Sustainable viticulture using organic fertilisers

Collaboration between researchers, vineyard owners and technology developers is helping to promote a sustainable approach to vineyard soil management that is also likely to improve vine and wine quality. Isabella Ghiglieno, project manager of Life Vitisom, presents the aims and results of a three-and-a-half-year study in Italy demonstrating how precision farming in the form of variable-rate technology could enable efficient, cost-effective and low-impact organic fertilisation of vineyards throughout Europe. This approach could also reduce the carbon footprint of the viticulture sector.

Innovative technologies applied to the wine sector can reduce greenhouse gas emissions.

The August 2019 IPCC report proposes adopting farming practices that work with nature, rather than forcing productivity through overuse of fertilisers, as an important part of mitigating climate change effects. Machines and fertilisers have enabled intensive farming, in which organic material is not returned back to the soil, leading to soil degradation and exhaustion of organic matter. Now it is clear that efforts must be made to provide agronomic methods that support conservation management practices, work with buyers and growers to encourage land-stewardship, and put soils and their health at the centre of land use. The viticulture sector must also tackle these issues and the comprehensive project undertaken in Italy that is described here is a step in that direction.

PROMOTING SUSTAINABLE VINEYARD MANAGEMENT IN ITALY

The project 'Life Vitisom' was funded by the LIFE programme, the European Union's funding scheme for the environment and climate action. It sets out to promote sustainable vineyard management as part of the priority area of environment and resource efficiency, and in support of green and circular economies and soil health.

The development, testing and scale-up of a cost-effective technology for vineyard organic fertilisation was a key part of this endeavour. The University of Milan was the coordinator for the project and was involved in the variable-rate technology (VRT) prototype design and validation, as well as evaluation of soil chemical and biological conditions, vine, grape and wine characteristics and social and economic effects.

The project included technical development of precision machinery in the form of VRT prototypes for different viticulture contexts that allow the application of organic fertiliser according to the needs of individual vines. The prototypes were tested to identify five different machines, each one suitable to be used in specific viticultural contexts. The final step is to develop prototypes for industry use.

The various studies were conducted with the cooperation of three Italian wineries (Castello Bonomi, Guido Berlucchi and Conti degli Azzoni). The VRT prototypes were designed and built by Casella Macchine Agricole. Greenhouse gas monitoring was done by University of Padua and West Systems. Communication and impact assessment were supported by Consorzio Italbiotec.

The work was complemented by efforts to increase the engagement of≈viticulture sector operators (wineries, contractors and agricultural machine producers), the public, the scientific community and public authorities in order to promote awareness of this sustainable approach to vineyard soil management and soil protection.

REDUCING THE ENVIRONMENTAL IMPACT OF FERTILISERS USING PRECISION FARMING

Progress in our understanding of soils is showing how organic fertilisers, applied with care, can regenerate soil organic matter and reduce the need for chemical fertilisers. Not only does organic matter provide stable nitrogen, it also has positive effects on soil structure, water retention and the availability of nutrients. It can enhance the biological properties of soil by creating better conditions for the hospitality of micro-arthropods and micro-organisms.

Spatial monitoring of GHGs from soil was caried out using a mobile instrument for measuring GHG variation that was developed by the LIFE+ IPNOA Project.

MECS-WOOD is an innovative system to quantify vine vigour from woody unleafed branches. This allows variable rate distribution of organic matrices to be carried out in real time.

We know that greenhouse gases, which contribute to global warming, enter the atmosphere through natural processes, including agricultural soil management. On the other hand, plants have a natural mitigating effect via CO_2 uptake by photosynthesis. However, a significant (and reducible) source of greenhouse gas emissions in agricultural practice is the use of fertilisers.

The technology available for the application of organic matter in viticulture is inefficient, leading to a significant waste of resources. Sustainable solutions for organic fertiliser application will increase both soil and vine quality. Using newly developed advanced agricultural machinery that preserves and protects cultivated land is an added bonus.

Precision farming using hi-tech instruments to apply fertiliser only where it is needed has now become possible. It enables less fertiliser use, which in turn saves money. It also helps the environment by enabling growers to reduce greenhouse gas emissions that result from the inefficient use of fertilisers. These measures could soon be part of best practice in viticulture. As part of the project undertaken by Life Vitisom, chemical and biological soil parameters were monitored to raise awareness of the physical, chemical and biological soil fertility. Such studies will help to improve the quality of vineyard soils in terms of soil structure, organic matter content and biodiversity and help to prevent erosion, compaction and organic matter decline.

Precision farming using hi-tech instruments to apply fertiliser only where it is needed has now become possible. Organic fertilisation is more efficient if variable-rate technology is used to match the actual needs of vines.

Modern agriculture has used up soil 100 times faster than it is replenished and areas of fertile land are being reduced to infertile desert every year. It is now crucial to promote restorative soil-building practices, such as using organic matter and no-till methods. This will ensure that soil organic content and biological fertility can be upgraded.

CARBON UPTAKE AND GREENHOUSE GAS EMISSIONS OF VINEYARD ECOSYSTEMS AND SOILS

The study outlined here set out to upgrade the economic and environmental efficiency of vineyard organic fertilisation by using VRT to both reduce the use of chemical fertilisers and reduce the amount of organic matter used in organic vineyards. The aim was to show that organic fertilisation is more effective if VRT is used to match the actual needs of vines.

