LIFE15 ENV/IT/000392

VITiculture Innovative Soil Organic Matter management: variable rate distribution system and monitoring of the impacts

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Life VITISOM Project
LAYMAN'S report

Project Title: "VITiculture Innovative Soil Organic Matter management: variable rate distribution system and monitoring of the impacts"

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Table of contents

The importance of soil organic matter for a healthy soil 3

The variable rate technology application: a way to improve the sustainability in viticulture 3

Life VITISOM: the innovation in viticulture 4

The objectives 5

The project partners 5

Actions 5

Expected Results 5

Obtained Results 5

Impacts 5

LIFE VITISOM Replicability 5

Dissemination Initiatives 5

Communication materials 5

The importance of soil organic matter for a healthy soil

Soil organic matter represents the organic component of soil. It consists of organic material of animal or plant origin at different stages of decomposition, caused by the activity of microorganisms present in the soil. It contributes to the biodiversity of soil and is the main responsible of the soil fertility and quality. Soils that contain more organic matter are equipped with a better structure that promotes water infiltration and reduction of soil susceptibility to compaction, erosion and landslides.

Therefore, the degradation of soil organic matter content is considered one of the most serious causes of soil degradation, especially in Southern Europe, where the Mediterranean climates show higher soil temperatures and suffer more from drought and heavy rain. This can accelerate the decomposition of soil organic matter, causing loss of soil nutrients.

Modern viticulture presents growing threats to the erosion of organic matter compared to the past, due to the tendency to set up intensive farming systems and of an increased mechanization. For this reason, certain land uses, such as vineyards, are more susceptible to erosion, which also leads to loss of soil organic matter. The recent trends of soil use, together with processes of climate change, have caused a loss of organic carbon in the European soils. It is necessary to identify management strategies which allow to preserve and increase the level of organic matter in the European soils.

The correct management of organic fertilization, intended as the supply of organic matrices, such as compost, solid fraction of digestate and manure, could represent an opportunity to overcome this problem.

The organic fertilization plays a key role as soil improver, since it is able to modify and improve the chemical, physical and biological characteristics of a soil.

The variable rate technology application: a way to improve the sustainability in viticulture

The supply of the organic fertilizers has to be weighted based on the soil conditions, in particular related to its structure (physical fertility), the availability of nutrients which can be assimilated by the plant (chemical fertility) and its biological activity (biological fertility). In this context, the precision farming makes possible the management of agronomical actions taking into consideration the real needs of the plant.

In the viticultural sector, the precision farming technique is essential to direct the management decisions based on the specific information regarding the grapevine state. This represents the concept of "*variable rate technology – VRT*", which allows to calibrate the supply of fertilizers based on the actual needs of the grapevine. For this reason, the

application of this technology in the viticultural sector owns a highly innovative meaning. This type of innovation allows to manage distributions according to pre-existing images of the vineyard vigour and consequently calibrate the intake of products (e.g. chemical fertilizers) in relation to the real needs of vines.
Nevertheless, this technology isn't today yet known for the organic fertilization in vineyard.
The project LIFE VITISOM proposes the introduction of an innovative system for the distribution of organic fertilizers in vineyards, which allows to contrast the soil organic matter erosion and to improve the quality of soil, through the adoption of the VRT.

Life VITISOM: the innovation in viticulture

The Project LIFE VITISOM is conceived to propose an innovative solution for the organic management of European vineyard.
The project aims at introducing the VRT distribution of different matrices for the organic fertilization in the vineyard sector, already existing for the application on field crops.
It shows a clear demonstrative character, aimed at the realization of 5 prototypes, adapted to specific pilot contexts (Fig. 1) and identified as representative of the vineyard variability on the European territory.
The application of this technology for the organic fertilization of vineyards allows to take into consideration the site-specific physical, chemical and biological properties of soil and vines and the real needs of the plants.
The different organic matrices (manure, compost and digestate) are distributed in relation of specific vigour maps.

