PhD School on Agriculture, Environment and Bioenergy

(http://sites.unimi.it/dottorato_aab/)

(XXXV cycle, 2019-21)

Project draft

1. Field of interest

AGR/02 - Agronomy and field crops. Precision agriculture. Conservation agriculture. Cropping systems models. Remote sensing.

2. Project title

Modelling of sustainable cropping systems (Precision and conservation agriculture)

3. Tutor: Marco Acutis

Co-tutor Alessia Perego

4. Relevance of the topic and state of the art (2000)

Precision and conservation agriculture are two important forms of agriculture that can improve the sustainability of cultivation. For this reason, there is an increasing interest in their application. Precision farming analyses the spatial and temporal variability of soil, crop and atmosphere, and applies spatially- and temporally-variable inputs, with the aim of reducing costs and increasing resource efficiency in crop cultivation (Lindblom et al., 2017). Conservation agriculture aims to preserve soil fertility by conserving water and organic matter in the soil (Giller et al., 2015); it is based on crop rotation, residue retention, minimum soil perturbation (i.e. no till or vertical tillage) and cover crop cultivation. Both types of agriculture can benefit from technologically advanced tools such as simulation modelling and remote sensing.

Cropping systems simulation models (e.g. Perego et al., 2013) reproduce the complex interactions of soil, crop and atmosphere in a computer program, and estimate agronomic and environmental variables, like crop yield, and components of carbon, nutrient and water budgets. Models can be used for a variety of purposes: to understand experimental measurements and to evaluate hypotheses about the system under study; to explore the effect of variable inputs like future weather conditions or different soil types within a region; to estimate what cannot be (easily) measured, such as when alternative management scenarios are compared; to rank the importance of environmental or management factors in influencing response variables and in the analysis of cropping system options for adaptation and mitigation of climate change. In precision farming, models can be used to quantify to what extent management and environmental factors affect the spatially variable agricultural productivity, and thus to identify homogeneous management zones. For this reason, they can provide valuable support to prepare prescription maps that dictate the amount of spatially variable inputs like water, nutrients, seed, or even tillage that need to be applied (Basso et al., 2001; Batchelor et al., 2002). In conservation agriculture, models can help to quantify important bio-physical effects of alternative soil management methods (tillage, cover crops, crop rotation), namely: soil water content, soil temperature, carbon and nitrogen turnover, and their impacts on crop growth and development (Powlson et al., 2014)

Remotely sensed information actually freely available and with metric spatial resolution about soil and crop status can be used as input for models and in forcing and assimilation procedures, thus increasing the possibility of their spatially variable application.

5. Layout of the project

5.1. Materials & Methods (2000)

The PhD project will make use of the ARMOSA simulation model (Perego et al., 2013), developed at the University of Milano.

These are the main activities that will be carried out during the project:

- Improvement of the ARMOSA model for soil carbon dynamics and gaseous emissions.
- Application of the model to identify the limiting factors in various sites in a test field, and to identify homogeneous management zones. This activity will involve the use of historical yield maps, multi-annual weather data and remote sensed images.
- Development of an algorithm to calculate a nitrogen prescription map.
- Field evaluation of nitrogen prescription maps obtained with different methodologies and different data sources, including the one developed in the previous point.
- Evaluation of the effect of conservation practices and precision agriculture for carbon sequestration.

5.2. Schedule and major steps (3 years) (2000)

- First year: quantitative bibliographic analysis on conservation and precision agriculture (preparation of a publication). Learn how to use, calibrate and validate a cropping system model, and how to use remote sensing images.
- Second year: improvement of cropping system model and validation in the field of its performance. Development of the procedure for multi-site, multi-year prescription maps. (2nd publication).
- Third year: validation of prescription maps; model analysis of options for improvement of cropping system management under actual and future climates (3rd publication); writing of the PhD thesis.

6. Available funds (source and amount)

H2020 LANDSUPPORT (Horizon 2020, European Union): 398,590 euro (principal investigator Dr. Alessia Perego).

7. Literature (max 10 citations)

Basso, B., Ritchie, J.T., Pierce, F.J., Braga, R.P., Jones, J.W., 2001. Spatial validation of crop models for precision agriculture. Agricultural Systems 68, 97–112. doi:10.1016/S0308-521X(00)00063-9

Batchelor, W.D., Basso, B., Paz, J.O., 2002. Examples of strategies to analyze spatial and temporal yield variability using crop models. European Journal of Agronomy, Process Simulation and Application of Cropping System Models 18, 141–158. doi:10.1016/S1161-0301(02)00101-6

Giller, K.E., Andersson, J.A., Corbeels, M., Kirkegaard, J., Mortensen, D., Erenstein, O., Vanlauwe, B., 2015. Beyond conservation agriculture. Front Plant Sci 6. https://doi.org/10.3389/fpls.2015.00870

Lindblom, J., Lundström, C., Ljung, M., Jonsson, A., 2017. Promoting sustainable intensification in precision agriculture: review of decision support systems development and strategies. Precision Agriculture 18, 309–331. https://doi.org/10.1007/s11119-016-9491-4

Perego, A., Giussani, A., Sanna, M., Fumagalli, M., Carozzi, M., Alfieri, L., Brenna, S., Acutis, M., 2013. The ARMOSA simulation crop model: overall features, calibration and validation results. Italian Journal of Agrometeorology 3, 23–38.

Powlson, D.S., Stirling C. M., Jat M.L., Gerard, B.G., Palm, C.A., Sanchez, P.A., Cassman, K.G., 2014. Limited potential of no-till agriculture for climate change mitigation. Nature Climate Change 4, 678–683.