INCREASINGLY CONNECTED equipment

One of the expected benefits is comfort, in the wider sense of the word: less strenuous work (auto steer), robots, remote control, etc.), time saving, better crop management planning and advance notice of required actions (decision support tools).

What will be new on the farm by 2025? There probably won't be a revolution, but the farming profession will evolve and crop management activity will gain in precision. Improving performance and margins is one of the challenges for the future. The development of connected tools will help achieve this.

Agriculture is currently benefiting from fast technological advances in various areas, such as the miniaturisation of smartphone sensors, automatic steering, connectivity, etc. The Internet of things offers a useful framework by segmenting data acquisition in the field, data analysis on remote servers, and redelivery of data on a terminal such as a smartphone or a tractor console, to help decision-making.

This is facilitating increasingly quick data acquisition and processing. In addition, greater automation means that cropping operations are becoming more precise. Both aspects not only complement each other but are inseparable. Ultimately, farmers will receive information relating to the state and dynamics of their land parcels, based on actual data and in real time, which is the only way this will be useful in their day-to-day activity.

> « Cropping operations are becoming increasingly precise through the development of integrated automation »

The next ten years will not revolutionise the farming profession. But over that time farmers will learn to capitalise more on technical means available in order to make tasks less strenuous and to increase precision.

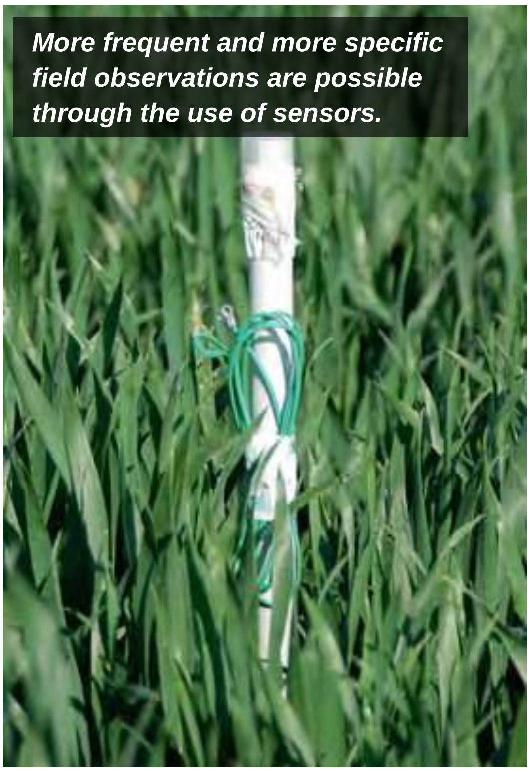
Increasingly efficient sensors

More frequent and more specific observation, including field observation, is enabling increasingly precise crop management operations. The widespread development of sensors triggered this trend. Their democratisation is the result of several factors. The integration of sensors in consumer products (cars, smartphones) has helped to dramatically reduce their cost of production. New types of miniature sensors, such as MEMS (Micro Electro-Mechanical Systems), can be produced cheaply to measure variables of interest. MEMS are also widely used in smartphones and cars (accelerometers, gyroscopes, temperature and moisture sensors). Bio-MEMS are emerging in the medical field, to help monitor blood composition in different molecules. Those cheap and low-energy miniature systems make it possible to deploy

connected sensor networks in fields for detailed crop monitoring. Measuring specific molecules in the air (volatile organic compounds such as pheromones) or in ground water (mineral nutrient content…) is becoming a real possibility.
The sensors can be fitted to tractors, drones or satellites. They can also be arranged as a static field system or be used in smartphone applications. Those different vectors must not compete with each other, but on the contrary be complementary. They must be chosen according to the type of information required, as well as to operating conditions. For example, plant detection for localised herbicide application during the intercropping season does not require the same level of detail as post-emergence weed control, where weeds need to be detected among the crop. In the first case, satellite imaging can work, whereas in the second the resolution must be within a range of a millimetre (on-board systems are best for this, on a tractor or a drone).

