life vitisom

WITH THE CONTRIBUTION OF THE LIFE PROGRAMME OF THE EUROPEAN UNION. LIFE15 ENV/IT/000392

VITICULTURE INNOVATION

THE VARIABLE-RATE TECHNOLOGY TO IMPROVING THE DISTRIBUTION OF ORGANIC FERTILIZER

Protection of soil and viticultural and agricultural ecosystem: Green Paper for the development of a European Strategy

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Contents

Glossary

Variable Rate Technology (VRT)	Applied in a variety of agriculture sectors, it is based on sensors detecting interesting information (for example crop vigour), which are used as indicators to regulate the distribution of various input types.
Soil Organic Matter (SOM)	The whole of the organic substances found in the soil, of both animal and vegetable origin. It is an essential factor in the assessment of soil fertility.
Greenhouse Gases (GHG)	Gases in Earth's atmosphere such as carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O), which have a particular impact on agriculture.
Organic Compost	Carbon-based compounds of animal or vegetable origin, rich in nitrogen and phosphorus in varying quantities depending on the original matter, as well as potassium and other secondary nutrients such as iron, magnesium, calcium and sulphur.
Global Warming Potential (GWP)	A measure of how much a certain greenhouse gas molecule (carbon dioxide, nitrous oxide, hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride) can contribute to the greenhouse effect.
Carbon Footprint	An environmental indicator measuring the impact of human activities on the environment and specifically on the global climate; it allows to quantitatively assess the effects on the climate of the so-called greenhouse gases produced in the various human activities.
Net Ecosystem Exchange	A measure of the net exchange of carbon (C) between an ecosystem and the atmosphere. In agriculture it takes into account both emissions from the system toward the atmosphere and the sequestration by crops.
Eddy Covariance	A technique for measuring the CO_2 flux within an ecosystem.

Acronyms

AMF	Arbuscular Mycorrhizal Fungi
C	Carbon
CH4	Methane
CO2	Carbon Dioxide
CEC	Cation Exchange Capacity
DSS	Decision Support System
EMI	Eco-Morphological Index
EAGGF	European Agricultural Guidance and Guarantee Fund
EAFRD	European Agricultural Fund for Rural Development
FU	Functional Unit
GHG	Greenhouse Gas
GHGAP	Greenhouse Gas Action Plan
GWP	Global Warming Potential
HFC	Hydrofluorocarbon
IC	Impact Category
ICP-MS	Inductively Coupled Plasma Mass Spectroscopy
IPCC	Intergovernmental Panel on Climate Change
LCA	Life Cycle Assessment
LCI	Life Cycle Inventory
LCIA	Life Cycle Impact Assessment
N	Nitrogen
N2O	Nitrous Oxide
NEE	Net Ecosystem Exchange
CAP	Common Agricultural Policy
PFC	Perfluorocarbon
PLFAs	Phospholipid Fatty Acids
RDP	Regional Development Programme
SOQ-ar	Soil Organic Quality - arthropodes
SF6	Sulfur hexafluoride
OM	Organic Matter
SOM	Soil Organic Matter
SWOT	Strengths, Weaknesses, Opportunities, Threats
TOC	Total Organic Carbon
UAV	Unmanned Aerial Vehicles
UNFCCC	United Nations Framework Convention on Climate Change
VRT	Variable Rate Technology
WTP	Willingness To Pay

1. The LIFE VITISOM Project

The LIFE VITISOM Project is the result of the collaboration among Università degli Studi di Milano – Department of Agriculture and Environmental Sciences (as leader), Consorzio Italbiotec, Università degli Studi di Padova, three companies in the wine sector, Guido Berlucchi & C. SpA, Castello Bonomi Tenute in Franciacorta, Conti degli Azzoni and two companies engaged in engineering applied to the agriculture and environmental fields, Casella Macchine Agricole Srl and West Systems Srl.

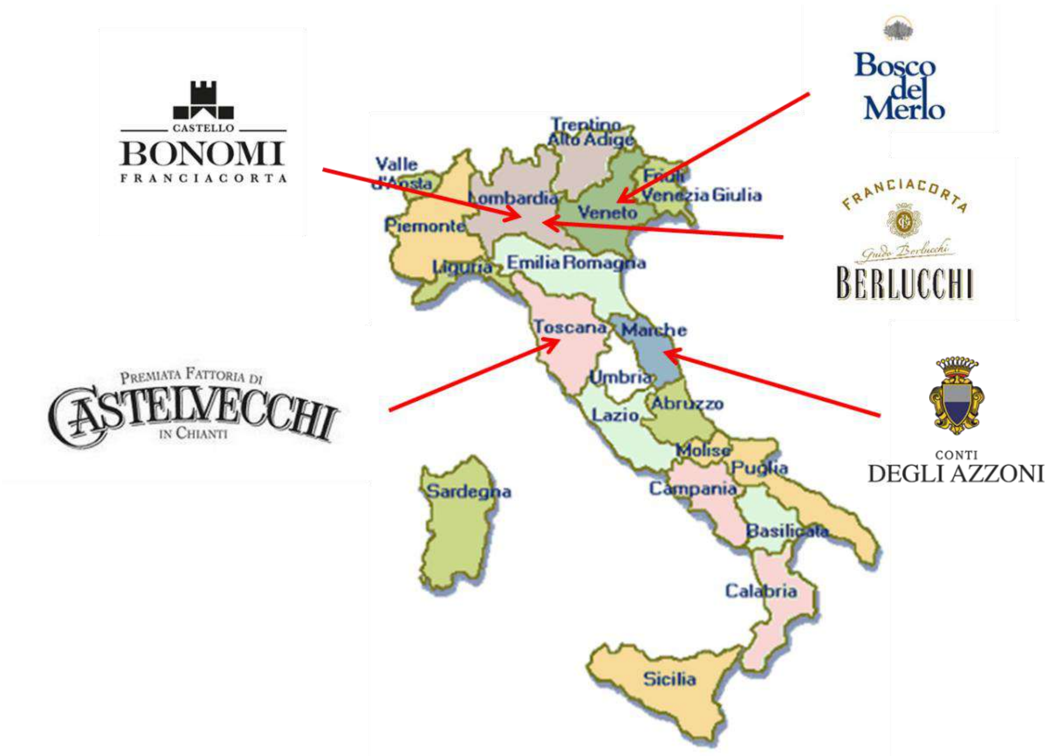


Figure 1. Trial sites involved in the VITISOM Project

The aim of the LIFE VITISOM Project is to create an innovative system for the management of the organic fertilisation of grape vines, allowing to counteract the depletion of the organic matter and improve the uniformity and quality of soils planted to vines.
The project promotes a sustainable management of the soil and is powerfully demonstrative, with the implementation of 5 prototypes, adapted to specific pilot contexts, which were identified as representative of the variability of vineyards in Europe.
The project is thus aimed to develop, test and scale up a technology for the organic fertilisation of vines, through the introduction of the Variable Rate Technology (VRT) in the wine production sector.
This is a well-known technology, so far used in wine-growing for farming practices other than organic fertilisation, where it counts as an innovative application.
VRT technology allows to adjust the application rates of organic fertilisers (compost, manure, or separate solid digestate) to the actual requirements of the vineyard, identified though prescription maps which can be produced by detection systems.
The rationalisation of organic fertiliser dosages allows to promote the use of organic matrices to more effectively combat the loss of organic matter (OM) of the soils planted to grapevines.

VRT technology improves soil and vine quality in terms of structure of the soil, organic matter content and biodiversity.
Moreover, the increase in the level of fertility of the soil brings about an improvement in the vine plant-productive balance and in the quality of the grapes and the wine, with a potential economic impact. The application of this technology allows to reduce N_20 emissions, to counteract the erosion of the organic matter in the soil and to increase the economic profitability of vineyard management.
The final aim of the project is to contribute to the definition of a comprehensive framework of the possible strategies for the management of soils planted to grapevines, providing a solution applicable on various soil types and exportable as a European virtuous model.
The development of the innovative technology under the LIFE VITISOM Project has been planned to be organised in three main phases:

1. Technical design and prototype development: design and application of an innovative machine for the various identified wine-growing contexts, which may rationalise the application of the organic matter in the vineyard through VRT technology;
2. Field tests and validation of prototypes in the wine-growing field: test and verification of the machine in the various scenarios;
3. Development of an exploitation strategy for the dissemination of the model: definition of a strategy for the protection of the intellectual property and possible applications for a possible scale-up in the market in wine.

The effectiveness of the project method and activities are sided with a continuous chemical and organic monitoring of soil, emissions and quality of wine production. Furthermore, the sustainability of the process will be ensured by an assessment of greenhouse gas emissions in the vineyard, environmental impact (Life Cycle Assessment) and socio-economic repercussions.
The preliminary results of the VITISOM project are presented in this publication, while the final ones will be shown in the final publication called "*Manual of good practices for organic matter management in the vineyard*".

2. The main themes within the VITISOM Project

The organic matter in soils planted to grapevines
In 2009 the European Union defined organic matter as the very foundation for healthy soils, highlighting how its erosion causes the degradation of the soil itself.
The importance of the organic matter content in the soil has long been known [1; 2], but it has been further highlighted by the progress in the knowledge about soil composition [3; 4; 5; 6; 7]. Its positive functions lie both in a general improvement of fertility conditions, and in positive effects as regards soil structure, water retention and availability of nutritional elements, as well as preservation of the necessary conditions for the good nutrition of soil organisms [6; 7; 8; 9; 10].
In short, organic matter is:

- a "source of food" for subterranean fauna and contributes substantially to soil biodiversity;
- the core of soil fertility. Organic carbon strengthens soil structure and, while improving its physical environment, it promotes the penetration of roots into the soil;

- capable of holding up to six times its weight in water. Soils containing more organic matter have a better structure, which helps the infiltration of water and reduces soil susceptibility to compaction, erosion and landslides.

As compared to the past, modern viticulture faces growing threats as regards the depletion of the organic matter. These are caused by the tendency to establish more and more intensive cultivation systems, with a reduction of planting distances, and by an increased mechanisation, which results in the creation of hardpan layers [11; 12]. The more or less recent tendencies in the use of the soil, together with the effects of climatic change have brought about a loss of organic carbon in the soil across Europe.
Almost half of the European soils are characterised by a low content in organic carbon (Fig. 2). In this context it is necessary to identify management strategies that allow to preserve and increase the level of organic matter in European soils. With a carbon content of about 60%[1], organic matter is an important carbon reserve and its dynamics influence the amount of CO^2 in the atmosphere significantly.

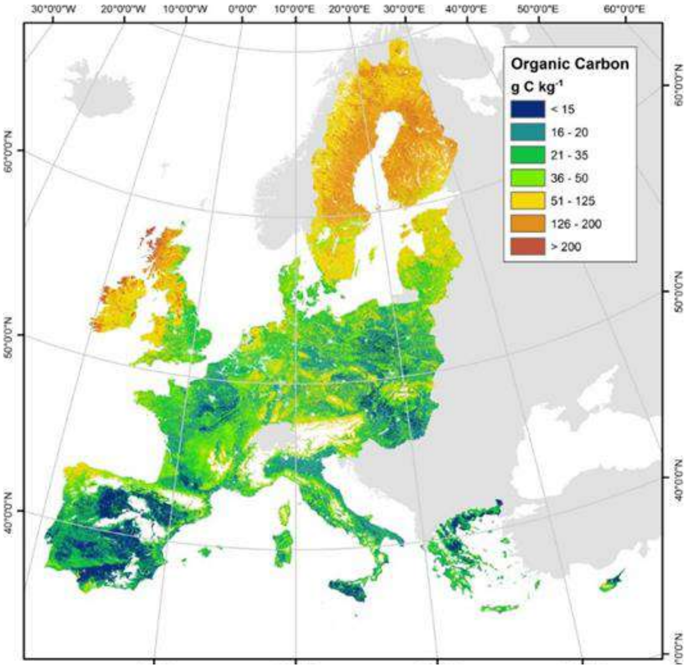


Figure 2. Map of predicted topsoil organic carbon content (gCkg-1) [13]

The correct management of organic fertilisation, intended as contribution of organic matrices such as compost, manure and separate solid digestate, is a possibility in that sense. The contribution of organic fertiliser performs various functions both for the soil and for the grapevine. Furthermore, it performs a soil conditioning function, intended as the capacity of modifying and improving the chemical, physical and biological characteristics of the soil.

GHG emissions from soils planted to grapevines
One of the main points in terms of environmental impact, to be considered in the use of organic and mineral fertilisers, are greenhouse gas emissions related to the loss of nitrous oxide (N_2O) in the atmosphere. Indeed, the latter has a Global Warming Potential (GWP) – the contribution of the gas to the greenhouse effect – of 265, which is considered to be very high [14].
In the field of agriculture, nitrous oxide is the result of nitrification and denitrification processes or immediate volatilisation phenomena [15].
About 1.975% of the nitrogen included in inorganic fertilisers is dispersed as this gas [16], although emissions are variable depending on environmental conditions (temperature and humidity), soil type (availability of organic matter, pH, soil compaction and texture) and type of fertiliser [17]. As shown by the literature, inorganic and organo-mineral fertilisers have a level of N_2O emissions which is 10 times higher than that of soil improvers, with a clear relation to the different C/N ratio and to the total nitrogen content [18].

[1] https://www.arpa.veneto.it/arpavinforma/indicatori-ambientali/indicatori_ambientali/geosfera/qualita-dei-suoli/contenuto-di-carbonio-organico-nello-strato-superficiale-di-suolo/view

Such considerations make it necessary to carefully evaluate both the various approaches in the management of the soil [19] and the quality and quantity of the fertiliser, which must be weighted based on the actual needs and method of administration.

Precision Farming

Organic fertiliser quantities must be weighted against soil conditions and specifically against its structure (physical fertility), its richness in chemical elements that can be readily available to the plants (chemical fertility) and the biological activity present therein (biological fertility) [21; 22].

In this context we find *precision farming*, a farming management that has already been applied in apiculture [23; 24] and that makes it possible to manage crops taking into consideration the real needs of the plant.

The "remote sensing" technique allows to obtain images showing the conformation, dimension and volume of the various crops through a number of technologies, including satellite imagery and aerial imagery from planes and helicopters or unmanned aerial vehicles (UAV) [25; 26; 27; 28]. The "proximal sensing" technique is also an instrument that allows to obtain images, however in this case the technology is based on different sensor types which collect data near the plant [29; 30; 31].

Precision farming is essential in the wine-growing field to guide management choices on the basis of specific information regarding the health status of the vine. This is based on Variable Rate Technology (VRT), which allows to vary the rate of crop inputs depending on actual vine needs [32; 33; 34].

The application of such technology to the organic fertilisation of the vineyard is thus a significant innovation [35].

3. Environmental Impact Studies

3.1 Impact on soil: chemical and biological fertility

3.1.1 Survey layout and experimental protocol

All 5 sites involved in the project were monitored in terms of soil chemical and biological fertility. The experimental protocol analysed various treatment types (Tab. 1) with the purpose of comparing different strategies in the application of organic fertilisers.

