**Tropentag, September 16-18, 2026, hybrid conference**

"Towards multi-functional agro-ecosystems
promoting climate resilient futures"

# Yield and yield response monitoring in on-farm trials: implications for cocoa yield improvement

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**Abstract**

Smallholder farmers in West Africa produce more than 60 % of the world's cocoa (*Theobroma cacao*), yet average yields remain low at about 500 kg ha $^{1}$ year $^{1}$. Reliable yield measurements are essential to assess productivity trends, evaluate management interventions, and understand climate impacts. However, measuring cocoa yields in farmers' fields is challenging because cocoa produces pods year-round, requiring repeated harvests to capture total annual production. Consequently, collecting full-year harvest data through direct harvest is usually feasible only in small-scale studies, limiting its application in large-scale and long-term research. At the same time, farmers' reported data remains unreliable, highlighting a fundamental trade-off between accuracy and feasibility. Despite these well-documented challenges, no standardised, scalable approach currently exists to derive comparable annual yield estimates from the irregular harvest data that dominate large on-farm networks. In this study, we developed a statistical methodology to derive standardised annual yield estimates from irregular on-farm harvest data. The approach was applied to harvest data collected over five years (2020–2025) from a large on-farm trial network established under the CocoaSoils programme in Cameroon, Côte d'Ivoire, Ghana, and Nigeria. Harvest observations, which were recorded at irregular intervals due to logistical constraints, were analysed using a linear mixed model that accounted for temporal dynamics within seasons and spatial variation among trials. The model was used to generate harvest predictions at equally spaced time points within the main and light seasons, which were subsequently aggregated to estimate annual yields. Uncertainty in yield estimates was quantified using a simulation-based approach in which the model was repeatedly refitted to simulated datasets to derive confidence intervals. Our analyses showed that most variation in harvested quantity is driven by treatment and country effects, while harvest dynamics variables (i.e. number of harvest rounds and harvest intervals) contribute significantly but with relatively small effect sizes. Our study demonstrates that cocoa yields can be estimated from incomplete and irregular on-farm harvest data using robust statistical methods, while remaining transparent about their limitations. Finally, our modelling approach can be applied to assess yield differences under alternative management scenarios, potentially offering a practical tool for decision-making in the cocoa system.

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**Keywords:** Cocoa yield estimation, irregular harvest data, on-farm trial network, smallholder farms, standardised yields