CocoaSoils

CocoaSoils Gazette

March 2025

New Consortium agreement signed

We are delighted to report that the majority of partners have recommitted to CocoaSoils through the cooperation agreement that runs from January 2023 until December 2027. The partners collectively share the goal to develop Integrated Soil Fertility Management (ISFM) recommendations based on medium- and long-term data from carefully planned and consistently managed core and satellite trials following agreed protocols and resource commitments and to deliver these and other productivity-enhancing recommendations towards the sustainable intensification of cocoa production.

The parties specifically express their intention to cooperate to support and strengthen:

- The establishment and management of research trials.
- The collection and sharing of data in a pre-competitive manner.
- Data analysis and development of recommendations.
- The dissemination of tested and validated recommendations into public and private policies and programs

CocoaSoils Funding

In December 2024, NORAD indicated continuing but limited support for CocoaSoils. We are delighted to announce some personal grants in contribution to the program: Lotte Woittiez – personal funding from WUR for mineral nutrition research and Marieke Sassen, Senior Expert Program Grant from The Netherlands (NL)- CGIAR research programme, for further research on biodiversity-yield interactions in cocoa (and coffee).

We are applying for additional funds for activities beyond the maintenance of the current trials, including additional data collection and analysis, building the data infrastructure. Additional measurements on cocoa tree phenological developments are needed to assess the effects of climate change and contribute to tree crop modelling. There is also need for support to develop Platforms for Advancing Agronomic Solutions at Scale

(PAAS), Agronomy Science Scaling and Acceleration Platform (ASSAP) for Cocoa in West Africa. The ASSAPs will be on-stop shop for cocoa agronomy information and decision support.

Read more: https://cgspace.cgiar.org/server/api/core/bitstreams/89e1ced1-1a39-4645-ac1d-d101892dc917/content

New Team Member

We welcome Dr. Urcil Kenfack Essougong, Science of Scaling and Impact expert who joined CocoaSoils in June 2024. Urcil is no stranger to CocoaSoils which funded his PhD at Wageningen University in agricultural innovation system and services delivery for Sustainable Cocoa Intensification. His main role in CocoaSoils is to provide scientific advice for the co-development, mapping, validation and dissemination of the STEPWISE decision support tool for scaling new cocoa fertilizer recommendations and good agronomic practices. He supports the CocoaSoils coordination unit and oversees the implementation of CocoaSoils trials in Ivory Coast where he is based. He will also facilitate the ASSAP for Perennials in West and Central Africa.

Departure of Team Members

Dr. Robert Asiedu – Program Coordinator, has retired and therefore left CocoaSoils at the end of December 2024. Reginald Kyere – Communications Officer and Abigail Tettey- Research Associate have both left to pursue further studies abroad. Rich Kofi Kofituo our MEL Research Associate, was appointed in February 2025 by the President of Ghana, H.E. John Dramani Mahama as Deputy Chief Executive Officer of the Tree Crop Development Authority. These colleagues made significant contributions to CocoaSoils, and we are grateful for their dedication and hard work during their time with the Program.

Review of status of the Satellite Trials

In Q4 of 2024, we began a review of the status and purposes of Satellite Trials, led by Dr. Urcil Kenfack Essougong. The main objective of the review is to assess the current functioning and management of the Satellite Trials (ST) and discuss how to consolidate the progress and achievements so far. In the field, the current management intensity of the Satellite Trials was assessed, noting occurrence of pests and diseases, and human resources available for the required tasks. Finally, we assessed the challenges encountered during field operations, and impact on data completeness, quality, and timeliness of collection.

Preliminary results suggest that treatments and data collection in some farms may need to be put on hold, in consultation with partners, if the following conditions are noted:

- Severe pest and disease infestation,
- Presence of CSSV symptoms on or near the farm,
- Insufficient or no farmer cooperation, farmer disinterest,
- General poor farm management,
- A significant number of cocoa trees lost from experimental plots
- Increased differences in cocoa tree numbers per treatment due to uneven die back.

The farmers hosting the STs were also surveyed. 99% of respondents noticed a difference in cocoa yields between plots with and without fertiliser. 96% of the latter stated that the plots with fertiliser had the best yields. Of these, 85% noticed a difference in the effect of the national and nutrient offtake model recommendations. 64% identified the plots receiving the nutrient off take model recommendations as the most productive. Despite some signs of apparent farmer disinterest, 97% of farmers stated that they are willing to continue to host STs and 78% are willing to contribute labour or money to maintain the STs.