Matrix Type	Management Type	Site of Implementation
Untreated	Unprocessed	All
Untreated	Processed	All
Compost	Unincorporated	All
Compost	Incorporated	All
Separate solid digestate	Unincorporated	All
Separate solid digestate	Incorporated	All
Manure	Unincorporated	All
Manure	Incorporated	All
Urea	Unincorporated	Bosco del Merlo
Urea	Incorporated	Bosco del Merlo

Table 1. Experimental protocol carried out at the five sites identified through the LIFE15 ENV/IT/000392 - VITISOM LIFE Project

3.1.2 Chemical analysis and microbial biodiversity

During the initial and final phases of the experimental activity threefold chemical analyses were carried out on each treatment type.

The surveys of the quality of soils were performed with two different test methods: **soil microbial respiration** and **PLFA analysis** (PhosphoLipid Fatty Acids) that, besides providing an estimate of the microbial biomass, can contribute information on the composition of the microbial community itself.

The measurements of the respiration are useful to assess microbial biomass activity [36] through the definition of the mineralisation rate of the organic matter [37].

Main results 2016

The selection of samples for the assessment of quality

13 representative soils among 120 available samples a time zero were selected for the assessment of soil quality (Tab. 2).

Samples	Management		pH_{H2O}	TOC (g/kg)	Ntot (g/kg)	C/N	P_2O_5 (mg/kg)
BONOMI							
1	C	L	7.8	14.9	0.91	16.4	86.0
2	C	NL	8.2	4.05	0.44	9.17	8.6
3	C	NL	7.8	13.4	0.81	16.5	55.8
4	T	L	8.1	10.4	0.58	17.8	14.4
5	T	L	7.5	10.0	0.48	20.9	0.32
BOSCO DEL MERLO							
6	C	NL	8.0	15.2	0.78	19.5	15.5
7	T	NL	8.2	9.34	0.53	17.6	9.9
BERLUCCHI							
8	L	L	6.9	12.7	1.01	12.6	51.4
9	T	L	7.8	7.9	0.52	15.1	11.3
CONTI DEGLI AZZONI							
10	L	NL	8.2	13.4	1.30	10.3	26.3
11	L	NL	8.2	7.5	0.84	8.9	5.3
CASTELVECCHI							
12	C	L	7.6	14.5	1.22	11.8	23.7
13	D	NL	7.9	12.9	1.30	9.8	11.9

Table 2. Chemical analyses of the soils selected for the quality assessment. The testing methods were those provided by Ministerial Decree 13/09/1999 Ordinary Supplement no. 185 Official Gazette 248 21/10/1999.

From the data in the table it is evident that the soil pH has a low variability, going from slightly/moderately alkaline values, except for one sample (n. 8) showing a near-neutral value. The amount of organic carbon appears to be quite low, thus confirming the need to fine-tune agronomic techniques that may restore it, in accordance with the general objectives of the project. The values of C/N vary from a minimum of 8.93 to a maximum of 20.9. In 38% of cases the value is close to 10, while in the remaining situations the analysis showed excessive values, a sign that mineralisation processes have slowed down and the concentration of nitrogen is reduced. There results to be a medium-to-low amount of phosphorus, consistently with pH data which do not promote processes that make phosphorus available in the soil.

Microbial respiration

Soil respiration is a key process in the carbon cycle of terrestrial ecosystems. Normally, the higher the soil respiration, the more microorganisms are present and active or the source of carbon made of organic molecules more easily biodegradable. However, the mechanism is more complex: the respiration of a soil does not depend solely on the quantity of carbon present therein, but also on its "respiration capability", that is, on how much it is recalcitrant. The curves shown in Figure 3 illustrate the great difference in the production of CO_2 among the various sampled soils.

Values range from a minimum of 1.29 to a maximum of 7.16 mg CO_2 g dry soil^{-1}. This is due to a number of factors, such as the presence of microbial communities that differ greatly by composition and size, the activities thereof and, most of all, the quantity of organic matter and its nature.

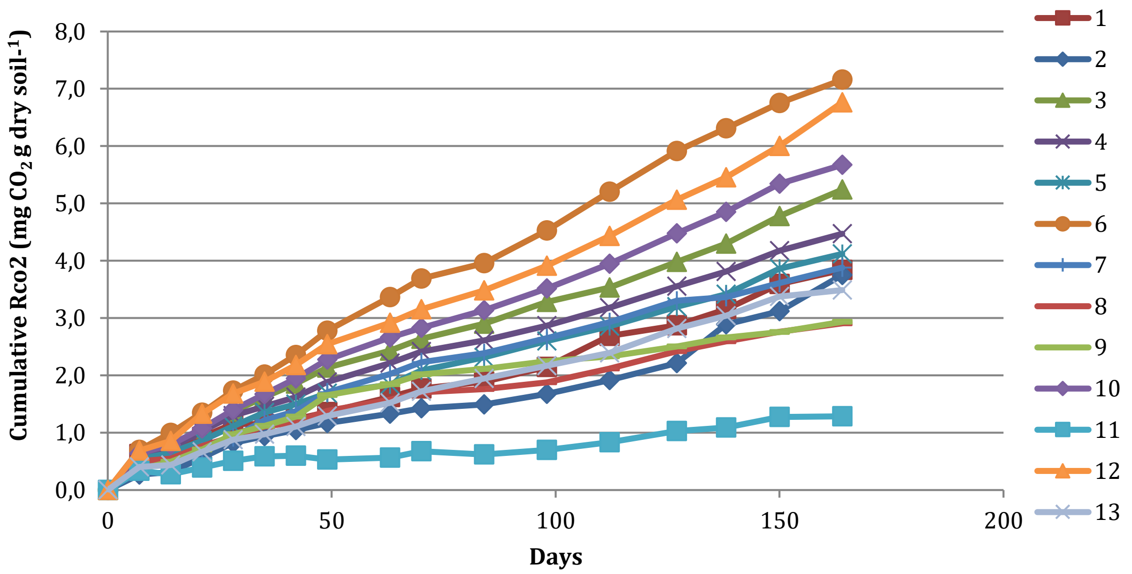


Figure 3. Cumulative soil respiration in time

PLFAs (PhosphoLipid Fatty Acids)

PLFAs are a part of the microbial cellular membrane from the domains Bacteria and Eukarya. Besides providing an estimate of the microbial biomass, the analysis of PLFA's can also inform on the composition of the microbial community.

From the obtained results a very variable content can be observed in the considered soils, though quite in line with data shown by the literature (average content of 1680 ng g^{-1} dry soil [38]).

Sample no. 3 has proved to be the richest in PLFAs in quantitative terms (about 4118 ng g^{-1} dry soil). In this study 23 PLFAs were identified overall.

Palmitic acid was also included in the calculation of the bacterial component, which might originate from plant tissues in the soil, e.g. roots, and for this reason be so abundant in the sampled soils.

The graphic included in Figure 4 shows the most representative PLFAs in quantitative terms, namely palmitic acid (16:0), octadecanoate (18:0), tetradecanoic acid (14:0), which are general bacterial biomarkers, and cis-7-palmitoleic acid, representing gram-negative bacteria.

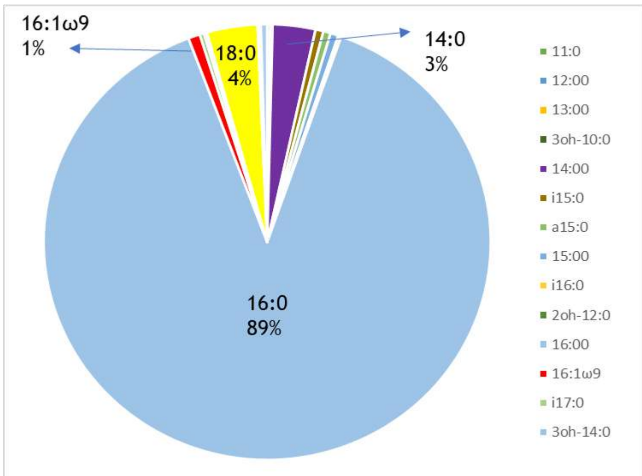


Figure 3. Pie chart of the relative abundance of the single PLFAs

3.1.3 Soil Micro-arthropods – Calculation of the QBS-ar Index

The Soil Biological Quality Index (QBS-ar) was applied in order to quantify the impact of the various treatments on pedofauna.

Such index is based on the principle that animals adapt to environmental conditions, regardless of their taxonomy: the higher the adaptation of an animal to soil life, the greater its importance as an indicator of the degree of conservation of the soil.

Such a consideration allows to introduce the concept of "life forms", that is, the whole of organisms having modified their morphological structures to better adapt to the environment in which they live.

The survey was carried out by the partner wine-growing companies in collaboration with agronomic agency Sata Studio Agronomico at the five trial sites involved in the project. About 2 litres of unshuttered soil were collected from surface layers to implement the analysis. The sample was placed in a Berlese-Tullgren funnel until it was completely dehydrated (Fig. 5). The little invertebrates tend to hide in the damp soil thus falling in the funnel cavity, from where

Figura 5. Berlese-Tullgren funnel for the extraction of terrestrial microfauna

they descend into a preservative liquid in a receptacle.
The distribution of organisms into life forms is made according to features relating to their ability to adapt to the soil, which allow to associate a numerical value called "Ecomorphological Index" (EMI) to a systematic group: the greater the number of morphological characters of soil adaptation, the higher such value, which is a number between 1 and 20.
The QBS-ar index is defined as the sum of the EMI values attributed to each systematic group. The QBS value can vary from a minimum of 0 to a maximum of 349.
Three samples were collected and analysed for each treatment (Tab. 3) in each sampling phase.
The quantification of the QBS-ar was carried out in the three years of the project: autumn 2016, summer 2018 and 2019.

Main Results
In general data have been divided into three groups:
- fertilised theses: they include all treatments fertilised with organic matrices, such as compost, separate solid digestate and manure;
- unfertilised control;
- chemical fertilisation with urea without organic fertiliser.

Furthermore, the three types of treatment have been grouped as:
- incorporated/processed treatments: incorporation into the soil immediately followed the application of chemical or organic fertiliser; the unfertilised control was processed;
- unincorporated/unprocessed treatments: application of chemical or organic fertiliser was only superficial without incorporation into the soil; the unfertilised control was not processed.

It should be noted that organic fertiliser dosages were calibrated with an equal amount of organic carbon for all three matrices and each application phase (spring 2017, autumn 2017, autumn 2018); in this case they were applied "with a variable rate". The urea, on the other hand, was applied with a fixed rate with a dosage of 90 U/ha of nitrogen.

Year	Sampling period	Group	QBS-ar average	QBS-ar standard deviation	Average QBS-ar delta 2016-2019
2016	Autumn	Incorporated organic fertiliser	86	43	
		Unfertilised processed control	111*	23*	
		Chemical fertilisation with incorporated urea	111*	23*	
		Unincorporated organic fertiliser	66	24	
		Unfertilised unprocessed control	80	24	
		Chemical fertilisation with unincorporated urea	80	24	
2019	Summer	Incorporated organic fertiliser	67	24	-19
		Unfertilised processed control	79	25	-32
		Chemical fertilisation with incorporated urea	71	4	-41
		Unincorporated organic fertiliser	64	16	-2
		Unfertilised unprocessed control	74	8	-6

		Chemical fertilisation with unincorporated urea	45	10	-35

Table 3. Summary table of obtained results for the Bosco del Merlo site in 2016 and 2019.

*Data are the same in this case because in the first year of the survey the two theses were used on the same parcel of soil, which was later divided as shown in Figure 6. Thus only one sampling was carried out

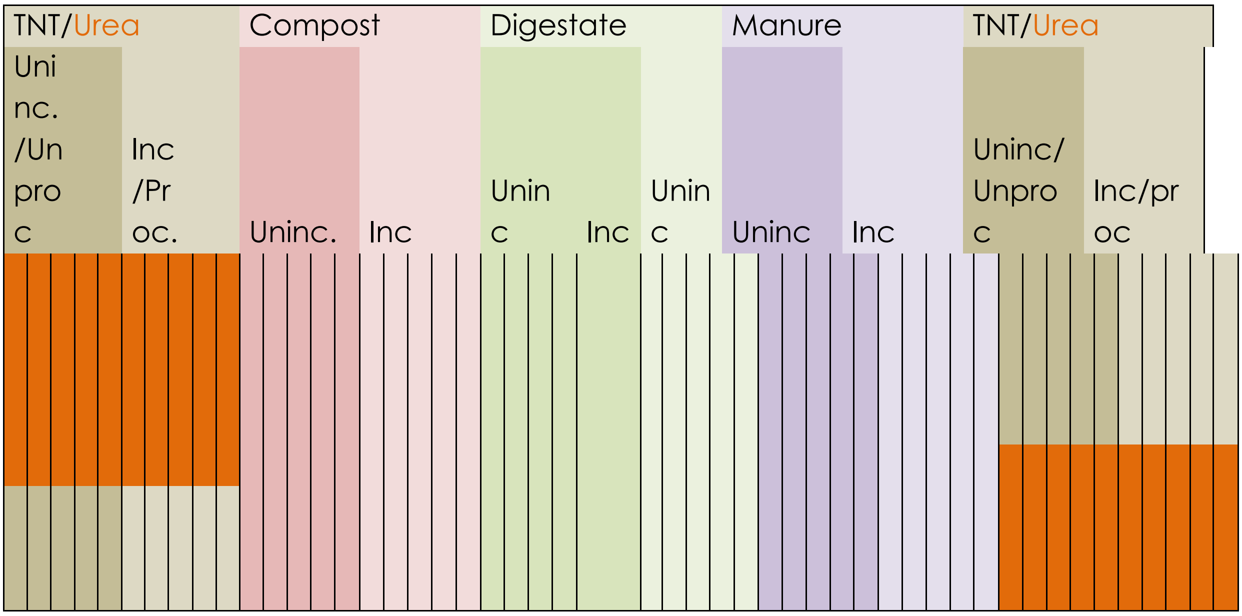


Figure 6. Map of treatment applications in the Bosco del Merlo vineyard

A general reduction in the QBS-ar index values was recorded in 2019. However, this is not indicative of the effect of the various treatments, as the weather variables have shown a greater influence than the effect of the treatment.
The values found in the "Average QBS-ar delta 2016-2019" column in Table 3 are of great interest, showing deviations of year 2019 data from 2016.
A 2019-2016 comparison can highlight that in organically fertilised theses a lower delta is recorded on average than in those treated with urea, with both incorporated and unincorporated matrices. The control also differs though the deviation is significant only where there was processing.
Unprocessed and unincorporated treatments registered lower decreases in the QBS-ar value compared to processed and incorporated ones.

