Manual of good practice of vineyard organic matter management

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Glossary

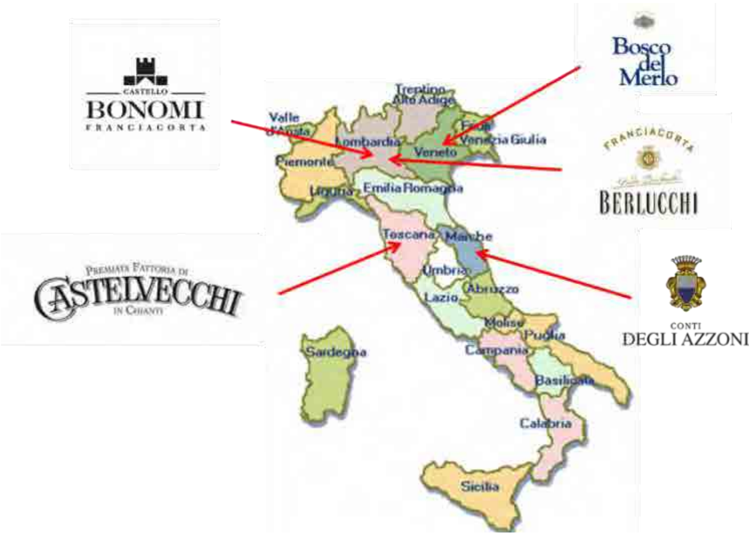
Variable Rate Technology	Applied in a variety of agriculture sectors, it is based on sensors detecting interesting information (for example crop vigour), which are used as indicators to regulate the distribution of various input types.
Soil Organic Matter	The whole of the organic substances found in 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

ACF	Composted soil conditioner with sludge
ACM	Mixed composted soil conditioner
ACV	Green composted soil conditioner
AMF	Arbuscular mycorrhizal fungi
C	Carbon
CH_4	Methane
CI	Canopy Index
CO_2	Carbon Dioxide
EAGF	European Agricultural Guarantee Fund
EAFRD	European Agricultural Fund for Rural Development
FU	Functional Unit (Unità Funzionale)
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
MAS	Maximum efficient nitrogen supply
N	Nitrogen
N_2O	Nitrous Oxide
NEE	Net Ecosystem Exchange
CAP	Common Agricultural Policy
PFC	Perfluorocarbon
PLFAs	Phospholipid Fatty Acids
PSR	Regional Development Program
PUA	Agronomic Use Plan
QBS-ar	Biological Quality of Soils – Arthropods
SF_6	Sulfur hexafluoride
SO	Organic Substance
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
URT	Uniform Rate Technology
VRT	Variable Rate Technology
WI	Wood Index
WTP	Willingness to pay

1. The VITISOM LIFE project

The VITISOM LIFE 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.



Experimental sites involved in the VITISOM LIFE project

The aim of the VITISOM LIFE 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 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. VRT technology improves soil and vine quality in terms of structure of the soil, organic matter content and biodiversity.

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 VITISOM LIFE 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 principal results of the VITISOM project are presented in this publication, for further information or need, please refer to the project website www.lifevitisom.com or contact the following address: ighiglieno.vitisommail@gmail.com.

2. 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 (Delas and Molot, 1968; Lalatta 1971), but it has been further highlighted by the progress in the knowledge about soil composition (Sequi, 1980; Scienza and Valenti, 1983; Vercesi, 1996; Morlat, 2008; Castaldi, 2009). 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 (Perelli, 1987; Vez, 1987; Morlat, 2008; Castaldi, 2009; Valenti et al, 2014).

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 (Colugnati et al., 2006; Valenti et al., 2012). 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 (Figure 1). In this context it is necessary to identify management strategies that allow to preserve and increase the level of organic matter in European soils.

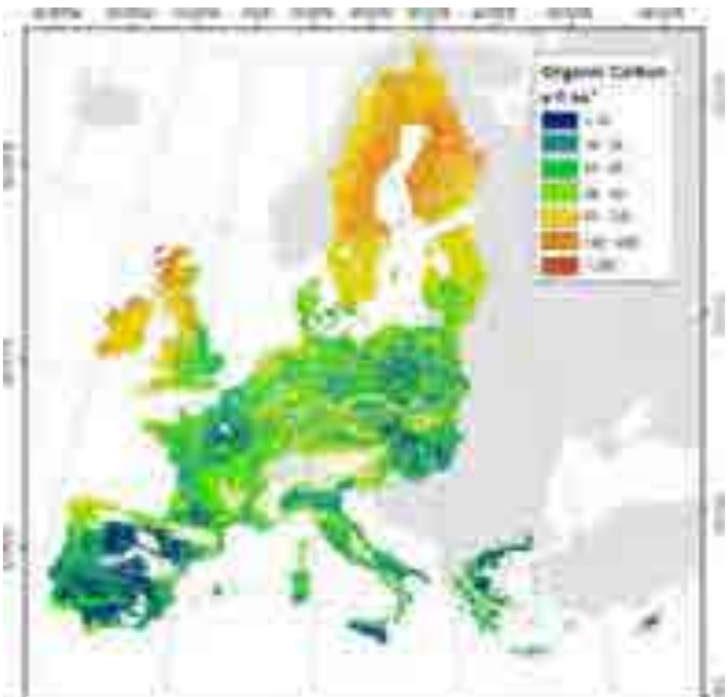


Figure 1. Map of predicted topsoil organic carbon content (gCkg−1). de Brogniez et al, 2015.

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.

3. The technological innovation introduced by VITISOM LIFE project: precision farming and Variable Rate Technology (VRT)

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) (Chaussod et al., 2010; Panigai and Moncomble, 2012).

In this context we find precision farming, a farming management that has already been applied in agriculture [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) (Hall et al., 2002; Zhang and Kovacs, 2012; Atzberger, 2013; Salamí et al., 2014). 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 (Viscarra Rossel et al., 2011; Di Gennaro et al., 2017; Anastasiou et al., 2018).

Precision farming is essential in the wine-growing field to guide management choices based on 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 (Bullock et al., 2009; Bramley et al, 2011; Lawes and Robertson, 2011). The application of such technology to the organic fertilisation of the vineyard is thus a significant innovation, while it has already been applied for other agronomic practices (e.g. chemical fertilization (Gatti et al., 2019) (Figure 2).

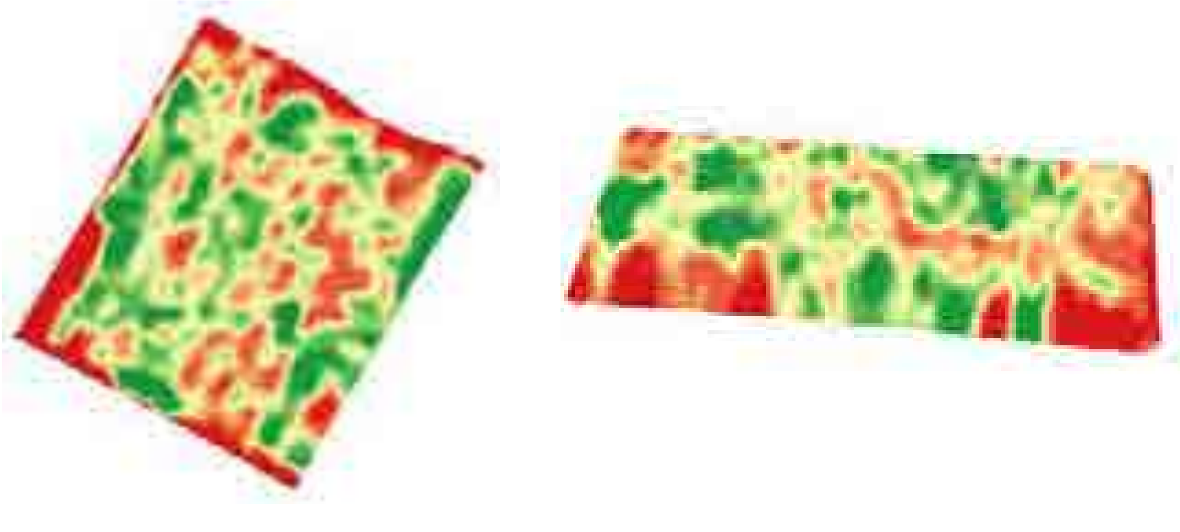


Figure 2. Examples of maps relating to the vigor of the vineyard detected through the proximal sensing technology implemented by the VITISOM LIFE project to read the vigor of the woody shoots in the absence of vegetation. The vigor index is the Wood Index implemented within the MECS-WOOD sensor

4. The prototypes of the VITISOM LIFE project

Figura 3. Free-surface distribution assessment test.

4.1 The design and validation

The aim of the VITISOM LIFE Project is to create an innovative technology for the management of the organic fertilisation of grape through the VRT technology. an innovative system, allowing to counteract the depletion of the organic matter and improve the uniformity and quality of soils planted to vines.

For the entire duration of the project, 5 prototypes were designed and tested in the field, each of which was initially designed for a particular viticultural condition represented by each of the 5 project test companies. The design and construction of the machine were managed by the partner Casella Macchine Agricole and the TEAM Group, in collaboration with the University of Milan. During the project it was also possible to test the prototypes in companies other than those directly involved in VITISOM and evaluate the various problems of use.

This has been possible through different types of tests, from the evaluation of the operation of the entire machine at constant rate, verified with tests of distribution in motion, on a free surface (Figure 3) to measurements made in the field (Figure 4).

Figura 4. Field distribution assessment test.

During the field tests, it was observed that the heap of product loaded inside the box of the machine is simultaneously subject to two forces: one vertical, produced by the proper weight of the pile; one horizontal, undoubtedly more substantial, caused by the progressive thrust of the mobile bulkhead which conveys the product towards the rear rotors. Each of the 3 matrices examined reacts differently to these stresses, also in relation to its physical and chemical composition and its state at the time of distribution (e.g. humidity), forming more or less large and compact blocks, difficult to manage. It was therefore considered necessary to proceed to a laboratory trial phase, in order to acquire information on the rheological behavior of the three matrices considered in the field tests, developing a specific apparatus, with experimental instrumentation and design:

- Test bench with hydraulic thrust cylinder, equipped with load cell (for compression - stress measurement) and displacement sensor (for strain measurement - strain);
- Containment cylinder (h = 600 mm, ∅ = 250 mm corer and precision balance;
- Matrices investigated: bovine manure, mixed and green compost, solid fraction of digestate;
-Measurement of the percentage deformation of the heap and measurement of the increase in density, at maximum loads of 5.000 and 10.000 N (predefined);
- Tests carried out at two different values of humidity (for each matrix as such and after 20 days of natural drying).

It was therefore possible to highlight different behaviour for the different matrices and in particular:

For the manure:

- o With the higher humidity (75.6%), the manure compacts less than the lower humidity (45.0%), because the interstices present in the material as it is (i.e. not subjected to compression) are filled more prematurely from the liquid that escapes following the force applied.
- o As expected, the manure already has a very high density in the condition as it is, which increases significantly with compression, increasing in a more than linear way up to over 2.5 times. Conversely, at lower humidity, the increase is much less marked (from 500 to 750 kg / m³).

For the compost:

- o for both the maximum loads investigated, the compost at the higher humidity (45.0%) is compacted more than the lower value (34.0%), substantially due to the much more uniform size than the manure, which causes that the interstices occupy much less volume.
- o By virtue of its much more homogeneous structure than the other two matrices, the compost shows a more predictable increase in density, as compression increases (from 0 to 200 kPa), i.e. from 700 to 950 kg / m³ approximately, if wet, and from 600 to 850 kg/m³ approximately, if drier. At the two-humidity tested, the differences in density are not noticeable, and reflect (roughly in proportion) the different water content.

For the separated solid digestate:

- o The digestate, on the other hand, shows a behavior that is relatively little dependent on humidity, despite having found a significant decrease in the water content after 20 days of natural drying (from 60.2 to 31.5%). In any case, the trend is more similar to compost, or with the same load the digestate deforms more when it is wetter.
- o The digestate presents substantial variations in density in relation to the difference in humidity, which in this case was very significant, i.e. almost double between the condition as it is and the less humid one. The density obviously increases with increasing compression, but in a much less striking way than with manure: from 550 to 830 kg³ at 60% humidity, and from 300 to 400 kg / m³ at 30.5%.

4.2 The final version of VITISOM LIFE project

At the end of the project the 5 prototypes are ready in their final version and able to work "in real time".

The 5 prototypes distribute the three types of organic fertilizer generally used in viticulture (manure, compost, separate solid digestate) in a differentiated and calibrated way according to the actual needs of the vineyard, following the principle of the variable rate. The software component of the machines allows direct communication between the vineyard prescription map and the wagon that distributes the matrix. The possibility of distribution in real time, thanks to the simultaneous action of reading the vigor and distribution, is made possible by the implementation of the MECS-WOOD sensor for reading the vigor of the vine from woody shoots: organic fertilizations are in fact generally carried out in autumn or in early spring, when vegetation is not actually present.

The various prototypes developed by the project and the MECS-WOOD sensor are presented below.

PROTOTYPE VRT3	
Originally developed for the Marche region of Conti degli Azzoni with sloping and variable counter-slope soils, this prototype was then found to be better used in contexts in the absence of significant counter-slopes. This prototype has a maximum distribution width of about 1.4 m and has a lower weight than the other models (about 100-150 kg less). It is therefore suitable for land with variable slopes (even sloping terrain) but without excessive compensation: the absence of the distribution plates (present instead in other models) has a lower distribution accuracy and can cause distribution asymmetry with excessive counter-dependencies.	

PROTOTYPE VRT4	
Prototype originally developed for the Tuscan reality of Castelvecchi; it is the most versatile as it allows distribution in conditions of extremely variable gradients. It also allows the distribution in conditions of counterdependency, thanks to the distribution plates that allow greater precision. For particularly critical operating conditions, we recommend the use of the prototype VRT 6, equipped with automatic self-levelling system. Also, thanks to the distribution plates, this machine allows the distribution for a width ranging from 1.2 to 3 m wide.	

PROTOTYPE VRT5	
Prototype identified by tendentially flat reality with the presence of vineyards of wide extension, such as those present in Bosco del Merlo in Veneto. Also in this case, the distribution plates allow a wider distribution width, up to 3 meters, thus making it easier to transit in alternate rows. Depending on the rotation rate of the distribution plates, the organic fertilizer can also reach the rows adjacent to the transit one.	

PROTOTYPE VRT6	
Prototype developed for vineyards that need critical manoeuvres such as those with strong slopes and dependencies. As part of the project has been tested in terraced vineyards of Castello Bonomi; it has then proved more suitable for the counters of vineyards of the Marche. It is in fact equipped with hydraulic braking controlled by the tractor through servo-valve and self-levelling system managed by the integration between the data provided by an inclinometer positioned on the body and the work of two cylinders placed under the body (whose work is to keep the case in a horizontal position). This feature allows good maneuverability and symmetry of distribution along the row even in vineyards characterized by steep slopes and dependencies.	

PROTOTYPE VRT7	
Prototype "scooping" model suitable for transit in narrow-sixth vineyards. At Guido Berlucchi was used in vineyards with a planting density of 10000 vines/ha. This machine is structurally different from the others, the distribution in this case is from above. This machine allows to distribute simultaneously on 4 1.25 m interlocks (for a total working width of 5 meters). The distribution takes place through rollers while the "fall" effect of the matrix (particularly accentuated in this model) is limited by containment bulkheads.	

MECS-WOOD SENSOR

MECS-WOOD sensor is a multi-parametric sensor specific for the characterization of the vegetative vigour and the micro-environment inside the vineyard. It represents an implementation of the already existing MECS-VINE® sensor sensor that allows the reading of vigor and other information about the vineyard from the foliar surface of the vine. MECS-WOOD has been validated as part of the project through the realization of comparisons made between maps made with the Canopy Index (CI) and Wood Index (WI) as part of the same vineyards in the 5 test companies project (Ghiglieno et al., 2019).

The MECS-WOOD sensor analyzes the force within the vineyard no longer by calculating the CI but through the WI, allowing you to create maps of vegetative vigour based on the strength detected by the woody branches in absence of vegetation. In this way it is possible to analyze the vegetative vigour also in the winter season and, consequently, to distribute the organic fertilizer in the vineyard in "real time".

For information on the results obtained from the monitoring of the force carried out at VITISOM LIFE companies during the project please refer to: ighiglieno.vitisom@gmail.com.

