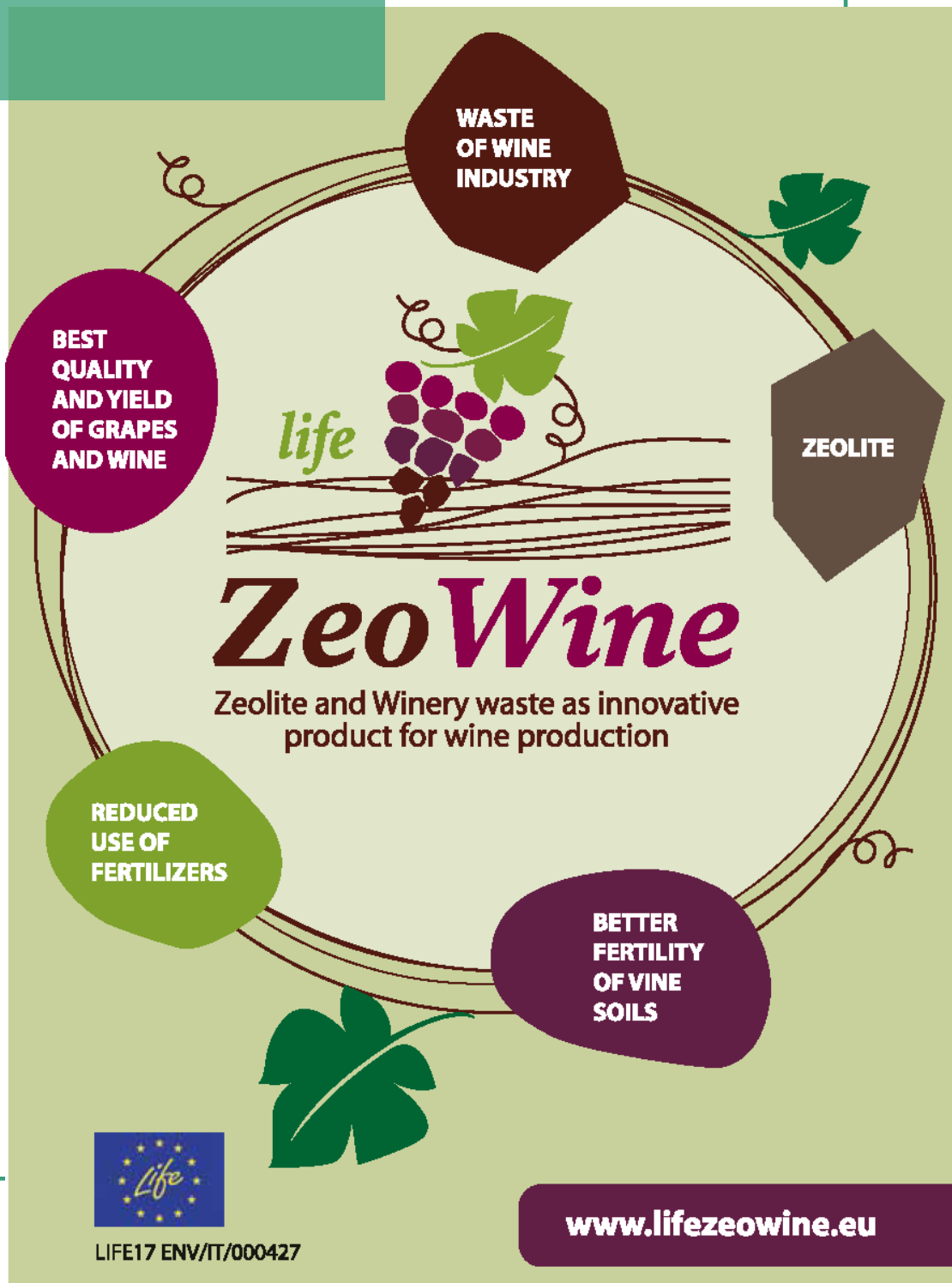
LIFE ZEOWINE

GUIDELINES FOR THE APPLICATION OF ZEOWINE ON YOUNG VINEYARD

May 2021



Title of the Project:	**LIFE ZEOWINE - Zeolite and Winery waste as innovative product for wine production**
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PARTNERSHIP

COORDINATOR

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LIFE ZEOWINE PROJECT

The LIFE ZEOWINE Project aims to demonstrate the efficacy of "ZEOWINE", a**n innovative product derived from the composting of the vine supply chain wastes and zeolite**, in improving the agronomic and biological fertility of the vineyard soils, in reducing the contribution of fertilizers in the vineyard, in increasing the sustainability and competitiveness of the wine supply chain, with the closure of the production cycle of waste material and ensuring a higher stability in yields and in the quality of grapes and wine.

