PhD Research Progress Report for the Year 2018/2019

TITLE: Nutrient use efficiency in banana-bean intercropping systems in the Upper Pangani Basin, Tanzania

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Timeline of study: 2015-2020

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Research Objectives

1. To contribute to an understanding of soil variability in the northern Tanzania banana growing areas and its role in increased crop production and as a starting point for site specific soil fertility management practices,
2. To evaluate soil fertility management practices suitable for banana production,
3. To assess the economic benefits of fertilizers in banana production,
4. To quantify nutrient transfers from maize production belt to the upland farming system.

Achievements

- Results from objective two have been accepted for publication as,
  "Optimizing soil fertility management strategies to enhance banana production in volcanic soils of the northern highlands, Tanzania" in Journal of Agronomy published by the MDPI.
- Final thesis compilation: ongoing.

Background

Banana is a major food staple and an important cash crop in highland areas of Tanzania, normally grown by resource-poor smallholder farmers in homestead gardens with little or no fertilizer input. The crop ranks fourth after maize, cassava, and sweet potato in terms of the quantities produced and is estimated to feed up to 30% of the total human population in the

country. Approximately 30% of the total produce is consumed at the homestead while the remaining 70% is sold in the local market, hence contributing significantly in food security and income stability. Nearly 80% of the cultivated bananas belong to the traditional East African highland cooking banana (EAHB), indicating that they are of considerable cultural importance for the community. However, the current banana fruit yields under the farmer's conditions are low (7 t ha^{-1}), only attaining 10% of itsyield potential in East Africa primarily caused by low soil fertility due to (1) larger nutrient exports without adequate replenishment, and (2) intrinsic low fertility of the natural soils. Earlier studies reported that soil N deficiency is amongst the main constraints to crop production in most areas of the country. Therefore, in order to increase banana fruit yields, the current soil N levels need to be improved.

Crop nutrient requirements in banana-based farming systems are currently addressed via cattle manure only. But, in most farms, the quantity of manure produced by stall-fed dairy cows is not enough to maintain the soil fertility of the farms.Supplementation with poultry, goat, sheep, and swine manure produced within homestead or additional cattle manure from nomadic pastoralists in the lowlands should be considered. Unfortunately, poultry, goat, sheep and swine manure is produced in negligible quantities, while the transport costs of cattle manure are too high. This explains the need to supplement organic with inorganic fertilizers, which are relatively cheap. The combined use of organic and inorganic fertilizer resources in turn will reduce the total reliance on animal manure while maintaining good soil fertility and high yield levels. Always, combined application of organic and inorganic fertilizers performs better than manure or mineral fertilizers alone. Nevertheless, banana growers in Tanzania do not use this strategy due to lack of knowledge on its appropriate use. Therefore, this study aimed to improve our knowledge on the appropriate use of N fertilizer in terms of application rate and strategy as an alternative approach to manage soil N under highland conditions.

Summary of the study

- Site characteristics had significant effects on plant growth ($p < 0.001$), crop cycle ($p < 0.05$) and yield ($p < 0.05$). Banana plants under the higher rainfall conditions were larger and produced higher yield than those in under less humid conditions. Likewise, the

shortest crop cycle was recorded under the rain intensive conditions of Lyamungo and the longest in the drier conditions of Tengeru.

- Fertilization treatments resulted in significant increase in banana yield ($p < 0.001$) and the highest value(51 t ha^{-1}) was attained with 153 kg N ha^{-1} $year^{-1}$ supplied via cattle manure in combination with urea at 50%, significantly higher than the same amount of N derived from cattle manure only (47t ha^{-1}) or urea alone (41 ha^{-1}).
- Consistently, applications of common bean residues (haulms)alone resulted in the lowest yield (27 t ha^{-1}) compared with other fertilization treatments.
- Still, yield levels attained in all fertilization treatments were significantly larger than those obtained under the farmer's fields.
- Foliar analyses indicated banana plants in all study sites contained insufficient concentrations of Cu and Zn.

Conclusion

Inorganic fertilization led to a significant and positive increase in the growth and yield of the Mchare banana. However, the combination of urea with cattle manure was superior to any other fertilization treatments. It also shows that inorganic/organic interactions enhanced the efficiency of the applied nutrient fertilizer. This infers that a combined use of inorganic and organic fertilizers could be used as an excellent alternative strategy to manage soil fertility in farms with insufficient quantities of animal manure. Integrated soil fertility management will, in turn, contribute towards improved soil fertility, increased crop production, and sustainable banana-based farming systems.