Maize Yield Prediction in Burkina Faso

Paul Wilkens, Guillaume Ezui, Sansan Youl, Olivia Gist, and Upendra Singh, IFDC

Introduction

Nutrient omission trials (NOT) were conducted on several soil types and across a range of climatic conditions in Burkina Faso over several years. The data sets collected were used to validate the CSM CERES-Maize model in DSSAT v4.5 (Decision Support System for Agrotechnology Transfer) for Burkina Faso. The goal of this research was to develop a spatially oriented, site specific fertilizer recommendation system for maize production to provide farmers with optimized maize recommendations within a spatial, temporal, and economic framework.

Methods and Materials

Field Study. This study was conducted in two agroecological zones of Burkina Faso, Comoe in the southwest and Fada N'Gourma (or Fada) in eastern Burkina Faso (Figure 1). In the NOT validation trials, N, P, or K was withheld while the other nutrients were applied at adequate levels (100 kg N, 30 kg P, and 35 kg K). Two varieties of maize were used; a long duration (120 days), SR22, and a medium duration (90 days), FBC6. The maize cultivars were provided from INERA (Institut de l'Environnement et de Recherches Agricoles, Burkina Faso).

Simulation Study. In the simulation studies, a treatment matrix was created to cover a range of management inputs. Four sowing dates (15 April, 15 May, 15 June, 15 July), four levels of nitrogen (0, 40, 80, 120 kg ha^{-1}) and three levels of both P (0, 30, 60 kg ha^{-1}) and K (0, 40, 80 kg ha^{-1}) were combined to create DSSAT experimental files for simulations. Genetic coefficients for maize cultivars SR22 and FBC6 were estimated from the NOT trials and used with the CSM model. Model inputs to the system included both daily weather data (precipitation, temperature, and solar radiation) from 1997 to 2007 from 10 meteorological synoptic stations and the analytical characteristics of the main soils types of Burkina Faso provided by BUNASOLS (Bureau National des Sols du Burkina Faso). To generate recommendations, the data was integrated with the Climate Information Analysis Toolkit, which provides a framework for simulating and analyzing outputs from regional scale simulations of cropping systems, allowing optimization of 288 management options.

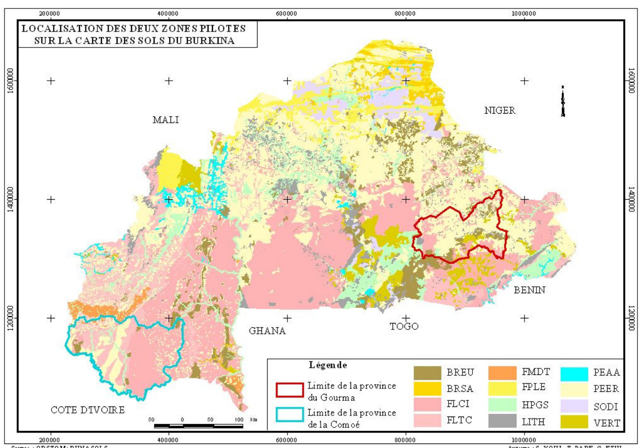

Fig 1: Soil types of Burkina Faso (1:500,000) with Comoe (blue) and Fada (Red) highlighted.

Results - Field Study

The NOT yield varied according to location; cultivar SR22 performed better in Comoe and FBC6 in Fada. The major soil in Comoe is a tropical ferruginous soil type (FLCI and FLTC) while in Fada, PEER is the dominate soil type. The NOT results showed that Comoe soils are more fertile than Fada soils (Fig 2). Fore each location, the most limiting nutrient for maize production was N, followed by P. Maize grain yields ranged from 1 to 5.4 t ha^{-1}.

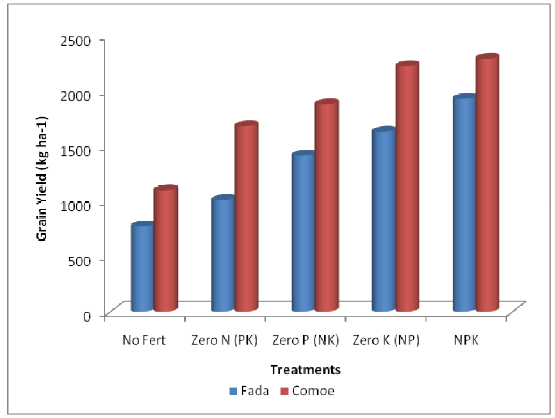

Fig 2. Maize grain yield in Fada and Comoe (No Fert = 0-0-0, Zero N = 0-30-35, Zero P = 100-0-35, Zero K = 100-30-0 and NPK = 100-30-35)

Results – Simulation Study

Output from the crop simulation models were used to generate cropping system recommendations. Figure 3 shows the rainfed potential yields of up to 5.5 t for Burkina assuming no nutrient limitations. Simulation results, optimized across 10 seasons, indicated the best overall sowing date is in June and in southwest Burkina Faso in May. Grain yields decreased from the South toward the North, reflecting the rainfall gradient, and the most profitable options for maize production in Comoe were N120-P60-K80 and N80-P60-K80 for cv. FBC6 (Fig 4) and N120-P60-K80, N80-P60-K80 and N120-P60-K40 for cv. SR22 (Fig 5). In all cases, fertilizer recommendations were based on current production costs and grain value in CFA francs. The most profitable options for maize production in Fada for both cultivars are N0-P60-K0, N0-P30-K0 and N0-P0-K0 (Figures 6 and 7), which do not give the maximum biological yields but are more cost effective. The use of organic manure or enhancing the soil health is a requirement to improve nutrient use efficiency in Fada.