A comprehensive report on the Satellite Trial review will soon be shared with all partners.

Taking stock of CT's - visits and current status.

At the end of February 2025, Dr. Leonard Rusinamhodzi and Dr. Joseph Eduah from CRIG visited the Core trials at Mambang and Buako in Ghana as part of Dr. Eduah's familiarization with the trials and field sites. Dr. Eduah was named recently as the new CT manager in Ghana to replace Dr. Amos Quaye who was assigned to another department within CRIG. Despite the challenges associated with the dry season both field experiments were observed to be in excellent condition. Pruning is urgently needed at Buako and a specialized team from the Seed Production Department of CRIG will accomplish this task.

Left: Three year old cocoa trees (clonal material) at Buako, and right: Five-year-old trees at Mabang [February 2025]

Together with partners, CocoaSoils research associates in Ghana, Cameroon, Nigeria and Côte d'Ivoire paid visits to the eight Core Trials run by CocoaSoils in Cameroon (1), Nigeria (2). Ghana (2), and Côte d'Ivoire (3). They are largely in good shape and have all entered into at least one production cycle. The main challenges observed are related to the replacement of dead trees and irrigation. In addition to these common challenges, the Cameroon Core Trial needs to be pruned urgently.

Nkoemvone CocoaSoils core trial in 2024

Insights from data collected in ST and CT

The WUR team are currently doing a full analysis of the Satellite Trial data (lead: Ekatherina Vasquez-Zambrano) and the Core Trial data (lead: Arun Pratihast and Lotte Woittiez). We aim to present the first round of results in April/May 2025.

In the paper of Vasquez-Zambrano et al. (2025), which describes the cocoa off-take model for calculating nutrient requirements, the first published analysis of the Satellite Trial data is presented (see below). The results, which are based on one full year's yield data, clearly suggest that the balance of nutrients recommended using the off-take model better matches the nutrient needs of cocoa and provides significant increases in cocoa yield compared with current fertilizer recommendations in West and Central Africa.

Updates on the CocoaSoils Database

The CocoaSoils database has evolved into a living dataset with >10,000 data points containing pictures, yield records,

vegetative growth variables, and biodiversity data (https://cocoasoils.containers.wur.nl/).

The database has already seen applications beyond the CocoaSoils project, including:

a) Land Suitability Assessment for Climate Adaptation

The data from the CocoaSoils project, combined with climate datasets, has been used to train AI and machine learning models to predict land suitability for cocoa production under changing climate conditions. This analysis focuses on the four major cocoa-producing countries in Africa: Ghana, Cameroon, Nigeria, and Côte d'Ivoire, providing insights for sustainable land-use planning and climate adaptation strategies.

b) *European Union Deforestation Regulation (EUDR) Compliance*

Ground truth data is crucial for verifying compliance with the European Union Deforestation Regulation (EUDR). Using our cocoa datasets, we have developed more accurate cocoa maps from satellite imagery and validated them through on-the-ground verification, ensuring the integrity of deforestation-free supply chains.

Read more: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4958236

c) Integration with Upcoming ESA Carbon and Biomass Missions

Within CocoaSoils, we have collected data on tree height and diameter at breast height (DBH), which allows us to accurately estimate biomass on the ground. This data can be used to calibrate and validate the upcoming ESA Biomass mission, enhancing the accuracy of biomass and carbon stock measurements from satellite observations.

Cocoa pod-counting using AI

AI-powered image analysis, integrated with geo-tagged field data, enables automated cocoa pod counting, improving yield estimation accuracy. These technologies enhance productivity by providing real-time insights into cocoa pod growth and supporting precision interventions that optimize farming practices for smallholder farmers. A smart-phone app that allows automatic counting of cocoa pods has been further developed and was presented at the FREE/Libre AND OPEN SOURCE SOFTWARE FOR GEOINFORMATICS conference in Seoul (see FOSS4G Asia 2023 Talk). Users can log in and test with their own datasets, either via the web or the mobile app by downloading the app from https://hilo.wur.nl

The service has been tested with farmers in Cameroon. The report is freely available at: https://doi.org/10.18174/686412.

