CORE organic

PART D (max 4 A4 pages in total)

D1. Proposal identification number
99

D2. Project title
Restoring optimal Soil functionality in degraded areas within organic Vineyards

D3. Project acronym
ReSolVe

D4. Project objectives and main hypothesis

Grapevine shows optimal growth and high quality yield in suboptimal soil conditions: soils with medium-low fertility and low water supply, which limit the excessive vine vigour. On the other hand, excessive stress can cause disease susceptibility and low grape yield and quality. On such suboptimal soils excessive stress is often linked to the loss of soil functionality due to several different causes. In vineyards, it is not rare to find small or large degraded areas of low fertility that have lost their soil quality and functionality (fertility, water retention) owing to inadequate soil preparation before vine planting, or too intensive soil or crop management during cultivation. Organic viticulture and "conversion agriculture" are not free from these fertility issues, since they use the same methods of land preparation and management as conventional viticulture, but they cannot use the same tools (such as fertilizer) to remediate these problems. The problem is made harsher under the current climate change.
Soil functions can also be degraded because of the use of Cu-based pesticides. Not much knowledge is available yet in order to mitigate Cu bioavailability through proper agro techniques.
The main hypothesis of this research project is the following: degraded areas within vineyards can be restored to the target soil functionality for grapevine. This can be obtained by different site-specific management systems including: i) addition of different types of compost; ii) green manure or ground cover; iii) dry mulching.
The overall objective of the project is testing suitable agronomic techniques, which follow organic principles, aimed at both increase soil health and restore soil functionality in degraded areas. Specific objectives are: i) increasing soil organic matter, structure, and nutrient availability, both in the topsoil and in depth; ii) increasing soil microbiota and mesofauna diversity, with particular attention to that species antagonist to vine-root diseases; iii) increasing vine-roots development and mycorrhization; iv) increasing soil depuration and water regulation capacity; v) strengthen soil resilience, in particular against climate change; vi) reduce the risks of soil copper toxicity for plants and soil biota; vii) improving grapevine efficiency, grape yield and quality, and their stability over the years; viii) decrease vine-root diseases.

D5. Description of the project:

Relevance of the proposal compared with the call text:
This proposal is extremely relevant for the topic "Plant/soil interaction in organic crop production". The ReSolVe project will contribute to improve the sustainability of viticulture management through the understanding of the interaction between soil physical and chemical properties, soil biota and grapevine under different practices to restore target soil functionality in vineyard.
The different restoring strategies will be tested to establish the efficiency regarding: i) optimizing plant

growth; ii) getting higher grape yield and quality; ii!) optimizing soil functions, and their stability over the years.

Expected results for the sector and how they will overcome barriers and support development opportunities for the organic sector:
Organic viticulture suffers from the loss of soil functionality owing to an improper land preparation and management harsher than traditional viticulture, because of the limitation of external input such as pesticides and mineral fertilizers. In addition, there are vineyards in general that are located on sloping lands, which is also a reason for their frailness to erosion. Weed suppression by tillage such as that used in organic farming leads to a steady decrease of soil organic matter degrading many soil functions. The EU Regulation on organic farming (834/2007 and 889/2008) includes generic considerations on the maintenance of soil fertility and biodiversity, but so far the regulation does not include guidelines about land preparation for plantation and soil fertility maintenance in perennial crops.
Moreover, the intensive use for over 100 years of copper-containing-fungicides (such as Bordeaux mixture) in vineyards has led to an important, widespread accumulation of Cu in the soil. Symptoms of Cu biotoxicity (vine chlorosis, micro- and meso-fauna population) exhibit stronger effects in soils with low pH, low cation exchange capacity and organic matter than in more preserved soils (Brun et al., 1998). Traditional farms converted to organic methods are not free from this soil pollution.
The ReSolVe project will provide guidelines for restoring optimal soil functionality and for limiting copper bioavailability in vineyard and, in general, in other perennial crops. The project will produce case study demonstrations and recommendations for farmers, agricultural industry confederations, agronomists and agricultural policy makers, both in organic and traditional farming.
The dissemination of the best practices for soil functionality restoration and optimal soil management in vineyard will allow for increasing grape yield and quality and, at the same time, making vineyard management more sustainable and resilient to climate change.