3.2 Impact of greenhouse gas emissions

3.2.1 Carbon fluxes in the vineyard ecosystem

Monitoring carried out during the project
The study of the carbon balance of the vineyard gained a central role within the VITISOM Project. The agroecosystem carbon balance results from two fundamental fluxes: the absorption and fixation flux, connected to plant photosynthesis (vine, but also grass sub-strata, if present), and the respiration and oxidation one (plants, but also microflora). These fluxes have similar magnitude and are both intense: the net ecosystem exchange (NEE) is the result of their combination. In general, in a virtuous agroecosystem from an environmental point of view, the absorption flux exceeds the degradation one thus allowing carbon to accumulate in time, increasing the organic matter content of the soil. The quantities at stake, however, are small: from a few dozens to a few hundreds grams of

carbon per square metre per year, which is stored in the permanent structures of plants and in the profile of soil explored by plant roots. It is virtually impossible to detect these quantities with direct analytical methods in the short period, because they are lower than the normal instrumental resolution and masked by a very high spatial variability. It is thus necessary to use alternative measuring systems, based on the direct measure of the carbon absorbed by the agroecosystem, observing how much CO_2 flows to (or from) the vegetation in the atmosphere with the *eddy covariance* technique.

The Eddy covariance method

Foliage absorbs CO_2 from the atmosphere during the day through the process of photosynthesis. At day and at night all vegetable organisms and even microflora breathe, releasing CO_2 in the atmosphere. It is a chaotic and complex movement, hardly characterisable, where three-dimensional "eddies" of air move and carry matter, mixing up the atmosphere. It is possible to imagine, however, that during the day, when photosynthesis is dominant, the downward movement toward the vegetation shall prevail. On the other hand, during the night the release of CO_2 by the whole system (plants, soil) supports the movement of CO_2 upwards. If it is possible to measure the dynamics of these eddies and the composition of the air that produces them then it is possible to measure these substances' flux.

It is, however, a very dynamic phenomenon, which experimental measure requires highly sophisticated equipment. First of all, the air movement must be measured in the three dimensions, including the vertical one. Secondly, given the great temporal and spatial variability of these whirling structures, the measurement must be taken several times in a second (typically, 10 or 20 times). A third constraint requires that the concentration of the species which movement needs to be quantified be measured in synchrony with the air speed measurements.

In this regard, the fast, continuous and synchronous measurement of the three components of the wind and of the concentration of the substance of inquiry, carried out on a wide, homogeneous and flat surface, allows to directly measure the flux through the simple formula:

$$F_c = -\rho\, \overline{w'c'}$$

where the vertical flux of the F_c substance is given by the product of the air density and the covariance between the vertical component of the wind speed w and the concentration of the substance c. It must be noted that this technique allows an actual measure of the flux, and not just an estimate. Negative fluxes suggest a net absorption by the vegetation, while positive fluxes show a release of CO_2 toward the atmosphere.

Main results

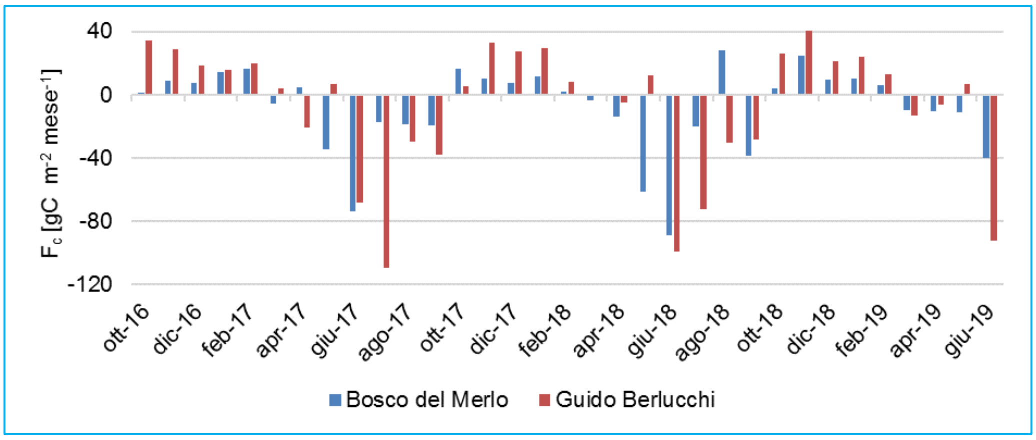
Within the VITISOM Project the *eddy covariance* technique was used at two of the vineyard sites involved in the trials: the "Arzelle" vineyard of the Berlucchi company (Corte Franca, BS) and the "Bosco del Merlo" vineyard of the homonymous company (Lison di Portogruaro, VE). Both vineyards have adequate extension, arrangement and homogeneity of application of the technique and monitoring was extended for the whole period of the project (October 2016 – October 2019), allowing to determine the seasonal dynamics of carbon accumulation and release as CO_2. However, this publication includes data processed up to June 2019.

Although the two vineyards differ in some regards (Arzelle vineyard: planted with Chardonnay trained by the spurred cordon system, density of plantation 10,000 plants/ha; Bosco del Merlo vineyard: planted with Sauvignon blanc trained by the Guyot technique, density of plantation 5,000 plants/ha), the overall removals in the three years were similar: -880 gCO_2/m_2 at the Arzelle vineyard and -1038 gCO_2/m_2 at Bosco del Merlo (Tab. 4).

Monitoring with the eddy covariance technique allowed to determine the effect of the main cultivation operations and of some adverse weather conditions on the carbon balance with good accuracy. For example, the frost of April 2017, which affected most of the land planted to grapevines in the North of Italy, and the recurring episodes of summer water stress in the months of July and August have caused a reduction in CO_2 removal.

	Accumulated Fc [gC m-2] Oct. 2016 – June 2019	Accumulated Fc [gCO2 m-2] Oct. 2016 – June 2019
Bosco del merlo	-283	-1038
Guido Berlucchi	-240	-880

Table 4. Results concerning the removals recorded in the October 2016 – June 2019 period in terms of both gC/m² and gCO_2/m^2



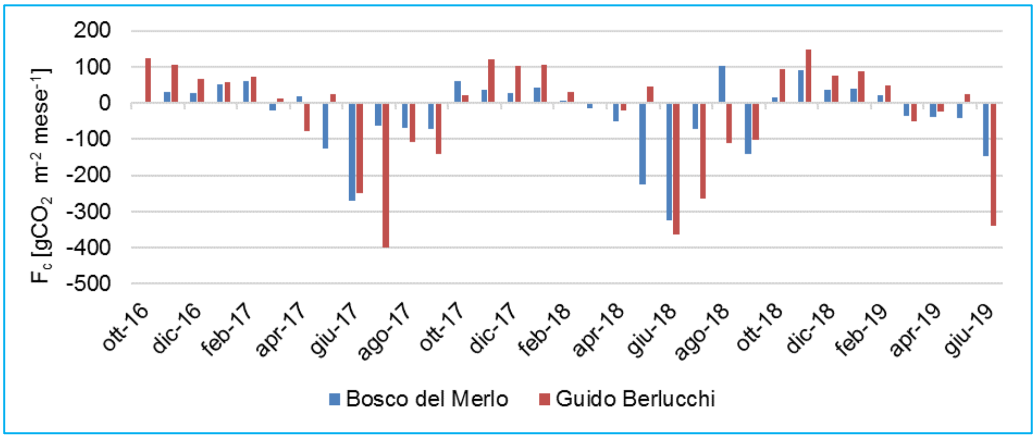


Figure 7. Charts on the pattern of CO_2 and C fluxes at investigated vineyards

3.2.2 Continuous monitoring of GHG from vineyard soil

Monitoring setting

GHG emissions from vineyard soil were constantly monitored at the here above-mentioned sites.

Data were continuously gathered, one measure every two hours, corresponding to 8 sensors placed on the ground. Each sensor was associated to a double treatment and specifically:

- Unfertilised unprocessed control (sensors 4 and 5);
- Unfertilised processed control (sensors 1 and 7);

- Unincorporated compost treatment (sensors 3 and 6);
- Incorporated compost treatment (sensors 2 and 8).

Starting from the second year each parcel was kept free of grass, so as to be able to assess GHG emission without herbaceous vegetation, thus without CO_2 sequestration.

Equipment description

Figure 8. The picture shows the instrumentation used for the continuous monitoring of GHG fluxes from soil planted to grapevines at the Bosco del Merlo site. Sensors were installed near the Eddy Covariance station.

The continuous monitoring station for the measurement of CO_2 and N_2O soil fluxes developed under the LIFE+ IPNOA (LIFE11 ENV/IT/000302) Project can perform measurements with eight accumulation sensors positioned in various places and automatically operated in a sequence, allowing to observe the temporal variability of the measurements in the eight chosen spots. The station is equipped with weather probes and each sensor is fitted with soil moisture and temperature probes.

The technique is based on the recording of the investigated gases concentration within the accumulation sensor over time, in the case of a specific gas flux from the soil. Initially, the increase of concentration in the sensor is linear in time.

Main results

In the period between 1 November and 17 May 2019 about 52,000 flux measurement were performed (Tab. 5).
During such monitoring period all N_2O fluxes were below 20 mol/(m²d), except for a number of events with higher peaks in a frequency of about once a month (November 2017: 100 mol/(m²d); May 2018: 50 mol/(m²d); August 2018: 230 mol/(m²d)).
A particularly significant event was recorded in the month of October 2018, when emission peaks reached 250 mol/(m²d) for sensors 6 and 8, 120 mol/(m²d) for sensor 3 and 80 mol/(m²d) for sensor 2 (Fig. 9).
In the period from November 2018 to May 2019 N_2O fluxes were once again lower than 20 mol/(m²d), with the exception of sensor 8, which recorded some fluxes between 50 and 180 mol/(m²d) with daily fluctuations and sensor 6, which recorded fluxes between 30 and 50 mol/(m²d) during the month of February 2019.
As regards CO_2 sensor 8 recorded emissions between 0,8 and 1,2 mol/(m²d) in the month of October, about twice as much as the other sensors (Fig. 10). Such emissions later decreased, just like with N_2O, going back to normal after 21 October.

Period	Measurements per sensor
Nov Dec 2017	732
Jan Feb 2018	622
Mar Apr 2018	732
May June 2018	556
Lug Ago 2018	744
Set Ott 2018	740
Nov Dic 2018	732
Gen Feb 2019	708
Mar Apr 2019	732
mag-19	196
Total per sensor	***6494***
Total measurements	**51952**

Table 5. Total measurements performed during the November 2017 – May 2019 period

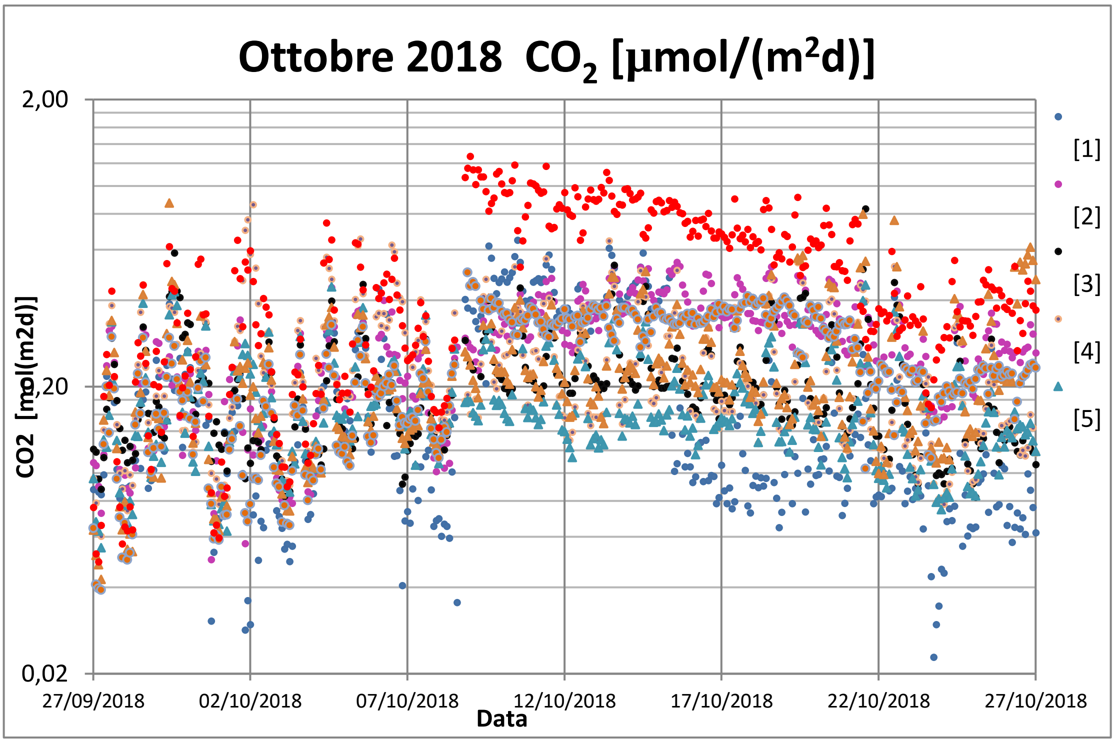


Figure 9. Chart on the distribution of N_2O fluxes in the month of October 2018

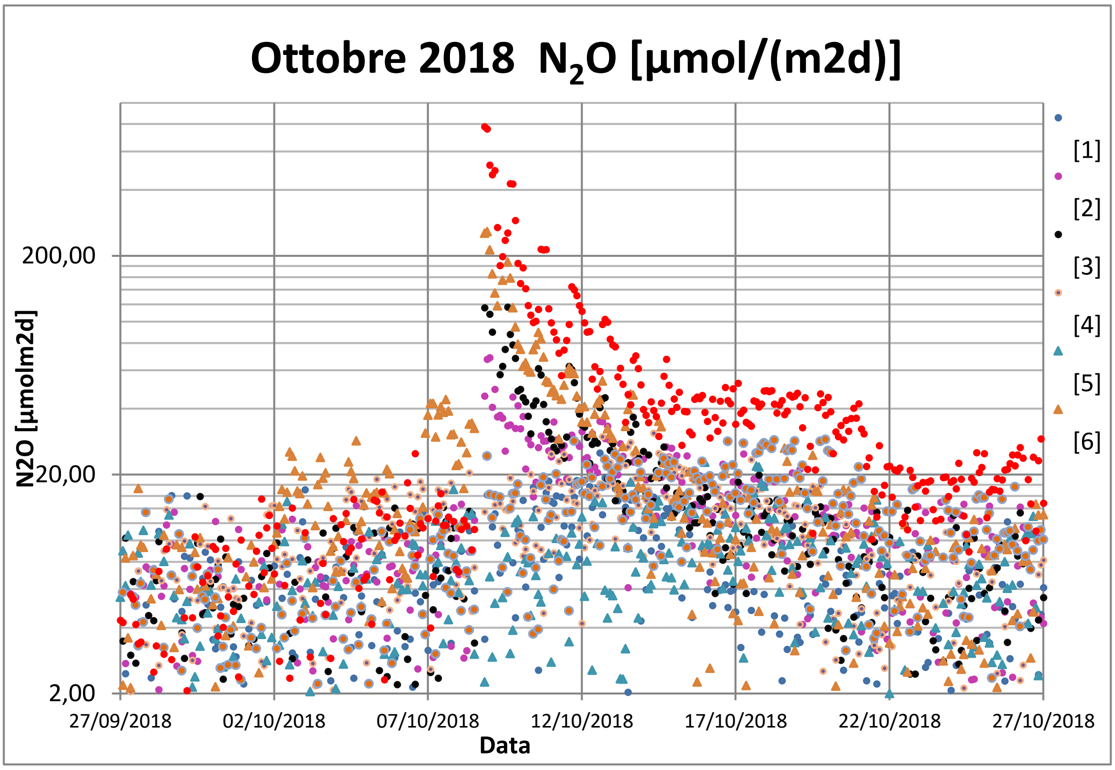


Figure 10. Chart on the Distribution of CO_2 fluxes in the month of October 2018

3.2.3 Spatial monitoring of GHG's from soil planted to grapevines

The monitoring performed during the Project

Spatial monitoring of GHG emissions from soil planted to grapevines was carried out at all 5 trial sites involved in the project.

