Technical Annex 7.2i - Deliverable Report on C.4 Action second year

Monitoring of greenhouse gases emissions

Project responsible: CERMANU
Field Measurements: Tetto Frati- AGROSELVIT; Castel Volturno CERMANU; Mellone: UNIBAS
Laboratory analyses of GHG fluxes from organic matrices: AGROSELVIT

1. Methods

1.1 Field treatments

- Tetto Frati: crop system maize

7 soil treatments: Trad (chemical fertilizers); 0N no nitrogen addition; CMB-B and CMP-A: low (1000 kgOC/ha) and high (2000 kgOC/ha) doses of compost from bio-digestate; SS-B and SS-A: low (1000 kgOC/ha) and high (2000 kgOC/ha) doses of fresh solid digestate; FeP: like TRAD with the addition of biomimetic catalyst (5 kg/ha)

- Castel Volturno: crop system maize

4 soil treatments: Trad (chemical fertilizers); CMB-B and CMP-A: low (10 tn/ha) and high (20 tn/ha) doses of on-farm compost; FeP: soil addition of biomimetic catalyst (5 kg/ha)

1.2 Field measurements

- project sites Tetto Frati, CastelVolturno

At the project site of Tetto Frati the gas-fluxes measurements are carried out periodically for 15 days for each months. At CastelVolturno the field measurement are provided by stable system placed in a dedicated filed facility. The GHG measurements are carried out with automated closed-chamber system coupled to a 1412-Photoacustic Field Gas Monitors (Fig. 1). The analyses are currently stopped during December and January for the decreasing sensibility of analytical system derived from the low temperature and high moisture contents of soil plots. The analytical systems provide high-time resolution of gas fluxes data, being able to perform day-long analytical cycle of 20 minutes for each chamber with a maximum of 10 operating chambers. At Tetto Frati the analyses are performed placing two/three chambers for each treatment, plus two chambers in non cultivated plots as control, with a weekly alternation between soil treatments (1^{st} week 8 chambers 4 treatments 2^{nd} week 8 chambers 3 treatments). At CastelVolturno two chamber are placed in soil for each treatment plus two chambers between treatments as control. Each chamber provided daily, on average, 7/8 measurements.

Photoacustic Field Gas Monitor operates collecting gas samples by means of pump from closed chamber; the gas sample is allocated in a small chamber (3 ml). Chamber is irradiated with pulsed, modulated by a chopper, narrow-band light. Gas absorbs light proportional to its concentration and converts it to heat. Temperature fluctuations determined by modulation generate pressure waves detected by sensitive microphones. Gases specific carousel, are available to select the appropriate light wavelength. The instrument is capable to measure gas concentration in few seconds.

Each chamber (Ø= 30cm, h= 10cm) is automated by means of electronic engine in order to modulate opening/closing cycle for the accumulation of soil air fluxes. Each cycle was run by a multiple channel sampler provided of 10 channels. Each chamber was equipped with a vent valve to avoid pressure variations inside the chamber Inlet and outlet tubes allow air circulation from chamber to detection instrument. Soil gases fluxes have been calculated for each chamber, considering a cycle of 10 measurements with open chamber and 10 measurements with closed chamber, covering a total time of about 20 minutes.

The amount of CO2 released C is derived by the mass proportion

$$CO2\ (kg\ ha\text{-}1) \times 12(\text{ mass of Carbon})/44\ (\text{mass of CO2})$$

Figure 1 Field chambers and GHG sampling photoacustic systems

- Project site: Mellone

.Preliminary design of the apparatus for soil respiration measurements

CO2 and N2O fluxes measurements, recognized as the most important Greenhouse Gases (GHG's) will be carried out, as agreed, within the demonstrative fruit orchards (kiwi and peach) located at "Azienda Agricola Mellone". This farm belongs to AOP "Armonia".

At the moment, a preliminary design of the soil respiration apparatus has been defined. Particularly, it is based on the development of a control system for the automatic operation of chambers (already existent) for soil respiration measurements. This system consist of a dedicated and programmable electronic card able to manage the functioning of the chambers during the measurement daily cycles in a completely automatic way, even for many weeks, consistent with the life of batteries. The system will have to manage a cycle structured as follows:

- start of the measurement cycle
- ignition of CO2 sensor and gas pump
- washing cycle of the gas circuit
- closing of the chamber
- measurement of CO2 accumulation rate for a specified time
- measurement of other environmental parameters (air humidity, temperature, soil water content)
- opening of the chamber
- sensors shutdown
- measurements saving on a non-volatile mass memory

The artifacts to be developed and delivered by the project are:

- complete electronic diagram of the entire control system
- scheme for the realization of the printed circuit
- source code of the program for the cpu (central processing unit) chosen for the control of the chamber functionality

- operator manual with all the instructions to operate and maintain the electronic and the program of the chambers
- detailed document of all the choices (hardware and software) made in the implementation of the control system.

