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- Translating science into policy and practice

Addressing the non-responsiveness of crops to fertilizers under some soils in sub-Saharan Africa

Introduction

Improving soil fertility is key to increase crop productivity in sub-Saharan Africa (SSA). The use of fertilizers to increase crop productivity in SSA is important, but often the right combinations of nutrients in these fertilizers is lacking. Soil nutrient status affects crop productivity but also the nutrient content in the plant parts consumed as food and feed. There is evidence for widespread crop non-responsiveness to NPK fertilizers in different parts of SSA. As early as 1990s, 20-50% of fields were deemed to be non-responsive to NPK fertilizers and a similar extent of non-responsiveness has been confirmed in more recent studies.

This brief presents the extent of non-responsiveness of crops to nitrogen (N), phosphate (P) and potassium (K), or NPK fertilizer application, and the associated factors to such lack of effect.

The brief is based on a synthesis of scientific literature and datasets from SSA of fertilizer application for cereals; maize, rice, sorghum and millet (see here).

Given the poor soil fertility in many parts of the region, the extent of acidic soils, and the limited ability of smallholders to invest in fertilizers, effective yield response to fertilizer application is needed. With this as a background, a synthesis of existing datasets

Key messages

- Combined application of macronutrients, secondary nutrients, micronutrients as well as manure is important to increase crop productivity and unlock crop responses to fertilizer applications in sub-Saharan Africa (SSA)
- Almost 25% of the cropland cultivated on smallholder fields do not respond to nitrogen (N), phosphorus (P) and potassium (K) fertilizers (i.e., NPK) due to low soil fertility
- Application of micronutrients and manure unlocks the responsiveness of sites with poor soil conditions. Maximum yields are achieved when micronutrients are added in combination with the NPK fertilizers
- The crops' non-responsiveness discourages farmers from continued investment in fertilizers. It could be a key factor contributing to the current low fertilizer use among smallholder farmers in SSA
- There is a need for identification of potentially non-responsive sites in sub-Saharan Africa and development of new recommendations/guidelines for targeting micronutrients and manure

and peer-reviewed scientific literature was conducted in order to assess;

1. Crop yield response to secondary nutrients, such as Sulfur (S), Calcium (Ca) and Magnesium (Mg) with micronutrients, for example Zinc (Zn), Boron (B), and Selenium (Se), organic manure and lime application, in comparison to yield response when only NPK fertilizers were applied.

2. The prevalence of non-responsive soils and key influencing factors of such lack of effect to fertilizer application in SSA.

Unlocking non-responsiveness

The review on which this brief is based upon showed that non-responsiveness due to poor soil fertility constitutes about 18% of all smallholder fields across SSA. For the fields showing high fertility, non-responsiveness occurs in 8% while the rest are responsive. Literature identifies that application of NPK fertilizers results in large increases in yields (on average of 152%) on the responsive fields but only 34% on the non-responsive fields (Figure 1). However, combined application of NPK fertilizers with micronutrients increases productivity with as much as 44% in the non-responsive category. The same treatment has very limited effect (only 4%) on productivity of the responsive fields. Similarly, manure application with NPK increases productivity by 27% under non-responsive fields while no effect is observed on the responsive fields.

Crop non-responsiveness

Crop non-responsiveness is defined as a small to no crop yield response after an NPK application and hence negligible economic return.

Crop non-responsiveness results from continued cultivation with inadequate application of nutrients. The occurrence of crop non-responsiveness is common in many parts of SSA characterized by high soil acidity and alkalinity, low cation exchange capacity (CEC) and to some extent in areas with salinity, sodicity and compaction problems because these constitute a limitation to crop growth. This poor soil fertility/condition constitutes a majority of non-responsiveness cases. In few cases also, high fertility can limit crop responses because the soil nutrient supply to crops is already sufficient. Therefore, any analysis of non-responsiveness should make this recognition.

Crop non-responsiveness to NPK fertilizers in SSA.