5. Organic matrices in viticulture - the regulatory framework

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5.1 Organic fertilisation in viticulture

Organic fertilisation may be carried out with materials belonging to two macrocategories: the first consists of materials of variable composition that can be used under specific prescriptive rules that set out the criteria for agronomic use (minimum quality requirements, dosages, periods, etc.), such as cattle manure, mechanical separation fractions of cattle and pig manure and solid fraction of agro-livestock and agro-industrial digestate; the second category is represented by all materials with constant and guaranteed quality (fertilizer products) that can be purchased on the market and freely used according to the principles of good agricultural practice, as conforming to the requirements of the *Legislative Decree 29 April 2010, n. 75 "Riordino e revisione della disciplina in materia di fertilizzanti, a norma dell'articolo 13 della legge 7 luglio 2009, n. 88" e s.m.i.*

In this context, the regulatory framework and the normal agronomic practices of both new organic materials from the farm (e.g. digestates) and commercial organic fertilisers (e.g. compost) are explored.

This will not examine the agronomic use of flows that can only be classified as "waste" pursuant to Legislative Decree n. 152/06 and s.m.i, such as sewage sludge whose use is regulated by Legislative Decree 99/92.

5.2 The digestate

5.2.1 The digestate from "non-waste": definition and regulation

The regulatory classification of digestate has always been very controversial and was only partially clarified with the approval of Legislative Decree 4/2008, corrective to Legislative Decree 152/2006. Law 134/2012 clarified, in the case of non-waste digestate, that it must be considered a by-product. Only with the Interministerial Decree 25/2/2016 did the digestate acquire a defined and sufficiently clear status.

The Ministerial Decree of 25 February 2016 therefore regulates the use of digestates from matrices defined as "non-waste", that is by-products, while digestates that come from the treatment of organic waste, sewage sludge and other organic waste, which remain regulated, are not regulated. by Legislative Decree 152/2010 and subsequent amendments

Pursuant to art. 22 of the Ministerial Decree, the digestate from "non-waste" intended for agronomic use is produced by farm or inter-company plants fed exclusively with the following materials and substances, alone or in mixture with each other:

a) straw, mowing and pruning;
b) agricultural material from agricultural crops;
c) livestock manure;
d) waste-water;
e) residues from agri-food activity;
f) vegetable waters of oil mills and wet pomace, whether or not pitted;
g) animal by-products;
h) agricultural and forestry equipment not intended for consumption.

The digestate produced with the matrices listed above is considered a by-product pursuant to art. 184-bis of the legislative decree 3 April 2006, n. 152, if produced by company or inter-company plants and intended for agronomic use in compliance with the provisions of the Decree itself. The DM then proceeds to classify two types of digestate:

A. agro-zootechnical digestate is produced with materials and substances referred to in letters a), b), c) e h).
B. agro-industrial digestate is produced with the materials referred to in letters d), e), f) e g), possibly also mixed with materials and substances referred to in the letters a), b), c) e h).

In any case, regardless of compliance with the requirements described above, the digestate, like all other materials, can be classified as a byproduct only if it complies with the requirements prescribed by the regulations (Article 184bis of Legislative Decree 152/2006).

The requirements for a material classified as a by-product are:

a) Originated in a process not intended for its production
b) Has a certainty of re-use by the producer or third parties
c) It does not need treatments to be used other than those of normal industrial practice
d) Does not lead to overall negative impacts on the environment and health

The by-product digestate must also comply with all the requirements established by the Ministerial Decree of 13 October 2016 n. 264. The Ministerial Decree of 13 October 2016, n. 264, the new by-product decree, which does not make substantial changes to the current legislation but defines some methods by which the holder can demonstrate that the general conditions for the qualification of by-product and not as waste are met, strengthening the bureaucratic obligations of producers and of by-product users. In particular, in order to demonstrate the use of digestate as a by-product, the following requirements must be met:

- the requirement of certainty of use: this requirement is demonstrated from the moment of production of the residue until the moment of its use. The existence of contractual relations or commitments between the producer of the residue, any intermediary and users.
- Direct use without treatment other than normal industrial practice.
- Provision of information necessary to allow verification of the residue characteristics and compliance of the residue with the intended process and use.

For the purposes of by-product classification, the digestate must also meet the chemical, physical and biological criteria described in Annex IX to the DM for agri-livestock and agro-industrial digestate.

If the digestate does not meet all the criteria in Annex IX, it must be classified as waste according to Legislative Decree 152/2006.

Some regions also provide criteria for the assimilation of digestate to manure (e.g. Piemonte with the DGR of 23 February 2009 n. 64-10874). In this case, the digestate is automatically subtracted from the waste regulations pursuant to art. 185 of Legislative Decree 152/2006 and it is not necessary to verify the requirements of by-product according to DM February 2016 and DM 264/2016.

The agronomic use of digestate shall be carried out in accordance with the nitrogen limit of 170 kg per hectare per year in vulnerable areas and 340 kg per hectare per year in non-vulnerable areas, the attainment of which contributes only to the quota which comes from the digestion of manure. The Regions can, however, impose more restrictive limits.

5.2.2 Digestate from "organic waste": regulatory references

The use of the digestate from the anaerobic digestion of waste should be brought back within the current classification of the soil improvers contained in the Legislative Decree 75/2010 and considering that it is the only legislative act that covers the digestate from waste; the entry into force of the Ministerial Decree of 25 February 2016 represents a precise regulatory act which finally establishes the characteristics of origin, classification and use of digestate (not "from waste" which we will call "agricultural digestate") indirectly defining the boundaries between the agricultural sectors and waste treatment. The differences in relation to the matrices that originate the digestate are therefore emphasized (agricultural waste and livestock effluents on the one hand and organic waste on the other), thus regulating the quality characteristics and methods of use of the two digestates. The free use (albeit with some restrictions) for the "agricultural digestate" is introduced with the Ministerial Decree of 25 February 2016, while the digestate from waste requires a post-treatment to "cease the qualification of waste" as required by annex 2 of the legislative decree 75/2010. This is due to the greater non-homogeneity of the fractions from separate collection (which originate the digestate from waste) compared to the waste from agricultural production.

5.2.3 Supplying

Interesting initiatives to encourage the exchange of digestate were born thanks to European funding, as in the case of the Life Dop project. On June 15, 2017, the web platform www.borsaliquami.it promoted as part of the Life Dop project was presented in Mantua. The Sewage Exchange aims to: enhance livestock waste for the production of renewable energy (biogas), reduce the impact of the livestock supply chain by increasing good waste management (reduction of methane emissions) and promote the export of fertilizers renewable sources (manure and digestate) outside areas with high livestock intensity. The platform, and the logistical support organization, promotes the exchange of livestock effluents between farms, breeders and biogas plants, putting supply and demand in contact between the various supply chains. The work of the platform has so far allowed the exploitation of over 200,000 tons of wastewater, the production of over 30 million kWh of renewable energy and about 750 tons of methane have not been released into the atmosphere. In addition, about 20,000 tons of renewable fertilizers (digestate and manure) have been exported and valorised in non-livestock areas.

5.3 The digestate from waste becomes composted soil conditioner

Annex 2 of Legislative Decree 29 April 2010, n. 75, concerning the reorganization and revision of the regulations on fertilizers was modified by the Decree of 10 July 2013 of the Ministry of Agricultural, Food and Forestry Policies (Official Gazette no. 218 of 17 September 2013).

As regards Annex 2, and therefore the composted amendments, in summary:

- the composted soil conditioner with sludge category is introduced to which is added the PCB verification (to the sludge itself) and a maximum allowed limit;
- for the Mixed Composted Amender, sludge is no longer considered as a base material for the production of this amendment;
- the Mixed Compost Amendant can be "manufactured" with the addition of *digestate from anaerobic treatment of organic waste;*
- the Mixed Compost Amendant may have a pH range from 6 to 8.8 (previously it was 8.5), a modification made necessary precisely by the presence of the digestate (with high ammonia concentrations and therefore with a high pH).

5.3.1 Compost is a soil improver

Compost is used in the agricultural and / or horticultural sector as a soil improver and marketed according to the indications and limits indicated by Legislative Decree no. 75/2010 (annex 2). Fertilizer legislation distinguishes Compost into three categories:

- Green composted soil conditioner (ACV - Ammendante Compostato Verde),
- Mixed composted soil conditioner (ACM - Ammendante Compostato Misto),
- Composted soil conditioner with sludge (ACF - Ammendante Compostato con Fanghi)

Depending on whether the organic matrices of origin are, respectively, only vegetable waste (grass clippings, twigs, pruning, wood) or vegetable waste mixed with other organic waste (domestic wet, agro-industry waste, digestates, purification sludge, other agroforestry by-products).

5.4 The formal obligations

Anyone who intends to distribute manure or palable fractions of agricultural slurry and digestates in the field must make, as a "producer / holder" or only "holder", if he receives them from third parties, the "communication of spreading" to the competent authority (Province or other, depending on the region in which it operates); this may be accompanied by the PUA (Agronomic Use Plan) according to the quantity of total nitrogen withdrawn annually and intended for agronomic use (also considering any own livestock effluents). The same Decree of 25.02.2016 provides for the complete exemption from compliance (communication and possible PUA) for the holder / user who assigns a total quantity of nitrogen not exceeding 1,000 kg / year for agronomic use in a vulnerable area; this threshold rises to 3,000 kg / year if the spreading takes place in non-vulnerable areas, as well as the exemption for the distribution of the green composted soil improver.

5.5 Use criteria: epochs, efficiencies and dosages of organic fertilization on the vineyard

At the base of an optimal organic fertilization there are three aspects: the crop and its removal, the time of distribution and the nature and efficiency of the material to be distributed.

It should be noted that the green and mixed composted soil improver does not require communication and a winter stop if with N <2.5% ss (art 40 dm 25/2/16). The Decree of 25.02.2016 provides all the elements to calculate the distributable quantity per hectare. As for the distributable dose according to the nutritional needs of the crop; the calculation criterion is based on nitrogen. For each crop, the MAS - maximum efficient nitrogen supply is provided with its reference yield. Below are the values indicated for the vineyards (Table 1), extracted from Table 1 of Annex X of the decree 25.02.2016.

Tabl1 1 – Maximum standard efficient nitrogen supply per vineyard

Culture	Maximum supply N efficient (kg/ha)	Reference production yield (t/ha)
Vineyards	70	9
Vineyards (high productivity)	100	18

In general, the efficiency of fertilization depends on the possibility of matching the inputs with the phases of greater nitrogen absorption by crops and greater activity of the soil microflora. Correlating the spreading period to the type of crop practiced (the vineyard in this specific case) results in the efficiency picture shown in Table 2.

Table 2 – Definition of the efficiency of the distributed N according to the method and time of distribution (taken from Table 1 of Part A of Annex V of the Decree of 25.02.2016)

Culture	Epochs of spreading	Mode	Distributed N efficiency
Arboree (vine)	Pre-implantation		LOW
	May-September	With grassy ground	HIGH
		With worked land	MEDIUM

In practice, the distributions near the plant or the phase of greatest demand of the crop reach the highest efficiency; those carried out well in advance generally have lower results. For the valuable effects related to the contribution of organic substance as such, please refer to the introduction in this publication, but as specified, it is nitrogen that governs the distributable quantities. The different level of efficiency that is achieved according to the time and spreading methods (high, medium or low) must then be translated into percentages of efficient NTK (available for cultivation) compared to the total distributed NTK; these percentages take on different values depending on the type of material and are also indicated in the same Decree of 25.02.2016 and reported in Table 3.

Table 3 – Coefficients of efficiency, expressed in%, of the nitrogen supplied with palable digestates, manure and palable fractions of sewage

Efficiency level	Palable fractions of digestate [1]	Manure, solid fraction of bovine and pig slurry		
		Coarse texture	Medium texture	Fine texture
LOW	26	28	26	24
MEDIUM	41	45	41	36
HIGH	55	62	55	48

Finally, for the purpose of calculating the dose to be distributed, the constraint linked to the location of the plots on which the spreading is carried out remains to be considered:

-in the VULNERABLE zone to nitrates the maximum quantity of nitrogen in the field of zootechnical origin must not exceed 170 kg / ha per year;

-in an area NOT vulnerable to nitrates, the maximum quantity of nitrogen in the field of zootechnical origin must not exceed 340 kg / ha per year.

In any case, based on the nitrogen balance, the total quantity of efficient nitrogen distributed must not exceed the nitrogen requirement of the crop (MAS). While for zootechnical manure the dose calculation criterion is defined in all the steps, in the case of spreading solid fractions of digestate produced not only starting from livestock manure but also from other matrices, to calculate the quantity per hectare it is necessary to know how much of the total nitrogen contained in the digestate is of zootechnical origin and what is not. As already specified above, the quota of zootechnical origin cannot exceed the maximum limits indicated above; the remainder goes to saturate the needs of the crop up to the value of the MAS. For greater ease of understanding, the following are two examples of calculating the maximum distributable dosage in a vulnerable area of two digestates with different levels of nitrogen of zootechnical origin (Box 1).

Box 1 – Calculation of the maximum distributable dosage of digestate with different zootechnical N content in order not to exceed 170 kg / ha of zootechnical N in vulnerable zone

Case 1	N to the field	Digestate	
	(kg/year)	(m^3/year)	(kg N/m^3)
N – zootecnico	30,000		1.5
N- vegetale (-20%)	68,000		3.4
TOTAL	98,000	20,000	4.9
Maximum distributable dosage		(m^3/ha)	113
		(kg N/ha)	555
Case 2	**N to the field**	**Digestate**	
	(kg/year)	(m^3/year)	(kg N/m^3)
N – zootechnical	68,000		3.4
N- vegetable (-20%)	30,000		1.5
TOTAL	98,000	20,000	4.9
Maximum distributable dosage		(m^3/ha)	50
		(kg N/ha)	245

The next step is to check whether the maximum possible dosage is also the one actually distributable on the basis of the nitrogen balance. As can be seen in Box 2 where a simplified example is reported, the maximum dosage of digestate in case 1 must be reduced, as it provides an efficient quantity of N higher than the MAS of the vine, even when distributed in moments of low efficiency.

Box 2 – Calculation of efficient nitrogen as a function of the spreading time and the relative efficiency coefficient provided by the two maximum quantities of digestate referred to in Box 1.

Dosage MAX (m3/ha)	Total N from DIGESTATE (kg/ha)	Coefficient of efficiency	N efficient from DIGESTATE (kg N/ha)
Case 1: 113 m^3/ha	555	26%	144
		41%	228
		55%	305
Case 2: 50 m^3/ha	245	26%	64
		41%	100
		55%	135

5.6 Management of organic fertilizers in BIO viticulture

Edited Paolo Di Francesco – Sata Studio Agronomico

Organic farming regulations have always identified a nitrogen ceiling and some types of organic fertilizer that can be used on crops: this is also the case for the latest published regulation, EU Reg. 848/2018. The envisaged nitrogen ceiling is 170 kg per year and per hectare of UAA area. The usable organic fertilizers that must respect this limit are: manure, dried manure and dehydrated poultry, composted manure including poultry, composted manure and liquid manure. It is also possible to use other organic products such as digestate and compost. These products do not fall within the limit of 170 kg / ha of N and therefore - only in non-vulnerable areas - they can be used up to 340 kg / ha of N. The most common compost is of two types: green composted soil conditioner and mixed composted soil conditioner. The first - consisting only of cuttings, leaves and twigs - can be used as it is provided that the manufacturer has registered it for use in organic farming; the second can only be used if its analysis complies with some limitations of heavy metal content. The digestate can also be used in organic farming, but its origin must be verified: only wastewater from farms deemed non-intensive by the Regulations can enter the digester, i.e. farms with animals mainly raised on litter and without the use of forced lighting.

6. Investigation of organic matrices

6.1 Availability of the different organic matrices in Europe

European viticulture is made up of very different realities from one country to another, both in terms of vineyard size, type of soil, wines produced or oenological practices linked to the climatic characteristics of each region. The LIFE VITISOM LIFE project seeks to go beyond the variability of vineyards, providing a solution for their sustainable management.

The project proposes an innovative application of variable rate technology for organic fertilization of vineyards, testing the prototypes developed in different Italian wine contexts, representing the variability of European vineyards. For example, the application of the VRT can be adopted in all European wine-growing areas and, at the same time, could represent a useful contribution to the sustainable management of organic vineyards. To demonstrate the effective reproducibility of the method, 3 maps on the availability of the different organic matrices in Europe are shown below. The first map (Map 1) shows the number of farms that own livestock manure storage facilities. From this first analysis it emerges that the countries most involved in the production and storage of manure are: Poland, Romania, Germany and France. The second map (Map 2), shown below, shows the percentage of compost originating from all the municipal solid/liquid waste treatment processes. From this it can be seen that the major compost producing countries are Austria, the Netherlands and Belgium with a respective percentage of 35%, 26% and 21%. Furthermore, we know that the use of substrates of organic origin (livestock manure, wastewater and/or sewage sludge and Forsu - Organic fraction of Urban Solid Waste) can be exploited for the production of primary energy from biogas. Just as reported in a study conducted at the end of 2016, it was possible to obtain a real European map (Map 3) which allows to identify all the main countries operating in the sector from biogas production (expressed in ktoe). It is possible to observe that the two European countries actively involved in this sector are Germany and Italy.