Relation of the consortium to the main target groups and how these will be involved and/or targeted in the project:
The main project target group is represented by wineries, grape-growers and consultants who can directly benefit from the results of the project activities. The experiments of this project will be done in commercial and demonstration vineyards and special care will be paid to the transfer of results through on-farm visits and demonstrations.
Research findings will be made available at multiple levels including: international (website, conferences, and scientific papers), national (guidelines, transfer networks) and local (training workshops and local broadcasting companies).
In the second and third years of the project, a series of training workshops will be carried out involving national and international transfer networks (European Innovation Partnership, Operational groups, best practices consortia), grape-growers, agricultural industry confederations, agronomists and specialists. Non-organic wineries will be also involved during the dissemination activity. In this way, best practices of organic viticulture could be exported to traditional farming.
A web-site of the project will be created, where results and best practices to restore soil functionalities in the vineyard will be published.

European added value of the project being carried out transnationally:
ReSolVe will contribute in several ways to European organic farming management. In this sense optimal soil functionality in vineyards will be restored, sustainability will be increased and grape yield and quality will be optimized.
Because of vineyard overexploitation and climate change, the unitary European grape production is foreseen to decrease in the future, especially in those areas characterized by loss of soil functions and biodiversity. A good efficiency of the vineyard soil should be fundamental to contrast plant diseases and to optimize the grape yield and quality over the years.
Transnational cooperation is fundamental to guarantee a high impact of the results and to provide general guidelines to resolve this common issue. With this transnational consortium structure, the restoring techniques could be tested in different climates, soils, viticulture history, grape typology (wine-grape and

table-grape) and cultivars. The international partnership allows for developing strong multidisciplinary work and for monitoring the soil and vine parameters with innovative non-invasive technologies such as infrared, thermal, and fluorescence techniques for evaluating plant development and bunch morphology; soil proximal sensing to control spatial variability; molecular methods to analyze microbial community; carbon isotopes to check plant water stress.

D6. Description of the scientific methods and work plan (may be divided into work packages)

The ReSolVe project consists of a holistic approach to the understanding of soil functionalities and grapevine deficiencies in the degraded areas of organic vineyards. Eight public partners from six different countries are involved in this project, and they are: CRA-Italy, BxScAgro and Vitinnov-France, UDLR-Spain, CU and Alata BKAI-Turkey, KIS-Slovenia and SLU-Sweden. The experimental vineyards have been selected and they are situated in: i) Italy, organic district of historical Chianti (Tuscany); ii) Spain, Abalos (La Rioja); iii) Turkey (Table grape), Ceyhan (Adana) and Tarsus (Mersin); iv) France (Bordeaux and Languedoc); v) Slovenia (Primorska).
The presence of complete expertise profiles is the strength of the project: i) soil science; ii) hydrology; iii) soil biology (microflora and mesofauna); iv) mycology; v) soil ecology; vi) viticulture and vine physiology; vii) vine pathology; viii) proximal sensing; ix) organic fertilization; x) cover crops and green manure.
The project is divided into 6 work packages that will be organized as follow:

- *WP1: Project management and coordination. (WP leader: CRA, Edoardo A.C. Costantini,Italy)*
The main tasks of the project management are to establish an efficient organisation to support the project, create the necessary networking and communications' environment and monitor results and deliverables. WP1 coordinates and harmonizes the monitoring set up and the soil restoring techniques tested in all the experimental vineyards. WP1 will organize annual project meeting and periodic video-conferences among project partners to avoid risks and useless expenses and/or trips. WP1 will also ensure relationships with the European Innovation Partnership, Operational groups and best practices consortia.

- *WP2: Grapevine monitoring. (WP leader: UDLR, Javier Tardaguila, Spain). Partners involved: UDLR, CRA, BxScAgro, Vitinnov, CU, Alata BKAI and KIS.*
Work package 2 (WP2) proposes the monitoring of the grapevine growth and development (*task 2.1*) over the 3 years during the most important physiological phases (budburst, blooming, veraison and pre-harvest period). Pruning wood weight will be recorded in the experimental plots during the winter. Each measurement will be carried out on all elementary units (treatments and controls) of each experimental plot.
The integration of three fundamental sensing technologies—chlorophyll-based fluorescence, RGB machine vision and IR thermography—to map non-invasively important agronomical and physiological parameters of grapevine and bunches will be used. Measurements of vine leaf water potential will also be performed (*task 2.2*) to test the water stress of grapevines. During the grape harvest, grape yield will be measured and grape quality will be checked through the analysis of physical characteristics of bunches and berries, sugar content and phenolic compounds (*task 2.3*). In selected non-irrigated plots characterized by scarce water availability, carbon isotopes ($\Delta^{13}C$) analysis will be conducted after micro wine-makings (*task 2.4*). Standard leaf or petiole analysis will be performed for major and minor chemical components (N, P, K, Mg, Ca, Na, Bo, Mn). The air temperature and total precipitation will be monitored in each experimental area (*task 2.5*). Common measurement methods and laboratory analysis protocols will be established (*task 2.6*).

