Regenerative agricultural approaches to improve ecosystem services in Mediterranean vineyards

https://www.revine-prima2020.org/

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Introduction

The ability to perform "sustainable agriculture" is conditioned by the valorisation of the environment in which it operates. Modern agriculture, by the extensive use of chemical inputs have strongly reduced the biodiversity of agroecosystems thus reducing the plant ability to adapt to a changing environment. In contrast, regenerative farming systems promotes soil health and biodiversity and benefits from the presence of other living organisms linked by synergic and antagonistic relationships.

REVINE, through a combination of new knowledge acquired from physiology, pathology, and genomics, along with innovative applications in agronomic and breeding processes intends to prove that the application of regenerative agriculture practises in farms of Mediterranean area is capable to preserve water resources and soil fertility, to control soil erosion thus achieving a better adaptation to climate changes.

The vineyard will be used as an agroecosystem model of the Project, considering that grapes (*V. vinifera*) both for table and wine production are among the most difficult crops to grow, being sensitive to subtle changes in temperature, rain, humidity and exposure to sunlight, especially at key developmental stages.

The approaches used in REVINE, which includes the application of biostimulants, biofertilizers, amendments and the use of tolerant/resistant genotypes provide environmentally friendly alternatives to the existing control methods, and allow to reduce the use of chemicals, thus improving human and plant health and increasing food safety and quality.

Keywords: Regenerative agriculture, microbiome, vineyards, phytosanitary

Our research

Development of novel biostimulants, biofertilizers and amendments

Definition and design of new microbial consortia to be applied as biostimulant (SynComs) by exploiting the already available microbial collection (e.g. grape endophytes) stored in the research institute microbial collections. A safety assessment will be performed on the most effective microorganism strains identified. Biofertilizers (compost and digestates) will be produced mixing vineyard residues with different ratio of raw materials (cow manure, milk or whey, wood ash, zeolite powder and pomace) to find the best performing mixture. The compost mixture will be also amended with selected PGP microorganisms.

Studying the effects of the selected strategies.

The effect of different cultivation protocols will be evaluated using a multidisciplinary approach. In particular, the effect on soil chemical and microbial composition, grapevine physiology and phenology, yield and quality of grapes will be evaluated. Standard targeted metabolomic approaches will allow to study the effect of different treatments on grape quality. Metabolomic analyses will be also performed on root extract from treated plants showing tolerance to pathogens, in order to identify differentially accumulated metabolites. Drought tolerance will be also evaluated, monitoring time course dynamics of plants subjected to water deficit. Results will be carried out using eco-physiological, water relation and abscisic acid (ABA) measurements to define the best strategy used in counteract drought effects. The effects of different treatments on the rhizosphere microbial community including viruses will be evaluated by metagenomic. Plant/soil microbiome interactions will be investigated at molecular level. The effect of microbial biodiversity on stress resilience will be assessed at molecular level investigating how this influences the expression of genes involved in stress responses (ABA metabolism and stress-related pathways).

Analysis of the environmental and socio-economic impacts

The impact of innovative approaches proposed in each area of study will be estimated using appropriate environmental, economic and social tools/indexes. The environmental impacts of the approaches proposed will be estimated using a dedicated Life Cycle Assessment in order to identify the environmental hotspots and the potential improvements. Overall analysis will lead to certain policy recommendations for new agri-environmental measures.

Publications:

Mycorrhizal symbiosis balances rootstock-mediated growth-defence trade-offs

In this study, the potential benefits of an inoculum formed by two AM fungal species, with or without a monosaccharide addition, were evaluated on young grapevine cuttings grafted onto 1103P and SO4 rootstocks. Inoculated and non-inoculated plants were maintained in potted vineyard substrate under greenhouse conditions for 3 months. Here, agronomic features were combined with biochemical and molecular techniques to assess the influence of the different treatments. Despite the opposite behaviour of the two selected rootstocks, in AM samples, the evaluation of gene expression, agronomic traits and metabolites production revealed an involvement of the whole root microbiome in the growth-defence trade-off balancing. Noteworthy, we showed that rootstock genotypes and treatments shaped the root-associated microbes, stimulating plant growth and defence pathways. Progresses in this field would open new perspectives, enabling the application of AMF or their inducers to achieve a more sustainable agriculture also in light of the ongoing climate change.

Abiotic Stress and Belowground Microbiome: The Potential of Omics Approaches

Nowadays, the worldwide agriculture is experiencing a transition process toward more sustainable production, which requires the reduction of chemical inputs and the preservation of microbiomes' richness and biodiversity. Plants are no longer considered as standalone entities, and the future of agriculture should be grounded on the study of plant-associated microorganisms and all their potentiality. Moreover, due to the climate change scenario and the resulting rising incidence of abiotic stresses, an innovative and environmentally friendly technique in agroecosystem management is required to support plants in facing hostile environments. Plant-associated microorganisms have shown a great attitude as a promising tool to improve agriculture sustainability and to deal with harsh environments. Several studies were carried out in recent years looking for some beneficial plant-associated microbes and, on the basis of them, it is evident that Actinomycetes and arbuscular mycorrhizal fungi have shown a considerable number of positive effects on plants' fitness and health. Given the potential of these microorganisms and the effects of climate change, this review will be focused on their ability to support the plant during the interaction with abiotic stresses and on multi-omics techniques which can support researchers in unearthing the hidden world of plant–microbiome interactions. These associated microorganisms can increase plants' endurance of abiotic stresses through several mechanisms, such as growth-promoting traits or priming-mediated stress tolerance. Using a multi-omics approach, it will be possible to deepen these mechanisms and the dynamic of belowground microbiomes, gaining fundamental information to exploit them as staunch allies and innovative weapons against crop abiotic enemies threatening crops in the ongoing global climate change context.

Novel sustainable strategies to control *Plasmopara viticola* in grapevine unveil new insights on priming responses and arthropods ecology

The results showed that at veraison downy mildew incidence and severity in all tested protocols were significantly reduced compared to nontreated controls on both canopy and bunches. Expression analysis of key genes involved in plant stress response, indicated that the two protocols for phosphites substitution induced a remodulation of salicylic acid (SA) and jasmonic acid (JA), with positive impact on yields. Analysis of the first protocol revealed that the primed state induced a short delay in bunch ripening, with a shift of carbohydrate metabolism to boost the plant defenses, involving an upregulation of defence related-gene, SAR response and a decreased ROS detoxification. Additionally, analysis on the arthropods populations, in parallel with the positive results achieved using alternatives to conventional fungicides, were enriched by those showing the potential of naturally occurring predators of spider mites. This study provides practical solutions to reduce the environmental impact of treatments for the control downy mildew in viticulture.

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