LIFE ZEOWINE is a demonstration project funded by the European Community, which aims to improve the protection and management of the soil, the well-being of the vine and the quality of grapes and wine, through the soil application of "ZEOWINE" an innovative product deriving from the composting of wastes from the wine production chain and zeolite.

Starting from the results of previous experimentations, which aimed to evaluate the effectiveness of the application of zeolite and compost in a separate way in other productive chains, we proceed with the intention of applying, for the first time, either on a new vineyard plant and in productive vineyards, the ZEOWINE product, with effects in terms of performance in soil management and in soil and plant biodiversity.

The synergy of the positive effects of ZEOWINE on the soil and on the plant is demonstrated by the improvement of nutritional and water efficiency, the reduction of the need for fertilizer supply, the closure of the production cycle of the waste material from the supply chain and the improvement of the quality of the wines produced.

The expected results of the ZEOWINE Project will be evaluated through:

Development of 3 demonstration cycles of application of the ZEOWINE product in the wine productive chain, with reference to the following parameters: production of approximately 140 t of ZEOWINE.

Testing and demonstration of the effectiveness and feasibility of these strategies: application of ZEOWINE on 0.35 ha of new vineyard plant and on 3.5 ha of vineyard in production;

Considering a single application of ZEOWINE at a dose of 30 t / ha, the project will demonstrate the EFFECTIVENESS IN THE IMPROVEMENT OF SOIL QUALITY of its application to the vines in terms of:

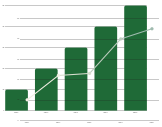
- CONTENT OF ORGANIC SUBSTANCE
- BIODIVERSITY
- INCREASE OF ZEOWINE WATER RETENTION CAPACITY
- SOIL STRUCTURE
- REDUCTION OF BIOAVAILABLE COPPER CONTENT
- IMPACT ON GREENHOUSE GAS EMISSIONS GENERATED BY SPECIFIC AGRICULTURAL ACTIVITIES
- Qualitative improvement of the final productions through an INCREASE OF THE APA CONTENT IN GRAPES
- Dissemination of the use of the ZEOWINE product,

LIFE ZEOWINE SPECIFIC OBJECTIVES

1) **improve the quality of vineyard soils**, in terms of the content of organic matter, biodiversity, water retention capacity, availability of nutrients and soil structure;

2) **reduce the mobility of copper in the soil**, the main fungicide used above all in organic and biodynamic viticulture, and therefore the risk of transfer of the pollutant to other environmental compartments;

3) define and disseminate **intervention standards for the application of ZEOWINE at different stages of the vine production cycle** at all production systems replicable also at the European level;



4) i**ncrease the sustainability and competitiveness of the wine supply chain**, implementing nutritional and water efficiency and reducing energy consumption, **closing the production cycle of waste material from the supply chain** and ensuring higher stability in yields and quality of the grapes, obtaining a more suitable for modern market demands

5) **improve consumer health protection**, creating ideal growth and development conditions for crops, capable of determining improvements in terms of resistance, healthiness and plant production.

Circular Economy, Environmental sustainability, Social and economic impacts

GUIDELINES FOR THE APPLICATION OF ZEOWINE ON A PRODUCTIVE VINEYARD

RATIONALE

A fertilization programme is generally included in viticulture to ensure a desirable health and growth of vine plants.

Many variables like climate, soil pH, texture etc. interfere with the availability of nutrients absorbed from the soil, so that controlled release fertilizers are commonly used for vine plants.

These guidelines provide indications on **how to use the ZEOWINE compost produced from winery wastes and zeolite as an amendment in young vineyard soils.**

Due to the increasing pressure imposed to agricultural soils and to their consequent reduction in fertility, **the development of management strategies able to increase the productivity and quality of soils has become a common priority**.

In particular, **Mediterranean vineyards are exposed to severe risk of soil quality decline due to erosion, loss of organic matter, contamination and compaction.**

In intensive viticulture, the continuous working practices using heavy machinery and inappropriate tillage, for eliminating competition between vines and other plants for water and nutrients, are responsible for increasing soil erosion rates, and CO_2 emissions.

