Site-Specific Nutrients Management for sustainable cocoa Intensification in Ghana

Second Year Student Progress report

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By

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Research Context and Gaps

The cocoa soils in Ghana are mostly Acrisols (70 %), characterized with low cation exchange capacity, pH and organic matter with a high potential for P fixation and nutrients leaching as well as unbalanced nutrients ratios in the soil. These underlying soil problems render the soils non/less responsive to cocoa fertilizer recommendation contributing to the low yield and widening the yield gap. Fertilizer recommendations are blanket, which do not address site-specific cocoa nutrients requirements (Dossa *et al*., 2018), nor more importantly the underlying soil problems that affect nutrients availability for plant uptake after fertilizer application. As such, blanket fertilization fails to support yield increase in a sustainable and economically variable manner for improved livelihood of smallholder cocoa producers.

In addition, blanket fertilization may cause wastage of farmers' financial resources and detrimental environmental effects such as surface and ground water pollution through run-off and leaching, respectively. There have been reported increase in P and N concentrations in surface fresh waters and estuaries in Ghana (Ansah-Asare and Asante, 2005; Fianko *et al*., 2010). This is mainly attributed to agricultural chemical fertilizer inputs since the highest concentration measuring stations were found within intensive agricultural cultivation, which was also far from industrialization (Fianko *et al*., 2010). In another development, there is higher demand for mineral fertilizers in international markets, fuelling exponential increase in fertilizer prices such that poorly resourced farmers who dominate the Ghanaian cocoa production industry can hardly afford. Therefore, the Ghanaian government has asked cocoa farmers to rely on organic fertilizers from farm organic residues and animal manure for the cocoa cropping.

Although it is laudable for the cocoa farmers to rely on cocoa residues and animal manure as organic fertilizers, they do not meet timely crop nutrients demand due to slow release of nutrients. An alternative approach could be the application of cocoa by-products (cocoa pod husk and placenta) and poultry manure co-compost supplemented with a small fraction of mineral fertilizers to form organo-mineral fertilizers (OMF), taking into account site-specific cocoa nutrients requirement. However, data gaps exist on co-composting ratios between poultry manure and cocoa pod husk only as well as the potential of cocoa placenta as a source of sugar to enhancing composting. In addition, there are no reported studies on site-specific organo-mineral fertilizer

recommendation nor its impacts on soil GHG emissions and nutrients losses in cocoa production systems. These limit scientific decision and implementation. Hence, there is an urgent need to identify and develop effective plant nutrition practices for cocoa, which will help to close the prevailing knowledge gaps that hinder application of effective crop nutrition practices in cocoa cropping systems.

Research aim

The project aims to identify cocoa productivity responsive crop nutrition interventions and quantify their environmental and economic impact.

Research objectives:

1. Identify optimal mixing ratio between cocoa pod husk and poultry manure co-compost when enhanced with cocoa placenta for formulation of site-specific cocoa organo-mineral fertilizer (OMF) ratios

2. Investigate OMF ratios on cocoa performance to identify OMF ratio that suits site specific cocoa nutrient requirements

3. Assess effects of OMF on GHG emissions on cocoa farms and to the wider environment

4. Assess economic viability on OMF versus existing nutrients management regimes

Progress to date

In my first year I focused on the literature review to identify the research gaps in cocoa nutrients management and the appropriate methods for bridging the gaps. Supervisory comments on the first draft of the review manuscript are being worked on. The review revealed that:

(i) Optimal co-composting ratios between cocoa pod husk and poultry only, have not been established for cocoa NPK requirement. (ii)Normal sugar has been explored as additional C source for enhancing composting but cocoa placenta, which is rich in sugar and other compounds, has not been tested for its potential in catalyzing composting. (iii)There are fewer studies looking into site-specific mineral fertilizer application on cocoa, but none was found on site specific OMF for cocoa. (iv) Studies on OMF mostly focused on agronomic attributes following OMF field application but not on OMF nutrients availability dynamics in the soil. (v)Several soil GHG studies follow

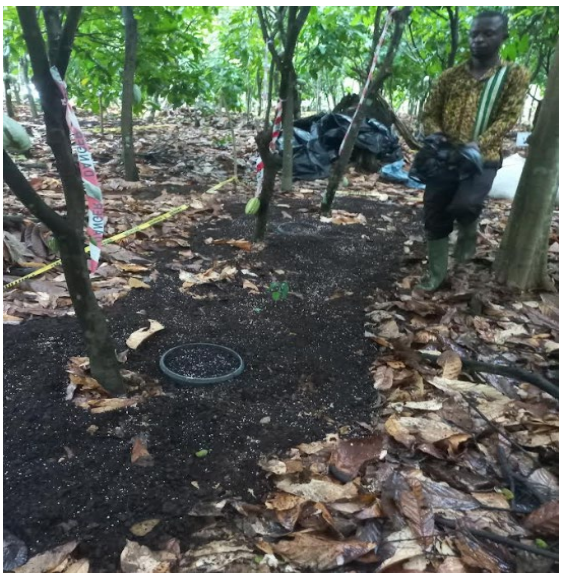
fertilizer applications under seasonal cropping system but there are no reported studies on soil GHG emission under organo-mineral fertilizer management in tree cropping system such as cocoa.

