What is the contribution of organic agriculture to sustainable development?

Long-term farming systems comparisons in the tropics (SysCom)

SysCom Alumni Event - Book of Abstracts


16th of November 2022

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This book of abstract was compiled to showcase the presentations held on the 23rd of August 2022 during the SysCom alumni event in Frick, Switzerland. The presenters were former BSc, MSc, PhD student or interns working in the SysCom trials in Bolivia, India, and Kenya. Further information on SysCom and the presentations can be found on our website: https://systems-comparison.fibl.org/

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Soil Biological Activity and Nutrient mineralization under Long-Term Organic and Conventional Management Practices

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Abstract: In conventional agricultural systems, mineral fertilizers are used to supply nutrients for plant growth, whereas organic systems largely rely on inputs of organic origin. The soils under organic management are supposed to be biologically more active and thus possess a higher capability to mobilize native or applied nutrients in the form of organic matter. In this study, we compared biological activity in soil of a long-term farming systems comparison field trial in vertisols under a subtropical (semi-arid) environment. Soil samples were collected from plots under seven years of organic and conventional management at four different time points in cotton crop sequence, including the crop growth stages of reproductive significance. Upon analysis of various soil biological properties such as dehydrogenase, β-glucosidase, acid and alkaline phosphatase activities, microbial respiration, substrate-induced respiration, soil microbial biomass carbon, and soil indole acetic acid (IAA) production were found to be higher under the organic and biodynamic system as compared to conventional and Bt-cotton system. A similar trend was observed with bacteria, fungi, and actinomycetes populations. Organic carbon content, carbon stock, and Glomalin content were also significantly higher under biodynamic and organic systems than in conventional and Bt-conventional cotton systems.

Keywords: Biological activity, Indole acetic acid, Carbon stock

Phosphorus availability and carrot growth as influenced by phosphate rock management under acid soils in Murang'a and Tharaka-Nithi counties

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Abstract: Soils from the Central Highlands of Kenya are characterized by low phosphorus (P) availability, with crops exhibiting P deficiency symptoms. The study's objective was to determine the P sorption characteristics of the soils and assess their standard P requirements to recommend the P fertilizer required for different crops in the area. Besides, the study aimed at assessing the efficiency of lemon and pineapple juices and the concentration and time needed to release more than 50% of available P from phosphate rock (PR), and the effect of different types of PR management on carrot yields, nutrient uptake, and P-use efficiency. Soils from Murang'a and Tharaka Nithi counties in the central highlands of Kenya fixed substantial amounts of phosphorus, and interventions will be required to reduce phosphorus fixation and enhance its availability to crops. The study identified that the dissolution of phosphate rock with lemon juice at a ratio of 1:5 phosphate rock to lemon juice and its combined application (immediately after dissolution) with compost at planting improves nutrient uptake, phosphorus use efficiency, and crop yields.

Keywords: Phosphorus adsorption, Phosphate rock dissolution, Phosphorus recovery

Impacts of Organic Cotton Production on the Livelihoods of Farmers: A Case Study from Central India

Presenter: Lou Habermann, Landratsamt Traunstein, *loukatrinhabermann@gmail.com*

Co-authors: Eva Goldmann (FiBL) and Gurbir Bhullar (University of Bern)

Abstract: Converting to organic farming systems is often related to numerous benefits for farmers, such as less exposure to toxic chemicals and more stable income. While many projects aim to improve farmers' livelihoods, most studies proving these impacts focus only on ecological or economic impacts. The present study aims to assess the perceived impacts of the bioRe organic cotton project in central India on the livelihood of participating farmers by applying the Sustainable Livelihood Framework. A survey with 45 organic and 45 conventional farmers and two expert interviews were conducted. Differences between the two farmer groups were assessed by using descriptive statistical analysis. The main results show an increase in livelihood capitals. Besides economic and natural assets, such as more stable yields and perceived improved soil fertility, improvements regarding social, human, and physical capital were detected: Organic farmers have a stronger farming network, feel more fulfilled through their farming practice, benefit from more capacity building and perceive their farm equipment as more adequate for the required work. More research is needed to capture the wide range of project impacts and the complexity of understanding wellbeing.

Keywords: Cotton, Sustainable Livelihood Analysis, India

Characteristics of soil nematode communities under organic and conventional farming systems in Kenya

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Abstract: Plant parasitic nematodes (PPN) are biotic constraints resulting in significant yield losses. Their management has primarily depended on chemical nematicides, but alternative methods have been considered due to the increased pressure for more environmentally friendly strategies. Two field trials were conducted for two seasons on maize-bean intercrop and bean sole crop to test the efficacy of conventional and farmer practice systems against an organic system in the suppression of PPN and on the abundance and diversity of free-living nematodes (FLN). A non-amended system was included as a control. The soil was sampled, and nematodes were extracted from 100 ml of soil and 5 g of roots and identified to genus level. Twenty-nine genera belonging to bacterivores, fungivores, omnivores, predators, and PPN were recovered. Bacterivores dominated the organic systems, while PPN prevailed in the non-amended systems. Principle response curves were used to establish the effect of farming systems on individual nematode genera over time, and the organic model showed reduced numbers of the main drivers (all PPN). Overall, significantly lower populations of PPN were recorded in the organic system across all seasons at both sites. We can therefore conclude that organic farming appears to suppress populations of PPN while promoting that of FLN directly.