The following characteristics are also required:
- the control boards must be easily replaceable in case of breakage, using standard and easily available connectors
- the electronics will have to be made with widely components with a certain availability over the years
- as much as possible, it should be used formats, languages and open source components.
- since the system must operate in a non-assisted way, it must be maximized battery life with appropriate design choices.

1.3 Laboratory measurements

All organic materials used at different project sited for field treatments were tested for NH3 volatilization and GHG (N2O, CO2 and CH4) emissions under potential conditions, in climate room incubation.

The tested organic materials used at different filed sites are: fresh solid digestate, compost from digestate (Agroselvit); on farm manure compost (Cermnau); on farm green compost (Unibas-Prima Luce)

For GHG measurements, the incubation experiment was carried out in a controlled climate (20° C, 65% relative humidity) and set-up as a randomised complete block design, with four replicates. Each experimental unit consisted of a cylindrical glass jar (volume 5 L).). Air-dried and sieved soil (3 kg for each jar) moistened with deionized water in order to reach 75% saturation. Two types of model soils with different properties (Table 1) were used for the experiment. All jars were fertilizes at 170 kg N ha-1. GHG emissions were measured by means of a closed-chamber technique.

Table 1 Textural composition and main characteristic of the two soils used in the experiment.

Soil type	Sand	Silt	Clay	Porosity[a]	$CaCO_3$	SOC	TN	C/N	pH	CEC	P[b]	K[c]	Ca[c]	Mg[c]
	%							-	-	($cmol_c\ g^{-1}$)	($cmol_c\ kg^{-1}$)			
SL	17,2	71,1	11,7	49,2	0,4	1,2	0,2	8,0	6,1	12,4	23	42	1452	179
SY	89,7	5,5	4,8	45,3	15,3	0,52	0,057	9,1	8,3	5,4	14	28	980	21

Abbreviations: SL= silt-loam, SY= sandy, SOC = soil organic carbon, TN= total nitrogen, CEC= cation exchange capacity ($cmol_c\ kg^{-1}$); **a** Calculated on the basis of bull density and particle density; **b** Available (Olsen P); **c** Exchangeable.

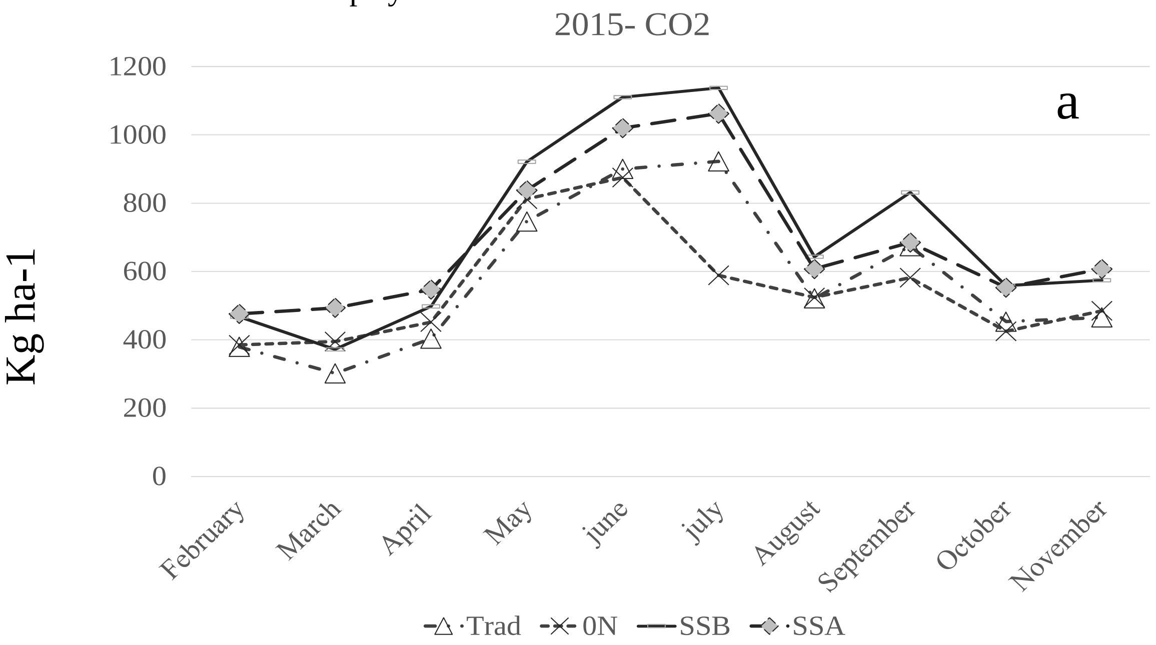
2. Results

For both Tetto Frati and CastelVolturno project sites the lower yields of nitrous oxide emissions, equivalent to less than 0.013 kg/ha/d (1500/2000 times lower than CO2 levels), and the consequent larger variability (± 75%), did not allow a reliable estimation of N2O contribution to soil GHG.