Figure 1. Experimental sites involved in the Life VITISOM project

The objectives

- Development and demonstration of innovative technology to manage vineyard organic fertilization: the project aims to implement the VRT (Variable-rate technology) to upgrade the vineyard organic fertilization distribution systems, an innovation for the viticultural sector.
- Promote a more sustainable approach to vineyard soil management: this new technology leads to an improvement, at local and European level, of the quality of vineyard soils in terms of soil structure, organic matter content and biodiversity. This allows to prevent erosion, compaction and organic matter decline.
- Contribute to the definition of a complete framework for vineyard soil and organic matter management and to exchange of best practices in viticultural sector: the project allows to identify, through testing carried out in different pilot contexts, a complete framework of vineyard soil management, reproducible at EU level.

The project partners

The project brings together the experience of the Environmental and Agricultural Department of the University of Milan, as project coordinator, and seven other partners qualified to develop specific actions. In order to meet the technical needs of the viticultural sector and improve SMEs competitiveness, three viticultural Companies are involved: Castello Bonomi, Conti degli Azzoni and Guido Berlucchi, that have previous experiences with variable rate in vineyard and share a sustainable approach of vineyard management.
Casella Macchine Agricole is involved for the prototype building, thanks to its experience in the application of the VRT to the chemical fertilization of vineyard.
The activities planned for the University of Padua and West Systems aims at introducing a new scenario of organic fertilization in vineyard through the evaluation of GHG emissions both at ecosystem and soil levels.
In order to check the global environmental impact of the VITISOM project, Consorzio Italbiotec will be responsible of Life Cycle Assessment (LCA) study focused on the evaluation of vineyard management impact at greenhouse gas emissions level and is responsible of ensuring the appropriate dissemination and exploitation of project's results.

Technical development of prototypes: the first phase of the project is aimed at producing and making available an innovative machine, one for each viticultural context identified, representatives of different European viticultural areas. The adoption of VRT allows to make more rational the use of organic fertilizer in viticultural sector at local, national and European level. The software component of the machines allows the direct communication between the prescription map of the vineyard and the prototype which distributes the organic matrix. The possibility to distribute in real-time is possible thanks to the MECS-WOOD sensor.

Figure 2. Example of developed prototype

Testing of prototypes on viticultural sector: the second phase of the project is aimed to make available a machine which could be utilized in all viticultural European contexts, through activities of testing and checking its good functioning in a large number of situations. The validation carried out on a large surface allows to improve and define technical aspects of the machine, while comparisons tests (setting in each different pilot context) allow to verify its functioning with different modality of soil management. This Action also include a strategy for the "After-Life prototype utilisation Plan", in order to identify the most interesting stakeholders at European level and areas where the prototype can be used.

Development of business strategy for expanding the tested methodology

The third phase of the project is aimed at definition of the intellectual property of the results (IPR) exploitation to ensure a correct and convenient sharing of project results among partners. This Action also includes a plan for the conversion of the new technology tested from the prototype version to a market product.

Expected Results

Upgrade of economic and environmental efficiency of vineyard organic fertilisation, thanks to the adoption of VRT and the consequent improvement of distribution efficiency with reduction the use of chemical fertilizers, reduction of the quantity of organic matter distributed in organic vineyards, and homogenization of vineyards vigour.

Validation of a Soil management system with a perspective of an average increase of 5% of the organic matter in vineyard soils, an increase of soil biodiversity of about 5%, a reduction of about 10% of emissions from vineyard soils (expressed in CO_2 – equivalent) compared to chemical fertilizers, a reduction of about 10% of odour emission from the distribution of organic fertilizers, a reduction of costs related to organic matter distribution of at least 20%.

Increasing awareness about viticulture soil organic matter management, through an important dissemination activity focused on developing best practices about viticulture soil management, improving public awareness about the benefit of a sustainable approach to soil vineyard management and improving knowledge about the environmental impact of soil management, in connection to the objectives of the Soil Thematic Strategy.

Obtained Results

Prototypes development

The activity of design and building of the prototypes have been performed by Casella Macchine Agricole and TEAM group, in collaboration with the University of Milan.

Figure 3. Example of developed prototype

Five prototypes have been developed during the first phase of the project:

- *VRT3*: initially developed for the reality of Conti degli Azzoni in the Marche region. It results suitable to soils with variable sloping.