VRT has been used in vineyards for chemical applications but not previously for organic fertilisation of vineyards. Other studies have found mineral fertilisers to have greenhouse gas (N_2O) emissions about ten times

An example of vigour maps obtained during the project development.

Net CO_2 exchange is monitored using the Eddy Covariance method, while GHG emissions at soil level are analysed.

higher than those of organic ones, indicating that organic applications are preferable.

To provide a framework for vineyard soil and organic matter management that could be replicated elsewhere in Europe and beyond, five prototypes adapted to different pilot contexts in Italy were identified. The project then set out to measure net carbon fluxes (at ecosystem level) and greenhouse gas emissions (at soil level).

Spatial and temporal monitoring of greenhouse gases (CH_4, N_2O and CO_2) emitted directly from soil was carried out to assess the effect of different organic matter management methods. This was done at intervals throughout a three-year period (2017-2018-2019) for five vineyard sites (including land that was flat, steep and terraced) in different geographical areas of Italy.

In each vineyard, greenhouse gas fluxes were evaluated for three organic fertilisers: compost, digestate and manure. Controls were not fertilised and either tilled or not tilled. Each of the organic fertilisers was tested by incorporating it or not incorporating it (till or no-till) into the soil. At one test site, urea (with and without incorporation into the soil) was applied.

The aim was to identify peak emissions for N_2O and to highlight seasonal variation in spatial emissions of greenhouse gases. The spatial emissions data obtained from the first year of monitoring suggest that solid fraction of digestate has least impact on CO_2 emissions while manure has the greatest.

Continuous monitoring of net carbon fluxes was done using Eddy Covariance to quantify release/uptake of CO_2 to/from the atmosphere at two Italian vineyard sites from October 2017 to October 2019. Results suggested that soil cultivation and canopy management can modify CO_2 uptake and emissions. However, the variability between the two sites monitored can also be attributed to different climatic conditions and vineyard characteristics. In parallel at the same sites continuous monitoring of GHG emissions was carried out at soil level.

Management methods like this could increase organic matter in vineyard soils and increase soil biodiversity.

This monitoring of soil emissions was done using a mobile instrument for measuring the variation of greenhouse gases that was developed by the LIFE+ IPNOA Project. The instrument is housed on a light-tracked vehicle that can be driven remotely. It can measure emissions directly in the field and real-time data can then be viewed on a smart phone.

TOWARDS GOOD PRACTICE IN VINEYARD ORGANIC MATTER MANAGEMENT

Additional aspects of the project worth mentioning were: the implementation of MECS-VINE technology to evaluate vine vigour from annual wood (WI index); odorimetric analysis of different components of applied organic matter; evaluation of biological soil quality; and monitoring of the quality of wine production. Finally, life cycle assessment (LCA) analysis, carbon footprint calculations and evaluation of the socioeconomic implications of the project were undertaken.

The project, which started in July 2016 and finishes in December 2019, is now in the last stages of data collection and processing. A final conference will be held and two publications will be available: a 'Manual of Good Practice of Vineyard Organic Matter Management' and a 'Green Paper on European Strategy of Vineyard Soil and Ecosystem Protection'.

Management methods like this could increase organic matter in vineyard soils and increase soil biodiversity (by about 5%). They could also reduce emissions from vineyard soils (by about 10% compared to chemical fertilisers), reduce the odour caused by distribution of organic fertilisers (by about 10%), and reduce costs related to organic matter distribution (by at least 20%).

Behind the Research

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Research Objectives

Isabella Ghiglieno studies viticultural soil management, specifically, how to improve organic fertilisation.

Detail

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Bio

Isabella Ghiglieno studied "Viticulture and Oenology" followed by a master degree in "Science of production and protection of plants" at University of Milan. Her experience in the wine sector began in 2007, including four years of a research fellowship at Agricultural and Environmental Sciences Department. Since July 2016, she has been Project manager of LIFE15 ENV/IT/000392 LIFE VITISOM Project.

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Collaborators

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References

Life Vitisom. Available at: https://www.lifevitisom.com/ [accessed August 2019]

Valenti L. et al. Project, viticulture innovation technology and GHG emission monitoring. BIO Web of Conferences 13, 02008 (2019). DOI: 10.1051/bioconf/20191302008

Change and Land: An IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems. Available at: https://www.ipcc.ch/report/srccl/ [accessed August 2019]

Personal Response

As a result of this project, do you have a personal recommendation for the best vineyard organic fertiliser application (compost, digestate or manure) using tillage or not?

"At this stage we are processing three years' worth of data collection, so we will be able to give recommendations for best vineyard organic fertiliser application after this process. Soil management and organic matter application in fact need different years to determine the positive repercussions on vineyard soil and vine health. At this stage we have used the output of the first year of spatial GHG monitoring to better calibrate the carbon footprint and LCA assessment, updating coefficient in software. We can also confirm the conclusion of our prototypes validation so the VRT technology is now available for organic fertilisation of vineyards."