Measurements corresponding to each treatment type (see Table at paragraph 3.1.1) were performed at each site and repeated in different periods of the year. Table 6 shows the number of measurements and the N_2O and CO_2 emission data gathered for each site.

A total of 4,823 exact values for carbon dioxide and nitrous oxide emissions from the soil were registered.

Prescription maps showing the varieties of vigour within the vineyard were then superimposed on one another and a vigour level and consequent matrix dosage were associated to each point of GHG emission measurement. The emissions were thus coupled with precise matrix dosage levels and with the intrinsic characteristics of the vineyard.

	2017				2018				2019			
	N. Plots	Month	Measurements month	Measurements year	N. Plots	Month	Measurements month	Measurements year	N. Campagne	Mese	Misure mese	Misure anno
Castelvecchi	3	January	69	325	3	June	128	384	1	April	128	128
		March	128			September	128					
		July	128			December	128					
Bonomi	5	January	80	554	3	May	119	369	-			-
		March	116			August	125					
		June	120			Octorber	125					
		September	119									
		October	119									
Berlucchi	4	January	101	485	2	May	127	271	1	July	133	133
		March	128			August	144					
		June	128									
		September	128									
Conte degli Azzoni	3	March	128	385	2	May	128	256	2	March	128	256
		June	128			July	128			July	128	
		October	129									
Bosco del Merlo	5	January	91	677	3	May	175	502	-			-
		March	118			July	156					
		April	156			October	171					
		June	156									
		October	156									

Table 6. Spatial monitoring performed at the five trial sites identified within the LIFE15 ENV/IT/000392 - VITISOM LIFE Project.

Equipment description

The portable tool, also developed in the framework of the LIFE+ IPNOA (LIFE11 ENV/IT/000302) Project, allows to perform measurements of N_2O, CO_2 and CH_4 fluxes from the soil in a fast and convenient way. The equipment is installed on an electric traction lightweight crawler powered with batteries and controlled from a distance through a remote control system.

The accumulation sensor is manually placed on the ground, above a collar, and connected to the moving device through a 20 metre-long pipe. A small quantity of gas is sent to the analysers and the increase in concentration for each gas species within the sensor is visualised in real time.

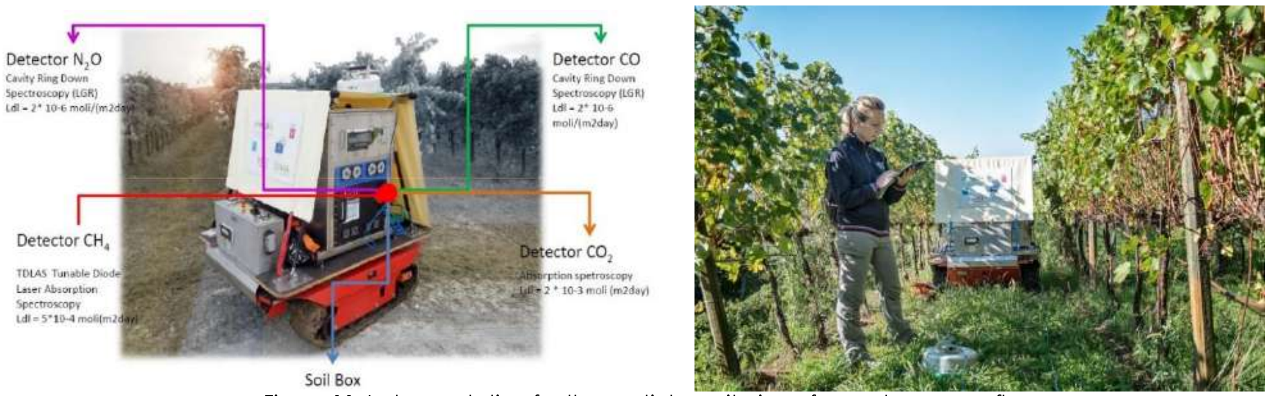


Figure 11. Instrumentation for the spatial monitoring of greenhouse gas fluxes

Data are then memorised on a handheld computer and later processed. It takes only 3 minutes to perform a flux measurement
through the spatial prototype, allowing to collect data extremely rapidly and to develop a very solid emission dataset.

Main results

Data gathered from the spatial monitoring of N_2O and CO_2 emissions have been treated from a statistical and geostatistical point of view with the purpose of defining the quantity of emissions produced by each treatment type and analysing their spatial distribution at each site.

Figure 12 shows an estimate of the nitrous oxide emissions, expressed as mg/(m^{2}day), produced in the year 2017 and concerning the Bosco del Merlo site. In this case it is possible to appreciate N_2O variations with reference to the various types of fertilisers and processing. For example, at this site, a strong decrease in emissions in the months of June and September can be observed, against higher quantities in March and April, that is, shortly after treatment application. Emissions from compost are higher than those from manure and eluate. Furthermore, much variability can be observed depending on the processing of the soil: in some cases, as with compost, the unprocessed kind seems to produce higher emissions, while in others the contrary is true.

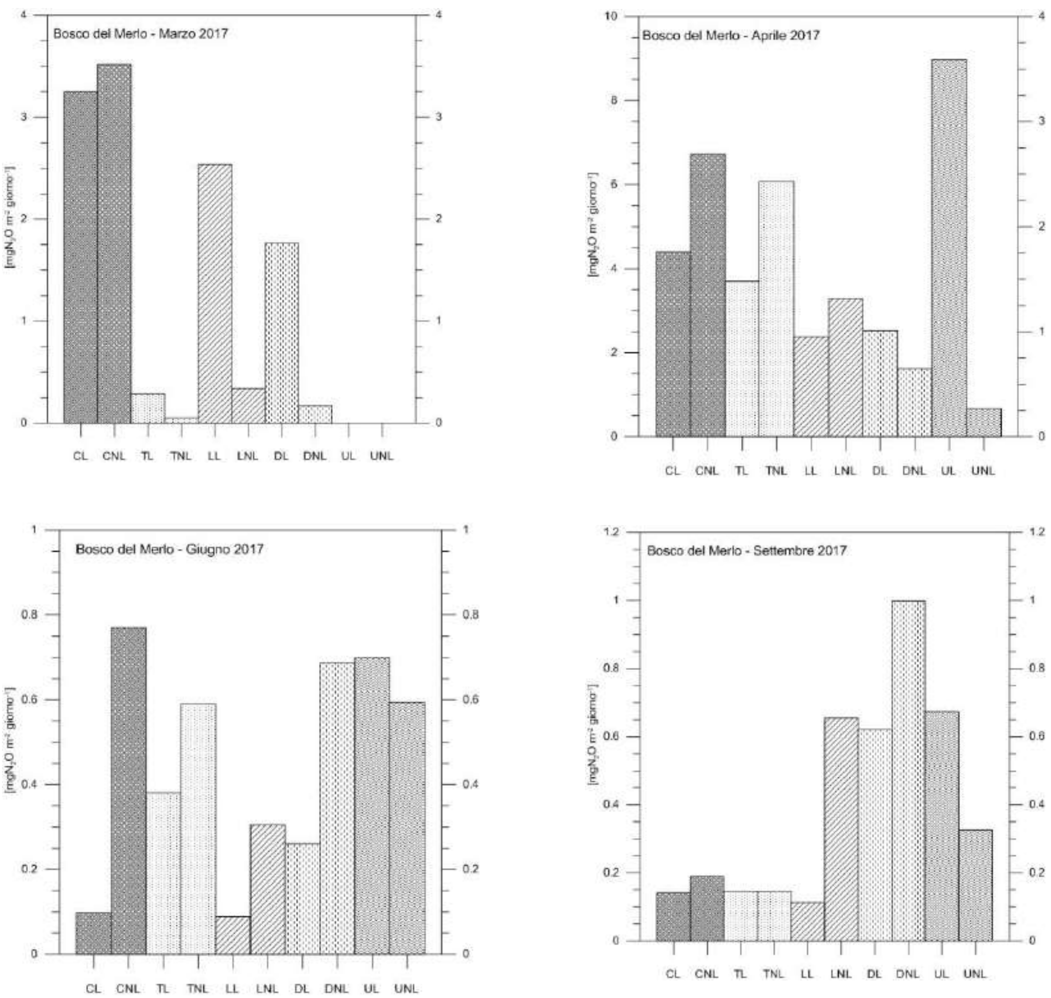


Figure 12. Bosco del Merlo, year 2017. Nitrous oxide emissions as a function of treatment types

Beside the statistical analysis, a spatial one was developed based on the gathered data, which allowed to draft isoflux maps showing the global emissions from the investigated site. In each N_2O and CO_2 measuring point the vigour and the quantity of applied fertiliser were defined, so as to be able to create an emission map showing N_2O gr as a function of the grams of applied nitrogen (Figure 13).

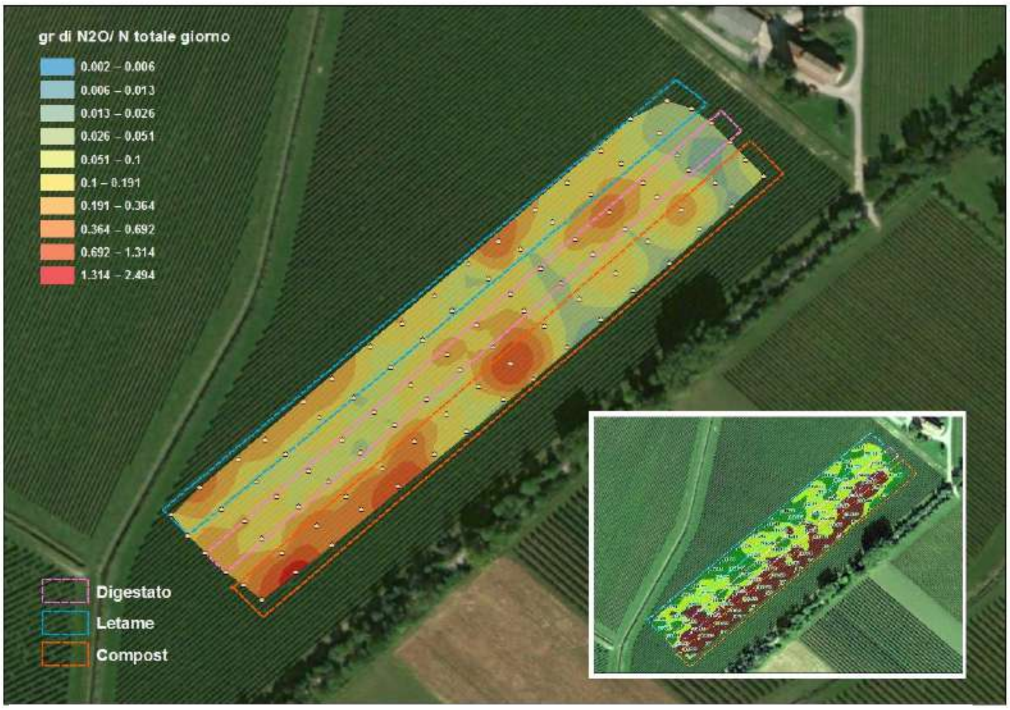


Figure 13. Bosco del Merlo, march 2017. Isoflux map of nitrous oxide emissions. The vigour map is shown in the box below right

In the case of Bosco del Merlo analogies between the isoflux map and the vigour map (see box, below right) can be observed, specifically for compost, where the areas with less vigour correspond to higher emissions. Given the great quantity of the gathered data, it was possible to analyse the correlation between vigour and emissions in each site, obtaining important information on the potential differences in the impact of the various treatments.

3.2.4 Carbon footprint evaluation

The carbon footprint

The carbon footprint is defined as the total greenhouse gas emissions caused by an individual company or product. There are many kinds of greenhouse gases, each of them contributing to the greenhouse effect in its own way. The Kyoto Protocol regulated a number of gases, namely carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4), hydrofluorocarbons (HFC), perfluorocarbons (PFC), and sulphur hexafluoride (SF_6). CO_2 alone accounts for 77% of total emissions and is thus considered as a reference unit to calculate the impact of all other gases on global warming. Such value is expressed in terms of Global Warming Potential, where CO_2 is the unit value of GWP[2]. For this reason we talk about "carbon footprint".

Investigation framework and applied method

During the whole duration of the Project data regarding only the management of the vineyard were gathered at the five trial sites. The Ita.Ca® calculation software was used to

[2] https://unfccc.int/process/transparency-and-reporting/greenhouse-gas-data/greenhouse-gas-data-unfccc/global-warming-potentials

quantify the equivalent CO_2, thus the carbon footprint. Such software is consistent with the main international protocols such as International Wine Carbon Protocol, UNI EN ISO 14064:2016[3] and the GHGAP protocol of the Organisation Internationale del la Vigne et du Vin[4].

Main results

This study shows that the main source of emissions is the use of fuel to move agricultural vehicles. The second main impact is due to fertilisation and the third to the emissions deriving from the use of plant protection products. As Figure 14 shows, the main difference among the five sites concerns fertilisation. The great variability is caused by multiple factors: different territorial characteristics, as well as varying productive objectives, soil and vineyard management and level of mechanisation. The different vineyard arrangements, such as terraces and slopes, influence the final result by affecting the quantitative needs for organic matter in the soils.