Map 1: European map of companies involved in the storage of organic matrices

Map 2: European map of % of compost from municipal waste treatment

Map 3: European map of primary energy production from biogas https://www.eurobserv-er.org/biogas-barometer-2017/

6.2 VITISOM LIFE and the investigation of organic matrices

6.2.1 Chemical composition analysis

During the project, analyzes were carried out on a total of 39 organic matrices and in particular 13 composted soil improvers (compost), 14 separate solid digestates, 12 manures.

The main results are summarized in the tables below (Table 4-5-6), the complete analyzes of all matrices including metal analysis can be downloaded at the link (https://www.lifevitisom.com/documenti)

Table 4 - Characterization of the digestates analyzed during the project (average value by locality); average *: average of 11 digestates from companies in the Lombardy area

Matrix	pH	SS % tq	C org %ss	C org tq	N-tot %ss	N-tot tq	$N-NH_3$ %ss	$N-NH_3$/tot %
average *	**8.68±0.94**	**47.5±28**	**45.4±5.1**		**1.67±0.5**		**0.42±0.3**	**23.5±13**
Franciacorta	8.70±0.28	22.6±1.50	42.2±3.21	9.54	0.54±0.07	0.12	0.14±0.02	25.9±3.13
Marche	8.78±0.36	25.9±1.65	44.2±1.93	11.5	0.83±0.10	0.22	0.18±0.08	21.7±8.18
Veneto	8.67±0.74	18.9±2.21	42.9±1.70	8.1	0.42±0.07	0.08	0.05±0.02	11.9±5.19
Toscana	8.78±0.36	25.9±1.65	44.2±1.93	11.5	0.83±0.10	0.22	0.18±0.08	21.7±8.18

Table 5 - Characterization of the compost analyzed during the project (average value per location); Limits *: Legislative Decree 75, 2010 (Reorganization and revision of the regulations on fertilizers, pursuant to Article 13 of the Law of 7 July 2009, no. 88.)

Matrix	pH	SS % tq	C org %ss	C org tq	N-tot %ss	N-tot tq	$N-NH_3$ %ss	$N-NH_3$/tot %
Limits*	**6.0-8.5**	**< 50***	**> 20**		**To declare**		-	-
Franciacorta	6.64±1.59	62.9±6.92	29±4.21	18.3	1.20±0.22	0.75	0,05±0.04	4.17±3.26
Marche	7.65±0.66	71.1±10.8	35±2.92	24.9	1.56±0.31	1.11	0.13±0.06	8.33±4.28
Veneto	7.90±0.78	71.6±6.60	30±0.76	21.5	1.53±0.61	1.10	0.18±0.13	11.8±6.08
Toscana	8.04±1.20	66.5±9.81	31±12.7	20.6	1.37±0.51	0.91	0.12±0.10	8.76±7.64

*If we look at the dry matter data, we can see, in this case, that the compost we use has a value higher than the legal limit which is 50 % as it is. Assuming that this value does not adversely affect the performance of the matrix itself, its variability is due to several reasons that can be influenced by both the manufacturer and the company that uses it. The causes may be related to the type of storage, whether in an outdoor or indoor, the method of transport of the material and the management of this once arrived in the company. It will be easy to bring the value of the dry matter within the limits of the law, mixing it and leaving it to air dry.

Table 6 - Characterization of the dung analyzed during the project (average value per location); *Schievano, A. Scaglia, B., D'Imporzano, G., Malagutti, L., Gozzi, A., Adani, F., 2009. Prediction of biogas potentials using quick laboratory analyses: Upgrading previous models for application to heterogeneous organic matrices. Biores. Technol., 100, 23, 5777-5782.

Matrix	pH	SS % tq	C org %ss	C org tq	N-tot %ss	N-tot tq	$N\text{-}NH_3$ %ss	$N\text{-}NH_3$/tot %
Cow manure*	**-**	**18±1**	**46.3±3.01**	**8.33**	**1.01±0.01**	**0.18**	**-**	**-**
Pig manure*	**-**	**30±1.01**	**34.9±1.12**	**10.5**	**1.64±0.21**	**0.49**	**-**	**-**
Franciacorta	8.09±0.82	23.2±1.29	44.5±0.84	10.3	0.96±0.03	0.22	0.23±0.07	23.9±7.22
Marche	8.48±0.21	22.7±0.78	36.3±7.27	8.24	0.58±0.05	0.13	0.04±0.05	6.89±9.80
Veneto	8.67±0.75	25.9±4.68	38.4±5.01	9.95	0.87±0.22	0.23	0.06±0.02	6.89±0.73
Toscana	8.41±0.17	30.3±15.7	35.9±6.39	10.9	0.92±0.51	0.28	0.01±0.01	1.09±0.73

Beyond the evaluations on the chemical composition of the different matrices it is interesting to observe how, considering the contents in carbon and nitrogen referred to the matrices as such, the compost is the one that records concentrations much higher than the other matrices. For this reason, if you want to administer a certain amount of organic carbon or nitrogen, compost always requires a lower dosage, often less than half, than the other two matrices.

6.2.2 Odor impact

The project involved the evaluation of the odor impact of the different matrices subjected or not to burial. The evaluations were carried out using the standardized method EN no. 13725 (CEN, 2003).

The survey, conducted for two consecutive campaigns (2017-2018) at the experimental sites of Guido Berlucchi and Castello Bonomi located in Franciacorta, was carried out for each matrix and for each campaign by measuring the dosages set as minimum and maximum. For this purpose, an aliquot of gas was collected from each biomass sample using a flow chamber. Once the organic matrix was distributed among the rows, the chamber (surface 0.16 m^2) was placed on the ground and blown with air (0.37 m^3 h^{-1}) through a pump. The gas exiting the chamber was then taken from the exit port and stored in a sampling bag in Nalophan.

The collected sample was then taken to a specialized laboratory that carries out the olfactometry test which consists in presenting the osmogenic air, diluted with deodorized air, to a panel of 6 people. The olfactometer is therefore an instrument that uses the human sense of smell as a sensor, numbering a sensation in UO/m^3. The results were then reported as odor emission rate (OU m^{-2} h^{-1}), Table 7.

Table 7 – Olfactometric analysis results

	Berlucchi Spring 2017	Bonomi Spring 2017	Bonomi Autumn 2017	Berlucchi Spring 2018
	SOER (UO m^{-2} h^{-1})			
Digestate (solid fraction)	347	347	648	590
Compost	2544	2544	1052	648
Manure	3469	3469	2174	624
	7°C	**20°C**	**22°C**	**10°C**
	SOER (UO m^{-2} h^{-1})			
	TNT			
Worked	335 ± 213	463 ± 33	1353 ± 703	266 ± 49
Not worked	665 ± 466	1468 ± 82	2995 ± 1161	208 ± 33
	Digestate (solid fraction)			
	(315-50 q/ha)	(140-35 q/ha)	(320-100 q/ha)	(300-100 q/ha)
Worked	289 ± 16	2220 ± 1603	1029 ± 163	358 ± 33
Not worked	278 ± 0	1197 ± 74	3076 ± 2355	324 ± 65
	Compost			
	(160-40 q/ha)	(120-20 q/ha)	(150-50 q/ha)	(150-40 q/ha)
Worked	283 ± 25	2526 ± 842	1613 ± 989	347 ± 114
Not worked	416 ± 164	3700 ± 1962	1532 ± 957	434 ± 188
	Manure			
	(300-50 q/ha)	(140-30 q/ha)	(270-90 q/ha)	(230-80 q/ha)
Worked	312 ± 65	2087 ± 809	1422 ± 605	231 ± 33
Not worked	324 ± 82	3989 ± 82	2018 ± 270	405 ± 49

From the results it emerges that the treatments that involved the incorporation of the matrices determined, even if not for all cases, a lower odor impact, while in general the solid separated from digestate was the one that recorded the lowest impact despite the the fact that the dosages of matrix are, in this case, higher than that of manure and compost.

It was also possible to quantify the positive impact of the adoption of VRT technology on the odor impact of the different matrices, related to the matrix savings that this technology allows to make. This impact was quantified in an average reduction of about - 13% of odors.

7. Assessment of environmental impacts, premise and experimental plan

As part of the VITISOM LIFE project, assessments have been carried out on different types of impact related to these specific themes and, in particular:

- Impacts on greenhouse gas emissions (CO_2, N_2O, CH_4);
- Impacts on the chemical and biological fertility of soils;
- Evaluation of different types of environmental impact through the analysis of the life cycle of the analyzed process (LCA Life cycle assessment method);
- Impacts on the vine, must and wines;
- Economic impacts;
- Social impacts.

In assessing the impacts, two main outputs were taken into consideration, associated with the two main project themes:

- Different types of management compared: different organic matrices with or without incorporation into the soil.

In this case, five experimental vineyards were identified at the five project test companies (Castello Bonomi, Conti degli Azzoni, Guido Berlucchi, Cantina Castelvecchi, Bosco del Merlo) in which the following comparison plan was set up:

Table 8 - Experimental plan set up at the five test sites identified as part of the LIFE15 ENV / IT / 000392 - VITISOM LIFE project

Type of matrix used	Type of management	Site of construction
Untreated	Not worked	All
Untreated	Worked	All
Compost	Not incorporated	All
Compost	Incorporated	All
Separate solid digestate	Not incorporated	All
Separate solid digestate	Incorporated	All
Manure	Not incorporated	All
Manure	Incorporated	All
Urea	Not incorporated	Bosco del Merlo
Urea	Incorporated	Bosco del Merlo

Advantages of adopting VRT technology in the management of the organic fertilization of the vineyard. In this case, the various project outputs have been processed in such a way as to allow an effective quantification of the environmental and economic benefit of the adoption of the technology implemented by VITISOM LIFE.

7.1 Carbon footprint and evaluation of GHG emissions and flows

One of the most important aspects in terms of environmental impact to be considered in the supply of organic and mineral fertilizers is the emission of greenhouse gases (GHG) mainly due to the dispersion of nitrous oxide (N_2O) in the atmosphere. The latter in fact has a Global Warming Potential (GWP) value, understood as the contribution of the gas to the determination of the greenhouse effect considering the unit value referred to CO_2, very high and equal to 265 (IPCC, 2014).
Nitrous oxide basically derives, in an agricultural environment, from nitrification and denitrification processes or from phenomena of immediate volatilization (Figure 5) (IPCC, 2006). It is considered that about 1.975% of the nitrogen distributed through mineral fertilizer is dispersed in the form of this gas (Georget, 2009), even if the emissions are very variable depending on the environmental conditions (temperature and humidity), on the type of soil (availability of organic matter, pH, level of compaction and texture) and of the fertilizer administered (Patak, 1999). Previous experiences have in fact reported that there are significant differences in terms of emissions with the administration of organic amendments compared to mineral or organic mineral fertilizers; the latter in fact have an emission value in N_2O that is approximately 10 times higher than that recorded for soil improvers, with evident relation to the different C/N ratio and to the total nitrogen content (Georget et al., 2012).
These considerations make it necessary to carry out careful evaluations both in relation to the different approaches in soil management (Bosco et al., 2013), and in relation to the quality and quantity of fertilizer to be applied, weighted according to actual needs, as well as to its administration method . As part of the project, it was therefore decided to pay particular attention to the assessment of N_2O emissions related to the different types of treatments being compared. Investigations were also carried out on CO_2 and CH_4 emissions from the soil and on CO_2 flows at the vineyard ecosystem level. For all 5 companies involved in the project, the carbon footprints at the vineyard level were calculated in order to better quantify the actual savings expressed in CO_2 - eq resulting from the adoption of the variable rate for organic fertilization.

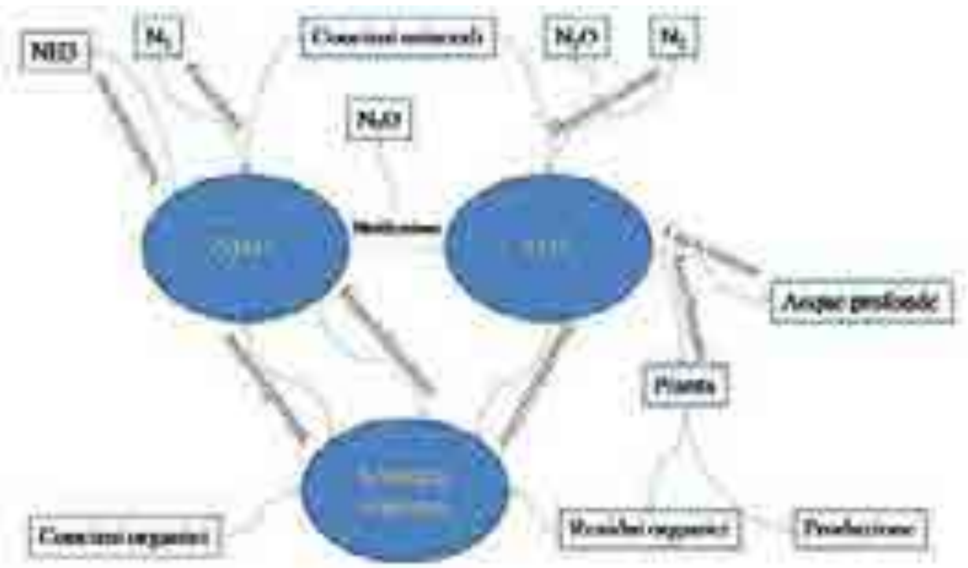


Figure 5 - Nitrogen cycle - Modified by: Masoni end Ercoli, 2010

7.1.1 Evaluation of N_2O emissions from soil under vines

The spatial monitoring of greenhouse gases was carried out using a mobile instrumentation, developed as part of a previous LIFE+ IPNOA project (LIFE11 ENV / IT / 000302), which consists of an electric tracked vehicle on which the analyzers of carbon dioxide, nitrous oxide, methane and carbon monoxide. The flows emitted from the soil are quantified using the methodology of the non-stationary static accumulation chamber.

Within the VITISOM LIFE project, over 4500 greenhouse gas measurements were carried out and this allowed us to obtain important information relating to the impact of the use of organic matrices and variable rate distribution.

SITE	2017				2018				2019			
	N. campaign	Month	Measurement/month	Measurement/year	N. campaign	Month	Measurement/month	Measurement/year	N. campaign	Month	Measurement/month	Measurement/year
CSV	3	January	69	325	3	June	128	384	1	April	128	128
		March	128			September	128					
		July	128			December	128					
CBON	5	January	80	554	3	May	119	369	-			-
		March	116			August	125					
		June	120			October	125					
		September	119									
		October	119									
BER	4	January	101	485	2	May	127	271	1	July	133	133
		March	128			August	144					
		June	128									
		September	128									
CDA	3	March	128	385	2	May	128	256	2	March	22	150
		June	128			July	128			July	128	
		October	129									
BDM	5	January	91	677	3	May	175	502	-			-
		March	118			July	156					
		April	156			October	171					
		June	156									
		September	156									

Spatial monitoring made it possible to identify site-specific emission factors for each organic matrix as a function of the quantity of distributed nitrogen. In particular, as can be seen in Table 9, it appears that:

- In Castelvecchi emissions are higher in the processed plots (with the exception of compost where the coefficient relating to the CL treatment has a value that differs from the average behavior of the other observations) and the highest emission factor is that of digestate
- Even in Bosco del Merlo, with the exception of compost, the emission factor is higher in the worked plots and the higher coefficient is associated with manure.
- In the Castello Bonomi company, the highest emission factor is that of processed digestate.
- In Berlucchi, as in Castelvecchi and Bosco del Merlo, the emissions in the unprocessed plots are lower for compost and manure with the same distributed treatment.
- Conte degli Azzoni has a very high emission factor for digestate which differs from the average of the other observations. The tillage appears to have caused an increase in the emission factor for the manure treatment.

Table 9 Site-specific and treatment-specific emission factors obtained from space monitoring throughout the duration of the project; the values shown in red differ from the average behavior of the other observations and, in the assessments described below regarding the carbon footprint of the vineyard, they have been appropriately re-weighted

	FE [mg N_2O/gr N day]				
	Castelvecchi	Bosco del Merlo	Bonomi	Berlucchi	Conti degli Azzoni
CL	0,00042	0.084	0.029	0.053	0.060
CNL	0.015	0.176	0.032	0.027	0.083
DL	0.043	0.121	0.057	0.064	0.319
DNL	0.028	0.098	0.024	0.135	0.229
LL	0.037	0.149	0.018	0.063	0.077
LNL	0.028	0.029	0.048	0.050	0.031

In general, a tendency can be observed in the emission factors to increase in the case of processed treatment and in the use of digestate; however, a non-negligible variability is observed between one site and another. This makes it necessary to investigate more deeply about the possible interactions between the meteorological and pedological conditions of each site and the results obtained; these considerations will be the subject of a forthcoming scientific publication on this topic. Thanks to spatial monitoring it is possible to appreciate the decrease in greenhouse gases due to the variable rate, in Figure 6, a map of nitrous oxide emissions is shown while in the box inside the image there is a detail of the vigor map, used for distributions. As can be seen, in the central area where the vigor is lower, and where more treatment has been distributed, the emissions are greater, on the contrary where less fertilizer has been distributed, the emissions decrease.

