Past Experience Supports Future Choices for Cropping Systems Management: The Italian Long-Term Agro-Ecosystem Experiments (LTAE) through the IC-FAR Project and the MaGGnet International Network

I. Iocola[1], D. Antichi[2], B. Basso[3], A. Berti[4], L. Doro[5], C. Grignani[6], A. R. Kemanian[7], M. Mazzoncini[2], L. Mula[1], R. Orsini[8], G. Seddaiu[1], F. Tei[9], D. Ventrella[10] and **P. P. Roggero**[1]

(1) University of Sassari, Italy, email: *pproggero@uniss.it* (2) University of Pisa, Italy (3) Michigan State University, MI (4) University of Padova, Italy (5) Texas Agrilife Research- Blackland Center, Temple, TX (6) University of Turin, Italy (7) Pennsylvania State University, University park, PA (8) University of Marche, Italy (9), University of Perugia, Italy (10 CREA-SCA, Bari, Italy

Introduction

MAGGnet (Managing Agricultural Greenhouse Gases Network), formed under the GRA Croplands Research Group (Liebig et al, 2016; *Carbon Manag*), is a global network which serves as a foundation for inventory and analysis of GHG mitigation and soil C sequestration experimental research. Currently, **315 experimental studies are included in MAGGnet** (Table 1).

The Italian IC-FAR project network (www.icfar.it) is contributing to MAGGnet with a partnership managing now **20 long-term agro-ecosystem experiments (LTAEs) in 10 different locations across the Italian peninsula and islands** (Figure 1). Most of the LTAEs were started many decades ago but are still useful to support the agronomic research challenges posed by climate change (CC) (Roggero, 2016; Eur J Agron).

The hypothesis underlying this effort is that such experimental networks provide a valuable source of field experimental evidence to be effectively used to support effective options for CC mitigation or adaptation through crop modelling tools.

Figure 1 – Location of the Italian LTAE network contributing to MAGGnet

Table 1 – current status and duration of studies included in MAGGnet

Country	No. of studies	Status: Completed	Status: Ongoing	Duration: 1-3 yr	Duration: 3-10 yr	Duration: > 10 yr
Argentina	10	4	6	8	1	1
Australia	16	16	0	16	0	0
Brazil	8	8	0	8	0	0
Canada	12	11	1	11	0	1
CostaRica	1	1	0	1	0	0
Denmark	5	2	3	0	0	5
Finland	12	12	0	8	4	0
France	104	90	14	95	8	1
Germany	15	15	0	14	1	0
Indonesia	2	2	0	2	0	0
Ireland	7	7	0	2	5	0
Italy	19	0	19	1	4	14
Japan	9	4	5	2	2	5
Korea	1	0	1	0	1	0
New Zealand	2	1	1	1	1	0
Spain	12	3	9	3	9	0
Switzerland	10	6	4	0	3	7
United Kingdom	36	36	0	35	0	1
United States	30	15	15	6	15	9
Uruguay	4	0	4	1	0	3
Total	315	233	82	214	54	47

Materials and Methods

The LTE datasets were used to understand the interactions of the long-term interactions between crop management, climate and the agroecosystem. As an example, we illustrate in this poster the methods applied to a **dataset from the AN site** (Seddaiu et al 2016 Eur J Agron) characterized by a rainfed two-year durum wheat -maize rotation:

1. **Recursive Partition Analysis (RPA)**. The **regression tree function *ctree*** available in the R package was used to **explore the interannual variation of crop yield as influenced by a range of meteorological and management variables**. RPA explores the structure of a dataset, developing decision rules for predicting a variable. Regression trees are constructed by recursively splitting the response variable (e.g. grain yield) into two groups on the basis of the explanatory variables so as to minimize variability within a group and maximizing variability between groups. At the end, the terminal nodes (leaves) are characterized by the mean values of the response variable, each followed by a P value indicating the significance of its splitting;
2. **Crop modeling**. The LTE database was used to **calibrate several simulation models** (DSSAT, EPIC, SALUS, CropSyst, CSS, Cycles, RothC) to simulate the impact of CC on soil organic C (SOC).
3. **Climate scenarios**. Climate scenarios were generated applying a statistical model, based on Canonical Correlation Analysis to the predictors of **CMCC-CM global model** to obtain temperature and precipitation at local scale over the **period 1971-2000** (**ContrRun**) and **2021-2050** (**RCP45 and RCP85 emission scenarios**). The impacts of climate change on both SOC and crop yields were assessed using the **Multi-Model (MM) Mean** obtained by the ensemble of the calibrated models.

