Imagine How Agriculture may look like in 40 years!

For the first time, the 15th New Ag Conference & Exhibition held in Berlin hosted a technical session on Precision Agriculture. This reaffirms the commitment of New Ag International with this new paradigm of agriculture. Ten high calibre speakers made their way to the stage and covered most aspects of Precision Ag: The dilemma of Precision Ag scale: Is PA only viable in large-scale farming? The use of weather information in PA: Different PA solutions using remote sensing data: Integral solutions implemented in the so called Farm Management Information Systems; the farmer’s point of view on PA and, finally, why PA is not a success (yet)? Maybe Precision Ag is not the ultimate solution to agricultural problems, but it is here to stay. "In 10-15 years agriculture will be PA or it will not be!"

"PRECISION AGRICULTURE IS HERE TO STAY..."

"...and in 10-15 years agriculture will be Precision Ag or it will not be!" This key sentence was one of the main conclusions of the keynote by Prof. José A. Martínez-Casasnovas (University of Lleida, Spain), who presented a particular overview of “What’s behind the name of Precision Agriculture”. Precision Agriculture (PA) is a relatively new paradigm in agriculture and farmers and technicians are starting to ask many questions: when does PA begin to make sense? How can we start implementing PA? How can we know the causes of within-field spatial variation? Is PA the ultimate solution to agricultural problems? “The first time I heard about Precision Ag was in 2003” said Prof. Martínez-Casasnovas. "In that time I was asked to deliver a course on Precision Ag for technicians but I had never heard about that term. In 2003, and for 10 years, I had been involved in teaching and research about the application of Geographical Information Systems and Remote Sensing technologies to soil erosion mapping and land evaluation, but not specifically to agriculture or Precision Ag". Actually, the first documents about precision or smart farming or agriculture appeared about 1995 (see the Precision Ag Corner published in the November 2016 issue of New Ag International). Since then, they have exponentially grown until today. And this tendency goes on.

This, together with the aforementioned advances in technology led to define the new paradigm of Precision Ag as “the production based on the analysis of crop/soil spatial variability and its differential management to optimize returns on inputs while minimizing environmental impacts”.

WHEN PRECISION AG BEGINS TO MAKE SENSE?

This is a big question that farmers or technicians ask when commercial try to sell PA services/products or when people attend courses or conferences about PA. For example, “Is my field big enough to return the investment in PA practices? Nevertheless, what few people realizes is that PA is not only a matter of size but a matter of variability and of how this variability is spatially structured (Figure 1). Then, the question could be reformulated as: Is my field variable enough and, if so, is variability structured in a way allowing the investment in PA practices to be returned?

HOW CAN A FARM START IMPLEMENTING PRECISION AG?

One of the first options is through yield monitoring. Actually, the availability of yield monitors since the 1990s, together with the possibility of georeferenced data collection using GPS or GNSS (see the Precision Ag Corner published in March 2017), is considered by many as the starting point of PA. However, high-resolution and multi-spectral satellite images soon appeared afterwards, making it possible to map the vegetation vigour prior to the harvest and to analyse the temporal spatial variability changes in detail. In addition, the availability of multi-spectral and hyperspectral cameras onboard aeroplanes, and nowadays in drones, have allowed higher spatial resolutions and the computation of a wide range of spectral indices to know specific characteristics of vegetation (e.g. chlorophyll content, water stress). These spectral
Measuring crop spatial variability is important but more important is to know and/or understand its causes, and for that, expert knowledge (mainly agronomic) is needed.

**PRECISION NUTRIENT MANAGEMENT FOR SMALL AND LARGE SCALE FARMING SYSTEMS**

Precision nutrient management was presented in the 15th New Ag International Conference as one of the main challenges that agriculture will have to face in the short term to feed the growing world population. The presenter, one of the main world authorities in Precision Ag: Prof Raj Khosla (Colorado State University, USA). He has over 300 publications with main research focus on “Management of in-field soil and crop variability using geo-spatial technologies for precision management of crop-inputs across large and small-scale farming systems”; and, among others, founder and founding-President of the International Society of Precision Agriculture.

“We are facing global challenges and for that we need global solutions”, Prof Khosla said. However, he noticed that Precision Ag is about 25 years old but still more than 50% of the arable land in the world is fertilized by hand and this is empowering agriculture. “Can we do better than this in the 21st century?” In the last 25 years there has been a revolution in agriculture to find solutions to make better decisions. Many innovations have taken place and today we cannot imagine how agriculture may look like in 40 years from now. “Think about the GPS system and compare how a receiver was in 1976 and how it is now: less than the size of a coin!”

Prof Khosla emphasized that humans have been doing agriculture for a long time and what we are doing at present with digitalization of agriculture is just looking at it through the window of computers. All the information is in cloud servers. Any activity performed on these servers. Any activity performed on

Figure 1: Maps of properties in fields of very different size showing spatial variability. After knowing the existence of such variability, the implementation of PA practices will depend on the importance of having a homogeneous product in yield and quality and in the ratio cost/benefit. Precision Ag is not only a matter of size but a matter of the variability and how it is structured.

