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Modeling the effect of alternative agro-ecological service crops termination and tillage strategies on SOC and GHG emissions in five European organic vegetable systems in future climates

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Short abstract *(50 words)*

Two agro-ecological service crops termination techniques and tillage strategies (i.e. tilled green manure and no-tilled roller crimper flattening) were compared in European organic vegetable systems (Italy, Spain, Estonia, Slovenia, Denmark) for Soil Organic Carbon stock change and GreenHouse Gas emissions, in a 30 years perspective under climate change scenarios.

Extended abstract *(750-1000 words)*

In organic farming, the use of alternative tillage regimes and of agro-ecological service crops (ASC), commonly known as cover crops, may promote the whole soil-plant system equilibrium, influencing soil, air and water quality, weeds abundance, and pests and diseases incidence (Canali et al., 2015). Traditionally the ASC is terminated and incorporated into the soil by green manure (GM). Nevertheless, alternative ASC termination techniques such as no-tilled - roller crimper flattening (RC) are receiving increasing interest and are considered a feasible management strategy in some regions. In the framework of the SOILVEG project (EU Core Organic Plus), the effect of two ASC termination techniques, i.e. GM and RC, on SOC dynamics, nitrogen cycling, and GHG emissions in five European organic vegetable systems was tested by modelling. Field data were used to calibrate and validate the Environmental Policy Integrated Climate (EPIC) model that was subsequently used to predict the effect of the two alternative ASC management strategies under climate change scenarios on selected agro-environmental indicators.

The sites included in the experiment were:

1. Metaponto (Italy), where the ASC was grown in the summer season followed by cauliflower (*Brassica oleracea* L. var. *botrytis*) as winter cash crop;
2. Pivola (Slovenia), where ASC was grown in the winter season followed by white cabbage (*Brassica oleracea* L. var. *capitata*) as summer cash crop;
3. Aarslev (Denmark), where the ASC was grown in the winter season followed by pointed-headed cabbage (*Brassica oleracea* L. convar. *capitata* (L.) Alef. var. *conica* DC) as summer cash crop;
4. Jõgeva (Estonia), where ASC was grown in the winter season followed by white cabbage (*Brassica oleracea* L. var. *capitata*) as summer cash crop;
5. Gallecs (Spain), where ASC was grown in the winter season followed by savoy cabbage (*Brassica oleracea* L. var. *sabauda*) as summer cash crop.

In all sites a control treatment was set up without ASC and with tillage (no ASC), and three replicates of RC and GM treatments were carried out. The EPIC agroecosystem model is extensively applied at field-scale, tested in many pedo-climatic conditions (Farina et al., 2011), and simulates

crop production as a function of weather, soil conditions, and management practices (Williams et al., 1984). The EPIC model v.0810 (Gerik et al., 2014) was selected because it has been widely and successfully used for assessing the effects of management on crop productivity, soil water balance, and SOC and N dynamics in a range of environments and agricultural systems (Farina et al., 2011 and references therein). EPIC has eight major components (i.e. modules on weather generation, crop growth, soil water dynamics, erosion, nutrient and carbon cycling, soil temperature, tillage, and soil-crop management), and operates on a daily time step for short- and long-term predictions. Simulated processes include the effects of tillage, fertilizer and irrigation on crop yield and soil agro-environmental quality (surface residue, soil bulk density, and biogeochemical cycles) in the considered crop rotations and cropping systems. Required inputs for the model are: management (tillage, irrigation volumes, amount of fertilizers distributed, and operation scheduling), soil and weather data, and crop growth data, such as plants density and crop growing period. Outputs are crop yields, nutrient and water cycling, and GHG emissions. Three different climate scenarios were used to run the model for long-term assessment. The climate scenarios were generated by General Circulation Models (GCMs) from a consolidated daily weather dataset with a grid of 25x25 km. The GCMs were: (1) METO-HC (METO); (2) DMI-HIRHAM5-ECHAM5 (ECHAM); and (3) ETHZ-CLM-HadCM3Q0 (ETHZ). Each GCMs climate was run for two-time projections (TPs), for 30 years. The TPs chosen were: (i) "2000" for the baseline (BL), representing mean climate change for the period 1985–2014; and (ii) "2030" for climate change (CC) predictions, representing mean climate change for the period 2015-2044. Atmospheric CO_2 concentrations, for the considered periods, were 400 ppm for BL and 450 ppm for CC. Data and detailed description of the dataset used are available at MARS-AGRI4CAST website (http://agri4cast.jrc.ec.europa.eu/DataPortal/Index.aspx?o=d).

In the trials, the simulation results included yields, SOC change, nitrate leaching, N_2O and CO_2 emissions for RC ASC termination strategies compared with the traditional GM and no ASC treatments. Moreover, data were expressed as relative change of future climate scenarios in respect to current climate. The precision and accuracy of the predictions were evaluated using statistical metrics. The model simulation, validated with measured biomass (for ASC) and yields (for cash crops), proved to be able to mimic the considered systems. Moreover, the EPIC model was able to discriminate, also in the long-term, all the considered treatments.

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