Environmental and economic impact assessment of different water and nitrogen management systems in vineyard

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**Abstract.**

Viticulture is slowly shifting to more sustainable production systems, and several studies are now using the Life Cycle Assessment (LCA) approach to examine the environmental impact of different technologies and practices used in wine production. Water, soil, and energy consumption, management of organic and inorganic solid waste streams, greenhouse gas emissions, and chemicals use are the key environmental challenges mentioned in current literature. Due to the site-specific application of water and fertilizers, precision viticulture techniques can play an essential role in the sustainable use of these inputs in grape production processes, enhancing yield and quality of grapes while reducing negative environmental effects. Precision viticulture, on the other hand, frequently involves investments and additional management costs.

The purpose of this research is to evaluate multiple water and fertilizer management systems in vineyards, ranging from those conventionally used in the Colli Morenici region (South of Garda lake, Lombardy region, Northern Italy), to the most innovative ones to date adopted in a pilot farm of this geographical region. Six scenarios have been explored, considering different irrigation water supply (private groundwater well *versus* water provided by an Irrigation Consortium), different irrigation management (sprinkler through a hose reel, uniform-rate drip irrigation, variable-rate drip irrigation) and, finally, different nitrogen management (fertilizer spreader *versus* fertigation). LCA, gross margin analysis and multivariate analysis have been used as a multidisciplinary approach to assess the sustainability of the different scenarios from both an economic and an environmental point of view.

Results obtained demonstrated that variable rate drip irrigation (VDI) and fertigation scenarios achieved the higher environmental and economical sustainability. In terms of the environment, variable rate drip irrigation and fertigation can dramatically cut CO2 equivalent emissions generated during grape production by more than 50% while increasing water use efficiency by more than 30% compared to the most widespread methods in the area. In terms of economic outcomes, scenarios based on precision viticulture have the highest investment costs for introducing advanced technologies. However, these costs are offset by a higher revenue (+23%) resulting from increased and more stable grape yield and quality.

However, VDI requires that irrigation water could be available on-demand rather than following a rigid irrigation delivery. Without finding a solution in term of collective irrigation service, farmers would rely on private groundwater wells to implement advanced irrigation and fertigation solutions.