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. Conservation agriculture. Cropping systems models.

2. Project title

"X-COVER - Innovazioni per estendere l'uso delle colture di copertura in Lombardia" ("Innovations to extend cover crop use in Lombardy")

3. Tutor

Luca Bechini

4. Relevance of the topic and state of the art

Cover crops are cultivated in between two cash crops for agronomic and environmental purposes (Thorup-Kristensen et al., 2003). Cover crop biomass is not harvested, but left on the soil surface or incorporated in it (green manure). Cover crops benefits include: reduction of nitrate leaching (catch crops) (Tonitto et al., 2006), increase of soil organic matter content (Poeplau and Don, 2015), improvement of soil structure, reduction of weed growth, increase of nutrient availability for the following cash crop and of its yield (Marcillo and Miguez, 2017).

Two factors currently limit the adoption of cover crops in northern Italy: 1) seedbed preparation and sowing require the investment of resources (time and money; in total, between about 100 and 200 €/ha) that are considered not negligible by most farmers; moreover, the scheduling of cover crop sowing, which need to be carried out as soon as possible to maximize its growth (Justes, 2017), may conflict with other farm operations like the harvest of summer crops; 2) information about the effects of pure species and mixes of cover crops is still scarce in our environments, in particular regarding their growth potential and their effects on the subsequent cash crop.

The objectives of this PhD project therefore are:

- To contribute to reduce the cost and the time needed to prepare the seedbed and to plant cover crops. This objective will be reached by testing in the field an innovative prototype of sowing machine that allows to carry out planting together with other operations (grain harvest, residue chopping, manure distribution, and mechanical weeding).
- To produce knowledge for supporting the choice of cover crop species and mixes, together with their sowing and termination dates, in different areas. This objective will be achieved through classical field experiments in two sites and via the application at the Regional scale of a cropping systems simulation model. The model will allow, by simulating dinamically the processes of the soil-crop system, to extend in time and space the experimental results obtained in the field.

5. Layout of the project

5.1. Materials & Methods

Innovative sowing. An innovative prototype of sowing machine that can be coupled with different machines will be developed by Condifesa Lombardia Nord-Est. This prototype will be used to plant pure cover crops in the field. Sowing operations coupled with manure distribution, residue chopping, and maize harvest will be carried out in September. Sowing coupled with mechanical weeding will be carried out in June. In the first three cases, the field experiment will involve the comparison, for two cover crop species, of the sowing made with the innovative prototype and with a traditional seed drill. In the fourth case (sowing carried out with mechanical weeding at about the six-leaf maize stage, i.e. interseeding) the control will be a no-cover crop treatment. A randomized block design will be adopted in all experiments. To compare the treatments, cover crop density (taken as an indicator of crop emergence) will be measured about 15, 30 and 45 days after cover crop sowing in all experiments. Moreover, cover crop biomass will be measured 60 days after sowing. In the interseeding experiment, the interaction between cover crop and maize will be measured until maize harvest. Cover crop growth after maize harvest will be measured in November.

Species and mix comparison. Another set of 3-year field experiments will be started in two sites, with the purpose of comparing pure species and mixes with a no cover crop control. For both sites these are the main management events during the three years: soil sampling and installation of weather stations (only first year); set up of experimental plots; cover crop sowing; if needed, cover crop irrigation and pest control; cover crop termination; cash crop sowing; cash crop management and harvest. These measurements will be carried out to compare the relevant agronomic and environmental effects of species and mixes: cover crop density, biomass and N uptake; concentration of soil mineral N; weed growth and N uptake; soil penetration resistance; cash crop residue decomposition; cash crop productivity and N uptake.

Modelling. A cropping systems simulation model (ARMOSA: Perego et al., 2013) will be used to simulate cover crops. With a daily time step, ARMOSA simulates water, carbon and nitrogen (N) budgets in the soil, and the growth of arable crops ARMOSA was calibrated with regional and European datasets in various management scenarios (Sándor et al., 2015; Pirttioja et al., 2015; Groenendijk et al., 2014). ARMOSA will be specifically calibrated for cover crops using a database of experiments carried out in northern Italy (including those obtained in the current project). Later on, cover crop management scenarios will be compared using the model. Model outputs of agronomic interest will be N dynamics (N uptake by cover crops and their subsequent mineralization; nitrate leaching), winter-killing of cover crops; soil status at the end of the winter (before cash crop sowing) in terms of water content, temperature and soil mineral nitrogen concentration, and cash crop yield.

5.2. Schedule and major steps (3 years)

- Experiments of innovative sowing will start in June 2020 and September 2020, and will be repeated in June 2021 and September 2021.
- Experiments to compare mixes and species will start in October 2019 and will continue until the end of the project in September 2022.
- Modelling will start during the second half of the first year and will continue until the end of the project.

The following GANTT chart provides more details about the timing of the activities.

Area	Activity	Year 1				Year 2				Year 3			
		Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep
Innovative sowing	Plot preparation; sowing			X	X			X	X				
Innovative sowing	Soil and crop sampling			X	X	X		X	X	X			
Innovative sowing	Soil and crop analysis			X	X	X		X	X	X			
Innovative sowing	Statistical analysis						X				X		
Species and mix comparison	Plot preparation; sowing; management	X	X	X	X	X	X	X	X	X	X	X	X
Species and mix comparison	Soil and crop sampling	X	X	X	X	X	X	X	X	X	X	X	X
Species and mix comparison	Statistical analysis		X		X		X		X		X		X
Modelling	Database preparation			X									
Modelling	Model development and calibration				X	X	X	X					
Modelling	Scenarios simulation at the regional scale						X	X	X	X	X	X	X

6. Available funds (source and amount)

VALERIE (FP7, European Union): € 146.951,06 (principal investigator Prof. Luca Bechini).

7. Literature

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