MATHS
comes onto the farm

Agriculture is already very familiar with forecasting models. For instance, the "soft wheat disease barometer" helps to detect the risk of disease and to plan interventions.

Forecasting models are increasingly available in all areas, and linked to information technology. They are integrated into various applications and are slowly transforming farmers' working practices.

In everyday life, those models can be used in many different areas, from weather forecasting and air quality monitoring in large cities to predicting road traffic congestion. The arrival of new technologies in agriculture, such as on-board sensors, drones and connected devices are opening up new modelling application possibilities, including through the acquisition of georeferenced high temporal resolution data. It is going to be possible to understand some agronomic phenomena that had not been within our reach until now. Such developments are only used directly on farms if they lead to the creation of more effective monitoring or decision tools that bring precision farming even closer, in real time, to the state of the crop in the field.

Fulfilling precise objectives

A model is established for a specific reason: to help understand the system that is being examined, to forecast its development or to optimise the way it works. For example, the STICS model developed by INRA analyses the factors that affect yield in a field of wheat. In another sector, a microorganism growth model can be used to optimise the production of a metabolite with yeast in a digester. There are different types of models. The most commonly used in agronomy involve mathematical functions. They describe certain aspects, some more complex than others, of biological systems. Those mathematical functions link up variables that need to be "explained" (like the yield of a field of wheat, for example) and parameters such as the apparent nitrogen uptake ratio. It therefore involves quantifying the impact of an explanatory variable on the variable that needs to be explained.

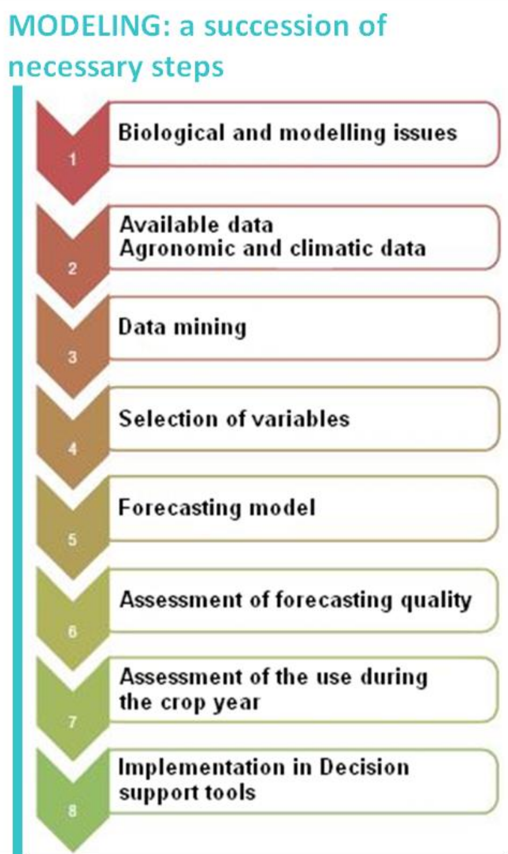


Figure 1: Schematic representation of the various steps leading to the integration of a forecast model into a decision support tool.

Specific competencies

A model is a simplified representation of reality. Before integrating it into a decision tool, it is crucial it undergoes a validation period. This stage is designed to ensure that the model delivers relevant information to the end user. However, it is important to remember that no model is perfect, and that the accuracy of the model depends on the level of forecasting error. Therefore, in the absolute, all models are erroneous: they cannot represent accurately every field situation. However, by coming close to it, they definitely help to comprehend what is happening in reality and to make decisions.

The relevance of a forecasting model depends on the quality of the data used. It must be precise, abundant enough, and cover a wide range of factors (soil, climate, cropping system…).

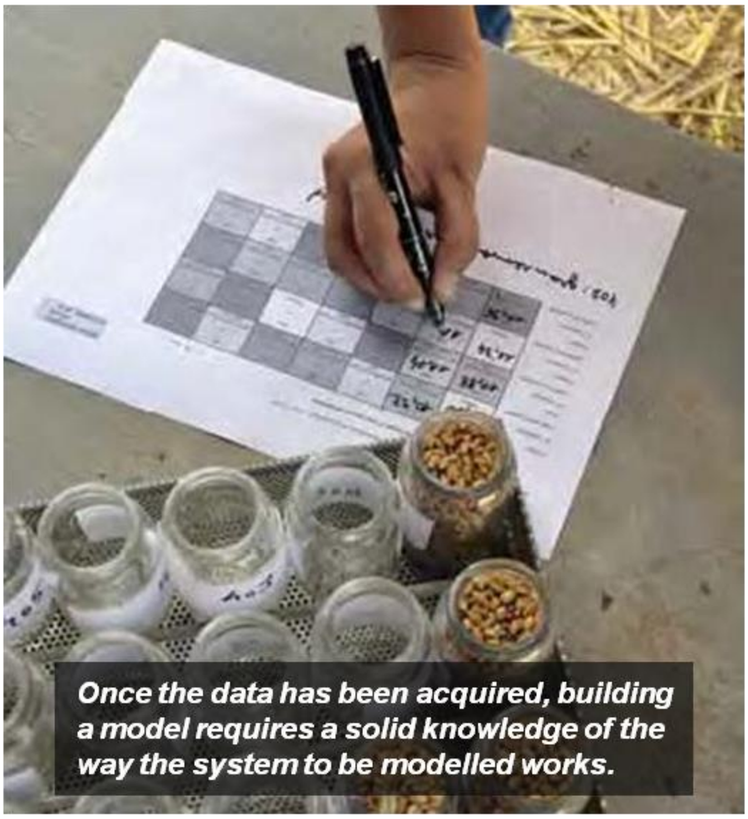
Helping with the tactical decision making process at farm level

