A MODEL FOR WHEAT YIELD PREDICTION BASED ON REAL-TIME MONITORING OF ENVIRONMENTAL FACTORS

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ABSTRACT

This paper presents the results of a one year preliminary study in which a real-time monitoring system was used to feed the STICS soil crop model. As indicated by the statistical criteria (RMSE and model efficiency), the optimization of some wheat crop parameters allows the model to predict the yields with good accuracy for different soil type and different nitrogen application rates.

Keywords: Microsensors, Wireless network, Crop model, STICS

INTRODUCTION

In Belgium, the second "*Sustainable Nitrogen Management Plan*" (PGDA) started since 2007 and deals with organic and mineral nitrogen fertilisation for crops, catch crops and soil nitrogen residue. Distributed soil crop models appear as a promising approach to estimate nitrogen fertiliser requirements (Houlès et al., 2004) and to quantify the impact on yields and environment (e.g. N leaching) (Beaudoin et al., 2008). This paper presents the performance and robustness assessments of a dynamic crop growth model based on real time data acquired by wireless microsensors.

METHODS

Analysed data come from seven different nitrogen applications rates trials (0 to 240 kgN/ha) carried out on a belgian wheat crop culture (*Triticum aestivum* L., cultivar Julius) implanted on three different soil types (silty, loamy and sandy loam) in Gembloux (BE). The soil profiles were initialy described, while the soil nitrogen concentrations (NO_3^- and NH_4^+) were regularly measured along the growing seasons. The plant characteristics (biomass/grain yields and protein content, LAI) were also followed during all the experimental period.

The wireless monitoring system (*eKo pro series* - *Crossbow*) was extended to cover the field spatial heterogeneity. It allows the measurements of suction, water content and temperature of the soil (2 depths), atmospherical temperature and humidity, solar radiation, wind and rain data.

The crop model *STICS* (INRA-France) provides insight into the mechanisms of plant development, taking into account the cultivation techniques, the climatic data, and being able of working with readily available spatialized inputs (Brison et al., 1998). The daily microclimatic measurements were used to feed the crop growth model, while the environmental data (e.g. soil water content) and the biophysical variables (yields and biomass) were simulated.

The model was first calibrated to the Julius wheat cultivar. To achieve this goal, a few crop parameters were optimised on a particular data set, according to the normalized deviation and the model efficiency criteria (Beaudoin et al., 2008). Then the model was run on all combinations of soil types and applied nitrogen rates.

RESULTS AND CONCLUSION

The results of the model were in close agreement with the experimental data whatever the soil type or the nitrogen rate applicated. Global RMSE of 1,71 $t.ha^{-1}$ (9,55% against mean) and 0,59 $t.ha^{-1}$ (5,25% against mean) were respectively found for biomass growth and grain yields. Differences between observations and forescast yields were most of the time lower than the standard deviation on the measurements. Model efficiencies of 0,49 and 0,79 were obtained respectively for dry matter and grain yields.

Further study will focus on the whole N balance prediction (soil and crop exportation), in order to develop a methodology that has the potential to be used as a tool for managing the nitrogen applications (date and rates of application).

REFERENCES

Beaudoin N., Launay M., Sauboua E., Ponsardin G., Mary B. 2008. Evaluation of the soil crop model STICS over 8 years against the “on farm” database of Bruyères catchment. Europ. J. Agronomy, 29 : p.46-57.

Brisson N., Mary B., Ripoche D., Jeuffroy MH., Ruget F., Nicoullaud B., Gate P., Devienne-Barret F., Antonioletti R., Durr C., Richard G., Beaudoin N., Recous S., Tayot X., Plenet D., Cellier P., Machet JM., Meynard JM., Delécolle R. 1998. STICS : a generic model for the simulation of crops and their water and nitrogen balances. I. Theory and parametrization applied to wheat and corn. Agronomie, 18 : p. 311-346.

Houlès V., Mary B., Guerif M., Makowski D., Justes E. 2004. Evaluation of the ability of the crop model STICS to recommend nitrogen fertilisation rates according to agro-environmental criteria. Agronomie, 24 : p. 339-349.