We hope you will download and use the app – please send feedback to Arun.Pratihast@wur.nl

Publications

The off-take model for deriving fertilizer recommendations for cocoa

Cocoa production in West Africa has increased over the years, yet yields are stagnant due to factors such as limited fertiliser use, poor maintenance, and inadequate pest control. The existing knowledge on cocoa mineral nutrition is limited, with outdated and inconsistent fertiliser recommendations across countries and regions. This study aimed to develop and describe a cocoa N, P, K offtake model based on nutrient export (pods and beans) and immobilisation in the tree. The model was used to calculate fertiliser rates for a series of 195 on-farm trials in Côte d'Ivoire, Ghana, Nigeria, and Cameroon. We compare the cocoa yields in response to fertiliser rates derived using the offtake model with the response to national recommendations in each country. On each farm, four treatment plots were delineated. The treatments were: T1 = current farmer practice, T2 = weeding + pruning + insecticide application + fungicide application (no fertiliser application), T3 = weeding + pruning + insecticide application + fungicide application + current national fertiliser recommendation, and T4 = weeding + pruning + insecticide application + fungicide application + offtake model-based fertiliser recommendation. Yields were recorded from September 2021 to August 2022 and an economic assessment was conducted using two different scenario prices for the years 2020/2021 and 2022/2023. Our results showed a positive effect of fertiliser on cocoa yield wherein T3 (1109 kg ha^{-1}) and T4 (1227 kg ha^{-1}) had significantly higher yields than T1 (912 kg ha^{-1}) and T2 (917 kg ha^{-1}). A positive overall yield effect of T4 over T3 was also observed; however, the difference was significant only in Côte d'Ivoire. The economic assessment showed that the treatment based on the offtake model (T4) gave a higher gross return than the national recommendations (T3) in all countries. However, the benefits decreased from 20/21–22/23 due to an increase in fertiliser prices. Our findings show that using an offtake model approach could provide a more accurate approximation of cocoa's nutrient needs. Nonetheless, while the cocoa farm-gate price remains low, the investment capacity of the farmers to purchase fertiliser will remain limited.

Read in full here: https://www.sciencedirect.com/science/article/pii/S1161030124003848

Climate change impacts on cocoa production

Climate change could significantly affect cocoa production in West and Central Africa, an area that produces over 70% of the world's cocoa. Climate change impacts are raising serious concerns throughout the cocoa sector and are spurring spikes in cocoa prices. Using a crop model, we analyzed how projected changes in temperature, precipitation, and atmospheric carbon dioxide (CO2) concentration might impact cocoa tree growth and yield by 2060. While higher CO2 levels and wetter dry seasons are expected to boost yields in many areas, the effects will vary regionally. On the contrary, if the dry season becomes drier, yields will decrease. Under conditions with wetter dry seasons, countries to the East (e.g., Cameroon) are likely to see increased yields and more suitable cocoa-growing areas, while to the West, countries (e.g., Côte d'Ivoire) may face declines. The importance of closing yield gaps will further increase with pressure from climate change, expected increases in cocoa demand and zero-deforestation policies. However, based on the modelling assumptions in this study, reducing the yield gaps in Côte d'Ivoire and Ghana from current levels at 86% to 73% through improved management practices, could almost double the total cocoa production on existing growing areas by 2060.

Read in full here: https://www.sciencedirect.com/science/article/pii/S0168192325000139

Seasonal rainfall reduction impact on Cocoa tree performance and yield

In West Africa, long dry spells are likely to become more frequent and intense because of global climate variability, which may significantly impact cocoa tree performance and asks for improved water management. This study investigated the effects of reduced water availability via shelters and K application on cocoa leaf traits, root growth, reproductive dynamics and yield of cocoa trees in a 6-year-old plantation. Two soil moisture levels and two K treatments were considered: a control (no shelter) and sheltered (67 % rainfall reduction) treatment, either with or without 200 kg ha−1 K application. The results showed that in a mature cocoa plantation, ∼65 % of precipitation reaches the soil. Rain sheltering during the wet season decreased cocoa yield by 31 %. Potassium application increased stomatal conductance, leaf greenness and hence yield. Potassium did not mitigate yield reduction in rain sheltering treatment. Finally, rain sheltering reduced root length and density, while potassium had a reverse effect. It also reduced stomatal conductance (Gs), flush intensity, leaf greenness and leaf size. Overall, results indicate a strong negative effect of reducing water availability during the wet season on leaf physiology, pod production and cocoa yield. Yields were mostly reduced because of a lower number of pods and much less by an effect on individual pod size. However, K application may not mitigate drought effects and sustaining cocoa yield would require integrated water management.