Results

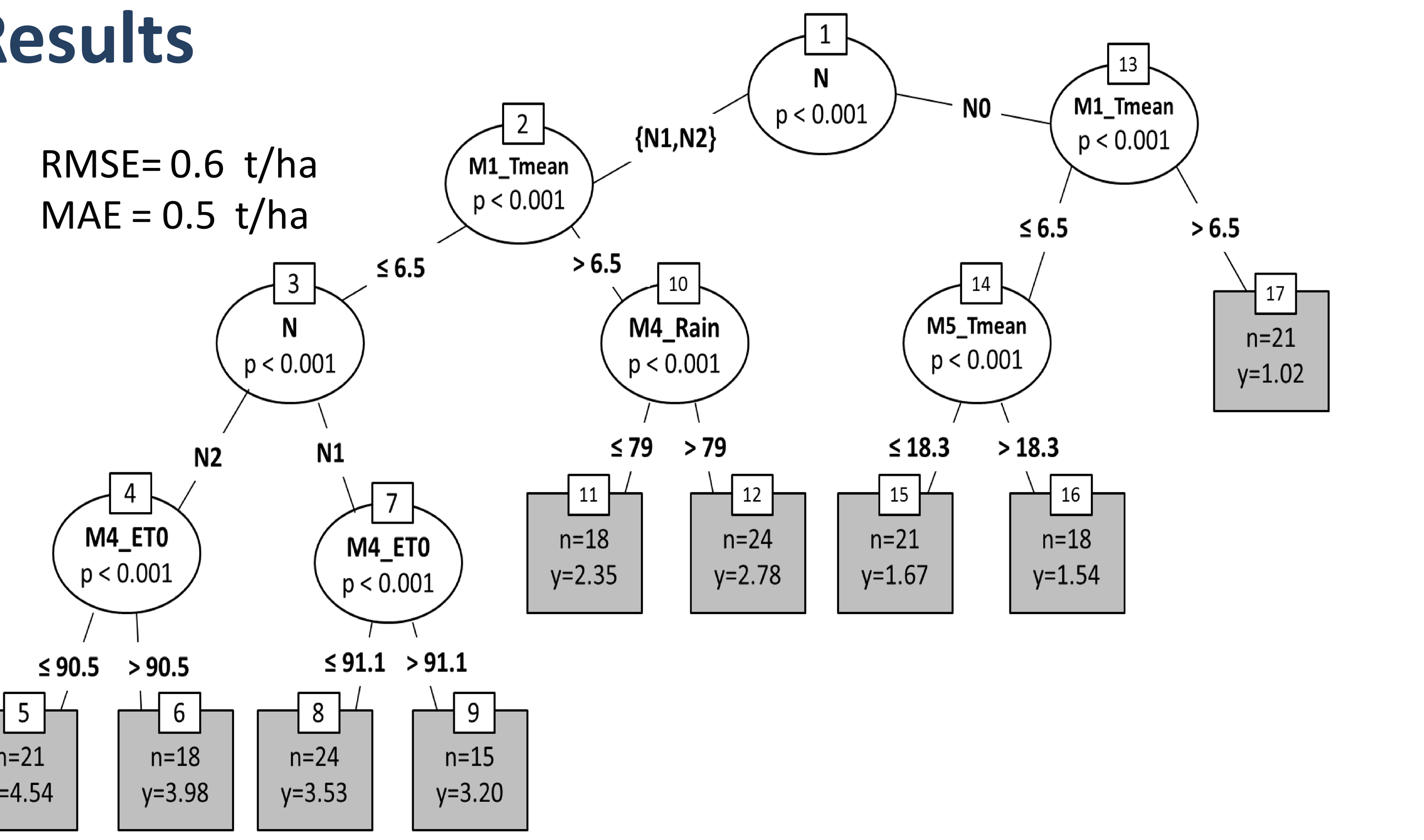

Figure 2 – **Regression tree showing the emerging drivers of the durum wheat yield interannual variation**: meteorological variables (Tmean = mean monthly temperature, RAIN = monthly precipitation, ET0 = cumulate monthly reference evapotranspiration; M[n] = month from 1=January to 5=May) and N fertilization rate (N0 -0, N1-90, N2- 180 N kg ha−1). n = number of observations and y = mean grain yield, t ha−1) in each terminal node.