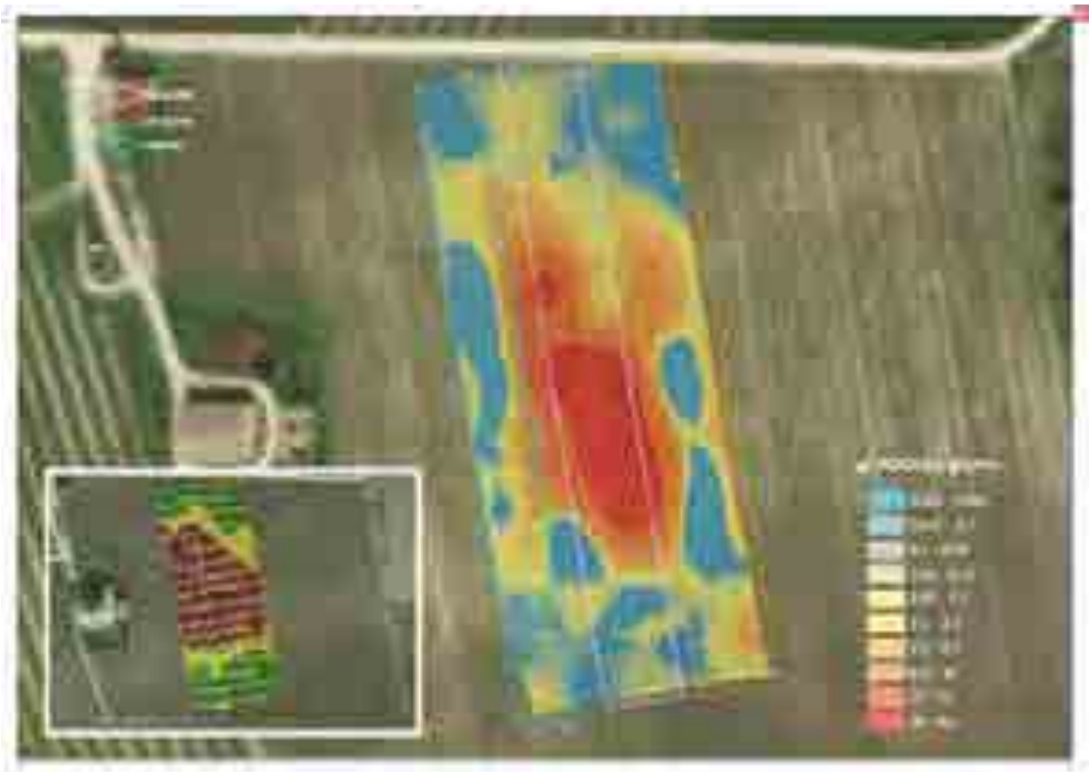


Figure 6 - Map of nitrous oxide emissions detected at the experimental vineyard of Conti degli Azzoni in March 2017

Continuous monitoring was also carried out (in fixed points of the soil but with continuous measurements of emissions) in the period October 2016-October 2019, comparing 4 different types of treatment: a non-fertilized control worked and not worked, contribution of compost with or without ground incorporation. Also, in this case, the overall results emerging from this monitoring will be presented in a dedicated scientific publication.

7.1.2 CO_2 and vineyard ecosystem

The carbon balance of agroecosystems is the result of two fundamental flows: that of absorption and fixation, linked to the photosynthesis of plants (vine, but also turf, if present), and that of respiration and oxidation (of plants, but also of microflora). These flows are very similar in size and are very high: the net balance (the so-called *Net Ecosystem Exchange*) is therefore the result - positive or negative and in any case rather small - of their combination. In general, in a "virtuous" agro-ecosystem from an environmental point of view, the absorption flux exceeds that of degradation and the system therefore accumulates carbon over time, fundamentally increasing the organic matter content of the soil.

The foliage, during the day, absorbs CO_2 from the atmosphere thanks to photosynthesis. During the day and night, all plant organs and also the microflora breathe, releasing CO_2 into the atmosphere. We can imagine that during the day (dominant photosynthesis) the transport of CO_2 downwards (i.e. towards the vegetation) on average prevails. At night, however, the release of CO_2 from the whole system (plants, soil) supports the transport of CO_2 upwards. If you are able to measure the dynamics of these vortices and the composition of the air they move, it is possible to measure the flow of these substances. This is possible through the Eddy covariance technique which allows a fast, continuous and synchronous measurement of the three components of the wind and the concentration of the substance of interest, carried out on a large, homogeneous and flat surface, allowing the direct measurement of the flow, expressed from the simple formula:

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

in which the vertical flow of the substance F_c is given by the product between the air density ρ and the covariance between the vertical component of the wind speed *w* and the concentration of the substance *c*. It should be emphasized that this technique allows a true measurement of the flow, not simply an estimate of it. Negative flows represent a net absorption by the vegetation, while positive a release of CO_2 to the atmosphere.

As part of the VITISOM LIFE project, this technique was used in two of the experimental vineyards involved in the tests: 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 are adequate in terms of extension, position and homogeneity for the application of the technique and the monitoring has been extended to the entire period envisaged by the project (October 2016 - October 2019), allowing the determination of the seasonal dynamics of carbon accumulation and release (in the form of CO_2). The two vineyards actually differ in some characteristics: in the Arzelle the variety is the Chardonnay, trained with spurred cordon, with a plantation density of 10,000 plants/ha, while in Bosco del Merlo the variety is the Sauvigno blanc, Guyot pruned. , with a plantation density of about 5000 plants/ha. In both sites the land is partially covered with grass. Below are the graphs of the daily flow trends of the two vineyards (Figure 7 - 8).

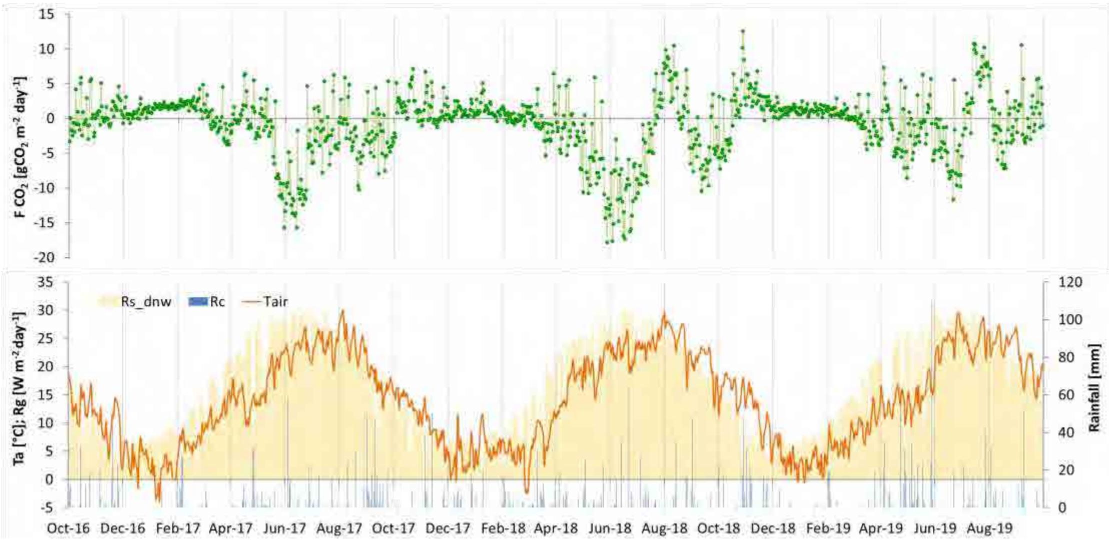


Figure 7 - Trend of daily flows of the Bosco del Merlo vineyard

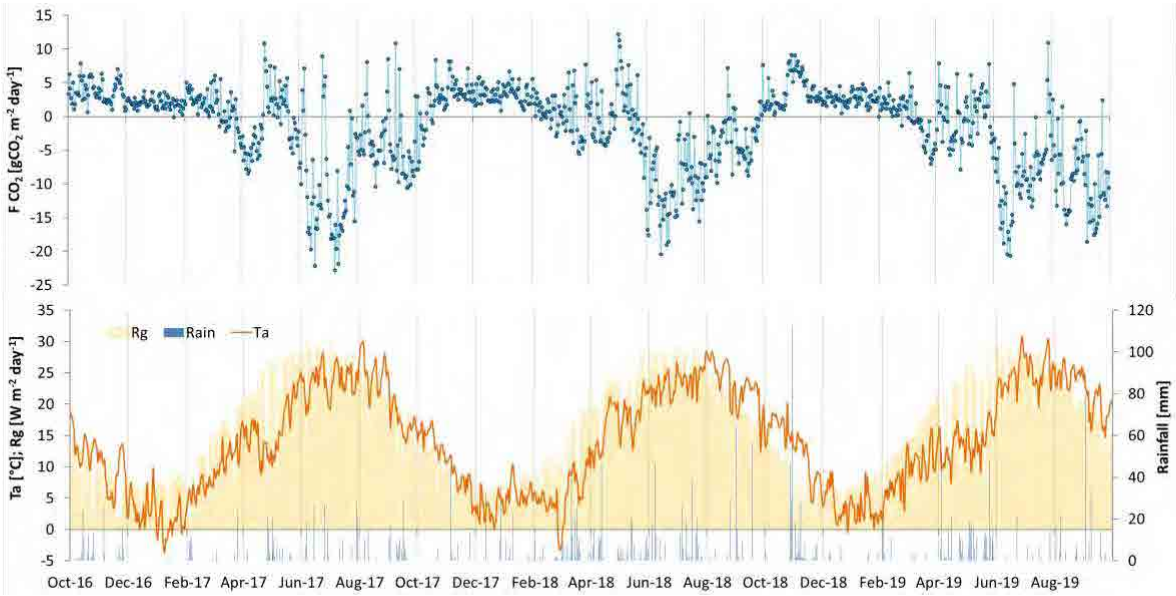


Figure 8 - Trend of daily flows Guido Berlucchi

From the graphs it can be observed how the CO_2 fluxes are negative during the vegetative season (in which the vegetation of the vine that carries out photosynthesis is present) and positive during the winter period (in the absence of photosynthesizing vegetation). Considering the monthly balances of both vineyards (Figure 9) it is possible to better appreciate the variation in the global net balance month by month and the differences between the two sites investigated.

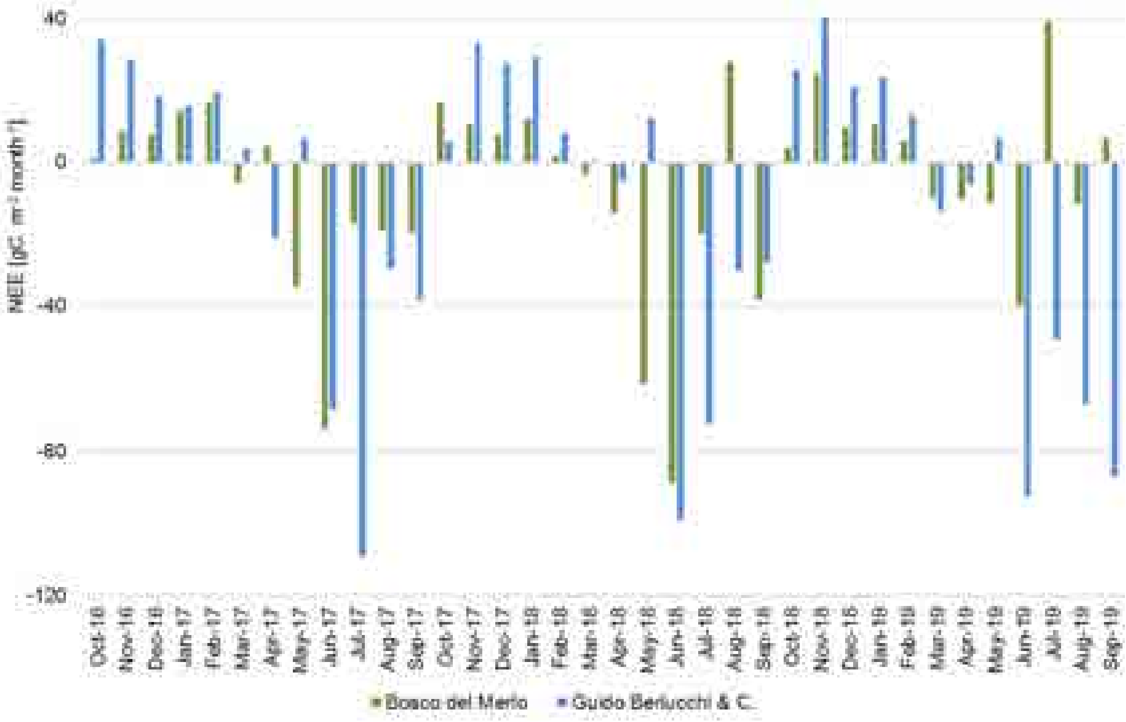


Figure 9 – Monthly balance of both vineyards

The overall budgets in the period considered during the VITISOM LIFE project (October 2016-October 2019), precisely in relation to the different conditions of the two vineyards, differed and were equal to:
Lison -249 gC/m^{-2}
Arzelle -443 gC/m^{-2}

The quantities, under the conditions observed during the VITISOM LIFE project, are in the order of 100-150 g_C m^{-2} $anno^{-1}$, highlighting the virtuous role of the vineyard for CO_2 sequestration. This important role can be maximized thanks to agronomic management that reduce emissions by maximizing seizures.

7.1.3 Carbon footprint at the vineyard level, advantages of adopting VRT

As part of the project, in order to obtain a more global vision of the impacts deriving from the different management of the contribution of the organic matrix in the vineyard, for each test site and for the three years of the project, the calculation of the Carbon footprint deriving from the management was carried out. fertilization and, more generally, the management of the vineyard. To this end, the Calculator Ita.Ca® (Italian Wine Carbon Calculator) has already been developed for the Italian wine sector and complies with the main international protocols such as the International Wine Carbon Protocol, la UNI EN ISO 14064:2016 and the GHGAP protocol of the Organisation Internationale del la Vigne et du Vin.

In view of the specific site coefficients for nitrous oxide mentioned in paragraph 7.1.1, it has been possible to refine the calculation by assigning to each site and to each type of management its own specific coefficient. In cases where the coefficient diverged excessively from the average of the other observations, it was decided, in order not to generate an overall value of CO2-eq that deviated excessively from the other business assessments, to correct the coefficients first through a weighting process of the coefficient itself. For each type of management were then customized calculations related to the amount of matrix distributed, consumption related to the distribution/incorporation process, consumption related to the transport of the matrix. The following are the graphs relating to the overall values expressed in CO2-eq for each farm and each treatment both for the management of organic fertilisation alone and for the entire vineyard management (Figure 10-11).