Figure 2: Comparison of a spectral vegetation index derived from a satellite image (Quickbird-2, 2.7 m/pixel) (left) and a yield map derived from a yield monitor in a vineyard. The maps represent averages of three consecutive years and show the similar intra-field spatial variability of both properties. Nevertheless, the images to compute the vegetation indices were acquired about one and a half months before harvest. The coefficient of correlation value (R) indicates the correlation between the spectral index and the yield and ranges from 0 to 1.

indices have shown, in most cases, the ability to predict yield (Figure 2) or even quality properties (e.g. wine grapes). Because of that, these indices are especially interesting in planning differential or site-specific actions to achieve more homogeneous yields or quality of the final product along the crop cycle. As important or more than knowing the existence of intra-field spatial variability is to know the causes.

**HOW CAN WE KNOW THE CAUSES OF SPATIAL VARIATION?**

Probably, the spatial variation is caused by different soil properties across the fields. On-the-go soil sensing through the measurement of apparent electrical conductivity is perhaps, at present, the best option to map the variation of soils with different properties, although they must be “discovered” through soil sampling in the distinct zones of variation (see Figure 1, left image). In addition, it is very important to know the history of the field, particularly in the last decades, in which agricultural land has suffered a huge transformation in many areas around the world to enlarge fields to favour mechanization.

I have a map that tells me how variable my field is (e.g. vigour, yield). Now what? This is a key question in the Precision Ag cycle that, if not properly addressed, can make PA projects fail. This is in fact the bottleneck of many service companies selling just yield or crop vigour maps, or in other words “a nice drawing of a field painted in different colours”, without any piece of advice based on agronomic expert knowledge. For this reason, Prof. Martinez-Casasnovas emphasized in his talk that “PA is rediscovering agronomy and for that agronomists with specific education in PA technologies are needed”. “We are passing from well-established uniform recommendations (e.g. a uniform dose of fertilizer, pesticide, water, etc.) to have to take decisions about site-specific recommendations based on previous knowledge of the spatial variation and its causes. This requires not only a “coloured map” but expert agronomic knowledge to integrate information about crop requirements, crop status, soils, fertilizer and other inputs characteristics”.

Precision Ag is not new in its concept, but technology now exists and is reasonable affordable for its implementation. “Be aware that benefits may be offset by the costs of adoption. So, be prudent in adopting and using PA technologies. Do not expect results overnight, just a learning curve. It may take several seasons to see and confirm expected results. Measuring crop spatial variability is
rates showed that field-specific N management could be a practical management strategy in those small-scale cropping systems. Compared with typical farmer practices, site-specific N management had the potential to save 128 kg N/ha, preventing under- or over-fertilization in these fields.

"Precision Ag is best described by five R’s: use of Right inputs, at the Right time, in the Right amount, at the Right place and in the Right manner”. Nevertheless, as Prof Khosla said, “there is NO handbook on Precision Ag out there that says you have to use complex and expensive large machines”.

Prof Khosla then captured the attention of the audience with the paradox of the average yield and variability. Usually farmers look at average yields per hectare. “However, do you know how many pixels of a yield map match the average yield of the field?” The answer…: only 2%. Actually only this percentage of pixels matched the mathematical average yield in grain field belonging to the best farmer of the 2015 in the USA. The message: “we have been looking at average numbers for too long but if we do so we are paying attention only to small parts of our fields and then we are losing money”. This, translated to management operations, such as fertilization, means that if we consider average numbers we will be over-fertilizing and/or under-fertilizing the major part of our fields, losing fertilizer, potential productivity and, definitely, money.

How large is within-field spatial variability? This could be stated as the paradox of size. A study conducted in small-scale agricultural fields of the North China Plain to determine the potential of savings in N fertilizers in wheat, demonstrated that N supply by farmers varied significantly, both within individual fields and across fields. Then, we could say that Precision Ag is not a matter of size but of natural or induced variability. Potential field-average optimum N

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However, there can be different, better low-cost solutions, that would be of interest to small-scale farming. This extends the possibilities of Precision Ag to not only developed countries and/or big farmers that can pay technology, “Precision Ag is not a solution for all the problems; it is just a tool to help us improve. Nevertheless, we need to focus on coupling human potential with machines and not technology alone”.

PRECISION WEATHER INFORMATION FOR ANY FARM

Dr Karl G. Gutbrod (CEO, Meteoblue AG, Switzerland), was exposed to Precision Ag for the first time in around 1995. “Since then, PA has been based on collecting and interpreting data on crop and

Figure 4: "The digitalization of agriculture is just looking at it through the window of computers and all the information will be in cloud servers”. Prof Raj Khosla.
soil spatial variability, mainly”. However, “we still know little about the weather”. Meteoblue forecast were initially developed at the University of Basel based on models of NOAA/NCEP. It was founded as a company in 2006, to ensure reliable operational forecasts and to better service the industry; an independent commercial computing infrastructure and product development was established. Starting in May 2008, the company offers local forecasts for more than 5 million places worldwide, using proprietary modelling to generate locally adapted forecast for surface and atmosphere.