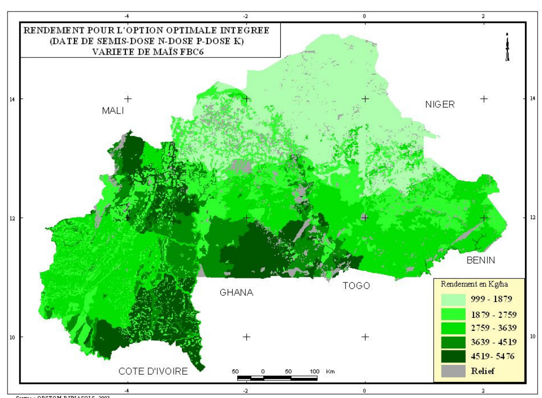

Fig.3. Water-Limited Potential Yield of Maize cv. FBC6 Planted in June

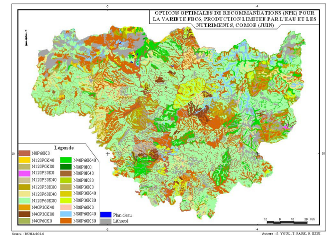

Fig. 4. Optimal NPK combinations for maize cv. FBC6 planted in June in Comoe

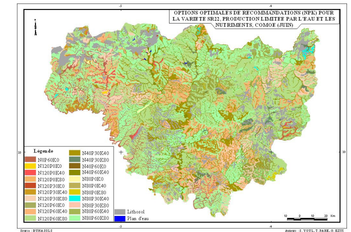

Fig. 5. Optimal NPK combinations for maize cv. SR22 planted in June in Comoe

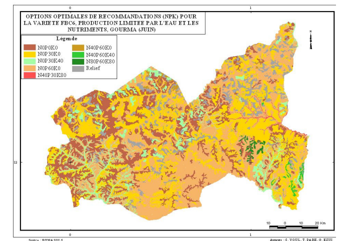

Fig. 6. Optimal NPK combinations for maize cv. FBC6 planted in June in Fada

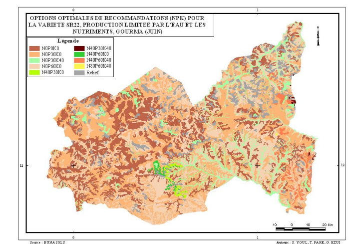

Fig. 7. Optimal NPK combinations for maize cv. SR22 planted in June in Fada

Conclusions

The optimal NPK fertilizer recommendations were in accordance with most of the nutrient omission trials, which showed that N is the most limiting nutrient, followed by P. The results showed that K was not a limiting nutrient, and as such the economic optimum is with a minimum potash application.

Unlike the blanket fertilizer recommendations in Burkina Faso, regardless of agroecological diversity and variability, this study helped develop site specific crop management and fertilizer recommendations for Burkina Faso. However, these results need to be validated on farm in both target areas to confirm their effectiveness. The validation trials have been implement this year. After this step, the crop model inputs could be adjusted and the recommendations disseminated to stakeholders.

The gap between the NOT trials yield and the yield potential reflects the degree to which crop and soil management practices allow expression of genetic potential. To bring up farmer yields closer to the rainfed potential, the yield gaps, whether soil limited (pH, organic matter, micronutrients), biotic (pathogens, insects), or crop management will need to be addressed.

References

Hoogenboom, G., J.W. Jones, P.W. Wilkens, C.H. Porter, K.J. Boote, L.A. Hunt, U. Singh, J.L. Lizaso, J.W. White, O. Uryasev, F.S. Royce, R. Ogoshi, A.J. Gijsman, and G.Y. Tsuji. 2010. Decision Support System for Agrotechnology Transfer (DSSAT) Version 4.5 [CD-ROM]. University of Hawaii, Honolulu, Hawaii.

Jones, J.W., G. Hoogenboom, C.H. Porter, K.J. Boote, W.D. Batchelor, L.A. Hunt, P.W. Wilkens, U. Singh, A.J. Gijsman, and J.T. Ritchie. 2003. DSSAT Cropping System Model. European Journal of Agronomy 18:235-265.

Acknowledgements

We thank INERA (Institut de l'Environnement et de Recherches Agricoles) and M. Pare Tahibou at BUNASOLS, Bureau National des Sols, for their invaluable help.

IFDC, PO Box 2040, Muscle Shoals, AL 35662
Email: pwilkens@ifdc.org, Web: www.ifdc.org