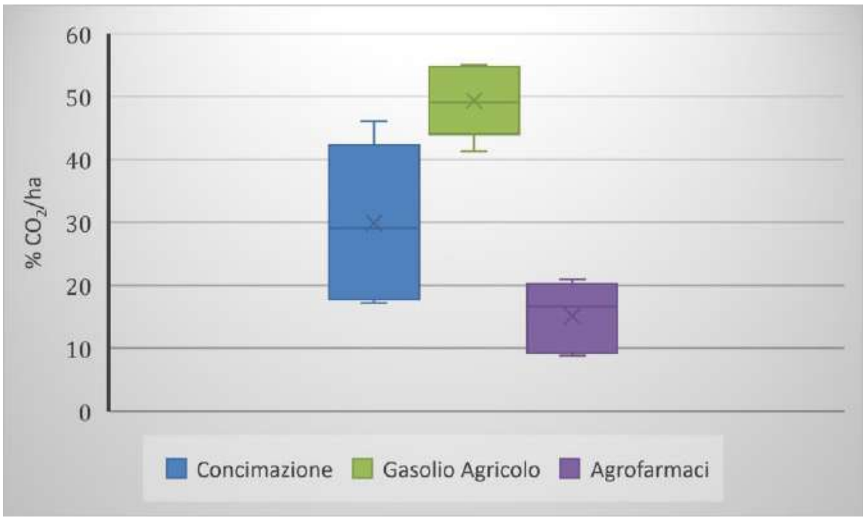


Figure 14. Graph relating to the percentage weight of the different sectors on the overall carbon footprint at the vineyard level

Fertilisation contributes to the total emissions by 20-40%. In this respect, the lowest results were obtained in Franciacorta, where company management is based on organic farming. Results were higher in other companies: in Marche there is a greater demand for organic matter for soil management and more intense fertilisation is needed in Veneto for wine-making and production needs connected to the strong vigour of the vineyards.

Fuel consumption is more homogeneous and depends on the quantity of treatment and processing in the vineyard. The highest results are those of Franciacorta where organic farming requires a greater number of plant protection treatments.

The use of the variable rate allows savings in economic and emission terms, as regards the use of fertilisers and thus of fuel for the movement and application of these masses. Indeed, instead of applying the same maximum dosage of organic fertiliser to the whole of the vineyard, the quantity is proportional to the need of the soil at every point, with a lesser matrix input where the organic matter is present.

3.2 Life Cycle Assessment

The Life Cycle Assessment (LCA) procedure allows to quantify potential impacts of goods or services on the environment and human health, based on emissions and resource consumption.

The LCA data collection phase is called Life Cycle Inventory (LCI), when information is collected regarding the "system" of interest at large, specifically its input (of energy, water, raw materials) and output (to air, land and water) flows.

[3] http://store.uni.com/catalogo/uni-iso-14064-1-2006

[4] http://www.oiv.int/public/medias/2109/oiv-cst-431-2011-it.pdf

It is important to quantify and analyse the available options to improve a production model, in order to actually evaluate the ratio of cost to benefits for each scenario.
Not all options are necessarily efficacious, regardless of the scenario. Sometimes only a shift of impact from one category to the other takes place. The LCA calculation is thus a decision-making support tool.
Through the LCA it is possible to:

- describe a whole system in quantitative terms, according to a standardised structure;
- understand the trade-offs of the various decisions, especially when different scenarios transfer impacts from a category to another.
-

An LCA study was carried out in the framework of the VITISOM Project to assess the environmental impacts of the various treatment types, the application of various organic matrices in the vineyard and their incorporation.

System borders
The system considered in this LCA study includes all matter and energy inputs and outputs for all production phases: organic fertiliser production, transport, pesticides, agricultural operations, use of agricultural machinery and all emissions into the water, soil and air due to agricultural production.
The functional unit (FU) is the reference for normalising all data in the evaluation. In this project the functional unit is set as the quantity of grapes (kg) ready and suitable for wine production.

Methods and impacts of evaluation
The Life Cycle Impact Assessment (LCIA) is used to aggregate registered data to support interpretation: data relating to emissions and resources identified during LCI are translated into indicators reflecting the environmental pressure and scarcity of resources. In this study the ReCiPe 2008 [41] method has been used, considering the impact categories on an intermediate level.

Main results

The main impacts of grape production are connected to fertilisation procedures.
Organic fertilisers can improve the quality of the production and of the soil and, at the same time, cause relevant impacts due to the transportation, distribution and efficiency of the use of nutrients. As for what concerns nitrous oxide emissions, no significant correlation with the type of used matrix has been found to the purposes of this work (e.g. N_2O emissions are usually connected to the quantity of applied nitrogen and to the specific conditions of the soil).
During the project years there was no record of any significant decrease in production due to a lack of fertilisation. Higher impacts were recorded for all other trials, including the application of organic matrices. Those with a lower content of water, such as compost, have caused lesser impacts due to the lower inputs in transportation and functioning on the field (e.g. the necessary digestate to provide the same quantity of N was twice as much the quantity of applied compost). The highest impacts were recorded for digestate (Fig. 15).

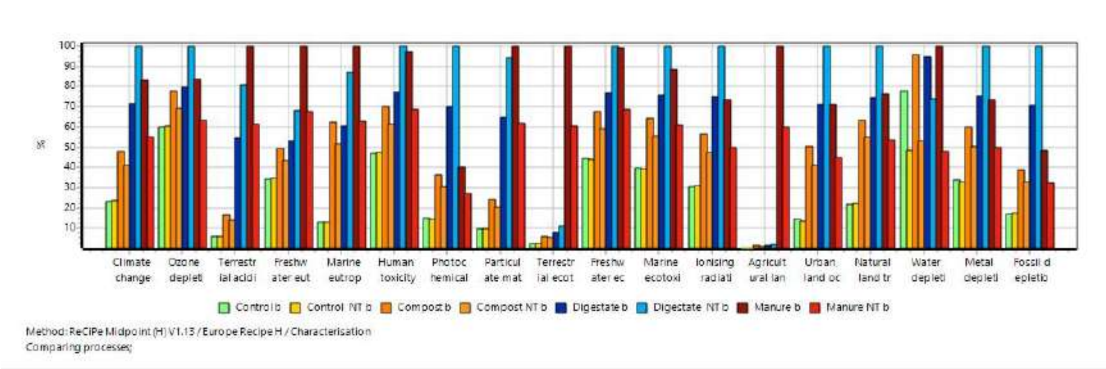


Figura 15. Comparisons of impacts of different field thesis (application of different matrices)

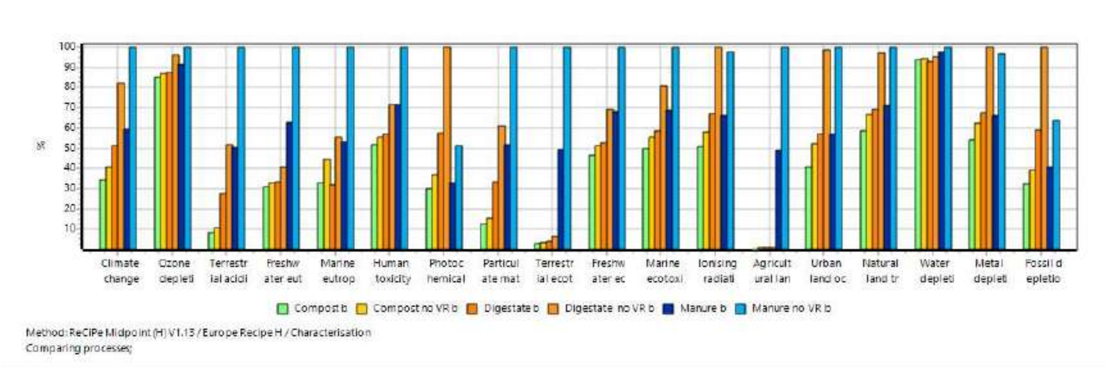


Figure 16. Comparisons of impacts of traditional technology and VRT for the application of compost, digestate and manure

An analysis of the effects of VRT use shows that there is a significant reduction of impacts, caused by a lower energy input for the transportation and application of organic matrices (when VRT is not used, the maximum number of matrices is applied to the soil), with a lower loss of nutrients in the environment.

Considering the normalised impact categories it can be noted that the key categories as regards nutrient loss in the environment, apart from greenhouse gas emissions, are soil acidification and eutrophication (sea and fresh water).

The quantity of the organic matrix should be defined to maximise results (cost-benefit approach). VRT application and the definition of the organic matrix can effectively improve environmental performances with a lower loss of nutrients and significant savings in terms of resources and operations (transport and application).

Process contribution in Climate change impact category	Unit	Amount	Percentage
Total of all processes	kg CO_2 eq	1.15E-01	100%
Field phase	kg CO_2 eq	3.97E-02	34%
Compost	kg CO_2 eq	1.93E-02	17%
Fuel	kg CO_2 eq	1.14E-02	10%
Distribution of organic matrix	kg CO_2 eq	7.55E-03	7%
transport	kg CO_2 eq	3.85E-03	3%

Process contribution in Acidification impact category			
Total of all processes	kg SO_2 eq	1.48E-03	100%
Compost	kg SO_2 eq	6.84E-04	46%

Field phase	kg SO_2 eq	4.21E-04	29%
Fuel	kg SO_2 eq	6.03E-05	4%
Distribution of organic matrix	kg SO_2 eq	5.17E-05	4%
Plant protection products	kg SO_2 eq	5.17E-05	4%
Process contribution in Marine Eutrophication impact category			
Total of all processes	kg N eq	8.21E-03	100%
Compost	kg N eq	6.08E-03	74%
Field phase	kg N eq	2.10E-03	26%
Plant protection products	kg N eq	1.18E-05	0%

Table 7. Process contributions to the 3 main relevant impact categories (Climate Change, Acidification, Marine Eutrophication)

4. Social impact evaluation

Consumer perception of biodiversity

The evaluation of the economic and social impact of the introduction of the agricultural practices set out in the LIFE VITISOM Project, which aim to preserve organic matter and biodiversity in the vineyards, falls within the scope of the evaluation of methods of goods that cannot be marketed. The hereby adopted method focuses on the monetary value that consumers bestow on a specific activity, service or quality of a specific product, through economic experiments that directly involve consumers.

Consumer demand for environmentally friendly and sustainable production practices has grown in the past decades, as evidenced by the various sustainable wine certifications (organic, sustainable, water-saving, biodynamic wines). Such certifications are communicated to the consumers through labels on bottles certifying that certain production standards are met [42].

The level of acceptability of new certifications among consumers must be assessed before products are introduced on the market, as a preliminary evaluation of the knowledge and communication level is necessary.

Methods: contingent evaluation and choice experiment

The first part of the questionnaire has the purpose of assessing the current knowledge about biodiversity among consumers.

A wide range of information on the interviewees was collected, such as socio-demographic data, their wine preferences, their shopping and consumption habits and their knowledge about wine.

Thus two different techniques were applied: the contingent evaluation and choice experiments to assess the consumers' willingness to pay (WTP) for a certification that guarantees production techniques that are compatible with biodiversity conservation. The purpose of the first method is to explicitly ask interviewees about their willingness to pay for a specific good or service; the second method aims to assess WTP through a hypothetical market for the good: interviewees are faced with a series of

choices and asked to choose their favourite option from a list of possible ones. Each option is described in terms of a set of attributes that describe the presented good at various levels. Such experiments were conducted on the occasion of events organised at the premises of the wineries involved in the LIFE VITISOM Project.

Company/event	Region	Products	Method	Participants
Azienda Agraria Conti degli Azzoni	Marche	Rosso Piceno DOC / Rosso Piceno Superiore DOC	Choice experiment	207
Fattoria Castelvecchi	Tuscany	Chianti Classico DOCG	Contingent valuation	130
Bosco del Merlo	Friuli Venezia Giulia	Prosecco Millesimato Brut	Choice experiment	100
Guido Berlucchi & C. SpA	Lombardy	Franciacorta Brut DOC / Franciacorta Satèn DOCG	Choice experiment	205
Castello Bonomi	Lombardy	Franciacorta Brut DOCG / Franciacorta Satèn DOCG	Choice experiment	100
Vinitaly	Lombardy	Franciacorta Brut DOCG	Contingent valuation	148

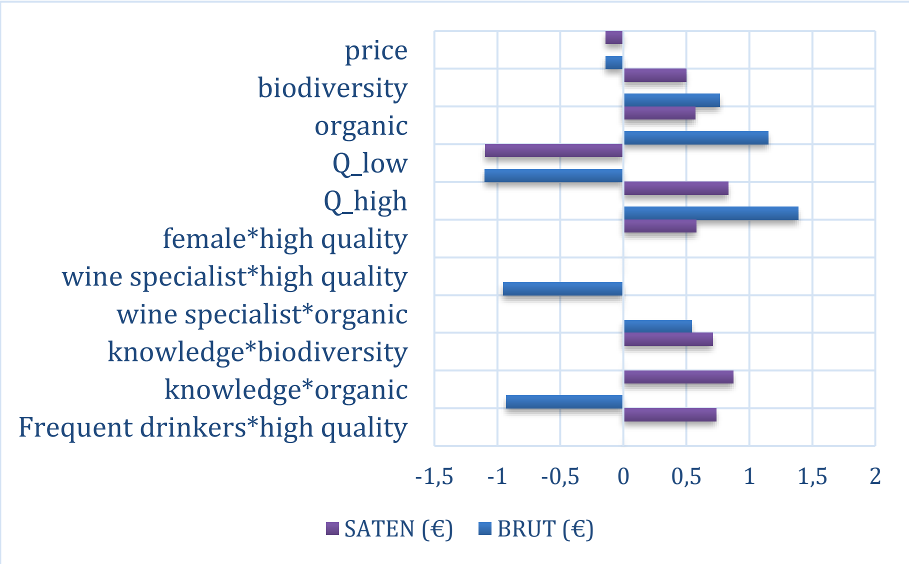
Main results

860 people participated in the survey overall, which was conducted in four territories with a strong Italian wine-production tradition.

Although 50% of the interviewees declared having a substantial knowledge of biodiversity, results show that only a minority of the interviewed sample knows the correct definition or the main causes of the loss of biodiversity. The concept is often confused with those of sustainable agriculture and of the specificity of animals and plants in the various ecosystems, while a large part of respondents thinks that pollution, the use of pesticides and climatic changes are the main causes of the loss of biodiversity.

Interviewees showed a positive WTP for the certification of sustainable practices in the vineyard, both for the medium-high price range products and for cheaper wines, estimated between 5% and 12% of the basic price of the reference products. Results confirm that such biodiversity certification could have a positive influence on consumer WTP, in a way similar to organic certification. However, respondents generally tended to prefer organic wines rather than wines with this hypothetical label.

Previous knowledge of the concept of biodiversity and the level of education proved to be relevant factors to increase the willingness to pay for a "biodiversity brand", suggesting that a deeper knowledge of the importance of biodiversity among consumers could favour the introduction of biodiversity-friendly wines. These results highlight the need for specific marketing actions aimed to increase consumer awareness, as the limited information on quality certifications and the lack of knowledge about agricultural production can be a limit to the viability of agricultural environmentally friendly practices.