2.1 Field measurements

- Tetto Frati

The analyses of CO2 evolution from field treatments (Fig. 2a, 2b) revealed higher emissions from soil amended with fresh solid digestate, while the lower values were found for the soil without fertilization (0N) and with biomimetic catalyst addition (FeP). The large emissions found in late spring and summer periods are associated with the contribution of root and rizho-sphere biomass associated with maize crop cycle



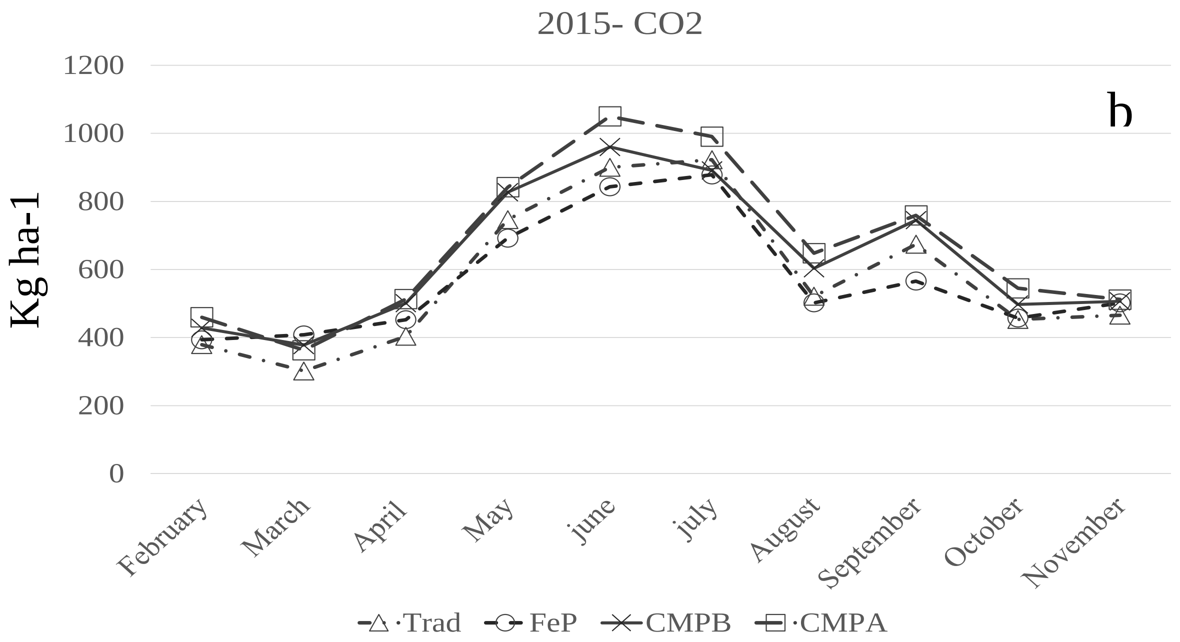


Figure 2. Monthly CO2 (kg/ha) emission from field treatments of Tetto Frati trial

The estimated annual cumulative C losses ranged from 1.9 to 1.8 t ha-1 for SS and CMP treatments in respect to the 1.6/1.5 found for traditional and FeP added plots (Fig. 3). These amounts correspond roughly to a decrease of about 0.5/0.6 g OC kg^{-1}/year for the Tetto Frati soil with a bulk density of 1.3 and for a tillage layer of 0.25 m

