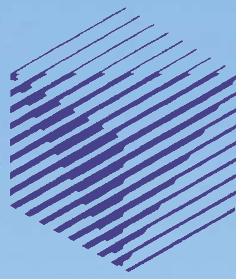


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Special theme:

Smart Farming



Also in this issue:

Research and Society:

Research Evaluation

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annotated (bottom-left side). Both these activities are supported by the controlled vocabulary that allows their representations to be semantically enriched. The added semantics allows logics to process these data structures in order to cross-reference them and compute the dashboard on the right-hand side of the Figure.

The dashboard presented here is implemented as a component of the SOA being developed in the SATFARMING project; hence it is readily available via the mechanisms defined by SOA. As an example, the component could be exploited for dissemination of PA knowledge (models, workflows and

products) from PA-savvy agronomists to agronomists in developing countries who do not have first-hand experience of these techniques. Agronomists with expertise in this area may define the flow leading to a given PA product so that an inexperienced agronomist can understand, by using the dashboard, which data and processing are required to achieve the final PA product. This is in line with the United Nations 2030 Agenda on Zero Hunger Goal which aims to: 1) ensure sustainable food production systems, 2) implement resilient agricultural practices that increase production, and 3) improve agricultural productivity of small-scale food producers.

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Please contact:

Simone Lanucara, CNR-IREA, Italy
+39 3496082982
lanucara.s@irea.cnr.it

Integrating Agronomic Knowledge into Precision Agriculture

by Marco Napoli, Anna Dalla Marta, Marco Mancini and Simone Orlandini (University of Florence)

Technology is increasingly being used to make farming processes more efficient. We are integrating agronomic knowledge and precision farming techniques in order to achieve an adequate agronomic planning at the farm or consortium level and then to transfer this knowledge to farmers, facilitators and farm advisors.

Modern agriculture is based on the control of in-field variability, which is determined by the interactions of numerous factors such as soil, climate and crop. However, growing areas in Italy are often characterised by a high heterogeneity in pedological, orographic and climatic conditions. This variability can be seen at a small scale, within fields of a few hectares, which results in highly variable grain yields and quality, posing a challenge for agronomic planning at the farm or consortium level. Furthermore, some limitations (e.g., too shallow soil or clayey soils) cannot be amended for technical or economic reasons and in these cases, it would be appropriate to limit inputs in function of the expected potential yield. Nevertheless, sometimes in an effort to improve the quantity and quality of yield in low productivity areas, farmers increase the chemical and energetic input rate without a real agronomic or economic justification. Therefore, understanding the causes and the spatial extent of poor performing areas, of agronomic options and of potential production can provide farmers with tools to evaluate and implement appropriate management techniques.

Our study focusses on wheat and the area is located between the Val d'Orcia and the Val d'Arbia, two rural areas of Tuscany (Central Italy), characterised by a typical Mediterranean climate (13.6 °C and 715 mm of annual average temperature and cumulated rainfall, respectively) and fine-textured soil. The "Department of Agrifood Production and Environmental Sciences of the University of Florence (DISPAA)" and the "Siena Provincial Agricultural Consortium (CAPSI)" have been carrying out these activities since 2009, as part of the projects "Precision farming for the Tuscany pasta producers (APPCoT)" and "Old wheat varieties – New cultivation techniques (GRANT)" which were partially funded by the Rural Development Plan of Tuscan Region 2007–2013 and 2014–2020, respectively.

In Central Italy, wheat is usually fertilised by two applications of nitrogen (N) as a function of vegetation vigour and expected yield potential of the field; one following tilling and the second just before the end of stem elongation. Owing to the in-field variability, the potential patterns of yield, as observed

over several seasons, cannot reliably drive N fertilisation. On the contrary, crop vigour monitoring allows the crop yield potential to be predicted for each sub-area, thus enabling a site-specific distribution of the fertiliser with positive implications for both economic and environmental sustainability.

For this reason, some Tuscan farmers, with a pioneering spirit, wired and equipped their combine harvesters and tractors with Trimble GPS sensors and computers for parallel driving. Moreover, a Real Time Kinematic (RTK) positioning was installed to enhance the precision of position data derived from satellite-based positioning systems. Combines were further equipped with yield monitoring sensors to measure and record information such as grain flow and moisture, area covered and location (Figure 1). Kuhn fertiliser spreaders, fitted with an electronic control box and actuators controlling the outlets, were adopted, so the fertiliser flow is automatically adjusted depending on the forward speed. DISPAA calculated vegetation indices, based on the RapidEye satellite images (resolution of 5×5 m), which



Figure 1: Combines equipped with yield monitoring sensors for measuring and recording information such as grain flow and moisture, area covered and location.

carried a multi-spectral sensor recording radiance in five broad bands of the electromagnetic spectrum. Two satellite images were acquired annually at the end of wheat tilling and during stem elongation, for timing the first and the second top-dressed fertilisation, respectively [1]. Moreover, to produce prescription maps for vari-

able-rate fertiliser application, the CERES-wheat model simulations were performed to identify the appropriate fertiliser rate to optimise grain yield [2] and the grain protein concentration [3] as function of both the field zonal characteristics and the seasonal meteorological forecasts. These prescription maps are then transferred to

farmers through the CAPSI's farm advisors to distribute the fertiliser.

The tests carried out in recent years have shown that it is possible to optimise fertilisation to achieve good production results and at the same time reduce the economic and environmental costs associated with inappropriate distribution of fertilisers.

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Please contact:

Marco Napoli
 Department of agrifood production and environmental sciences of the University of Florence
 Piazzale delle Cascine 18, 50144, Florence, Italy
 +39 0552755746
 marco.napoli@unifi.it

Farming with Mathematical Precision

by Simon van Mourik, Peter Groot Koerkamp and Eldert van Henten (Wageningen Universiteit)

A key challenge in precision farming is complex decision making under variable and uncertain circumstances. A possible solution is offered by mathematical models and algorithms.

The enormous quantities of fertiliser, pesticides, fresh water, and fossil fuels that have been used in modern farming over the last century have had an enormous impact on the local and global environment. Furthermore, resources such as fresh water, phosphate, oil, and affordable labour are getting scarce. This situation is not sustainable, especially given the rapid growth of the world population.

In our group we research precision farming, a farm management approach

that uses information and precision technology to address these sustainability issues; firstly by automation to save on labour input, and secondly by precision management to save on resources, and reduce environmental impacts. The term precision in this context reflects accurate dosage of resources, the timing with which they are applied, and sometimes even how these dosages are allocated; for example feeding per individual animal or fertilising at specific field locations.

We apply the precision farming approach in a range of agricultural settings, for example in arable farming, greenhouse horticulture, and livestock farming. Well known applications are milking robots, automated irrigation, air conditioning, and individual cow feeding. However, most aspects of management are not yet automated or precise. Identifying what is the optimal dosage, timing, and allocation is complicated for a number of reasons. The response of crops, animals, indoor cli-