- *WP3: Soil chemical, physical, hydrological properties and functionality. (WP leader: CRA, Simone Priori, Italy). Partners involved: CRA, CU, SLU, Vitinnov and BxScAgro.*
WP3 provides the characterization and analysis of soil features in the experimental fields. The differences of soil traits between degraded areas and non-degraded areas will be investigated in detail using profile descriptions (*task 3.1*), soil sampling and standard laboratory analysis (*task 3.2*). The laboratory analysis will include: texture, bulk density, pH, electrical conductivity, calcium carbonate, organic carbon, cation exchange capacity, exchangeable bases (Ca, K, Mg, Na), N, K, P, Fe and Zn. Total and bio-available Cu

will be analysed every year. Soil hydrological features are studied utilising field (Guelph permeameter and infiltrometers) and laboratory methods (soil water retention curve by suction table and pressure plate extractor). During the 2nd and 3rd years of the project, the soils in the experimental sites will be monitored during the main vine phenological phases (budburst, berry formation, pre-veraison, post-veraison) for soil moisture and temperature (*task 3.3*), organic carbon and nitrogen (task 3.4). Common measurement methods and laboratory analysis protocols will be established (*task 3.5*).

- *WP4: Soil Ecosystem provisioning and Ecosystem providers. (WP leader: BxScAgro, Maarten Van Helden, France). Partners involved: BxScAgro, Vitinnov, CRA, CU, KIS and SLU.*

WP4 focuses on identifying the underlying mechanisms of the changes in 'provisioning ESS' (grape growth) observed (WP2) and changed in soil characteristics (WP3, supporting ESS) in the experimental plots. It is of major importance that a limited set of measurements both to measure Ecosystem services and service providers have been selected with these types of measurements:

- For service provision: SOM turnover (litterbags, soil respiration and soil enzymatic activity BIOLOG Ecoplate® system to measure the degradation of 25-30 different substrates by the extractible microfaune of the soil).
- For service providers: selected set of taxon as indicators for overall soil biota diversity including macro-faune: earthworms; meso-fauna (Arthropods and Collembola abundance); micro-organism: taxonomic and functional diversity of soil microbial community (DNA fingerprinting).

The selection of this set will be finalised during the first year of the project where different techniques will be tested and more detailed knowledge on the experimental plots from the data of WP2 and WP3 will be acquired. Different soil services will be modified by soil treatments in the experimental plots mainly linked to changes in quantity and quality of organic matter. Most of these measurements will be performed at least once a year between budburst and blooming of the vines. Each measurement will be carried out on all elementary units (treatments and controls) of each experimental plot.

- *WP5: Grapevine rhizosphere ecology (WP leader: KIS, Hans-Josef Schroers, Slovenia) Partners involved: KIS, SLU, Vitinnov and BxScAgro.*

WP5 centres on identifying potential service providers in the rhizosphere from grapevines in plots where significant changes in plant performances can be detected. Rhizosphere of experimental grapevines will be described during the first and third year and samples will be collected (task 5.1) during the soil profile description (WP3).

Cultivation dependent analyses in the first year will provide insights into the health condition of tested plants and may identify prominent disease causing organisms, specifically fungi so far as they are present (task 5.2). In the third year, identifying and building up a culture collection of potential beneficial microorganisms (task 5.3) is targeted. The culture-depended microbiological methods are based on various root washing treatments (with and without surface sterilization). Gold standard methods based on molecular barcodes are applied for the identification of the encountered bacteria and fungi.

- *WP6: Best practises transfer, dissemination, stakeholders training (WP leader: Vitinnov, Emma Fulchin, France). Partners involved: BxScAgro, CRA, UDLR, KIS, SLU, CU and Alata BKAI.*

WP6 sets up the project website for accessing information, project results, research activities and technical transfer (task 6.1). It will be regularly updated during the project to provide information on the progress of the experimental phases. It will also include a calendar of events and references of press articles related to the project. Additionally, WP6 will coordinate the organization of the stakeholders training workshops in the countries involved in the project (task 6.2).

Guidelines of techniques to restore soil functionality in vineyards will be written in agreement among partners and translated into the languages of all project partners (task 6.3). Consequently, these guidelines will be distributed to stakeholders during the training workshops and technical events. They will also be available on the website.

Project outcomes will also be transferred to farmers and stakeholders through technical and public outreach articles written by each partner in his/her respective country and language and through press releases. The major results will be disseminated for joint scientific publications and presented at national and international meetings attended by project partners (task 6.4).