5. Other European projects

5.1 LIFE projects in the wine sector

Project title	**LIFE GREEN GRAPES – New approaches for protection in a modern sustainable viticulture: from nursery to harvesting.**
Website	www.lifegreengrapes.eu
Location	Tuscany and Puglia (Italy) – Cyprus
Cost	€ 2,492,618
Duration	July 2017 – June 2021
Partnership	Project coordinator: CREA – Consiglio per la ricerca in agricoltura e l'analisi dell'Economia Agraria. UNIFI - Department of Agricultural, Food, Environment and Forest Sciences and Technology; P.Ri.Ma. - Forma progettazione, Ricerca e Management per la formazione; Vivai F.lli Moroni; Consorzio Vititalia;

	Castello di Gabbiano – Beringer Blass Italia; Soc. Agr. F.lli Tagliente; Cyprus University of Technology (CUT).
Reference	LIFE16-ENV-IT-000566 Project
Project description and objectives	The project aims to define vine management protocols, from the nursery to (table and wine) grape production, using resistance induction products and biocontrol agents that allow the reduction of chemical inputs, the preservation of and increase of soil biodiversity and the improvement of the final product quality. The project partnership includes two nursery companies for the production of rooted grafts, a wine-making company in Tuscany, and two table grape producers in Puglia and Cyprus. The testing of resistance induction products is combined with a 50% decrease in the normal treatments and with soil management with green manure. The scientific activity is conducted by research institutions CREA and UNIFI, which collect, process and validate data gathered by Operational Unit with the purpose of defining vineyard/nursery management protocols; the obtained results will be disseminated through events involving both business operators and researchers.
Expected and/or attained results	In the first and second year of the project evaluation tests of the protocols defined for the reduction of phytopharmaceuticals were carried out, collecting data on plant vigour, health (impact and nature of illnesses), productivity, grape and rooted graft quality, table grape preservability, presence of phytopharmaceuticals residues. Such data are currently being processed and will be published on the project website.

Project title	**ZEOWINE - Zeolite and Winery waste as innovative product for wine production**
Website	www.lifezeowine.eu
Location	Tuscany, Sicily
Cost	€ 1,447,333
Duration	July 2018 – July 2022
Partnership	Project coordinator: Consiglio Nazionale delle Ricerche - Istituto di Ricerca sugli Ecosistemi Terrestri, Pisa. Cosimo Maria MAsini - Tenuta di Poggio S.S. Società agricola; DN360 s.r.l.; P.Ri.Ma.Forma - Progettazione Ricerca e Management per la Formazione S.coop a rl;

	UNIFI – Department of Agricultural, Food, Environment and Forest Sciences and Technology.
Reference	LIFE17 ENV/IT/000427 Project
Project description and objectives	LIFE ZEOWINE aims to improve soil protection and management, vine well-being and grape and wine quality through the application of "ZEOWINE", an innovative product deriving from the composting of waste from the wine sector and zeolite. The positive effects of ZEOWINE on soil and plants are proved by an improvement of nutritional and water efficiency, a reduction of fertiliser input, the closure of the productive cycle of waste and the upgrade of the wines produced. The following action for three productive cycles will be implemented at the demonstration companies: - Composting of waste from the wine sector and zeolite for the production of ZEOWINE and the monitoring of the process; - Definition of the ZEOWINE production protocol and technology transfer; - Application of ZEOWINE as fertiliser in productive vineyards and monitoring of soil characteristics and vine, grape and wine quality; - Definition of the ZEOWINE application protocols for productive vineyards and technology transfer.
Expected and/or attained results	The project will demonstrate the effectiveness of a single ZEOWINE application on soils planted to grapevines in: - improving the agricultural and organic fertility of soils planted to grapevines, in terms of organic matter content, biodiversity, water retention, availability of nutrients and soil structure; - reducing the mobility of copper in the soil, which is the main fungicide use in the organic and biodynamic wine sectors, thus the risk of transferring the pollutant to other environmental compartments; - reducing the systemic use of chemical fertilisers with a reduction of greenhouse gas emissions; - improving the sustainability and competitiveness of the wine sector closing the production cycle of waste material and guaranteeing a higher stability in yields and grape and wine production.

Project title	**SOIL4WINE - Innovative approach to soil management in viticultural landscapes**
Website	www.soil4wine.eu
Location	Emilia-Romagna, the protected areas of Parco del Trebbia, Parco dello Stirone-Piacenziano, Parco del Taro and Boschi di Carrega

Cost	€ 1,605,328
Duration	January 2017 – December 2019
Partnership	Project coordinator: Università Cattolica del Sacro Cuore. Ente di Gestione per i Parchi e la Biodiversità Emilia-Romagna Occidentale; Art-ER; Horta srl; VINIDEA srl.
Reference	LIFE15 ENV/IT/000641 Project
Project description and objectives	The Soil4Wine project aims to identify good practices for soil management in the whole "vineyard" ecosystem, minimizing the effects of the main threats to the soil. The project involves 9 companies located in protected areas, where a number of grassing types and water management techniques have been compared. An innovative decision-making support system will guide winegrowers in the identification of the main threats to the soil in their vineyards and in the choice of the best soil management technique. The gathered data from the quantification of parameters regarding soil quality and from the description of the various vine responses will be used to assess the effectiveness of the demonstrative actions through a SWOT approach. Special attention is given to the determination of the possible socio-economic and environmental limits to a sustainable management of the soil and to the definition of criteria for the financial recognition of the ecosystem services provided by the soil.
Expected and/or attained results	The project aims to define good practices for a sustainable management of the vineyard soil. The development of a Decision-making Support System (DSS) will guide wine growers in the identification and recognition of the problems in the vineyard, suggesting moderating and improving actions to put in place. The aim is also to economically quantify the main ecosystem services provided by the soil in the vineyard (water storage, improvement in biodiversity and in landscape quality, erosion control), defining guidelines, shared among the main stakeholders, for a remuneration of the activities carried out by agricultural enterprises.

Project title	**Life ADVICLIM - ADapatation of VIticulture to CLIMate change: High resolution observations of adaptation scenarii for viticulture**
Website	www.adviclim.eu
Location	France, Germany, Spain, Romania, United Kingdom
Cost	€ 3,019,930
Duration	July 2014 – February 2020

Partnership	Project coordinator: CNRS France - Centre national de la recherche scientifique e University of Rennes 2 (France). INRA Centre Bordeaux-Aquitaine (France); IFV (Institut Français de la Vigne et du Vin) (France); ECOCLIMASOL Company (France); USAMV Iaşi (University of Agricultural Sciences and Veterinary Medicine Iasi) (Romania); Plumpton College (United Kingdom); UGM (Hochschule Geisenheim University) (Germany); Public University of Navarra in Pampeluna (Spain).
Reference	LIFE13 ENV/FR/001512 Project
Project description and objectives	In the age of climate change the wine sector is facing a number of challenges, including the adjustment of its practices and the reduction of greenhouse gas emissions related to its activities. In response to these challenges, recognising the need to assess climate and its impacts on the wine sector at the vineyard scale, the LIFE ADVICLIM project aims to study climate change adaptation scenarios for a range of vineyards representing the climate diversity of the European wine-growing regions. The goal of the LIFE ADVICLIM project is to develop adaptation strategies to climate change, which can be adapted to the European wine regions, and to demonstrate their application at the vineyard scale. The measurement network and the web-based platform will enable wine producers to assess the impacts of climatic changes on their plots, simulate scenarios of adaptation and measure greenhouse gas emissions related to their practices. Such technologies are being tested at demonstrative sites in six European wine-growing regions: Cotnari, Rheingau, Bordeaux, Sussex, Rioja and Val de Loire.
Expected and/or attained results	The variability of spatial climate on the local scale has been integrated in the results of regionalised climatic change models. Agri-climate models on the fine scale, combined with the winegrowers' production strategies in a multi-agent system, allowed to build adapting scenarios to climate change based on the variability of spatial climate at the vineyard level. An assessment of greenhouse gas emissions was then carried out in order to evaluate the carbon footprint for each adaptation scenario. The main results show that the high spatial variability of the climate caused by local factors is often similar or even higher than the increase in temperature simulated by the various IPCC scenarios. Winegrowers can adapt to this spatial variability of the climate, specifically through their farming practices. In the context of climatic change, the preliminary knowledge of the spatial variability of the climate on the small scale is a resource for the definition of adjustment possibilities to the evolution of the climate in the medium and long term.

Project title	**LIFE SARMIENTO "Demonstration of an innovative solution to reduce GHG emissions in vineyards while improves the soil in arid area"**
Website	www.lifesarmiento.eu
Location	Bullas Protected Designation of Origin (Region of Murcia, Spain)
Cost	€ 835,020, EU contribution: € 495,365
Duration	September 2019 – December 2020
Partnership	Project coordinator: MICROGAIA BIOTECH SL. Cooperativa Virgen del Rosario; EuroVértice Consultores S.L.
Reference	LIFE15 CCM/ES/000032 Project
Project description and objectives	About 57 million hectares are cultivated in Europe, 5.6% (3 million hectares) of which is planted to vines. One of the main residues produced in wine growing is pruned vine shoot, of which 800 to 1,500 kg/ha are estimated to be produced during the annual grapevine pruning. A third of European vineyards is in Spain and the management of vineyard waste contributed to over 5.5% of total CO_2 emissions, shared with Spanish agriculture. A significant contribution to vineyard sustainability could be achieved by improving the traditional pruning waste management, which is currently based on burning, thus reducing the impacts of the wine growing sector on the climate. The main goal of the LIFE SARMIENTO project is to contribute to the mitigation and adaptation to climate change by reaching significant reductions in CO_2 emissions from the vineyards and to the improvement of climatic governance with new soil management practices, which may enhance vineyard productivity, stop soil degradation and promote soil resilience and biodiversity in arid climatic conditions. The project applies a principle of circular economy to vine pruning residues, converting them into a substrate that may be applied as an enriched compost to vineyards, seedbeds and urban gardens, instead of burning it. The process is being developed and tested on 750 hectares of vineyard in Murcia. The project is also developing tools, training modules and guidelines to effectively transfer the solution to other wine production areas in Europe.
Expected and/or attained results	- CO_2 emissions reduced by 85% (2.4 tons/ha/year) compared to the current management practices; - Improvement in soil conditions, avoiding its degradation and increasing its carbon storage capacity, thus providing better resilience to support the adaptation to climatic change; - Setting up of a process for the conversion of over 250 kg/ha of pruned vine shoot from waste to by-products with a new added value, promoting the concept of circular economy at the local level and involving a number of stakeholders; - 750 ha of vineyards managed with this method;

	- 1,850 tons/year of saved CO_2 emissions; - 200 tons/year of waste transformed into by-products, enriching 650 m^3/year of compost to be used as fertiliser and bio-pesticide in vineyards and 150 m^3/year of compost and substrate for urban areas and seeds; - Development of tools to promote the sustainability of this solution and its self-management by the interested parties; - Transfer of the project methods to other wine production areas in Spain and beyond (at least 1,500 ha with this type of management within three years from the end of the project). The combustion of 597.6 tons of pruned vine shoot was avoided as of today through its transformation into organic fertiliser. This allowed to reduce CO_2 by 98% compared to what would have been produced by burning the waste. Furthermore, an improvement of over 30% in 2017 and 45% in 2018 has been reached in terms of sequestration of carbon in the total balance of the wine production cycle. The application of the compost on the soil helps to slow down its degradation, enhancing its fertility, biodiversity, resistance to erosion, and yield, which increases its adaptability to climate change. LIFE SARMIENTO therefore aims to improve soil fertility, while being a low-emission project and contributing to climate change mitigation and adaptation.

5.2 LIFE projects on the theme of soil conservation, fertilisation and nutrient recycling

Project title	**LIFE DOP - Demonstrative mOdel of circular economy Process in a high quality dairy industry**
Website	www.lifedop.eu
Location	Lombardy, Mantua Province
Cost	€ 3,691,795, EU contribution: € 2,083,547
Duration	September 2016 – March 2021
Partnership	Project coordinator: Consorzio Latterie Virgilio. Aral; Università degli Studi di Milano; Cooperativa San Lorenzo; Consorzio Agrario del Nordest; Consorzio Gourm.it
Reference	LIFE15 ENV/IT/000585 Project
Project description and objectives	The LIFE DOP project activities are taking place in the Mantua province and aim to demonstrate a new model for the production of Grana Padano DOP and Parmigiano Reggiano DOP, which may reduce the

	environmental impacts due to greenhouse gas emissions. The project includes integrated nutrient management, from the production of fodder to the effluent treatment (through anaerobic digestion), new practices to apply nutrients to plots (through the use of digestate) and a correct management of barns, thus improving the whole production chain. The reuse of digestate as fertiliser will contribute to the reduction of environmental impacts, reduce ammonia emissions and improve the organic content of the soil, thus contributing to the Soil Thematic Strategy. Project actions: Sewage exchange platform: the project implemented a platform for sewage exchange, capable of collecting the sewage, separated fractions and manure from small milk dairy barns, exploiting such products in anaerobic digestion plants. The web platform enables to match demand and supply, providing a logistic organisation and a support for contracts and other bureaucratic procedures. Sewage and output fractions (shredded manure, separated solid fraction and sewage-manure mixture) are sent to the anaerobic digestion plants (2, in the demonstrative activities of the project). This way biogas plants replace energy crops with the fractions obtained from sewage up to 70%. During the project a specific prototype (mobile cavitator) to support the management of sewage and its fractions in the anaerobic digestions plants.
Expected and/or attained results	Environmental results: in the first two years of the project over 66,000 tons of fractions deriving from sewage-manure were transferred to 6 biogas plants with a production of 18.5 million KWh of renewable energy, thus preventing the emission of 350 tons of methane from sewage storage. The total saved CO_2 was equal to 18,000 tons, taking also into account the produced renewable energy. The total carbon footprint of milk production was reduced by 8-13% in the involved companies. Contribution to the nutrient recovery and management: the quantity of nutrients (N and P) concentrated in the solid digestate was 3 times higher than that from corn digestate. The higher nutrient content makes these materials more precious than standard digestate for exporting operations to fields other than livestock farming (organic farming, horticulture, orchards). More than 9,000 tons of recovered renewable fertilisers were exported to non-zootechnical farms as a replacement for chemical ones. Field tests in non-zootechnical farms proved that it is possible to reduce the synthetic nitrogen-based fertiliser by 100 kg/ha, thanks to the application of solid digestate in autumn. Production was slightly higher than the control (urea standard fertilisation). From an environmental point of view, this means: - reducing the nutrient load in the zootechnical district compared to standard practices; - reducing the use of synthetic fertiliser and the related emissions, applying organic matter outside the district, improving soil quality and increasing the carbon stocked by mineral colloids in the soil.

	The liquid fraction of the digestate was exploited locally with greater effectiveness compared to sewage and manure fractions before anaerobic digestion. Field tests have demonstrated that it is possible to zero the use of the synthetic nitrogen-based fertiliser in zootechnical areas and apply liquid digestate achieving greater efficiency through injection or drip irrigation in pre-sowing and cover, reducing ammonia emissions by 40% compared to standard practices (use of sewage and urea). The solid fraction of digestate of the LIFE DOP model is exported to rebalance the load of nutrients in zootechnical areas.