- *VRT4*: initially developed for the reality of Cantina Castelvecchi in Tuscany region. This is the most versatile prototype, since it allows to distribute the organic matrices in extremely variable, but not too high, sloping conditions.
- *VRT5*: this prototype has been developed for realities basically plain, with wide extension vineyard, such as the ones of Bosco del Merlo in Veneto region.
- *VRT6*: this prototype has been developed for vineyard characterised by strong sloping and countersloping. It has been tested in the terraced vineyards of Castello Bonomi in the Franciacorta region (Lombardy) and it demonstrated to be suitable also for the counterslopes of the Marche region vineyards.
- *VRT7*: model of prototype suitable to the transit in narrow spacing vines. It has been tested in the Guido Berlucchi vineyards (Franciacorta region), which have a planting density of 10.000 stocks/hectar. In this machine, the distribution takes place from above.

Organic matrix saving

Currently, the targeted distribution of organic matrix was limited to a manual regulation of the distribution speed, in which the operator did not have the tools to regulate the distribution automatically. Furthermore, the distributions were performed in a heterogeneous way.

Thanks to the introduction of the innovative technology of VITISOM, the organic fertilization of vineyard through the VRT is now automated, resulting in a maximized efficiency of distribution.

For each of the experimental site, 3 distribution campaigns have been carried out, in order to validate the prototypes on wide areas planted with vines and more than 600 hectares have been fertilized during the project.

One of the objectives of the project was focused on the matrix saving of about the 20% of that utilized in absence of the VRT technology.

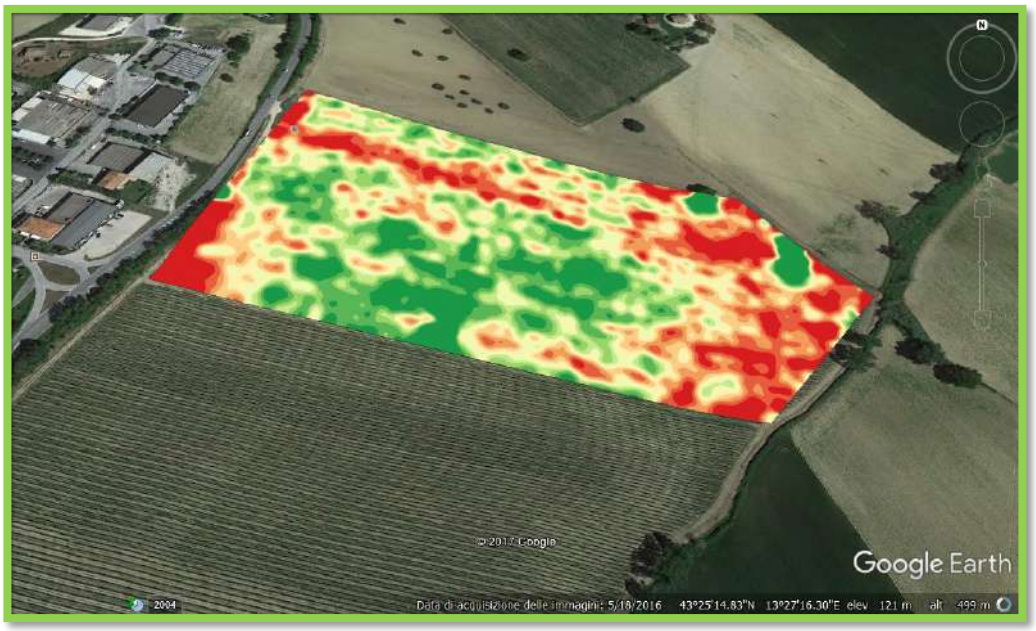


Figure 4. Example of prescription map

The application of VRT is based on the principle of the differentiated dosages, basing on the vigour area identified through the prescription maps. For this reason, for each vigour area of the different wine companies, the reference dosages have been identified. In the project, maps with three levels of vigour have been used, to

which a specific amount of matrix to distribute has been associated (eg: high vigour = lower amount of matrix; medium = intermediate amount of matrix; low = highest level of matrix).
In absence of VRT and of information related to the vineyard's variability and to the possibility of managing a differentiated distribution, the wine company is obliged to choose the maximum dosage, in order to ensure the correct supply to all the areas. Instead, to represent the amount of matrix administered in presence of VRT, the intermediate dosage has been considered.
Taking in account these premises, **the matrix saving amounts to -38% with the adoption of VRT technology.**