Keywords: Plant-parasitic nematodes, Free-living nematodes, Nematode diversity

Promoting and Hindering Livelihood Factors on Adoption of novel Farm Management Practices in Kangari, Kenya

Presenter: Sabrina Stoffel, *stoffel.s1990@gmail.com*

Abstract: A household study was conducted in 2018 in Kangari, Kenya. The aims were to describe the household characteristics of farm households, their farm practices, and resources, to detect the distribution of training and the adoption rate, and to analyze the correlation of promoting and hindering livelihood factors on adopting novel farming technologies among Kangari farmers.

Keywords: Household study, Promoting and hindering livelihood factors

Ecological Sustainability of Cotton Farming Systems

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Abstract: Cotton is the most important fiber in the world: it is also the most polluting cash crop in the world. India is responsible for 26% of global cotton production, of which more than 95% is genetically modified Bt-cotton. As well as being a major conventional producer, India is also the largest country producer of organic cotton. Despite this leading role, India has one of the lowest yields per hectare in the world. Its low productivity is attributable to challenges in soil fertility and plant protection. Focusing on the impact of agricultural management on biodiversity is essential to ensure that cotton productivity is ecologically sustainable in the long term. In this study, the functional biodiversity above and below ground was evaluated on plot-scale systems using biodiversity indicators to evaluate the potential ecological sustainability of four cotton farming systems (CFS) practiced in India: conventional, Bt-conventional, organic, and biodynamic. This study has attempted to increase the knowledge of the effect of CFS in tropical climates on biota. The above and below-ground general diversity of species was higher in both organic systems compared to both conventional systems. The long-term comparison study showed that Bt-cotton has no other significant effect on the biota.

Keywords: Sustainability, Ecology, Biodiversity

Microbial Community Diversity, Structure, and Function within Organic and Conventional Farming Systems in Central Highlands of Kenya

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Abstract: Microbial diversity and function in agro-ecosystems is influenced by various aspects linked to soil and agronomic practices, for example, tillage, irrigation, crop rotation, and application of organic and inorganic inputs. Farming systems practices may affect the dynamic interactions between soil, plant, and microorganisms in different agricultural biomes. We have explored the effects of conventional versus organic farming systems on soil microbial diversity and function in the long-term farming system comparison trials at Chuka and Thika in Kenya. Illumina sequencing technology and analysis of 16S rDNA, 16S rRNA cDNA amplicons, fungal ITS, and mRNA transcripts were used to determine the diversity, structure, and function of bacteria, archaea, and fungal communities within farming systems. Conventional systems had a higher species richness and diversity when compared with organic systems. pH, C, N, Zn, Fe, Al, B, and micro-aggregates were the major drivers of microbial diversity within farming systems in both sites. Major metabolic pathways comprised carbohydrates and energy metabolism, biodegradation and metabolism of xenobiotics, and secondary metabolites biosynthesis. This shows that microbes in farming systems utilize diverse carbon sources for survival, as revealed by metabolic processes and genes responsible for specific pathways. These findings indicate that the integration of organic and inorganic inputs affects the soil chemistry, the microbial population dynamics, and their functional roles.

Keywords: Microbial Diversity, Farming systems, Metagenomics, Metatranscriptomic

Exploring Structural Effects due to Planting Design in Cocoa Agroforestry Systems

Presenter: Wiebke Niether, Chair of Organic Farming / Sustainable Soil Use, Justus-Liebig-University Giessen, *wiebke.niether@agrar.uni-giessen.de*

Abstract: Trees in agroforestry systems have above- and below-ground effects on crop production and environmental interactions between species and plants and their living and non-living environment. The system comparison trial in Sara Ana, Alto Beni, Bolivia, is the perfect occasion to study the impact of shade trees on cocoa production and their environmental interactions. The high planting density in agroforestry increased biomass production and, due to the integration of fruit trees, the entire system yield, even though the cocoa yield was lower than in monoculture. Tree crowns also affect the microclimate by buffering climate extremes while also reducing the incoming light and the water input by throughfall. Effective pruning can be a way to modulate these impacts. In addition to the aboveground stratification of shade and cocoa trees, we found a stratification of the roots in different soil depths, increasing the exploration of different soil horizons and the exploitation of resources like water from a greater soil volume, thus decreasing competition. A multidimensional meta-analysis on cocoa agroforestry and monocultures shows their main differences, e.g., their potential to mitigate climate change and to adapt agricultural production, as well as the additional need for further investigation that can be conducted in Sara Ana.