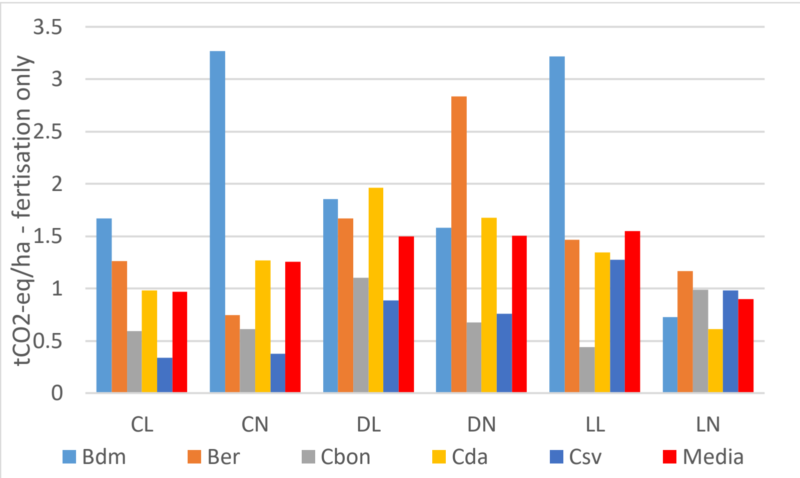


Figure 10 - Emissions referring to the single vineyard hectare generated only by the fertilization practice divided by site and by type of treatment

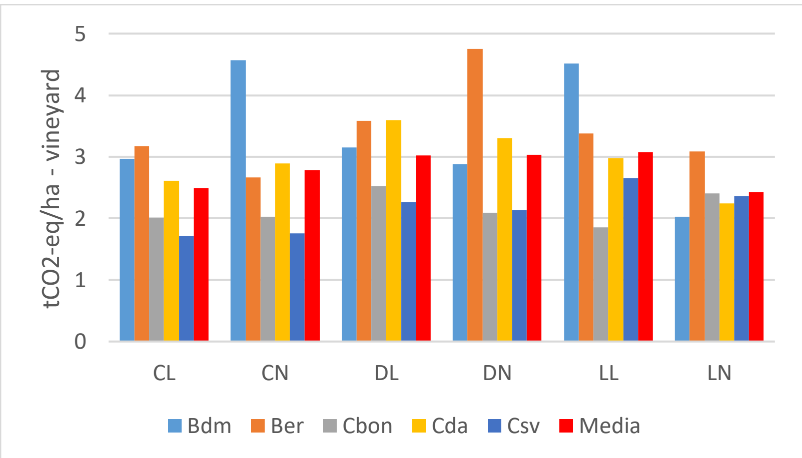


Figure 11- Emissions referring to the single vineyard hectare generated overall by the management of the vineyard divided by site and by type of treatment

From the diagrams it emerges as the situation turns out much differentiated from site to site, in general it can be observed a value tendentially inferior for the compost (probably relationed to the inferior amount of distributed matrix to parity of organic carbon (see par 6.2.1). The effect of processing is particularly evident in manure management, where processing generally tends to lead to higher emissions, while for compost the situation appears to be reversed.
As previously mentioned, this makes it necessary to investigate more in depth about the possible interactions between the meteorological and pedological conditions of each site and the results obtained; these considerations will be the subject of a forthcoming scientific publication on this topic.
As described in paragraph 7.1.2, from the evaluation of C exchanges in the vineyard, it was possible to quantify a seizure equal to - 249 gCm^{-2} (9,13 tCO_2/ha) for the Lison site (Bosco del Merlo) and 443 gCm^{-2} (16,24 tCO_2/ha) for the Arzelle site (Guido Berlucchi). This highlights the already mentioned virtuous role of the vine in the CO_2 balance related to vineyard management.
Attention to agronomic practices adopted in the countryside and the adoption of techniques that allow on the one hand to reduce emissions and on the other to maximize seizures, must therefore be duly considered in order to maximize the mitigating potential of CO_2 emissions from vineyard ecosystem. The monitoring carried out at the level of each company during the three years of the project made it possible to carry out evaluations also regarding the comparison between the management of the organic matrix with the adoption of VRT technology and fixed rate (assuming in this case that the company must forcibly distribute the maximum dosage foreseen to satisfy the nutritional needs of the most demanding areas). From the global analysis of the data, it was possible to quantify a CO_2-eq saving of 15% on the total management of the vineyard and 35% on the management of only the organic fertilization of the vineyard.

7.2 The chemical, physical and biological fertility of the soil

The definition of soil has evolved over time and numerous definitions have been given of it (Hartemink, 2016, Certini, 2013, Soil Taxonomy, 1999) taking into consideration its physical, chemical and biological composition and its role in support plant growth. The important role of the chemical composition of the soil and, in particular of its content in organic matter, in generating an improvement in the conditions of fertility, soil structure, water retention and availability of nutritional elements has already been widely described (Perelli, 1987; Vez, 1987; Morlat, 2008; Castaldi, 2009; Valenti et al, 2014).
The importance of edaphic biodiversity (of the soil) has recently been highlighted, as the soil represents one of the richest habitats in terms of species diversity (Wolters, 2001; Decaëns 2006; Geisen, 2019). This biodiversity is one of the most sensitive components of the agro-ecosystem to environmental stress and, therefore, constitutes a useful indicator of the impact of agricultural practices and soil management on the quality of the soil itself. Awareness of soil biota behavior and characterization is increasing but remains largely unexplored (Cameron et al., 2018). To this end, during the project it was decided to focus also on these issues by carrying out assessments on the evolution of the soil both as regards its chemical fertility and as regards biological fertility.

7.2.1 Chemical fertility of soils and organic matter

Soil samples for each thesis of each Company were subjected to a chemical characterization both at "zero" time (2016) and at the final time (2019). The data shown in Table 10 concern the content of carbon, nitrogen and phosphorus in the soil, while on the link https://www.lifevitisom.com/documenti it is possible to find all the data of the analyses carried out. The reported data were not grouped for each individual company but for each thesis studied, this is because one of the interests of the project has been to verify the improvement of the organic matter of the soil due to the use of organic matrices and their management.

Table 10 – Chemical characterization of soils: different letters correspond to significantly different values based on data processing carried out with univariate ANOVA and Tukey's post-hoc test P < 0.05

			TOC g Kg-1	N tot g Kg-1	C/N	P2O5 mg Kg-1
Control	2016	Worked	11.5a	0.77 a	15.7 c	42.4 ab
	2016	Not worked	11.6a	0.79 a	15.2 cb	39.6 a
Compost	2016	Incorporated	13.1ab	0.94 ab	14.5 cb	68.3 ac
	2016	Unincorporated	11.6a	0.80 a	15.1 cb	58.2 ac
Digestate (separate solid)	2016	Incorporated	11.8^{a}	0.88^{ab}	14.2^{ac}	52.2^{ac}
	2016	Unincorporated	11.5^{a}	0.79^{a}	15.8^{c}	44.2^{ab}
Manure	2016	Incorporated	11.9^{a}	0.87^{ab}	14.1^{abc}	51.0^{ab}
	2016	Unincorporated	11.7^{a}	0.85^{ab}	13.9^{abc}	45.1^{ab}
Control	2019	Worked	19.4^{ab}	1.80^{ab}	10.5^{ab}	76.1^{ac}
	2019	Not worked	22.0^{ab}	2.15^{c}	9.73^{a}	78.5^{ac}
Compost	2019	Incorporated	27.9^{ab}	2.41^{c}	11.0^{ac}	106^{bd}
	2019	Unincorporated	24.3^{ab}	2.24^{c}	10.9^{ab}	97.0^{ad}
Digestate (separate solid)	2019	Incorporated	29.0^{b}	2.18^{c}	12.9^{ac}	144^{d}
	2019	Unincorporated	25.2^{ab}	2.21^{c}	10.8^{ab}	115^{cd}
Manure	2019	Incorporated	23.8^{ab}	1.79^{bc}	12.7^{ac}	104^{bd}
	2019	Unincorporated	22.3^{ab}	1.79^{bc}	11.9^{ac}	105^{bd}

In general, from the observation of the data it is possible to observe how the year 2016 to 2019 there was a general increase in organic carbon values (TOC - Total Organic Carbon). The difference is however significant to the statistic only in the case of the embedded solid separate digestate which therefore showed a positive effect on this element compared to 2016.

For the total nitrogen content, at the end of the experimentation, the matrices that showed a statistically significant increase were the compost and the separate digestate, usually regardless of the management method. However, it should be noted that even the unworked control presented an increase for this element between the year 2016 and the year 2019. The C/N ratio decreases over time and settles at values of 10-12 for each thesis, this in relation to the increase of nitrogen in the soils, however no significant differences are observed for this index with the exception of the unprocessed control (in relation to the increased value of nitrogen unbalanced by an equivalent increase in carbon).

The phosphorus content, reported as P_2O_5, shows a statistically significant increase for the separated solid digestate matrix regardless of the type of management. For the purpose of evaluating the impact on organic matter, it seemed useful to also work on percentage increase wastes without just thinking about absolute values or individual percentage increases since:

- these values are strictly connected to the single context of realization and do not give generalizable information, as seen;

- there are cases in which even at the level of untreated control there have been increases in organic matter on the ground in the three years.

On the other hand, by carrying out an evaluation of the waste with respect to the control, it is possible to appreciate the actual effect of the contribution of the organic matrix on the content of organic matter to the soil, regardless of the individual absolute values.

Company	Type of treatment	Increase deviation% TOC resp. control	Average deviation increase% TOC resp. control
Castello Bonomi	Compost	8,8	
Castello Bonomi	Separate solid	10,7	
Castello Bonomi	Manure	3,4	7,6
Castello Bonomi	Control	ref	
Guido Berlucchi	Compost	-7,9	
Guido Berlucchi	Separate solid	16,0	
Guido Berlucchi	Manure	35,6	14,6
Guido Berlucchi	Control	ref	
Castelvecchi	Compost	17,4	
Castelvecchi	Separate solid	5,6	
Castelvecchi	Manure	-4,9	6,0
Castelvecchi	Control	ref	
Conte degli Azzoni	Compost	24,4	
Conte degli Azzoni	Separate solid	26,7	
Conte degli Azzoni	Manure	19,9	23,7
Conte degli Azzoni	Control	ref	
Bosco del Merlo	Compost	-34,13359695	
Bosco del Merlo	Separate solid	2,621956439	
Bosco del Merlo	Manure	-22,81724744	-18
Bosco del Merlo	Urea	-16,86663112	
Bosco del Merlo	Test	ref	

From the data shown in the table it emerges that in all sites except the Bosco del Merlo site the increase in organic matter was on average higher in treatments fertilized with organic fertilizer than in the control. For the Bosco del Merlo site an increase was observed only for the fertilized treatment with separated solid digestate. The average increase in organic matter compared to the control, also including the Bosco del Merlo site, is equal to + 6.8%.

7.2.2 Biological fertility of micro and meso - biota soils

BIOLOGICAL PARAMETERS: PLFA (PHOSPHOLIPID FATTY ACID)

The PLFAs are part of the microbial cell membrane of the organisms belonging to the *Bacteria* and *Eukarya domain*, they correspond to a "photograph" of the living microflora of the soil being subject to rapid degradation after the death of the microorganisms.

On the basis of the attributions reported in the literature, it was possible to attribute to each of them a different component of the microbial community: bacteria, gram positive, gram negative and fungi, with different metabolic properties. Although most of the attributions are unique, for some, C14:0 (Methyl tetradecanoate), C16:0 (Hexadecanoic acid, methyl ester), C18:0 (Octadecanoic acid, methyl ester) and C18:ω9 (Metyl elaidate trans), more attributions were found and for this reason it was decided to exclude them, as a precaution, from subsequent processing.

This analysis was carried out not for all soil samples but on 13 samples considered among the most representative, both at time zero and at the final time of the experiment (Table 11 - 12).

Table 11 – Study of PLFAs at time zero (2016)

	Bon CL	Bon CNL I	Bon CNL II	Bon TL I	Bon TL II	BdM CL	BdM TL	Ber CL	Ber TNL	CdA LNL I	CdA LNL II	Csv CL	Csv DNL
	µg/g soil dry												
gram positive	0.0706	0.0811	0.0444	0.0043	0.0227	0.1451	0.0339	0.0167	0.0042	0.0124	0.0216	0.0195	0.0070
gram negative	0.0339	0.0032	0.0305	0.0018	0.0054	0.0388	0.0193	0.0081	0.0105	0.0017	0.1590	0.0028	0.0040
fungi	0.0002	0.0002	0.0022	0.0000	0.0001	0.0056	0.0002	0.0005	0.0000	0.0000	0.0003	0.0001	0.0001
PLFA tot	0.1160	0.0999	0.0817	0.0063	0.0321	0.2114	0.0638	0.0270	0.0174	0.0179	0.2002	0.0241	0.0138
% bacteria	99.8	99.8	97.3	100.0	99.7	97.4	99.7	98.1	100.0	100.0	99.9	99.6	99.3
% funghi	0.2	0.2	2.7	0.0	0.3	2.6	0.3	1.9	0.0	0.0	0.1	0.4	0.7
GP/GN	0.0339	0.0032	0.0305	0.0018	0.0054	0.0388	0.0193	0.0081	0.0105	0.0017	0.1590	0.0028	0.0040
F/B	0.0002	0.0002	0.0022	0.0000	0.0001	0.0056	0.0002	0.0005	0.0000	0.0000	0.0003	0.0001	0.0001

Table 12 – Study of the PLFAs at the final time (2019)

	Bon CL	Bon CNL I	Bon CNL II	Bon TL I	Bon TL II	BdM CL	BdM TL	Ber CL	Ber TNL	CdA LNL I	CdA LNL II	Csv CL	Csv DNL
	µg/g soil dry												
gram positive	1.5259	0.8246	1.1919	1.2727	1.2067	0.4335	1.2978	0.7913	0.3979	0.3218	0.3544	1.7186	0.5579
gram negative	2.1148	1.3786	1.4688	1.9581	2.4580	1.1796	2.0803	1.6713	1.1397	0.8614	1.2502	2.9623	2.9777
fungi	3.6594	2.1417	1.8689	2.6956	5.0633	0.5929	2.2763	1.9449	1.5196	0.6846	0.4645	6.5664	2.6951
PLFA tot	7.5719	4.5035	4.6126	6.1470	8.8744	2.2602	5.8488	4.5577	3.1139	1.9173	2.1231	11.5595	6.3404
% bacteria	51.7	52.4	59.5	56.1	42.9	73.8	61.1	57.3	51.2	64.3	78.1	43.2	57.5
% funghi	48.3	47.6	40.5	43.9	57.1	38.9	42.7	48.8	35.7	35.7	21.9	56.8	42.5
GP/GN	0.7215	0.5982	0.8115	0.6500	0.4909	0.3675	0.6239	0.4735	0.3491	0.3736	0.2835	0.5801	0.1873
F/B	0.9353	0.9068	0.6812	0.7810	1.3285	0.3556	0.6372	0.7444	0.9531	0.5554	0.2801	1.3151	0.7393

Comparing the two tables (Tables 11 and 12), it can be seen how the total number of PLAFs has increased in recent years and how there has been a rebalancing of the distribution of microorganisms in the soil. In fact, in 2016 the bacterial component predominated over the fungal one, while in the final time it is observed that their presence in the soil has become fair. The fungal component is linked to a greater capacity of the soil to store C thanks to the production of hyphae and aggregates (Frostegård and Bååth, 1996; Malik et al., 2016).
Moreover, in 2016, among the bacteria that dominated were gram positives, associated with a less rapid proliferation rate usually linked to the degradation of more recalcitrant humidified organic substance (Willers et al., 2015). At the end of the experimentation, in 2019, it is noted that the most present bacteria are the gram negative ones, characterized by the ability to readily use the most available forms of carbon (Willers et al., 2015). Through the bibliographic study, two indices were used: F/B and GP/GN. The former is an indicator of the effect of agricultural practices on the soil microbial community (Frostegård e Bååth, 1996; Bailey et al., 2002; Willers et al., 2016) while the latter is an indicator of the relative bioavailability of organic matter and / or the energy limitations of bacterial communities (Fannin et al., 2014).
Both indices, at the end of the project, are increased indicating a general growth of microorganisms in the soil due to the increase in organic matter.
To better focus on the actual effects of the contribution of organic matter on these indices, a summary graph is proposed below that represents the increases in the F/B and GP/GN indices recorded in 2019 compared to 2016.

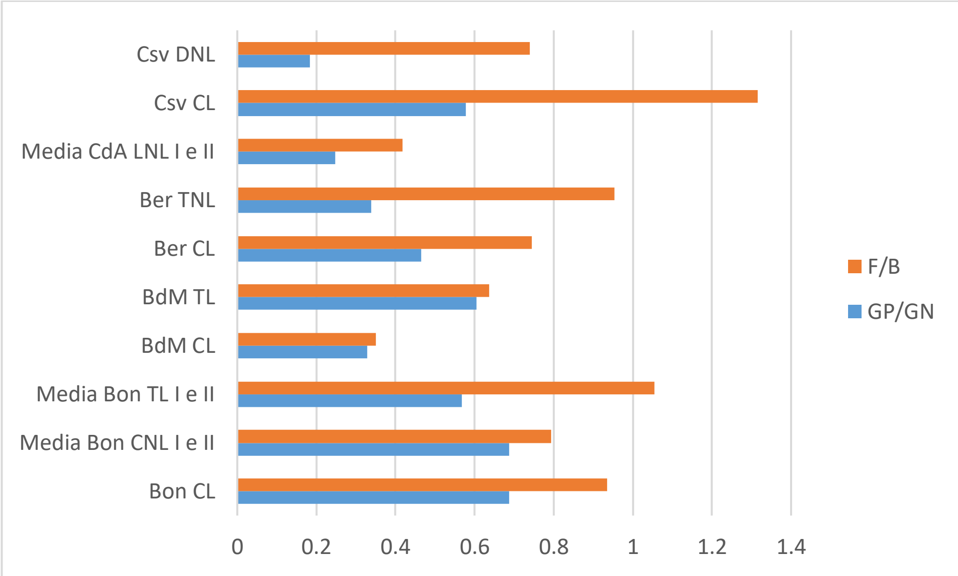


Figure 12 –Difference in F/B and GP/GN indices recorded in 2019 and 2016.