Odour impact reduction

Initially it was assumed a reduction of the odour impact deriving from the distribution of the organic matrix in the vineyard equal to 10%.
The investigation has been conducted by the University of Milan for 2 consecutive campaigns at the experimental sites of Guido Berlucchi and Castello Bonomi in Franciacorta region for each matrix (compost, solid digestate, manure), basing on the standardized method EN n. 13725 (CEN, 2003).
The treatments that involved the incorporation of the matrices determined, even if not for the totality of the cases, a lower odorous impact, while in general the separated solid digestate is the one that recorded the lower impact. **The odour impact identifies a reduction of 13% on average.**

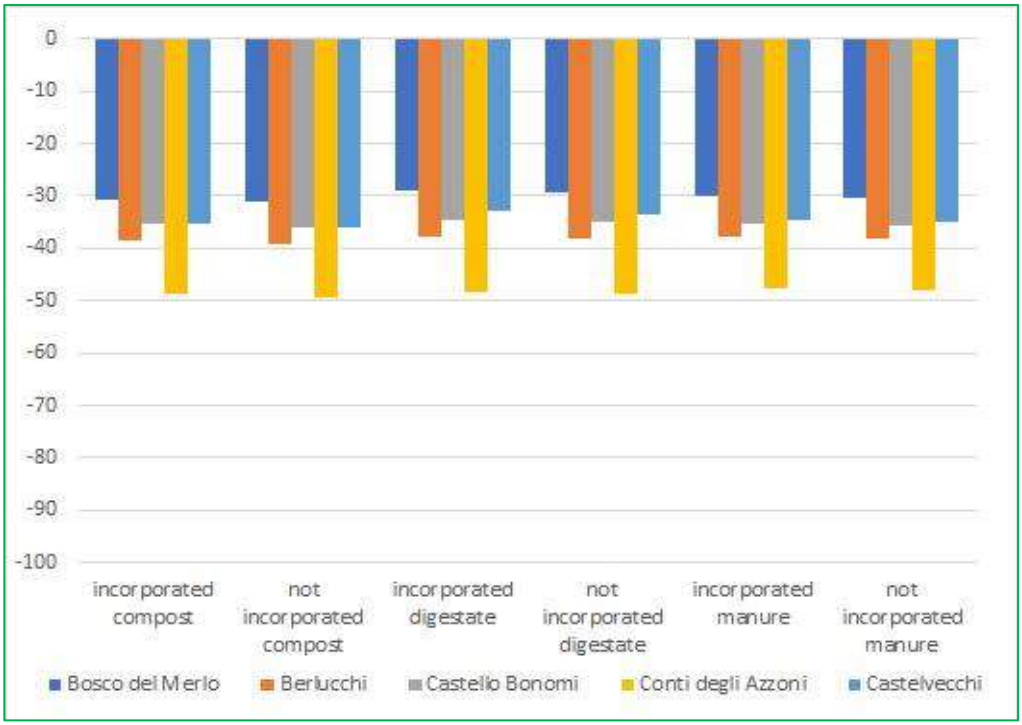
Greenhouse gas emissions (GHGs) reduction from vineyards

The utilization of two instruments developed by the LIFE+IPNOA project (LIFE11 ENV/IT/000302) have allowed the realization of spatial measurements of emissions (performed in a high number of places in different areas of the vineyard in limited time points) and continuous measurements (through the use of fixed cameras on a fixed point which registered the data continuously).

For the spatial monitoring, the nitrous oxide (NO_2) emissions from each matrix have been investigated. This measurement has been then implemented to calculate the Carbon Footprint of the vineyard, which allowed the identification of the effective reduction deriving from the use of the VRT technology in viticulture.
In the first phase of the project, the percentage of reduction of emissions have been calibrated compared to the chemical fertilizer supply and it is estimated in a reduction of 10%, in term of CO_2 eq emission. At the end of the project, has been decided to calibrate the percentage basing on the application or not of the VRT.