Based on the literature review and the knowledge gaps identified, I have developed detailed experimental plans which are geared towards bridging the research gaps as well as achieving the project aims and objectives.

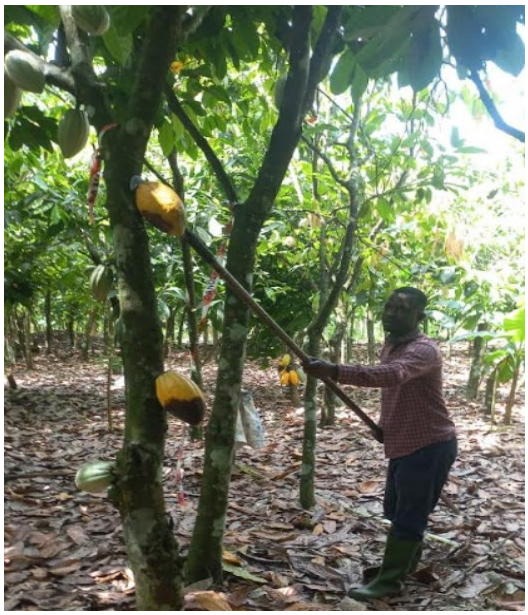
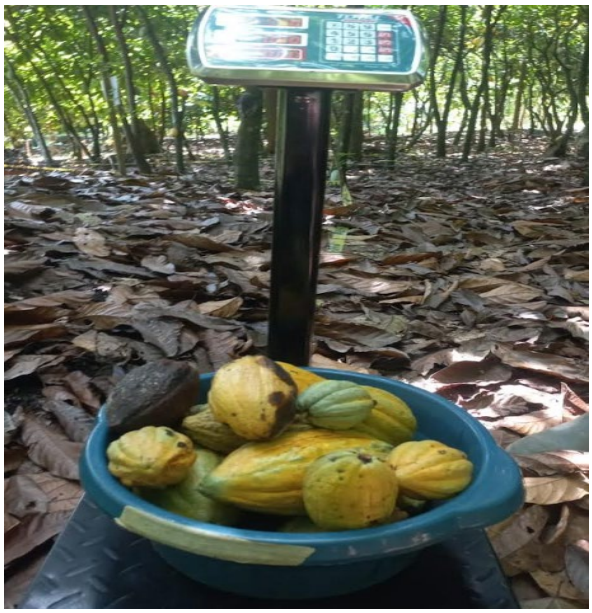
Progress Since Year I Report:

The composting experiment (objective 1) involving various mixing ratios between cocoa pod husk and poultry manure with and without addition of cocoa placenta has been completed including data analysis and interpretation. First draft of the compost manuscript has been shared with the supervisory team for comments after which it will be submitted to journal for publication. Data from this experiment was used to decide on optimal mixing ratio between cocoa pod husk and poultry co-composting for upscaling for cocoa OMF formulation and field applications.

Furthermore, the OMF has been applied to cocoa field trial sites for the next phase of my study which will seeks to understand the impact of OMF on cocoa agronomic performance (objective 2); GHG emissions in cocoa farm/environment (objective 3) and economic viability (objective 4). Data collection for the objective '2' and '3' are on-going.