The most relevant management factor influencing wheat yield was **N fertilization**. The interannual wheat yield variability was constrained by **the low temperatures in the early growth stages**, in relation to the beneficial effects of low T on tillering, and by **the water stress constraining grain numbers and weight** in spring.

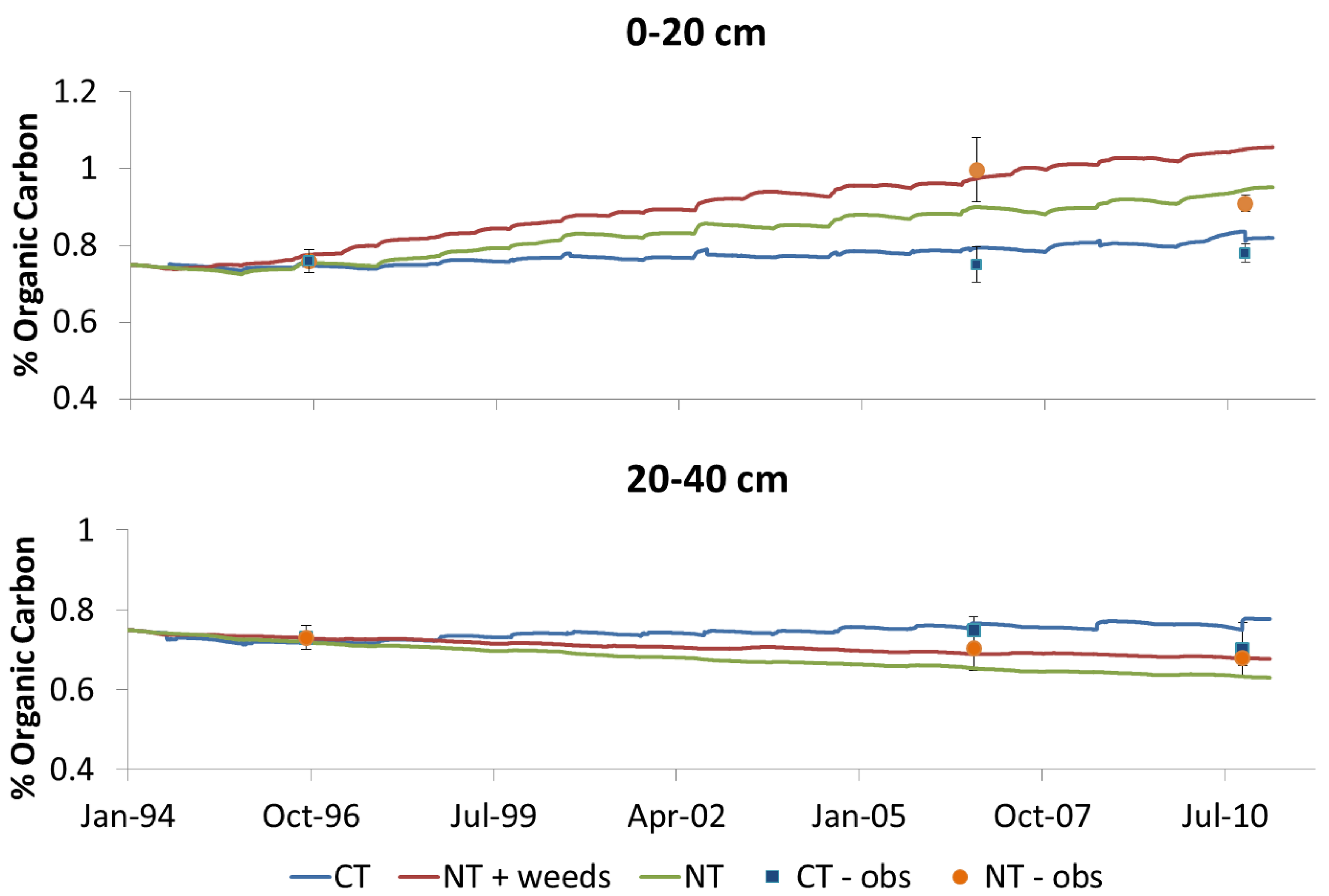

Figure 3 – Observed and **simulated SOC using DSSAT model** in the 0-20 and 20-40 cm soil layers as influenced by crop management with 90 kg N ha^{-1}. Points denote measured data and bars the standard error. **CT = 40 cm inversion tillage**, **NT= No Till**, **NT + weeds = NT including the contribution of weed plants** during wheat-maize intercropping, simulated by DSSAT as bahia grass.