From the graph it can be seen that in two of the sites investigated (Castello Bonomi and Guido Berlucchi) the control treatment recorded a higher increase for the F/B index, lower for GP/GN compared to the treatments fertilized with compost compared. For the Castello Bonomi site, the incorporation of the compost soil resulted in an increase in the F/B value, while for the Castelvecchi site the compost seems to have generated higher values of the two indices compared to the separated solid digestate. The integration of the meteorological and pedological variables of the various sites will make it possible to better identify the relationships between chemical, physical and biological fertility of each sampled soil.

QBS-AR INDEX (BIOLOGICAL QUALITY OF SOILS – ARTHROPODS)

To quantify the impacts of the various treatments on pedofauna, the QBS-ar evaluation index was applied (Parisi, 2001 - for an explanation of the index calculation method, see the bibliography).
The principle on which this index is based is that of the more or less marked adaptation of the animals to the environmental conditions, irrespective of the taxonomy: the greater the adaptation of an animal to the life of the soil, the greater the importance of the animal as an indicator of the degree of conservation of the animal. This consideration allows the introduction of the concept of biological forms, in other words, the set of organisms that present certain changes in morphological structures aimed at adapting to the environment in which they live. The survey was conducted by partner wineries in collaboration with Sata Studio Agronomico, in the five test sites involved in the project.
The quantification of the QBS-ar was carried out in three years as part of the project: the first sampling was carried out at the beginning of the project, in the autumn of 2016. At that stage, the diversified treatments had not yet been carried out and therefore the different plots they did not differ in treatment. This sampling was carried out in order to obtain a basic reference on which to then calibrate the subsequent findings. Samplings were then carried out in summer 2018 and 2019. Between the sampling carried out in 2016 and that of 2019, the average values recorded for the different treatments in the various test sites were variable: in some they suffered a general lowering (probably related to the different sampling times in the two years and to the variability of the same vintages) while in others the values have increased. It was not possible to highlight a homogenous behavior in the comparison between the unfertilized control and the organic

fertilization, it is therefore not possible to draw conclusions regarding the effects of organic fertilization with respect to the control. The result achieved for the Bosco del vineyard was instead interesting in relation to the effect of the administration of urea alone. The table shows the results relating to the Bosco del Merlo site only, which show the differences (which in this case are negative) between the average values for 2016 and 2019.

	Year		Delta QBS-ar average 2016-2019
	2016 (autumn)	2019 (summer)	
Incorporated organic fertilizer	86	67	-19
Unfertilized and worked control	111	79	-32
Chemical fertilization with incorporated urea	111	71	-41
Organic fertilizer not incorporated	66	64	-2
Unfertilized and not worked control	80	74	-6
Chemical fertilisation with non-integrated urea	80	45	-35
Avarage organic fertilizer	76	65	**-11**
Avarage Control	96	76	-19
Avarage chemical fertilization with urea	96	58	**-38**
Avarage incorporated /worked	103	72	**-31**
Avarage not incorporated /not worked	75	61	**-14**

From the table it can be observed that for the organic fertilizations the QBS-ar value has undergone a lowering similar to the untreated control, while the treatment with urea alone has registered a higher lowering. The latter therefore seems to have generated a greater reduction in the value of QBS-ar (this behavior was already visible in 2018 where treatments fertilized with organic and control recorded similar differences compared to 2016, while the treatment with urea recorded lower values). Other interesting behavior emerges when comparing the incorporated/processed treatments and those not incorporated / processed. The example of Bosco del Merlo shows how the reduction in value is lower for non-incorporated / processed treatments which therefore lead to a better level of biodiversity conservation. This behavior is confirmed for the majority of the sites investigated, although not for all of them.

7.3 Life Cycle Assessment (LCA)

LCA analysis is a procedure for calculating the environmental impact of a product or service, throughout the production life cycle. As part of the VITISOM LIFE project, the LCA study was conducted to assess the environmental impacts of the various production choices tested in the project. In particular, we investigated the use and impact of the different organic matrices in the management of the vineyard (digested manure, compost) and the evaluation of the possible advantages deriving from the use of VRT technology.

SYSTEM BOUNDARIES AND FUNCTIONAL UNIT

The system considered in this LCA study includes all material and energy inputs for all the following production phases: cultivation operations in the vineyard, production and transport of organic fertilizers, transport and use of pesticides (Figure 13).

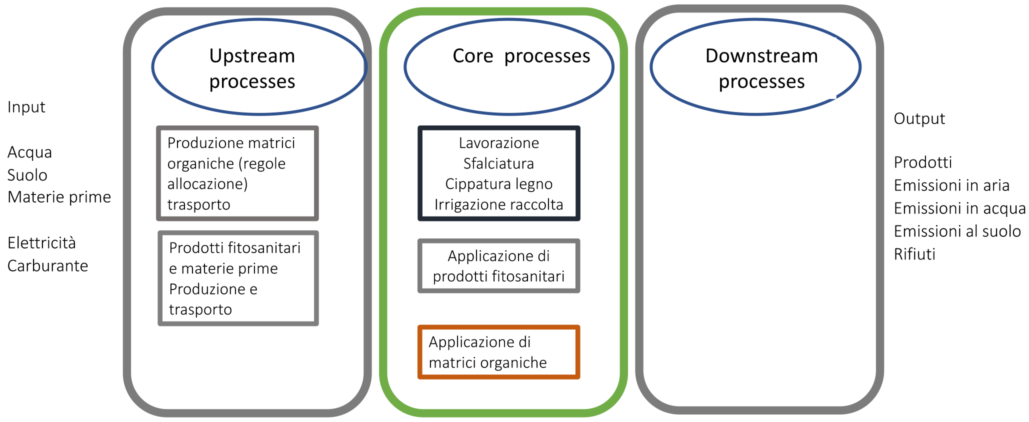


Figure 13: System boundaries considered for the LCA analysis

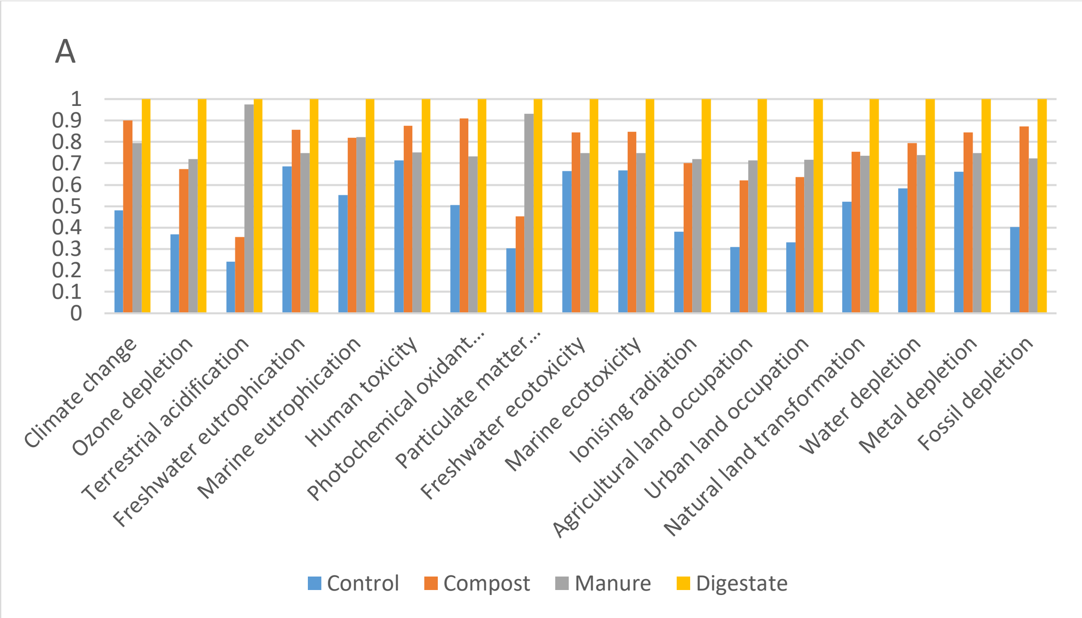
The functional unit (FU) is the quantity of grapes (1 kg) produced on the farm and suitable for vinification, it is not investigated, because the wine production, distribution and consumption phase is outside the scope of the project. The data used for the LCA calculation were collected in the project companies in the years 2016-2017, 2017-2018 and 2018-2019.

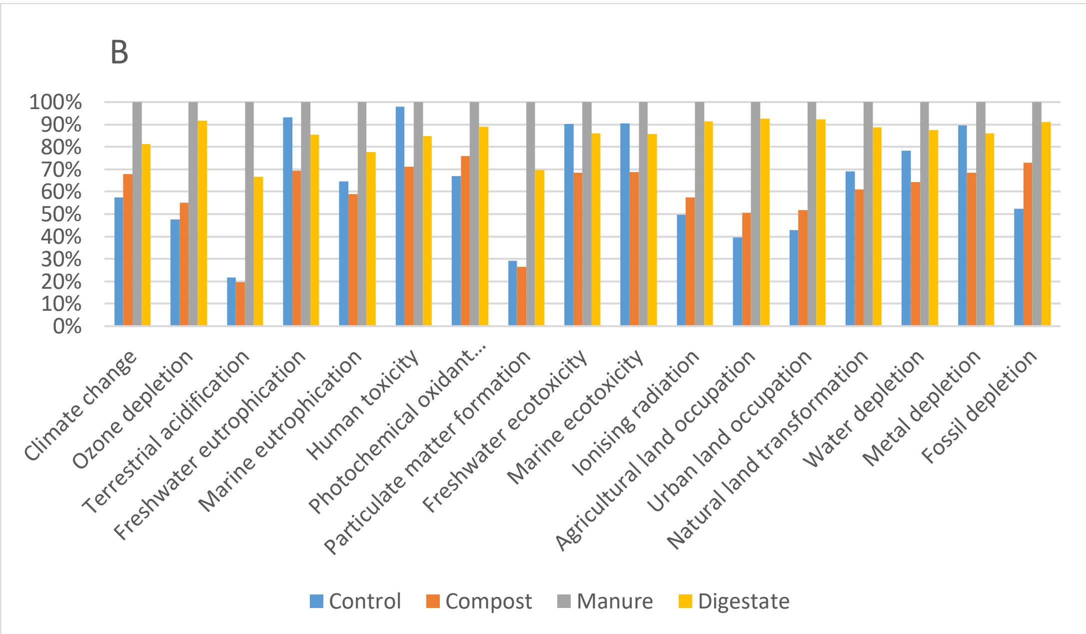
RESULTS

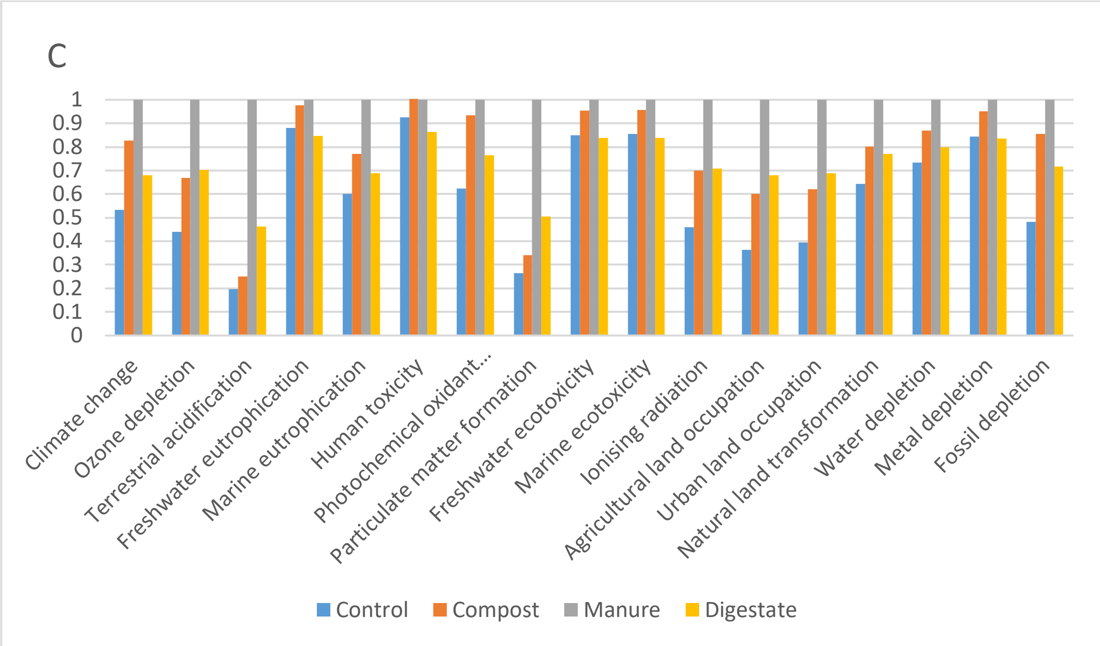
The main impacts of grape production are related to fertilization operations. Organic fertilizers can improve the quality of production and the quality of the soil, at the same time they can cause significant impacts due to the transport, distribution and efficiency of the use of nutrients. For example, each unit of nitrogen distributed in the field and not used by the plant has a potential impact on the environment. The lowest impacts are recorded for witnesses, in which the transport and distribution costs of the matrices in the field are not accounted for and no additional emissions of nutrients into the environment are generated. During the years of the project, no significant reduction in production was recorded due to the lack of fertilization in the control theses, and therefore this always generated minor impacts for these treatments (Figures 14A-14B-14C-14D). Greater impacts are recorded for all other theses.

Organic matrices with lower water content, such as compost, caused fewer impacts due to fewer inputs in transport and field operations: for example, to provide the same amount of carbon, it was necessary to use double the amount of separated solid digestate compared to that of compost (see paragraph 6.2.1). Furthermore, compost is the matrix with the lowest amount of nitrogen compared to the carbon supplied, and therefore in compost theses the impact due to the dispersion of nutrients in the environment is also lower.

The highest impacts were recorded for digestate and manure (Figures 14A-14B-14C-14D). Furthermore, the results are also influenced by the average production of the parcels over the two years. For company 1 (Figure 14A) there is a lower impact of the theses fertilized with manure, compared to those with compost, since in the 2 years the productivity of the theses fertilized with manure was significantly higher than those fertilized with compost.







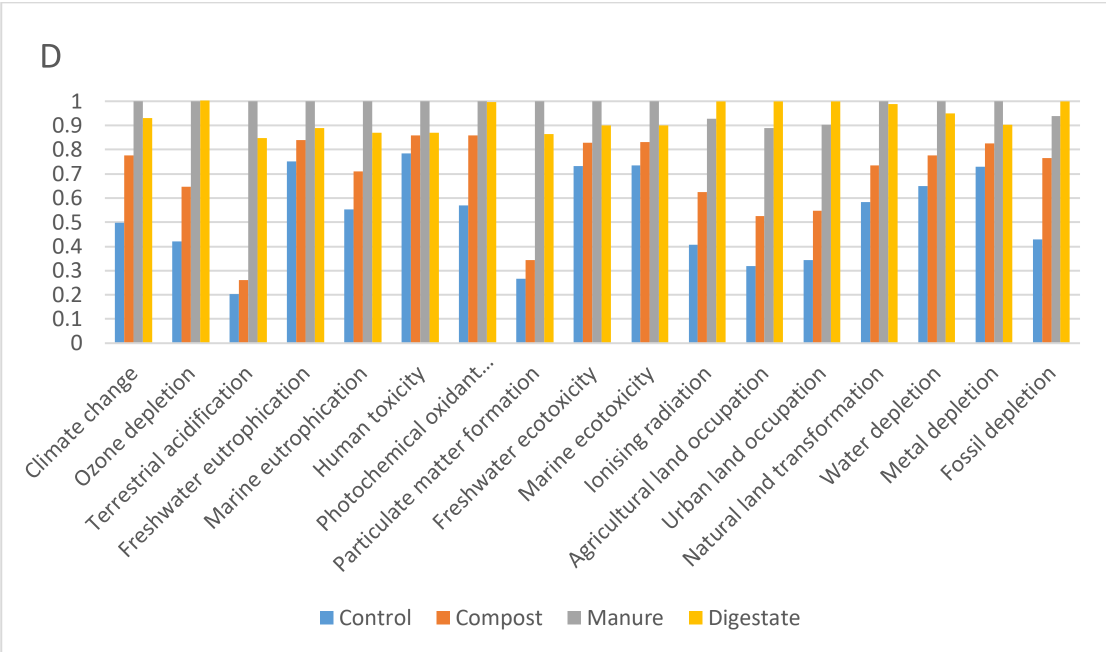


Figure 14 A-B-C-D: comparison of the impacts of the different theses (using different matrices) in 4 of the companies involved in the project. Fig. A: Castello Bonomi. Fig. B: Guido Berlucchi. Fig. C: Conti degli Azzoni. Fig. D: Cantina Castelvecchi.