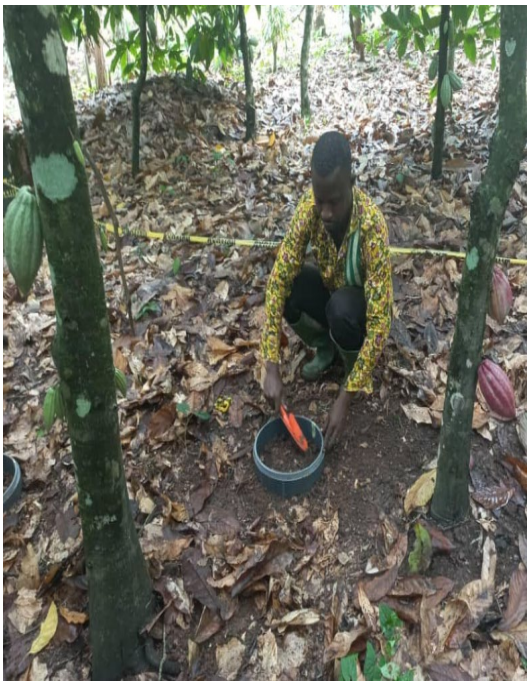



OMF application

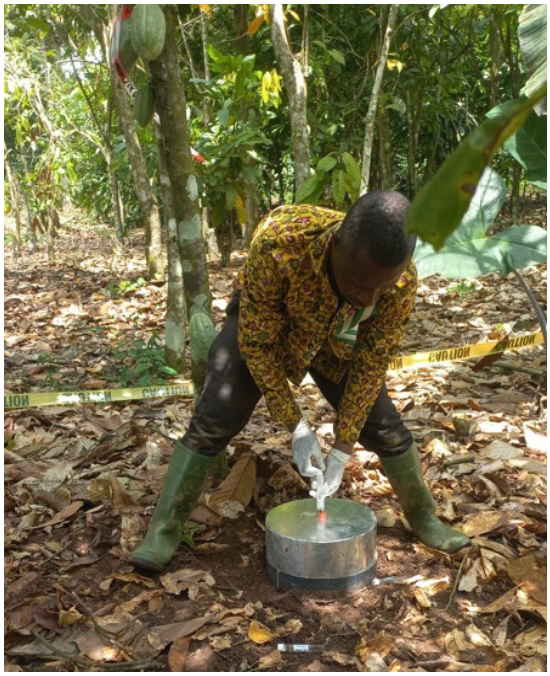



Cocoa pod harvesting

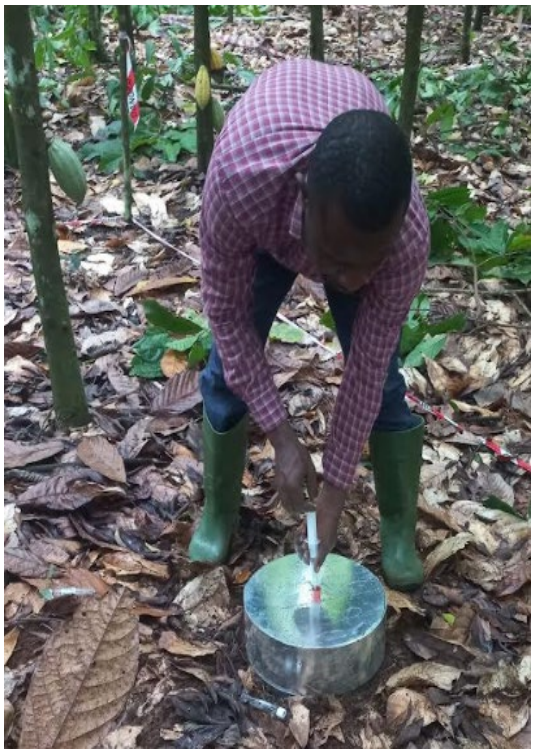
Cocoa pod husk weighing



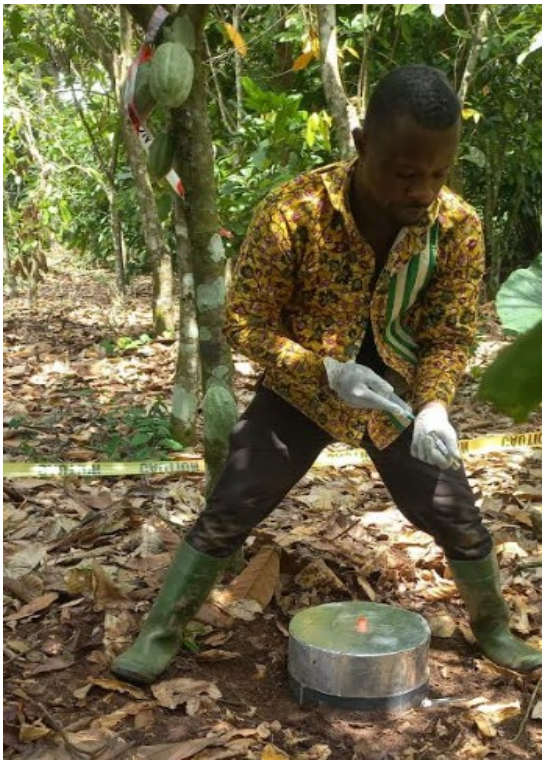
Chamber installation



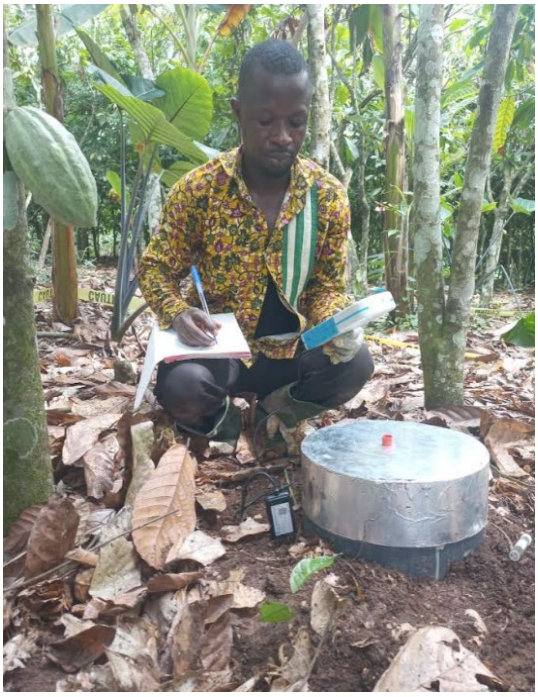
GHG sampling



GHG sampling



Transferring GHG sample into glass vials



Soil moisture & temperature reading during GHG sampling

Soil sampling for microbial analysis during GHG sampling

Anticipated impact of the research project

Reduction in deforestation: Formulation and recommendation of cocoa organo-mineral fertilizers will improve cocoa productivity, thereby reducing land expansion or forest encroachment by farmers in their attempt to increase yield. This will reduce deforestation and its attended consequences. Thus, reduction in deforestation implies that there will be vegetation within the catchment. The vegetation will enhance soil organic C, which attracts microbes. During run-off, oxygen concentration in soil decreases thereby increasing oxygen demand by the microbes. This will force the microbes to derive their Oxygen from PO_4^-(Phosphates) and NO_3^- (Nitrates) containing in the run-off thereby reducing P (PO_4^-) and N (NO_3^-) pollution in the catchment. Vegetation can also reduce the run-off speed to help reduce flood risk and increase flood resilience within catchment. In addition, the vegetation can sink CO_2 through photosynthesis, which mitigates climate impact of CO_2 on drought and flood in the catchment. Hence, environmentally friendly agricultural land management practices are critical to catchment management since it influences raw water quality on a catchment scale.

Reduction in GHG emissions as well as nutrients leaching and run-off associated with mineral fertilization: This is because the mineral component of the OMF will be immediately available for plant uptake while the organic component, which forms the higher fraction, will be released moderately over time. Reduction in GHG emissions and NPK losses (leaching and run-off) could in turn mitigate climate change and water pollution, respectively in catchment and to wider environment.