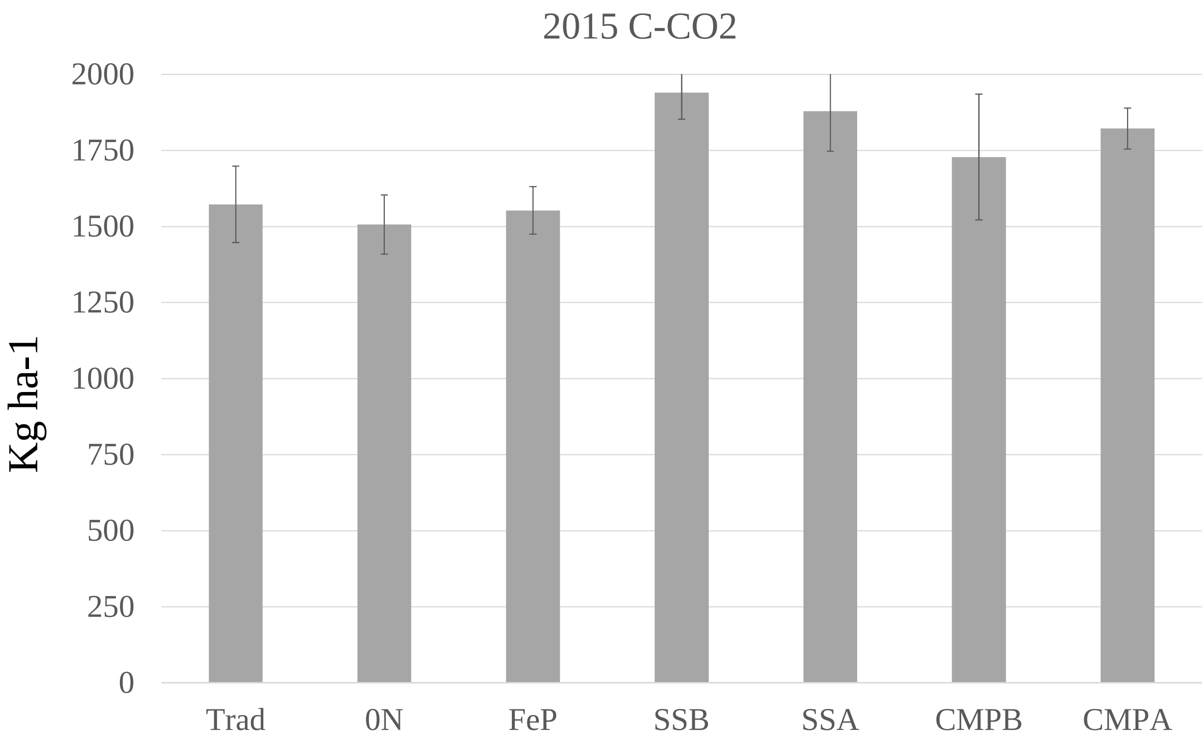
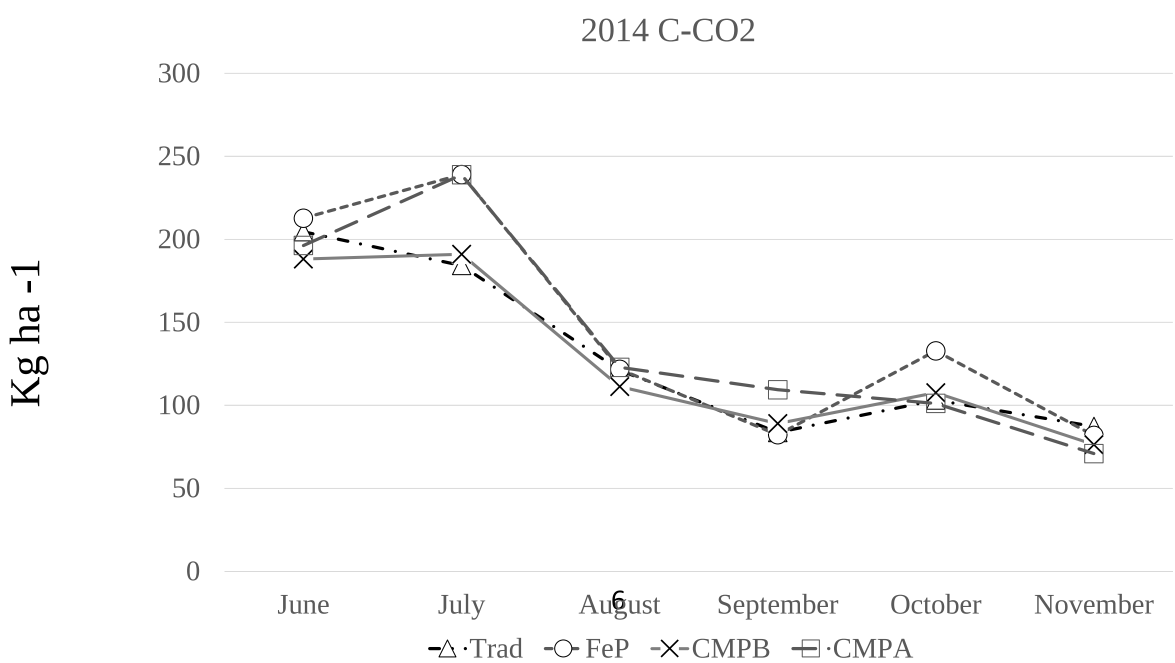


Figure 3. Cumulative C-CO2 emission from field treatments of Tetto Frati trial

- CastelVolturno

No significative different trends were found in the monthly CO2 fluxes from various filed tests in the first two years of SOM management application (Fig. 4). The additional organic material provided by compost application produced a comparable emission with traditional treatment. Again the larger values shown in June and July may be associated to the higher contribution of crop roots and to the associated rhizo-biomass microbial activity.