As we all know, there are technologies for simulating weather that have been improving during the last 30 years in accuracy. For example, the site-specific forecast for 1-3 days is very good, although some inaccuracies remain (thunderstorms, precipitation amounts, micro-climate). The current accuracy for temperature forecast is about 1.5 °C, although the error increases with distance to meteorological stations. Nevertheless, and in the words of Dr Gutbrod, “agriculture has worked without weather data for more than 5,000 years”. Then, “why weather data is necessary today? For what can precise weather data be useful?” One answer is the use of simulated weather data to perform instant crop risk assessment and crop production tracking. For example, sidedress nitrogen applications in grain crops can be partially lost (25-50%) in one week if there is no rainfall after the application. This can suppose a loss of money both in N and in grain yield. In these cases, rainfall forecast may allow better planning of N application to avoid losses.

Dr Gutbrod also presented other examples of precise weather forecast to evaluate spring frost risk in fruit plantations or to predict grain yields for productivity tracking. With that, he tried to demonstrate that there is a huge opportunity of using precise weather data to add value to agriculture. The cost to serve 1 point/year with simulated and quite accurate data (e.g. 85% accuracy) is estimated in €20 (excluding the cost of distribution), which may be accessible to a wide range of farms. Finally, Dr Gutbrod aimed at starting a new era for science-based farming with weather data, as well as to make top quality weather available for every farm worldwide by 2020. “Useful weather data is there everywhere, since 1984. Use it!”

**REVOLUTION FOR PRECISION FARMING ON THE DOORSTEP-LPWA**

Pessl Instruments is a company based in Austria that has been producing measuring instruments for more than 30 years for informed decision-making. Among other: weather stations, loggers for soils moisture and hydrology, Internet irrigation controllers, frost alerts, etc. The company produces new weather stations connected in network with a new way of communication: the LPWA (Low-Power Wide Area network). Gottfried J Pessl (CEO, Pessl Instruments GmbH, Austria) said that “LPWA is a technology that is specialized for interconnecting devices with low-bandwidth connectivity, focusing on range and power efficiency. Batteries can last 10 years or more and it is a low cost technology, lower than mobile networks. With it, many things can be connected to build a system of systems”.

The first case connecting weather stations using Narrow Band in Internet of Things (IoT) was presented recently in the Mobile World Congress in Barcelona 2017. This now opens new opportunities of building a new type of Farm Management Systems (system of...
systems), which connects weather data, seed optimization, irrigation, farm equipment for description and diagnosis of what is happening, modelling a prediction and make prescriptions. In other words, a system that converts data in information to take decisions and actions.

One of the products presented by Mr Pessl was iMETOS, a weather monitoring and forecast modelling device that combines measurement of weather parameters and delivers models of 7 days localized forecast. Another product was a weather station with temperature, humidity, rainfall, global radiation and wind speed used to calculate the potential evaporation (ET0). It also incorporates a multiple volumetric soil moisture sensor with measures at every 10 cm, or a single sensor for measuring volumetric soil moisture, electrical conductivity and tempera-

“LPWA technology is predicted to be 53% of all Machine-to-Machine (M2M) connections by 2024”. This means that, with decreased power requirements, longer range and lower cost than a mobile networks, LPWA are thought to enable a much wider range of M2M and Internet of Things (IoT) applications.”

GOTTFRIED J PESSL (CEO, PESSL INSTRUMENTS GMBH, AUSTRIA)

Figure 7: iMetos. One of the products of Pessl Instruments that can work in network to provide weather data in real time and forecast modelling.

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This information is incorporated in an application (Irrimet) that provides a simple water balance. The water balance is calculated as a function of ETc, rain and rain efficiency, type and efficiency of irrigation system and irrigation events.

Other applications and services from these meteorological stations include “plant disease risk modelling”. The models are calculated with measured and forecasted weather data. “Today we are able to offer models for many tree fruits, soft fruit, vegetables and arable crops”. “Real time work tracking and alerting”, a service that allows knowing where the machines are working, which implement is attached, which weather conditions during the work and with automatic warning of abnormalities. “Crop monitoring”, with field cameras that show the field conditions, growth and weather in the fields remotely. “Insect monitoring”, with traps with built-in camera and Internet connection, to determine the best spray date. “Realtime 4D crop growing decision support eco-system”, with full integration of satellite imaging (optical, radar, climate monitoring); local ground weather monitoring and forecasting; plant and insect monitoring; and soil (moisture, fertility) and irrigation monitoring.

After all, the idea is to provide end-to-end solutions based on local networks of connected sensors in the field, which transfer the data to supra-network infrastructures to serve the end user segment. This allows different types of business solution concepts: independent farm solutions, private network platform solutions or country network platform solutions that the company with local partners can offer.

Figure 8: The main components of Planet’s Monitoring solution and their main features based on different constellations of satellites, included the own PlanetScope. “The most important fact to consider is that this daily and updated data may enable immediate action”. We create natural solutions tailor-made to your crops. Try it!