Wine supply chain produces a considerable amount of organic wastes which remain as residues in the ecosystem.
The environmental-friendly management of agricultural soils, usually involves the application of organic amendments.
In addition, several recent researchers proposed the use of soil conditioners, such as zeolite, to improve the physical and chemical properties of agricultural soils.

With a double scope of reusing organic wastes and, at the same time, improving the agronomic value of compost, ZEOWINE developed a vine management system based on the composting of winery organic wastes and zeolite to obtain a fertilizer to be used for vineyard soils.

The innovation of this composting process lies in the role of the natural zeolite on winery wastes valorization and recycling.

ZEOWINE, A SIMPLE EQUATION = COMPOST + ZEOLITE

COMPOSTING

Grape is the leading fruit crop cultivated in the world (FAO, 2017). In 2018 the annual world production of wine was 292 million hectoliters and the world's agricultural land devoted to the production of wine was 7.4 kha (2019 Statistical Report on World vitiviniculture, 2019).
The amount of solid organic wastes generated per wine's hectoliter is estimated to be about 25 kg, thus the yearly production of residues which requires to be treated and disposed of represents more than 7 million tons. These quantities and data related to wastes generated from winery industry are addressed as a world growing environmental problem.
The development of strategies to reduce the consumption of resources (energy, materials, chemicals) and the amount of waste released, by maximizing the recovery and recycling of by-products throughout a product's life cycle is acknowledged as an universal contemporary challenge (European parliament, June 2015).

However, **in most grape growing states, grape marc, skin, stalk, and pomace from the winery supply chain are still treated as waste with little or no value**; they are usually disposed of in open areas and are a source of environmental pollution due to the emanation of volatile organic compounds (VOC), the increase in chemical oxygen demand (COD), the presence of recalcitrant compounds and the free-run juices percolation (Rondeau et al., 2013)..

Several studies described **the suitability of composted winery residues as amendment for agriculture and for degraded soil restoration.**

Composting of winery wastes and the integration of compost into the activities of the winery industry as amendment for vineyard soils have been also regarded as a recommendable waste management strategy to promote the increase in soil organic matter and to protect soil structure in usually poor vineyard soils (Paradelo et al., 2013).-

Composting is based on the aerobic biological decomposition of fresh organic substrates, and the successive stabilization of the organic matter.

During composting process it is possible to identify 3 different phases:

- a **mesophilic phase**, characterized by a quick growth of fungi and bacteria, which mineralize simple organic compounds, such as sugars, producing CO_2, NH_3 and organic acids.
- a **thermophilic phase**, characterized by the biological produced heat and by the degradation of organic compounds, such as fats, cellulose and lignin. The high temperature in this phase (above 55 °C) allows to obtain a product free of pathogens and plant seeds.
- and a **maturation phase**, characterized by the decrease in microbial activity, resulting from a decrease of biodegradable organic compounds, and by formation of stable humic substances.

Despite of the benefits of composting process, there are also some negative aspects. N loss thorough ammonia volatilization is accounted for up to 50% of the initial total N and the released ammonia is considered as one of the main atmospheric pollutants during the composting process (Wang and Zeng, 2018; Chan et al., 2016).

ZEOWINE, A SIMPLE EQUATION = COMPOST + ZEOLITE

ZEOLITE

Different compounds have been used as potential additives in order to decrease ammonia emission and improve the quality of compost.

Several researchers showed that **the use of natural minerals, such as zeolites, due to their unique physical and chemical properties, coupled with their abundance in sedimentary deposits and in rocks derived from volcanic parent materials, is an effective and practical approach for improving the quality of compost.**

Zeolites are natural minerals belonging to the tectosilicates class, with a porous three-dimensional frameworks made of SiO_4 and AlO_4 tetrahedral. Due to their porous structure, high surface area, cation exchange and adsorption-desorption characteristics, zeolites are able to retain ammonium in a selective manner, thereby reducing losses of nitrogen to the environment.

Several studies have been showed the potential of zeolite in enhancing the rate of degradation and in reducing NH_3 losses during composting process.

As an example, it has been observed a reduction in electrical conductivity, an improvement in compost maturity and an higher nitrogen content (reduction in ammonia volatilization of 18%) during "struvite" food waste composting by 10% zeolite amendment.

Similarly, in a composting process with sewage sludge, wheat straw and lime, the addition of zeolite at the rate of 30% drastically reduced the GHGs emissions, NH_3 loss and improved the maturity of compost.