The categories of greatest impact (IC), on a normalized scale with respect to the impact of an average European inhabitant are: Eutrophication of marine waters, expressed in equivalents of N released into the environment (leaching of nitrogen from the soil), Terrestrial acidification expressed in equivalents of kg SO_2 eq., due to ammonia emissions, Eutrophication of fresh water, expressed in equivalents of P released into the environment. The most relevant categories are therefore those related to the dispersion of nutrients in the environment. Precisely for this reason, the environmental value of the variable rate technique is high, which allows, with precision fertilization, to reduce the intake of excess nutrients and thus ultimately reduce dispersion into the environment and pollution. Figure 15 shows the results of distribution with variable rate (yellow) and traditional distribution with fixed or network, assuming in this case that the company must forcibly distribute the maximum dosage foreseen to satisfy the nutritional needs of the most demanding areas (green) , where there is a significant decrease in the impacts in all categories in the case of the adoption of variable rate technology.

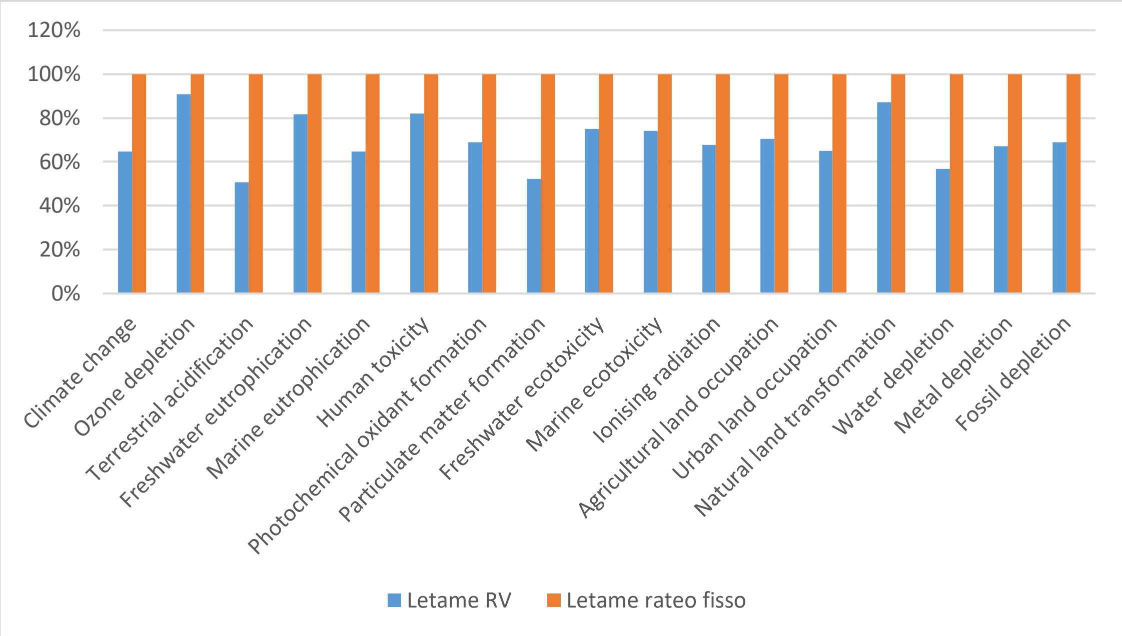


Figure 15: impacts of variable rate and fixed rate distribution

7.4 Impacts on vines, musts and wines

During the project, investigations were carried out on the results obtained in terms of productivity and vegetative-productive balance of the vine, quality of musts and, consequently, of wines. The data was collected during the 2017, 2018 and 2019 harvests for the five test sites (with the exception of the Bosco del Merlo site where data was collected only for the first two campaigns). In fact, it is known that the practice of fertilization can have repercussions on the productivity of the crop (Williams, 1943; Morris et al, 1983; Wolf and Pool, 1988; Keller et al., 1998), and on the qualitative characteristics of musts (Delas et al., 1991; Spayd et al., 1991; Colugnati et al., 2004) and wines (Valenti et al., 2012).

In order to provide a summary of the data collected, the processing was carried out by comparing the reference year (2017) and the last year of the survey (2019), dividing the theses based on the following criteria:

- Type of matrix vs control: the various types of matrices with respect to the non-fertilized control (thus mediating the data between surface distribution and incorporation as well as processing and non-processing for the control);

- incorporation/processing vs surface/not processed: comparing the incorporation to the soil or the surface distribution (thus mediating the results for different types of organic matrix), processing without fertilization and the unfertilized and not processed control.

For the sake of synthesis, the main results obtained for what concerns the productivity and the vegetative-productive balance of the vine, and the qualitative variables of the musts are reported below. Tables 13 and 14 derive from the processing of data from the 4 test sites Guido Berlucchi, Conti degli Azzoni, Castelvecchi, Castello Bonomi.

Subsequent publications will report the full results of the project.

By comparing the type of distributed matrix (Table 13) it can be seen how, at the production level (neither at the level of production weight, nor at the level of average weight of the bunch) the contribution of organic fertilizer has determined an increase in production between 2017 (reference year) and 2019. The treatments fertilized with organic matrix in fact have values similar to the untreated witness and, in the last year there are no significant differences for these variables. This could be related to the fact that organic fertilizers, precisely in relation to their composition, require more or less slow mineralization times based on the weather of the year.

On the other hand, the results at the qualitative level of musts are more interesting, where it can be observed how organic fertilization (regardless of the type of matrix distributed), determines an increase in acidic conservation passing from 2017 to 2019. At the pH level, the significant differences recorded in 2019 reflect the initial condition present in 2017, therefore not showing an effect of fertilization in this sense. In terms of sugar content, it can be seen that the difference existing in 2017 between compost and separate solid digestate then vanishes in the last year; it therefore seems that the digestate has led to an improvement in the sugar-acidic balance (leading to an improvement in acidic conservation accompanied by good sugar accumulation); for compost, on the other hand, the effect is more associated with a delayed ripening phenomenon (with higher acidic conservation accompanied, however, by a slowdown in the accumulation of sugar).

Table 13- Table relating to the statistical differences found in the comparison between types of fertilizers and non-fertilized witness. The letters indicate statistical significance in the REGW F test ($P < 0.05$). Where there are no letters it was not possible to detect significant difference in the test.

Year	Matrix vs Control	Titratable acidity (g/l)	pH	Sugars (°Bx)	production weight(kg)	real fertility	average cluster weight (g)	Index of Ravaz
2017	Compost	5,8	3,38 b	22,4 a	1,5 a	0,9 ab	150b	4,9 a
2017	Digestate	5,9	3,41 ab	21,4 b	1,5 a	1,0 a	149b	3,3 b
2017	Manure	6,2	3,45 a	21,5 ab	1,4 ab	0,9 b	199 a	3,4 b
2017	Control	5,9	3,4 ab	21,6 ab	1,3 b	0,9 ab	148b	3,1 b
2019	Compost	7,1 a	3,36 b	21,3	1,7	0,8	105	4,4 a
2019	Digestate	7,1 a	3,37 ab	20,7	1,6	0,8	100	3,7 b
2019	Manure	7,2 a	3,41 a	20,7	1,6	0,8	102	4,1 ab
2019	Control	6,4b	3,41 ab	21,0	1,7	0,8	99	3,7 b

Observing Table 14 it can be seen that also in this case at the production level no significant effects were found deriving from the incorporation of the matrix or its surface distribution in 2019, in fact, no significant differences were recorded either for the average weight of the bunch, nor for the productivity of the plant. On a qualitative level, on the other hand, it can be observed that grapes derived from non-fertilized and processed treatment have caused a reduction in value compared to other treatments, especially in consideration of the significance recorded in 2017 and, subsequently in 2019. In this last year, always with reference to the 2017, on the other hand, there is a better acidic conservation given by treatments with fertilizer incorporated into the soil. These behaviors recorded for the titratable acidity are then reflected in the pH differences since, in 2019, treatments with fertilizer incorporation generated lower pH values than the processed test. At the sugar level, no significant differences were found in any of the survey years.

Table 14 Table relating to the statistical differences found in the comparison between types of fertilizers and non-fertilized witness. The letters indicate statistical significance in the REGW F test ($P < 0.05$). Where there are no letters it was not possible to detect significant difference in the test.

Year	incorporation/ working vs surface/unworked	titratable acidity (g/l)	pH	Sugars (°Bx)	production weight (kg)	Real fertility	Average cluster weight (g)	Index of Ravaz
2017	Incorporated	5,7 bc	3,42	21,8	1,5 a	0,94	158 ab	3,8 a
2017	Not incorporated	6,2 ab	3,40	21,7	1,4 ab	0,91	174 a	3,9 a
2017	Worked	6,5 a	3,40	21,8	1,3 b	0,86	156 ab	3,0 b
2017	Not worked	5,3 c	3,40	21,3	1,3 b	0,98	139 b	3,2 ab
2019	Incorporated	7,0 a	3,37 b	20,9	1,6	0,79	101	4,2 a
2019	Not incorporated	7,3 a	3,40 ab	20,9	1,6	0,80	103	3,9 ab
2019	Worked	6,1 b	3,43 a	21,1	1,6	0,77	93	3,5 b
2019	Not worked	6,7 ab	3,39 ab	20,9	1,7	0,75	104	3,9 ab

As regards the investigations carried out on finished wines, for the sake of synthesis, the results obtained from the preference test carried out during the technical tastings in 2018 and 2019 are reported. It should be remembered that, for the wines, chemical analyzes and description of the sensory profile in tasting. For the consultation of the complete results of these surveys you can consult the link https://www.lifevitisom.com/documenti.

From Table 15 it can be seen how:

- in passing from the evaluation of the 2018 wines to the 2019 ones, the processed control tends to position itself towards lower ranking values in 2019 (with the exception of the vineyard of Conti degli Azzoni - CDA). In the case of the CSV vineyard, this behavior is observed in the last year where the decrease in the level of approval is marked compared to the previous year. This seems to suggest that this type of treatment led to a general reduction in the perceived quality of wines at tasting;
- the TNL treatment tends to be positioned on average values of preference, however it never appears in the positions of greatest preference;
- in relation to the sparkling bases (CBON and BER vineyards) it is in general the wines obtained from fertilization with compost that give higher levels of satisfaction even if, considering the burial or not of the matrix, the results appear contrasting between one vineyard and another : CBON recorded higher approval for compost without incorporation while BER for treatments with matrix incorporation;
- in vineyards suitable for producing grapes for red vinification (CDA and CSV) the behavior is differentiated as the manure matrix seems to guarantee better quality levels for CDA considering wines obtained in the last year of testing (2019); for CSV, on the other hand, the contribution of compost and digestate seem to confer higher quality levels. In both cases, the way the fertilizer is managed (incorporated or not) does not seem to affect the perceived quality of the wines.

Table 15 - Table showing the results obtained in the preference test for 2018 and 2019 wines of the 4 sites (ber, cbon, cda, csv). The sorting of wines is carried out from 1st to 8th position in decreasing wine appreciation.

Sorting: 1 = preferred 8 = least preferred	CBON		BER		CDA		CSV	
	2018	2019	2018	2019	2018	2019	2018	2019
1°	CL	CNL	DNL	CL	CNL	LL	TL	DNL
2°	CNL	LL	CL	DL	DL	LNL	DL	CL
3°	DL	DL	LNL	DNL	DNL	TL	LL	CNL
4°	DNL	TNL	TNL	TNL	CL	TNL	DNL	DL
5°	LNL	DNL	DL	LL	LL	DL	TNL	TNL
6°	LL	LNL	TL	LNL	LNL	CL	CL	TL
7°	TL	CL	CNL	CNL	TNL	CNL	LNL	LL
8°	TNL	TL	LL	TL	TL	DNL	CNL	LNL

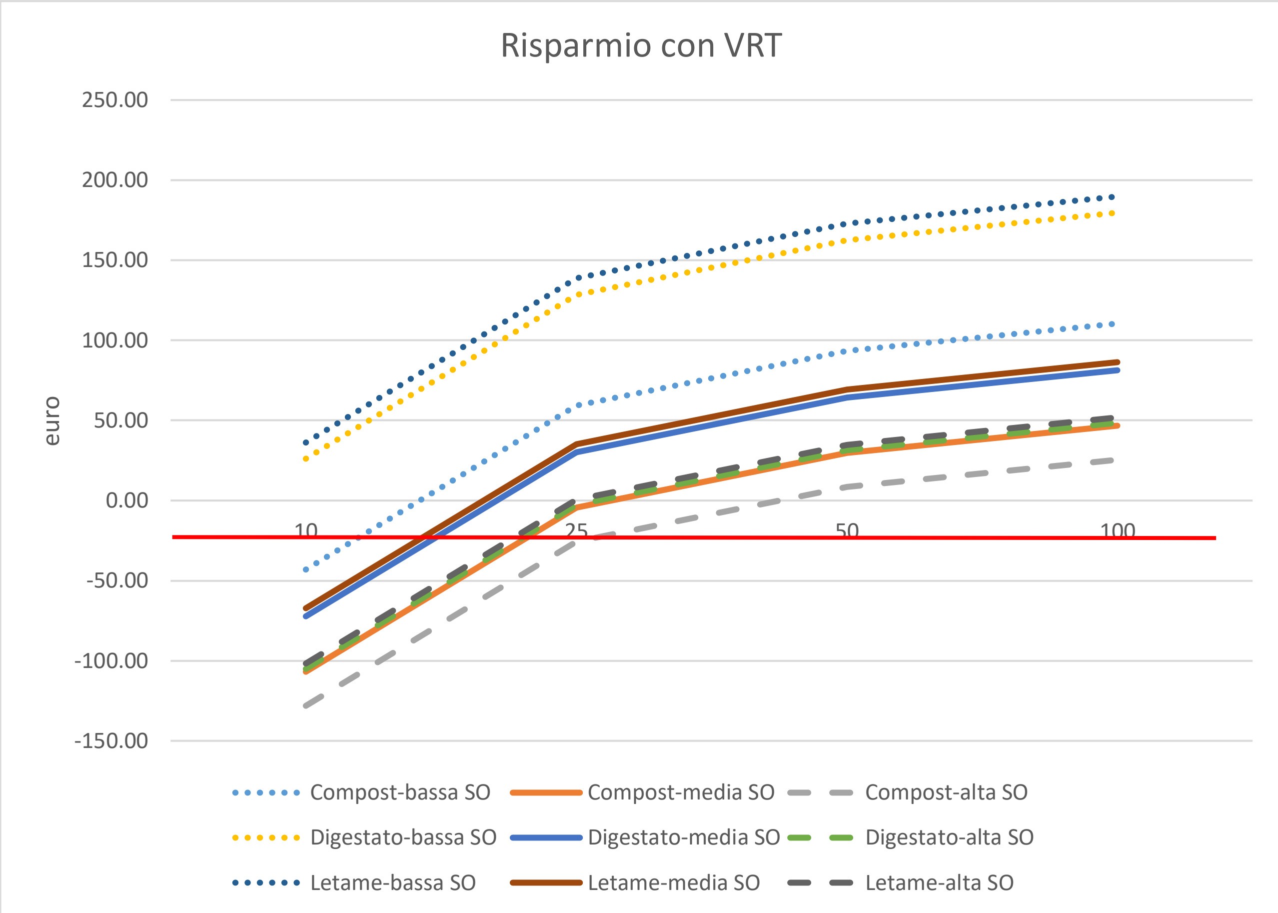
8. Assessment of socio-economic impacts

8.1 Economic advantages of adopting the VRT

The use of VRT technology in business management can generate advantages over URT (Uniform Rate Technology) even if the advantages must be evaluated on the basis of many factors and variables (Surjandari I. et al, 2003).In order to quantify the possible economic advantage of wineries at national and European level of the adoption of VRT technology for the management of the organic fertilization of the vineyard, different scenarios of possible business realities have been set up by dividing the type of company based on the following criteria:

Average organic matter content of the company's vineyards	**Frequency of use of the organic fertilizer spreader machine**
<1%	All years
1%<S.O.<2%	Every two years
>2%	Every three years
Business dimension	
10 hectares	
25 hectares	
50 hectares	
100 hectares	

In evaluating the costs of managing the organic fertilization of the vineyard with VRT or with a fixed rate URT, the basic assumption was based that, in the absence of a variable rate, therefore without information regarding the variability of the vineyard or the possibility of managing a differentiated distribution, the company is forced to opt for the maximum dosage, in order to ensure the correct intake in the leanest areas. It should be noted that this represents a generalized assumption that represents the average behavior of companies in the absence of variable accruals. Starting from this, by carrying out calibrated calculations on all companies during the course of the project, it was possible to calculate on the one hand the economic savings deriving from the lower consumption of differentiated matrix for each single type (compost, separated solid digestate and manure), from another is the saving deriving from the consequent reduction in transport costs, as well as in the diesel fuel required for loading and distributing the matrix. The costs deriving from the personnel employed for the distributions remain not considered in the calculation. In order to perform a real calculation on the possible economic advantage, the amortization cost aspect of the innovative variable rate technology was then introduced, compared to the URT technology already existing before the implementation of VITISOM LIFE. This is in order to take into account the higher economic impact of purchasing the machine compared to a less technological model. From the assessments made, the results shown in the graph below emerged.



