Managing local field variability in the framework of Precision Viticulture

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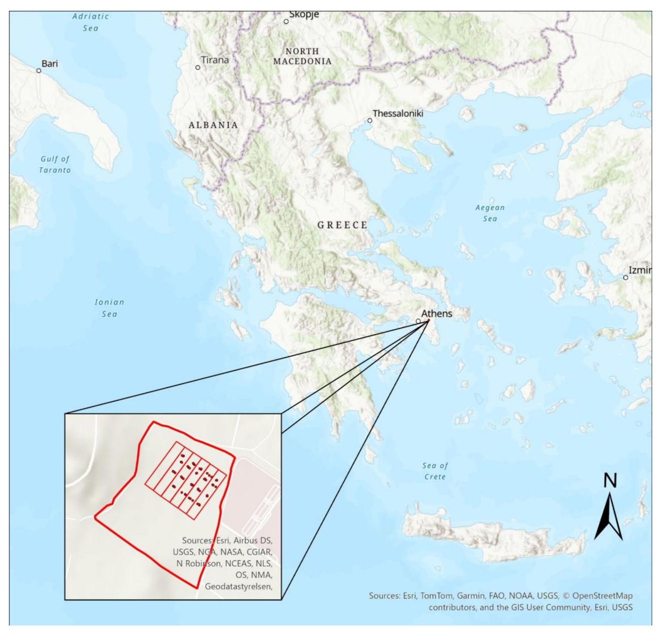
Abstract

Managing grapevines according to the practices of Precision Agriculture (PA), may prove to be an asset in the hands of the modern grape growers. Precision Viticulture (PV), namely the application of PA in viticulture has gained significant attention from the grape growers and scientist in the recent decades enhanced by the emergence and availability of digital technologies dedicated to farming applications. In this work, the outcomes of applying PV practices and digital technologies in a commercial vineyard in the region of Attica in Greece are presented from a study conducted in the framework of "AGROSYS" project.

Objectives

- To evaluate the utilisation of applying PV practices and digital technologies in a commercial vineyard in the region of Attica in Greece.
- To investigate the potential of different sensors, gound-based or aerial-based, manual and automated, for mapping the spatial variation of soil and landscape properties and examine the possibility of predicting vine and grape properties from in-season measurements.
- To evaluate the effect of soil and landscape properties on grapevines

Methodology



- The experimental area was 3.5 ha, a subsection of a 26 ha vineyard located in the region of Attica in Greece grown with Savvatiano (Vitis vinifera L.).
- The apparent soil electrical conductivity (ECa) was initially mapped, and a digital elevation model was prepared utilizing measurements from an RTK-GNSS.
- The soil and terrain properties were analysed using Fuzzy clustering algorithm and management zones were created based on which the experimental plots were set up.
- Three representative sample vines were selected in each plot and were measured for their physiological and phenotypical status utilizing both traditional sampling and analysis and digital sensing technologies.
- Vine growth was measured in terms of reflectance with ground-based (CropCircle – Holland Scientific) on UGV and aerial-based sensing UAV systems (MAVIC 3M multispectral with RTK GNAA - DJI).
- For the statistical analysis of the collected data, the JASP software was utilized to export descriptive statistics and perform analysis of variance (ANOVA) and correlation analysis (Pearson's correlation).

Results

The spatial analysis of the soil and terrain parameters led to separating the vineyard's experimental section into four zones. Based on the hypothesis, the field properties show maximum differences between zones, and maximum homogeneity within each zone.

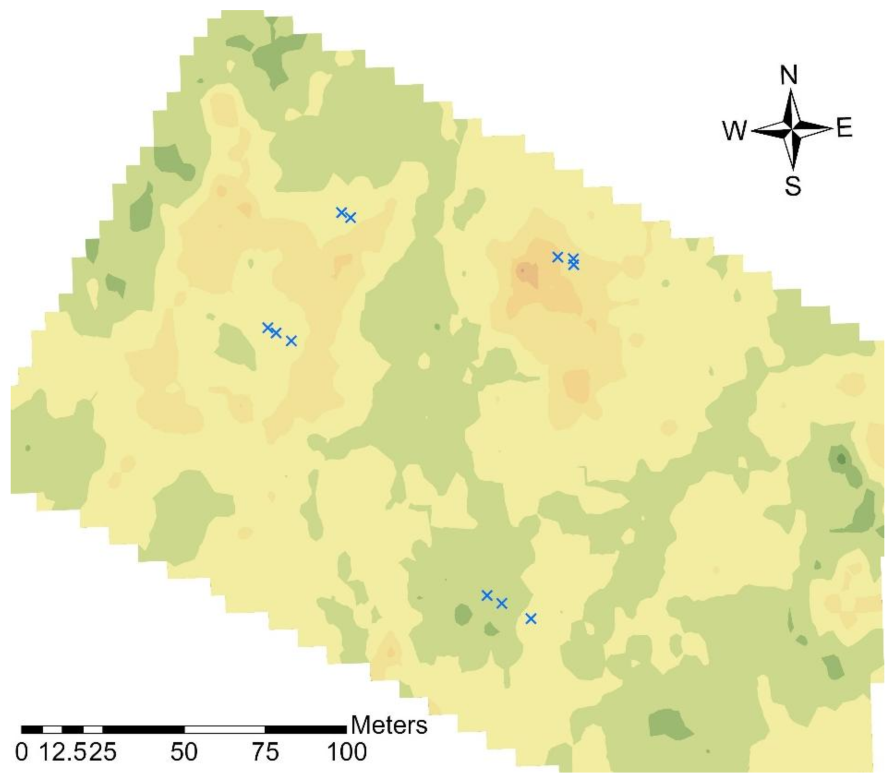


Figure 1. Management zones.