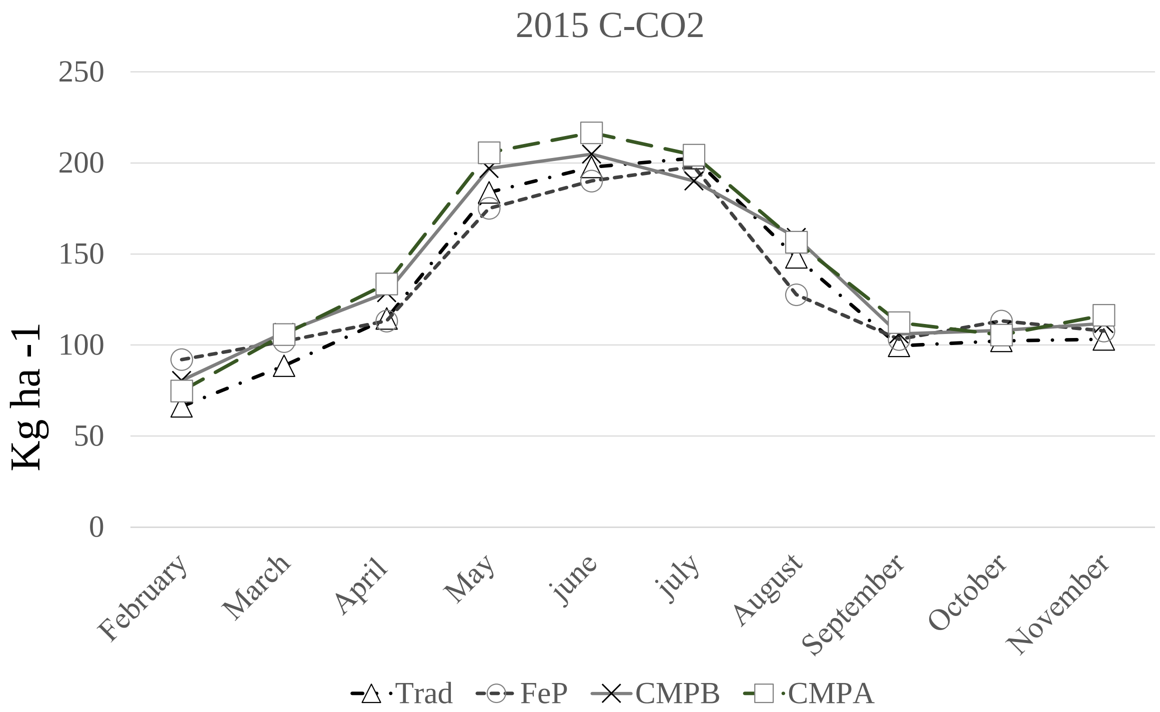


Figure 4. Monthly C-CO2 emission from field treatments of CastelVolturno trial in 2014 and 2015