The matrix saving generated by the use of VRT determined a GHGs emission reduction, that is expressed in % in the graph below (Fig. 5). **The average percentage of emission reduction thanks to the use of VRT for organic fertilization of the vineyard in terms of CO_2 eq is equal to -37%.**

Figure 5. % of GHG emission reduction in the different testing areas and for the different matrix



Homogeneity of vineyard vigour

One of the objectives of VITISOM was concentrated on the increasing of the vineyard uniformity through the application of the VRT for the organic fertilization. During the project, the five experimental sites (Castello Bonomi, Conti degli Azzoni, Guido Berlucchi, Cantina Castelvecchi e Bosco del Merlo) have tested the 5 prototypes developed for the organic fertilization of vineyards.

For the three wine company partners (Castello Bonomi, Conti degli Azzoni e Guido Berlucchi), through the use of the MECS-WOOD sensor, has been possible to measure the effective vigour variability with each vineyard.

During the project, about 1.200 vigour maps have been analysed and evaluated. Each of them represents the internal variability of the single vineyard with different colours. Each gradation of colour is associated to an index value (Canopy

MECS-WOOD sensor

Multi-parametric sensor specific for the characterization of the vegetative vigour and the micro-environment inside the vineyard. It allows the elaboration of vigour maps detected by woody branches in absence of vegetation. In this way, it is possible to analyse the vegetative vigour also in the winter season and, consequently, to perform the distribution of the organic fertilizer in real-time.

Index – CI or Wood Index – WI) (Fig. 3). The homogeneity variation has been assessed through the analysis, for each map, of the index range among the maps performed at the start (2017) and at the end (2019) of the project (Fig. 4).