Improving farmers' resilience to mineral fertilizer scarcity or prize hikes: The findings will serve as a platform for cocoa farmers to optimally co-compost poultry manure and cocoa by-products (cocoa pod husk and cocoa placenta) and afterwards supplement it with a small amount of mineral fertilizer for applications in their cocoa fields. This implies that under mineral fertilizer scarcity or prizes hikes farmers will still be able to carry out their cocoa fertilization without compromising yield. Capacity building workshop will be carried out to train cocoa farmers on the co-composting process and organo-mineral fertilizer formulation. In addition, cocoa farmers in the cocoa farming community would be brought to the cocoa experimental fields to witness the impact of the organo-mineral fertilizer on cocoa yield based on which they can adopt the intervention and subsequent recommendation to their colleagues' farmers. The project involves the Ghana COCOBOD who will also help disseminate the project output nationally.

Improving Farmers' livelihood: The findings will contribute to nutrient retention and availability, thereby improving cocoa yield sustainably. This will increase the income of farmers and increase financial capacities to taking care of household responsibilities as well as hiring additional labour.

Creation of business opportunities: The findings could also provide basis for companies to produce cocoa OMF and sell to farmers.

Research/Scientific Capacity Building: The project is helping strengthen my capacity in terms of knowledge and skills in nutrients management for sustainable cocoa production and after project

completion; I will be able to launch analogous projects in other related crops in the region using the applied methodologies of this project.

References

Ansah-Asare, O. D. and Asante, K. A. (2005). Changes in the chemistry of the Weija dam Reservoire in Ghana, twenty years after impound-ment. West Africa J Appl Ecol 8:35–47

Dossa E L, Arthur A, Dogbe W, Mando A, Snoeck D, Afrifa A A. Acquaye S (2018). Improving Fertilizer Recommendations for Cocoa in Ghana Based on Inherent Soil Fertility Characteristics. Springer, pp 287-299.

Fianko, J. R., Lowor, S. T., Donkor, A. and Yeboah, P. O. (2010). Nutrient chemistry of the Densu River in Ghana. Published online: Springer Science+Business Media, LLC