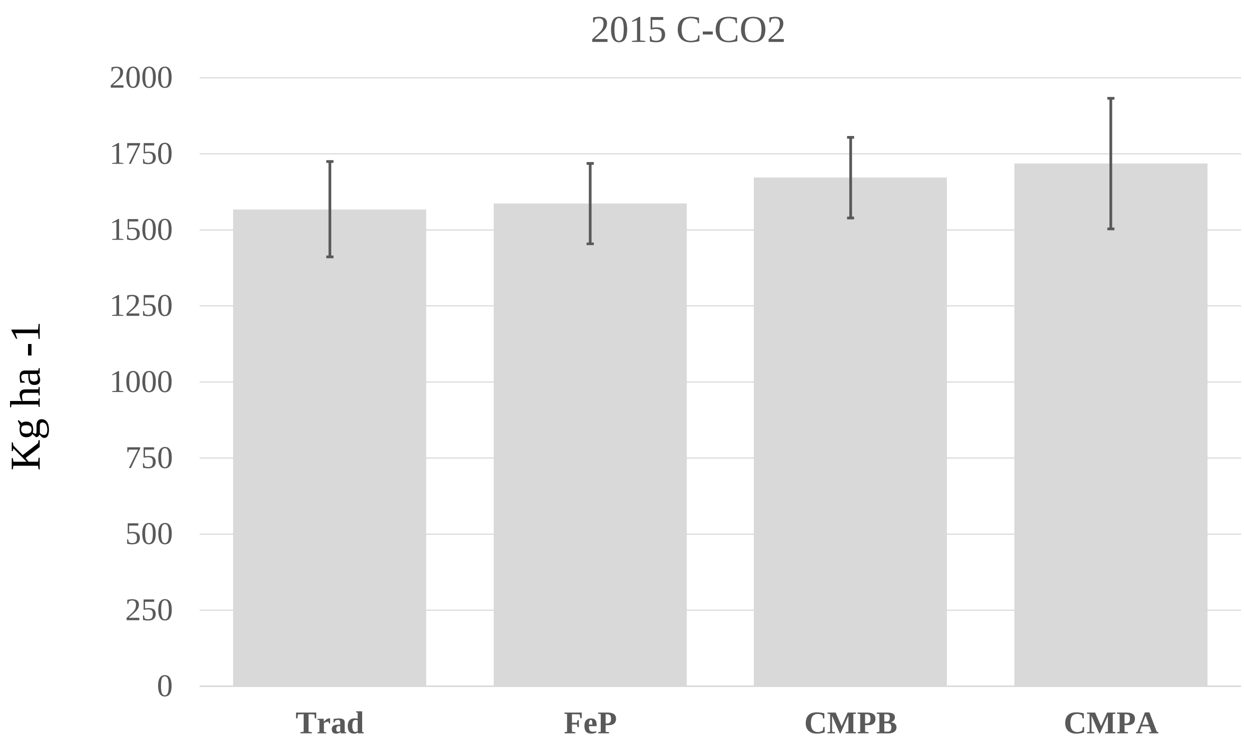


Figure 5. Cumulative C-CO2 emission from field treatments of CastelVolturno trial

2.2 Laboratory analyses

The GHG emissions from organic matrices measured during the 93-day incubation for SY and SL soils are shown in Figures 6 and 7 and Figures 8 and 9, for carbon dioxide and nitrous oxide in the order. For both model soils the larger CO2 emission was found for the less stabilized fresh solid digestate, while the composted materials has CO2 fluxes comparable with the soil treatment with mineral fertilizer

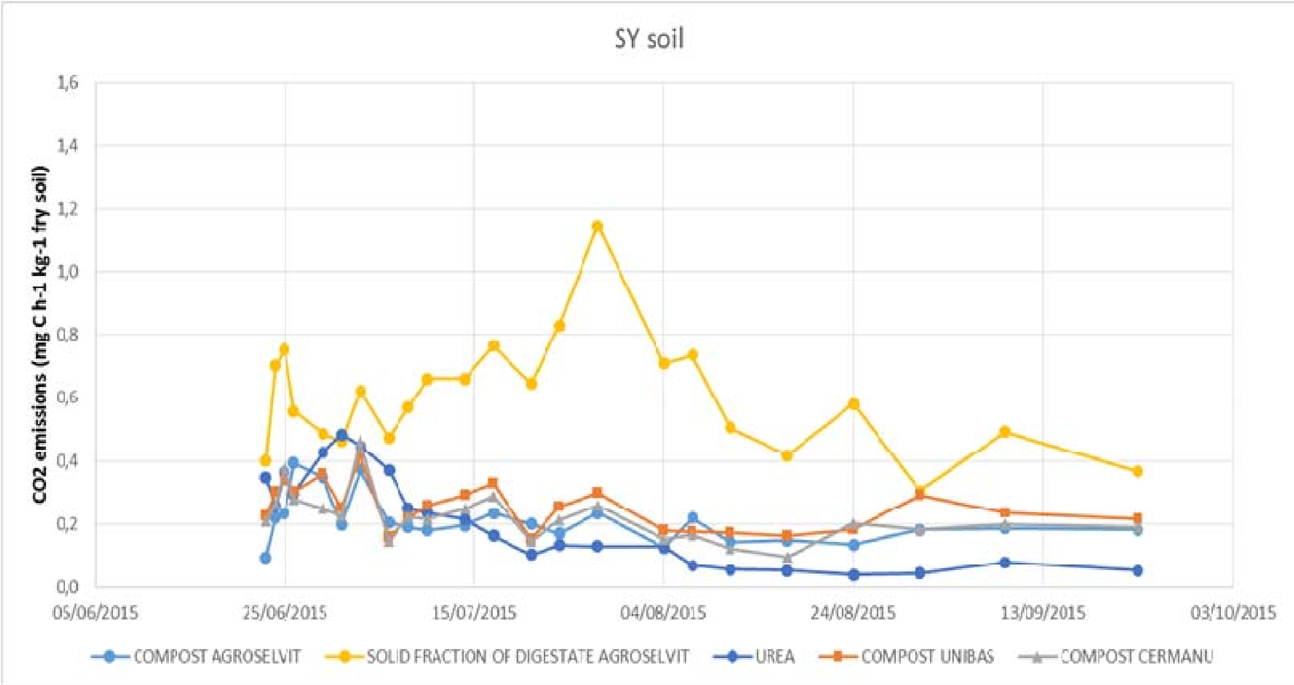


Figure 6. CO2 emissions for SY soil.