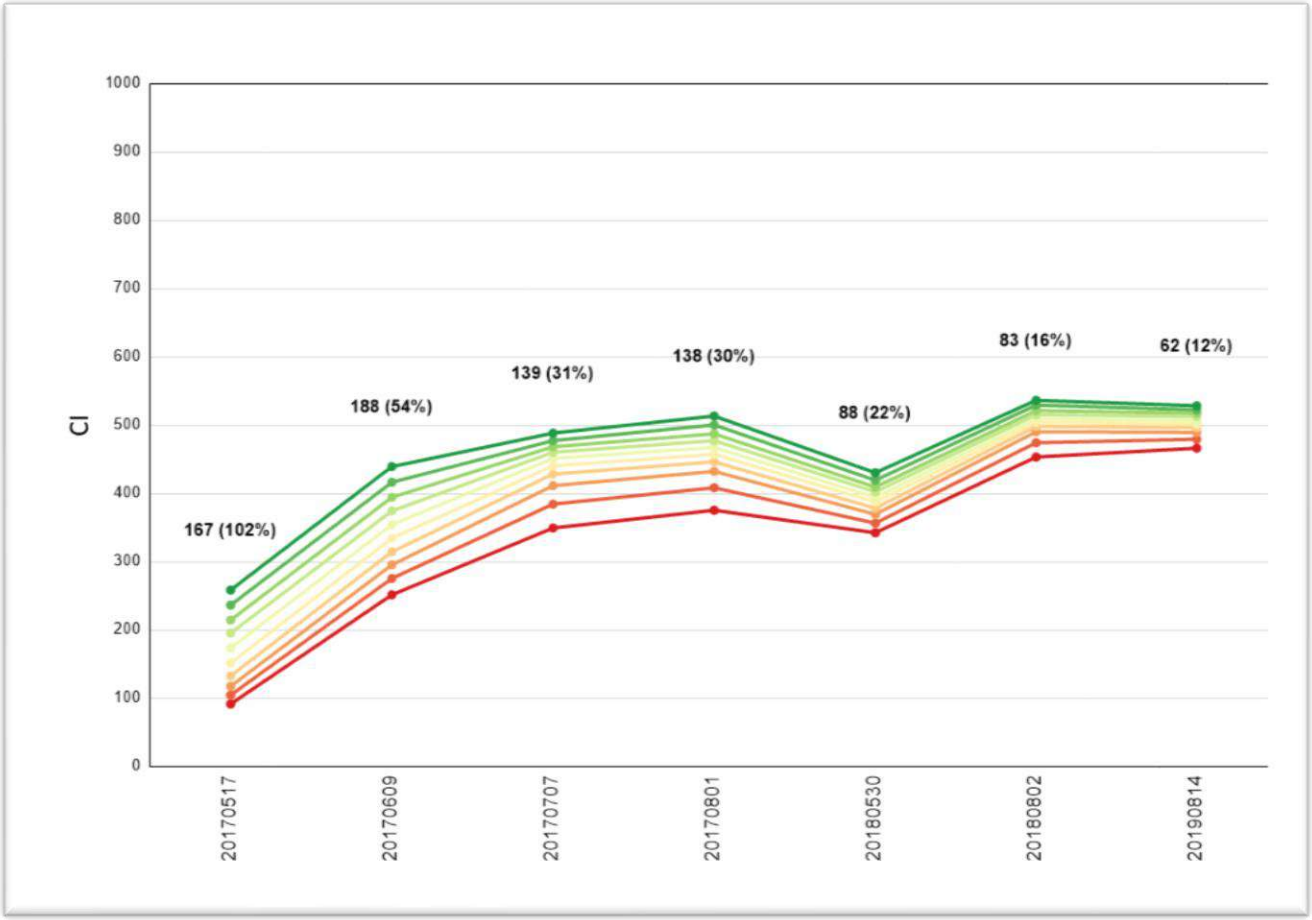


Figure 6. Example of a graph in which the variation of the variability of vineyard's vigour is represented on the one hand, and on the other hand the trend in the overall vigour of the vineyard. On the ordinate the CI index values are reported and on the abscissa the days of the various surveys carried out in this specific vineyard. In the example we can well see how the variability of the index is reduced within the vineyard and how the vigour in general has increased.

Impacts

- ## Economic impact of LIFE VITISOM project

The application of Variable Rate Technology (VRT) can generate advantages compared to the Uniform Rate Technology (URT), even if the advantages must be assessed basing on many factors and variables (Surjandari et al, 2003). Initially, an estimated 20% benefit was estimated; however, in the processing of real data it has been necessary to consider several aspects. In absence of variable rate and of information related to the vineyard's variability and to the possibility of managing a differentiated distribution, the wine company is obliged to choose the maximum dosage. With these premises, it has been possible to calculate a cost saving deriving from the lower consumption of matrix, differentiated from each single typology (compost, digestate and manure). Furthermore, a saving resulting from the reduction of transport costs and fuel for the matrix distribution can be assessed.

The purchase of the technology developed by VITISOM for the management of organic fertilization at variable rates can always be convenient for wine companies over 40

hectares. Below this dimension, the advantage is variable depending on the type of matrix used and the average organic substance of the soil. On average, **the percentage advantage value amounts to 16%.**

- Impact on the soil organic matter content

One of the initial objectives of LIFE VITISOM project was focused on the average increase of the organic matter of about the 5% of its initial value.
In all the involved experimental sites, except for Bosco del Merlo, the average increase of the soil organic matter has resulted higher in the fertilized treatments with organic fertilizer, compared to the control. In the Bosco del Merlo site, it has been possible to observe an increment only for the fertilized treatment with the solid digestate.
The mean value of soil organic matter increment, compared to the control, results equal to +6,8%, consistent with the project objectives.

- Impact on the soil biodiversity

The evaluation of the soil biodiversity has been performed by calculating the QBS-ar index (Biological Quality of Soils - arthropods), in order to identify the benefits in terms of biodiversity generated by the different types of organic fertilization compared to an untreated and, only in the case of the Bosco del Merlo vineyard, compared with chemical fertilization (urea).
At the beginning of the project an increase of 5% was estimated, in terms of the presence of arthropods (calculated using the QBS-ar index). It is not possible to observe an increase in biodiversity values in relation to organic fertilization. However, an interesting result emerged in relation to the negative effect of the supply of only urea fertilizer, which generated a **higher decrease of the QBS-ar value between 2016 and 2019: 17% higher than the control and 21% higher compared to the organic fertilizer.**

Figure 7. Berlese-Tullgren selector for the sampling of the soil microfauna and QBS-ar index calculation

LIFE VITISOM Replicability

European viticulture is made up of very different realities from one country to another, whether in terms of vineyard dimension, type of soil, produced wines or oenological practices linked to the climatic characteristics of each region.