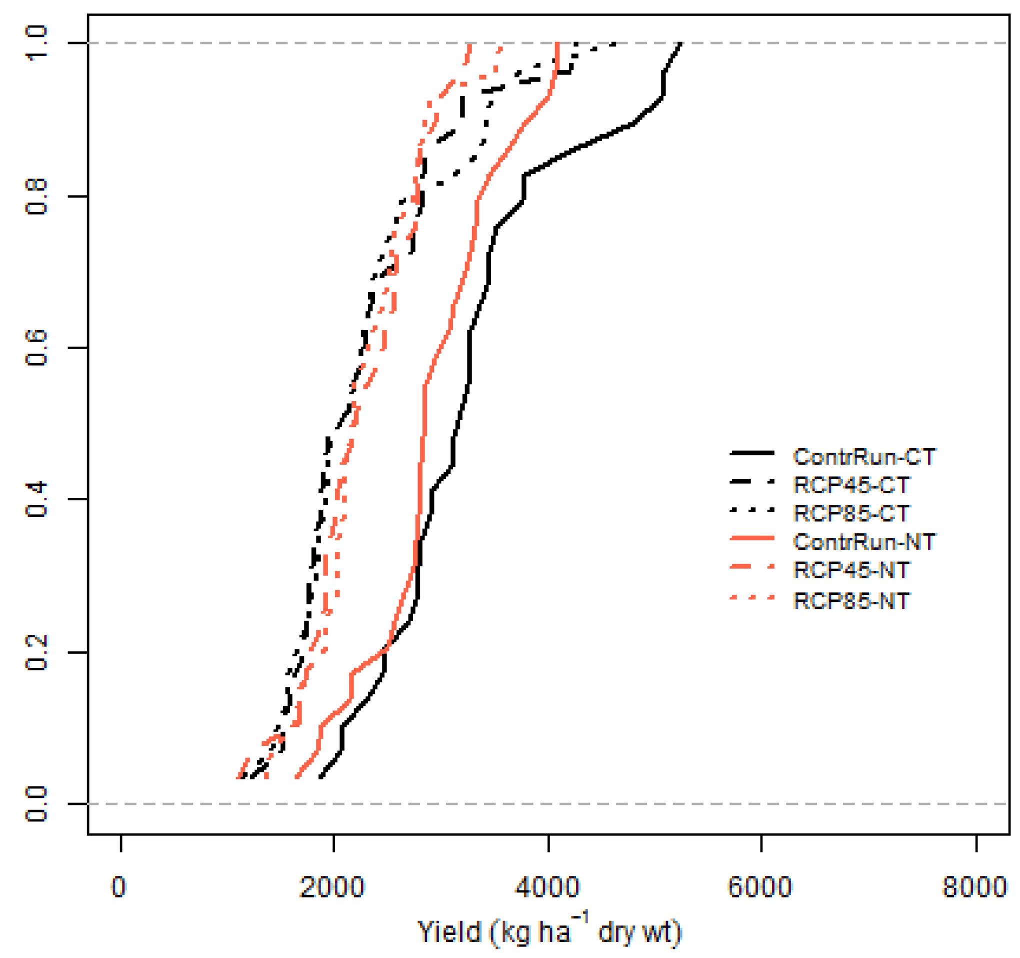

Figure 4 – **Cumulative probability distributions** of **MZ yields** in the AN site LTE obtained using the **MM Mean** (DSSAT, EPIC, SALUS) under the future climate change scenarios (RCP45 and RCP85) for 2021-2050 compared to the 1971-2000 baseline period (ContrRun). No Tillage (NT) is shown by red lines, Conventional tillage (CT) by black lines.

Conclusions

We reported an example of how LTAE data can contribute to a robust assessment of the long term effects of cropping systems on crop yield and soil fertility. The MAGGnet and ICFAR LTAE network data are an invaluable source of information for site-specific assessments of long term soil C dynamics and GHG emissions. LTAE data coupled with crop models can be contribute to develop adaptive responses and mitigation options on crop management addressing the resilience issues associated to food security and environmental sustainability posed by CC.