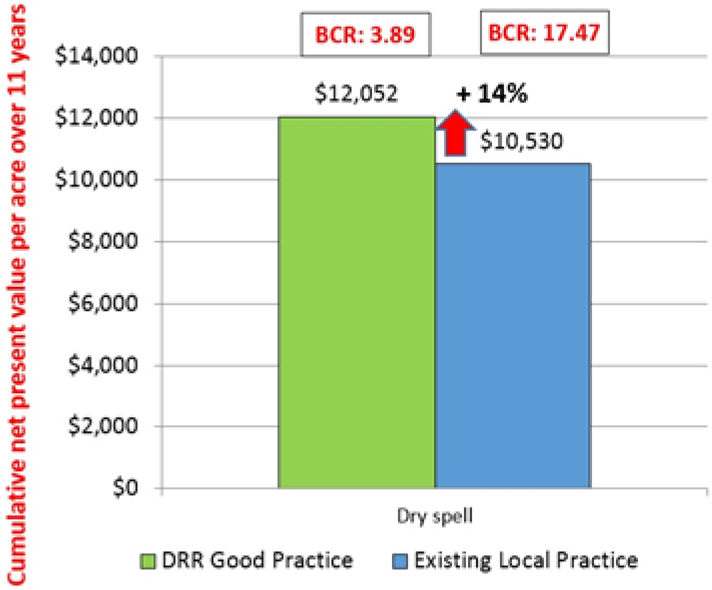
- Mulching
- Trenches
- Organic composting
- Intercropping

2. Benefits

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.

2.1 Economic

Cost-Benefit Analyses were conducted based on quantitative data collected during the monitoring period in the 2016 dry season (Jun-Aug). The monitoring was done in farms that have been implementing mulchingtrenches, organic composting and shade trees since 2 to 7 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. Graph 1 shows that, in dry spell conditions, coffee cultivation with mulching, trenches, organic composting and shade trees brings returns 14% 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 labor 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.



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Graph 1: ?Cumulative Net Benefits and Benefit Cost Ratios of Good Practice and Local Practice ($ per acre per year) 2016 Dry Season (Jun-Aug)"

2.2 Environmental

According to farmers interviewed, soil quality has improved considerably since the implementation of the good practice. Furthermore, the planting of shade trees increases carbon sequestration, contributing to mitigation of climate change. In addition, agroforestry can reduce temperature variation in the plots and can be an adequate option to reduce vulnerability to expected climate change.

FURTHER READING:

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