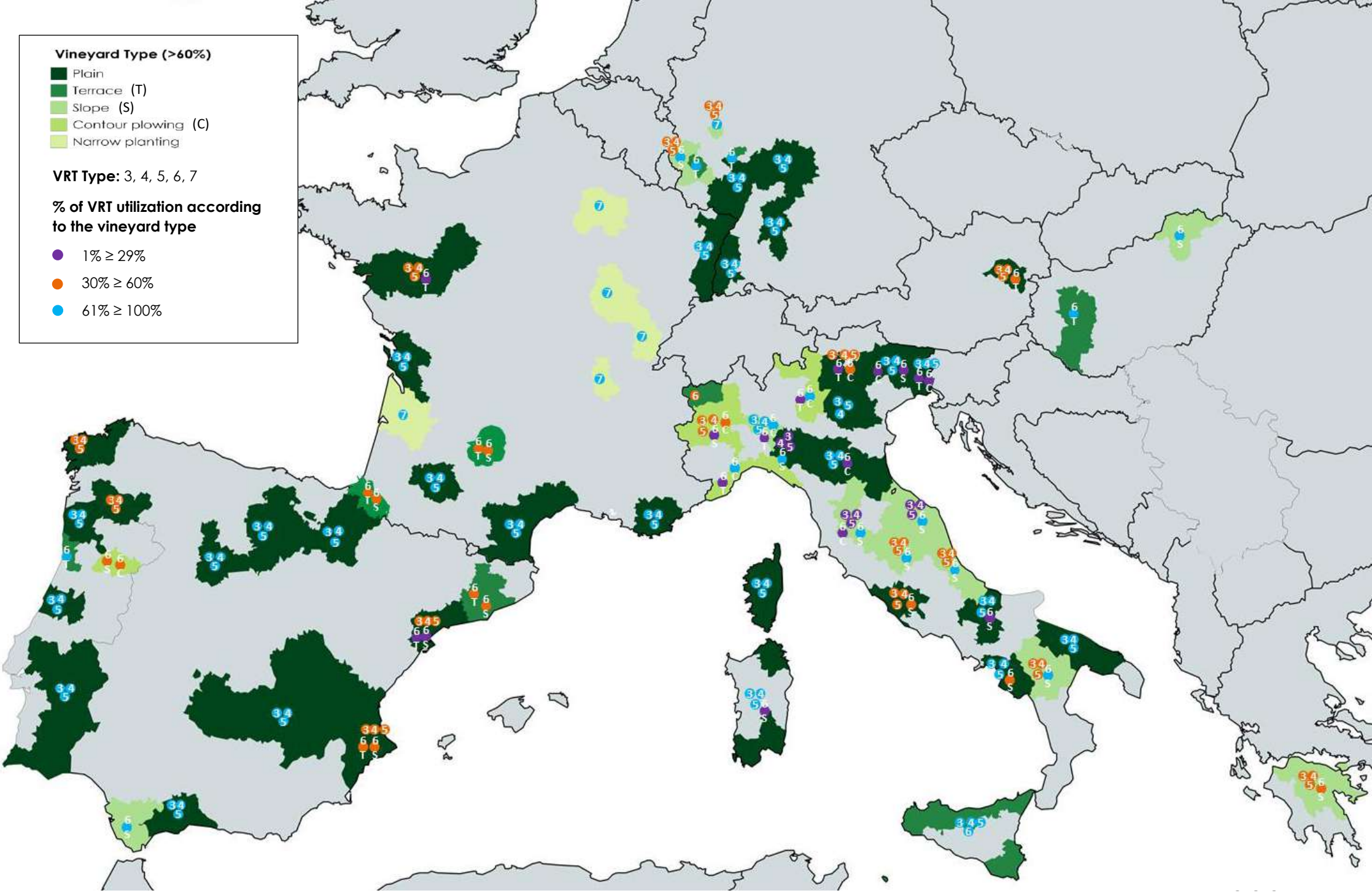
LIFE VITISOM project goes beyond the vineyard variability, providing a solution for their sustainable management and supporting the Soil Thematic Strategy.

The project proposes an innovative application of the variable rate technology for the organic fertilization of vineyards, testing the developed prototypes in different italian viticultural contexts, representatives of the variability of the European vineyards. For instance, the application of the VRT can be adopted in all the European viticultural areas and, at the same time, could represent a useful contribution to the sustainable management of the biological vineyards.

To demonstrate the effective reproducibility of the method, a map of the Europe is reported.

