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ISLAND AND COASTAL VINEYARDS IN THE CONTEXT OF CLIMATE CHANGE

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Abstract

Aim: The notion of "terroir" enables the attribution of distinctive characteristics to wines from the same region. Climate change raises issues about viticulture, especially the growth of the vines and even more importantly the economic situation of actual wine-growing regions (Schultz and Jones 2010; Quénol 2014). Several studies have addressed the impacts of climate change on viticulture in many wine-growing regions of the world, but only a few have focused on the potential of island and coastal vineyards. However, in the context of climate change, ultramarine and coastal vineyards could become increasingly coveted according to their specific climatic conditions. In regions subject to significant warming, thermal regulation and oceanic influence can limit extremes temperatures, which could be a major advantage for grapevine production. This contribution, first step of a spatial optimization approach to define suitable agro-climatic patterns, will present a typology of these vineyards, to understand their specificities and their adaptability.

Methods and Results: An in-depth bibliographical search has been conducted to provide a global inventory and to highlight relevant variables to describe and categorize the world's island wine-growing regions. From this approach, three main themes have been defined as variables: climate characteristics, vineyards characteristics and cultivars and associated management systems.
Climate plays a very important role in terroir, and especially temperatures, which determine the regional characteristics of viticulture (van Leeuwen *et al.,* 2004; Hall and Blackman, 2019). In this study we consider the following climatic data: seasonal[1] average temperatures, annual and seasonal[1] mean daily amplitude, completed by the average annual sunshine duration, average annual precipitation, winds and sea sprays.
Concerning vineyard characteristics, topological aspects like altitude or distance to ocean can limit diurnal and extremes temperatures (Bonnardot *et al.,* 2001; Koufos *et al.*, 2013; Fourment *et al.,* 2017; Heras-Roger *et al.,* 2018). Vineyards soils and especially soils' composition, depth and water holding capacity are also completed. Vineyards' characteristics were supplemented by economic data like surface area (ha), production (hl), market target and appellations.
Due to their specific climatic conditions and/or because their relative isolation from other continents, many islands harbour autochthonous and rare varieties (Scherrer *et al.,* 2009). In connection with vine variety, rootstock and diseases variables are integrated in the typology. Moreover, several coastal and island vineyards integrate traditional practices to manage the hydric stress without irrigation (i.e. mitigate wind effects on plants) (Drumonde-Neves *et al.,* 2017; Heras-Roger *et al.,* 2018). These practices were highlighted with management systems variables (implementation and management system, space between vines and rows, vine density, mechanization and irrigation system).
When applied to vineyards of Lanzarote, this approach describes structural elements of ultramarine vineyards. In 2009, Canarian viticulture represented 36% of total cultivated area of the archipelago, and 2.9% of total Spanish viticulture. In Lanzarote's island, the climate is defined as subtropical with low precipitation (average of 150 mm/year), warm temperatures throughout the year and a high average annual sunshine duration (3000 h/year).
Lanzarote's island has a low relief and vineyards are planted on volcanic soils. Poured thick layers of volcanic ashes called "picóns" are added at the base of the vine stock. These porous volcanic granules have a great thermal inertia. Indeed, during the day picóns store heat and give it back to the plant at night. Picóns also have good water retention capacity (Troll *et al.,* 2017; González Morales *et al.,* 2015). Lanzarote's vineyards under the appellation "Denominación de Origen Protegida de Lanzarote" were about 1850 ha in 2016-2017, for a production above 4330 hl and 1800 winegrowers (DO Lanzarote, 2020). The target market is local in scope. Mainly due to the isolation of the archipelago from the mainland, phylloxera is not present in the vineyards of

[1] *Seasonal: from April to September*

Lanzarote. Vines are not grafted and Malvasia represents ¾ of the vine stock of the island. Vine varieties such as Listàn blanco, Moscatel de Alejandria, Verdello and Gual are often planted to produce dry and sweet white wines. Listàn negro and Negramoll varieties are preferred to produce red wine (DO Lanzarote, 2020). Low-growing vines are planted in drilled holes, and low walls of volcanic rocks are built to protect them from drought and hot drying winds. Due to their specific implementation, vines are widely spaced (400-500 m between them), yields are low and mechanization is not possible.
This information has been documented and summarised for each wine-growing region. Thanks to this approach, key elements of insular vineyards can be described with generic indicators. The resulting typology enables comparisons between different wine-growing regions with a generic framework.

Conclusions: This first step of characterization of vineyard variables highlights the specificities of insular and coastal vineyards. Then, discriminant characteristics will be exploited in a process of spatial optimization in order to identify suitable agroclimatic patterns for different climate change scenarios. The main objective is to implement an approach under multiple constraints (climatic, agronomic, spatial, etc.). The results expected will be compromises between these several constraints.

