GEOSPATIAL TECHNOLOGIES IN SPATIALLY DEFINED VITICULTURE: CASE STUDY OF A VINEYARD WITH AGIORGITIKO VARIETY IN KOUTSI, NEMEA, GREECE

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Abstract:

Context and purpose of the study - Geospatial technologies have significant contribution to viticulture, especially in small-scale vineyards, which require precise management. Geospatial data collected by modern technologies, such as Unmanned Aerial Vehicle (UAV) and satellite imagery, can be processed by modern software and easily be stored and transferred to GIS environments, highlighting important information about the health of vine plants, the yield of grapes and the wine, especially in wine-making varieties. The identification of field variability is very important, particularly for the production of high quality wine. Modern geospatial data management technologies are used to achieve an easy and effortless localization of the fields' variability. The aim of this study is to record and investigate the variability of all factors (soil, relief, etc.) that affect the qualitative and quantitative yield of the vineyard and their correlation to the characteristics of yield.

Material and methods - The study area is located in Koutsi, a region of the Municipality of Nemea, which is a famous area for its early ripening vineyards. The 1.3 ha vineyard was planted in 1980 with the Black Nemea (Agiorgitiko) variety on 41B rootstock, with planting distances of 2.30 x 1.20 m and planting density of 362 stumps per 0.1 ha. The orientation of the planting lines is North to South.

The vineyard was divided into 13 blocks of about 0.1 ha each, after its study by orthomosaic, collected from UAV, and taking into account the planting lines and its shape.

From each block, soil samples were collected in areas with different color (macroscopic observation using UAV data), at 13 points, in two depths of 0-30 cm and 30-60 cm. Soil analysis showed that the soil is characterized as normal, heavy clayey, moderately alkaline, moderate in organic matter, adequately supplied with phosphorus (P), poor in potassium (K), slightly low in boron (B), and low to moderate levels of trace elements. Total calcium carbonate ($CaCO_3$) ranges from 56 to 74%, except for one sampling site which is approximately 30%.

Harvesting conducted in early September when Baume degrees were greater than 13^{o}. UAV flights were conducted using the DJI Matrice 100, DJI Phantom 3 and Sensefly Ebee platforms. The sensors used for this study were Parrot Sequoia (bands: G (550nm), R (660nm), Red-Edge (735nm) and Near-Infrared (790nm), RGB) and a modified Go-Pro camera.

Results - The obtained UAV images were used to extract Digital Terrain Model (DTM) and orthomosaic. Altitude and slope were calculated in the vineyard using the DTM. The orthomosaic was used to observe the phenotypic characteristics of the vineyard, such as soil variation (e.g. soil color) and cultivation characteristics. Thus, it was possible to monitor the condition of the vineyard in order to schedule and apply the required cultivation techniques and procedures. Important observations have been also made through vegetation indices. Exporting indices, such as Normalized Difference Vegetation Index (NDVI) supplied valuable information on the vigor and plant health of the vineyard. Thematic maps related to fertilization, irrigation and plant protection were also created. Using this information, cultivation techniques were more efficient, because farmers could focus on plants which were less productive and in need of more nutrients. Finally, thematic maps were useful in delineating management zones, which is extremely beneficial to viticulture.

Keywords: Geographical Information Systems, Unmanned Aerial Systems, Spatial analysis, Viticulture, Grapevine

1. Introduction.

Geospatial technologies in spatially defined viticulture: Case study of a vineyard with Agiorgitiko variety in Koutsi, Nemea, Greece

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Introduction & Objective

Geospatial technologies have significant contribution to viticulture, especially in small-scale vineyards, which require precise management. Geospatial data collected by modern technologies, such as Unmanned Aerial Vehicle (UAV) and satellite imagery, can be processed by modern software and easily be stored and transferred to GIS environments, highlighting important information about the health of vine plants, the yield of grapes and the wine, especially in wine-making varieties. The identification of field variability is very important, particularly for the production of high quality wine. Modern geospatial data management technologies are used to achieve an easy and effortless localization of the fields' variabilitiy. The aim of this study is to record and investigate the variability of all factors (soil, relief, etc.) that affect the qualitative and quantitative yield of the vineyard and their correlation to the characteristics of yield.

