Coupling a generic economic farm-type model and a generic crop model

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Introduction

An integrated modelling approach is proposed to assess the impacts of policy and/or environmental changes on the EU agriculture. It is based on the coupling of the STICS agronomic model and the AROPAj micro-economic model. Their genericity allows the modelling of a wide range of situations consisting of economic policy scenarios combined with various management and agro-environmental conditions. AROPAj simulates farmer economic behaviours accounting for their crop and animal production levels provided by the FADN[1] [1]. AROPAj is based on farm-types that are representative of European agriculture diversity at the regional level. STICS simulates crop growth, water and nitrogen soil balances, dynamically, using weather, soil and management inputs [2]. In this study, it is used to calculate crop yield response to nitrogen fertilization at farm-type level. The two models are linked by economically fitted response curves.

Method

STICS input parameters are derived from : (i) FADN and AROPAj for organic supplies, mineral nitrogen fertilizations and irrigations ; (ii) regional experts for other crop management data; (iii) the MARS[2] database for soil and climate parameters. STICS inputs are either pre-determined or fitted to the economic data. Within a given region, climate inputs are related to farm-types according to their altitude class ; the sowing date, fertilizer type and calendar are imposed for each crop. The following set of inputs are selected so that yield and fertilizer supplies meet economic data : soil parameters set (one out of five), preceding crop (a legume or a cereal), and variety characterized by precocity group (one out of three). The BAO-MdC software [3] combines all the inputs and launches the simulation set. A non-linear fitting procedure (SAS NLIN) provides the estimation of the parameters of the response curve, $r = B - (B - A)\, e^{-t N}$, where r is yield, and N is the nitrogen fertilizer amount [4]. Then, STICS inputs are chosen as the ones that optimize the three following criteria (ranked by increasing importance) : 1) the actual reference yield is reached, 2) the difference between the price ratio (fertilizer purchasing price w, over crop selling price p) and the derivative value for the economic optimum is minimal, 3) at the economic optimum, fertilizer rate falls within regional limits.

Results

This approach was tested for four French regions, and several crops. Here is presented the case of maize in a South-Western France farm-type. For a fertilizer amount, STICS was run thirty times (5*2*3) and simulates the yields corresponding to each input parameters sets. Figure 1 displays STICS output obtained with the input set that suited best our selection criteria in the appropriate ranking, and the fitted response curve. The dotted horizontal line

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[1] FADN : Farm Accountancy Data Network
[2] MARS : Monitoring Agriculture with Remote Sensing

representing reference yield (r0) intersects the fitted curve at the economic optimum, where theoretical (w/p) and estimated (r'(N0)) derivative are displayed. The upper regional limit considered in this case was 250 kg N ha^{-1}.

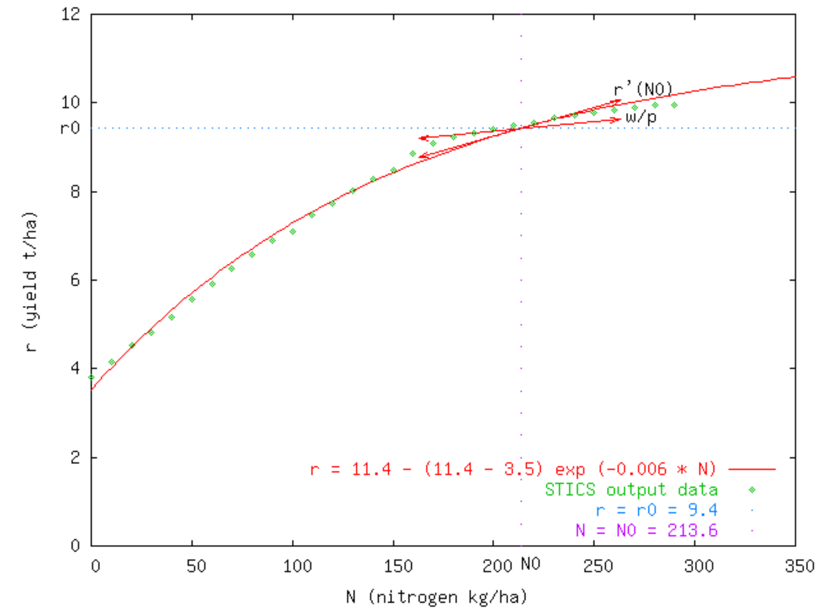

Figure 1. Nitrogen response curve for maize in South-Western France.

Discussion and conclusion

This approach of linking economic and agronomic modelling by yield/fertilizer response curves allows to precise the agronomic context of a farm-type through a soil parameter set, a variety, and a preceding crop. Further research is needed to study the extent of nitrogen application range where such a curve can be used.

The proposed method is general enough to be applied to various crops and agro-environmental and economic conditions. The economic model is given an additional sensitivity to crop management and environment parameters influencing agricultural production.

References

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