Keywords: Viticulture, insularity, coastal, climate change, adaptation

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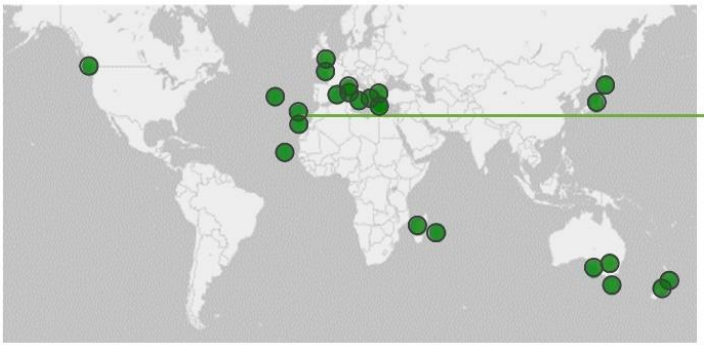
CONTEXT AND AIMS



Apply to vineyards of Lanzarote, this approach describes structural elements of ultramarine vineyards. In 2009, Canarian viticulture represented 36% of total cultivated area of the archipelago, and 2.9% of total Spanish viticulture.

Studies have addressed the issue of climate change on viticulture in many wine-growing regions of the world and show major transformations on a global scale. Due to their climatic characteristics, island and coastal vineyards could become coveted areas for adaptation, especially in regions subject to significant temperatures' increases.

A global bibliographical approach has conducted to provide an inventory and highlight variables which can be used to describe specificities and adaptations of ultramarine and coastal vineyards. From this approach, three main parts have been declined in variables: climate characteristics, vineyards characteristics and then, cultivars and management system.

METHODS AND RESULTS

CLIMATE CHARACTERISTICS			
Annual average temp.	20°C	**Annual average ppt.**	150-200 mm
Seasonal average temp.	21° C	**Seasonal average ppt.**	15 mm.
Annual - average daily thermal amplitude	6,5°C	**Annual sun. duration**	3000 h.
Seasonal - average daily thermal amplitude	7°C	**Winds**	From Sahara : hot and dry

VINEYARDS CHARACTERISTICS			
TOPOGRAPHY		SOILS CHARACTERISTICS	
Altitude	100-500 m.	**Composition**	Volcanic soils
Slope	Low relief on the island	**Depth**	Hole depth up to 3m
Distance from ocean	Max. 6km		
ECONOMIC CHARACTERISTICS			
Area – 2016	1862 ha.	**Market target**	Local/tourism
Production– 2016	4330 hl.	**Appelations**	DOP Lanzarote
Nb. of winegrowers – 2016	1859		

VINES CHARACTERISTICS			
CULTIVARS			
Varieties	Malvasia, Listàn blanco, Verdello, Gual, Moscatel de Alejandria *(white)*, Listàn Negro, Negramoll *(black)*		
Rootstock	Not grafted	**Diseases**	No phylloxera
MANAGEMENT SYSTEM			
Implantation	Planting in holes if the lapili layer is thick, or in trenches if the lapili layer is thinner ; lows walls builder against winds.		
Management system	Low-growing vines in drilled holes		
Spacing	1,5 – 4 m.	**Density of plants**	400-500 ceps/ha
Mechanization	Not possible	**Irrigation**	Not possible

Climate is one of the most important element in the notion of terroir, and especially temperatures and that determine the regional characteristics of viticulture.

In Lanzarote's island, climate is qualify as a subtropical climate with few precipitations, warm temperatures throughout the year and high average annual sunshine duration.

Topographical aspects like altitude or distance to ocean can limit diurnal and extremes temperatures

Lanzarote's island has a low relief and vineyards are planted on volcanic soils. During the day, porous volcanic granules store heat and give it back to the plant at night. Moreover, they permits a good water retention due to its capacity to retain the night humidity. The appellation "Denominación de Origen Protegida de Lanzarote" exists since 1995.

Terroir identity is often associated to emblematic wine varieties. These varieties can be adapted to local environment, which can be interesting in a climate change's context.

Mainly due to the isolation of the archipelago from the mainland and other archipelagos, phylloxera never affected the vineyards of Canaries. Vines are not grafted and Malvasia represents ¾ of the vine stock of the island. Low-growing vines are planted in drilled holes, and low walls of volcanic rocks are built to protect them from drought and hot/drying winds.

AND THEN ...

CONSTRAINTS

CLIMATE CHANGE SCENARIOS

- Hypothesis *1*
- Hypothesis ...
- Hypothesis *x*

This first step of characterization of vineyards variables tend to highlight the specificities of insular and coastal vineyards. A typology based on synthetic indicators has been produced to characterize the specificities of coastal and island vineyards.

Discriminant characteristics will be exploited in a process of spatial optimization in order to identify suitable agroclimatic patterns for different climate change scenarios. The main objective is to implement an approach under multiple constraints (climatic, agronomic, spatial, etc.).

SPATIAL OPTIMISATION PROCESS

Spatial optimization will be approached with algorithms allowing computing several solutions, and not only one: objectives are often in conflict/not compatible with each other, and a single solution optimizing all objectives is rare. Therefore, a multi-objective spatial optimization problem has several optimal solutions where none can be better than another.