



FERTILIZER RESEARCH & RESPONSIBLE IMPLEMENTATION

FERARI **RESEARCH** DEMONSTRATES **ADDITION** OF **SULPHUR** TO **NPK INCREASES** MAIZE **YIELDS** IN GHANA

Over 400 experiments on maize, soybean, and rice during the seasons 2020, 2021, and 2022, were conducted by FERARI through Ghanaian universities and research institutions, while training students. Currently in 2023, FERARI is conducting experiments to validate its preliminary fertilizer recommendation. These are based on 3 years of field data and legacy data from national research institutes and universities with over 1,000 experimental observations on maize.

The 2020 experiments were to verify recommended NPK rates and the impact of zinc

(Zn), sulphur (S), and iron (Fe) on crop yields. In 2021, a briquettes technology was tested alongside the 2020 experimental designs. In 2020 and 2021, experimental localities were selected based on recommendations from researchers of partner institutions. On-station, on-farm, and farmer-managed experiments were conducted.

In 2022 and 2023 however, the sites were selected based on a combination of the soil properties organic matter content, slope of the land, and soil pH (Fig. 1). This allowed establishment of experiments to account for the heterogeneity in the soil properties and to understand the impact of fertilizer formulations on crop yields in the Guinea Savannah and Transitional zones of Ghana.



Collecting physical crop data.

ABOUT THE PROJECT FERARI is a public-private program in Ghana that implements on-the-ground activities to develop the fertilizer value chain based on transdisciplinary research by M.Sc. and Ph.D. students and researchers to build the research capacity of the involved institutions. The program aims to develop a systematic approach to support widespread adoption of balanced fertilizers by famers in the less developed markets of sub-Saharan African countries, especially Ghana, as a means to improve their food and nutrition security.



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OBSERVED AND POTENTIAL YIELDS OF MAIZE

The data reveals observed yields from close to zero to about 6 tons per hectare (t/ha) across the major agro-ecological zones of Ghana (Guinea Savannah, Transition Forest, Deciduous, and Sudan Savannah). Observed yields are higher around the south-western part towards the central part of the country. NPK resulted in the highest yield while NPK including S tended to exceed those yield levels.

Preliminary analyses (*Fig.* 2) show that optimal maize yield of around 5-7 t/ha, can be attained at NPK rates somewhat below the current national recommendations of NPK 90-60-60 kilograms per hectare (kg/ha) and NPK 100-40-40 kg/ha for the Guinea Savannah and Transitional Zone, respectively. Based on FERARI analyses, application rates of NPK 70-50-50 kg/ha and 95-50-50 kg/ ha seem optimal for yield levels of 5-7 t/ha in the Guinea Savannah and Transitional zones, respectively (*Fig.* 3).

Figure 1. Soil properties map used for site selection for the 2022–2023 experiments.



Figure 2. Maize yield levels attained at varying NPK application rates in Ghana.



Figure 3. Statistical rationale for recommendation rates.*



Figure 4. Spatial analysis maps of observed and potential yields, and yield gaps of maize.



The yields of maize can reach "potential yields" from 5 t/ha in the southern part of Ghana to over 8 t/ha in the north (*Fig.* 4), under perfect production environment with irrigation (as done with rice), optimal fertilizer application, and adequate control of weeds, pests, and diseases. With observed (farm) yields being higher in the south than in the north, the yield gap ranges from a mere 2-3 t/ha in the south to 5-7 t/ha in the north. Observed yields are high in the south due to the better soil conditions that can supply more nutrients to the crop and hold on to more rainwater that can be used by the crop. This indicates the large potential for improving maize production in Ghana, even more in the north than in the south, by providing the required production environment for the growth of maize (and other crops).





^{*} The limited number of observations at higher rates does not justify their consideration.

CLOSING THE YIELD GAP

FERARI has been experimenting with various practices to identify how to close the yield gap. The application of sulphur at a rate of 20 kg/ha with NPK is found to be helpful in this regard (*Fig. 5*); maize yields increase on average by 0.5 t/ha in the Transitional Zone up to 1.5 t/ha in the Guniea Savannah. In addition, the use of mulch in the north prevents rapid drying of soils and increases yields. Clearly, enhancing the capacity of the soil to hold more water, especially in the north, is key to raising yields. Findings about other practices such as raised beds, improved planting densities, or briquettes are not yet conclusive and are still being studied.

"RECALL" CONFIRMS SULPHUR INCREASES YIELD

There is a large gap between yield attained in on-station experiments and actual farm yields. FERARI has therefore also conducted farm surveys to understand the perception of farmers and their yield levels. It appears that farmers "recall" their yield to be almost 1 t/ha less as compared to yield measured by FERARI through physically harvesting parts of their plots. Figure 6 show the average maize yields from "recall surveys" of farmers for 2019–2021 averaged 1,511.7 kg/ha over the three years, Yet, this ought to be interpreted to be about 2.5 t/ha. In terms of the nutrient combinations used by farmers, yields are highest when NPK is combined with sulphur.





IMPACT OF SULPHUR ON YIELD AND SMALLHOLDER FARMER INCOME

Application of sulphur through, for instance, NPK 11-22-21+5S with urea topdressing would increase fertilizer application in Ghana to 5 million bags (50 kg) of NPK+S and 2.4 million bags of urea. This will increase maize production by 1.2 million tons in addition to the 3 million tons currently observed. The total added value of 1 t/ha of additional maize produced would increase income to approximately US \$360 for about 600,000 smallholder farmers.

CURRENT CONCLUSIONS

- Optimizing fertilizer application is important for attaining higher yields and maximizing economic benefits while minimizing environmental impacts.
- The gains made by improving yields should be pursued using NPK fertilizers fortified with

sulphur in combination with measures to improve soil quality, such as mulching and organic amendments, primarily to improve the capacity of soils to hold more water.

- This will lead to improvement of the fertilizer use efficiency; i.e. more grain produced per kg of fertilizers applied and therefore more grain, better economic returns, and less environmental loss.
- Nationwide validation and confirmation of the recommendations obtained from observed and modelled data is strongly encouraged.
- During this process FERARI has trained over 50 BSc/MSc students and over 12 MSc students from the UM6P who are all employed in the fertilizer sector across Africa. FERARI has strengthened the capacity of over 30 scientists, is still training 6 PhD candidates, and has drafted many reports and scientific journal articles.