Descriptive statistics:

- NDVI and NDRE indices from ground and aerial sensing systems showed high variability
- thermal measurements showed low variability due to the capacity of the grapevine plants in adjusting to the environmental conditions.

ANOVA:

- Grape Weight, grape length, Total soluble solids (Brix), Total phenolics content, gallic acid, ascorbic acid and tartaric acid content showed statistically significant differences among the zones.
- Similar results were attained for the canopy temperature and the NDVI measurements acquired using the UAV.

Correlation Analysis:

- NDVI measured from the UAV was statistically significantly correlated with NDVI from ground sensor.
- NDVI measured from the UAV was correlated with grape quality and crop physiological parameters.
- Reflectance measurements taken from the side part of the canopy using the CropCircle sensor, were correlated with grape quality parameters.
- During veraison, NDRE and NDVI were negatively correlated with the leaf temperature (thermal camera).
- Several physiological and grape quality parameters such as the percentage of skin weight per berry (%), Fumaric acid content in the must, Chlorophyll content, grape length, transpiration (E), and stomata conductivity (gs) were significantly correlated with thermal measurements only at veraison due to the higher water stress of the vines.
- The study confirmed the high potential of thermal cameras to quantify water stress effects in vineyards. The negative relationship is explained by the reaction of the plants to heat stress.

Table 1. Results from the correlation analysis (Pearson's)

			Pearson's r		p
UAV NDVI (harvest)	-	NDVI (harvest)	0.706	*	0.015
UAV NDVI (harvest)	-	Percentage of skin weight per berry (%)	0.657	*	0.02
UAV NDVI (harvest)	-	Tartaric acid/ must	0.602	*	0.038
UAV NDVI (harvest)	-	Ascorbic acid/ must	-0.609	*	0.035
UAV NDVI (harvest)	-	E-transpiration (harvest)	0.667	*	0.018
UAV NDVI (harvest)	-	gs - stomatal conductance (harvest)	0.595	*	0.041
UAV NDVI (harvest)	-	Chlorophyll (harvest)	0.87	***	< .001
NDRE (harvest)	-	Total soluble solids (Brix)	0.696	*	0.017
NDRE (harvest)	-	Tartaric acid/ must	0.677	*	0.022
NDRE (harvest)	-	Malic acid/ must	0.602	*	0.05
Thermal (harvest)	-	Weight of grape (gr)	-0.6	*	0.039
Thermal (harvest)	-	Length of grape (cm)	-0.616	*	0.033
Thermal (veraison)	-	NDRE (veraison)	-0.706	*	0.01
Thermal (veraison)	-	NDVI (veraison)	-0.698	*	0.012
Thermal (veraison)	-	Percentage of skin weight per berry (%)	-0.707	*	0.022
Thermal (veraison)	-	Fumaric acid/ must	0.701	*	0.024
Thermal (veraison)	-	Chlorophyll (veraison)	-0.647	*	0.043
Thermal (veraison)	-	length of grape (cm)	-0.801	**	0.005
Thermal (veraison)	-	E(transpiration)	-0.814	**	0.004
Thermal (veraison)	-	gs - stomatal conductance (harvest)	-0.821	**	0.004

* p < .05, ** p < .01, *** p < .001

Conclusions

- The results of the study are signifying the importance of terroir regarding the growth of the grapevines, and its effect on yield and quality of the grapes. This was stemmed by the statistically significant differences of key physiological and quality parameters of vines and grapes among the different soil-based management zones. This finding indicates the significance and potential benefits of managing local field variability in commercial vineyards.
- The potential of the use of UAV and UGV-based systems to monitor the physiological status of vines and predict grape quality parameters was highlighted. Further studies are required to enrich the datasets and investigate the effects of soil and landscape properties on grapevines characteristics during different years with diverse abiotic conditions.

Greece 2.0 NATIONAL RECOVERY AND RESILIENCE PLAN
Funded by the European Union NextGenerationEU
iBO Institute for Bio-Economy and Agri-Technology
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This research was carried out as part of the project «ΑΓΡΟΣΥΣ - Development of an autonomous collaborative robotic system of precision viticulture incorporating electrically powered terrestrial and airborne unmanned vehicles and small-scale solar charging stations» (Project code: ΤΑΕΔΚ-06184) under the framework of the Action «Research-Create-Innovate», Greece 2.0 National Recovery and Resilience Plan that is co-funded by the European Union and ESPA 2021-2027.