EVALUATION OF INTRA-VINEYARD SPATIAL AND TEMPORAL VARIABILITY OF LEAF AREA INDEX USING MULTISPECTRAL IMAGES OBTAINED BY SATELLITE (LANDSAT 8, SENTINEL-2) AND UNMANNED AERIAL VEHICLE PLATFORMS

Authors:Yolandi BARNARD[1], Guillermo OLMEDO[2], Albert STREVER[1], Carlos POBLETE-ECHEVERRÍA[1]*

[1]*Department of Viticulture and Oenology, Stellenbosch University, Private Bag X1, Matieland 7602, South Africa.*
[2]*EEA Mendoza, Instituto Nacional de Tecnología Agropecuaria, Mendoza M5507EVY, Argentina.*

*Corresponding author: *cpe@sun.ac.za*

Abstract:

Context and purpose of the study - Estimation of vineyard leaf area index (LAI) is an important aspect for the winegrowers. However, tracking and monitoring are difficult tasks due to time constraints. Satellite and unmanned aerial vehicle (UAV) imaging have become a practical monitoring method for LAI. Nevertheless, for a proper LAI determination, the image's spatial resolution is a key factor, since low-resolution images are incapable of distinguishing between adjacent vines due to the large area covered in each pixel, this leads to misinterpretation or generalisation of vineyard information.
The objective of this study was to evaluate the effect of spatial resolution on the accuracy of LAI estimation using different spatial resolutions: Landsat8 (30 m), Sentinel-2 (10 m) and UAV Multispectral images (0.05 m).

Material and methods - This study was carried out in a dryland vineyard cv. Pinotage situated in Stellenbosch, at the Welgevallen experimental farm (33°57'8" S, 18°52'26" E). The block (1.9 ha) has a North-South orientation and was planted on a West-South-West slope. The vines are trained on a seven-wire (moveable) hedge trellis, VSP (vertical shoot positioning) system.
Three sources of remote sensing data, with different spatial resolutions, were chosen: i) Multispectral images acquired by a multi-rotor unmanned aerial vehicle (UAV) (spatial resolution 0.052 m); ii) Landsat 8 images (spatial resolution of 30 m) and iii) Sentinel-2A images (spatial resolution of 30 m). Images from these three sources were used to calculate the normalised difference vegetation index (NDVI) from the experimental site, and these values were compared with field measurements (empirical LAI model).

Results - Results obtained from low-resolution satellite images show a poor accuracy in the estimation of LAI on a plant scale. The image resolution of Landsat 8 and Sentinel-2 was not high enough to differentiate between adjacent groups of vines. The UAV multispectral images obtained the best agreement with the field LAI measurements, due to the high resolution (0.052 m pixel size). It is evident with the results obtained that UAV imaging is the most appropriate and accurate monitoring methodology since this technology providing enough information to estimate LAI per plant.

Keywords: Normalised difference vegetation index (NDVI), Unmanned aerial vehicle (UAV), Grid analysis, Spatial variability.

1. Introduction.

Evaluation of intra-vineyard spatial and temporal variability of leaf area index using multispectral images obtained by satellite (Landsat 8, Sentinel-2) and unmanned aerial vehicle platforms

Yolandi BARNARD[1], Guillermo OLMEDO[2], Albert STREVER[1] & Carlos POBLETE-ECHEVERRÍA[1]*

[1] Department of Viticulture and Oenology, Stellenbosch University, Private Bag X1, Matieland 7602, South Africa.
[2] EEA Mendoza, Instituto Nacional de Tecnología Agropecuaria, Mendoza M5507EVY, Argentina.
*Corresponding author, Email: cpe@sun.ac.za

GIESCO 2019
June 23-28, 2019 in Thessaloniki, Greece.

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Material & Methods

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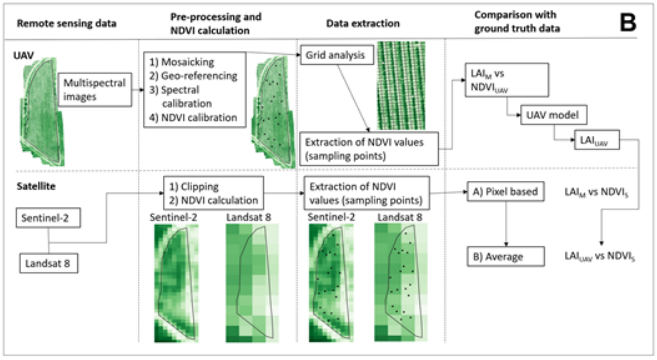

Figure 1. (A) Remote sensing platforms and **(B)** Methodology for the image analysis of the UAV multispectral and satellite images, resulting in the LAI estimation from the NDVI values.

Results

Table 1. LAI-NDVI relationships. Pixel-based (UAV, Sentinel-2 and Landsat 8) and average (Sentinel-2 and Landsat 8).

	UAV		Sentinel-2				Landsat 8			
EL	r^2_{PB}	$RMSE_{PB}$	r^2_{PB}	r^2_{AVG}	$RMSE_{PB}$	$RMSE_{AVG}$	r^2_{PB}	r^2_{AVG}	$RMSE_{PB}$	$RMSE_{AVG}$
23	0.35*	0.070	0.019	0.023*	0.086	0.051	0.011	0.047	0.086	0.039
27	0.51*	0.060	0.20	0.450*	0.078	0.052	0.057	0.020	0.084	0.048
31	0.69*	0.048	0.15	0.390*	0.080	0.051	0.037	0.006	0.085	0.039
35	0.42*	0.060	0.15	0.290*	0.080	0.052	0.05	0.220*	0.085	0.051
38	0.56*	0.057	0.054	0.003	0.085	0.058	0.03	0.100	0.086	0.048

EL = Modified Eichhorn-Lorenz code; r^2 = Coefficient of determination; RMSE = Root mean square error; PB = pixel based; AVG = average. * indicates a significant linear regression (p-values < 0.05); EL23 Flowering; EL27 Setting; EL31 Berries pea-size; EL35 Veraison and EL38 Harvest.

Conclusion

Results obtained from low-resolution satellite images show a poor accuracy in the estimation of LAI on a plant scale. The image resolution of Landsat 8 and Sentinel-2 was not high enough to differentiate between adjacent groups of vines. The UAV multispectral images obtained the best agreement with the field LAI measurements, due to the high resolution (0.052 m pixel size). It is evident with the results obtained that UAV imaging is the most appropriate and accurate monitoring methodology since this technology providing enough information to estimate LAI per plant.

Acknowledgements

This study was support by Institute for Grape and Wine Science (IGWS) (Robotics project), the Subcommittee B (New Appointees programme), the Early Research Career (ERC) programme and Winetech (project DVO 07 "Near-real-time characterization of vines for more efficient vineyard managementNear-real-time characterization of vines for more efficient vineyard management"