Modeling Sorghum yield in response to inorganic fertilizer application in semi-arid Ghana

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Introduction

In semi-arid Ghana (Figure 2), cereals production is characterized by low external inputs (Figure 1). Over the last decades this has resulted in depletion of soil nutrients. The conventional system of restoring moderate soil fertility on bush farms by extensive fallow periods is no longer effective. Hence cultivation of cereals like Sorghum (Sorghum bicolor (L.) Moench) is restricted to the compound farms where manure is applied. The demand for Sorghum by far outweighs its production. Thus, there is a need to explore the use of mineral fertilizer in both the compound and bush farms, and also to assess the seasonal fluctuation of grain yield in view of an adaptive risk management, using a crop simulation model - DSSAT.

Figure 1. Land preparation in low input systems

Figure 2. Map of showing study site

Methodology

As a first step to assess yield response of Sorghum to environmental conditions (seasonality/variability of rainfall) and fertilizer management, Sorghum was grown without nutrient and water limitation. Data were used to calibrated the Crop Simulation Model DSSAT (Figure 3). Subsequently, fertilizer experiments were conducted in two management zones; Bush farm and homestead. The observed data were used to evaluate the model performance. Grain yield was then projected into 2035, using forecasted weather data generated by LARS-WG (a stochastic weather generator).

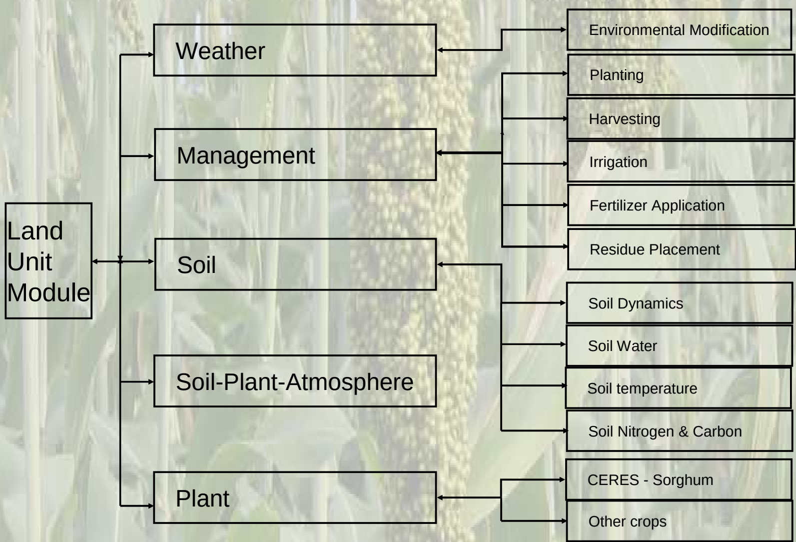

Fig. 3 Modified overview of the framework of DSSAT-CSM

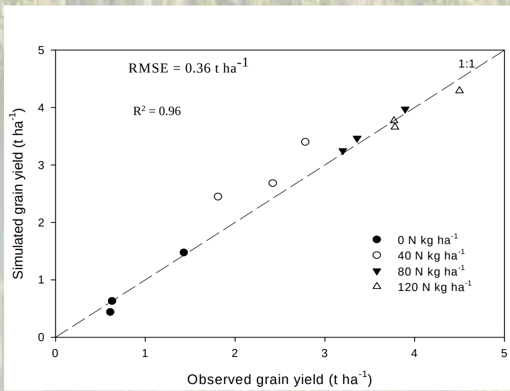

Fig. 4 Evaluation of model performance in predicting Sorghum yield

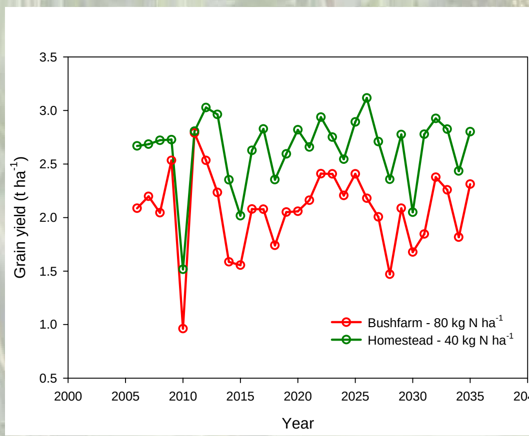

Fig 5. Projection of Sorghum yield on different management systems

Results and Discussions

DSSAT predicted the effect of different levels of mineral fertilizer on crop yield well (figure 4) with a median unbiased absolute percentage error (MdUAPE) of 28% and RMSE of 0.36 t ha^{-1}. Application of 40 kg N ha^{-1} mineral fertilizer in the homestead yielded the best value to cost ratio whilst 80 kg N ha^{-1} produced the highest value to cost ratio in the bush farms. Sorghum grain yield at 40 kg N ha^{-1}in the homestead were consistently higher than at 80 kg N ha^{-1} in the bush farm for all projected years. The higher grain yield in the homestead at half the amount of mineral fertilizer applied in the bush farm can be attributed to the multiple benefits provided by the organic manure. Yield projection into 2035 (figure 5) highlighted that the amount and distribution of rainfall poses a higher risk to an efficient use of mineral fertilizer on soils with low organic matter content as opposed to enriched with organic matter by application of manure

Conclusion

The use of mineral fertilizer in Sorghum cultivation is feasible in both management systems with higher returns from the homestead. Also, the risk of lower Sorghum yield due to variability in rainfall is higher in the bush farms. The model thus, provides a sound scientific anticipations into yield variations and can serve as an input to policy and decision making.

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