The model integrated into the "Septo-LIS" (ARVALIS) decision support tool is already making it possible to treat a pathogen in a field before any symptom becomes visible. It determines the optimum date for the first treatment against septoria, based on the forecasted fungus development on the plant. For crop management at field level, "Farmstar" (Airbus Defence and Space, ARVALIS, Terres Inovia) combines agronomic models and satellite imaging to deliver advice on nitrogen input management.

"Myco-LIS", ARVALIS's mycotoxin risk forecasting model, helps to forecast the expected risk over the grain collection area.

For more details on those applications, go to www.arvalis-infos.fr, and click on "Mes outils" (Tools).

The arrival of "big data" *(1)* and easily accessed data through the use of sensors or "open data" *(2)* for example, makes it possible to develop and validate agronomic forecasting models. The optimisation of data that does not fit exactly the purpose of the model remains a challenge. Once data has been gathered, the construction of the model relies on a good knowledge of the system that is being modelled, as well as on drawing on the skills of experts in various fields (statistics, agronomy, IT) and having a long enough period at one's disposal. The development of a model and its implementation into a decision support tool takes between one and two years minimum. A model remains dynamic. It must also incorporate the fluctuations of a constantly changing environment (weather, new fungus strains, agronomic practices, varieties…).



Combining in-field management and a global approach

Models play an important role in a farmer's decision-making process. Those decisions either relate to long term objectives (strategic decisions), or technical interventions during the cropping season (tactical decisions). For example, when implementing integrated crop protection, a farmer must consider both types of decisions, and apply them to different time scales. Strategic decisions, taken in winter, must lead to reduced pressure from pathogens, in conjunction with agronomic choices (rotation, varieties, soil cultivation, etc.) Whereas during the cropping season, weather conditions and observations made in the fields, as well as any other information relating to pressure from bio-aggressors are going to lead to the decision to intervene, which is subject to numerous constraints, in a limited period.

« A model must incorporate the changes occurring in a constantly evolving environment »

This is when models play a crucial role. When making tactical decisions, their value plays out on several levels (insert). They help, among other things, to limit and optimise operations within a field, to adapt, or even eliminate some treatments, and to get the benefit of information otherwise difficult to access, regarding the state of the cropping system (water situation, nitrogen deficiency, etc.).

On a strategic level, models can help simulate the behaviour of a production system in certain conditions, in order to determine the best strategy to adopt. For example, the yield of a field of maize can be estimated according to various weather scenarios and with different irrigation strategies *(3)*. It is then possible to choose the strategy giving the best results over all the weather scenarios. Models are also used to study the impact of climate change on the advent or the development of pathogens. Those medium or long-term projections help and guide varietal choices, and even the choice of a cropping system.

(1)Typically, "Big data" involves handling a very high volume of varied data, including building forecasts.
(2) Open and unrestricted data, see Perspectives Agricoles n° 426, October 2015, p 61.
(3) Tool "LORA", see Perspectives Agricoles n° 421, April 2015, p. 14.

Increasing use of sensors

Digital technology is going to revolutionise crop management and the way advisors work, Farmers will increasingly be able to use decision support and monitoring tools to manage their farms. This major development is the result of several factors: the increase in cropped area per person, the comfort provided by automation, the need to prove and justify technical actions, the increasingly technologically-minded new generations of farmers, and the increasingly lower price of those technologies.

As time goes on, decision support tools will integrate more and more data from sensors, the number of which is going to increase rapidly in the next few years (sensors on-board tractors, sensor networks in the field, satellites, drones, etc.). In addition, technical references are increasingly based on variables measurable for each sensor, in order to get greater benefit from them in decision support tools, among other advantages.

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November 2015

Combined with weather forecasts, agronomic models help to anticipate the development of the cropping system.