Project title	**F.A.RE.SU.BIO - Fertilità, Ambiente e Reddito attraverso suolo e biodiversità (Fertility, environment and income through soil and biodiversity)**
Website	
Location	Lombardy Region – Franciacorta e Oltrepo' Pavese
Cost	€ 586,500,37 with a EU contribution of € 477,748,92
Duration	March 2019 – December 2021
Partnership	Project coordinator: Consorzio per la Tutela del Franciacorta. Università degli Studi di Milano; Az. Agr. Bisi soc. agr.; Az.Agr. Montelio di C e G Brazzolasocagr; Az.Agr.Rebollini Bruno e c di Rebollini Gabriele soc semplice agr; Az.Agr. Santa Lucia sssocagr; AzAgr Uberti G & GA socagr; Barone Pizzini Sapa; Castello Bonomi Tenute in Franciacorta socagrrl; Castello di Gussago La Santissima socagrss; Corte Bianca Soc. Agr.; Frecciarossasrlsocagr; Gianpaolo e Giovanni Cavallerisocagrss; Guido Berlucchi& C Spa; Il Mosnel di E Barboglio e figli socagr semplice; Roco Calino socagrsrl; Santus Maria Luisa; SocAgr Brambilla Vigne Olcrsrl; SocAgr Mazzolino srl; Torrevilla viticoltori associati soc coop agr.
Reference	Project financed in the framework of Measure 16.1 Lombardy Region RDP 2014-2020
Project description and objectives	The project comprises three experimental areas that communicate and complement each other, to analyse different but interacting specificities in the wine field in the landscape of research of farming methods that may enhance quality product, environmental protection, company sustainability and profitability.

	- Biodiversity and population dynamics area, which specific purpose is to guide the most suitable choice of the essences, be they pure or mixed, calibrating them according to the various conditions and objectives that must be tailored to each specific case; - Organic matter, soil and product/matrices quality and management area, divided into two subareas with the purpose of providing documented evidence of the effects of different management types of soil planted to grapevines, which vary depending on soil type and climatic context. To this purpose, various analyses from different points of view and based on interacting parameters will be carried out: evolution of organic matter in the soil, biodiversity quality, product, grape and wine quality; - Specific microbiota population analysis transversal area: specifically, these analyses will be carried out with a molecular microbial ecology approach, as most of soil microorganisms cannot currently be grown. This kind of approach allows to obtain an in-depth knowledge of the structure and composition of microbial communities, of their dynamics and their effects on fertility.
Expected and/or attained results	The results that the project aims to achieve concern the possibility to offer wine growers a new, innovative and solid awareness of the most suitable strategies for each specific context in order not to dissipate, but rather to exploit the natural resources of the soil and the consequent environmental specificity. The benefits of the product quality and image and the protection of the environmental heritage can thus be combined in a context of environmental and economic sustainability. In particular, the expected results are: - an improvement of the balance between growth and production of the vine through a correct and balanced input of organic matter to the soil; - a higher efficiency in the management and technique for the application of manure on soils planted to grapevines with consequent economic savings for the company; - an improvement in grape and wine quality as a consequence of the improvement and homogenisation of the fertility level of soils planted to grapevines; - an incentive for a sustainable management of soils planted to grapevines through innovative techniques for its management and for a low-impact control of complex diseases through integrated choices; - the conservation and protection of the organic matter in soils planted to grapevines, eliminating any lack of balance and homogeneity ; - a boost of the vineyard biodiversity through the use of attractive essences defined at plot level.

Project title	TRASFERIMENTO E ADATTAMENTO DEL MODELLO AGRICOLO BIOLOGICO CONSERVATIVO NEI SISTEMI COLTURALI MARCHIGIANI (Transfer and adaptation of the conservative organic farming model in crop systems in the Marche region)
Location	Marche Region
Cost	€ 345,345.50
Duration	February 2019 – February 2022
Partnership	Project coordinator: Soc. Agr. Biologica Fileni. Arca Srl Benefit; Aea Srl; Università Politecnica Marche; Soc. Agr. Agri Blu ss.
Reference	Marche Region RDP 2014-2020, Submeasure 16.1 – Support to the creation and functioning of EIP Operational Groups. Action 2 "Funding of operational groups"
Project description and objectives	The project comes about from the consideration that many agricultural soils in the Marche Region are affected by a marked erosion due to the geomorphological characteristics of this territory, to the climatic conditions and to the loss of organic matter content caused by inadequate soil management, which led and is leading to its mineralisation and thus to an increase in atmospheric CO_2. This is causing a progressive reduction in soil thickness and a reduction of its physical, chemical and microbiological fertility, which has a negative influence on biodiversity and crop yields. The project has the objective to mitigate the current degradation of soils in the Marche region, protecting and improving its functionalities, biodiversity and its strictly connected ecosystem services. Such results will be made possible through the transfer and adaptation of agricultural conservation techniques and technologies (known as "organic conservation agriculture") and the application thereof to organic farming systems in the region, specifically to the most common crops in rotation. The general goal is to protect the functionality, structure stability and biodiversity of the soil through the development and application of soil conservation and improvement techniques. Economically sustainable models shall increase the local companies' competitiveness based on the production of all the more environmentally-friendly products. The operational goal will be the application of techniques and technologies that are typical of conservation farming and agroecology to organic farming in cropping systems in the Marche region.
Expected and/or attained results	- Social: a community-led experimental project is meant to increase the farmers' awareness on the importance of keeping the soil alive and productive; counteracting the continuous degradation of soils depleted by intense mechanical operations; introducing the concept of eco-efficiency of the

	farm; introducing an innovative model of business management and technical competence; promoting products with a high health and environmental content. - Economic: product differentiation from "simply" organic to based on the regenerative organic properties of the soil; higher stability of crop yields; about 50% reduction of fuel consumption; creation of a production chain supported by competences of solid agrifood businesses; - Environmental: qualitative improvement of the soils, decrease in soil erosion, increase in the organic carbon content of the soil; increase in organic fertility of the soil; greater agroecological services through a greater respect for biodiversity and water protection; - Technological: products such as sensors, prototypes and IT applications will be disseminated on the territory to measure and assess the impact of agricultural organic conservation practices in the long term, specifically on the water balance and erosion.

Project title	**Guidelines for good farming practices for the preservation of soil in the most important wine growing areas on the hills of Emilia and Romagna**
Website	https://www.pedologia.net/it/PRO-VITERRE/cms/Pagina.action?pageAction=&page=InfoSuolo.35&localeSite=it
Location	Emilia-Romagna Region
Cost	€ 189,408.41 Eligibile expenditure: € 170.219,57
Duration	April 2016 – September 2019
Partnership	Project coordinator: I.TER Soc. Coop. Università Cattolica del Sacro Cuore di Piacenza; Azienda Tenuta la Pernice; Azienda Res Uvae; La Sabbiona Soc. Agr.; Azienda Agricola La Tosa; Emanuel Piacentini Azienda Agricola; Azienda Agricola Il Baraccone; San Mamante Soc. Agr.; Perinelli Soc. Coop. Agr. Sociale; Eredi Azienda Agricola Conte Otto Barattieri di San Pietro; Azienda Agricola Il Ghizzo di Anselmi Adele.

Reference	Emilia-Romagna Region RDP Measure 16.1.01 – Operational groups of the European Innovation Partnership: “Productivity and sustainability of agriculture” – Focus Area 4C. PRO-VITERRE Project n. 5004519.
Project description and objectives	The PRO-VITERRE project started specific monitoring activities at the partner companies in various pedological fields on the physical and chemical characteristics of the soils, and demonstrations of soil management practices followed by analyses of the associated vine growth/production responses. The project has the purpose of identifying and sharing suitable agricultural techniques for soil preservation, especially with reference to surface water erosion and the conservation and/or increase of the organic matter, while allowing the fulfilment of satisfying production objectives for wine growers. The use of grassing, for example, might be ideal for the preservation of soils from erosion and may facilitate the access of machinery to the vineyard in the wet seasons. However, it could negatively affect the plant water stress, considering global warming, with a consequent loss of production. How, when and on which soil such technique should be used was thus considered, along with its undoubtable benefits in terms of reduction of erosion phenomena, increase of soil bearing capacity and levels of organic material. All partners, farmers and researchers have thus collaborated to the definition of “Guidelines for good farming practices aimed at soil conservation”, which were developed for the main pedological environments for wine production on the hills of Emilia and Romagna.
Expected and/or attained results	The project achieved many objectives, all feeding into the main goal of defining “guidelines for good farming practices aimed at soil conservation in the main wine production areas of the hills of Piacenza and Faenza”. The quality of the final result was determined by the joint efforts to test and verify data collected on the field in the plots owned by partner companies, in order to share and thus to define good farming practices for the managament of soils planted to grapevines, ensuring their conservation without compromising wine production results. Such guidelines promote and enhance the role of the wine grower as a guardian of the soil and of the wine-growing landscape. The guidelines took into account the results and information gathered in the following actions: - effect of grassing compared to processing on the content of organic matter; - effect of grassing compared to processing on the protection of soil from erosion; - effect of grassing compared to processing on the vegetative-productive status of the vine; - demonstrative study in the vineyard of the effect of various lane management practices on the conservation of organic matter, on the risk of erosion and the vegetative-productive status of the vine.

Project title	**SYSTEMIC - Systemic large-scale eco-innovation to advance circular economy and mineral recovery from organic waste in Europe**
Website	https://systemicproject.eu/
Location	Italy, Netherlands, Belgium, United Kingdom, Germany, Finland, Austria
Cost	€ 7,859,828
Duration	June 2017 – June 2021
Partnership	Project coordinator: Stichting Dienst Landbouwkundig Onderzoek (NL). AM Power (BE); Groot Zevert Vergisting (NL); Acqua & Sole S.r.l. (IT); RIKA Biofuels Development Ltd. (UK); GNS Gesellschaft für Nachhaltige Stoffnutzung mbH (D); A-Farmers Ltd (FI); ICL Europe (NL); Nijhuis Water Technology (NL); Proman Management GmbH (AU); Ghent University (BE); Milano University (IT); Vlaams Coördinatiecentrum Mestverwerking (BE); European Biogas Association (BE); Rural Investment Support for Europe (BE).
Reference	Horizon 2020 Framework Programme for Research and Innovation under Grant Agreement no. 730400
Project description and objectives	The SYSTEMIC project is a European project comprising 15 partner organisations including research entities located in 7 European countries. The project aims to demonstrate the effectiveness of the combination of anaerobic digestion with new nutrient recovery technologies in the production of high-value soil fertilisers and improvers based on the recycling of the most abundant biowaste streams in the EU. Implementing the most innovative nutrient recovery technologies, the anaerobic digestion plants involved in the project can use both agricultural and urban waste to obtain different kinds of fertilisers. The nature of the starting substrate and of the final product, as well as the technologies used in the plant, have been designed to integrate with the local economy, in order to develop optimised solutions for European areas with different characteristics. The obtained fertilisers have been largely tested both in the laboratory and in the open field, with the objective of verifying their performances, but also any effects on crops and the environmental impacts on the soil and atmosphere. Specifically, as concerns the environmental impact, the first two years of experiments in the open field have excluded the risk of nitrogen leaching or ammonia and

	greenhouse gas emissions being higher than those associated with the use of urea in similar experimental conditions.
Expected and/or attained results	The SYSTEMIC project is demonstrating new approaches to the exploitation of organic waste as green energy, mineral resources, fertilisers and organic conditioners in five biogas plants on a large scale in Europe. Such pioneering plants will be enriched with new nutrient recovery technologies and will have an important role in the experimentation of new circular economy solutions. The composition and quality of the recovered products will be adapted to satisfy the regional market demands. Such market-oriented approach is necessary to develop a sustainable industry. The widest possible adoption of our approaches and the transition toward a circular economy will be promoted through: - the creation of business opportunities for 10 additional plants (in sensitive positions); - the dissemination of the economic and environmental benefits; - policy recommendations. The SYSTEMIC project will promote the implementation of circular solutions for the management of organic waste in Europe.

Project title	**FERTIBIO - Sviluppo del processo produttivo di FERTIlizzanti BIOlogici e loro applicazione in diversi settori produttivi dell'agricoltura toscana (Development of the organic fertiliser production process and application in various sectors of Tuscan agriculture)**
Website	Under construction. https://www.facebook.com/Fertibio-102171111133459/?modal=admin_todo_tour
Location	Tuscany
Cost	€ 366,321.09
Duration	2019 - 2021
Partnership	Project coordinator: Terre dell'Etruria, Donoratico, Livorno. Gruppo Interazioni Pianta-Suolo dell'Istituto di Scienze della Vita della Scuola Superiore Sant'Anna; Azienda Agricola Grappi Luchino (Pienza, Siena) Cooperativa Agricola Spontanea (Pienza, Siena) Azienda Agricola Ughetta Bertini (Collesalvetti, Livorno) Fattoria Le Prata (Pisa) Azienda Agricola Musu Giuseppe e Francesco (Fauglia, Pisa) Rinnovamento Agricolo (Santa Luce, Pisa) Azienda Agricola il Bambù (Pisa) Idea Verde (Santa Croce sull'Arno, Pisa) Confederazione Italiana Agricoltori Toscana

	Agricoltura è Vita Etruria (Siena)
Reference	Rural development 2014-2020 for Operational Groups
Project description and objectives	The main goal of the FERTIBIO project is to develop and validate biofertilisers for herbaceous species and vegetables to improve soil fertility and reduce the use of mineral fertilisers, maintaining crop productivity and improving yield quality. The specific objectives are as follows: transfering the productive process of Arbuscular Mycorrhizal Fungi (AMF) from lab to prototype scale (Scuola Superiore Sant'Anna; Azienda Agricola il Bambù); building an ad hoc greenhouse for AMF production; producing biofertilisers in granular and/or pellet of organic material (Idea Verde); testing the application of biofertilisers on wheat (Azienda Agricola Grappi Luchino); spontaneous species for catering (Cooperativa Agricola Spontanea); alfalfa and chickpeas (Ughetta Bertini); tomatoes (Fattoria Le Prata); sunflower (Azienda Musu); wheat/barley (Rinnovamento Agricolo); test monitoring (Scuola Superiore Sant'Anna); training of technicians to assist farmers in the biofertilisation process (Agricoltura è Vita); disseminating the results of the project and organising guided tours (CIA).
Expected and/or attained results	1) Development of two prototypes for the production of biofertilisers: one for the in-vitro cultivation of AMF and one for the production of (homogenised and concentrated) crude inoculation; 2) Production of different kinds of biofertilisers: (a) AMF spores and bacteria to be used in granular formulas and/or pellet based on organic materials (leather); (b) crude inoculation of homogenised and concentrated AMF; 3) Testing of biofertilisers on various crops in the open field and in a protected environment though yield and product quality assessment for at least two growing cycles; 4) Increase in the use of biofertilisers in conventional and organic agricultural companies and reduction of the use of mineral fertilisers in conventional ones; 5) Increase in soil fertility; 6) Training of qualified technicians and dissemination to farmers through company visits and workshops which will allow to extend the use of biofertilisers on the whole Tuscan territory; 7) Production of an informative guide with operational guidelines for biofertiliser application.