The main European viticultural regions are identified through different colours (from the darkest to the lighter green), which represent the Vineyard Type for a value major than 60%: plain, terrace, slope, contour plowing and narrow planting. For accuracy, it has to be specified that the areas with extreme conditions (very extreme slopes) are not prone to be treated with the VRT technology and, for this reason, are not taken in account into the coloured regions.

In each region, the typology of prototype which could be adopted is reported, according to the percentage of utilization (reported in different colours: violet for a % of utilization between 1% and 29%; orange violet for a % of utilization between 30% and 60%; light blue violet for a % of utilization between 61% and 100%).


Vineyard Type (>60%)
Plain
Terrace (T)
Slope (S)
Contour plowing (C)
Narrow planting
VRT Type: 3, 4, 5, 6, 7
% of VRT utilization according to the vineyard type
1% ≥ 29%
30% ≥ 60%
61% ≥ 100%

Dissemination Initiatives

During the LIFE VITISOM project, a strong dissemination activity has been promoted, with the aim of increasing awareness about viticulture soil organic matter management, improving public awareness about the benefits deriving from a sustainable approach and about the environmental impact of an incorrect management, through the development of best practices about viticulture soil management.
These objectives are reflected into 2 dissemination products, released at the end of the project:

- "*Manual of good practice of vineyard organic matter management*": it represents the final summary obtained by the collection of results of the prototypes testing and impact assessment activities. It is conceived to be the very first publication with a high level of detail about vineyard organic fertilisation management, with the aim of being available to the largest possible public (technicians of the viticultural sector, consumers, institutional and scientific bodies);
- "*Green Paper on European Strategy of Vineyard soil and ecosystem protection*": aimed at supporting knowledge production on topics for which there is a lack of information, such as the impact of GHGs emissions from vineyard soil and ecosystem, including a preliminary evaluation of main barriers on the organic farming development

Figure 8. Italian version of the "Green Paper on European Strategy of Vineyard soil and ecosystem protection"

The project involved a network of several stakeholders active in the vineyard soil management, with a special attention for the achievement of a more sustainable approach to improve quality of vineyard soils in term of structure, organic matter content and biodiversity.

The clear demonstrative character of VITISOM has been focused on the organization of 10 demonstration events in the five areas of the companies involved in the prototypes testing activities (Lombardy-Franciacorta, Veneto, Tuscany, Marche), which reached the participation of a total of 800 people. The events were open to the general public with the aim to illustrate technical aspects, environmental performance, economic sustainability of the prototypes and promoting technological solutions to reduce land degradation and support organic farming. The selected areas are representative of the main EU viticultural contexts, and therefore are intended to illustrate the different conditions of application of the prototypes in the specific soil nature, climatic conditions and phases of soil fertilization.

The events have been articulated in educational sessions and demonstrations conducted by a panel of speakers of the project partners, industry experts and local authorities (Public, Policy makers).

Month	Region	SMEs premises involved
Mar 2017	Marche Region	Conti degli Azzoni
May 2017	Lombardy Region	Castello Bonomi
Dec 2017	Lombardy Region	Berlucchi
Feb 2018	Veneto Region	Bosco del Merlo
May 2018	Tuscany Region	Castelvecchi
Dec 2018	Marche Region	Conti degli Azzoni
May 2019	Veneto Region	Castello Bonomi
June 2019	Tuscany Region	Castelvecchi
Sept 2019	Marche Region	Conti degli Azzoni
Nov 2019	Lombardy Region	Berlucchi

Communication materials

Online	Offline
Website www.lifevitisom.com published in October 2016 and monthly updating of the contents - N° interactions: 13,175 - N° page views: 30,887 - N° sessions: 17,000 - +120 news and updates published **Newsletter** - 20 newsletters produced and +1,500 readers reached **Social media promotion** Channels: Facebook and Google Ads: - +20 viral marketing campaigns designed with + 95,000 users reached - N° of Facebook followers: 3,200 - N° "like": 3,100	**Materials** - 100 Welcome bags - 400 USB pen drive - 500 Pens - + 1,500 Factsheet distributed during the events - + 10 notice boards displayed at the experimental sites involved by the project - 20 video products - + 50 articles published in magazines and sector blogs