The red line indicates the limit above which the company can benefit from the acquisition of the technology, below which it has a disadvantage. The results are expressed as a function of the matrix. For a better understanding of the graphs, the table with the details of the data is shown below.

Matrix	SO%	Company size				Minimum Surface (ha)*
		10	25	50	100	
compost	<1	-13%	18%	29%	34%	13
	>1<2	-33%	-1%	9%	15%	27
	>2	-40%	-8%	3%	8%	40
digestate	<1	5%	25%	32%	35%	9
	>1<2	-14%	6%	13%	16%	17
	>2	-21%	-1%	6%	10%	26
manure	<1	7%	26%	33%	36%	8
	>1<2	-13%	7%	13%	16%	17
	>2	-19%	0%	7%	10%	25

* Minimum company area for which the adoption of VRT is convenient considering all the factors described.

The survey shows specifically that the purchase of the technology developed by VITISOM LIFE for the management of variable rate organic fertilization can always be convenient for companies over 40 hectares. Below this dimension, the advantage varies according to the type of matrix used and the average soil organic matter. In order to provide a tool accessible to all wineries for evaluating the economic advantage in the adoption of VRT, a calculation software was finally produced which can be accessed from the link https://www.lifevitisom.com/documenti.

The software provides the average cost of using the VRTs and an indication of the convenience according to the business area and the type of matrix available.

8.2 Social impact: the consumer and the perception of the biodiversity of the vineyard

In recent decades, consumer awareness of the environmental problems associated with conventional agricultural production has increased (Ricci et al., 2018) and an increasing number of people participate with growing interest in consumer practices perceived as more sustainable (Planck and Teichmann, 2018)).

The world of wine is also undergoing important changes, with companies increasingly turning to viticultural production techniques that respect and protect natural resources. Among these, biodiversity is a rising theme also in the wine sector, considered on the one hand, a fundamental component for the sustainable management of the vineyard, on the other, a wealth due to its positive effects on the production process (Chou et al., 2018).

The VITISOM LIFE project explores its significance in relation to the management of organic fertilization in viticulture (ref par 7.2).

At the same time, the project proposed the study of consumer perception regarding biodiversity in the vineyard, in order to:

- evaluate consumers' **knowledge** on the subject of biodiversity;
- estimate the **value** that consumers attribute to it;
- investigate the influence of any **socio-demographic and aptitude variables** on consumer sensitivity towards biodiversity.

The study was carried out by applying the Choice Experiments method, widely used in the evaluation of new food products to be launched on the market, but also in the evaluation of environmental assets, alongside the Contingent Valuation method. Both methods make use of direct interviews, in which respondents are asked to evaluate their preference, and to monetarily estimate its value, for the main characteristics of the asset being valued. In the case of VITISOM LIFE, the asset being assessed was a wine that may or may not have sustainability characteristics, given by the application of practices aimed at protecting biodiversity in the vineyard and by the use of organic farming practices.

The survey was conducted in all five corporate contexts of the project by applying the two methodologies to the "flag" wine of the company under consideration from time to time, with direct interviews with customers at corporate events. For both the Contingent Assessment and the Choice Experiments, the first part of the questionnaire administered to the interviewees included the detection of socio-demographic variables (age, gender, etc ...) and attitudinal variables of interest (knowledge of biodiversity, frequency of wine purchase, etc. ...), While the second part differed according to the model used. Here are two examples of Contingent Assessment and Choice Experiments.

Example of a part of the Contingent Assessment questionnaire (applied to the companies of Franciacorta, Lombardy and Chianti Hills, Tuscany):

"Suppose you have to buy a bottle of Franciacorta Brut DOCG at the price of € 16.50:
Would you be willing to pay € 19.80 for a wine with a brand that guarantees more attention to biodiversity in the vineyard than a conventional wine with similar characteristics?
o Yes
o No

Would be willing to pay € 21.45 for a wine with a brand that guarantees more attention to biodiversity in the vineyard than a conventional wine with similar characteristics?
o Yes
o No "

Example of a part of the questionnaire from Experiments of Choice (applied for the companies of Franciacorta, Lombardy, Colline Maceratesi, Marche, Colline del Prosecco, Veneto):

In this case, the characteristics that the interviewees were asked to evaluate concerned (as in Figure 1): a) the presence or absence of the logo that guaranteed the use of biodiversity practices in the vineyard; b) the presence or absence of the organic certification logo; c) different levels of wine evaluation scores by the Wine Spectator Guide; d) price of wine. The interviewee had to choose which bottle he would buy if he found himself having to buy it. The interviewee was asked to answer all the "choice sets" that were asked (for each interviewee, 10 choice sets), with the recommendation to choose only one of the wines proposed in the choice set.

Main results

Franciacorta (Castello Bonomi, Berlucchi):

Willingness to pay for biodiversity protection certification was noted, although organic certification remains the preferred one and the one for which you are willing to spend more, probably due to greater knowledge of the logo and the existence of a real specification. Alongside this, the quality score given by the guides is also an element for which consumers are willing to pay, as also noted in the literature (Costanigro et al., 2014). Regarding the socio-demographic characteristics of the interviewed sample, frequent drinkers choose organic and high quality wines, and a greater knowledge of biodiversity leads to a greater willingness to pay for organic and "biodiverse". Significant differences are also found between *Brut* and *Satèn*, whereby consumers have expressed greater willingness to pay for the biodiversity and organic farming brand when they have to buy the

Brut product, most likely because *Satèn* is perceived as a higher quality product that requires less of this type of certifications.

Prosecco hills (Bosco del Merlo):
The investigation carried out on Prosecco DOCG wine confirmed the results obtained in the case of Franciacorta DOCG, for all three attributes. Furthermore, a positive relationship was highlighted between those who attended the degistation courses and the choice of bottles bearing the biodiversity mark.

Maceratesi hills (Conti degli Azzoni):
Also for the wines of this area, Rosso Piceno DOC and Rosso Piceno Superiore DOC, very positive values were found in both wines regarding the willingness to pay of consumers for a certification of biodiversity protection. The same result was obtained for the quality, in accordance with what was obtained in the context of the results regarding the sparkling wines of Veneto and Franciacorta. For the organic certification, however, on the base wine, Rosso Piceno DOC, no statistically significant results were obtained, which suggests that, for lower priced wines, at least on the reds of this area, there may be little interest. of consumers regarding this aspect. Another of the interesting elements that emerged from the survey was that the 35-47 age group would be more interested in buying organic wine, probably because they have greater availability of money, being of an active working age.

Chianti hills (Cantina Castelvecchi):
On the basis of the Contingent Assessment analyzes, the following considerations were formulated: 90% of respondents state that they have heard of biodiversity, but only 40% of respondents are able to recognize the correct definition of biodiversity and the main causes of its perita. In fact, the concept of biodiversity is often confused with that of sustainable agriculture and, above all, with the specificity of animal and plant species in the various ecosystems. The main results of the analysis suggest that there is a consumer's willingness to pay for a biodiversity label and that this is especially true for those who claim to know what biodiversity is. Furthermore, in the sample, women are more interested than men in the brand of biodiversity protection in the vineyard.

9. Good practices for the management of organic fertilization in viticulture

The results obtained during the VITISOM LIFE project are summarized below. From them, the operators in the sector at national and European level can obtain useful information in order to guide the choices regarding the management of the organic fertilization of the vineyard and in particular:

- in making choices regarding the choice of organic fertilizer to be used and the impacts generated by its incorporation or not in the soil Table 16;
- on the evaluation of the possible advantages generated by the adoption of VRT technology for the organic fertilization of the vineyard Table 17.

Table 16 – Summary tables of the main results obtained during the VITISOM LIFE project. Choice of fertilizer to use.

Treatment considered	Impact considered	Impact (-- = very negative; - = negative; ⁓ = indifferent; + = positive; ++ =very positive; / = not detected)	Note
Incorporation of the matrix on the ground	Odor impact reduction	++	Result observed for compost and manure
	Emission of N_2O	-	Result observed in most cases
	Reduction of carbon footprint	⁓	Very variable behavior from site to site
	Organic matter	+	Only for the separated solid digestate in the other cases it did not give significant results
	Soil biodiversity	⁓	Increases F/B index in the case of compost at CBON, reduces the QBS-ar value for Bosco del Merlo
	LCA	/	
	Vine productivity	⁓	
	Quality of musts	+	Better acidic preservation of musts and lower pH with the same sugar concentration
	Quality of wines	⁓	
	Economic impact	-	All things being equal, the cost of processing is added
Processing without fertilization	Odor impact reduction	+	Observed in three out of 4 cases detected
	Emission of N_2O	/	
	Reduction of carbon footprint	/	
	Organic matter	⁓	
	Soil biodiversity	-	Reduces QBS-ar for the Bosco del merlo site
	LCA	/	
	Vine productivity	⁓	
	Quality of musts	-	Acidic conservation reduction and pH increase with the same sugar concentration
	Quality of wines	-	Result observed for most of the cases
	Economic impact	-	All things being equal, the cost of processing is added
Composted soil conditioner (compost)	Odor impact reduction	-	Compared to the separated solid digestate
	Emission of N_2O	+	Result observed for most of the cases
	Reduction of carbon footprint	+	
	Organic matter	⁓	
	Soil biodiversity	+	

			Increases F/B and GP/GN compared to digestate for the Castelvecchi site
	LCA	--	Compared to the other matrices, in relation to the smaller quantity of matrix that is distributed with the same TOC
	Vine productivity	~	
	Quality of musts	+/-	Ripening delay, positive or negative effect depending on the oenological objective
	Quality of wines	+	Observed in most cases for sparkling base wines and for the Castelvecchi vineyard
	Economic impact	+	Compared to other organic matrices: reduction in transport and purchase costs deriving from the lower quantity to be distributed for the same TOC
Manure	Odor impact reduction	-	Compared to the separated solid digestate
	Emission of N_2O	~	
	Reduction of carbon footprint	-	Compared to compost
	Organic matter	~	
	Soil biodiversity	~	
	LCA	++	Compared to compost
	Vine productivity	~	
	Quality of musts	+	Better acidic conservation
	Quality of wines	~	Positive effect only for wines from the CDA vineyard
	Economic impact	-	Compared to compost
Separate digestate soildo	Odor impact reduction	+	Compared to compost and manure
	Emission of N_2O	-	Result observed for most of the cases
	Reduction of carbon footprint	-	Compared to compost
	Organic matter	+	Result observed for most of the cases
	Soil biodiversity	-	Reduces F/B and GP/GN compared to compost for the Castelvecchi site
	LCA	+	Compared to compost

	Vine productivity	~	
	Quality of musts	++	Better acidic conservation and improvement of sugar accumulation
	Quality of wines	~	Positive effect only for wines from the Castelvecchi vineyard
	Economic impact	-	Compared to compost
Urea	Soil biodiversity	--	Reduces QBS-ar for the Bosco del merlo site

Table 17 – Summary tables of the main results obtained during the VITISOM LIFE project. Advantages generated by the VRT

Scope	Estimated impact	Achieved impact	Explanatory Notes
Organic matrix savings by VRT adoption	-20%	-38%	Assumption that without VRT technology* the company distributes the maximum dosage set
Reduction of odour impact by VRT adoption	-10%	-13%	
Reducing GHG emissions by VRT adoption	-10%	-37%	
Economic savings for VRT adoption	+20%	+16%	Average observable benefit for companies that actually have a benefit based on matrix, size and content in average soil S.O. (par 8.1)
Homogenisation of vineyard vigour	Generale decremento della disomogeneità	-38%	Data obtained on the basis of observations made on the companies Castello Bonomi, Guido Berlucchi, Conti degli Azzoni
Impact on organic matter content through organic fertilisation practice	+5%	+6,8%	On average of the various test sites, considering the increase from 2016 to 2019 compared with the unfertilized witness
Impact on soil biodiversity	5%	A negative effect of exclusively chemical fertilization was observed with a reduction of the QBS-ar value equal to -17% more than the unfertilized witness and equal to -21% more than the theses fertilized with organic fertilizer	Data evaluated only on the toe of Bosco del Merlo where treatment with only chemical fertilization (urea) was introduced

10. VITISOM LIFE and the PSR

We thank Alessandro Monteleone and Danilo Marandola - CREA - Center for Policies and Bioeconomy - National Rural Network 2014-2020 and the Office of the LIFE national contact point of the Ministry of the Environment and Protection of the Territory and the Sea (Department for ecological transition and green investments - Division III "Cohesion policies and unitary regional planning").

European viticulture is made up of completely different realities from one country to another, both in terms of the size of the vineyard, the type of soil, the wines produced and the oenological practices linked to the climatic characteristics of each region.

Viticulture represents an important and not indifferent source of employment, seeing the use of a large number of manpower. Overall, wineries employ more than 1.500000 full-time equivalent employees (approximately 15% of all annual work units in the agricultural sector)[1].

Precisely for these reasons, the European policies of the wine sector aim at encouraging its development, modernization and market orientation, strengthening its competitiveness and improving promotion and investment measures. The continuous increase in demand for products and processes increasingly attentive to sustainability in all its facets, has led to the need to better define the most appropriate production conditions throughout the EU to meet the consumer demand for quality organic wines. The VITISOM LIFE project is located in this scenario, focused on environmental and economic sustainability and biodiversity, considering the soil as a non-renewable resource that must be preserved, in full compliance with the Soil Thematic Strategy[2].

The VITISOM LIFE project has a high added value not only at the regional level but above all at the European level since its results will contribute to a potential strengthening of the European wine sector. The application of VRT technology can be adopted in all European wine-growing areas and at the same time can represent a useful contribution to the management of organic vineyards.

The impossibility of identifying different geographical contexts within the same territorial area makes access to regional funding, such as that provided for the RDP, more complicated.

The main results of the VITISOM LIFE project may find useful contextualization in the context of various PSR measures[3,4], of interest both for the implementation of material actions, such as productive investments and agri-environmental practices (Measures 4 and 10-11), and for the development of communication and demonstration activities related to transversal themes of rural development (Measure 1: "Transfer of knowledge and information actions ").

In particular, the innovative machine developed during the project, to optimize the distribution of the organic matrix on the basis of VRT technology, has a high value of technological innovation that can be included, within the RDPs of some regions, in the planned funding from Measure 4 "Investments in tangible fixed assets". With this measure, a series of investments are financed including the construction and development of equipment applicable in the agricultural field. In addition, the methods of managing the organic fertilization of the vine soil tested by the project are among the admissible practices in the context of the agri-environmental payment schemes envisaged by the RDPs for integrated production and for soil conservation (Measure 10 "Agro-climatic payments- environmental ") or for organic farming (Measure 11" Organic farming "). Precisely this last measure of the RDP, through organic farming, helps to strengthen the resilience of agroecosystems by maintaining and increasing their biodiversity.

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[1] https://ec.europa.eu/agriculture/capreform/wine/infopack_it.pdf
[2] https://ec.europa.eu/environment/soil/three_en.htm
[3] https://www.psr.regione.lombardia.it/wps/portal/PROUE/FEASR
[4] https://www.reterurale.it/RapportoNatura2000

The dissemination of the results at European level is of fundamental importance, which directs towards the choice of a European financing instrument, such as that provided for by the Common Agricultural Policy (CAP)[5].
The CAP represents a common policy for all 28 EU countries, with the aim of strengthening the competitiveness and sustainability of EU agriculture by funding projects capable of responding to the specific needs of each country through development programs national (or regional) rural areas also covering the broader context of the rural economy.
The also provides for a series of market measures and other support measures for farmers, such as quality logos or the promotion of EU agricultural products. The overall CAP budget for the 2014-2020 period is € 408.31 billion, in the form of EU funding.
In particular, the CAP is financed through two European funds:
• the European Agricultural Guarantee Fund (EAGF), provides direct support and funds market support measures;
• the European Agricultural Fund for Rural Development (EAFRD), finances rural development. The European Agricultural Fund for Rural Development (EAFRD) supports the European policy on rural development and, to this end, finances the rural development programs carried out in all Member States and regions of the Union.
Over the period 2014-2020, the Fund will focus on three main objectives:
• improve the competitiveness of the agricultural sector;
• ensure sustainable management of natural resources and promote climate action;
• achieve balanced territorial development of economies and rural communities,
including the creation and maintenance of jobs.

[5] https://www.europarl.europa.eu/factsheets/it/sheet/103/la-politica-agricola-comune-pac-e-il-trattato

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