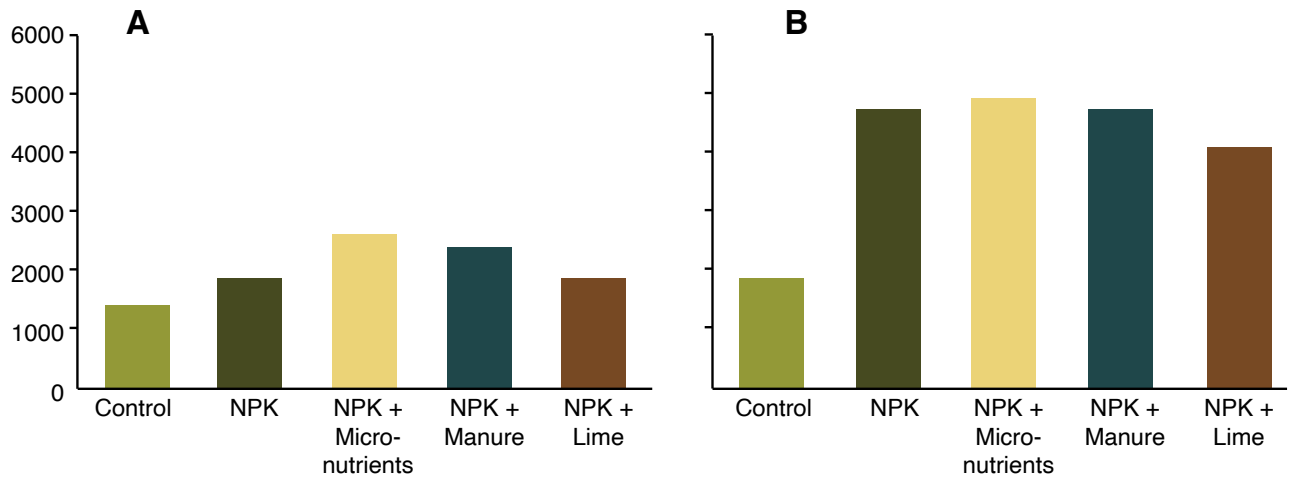

Figure 1. Maize grain yields (in Kg/ha; Y-axis) affected by application of NPK fertilizer and NPK fertilizers with secondary nutrients (Sulfur, Calcium and Magnesium) and micronutrients (Zinc and Boron) and organic manure on fields where crops are non-responsive to NPK under poor fertility (A) and where crops are responsive (B). Unlike (B), fields in (A) are characterized by poor soil fertility/conditon including acidity and low cation exchange capacity. It shows that non-responsiveness can be addressed through addition of micronutrients and manure. But for already responsive fields, this additional management measure is not helpful yield wise.

Macro, micro and secondary nutrients

Macronutrients refers to *nitrogen (N), phosphorus (P) and potassium (K)*, nutrients that are required by plants in fairly large quantities.

Micronutrients are nutrient elements that have specific functions in the metabolism of an organism and are vital for the completion of its life cycle or its optimal growth, yet required in very small quantities. *Key micronutrients include: Selenium (Se), Boron (B), Copper (CO), Iron (Fe), Manganese (Mn), Molybdenum (Mo), and Zinc (Zn).*

Secondary nutrients, like micronutrients, are essential plant nutrients. They are called "secondary" nutrients because plants require them in smaller quantities than nitrogen, phosphorus, and potassium. On the other hand, plants require these nutrients in larger quantities than the "micronutrients". *Key secondary nutrients include: Sulfur (S), Calcium (Ca), Magnesium (Mg).*

Some further key results were:

1. The maximum NPK and NPK + micronutrients responses were attained when soil organic carbon levels were moderate (around 1 to 1.5%).
2. Non-responsiveness occurs more in sandy soils (with an average sand content of 62%), as sandy soils have low nutrient retention capacity.
3. Less acidic soils (pH ≥5.2) responded more to application of micronutrients and manure in combination with NPK, increasing maize yields by 51% and 43%, respectively. For soils with a low pH (pH<5.2), the effect of micronutrients and manure application was not significant.
4. Crop yield on poor non-responsive soils with low cation exchange capacity increased by 35% and 29% with additional application of micronutrients and manure, respectively. Responses under high cation exchange were low.

This implies that targeted application of micronutrients and manure to the fields, where crops are non-responsive to NPK fertilizers, offer potential of pushing yields further than what is realized with the conventional NPK fertilizers.

Fertilizers recommendations in SSA have been mostly NPK-based. NPK have been the nutrients supplied in the available fertilizer blends in the market until very recently when, based on the realization of micronutrient deficiencies, new blends with micronutrients are becoming available. However, access to such new blends in the region is still very low and needs to be improved.
Overall, the crop non-responsiveness discourages farmers from continued investment in the traditional fertilizer blends and could be one of the factors

Crop rotation of maize and velvet bean.

contributing to the current low fertilizer use among farmers. Unlocking the non-responsiveness through increasing the access of fertilizer blends with the required nutrients is likely to reverse the low adoption of fertilizers across SSA. However, more efforts by scientists and the fertilizer industry are needed to tailor fertilizer recommendations to the local soil conditions. Furthermore, these recommendations need to be packaged in suitable tools usable by farmers, extension agents and development practitioners.

Recommendations and ways forward

- Application of micronutrients and manure on the poor fertility soils is a good approach for improving crop response to NPK fertilizers.
- Combined application of macronutrients, secondary nutrients, micronutrients and manure is important to unlock crop responses to fertilizer applications of the non-responsive category of fields through balanced fertilization.
- Management practices that maintain or improve soil fertility, e.g. soil organic carbon, are also important measures for continued productivity and responsiveness to fertilizers.
- There is need for site-specific recommendations that clearly address underlying nutrient deficiencies. This will increase overall nutrient use efficiencies and economic benefits from applied nutrient resources.
- Factors that cause the observed variability in crop non-responsiveness to applied fertilizers in SSA need further investigations. We especially need to further understand the role of soil-water-plant relations, and plant-nutrient stochiometric relationships on crop yields.

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The brief is based on a new synthesis of data and literature, aimed for publication in a peer-reviewed scientific journal.

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