Project title	**DIG-control - Gruppo operativo per la sperimentazione di tecniche di distribuzione controllata dei digestati e di inibitori della nitrificazione (Operational group for the testing of techniques for the controlled application of digestates and nitrification inhibitors)**
Website	https://www.digcontrol.it
Location	Veneto Region, Provinces of Padua, Venice, Verona
Cost	€ 569,002.06

Duration	January 2018 – December 2021
Partnership	Project coordinator: Società Agricola Sant'Ilario Beneficiari: Azienda Agricola Agrival Azienda Agricola Valbissana Università degli Studi di Padova – DAFNAE ITPhotonics SRL Arpa Veneto Confagricoltura Veneto
Reference	Project financed under Measure 16.1-16.2 of the Veneto region RDP 2014-2020, DGR 2175/2016
Project description and objectives	The presence of organic matter in soils in the Veneto region is very diversified and also includes particularly poor soils in some areas of the plain. The provinces with the largest presence of soils low in organic carbon (<1%) are Rovigo, Verona, Venice and Padua. The intensive agricultural use of the land without input of organic matter through livestock manure or other soil improvers leads to a progressive reduction of organic carbon in the soil until the balance is lost. The lack of organic matter is compromising the degree of fertility of farming soils in Veneto, reducing their productiveness and resistance to tree and herbaceous crop diseases. The increase in organic matter is an important challenge for the primary sector, which must be faced also taking into account the negative effects that an incorrect handling of effluents might have on waters and the consequent environmental pollution (Nitrate Directive). The use of controlled application techniques for organic soil improvers would allow to increase the productive yields of soils, with the input of the right dosage of organic matter where farming soils are most lacking and complying with the prescription of the Nitrate Directive. The project involves applying organic matter in a punctiform manner, depending on the actual concentration of available nitrogen (precision fertigation), mediating between the need to preserve/increase crop yields and that of protecting the environment, minimising the impact of fertilisers on soils and water resources.
Expected and/or attained results	The DIG-control project is aimed at developing an innovative farming protocol based on the use of techniques for the controlled application of organic soil improvers, in order to use the organic matter applied to the soil in a more targeted and efficient way. The group has planned an integrated approach to fertilising techniques divided into two phases: 1. Preliminary mapping of the presence of organic matter in the soils, through the use of the patented poliSPEC-NIR technology; 2. Application of organic matter to the soils with a comparison of farming theses based on the application of a controlled distribution of digestates through variable rate systems. This phase involves the use of the patented poliSPEC-NIR technology and the testing of new nitrification inhibitor products, able to increase the efficiency of the use of the

	nitrogen found in sewage and digestate. The efficiency of inhibited organic nitrogen was thus verified, which shall be compared to organic theses and a mineral fertiliser thesis.

5.3 Topic of greenhouse gas emissions and fluxes

Project title	**NUTRI2CYCLE: Transition towards a more carbon and nutrient efficient agriculture in Europe**
Website	www.nutri2cycle.eu
Location	12 countries from the European Union: Belgium, Italy, Poland, Spain, Germany, Hungary, The Netherlands, Portugal, Denmark, France, Ireland, Croatia.
Cost	€ 7,048,003.75
Duration	October 2018 – September 2022
Partnership	Project coordinator: Ghent University. Universita Degli Studi di Milano, Politechnika Czestochowska, United Experts, Fundación Cartif, Johann Heinrich Von Thuenen-Institut, Soltub, Trade And Service Providing Limited Liabilty, Stichting Wageningen Research, Instituto Superior de Agronomia, Kobenhavns Universitet, Terra Humana, Chambre Departementale d'Agriculture, Zuidelijke Land- En Tuinbouworganisatie Vereniging, Institut de Recerca i Tecnologia Agroalimentaries, Teagasc - Agriculture And Food Development Authority, European Biogas Association, Ips Konzalting Doo Za Poslovne Usluge, Inagro, Consorzio Italbiotec.
Reference	Horizon 2020 research and innovation programme under grant agreement No 773682
Project description and objectives	The Nutri2Cycle project aims to close the nutrient cycle with a pragmatic approach: identifying the most efficient farming systems in Europe using a common methodology; defining indicators to monitor and demonstrate the environmental advantages of closed, more efficient nutritive cycles in a comprehensive way; establishing innovative business cases on a pilot scale (12-16 pilots) which shall act as flagship examples for an effective out-scaling. As a consequence, it will act in collaboration with all stakeholders influencing nutritional cycles with the purpose of: - Providing a full analysis of C, N, and P fluxes and of cyclicality in farms and within landscapes, different types of production systems; - Analysing the synergies among impacts (on the climate, water quality, air, soil) of farming productivity of the C, N and P fluxes and the quality of agricultural products; - Designing efficient and closed cycles, including interfaces between plants and animal production;

	- Prototyping sustainable agroecosystems, including organic systems; - Supporting the durable implementation of results / dissemination, providing scientific support on effective regulatory frameworks to reduce emissions and increase European self-sufficiency for food, energy and nutrients in the next century.
Expected and/or attained results	In the main phases of the mapping of the current C, N, and P fluxes in the European farming systems (Baseline Determination & Toolbox Development) the selection and aggregation of sustainability indicators was carried out, such as: a) agricultural indicators; b) resource consumption indicators; c) environmental indicators; d) economic indicators; e) social value indicators; and f) integrated sustainability indicators. Data were gathered to assess carbon, nitrogen and phosphorus fluxes and stock at farm level and to model and analyse the impact of the innovations evaluated during the project. As concerns the innovations, 76 technical and management solution proposals were selected from a wider initial list for agricultural systems aimed at closing nutrient cycles with efficient mitigation measures. Such solutions have been developed with the collaboration of partners and stakeholders, with a special focus on the practices/strategies for the final users and multi-actor chain approaches. 5 research areas have been identified as innovation channels within the above-mentioned list. The listed solution shall be further assessed in such funnel approach.

Project title	**IPNOA - Improved flux prototypes for N2O emission reduction from agriculture** IPNOA Improved flux Prototypes for N_2O emission from Agriculture
Website	www.ipnoa.eu
Location	Tuscany - France
Cost	€ 2,058,612
Duration	October 2018 – September 2022
Partnership	Project coordinator: West Systems Srl. Regione Toscana (RT); Scuola Superiore Sant'Anna di Studi Universitari e Perfezionamento (SSSUP); Institut National de la Recherche Agronomique (INRA).
Reference	LIFE11 ENV/IT/000302 Project
Project description and objectives	In order to achieve the European objective of reducing gas emissions by 20% within 2020 as compared to the reference values of 1990, it is necessary to curb the production of such gases by their main sources. Even farming, which produces about 7% of total emissions at national level, can contribute to the fulfilling of such objective. Indeed, farming activities share responsibility for the emissions of the three

	main greenhouse gases, namely carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). Specifically, 70% of N_2O emissions in Italy originate in the farming sector. In order to obtain a containment of such emissions it is thus useful to promote the growth of crop systems and farming practices that may limit their production, assessing their effect in view of the great spatial and temporal variability of N_2O emissions. The LIFE-IPNOA project has the objective to improve the techniques for the monitoring of N_2O and the other main greenhouse gas emissions from farming soils, through the development of an advanced instrumentation, able to measure both the spatial and temporal variations of greenhouse gas fluxes on field. Furthermore, thanks to these newly developed monitoring technologies, the project tested the influence that some farming practices can have on the reduction of N_2O emissions and, on the basis of the obtained results, defined good practice guidelines.
Expected and/or attained results	The main expected and attained results of the IPNOA project were: - The development of tools for the monitoring of N_2O fluxes, able to measure the emissions of this greenhouse gas directly on field, in relation to the adopted farming practices. Two tools have been developed to this purpose: a) a continuous monitoring system of the fluxes, for the assessment of temporal variations, installed on corn at the Centro di Ricerche Agro-Ambientali "Enrico Avanzi" (CIRAA) – San Piero a Grado (Pisa) of Università di Pisa (Picture 1); b) a portable tool for the assessment of the emission spatial variations, used both at the Centro per il Collaudo dell'innovazione di Terre Regionali Toscane (CATES) - Cesa (Arezzo) and at CIRAA (Picture 2). - The identification of the best agroecosystem management practices to reduce greenhouse gas emissions from farming activities in the Tuscany Region through a series of field tests carried out on various crop types at two different sites in Tuscany, having different pedological and climatic conditions. - Development of good practice guidelines based on test results. - Scenario analysis at regional scale for the identification of the farming practices that could make a greater contribution to the mitigation of N_2O emissions. Downloadable from the project website, the "Good Practice Guidelines" are a synthesis of the observations made, integrated with the most recent results from the scientific literature, and is meant to provide an easy means of consultation to assess crop system management systems in the farming sector that may promote the mitigation of greenhouse gas emissions, particularly nitrous oxide.

6. Measures and legislation at European level

European viticulture includes situations that vary greatly from country to country, in terms of vineyard size, soil type, wine production or wine-growing practices connected to the climatic characteristics of each region.
Viticulture is an important source of employment, hiring significant numbers of labour: on the whole, wine-growing companies employ more than 1,500,000 workers (full-time equivalent), accounting for 15% of all annual work units in the farming sector[5].
Precisely for this reason, European policies in the wine-growing sector aim to promote its modernisation and market orientation, strengthening its competitiveness and improving its promotion and investment measures.
The constant increase in product demand and processes which sustainability in all its facets is steadily improving, have led to the need to better define the most adequate production conditions across the EU to satisfy the consumer demand for quality organic wines.

Against this backdrop, focusing on environmental and economic sustainability and biodiversity, the LIFE VITISOM Project considers the soil as a non-renewable resource, which must be preserved, in full compliance with the Soil Thematic Strategy[6].
Notwithstanding the national partnership, the project has a great European added value in that its results will contribute to a potential strengthening of the European wine-growing sector.
The application of the variable rate technology can be implemented in all European wine-growing regions and at the same time can contribute positively to the management of organic vineyards.
The impossibility to identify the various geographic contexts within the same territorial area makes it more complicated to access regional funding, such as that provided by the Rural Development Programme (RDP)[7].
However, the results of the VITISOM Project can be usefully contextualised in the framework of various RDP measures, addressing both material actions, such as productive investments and agri-environmental practices (Measures 4 and 10-11), and communication and demonstration activities connected to cross-cutting themes of rural development (Measure 1).
Specifically, the innovative machine developed through the Project to optimise the application of the organic matter in the vineyard through VRT technology has a high technological value that may be considered in the funding set out by Measure 4 in the framework of some regional RDP's.
Moreover, the management methods for the organic fertilisation of soils planted to vines tested in the project are included in the eligible practices for the purposes of the agri-environmental payment schemes set out by PSR's for the integrated production and conservation of the soil (Measure 10) or for organic farming (Measure 11).
The dissemination of results at the European level is particularly important. To this purpose European funding tools are available, such as that of the Common Agricultural Policy (CAP)[8].
The CAP is shared among all 28 European countries, with the purpose of strengthening the European competitiveness and sustainability, funding projects able to address each

[5] https://ec.europa.eu/agriculture/capreform/wine/potential/leaflet_it.pdf
[6] https://ec.europa.eu/environment/soil/three_en.htm
[7] https://www.psr.regione.lombardia.it/wps/portal/PROUE/FEASR
[8] http://www.europarl.europa.eu/factsheets/it/sheet/103/la-politica-agricola-comune-pac-e-il-trattato

country's specific needs through national (or regional) rural development programmes also concerning the wider context of the rural economy.
Moreover, the CAP includes a series of market measures and other support measures for farmers, such as quality logos or the promotion of European agricultural products.
The total CAP budget for the 2014-2020 period is 408.31 billion euro, in the way of EU funding.
Specifically, the CAP is funded through two European funds:

- the European Agricultural Guidance and Guarantee Fund (EAGGF), providing direct support and funding market support measures;
- the European Agricultural Fund for Rural Development (EAFRD), funding rural development.

The latter promotes European rural development policies and it supports rural development programmes in all Member Countries and regions to this purpose.
The three long-term CAP objectives for the 2014-20 period include:

- fostering the competitiveness of agriculture;
- ensuring the sustainable management of natural resources, and climate action;
- achieving a balanced territorial development of rural economies and communities including the creation and maintenance of employment.

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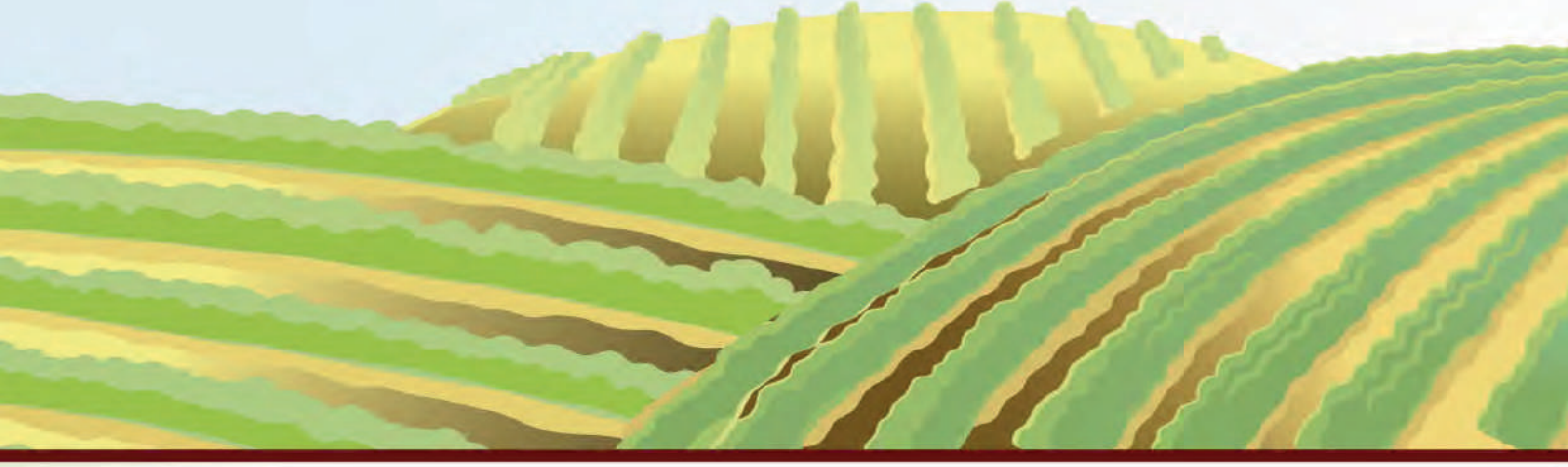

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