Keywords: Water, Microclimate, Complementarity

The Role of Shade Tree Pruning in Cocoa Agroforestry Systems: Agronomic and Economic Benefits

Presenter: Laura Esche, Wageningen University & Research, *l.esche95@gmail.com*

Co-authors: Monika Schneider (FiBL), Johanna Rüegg (FiBL), Joachim Milz (Ecotop), Ulf Schneidewind (Ecotop) and Laura Armengot (FiBL)

Abstract: Cocoa (*Theobroma cacao*) is commonly produced in full-sun monoculture systems to increase yields in the short term. Nevertheless, cocoa is a suitable crop for production under shaded conditions and is traditionally cultivated in agroforestry systems in Latin America. To ensure productivity and profitability, however, developing best practices for shade management is crucial, but shade tree pruning is not commonly practiced. This study investigates the influence of pruning shade trees in cocoa-based organic agroforestry systems in Bolivia on agronomic and economic performance. Four organic agroforestry farms were selected, where shade trees were not pruned for at least ten years. At each site, half of the plot was kept unpruned, the other half was pruned, and all other management practices were kept equal. Data on yield formation were collected subsequently for two harvesting seasons. The trial results show a significant increase in cocoa yield under pruning conditions ranging compared to unpruned plots. This is attributed to increased flowering and fruit sets in pruned plots. No differences in the incidence of pests and diseases in the pods were found. Different scenarios of yield increase based on local cocoa producers' minimum, average, and maximum yield were used to evaluate whether pruning shows an economic benefit for farmers. Other sources of income, such as by-crops, were not considered in the calculations. For the average yield level of 287.4 kg ha^{-1} (dry), an increase of 51% in two consecutive years will cover the pruning costs. Despite the promising results and indication that the yield increase will last for more than two years, the initial costs of pruning might still discourage farmers. Therefore, financing programs for farmers that support tree pruning are necessary to increase both cocoa production and farmers' income.

Keywords: Cocoa, Pruning, Income

Responses of Soil Organic Carbon and Soil Structure at the SysCom Trial in India

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Abstract: Organic matter management can improve soil structural properties. This is crucial for agricultural soils in tropical regions threatened by high rainfall intensities. Compared to conventional farming, organic farming is usually deemed to increase organic carbon and improve soil structural properties such as stability and permeability. However, soil type and environmental factors determine how much buildup of organic carbon is possible or indeed occurring. We compared the impact of seven years of organic farming (annually 13.6 t ha^{-1} of composted manure) with that of conventional practices (2 t ha^{-1} of farmyard manure with 150-170 kg N ha^{-1} of mineral fertilizers) on soil structural properties. The study was conducted on a Vertisol in India with a two-year crop rotation of cotton, soybean, and wheat. Despite large differences in organic amendment application, organic carbon was not significantly different in the topsoil. However, the size distribution of water-stable aggregates shifted toward more aggregates <137 µm in the organic systems. Cumulative water intake was lower compared to the conventional systems, leading to higher runoff and erosion. These changes might be related to the organic systems' lower pH and higher exchangeable sodium. Our results indicate that higher application of organic amendments did not lead to higher soil organic carbon and associated improvement in soil structure properties compared to integrated fertilization in this study. Chemical properties may dominate soil aggregation retarding the uptake and integration of organic amendments for sustainable agricultural intensification in tropical, semi-arid climates.

Keywords: Soil organic carbon dynamics, Aggregate stability, Rain simulation

Soil microbial communities in organic and conventional farming systems in the tropics

Presenter: Hans-Martin Krause, Research Institute of Organic Agriculture (FiBL), *hans-martin.krause@fibl.org*

Abstract: Soil microbial communities are crucial to maintaining ecosystem functioning, especially in agricultural systems. There are great opportunities to harness these microbial resources to enhance the environmental performance and crop productivity of agricultural systems. Distinct agricultural management practices, such as organic farming systems, were shown to cause shifts in soil microbial diversity in temperate arable farming. Yet, there is a knowledge gap when it comes to tropical systems. To identify the impact of organic farming systems on soil microbial community structure in the tropics, soil sampling campaigns in the SysCom trials were conducted in 2019. Soil microbial community composition was characterized via amplicon sequencing of the bacterial 16S rRNA and fungal ITS genes and correlated with soil quality indicators such as soil organic carbon contents, soil pH, C and N mineralization potential, and abundances of functional genes involved in microbial nitrogen cycling. Results show distinct microbial community composition in organic and conventional farming systems at all field sites. In Bolivia, the fungal community showed a stronger response to different farming systems compared to bacterial communities, and microbial community structure was mainly driven by organic management and, to a lesser extent, by implementing agroforestry systems. Results from Kenya show that for arable farming systems, high input levels were needed to distinguish between organic and conventional farming systems. Soil microbial community structure in the Indian trail shifted in response to farming systems and across the vegetation period. Especially the abundance of bacterial nitrifiers increased during the vegetation period in the conventional system by 2-3 orders of magnitude, indicating excess N and potential N loss. In summary, organic farming systems increase soil quality and shape soil microbial community structure and functional capacity for soil nitrogen cycling in tropical farming systems.

Keywords: Soil microbial community structure, Nitrogen cycling, Soil quality