Further findings reported that:

- adding biochar & zeolite together can decrease the nitrogen loss and mitigate the emissions of ammonia and N_2O during pig manure composting;
- the addition of zeolite and superphosphate to windrow composting of chicken manure improved fertilizer efficiency and reduced greenhouse gas emission;
- Zeolite also increased porosity when used as a bulking agent in a domestic sewage sludge composting process.

In addition, when applied to soil, compost modified with zeolite improved crop yield and water retention and prevented soil nutrient losses.

However, even if previous works have focused on the use of zeolite and/or other additives in the composting process, its application in the composting process has not been studied to date in winery waste composting.

ZEOWINE, A SIMPLE EQUATION = COMPOST + ZEOLITE

LIFE ZEOWINE project demonstrated that **the presence of zeolite into composting process of winery wastes is able of preserving nutrients content, stimulating the microbial activity and promoting humification, thus enhancing compost value.**
In view of this, the trials were focused on investigating the evolution of physical, chemical and biochemical parameters during the composting process of winery supply chain residues (pomace and stems), in association with clinoptilolite-zeolite at different rates:

1) zeolite 0% : wastes 100% (0%, control);
2) zeolite 10% : waste 90% (ZEOWINE 1:10);
3) zeolite 30% : waste 70% (ZEOWINE 1:2.5).

The different rates of zeolite was tested in order to determine the combination that optimizes the performance of the composting process and improves the agronomic and environmental quality of the end-product.
The presence of zeolite at the two rates (10% and 30%) during the composting of winery wastes enabled an higher retention of nutrients, enzymatic activity and humification of organic matter with respect to control compost.
In addition, it decreased the electrical conductivity and increased the germination index, thus improving the agronomic quality of the compost.

In the project, we monitored the response of chemical and biochemical properties to different rates of zeolite on winery waste composting process.

COMPOSTING FEATURES

WHAT:
Use stalks, vine pruning and grape pomace

WHERE:
Set up composting heaps in specific areas in the farm

WHEN:
The best periods to start the composting process are after harvesting, i.e.: November /December/January

End of composting in May/June

HOW:
Add suggested zeolite with a granularity of larger grain size (1-2.5 mm)

Periodical turning to increase the oxygen supply to microorganisms, homogenize the materials and redistribute microorganisms, moisture and nutrients

A CASE-STUDY: ZEOWINE DEMONSTRATION TRIALS

The following demonstration sites were selected for the experimentation in the San Miniato area (Pisa, Tuscany) in Central Italy.

The climate is typically Mediterranean, semiarid, with a mean annual precipitation of 859 mm and a mean annual temperature of 14.3°C.

Soil classification was Calcixerept (Soil Survey Staff, 2014) with a sandy clay loam texture (51.1% sand, 28.3% clay and 20.6% silt) (USDA classification), an organic matter (OM) content of 1.8% (±0.2), a high level of carbonate (bivalve shells were very common) and a slightly alkaline pH.

In the new vineyard, Sanforte cultivar, the vine spacing was 2.5 m between rows x 0.8 m between plants.
In this site the following treatments (in triplicate) have been applied:

- Organic matter (compost) (20 t/ha)
- Zeolite (10 t/ha)
- ZEOWINE (30t/ha)

The vineyard was divided into three plots (0.35 ha), where compost, zeowine and zeolite were applied, respectively, and mixed by plowing to a depth of 30 cm. So as to isolate soil variability, in each plot three sub-plots were chosen and judged to be independent true replicates.

Experimental sites

COSIMO MARIA MASINI
San Miniato, Pisa
Cultivar: ***Sangiovese***
Sanforte

COL D'ORCIA MONTALCINO
Montalcino, Siena
Cultivar: ***Sangiovese***

TENUTA RIPALTE ISOLA D'ELBA
Capoliveri, Isola D'Elba
Cultivar: ***Aleatico***

TENUTA SANTO SPIRITO
Vittoria, Ragusa
Cultivar: ***Nero d'Avola***

Selection of the ideal granulometry of the zeolite

Composting is represented by aerobic processes that lead to the decomposition of the organic substance and is particularly favored by conditions such as high humidity (50%) and an optimal circulation of water and nutrients in its structure.

From these considerations it was found that the company chose to use a larger grain size (1-2.5 mm) than the one initially envisaged by the project (0.2-1.0 mm). The particle size is in fact of fundamental importance to be able to expose the greatest possible specific surface to the contact with the matrix to compost without however representing an obstacle to the circulation of oxygen, water and nutrients. The granulometric fraction is thus the ideal size for the composting process and for subsequent soil conditioning.