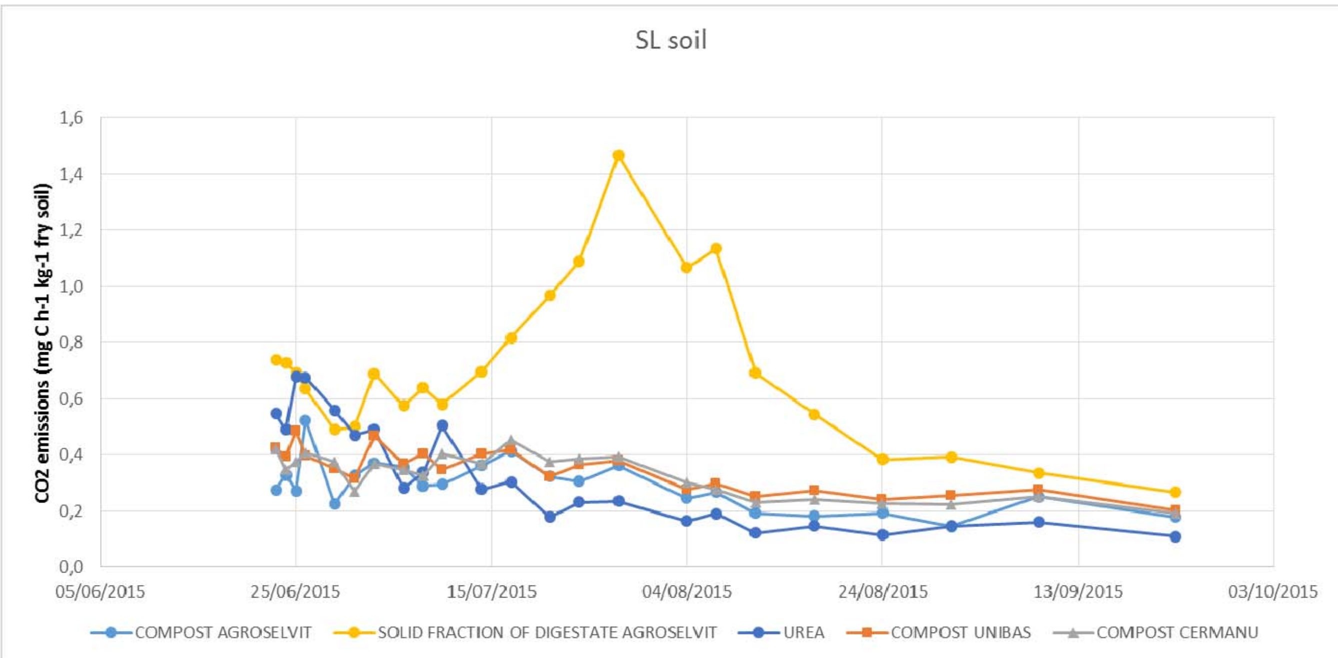


Figure 7. CO2 emissions for SL soil.

The analyses of nitrous oxide revealed an intense initial pulse emission from soil samples added with urea and minor losses from fresh solid digestate, may be associated with the release of available nitrogen, followed by a sharp lowering to the steady ground values of other organic treatments

