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Modeling the potential adaptation of organic horticultural systems to climate change scenarios in Southern Italy

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Short abstract *(50 words)*

Adaptation practices are crucial to reduce future severity of climate change impacts on food production. An innovative long-term experimental device was set up in an organic horticultural system of Southern Italy to assess the best synergistic combination of a set of agro-ecological techniques as potential adaptation strategies to climate change.

Extended abstract *(750-1000 words)*

Agriculture is highly sensitive to interannual climate variations and climate extremes (e.g., changes in temperature, droughts and floods), which are the main causes of crop yields reduction and yield stability decrease, thus affecting food production and security (Altieri et al., 2015). To be sustainable, agro-ecosystems need to be resilient both to abiotic (climatic variability) and biotic (disease and pests) stressors. Therefore, their adaptation to extreme climate events can be obtained by adopting different agro-ecological management strategies (e.g., cover crops introduction in crop rotations, organic fertilization, etc.). These practices increase the system complexity and perform different ecological services (then cover crops can be named agro-ecological service crops – ASC) such as recycling of nutrients, regulation of microclimate and local hydrological processes (Diacono et al., 2016). The positive effect of agro-ecological strategies to sustain agricultural production and to promote environmental protection is well acknowledged. Nevertheless, to empower the use of ASC in sustainable farming systems, research activities should be encouraged. Thus, in the MITIORG innovative long-term experimental device, set-up at ‘Azienda Sperimentale Metaponto’ of the Research Centre for Agriculture and Environment (CREA-AA; lat. 40°24’ N; long. 16°48’ E), different combinations of agro-ecological techniques such as soil surface shaping, crop rotations and ASC termination were tested. The aim was to identify the potential adaptation strategies for organic horticulture in Mediterranean environment using EPIC model under future climate change scenarios context. Since 2014, the field experiment was set-up combining the following functionally integrated techniques: (i) soil hydraulic arrangement (i.e. soil surface shaping as a kind of ridge system and furrow strips); (ii) crop rotations; (iii) ASC introduction in order to protect the soil from erosion and provide N via biological fixation; iv) ASC termination techniques; and (v) organic fertilization strategy in order to maintain or increase long-term soil fertility. Vegetable crops and ASC are cultivated on the top of both ridges and furrow strips (2.5 m wide each). In the furrow strips, crop rotation was set-up to avoid cash crops, i.e. tomato (*Solanum lycopersicum* L. cv. Donald), zucchini

(*Cucurbita pepo* L. cv. President) and lettuce (Lactuca sativa cv. Romana) cultivation in the winter-rainy period because the strips could be waterlogged in the case of temporary flooding (heavy rain). Thus, an ASC mixture of legume and cereal crops (potentially resistant to temporary water excess) is cultivated in this period as break crops. The ASC is terminated either as green manure (GM) or by the no-till roller crimper technique (RC) before the transplant of the next summer cash crops. On the top of the ridges, a leguminous ASC (crimso clover, *Trifolium incarnatum* L.) is living mulched in the winter vegetable crops, i.e. cabbage (*Brassica oleracea* L.), fennel (*Foeniculum vulgare* Mill. cv. Tiberio), and tomato (*Solanum lycopersicum* L. cv. Donald) and maintained as a living ground cover throughout its cycle, controlling its growth by mowing. In both ridges and furrow strips, the tested treatments (ASC + organic fertilization) were compared with an unfertilized control in which ASC was not sown and the soil was tilled before cash crops transplanting. Three replicates per each treatment were carried out. The EPIC agroecosystem model simulates crop production as a function of weather, soil conditions, and management practices (Williams et al., 1984). It is extensively applied at field-scale and tested in many pedo-climatic conditions. EPIC operates on a daily time step for short- and long-term predictions and it is composed by the following eight main modules: weather generation, crop growth, soil water dynamics, erosion, nutrient and carbon cycling, soil temperature, tillage, and soil-crop management. Required inputs for the model are: management, soil, weather, and crop growth data. Prediction processes investigate the long-term effects of the agro-ecological strategies on crop yield, soil carbon and nitrogen dynamics, and greenhouse gas emissions. EPIC was run under different climate scenarios, generated by General Circulation Models (GCMs) from a daily weather dataset with a grid of 25 km^2. The GCMs were: METO-HC (METO); DMI-HIRHAM5-ECHAM5 (ECHAM); and ETHZ-CLM-HadCM3Q0 (ETHZ). Each GCMs climate was run for 30 years, considering the following two-time projections: "2000" for the period 1985–2014, representing the mean climate change for the baseline (BL); and "2030" for the period 2015-2044, representing the mean climate change for climate change predictions (CC). Atmospheric CO_2 concentrations, for the BL was set to 400 ppm, while for the CC was set to 450 ppm. The dataset used is available at MARS-AGRI4CAST website (http://agri4cast.jrc.ec.europa.eu/DataPortal/Index.aspx?o=d). The model was calibrated and validated using measured biomass (for ASC) and yields (for cash crops). Subsequently EPIC was used to predict agro-ecological strategies effect under long-term climate change scenarios on selected agro-environmental indicators, which include yields, SOC change, nitrate leaching, N_2O and CO_2 emissions. The climate change simulation results were expressed as relative change of CC scenarios with respect to the BL. Our findings comparing measured and predicted values, suggest that: (i) ASC termination techniques and organic fertilization, positively influenced cash crop performances (crop yield and biomass); (ii) soil fertility varied over the growth stage and the cash crop type; (iii) EPIC model accurately predicted crop yield, discriminating differences among treatments in the considered systems; (iv) EPIC model was able to discriminate the tested strategies in the long-term also in terms of GHG emissions, as confirmed by the statistical metrics used to assess the precision and accuracy of the predictions.

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