Mixing zeolites with the wastes from the wine production chain

Two different rates of zeolite (10% and 30%) in zeowine preparation were carried out in order to identify the most suitable practical application for improving the winery wastes composting process and, at the same time, for saving on the cost of providing zeolite.

Three different composting piles were set up by mixing (w:w of fresh weight): 1) 0% of zeolite and 100% of organic residues (control pile); 2) 10% of zeolite and 90% of organic residues; c) 30% of zeolite and 70% of organic residues. Each pile was about 10 m3, with a form of a truncated pyramid (base length 3 m, height 2.5 m, top length 1 m).

The composting processes were performed in a completely randomized factorial design. Periodical turning of each pile in order to increase the oxygen supply to microorganisms, homogenize the materials and redistribute microorganisms, moisture and nutrients, was carried out at least twice a month, until the end of the composting process. Since microbial activity generates heat and evaporates water, the optimal moisture level of about 40 % was maintained by sprinklers on top of each pile. Temperature and humidity were monitored every two days until the end of the composting process. A cover system of each pile was predisposed. The composting was carried until mature composts were obtained (about 150 days).

COMPOST **20 t ha^{-1}** | ZEOWINE **30 t ha^{-1}** | ZEOLITE **10 t ha^{-1}**

ZEOWINE distribution

For the ZEOWINE distribution, spandicompost or self-filling machineries are preferable; this to ensure the simple and uniform spreading of ZEOWINE over the entire soil surface. The ZEOWINE can be easily distributed also by traditional manure spreader, adopting, if necessary, simple tricks which take into account the humidity and the size of ZEOWINE.
In all cases (new vineyard plants and productive vineyards) the ZEOWINE must be buried by means of mechanical plowing (digging, milling or hoeing).

ZEOWINE application rates

ZEOWINE should be considered a slow-release source of nutrients. ZEOWINE was applied at rates high enough to meet immediate vine nutrient requirements without determining an excess of nutrient availability for plants.
The amount of ZEOWINE to apply was calculated from the recommended rate of the priority nutrient and the plant-available nutrient content of the ZEOWINE. ZEOWINE application rates are based on available nutrients rather than the total nutrients.
Decisive for the amount of ZEOWINE to be apply is the warrantee of abalanced nutrient content. According to the rules of "good codes of practice" the optimal ZEOWINE dose, whereby positive balances of phosphor and potassium rarely arise, lies around 30 t/ha.
In case of unfavorable soil conditions, such as structural problems, higher ZEOWINE rates up to the upper level of 30 t/ha are allowed, in exceptional cases even higher, sometimes reasonable to achieve an efficient and quick soil improvement.

The following application periods and technical advices for the ZEOWINE application proved to be successful in practice.
Basically, ZEOWINE should be spread before the start of the plant growth period. Hereby decisive is the good workability of the arable land, in order to avoid soil compaction through unfavorable conditions (e.g. wet soils).
A convenient application time suitable for vineyards is between November and March.

Among the technical advices for ZEOWINE application the spreading intervals are the key aspect. The application of up to 30 t/ha in 8-years will be the usual case in vineyard soils on account of costs and spreading technique reasons because it guarantees low costs and less traffic on arable land.

RECAP AND TIMING

Production and application of ZEOWINE

COMPOSTING OF WINERY WASTE WITH ZEOLITE

- Realizzation of composting heaps in the vineyard/farm using stalks, vine pruning and grape pomace
- Add and mix suggested zeolite
- BEST TIMING TO START: after harvesting approx. November-January

APPLYING ZEOWINE IN VINEYARD IN PRODUCTION

- Use dedicated machineries such as spreader
- Treatments application and incorporation by ploughing to a depth of 30 cm
- BEST PERIOD: basically, ZEOWINE should be spread before the start of the plant growth period

MONITORING, ASSISTING AND SUPPORTING COMPOSTING PROCESS

- Periodical turning of the heaps, helps to increase the oxygen supply to microorganisms, homogenize the materials and redistribute microorganisms, moisture and nutrients: at least once a month, until the end of the composting process
- Irrigation in order to optimize water level by sprinklers on top of each pile: moinstureincreased to 50% and maintained
- Monitoring: Temperature and Umidity every day until the end of the termophilic phase, successively every week
- Predisposition of cover systems of each pile
- PERIOD CONCERNED: between the composting start and May-June

life ZeoWine

CONSORTIUM

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