"Narrow band" communications

Data transfer modes have also benefitted from recent innovations. The so-called "narrow band" system based on the radio waves principle, provides cheap and low energy long distance connectivity. New specialists are positioning themselves alongside established operators in this market, and are rolling out their narrow band communication networks (Sigfox, LoRa). This helps to take greater account of the agronomic and meteorological characteristics of a parcel and of its crop to control diseases and pests for example, or to manage water or fertilisation resources.



More frequent and more specific field observations are possible through the use of sensors.

Green and grey matter

Sensors alone cannot provide useful information to the farmer. They must be linked to efficient processing algorithms in order to quickly analyse the flow of data. In addition, suitable communication systems must be in place in order to relay this data from the field to the office or smartphone. Finally, to turn measurements into advice, decision-making rules must be drawn up and validated, taking into account the sheer variety of cropping systems as well as of soil and weather conditions.
Here again, the development of new tools such as narrow band networks for data transfer *(insert)* or the increasing use of "machine learning" for weed and insect detection in fields and disease detection on leaves, is based on technological innovations. Applying those techniques in experimental conditions will help to develop and hone the precision of new management tools.
There is one last prerequisite to being able to fully utilise the data obtained and to carrying out a complete assessment of the parcel: it must be possible to combine this information with meteorological, soil and crop data. That is precisely the role of information systems, as well as the challenge they present, which must be capable of integrating data from various sources, as well as be open. The added value of the services offered will derive from the compilation of several sets of data. More services should therefore be based on interconnected data that can be shared.

The development of robots with a self-sufficient energy supply could ultimately revolutionise crop management operations.

Applied robotics

The other major source of change is the automation and robotisation of farm work. They improve comfort and precision. This type of technology is already used in agriculture, for tractors' auto steer systems, using RTK geopositioning to ensure precision during activities such as sowing, which in turn determines where machinery will run to carry out subsequent operations. The same goes for spraying, with the possibility of adjusting sprays for each boom section or even for each nozzle. The use of this type of system is increasingly popular and is routinely found on equipment. Another example is direct injection, which helps to adjust plant protection product rates based on a modulation map.

Fleets of robots in the fields

While providing the same level of work output, the simultaneous use of several smaller tractors could, among other things, be one of the solutions to the growing size and weight of agricultural machinery, which increases the risk of erosion and of damage to the soil structure. Robotic machinery could work while being monitored by a single operator sitting in a tractor that controls them all. The machines would communicate with each other to coordinate their actions and adjust to the terrain. Research work has been undertaken in this area, especially by IRSTEA (www.irstea.fr). Another benefit would be that lighter and less powerful tractors would be more likely to use renewable energy sources such as fuel cells.

The notion of fleet coordination is currently the subject of much research, aiming to synchronise the movements and operations of several tractors *(insert)*, for harvest for example. Such innovations are still heavily restricted by regulations. However, work carried out in the totally different field of driverless cars is likely to bring rapid changes to the current framework. At the moment, the large scale use of fully autonomous robots for field operations is still not a possibility. Several applications are nonetheless being studied, such as hoeing, thermal or chemical treatment, data acquisition, logistical support for equipment or product transportation, etc. Robots are increasingly being used for vegetable farming (Naïo's Oz robot) and varietal selection (Phénomobile, ARVALIS/INRA); for arable crops, however, we are likely to have to wait until around 2030.

Benoît de Solan - b.desolan@arvalisinstitutduvegetal.fr

ARVALIS - Institut du v3egetal

Mars 2016

Digitally controlled agronomy

The purpose of the "Digifermes" established on two ARVALIS experimental farms in partnership with Terres Inovia, ITB and IDELE is to assess connected tools and services under real conditions, and to evaluate the way they work as well as their reliability. One of them is dedicated to arable crops (Boigneville, near Paris), with three production systems (organic, under permanent cover, and regional objective and context). The second one is on the Saint-Hilaire-en-Woëvre (in Lorraine, North Eastern France) site with beef cattle. The work focusses on four areas: digital control of the production using existing technology, the research institutes' development of new tools, testing of tools and prototypes supplied by external companies, and opening our facilities to those businesses to enable them to test and refine their concepts.