Read in full here: https://doi.org/10.1016/j.agwat.2024.108995

The impact of irrigation and potassium application on the negative effects of water deficit on cocoa tree yield

Yields of most tropical crops are strongly reduced by drought, but this may be partially mitigated by irrigation and potassium application. Understanding the mechanisms regulating these relationships is essential to select crop varieties reaching high yield under environmental stress. This study consisted in a 2-year field experiment (2020–2022) to investigate the effects of seasonal irrigation, potassium application and their interaction on cocoa reproduction and yield, using six genotypes in Côte d'Ivoire. The findings showed that Cocoa yield is sensitive to water deficit, and drought conditions significantly reduce yield components such as pod number, bean number per pod, and individual bean massIrrigation increased the number of cherelles (young pods) and reduced cherelle wilt, which are critical factors for pod development and yield. However, irrigated trees had a higher fraction of cherelle wilt due to competition for resources among a larger number of cherelles.

Irrigation during dry seasons almost doubled the yield of cocoa trees, highlighting its importance in mitigating drought effects. The positive effects were most pronounced when combined with potassium (K) fertilizer application. Potassium application alone did not significantly mitigate the negative effects of water deficit on yield components without irrigation. However, when combined with irrigation, potassium significantly enhanced overall yield. The combination of irrigation and K application was more effective. There was a considerable genotypic variation in yield responses to irrigation and potassium application. Some genotypes (e.g., CI01) showed higher yields and better drought tolerance, indicating the potential for breeding more resilient cocoa varieties. Effective management of cocoa under drought conditions requires an integrated approach that includes irrigation, potassium fertilization, and the selection of drought-tolerant genotypes.

Read in full here: https://doi.org/10.1016/j.agwat.2024.108789

Biodiversity plays a key role in the ecological sustainability of cocoa production

In a review of eight commodity crops, the "interdependence" of crop production systems on their local biodiversity were assessed. "Interdependence" reflects the idea that cropping systems could be considered ecologically unsustainable, if they harm the same species that they depend upon for ecosystem services. In this narrative case-study driven review, the evidence for two hypotheses for a range of crop, ecosystem service, and species group combinations were examined. The first hypothesis related to dependence – the benefits production systems gain from the species groups (pollination, pest control or biodiversity-mediated soil health maintenance services). The second related to impact – the harm done to the species groups by the land system. Where both were found to be true, a local-biodiversity related risk to the crop was identified. The review found that cocoa production is likely at risk from local biodiversity loss for species groups such as spiders, birds, ants and bats. The review also highlighted the importance of further work on the role that non-cocoa tree communities can play in enhancing ecosystem services related to pest control, pollination, and soil health in cocoa systems. Specifically, identifying the most complementary mixture of tree species or traits to optimise benefits tailored to the specific contexts of farming systems is of key importance.

Read in full here: https://royalsocietypublishing.org/doi/pdf/10.1098/rsbl.2024.0283

Identifying areas where biodiversity is at risk from potential cocoa expansion in the Congo Basin

Low productivity and climate change are projected to affect cocoa production in major parts of West Africa. This is expected to drive expansion into Central Africa where governments are looking towards commodity crop production, including cocoa, to support economic development objectives. Some have set ambitious production targets, which are unlikely to be met without expansion. At the same time, new legislation in the UK and the EU, bans the import of commodities linked to deforestation. Cocoa is the fastest expanding export crop in Sub-Saharan Africa, but little is known about potential expansion areas in the Congo Basin and how this will impact biodiversity. In this study, we explored two questions: (i) Where are available suitable areas to grow cocoa in the Congo Basin? (ii) Where are the likely impacts of cocoa expansion on biodiversity? The study highlights the Congo Basin's central belt as an area where biodiversity would be put at high risk from cocoa expansion. Even with an effective no deforestation policy, biodiversity loss remains a concern in agricultural areas like western Cameroon and the northeastern and eastern edges of the Democratic Republic of Congo. These insights can be used to guide the development of strategies that mitigate the adverse effects of cocoa expansion on biodiversity within and outside forests.

Read in full here: https://doi.org/10.1016/j.agee.2024.109216

Plans for meetings/ updates / webinars

In April 2025, the CocoaSoils coordination team members from IITA and WUR will meet to identify research priorities and discuss a new approach to the organisation and management of CocoaSoils.

In May 2025, we will send out a draft schedule for meetings and webinars in 2025, including:

- Science Committee Meetings (once per three months)
- Webinars (once per two months)
- Core Trial managers meetings (frequency to be determined)
- Annual meeting