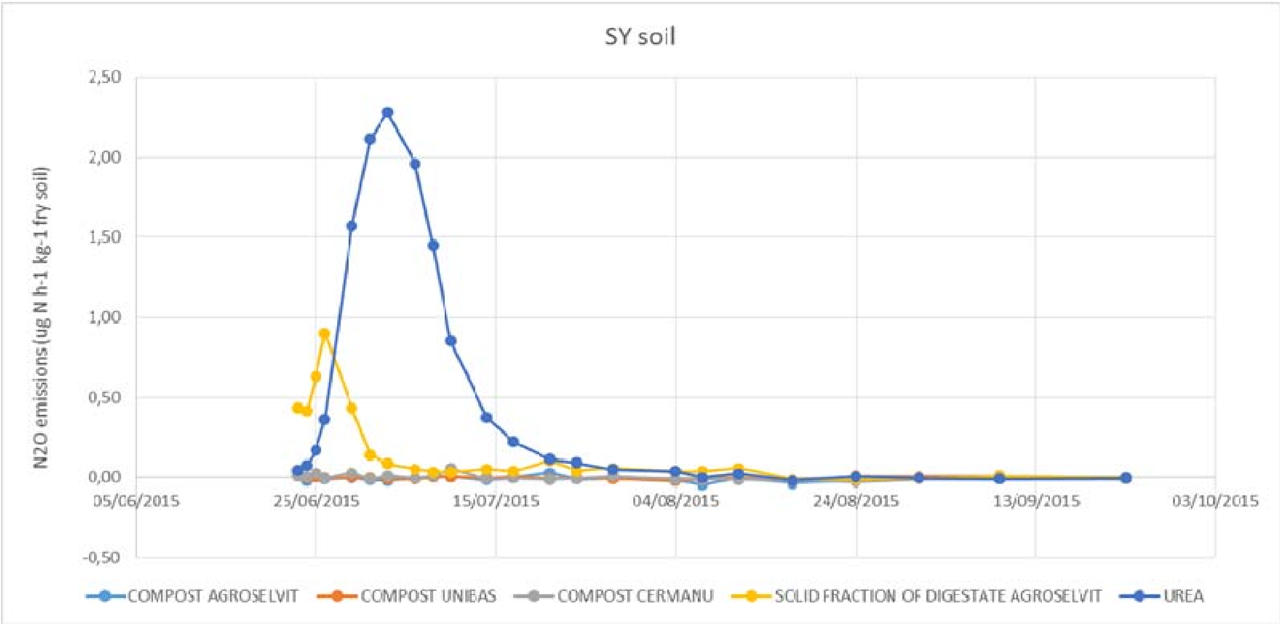


Figure 8. N2O emissions for SY soil

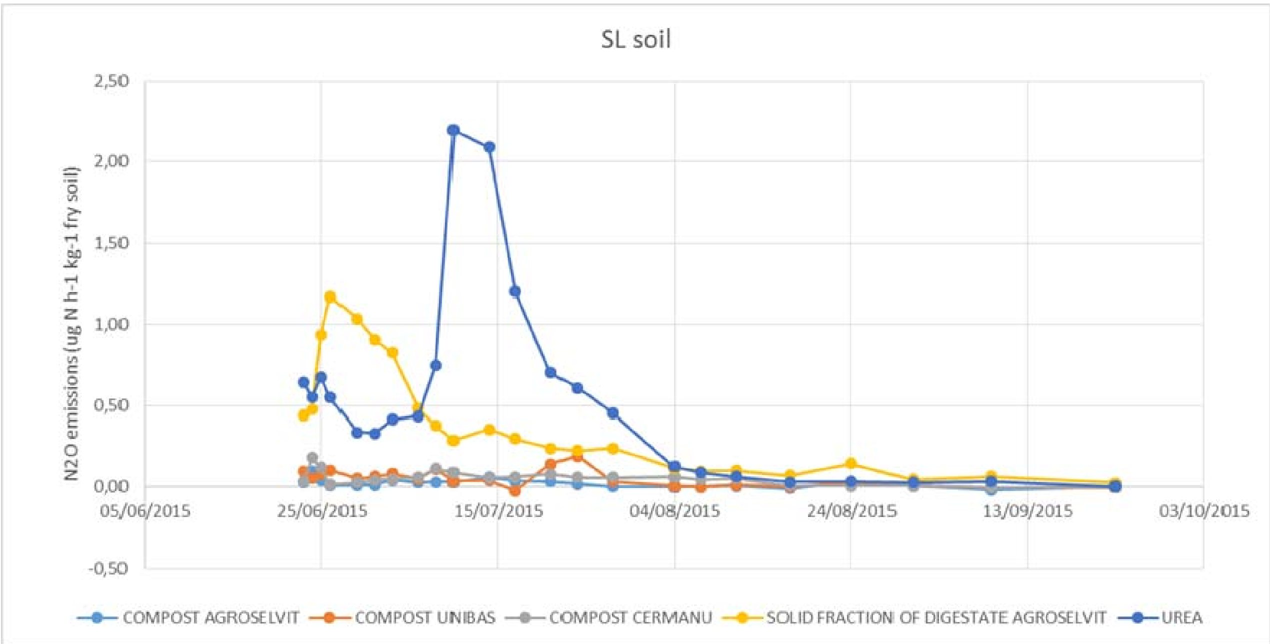


Figure 9. N_2O emissions for SL soil