Soil & Spatial Data Analysis

Soil analysis showed that the soil is characterized as normal, heavily clayey, moderately alkaline, with moderate organic matter content, adequately supplied with phosphorus (P), poor in potassium (K), slightly low in boron (B), and low to moderate levels of trace elements. Total calcium carbonate ($CaCO_3$) ranges from 56 to 74%, except for one sampling site where it appears to be approximately 30%. The orthomosaic (Fig. 1) was used to observe the phenotypic characteristics of the vineyard, such as soil changes (e.g. soil color) and cultivation practices. The intense presence of soil variability can be easily noted. Slope fluctuations (CV=55.78%) in the studied vineyard are a result of variable altitude values (from 447.9 m up to 492 m). Higher inclination values were observed southwest. Soil analysis showed great variability (increased values of CV percentage as displayed on Table 1) in some characteristics, such as clay, sand, organic matter and total calcium carbonate content percentage. Aerial data also provided useful information about plant health and development. During our study, fungal infection was detected in the vineyard via the aerial means and year by year became worse, so the number of healthy rows decreased. Infection spreading was studied in detail, with the use of geospatial technology. The results of the combination of all these data showed high rate of variability within the vineyard, especially in some characteristics, such as slope and plant health.

Table 1: Descriptive variables of soil characteristics

N= 13, 0-30 cm	Min	Max	Mean	StD	CV (%)
Clay (%)	42.00	58.00	48.85	5.99	12.27
Silt (%)	25.00	42.00	31.69	5.22	16.46
Sand (%)	4.00	30.00	18.31	7.85	41.44
EC (25°CmS/cm)	0.28	0.37	0.33	0.03	8.13
pH	7.80	8.01	7.92	0.06	0.74
SP (%)	42.00	63.00	47.77	5.61	11.75
CEC (meq/100g)	29.20	42.4	33.55	3.45	10.29
OM (%)	0.76	3.00	1.64	0.64	38.78
$CaCO_3$ (%)	30.00	74.00	64.54	11.59	17.95
ESP (%)	0.30	0.80	0.61	0.12	19.54

Materials & Methods

The study area is located in Koutsi, a region of the Municipality of Nemea, which is a famous area for its early ripening vineyards. The 1.3 ha vineyard was planted in 1980 with the Black Nemea (Agiorgitiko) variety on 41B rootstock, with planting distances of 2.30 x 1.20 m and planting density of 362 stumps per 0.1 ha. The orientation of the planting lines is North to South. The vineyard was divided into 13 blocks of about 0.1 ha each, after its study by orthomosaic, collected from UAV, and taking into account the planting lines and its shape. From each block, soil samples were collected in areas with different color (macroscopic observation using UAV data), at 13 points, in two depths of 0-30 cm and 30-60 cm. Harvesting conducted in early September when Baumé degrees were greater than 13° (depending on the weather conditions). UAV flights were conducted using the DJI Matrice 100 platform. The sensors used for this study were Parrot Sequoia and a modified Go-Pro camera. The obtained images were used to extract digital terrain model (DTM) and orthomosaic. Altitude and slope were calculated in the vineyard using the DTM.

NDVI Vegetation Index Analysis

NDVI vegetation index maps were extracted from aerial data at certain time intervals during our study. The extraction of NDVI vegetation index for each row of the vineyard had also been calculated (NDVI-row, Table2). NDVI vegetation index analysis showed great variability within the vineyard (Table 2), since the mean NDVI value of the 13 patches blocks ranges from 0.35 to 0.51 and the mean NDVI-row from 0.41 to 0.63. NDVI values showed significant correlation with clay content percentage. It can be deduced that blocks of the vineyard with high percentage of soil clay content are more fertile, resulting in higher NDVI levels. Moreover, NDVI values showed negative correlation to the Baumé degree. We can conclude that greater vegetation leads to lower quality of fruits. As a result, NDVI values approach lower levels. The iterative study of NDVI vegetation index maps during the cultivation period can provide valuable data, supporting the decision making process, which often involves recognition of the necessity for precision viticulture in the vineyard or specific rows of the field.

Figure 1: Vineyard Orthomosaic

Figure 2: NDVI map on 11/4/2017

Table 2: Descriptive variables of NDVI on 29/07/2016

29/07/2016	N	Min	Max	Mean	StD	CV%
NDVI	1	-0.19	0.93	0.44	0.20	46.97
NDVI-row	1	0.16	0.93	0.54	0.21	37.96
NDVI	13	0.35	0.51	0.44	0.05	11.88
NDVI-row	13	0.41	0.63	0.54	0.07	12.78

Conclusion

As suggested by the results the use of geospatial technologies, such as UAV & GIS, can provide valuable information about soil variability of the vineyard, plant health and development, thus, making it possible to monitor the condition of the vineyard in order to formulate the required cultivation strategies. These data could also facilitate decision making for the important procedure of zoning. This study highlights the contribution of technological means in viticulture and the necessity of precision viticulture, especially in fields with variable characteristics.

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