The Ability of NDVI to Assess Vegetative Growth in Olive Groves: Effect of Water Regime and Variety

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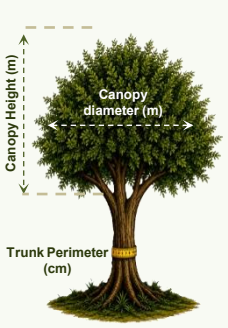
INTRODUCTION AND OBJECTIVES

The use of vegetation indices obtained through remote sensing, such as NDVI (Normalized Difference Vegetation Index), has demonstrated high potential as a non-destructive tool for assessing plant vigor. The objective of this study was to evaluate the relationship between the NDVI and vegetative growth parameters in olive orchards, considering the effect of variety and water regime.

MATERIALS AND METHODS

The study has been conducted since 2024 in the INIAV experimental olive plots in Elvas, with the 'Picual' and 'Galega Vulgar' varieties, under irrigated and rainfed conditions, with planting spacings of 7 m × 5 m and 6 m × 6 m, respectively. The olive trees of each variety are clonal material and are grown on their own roots. Annual production pruning is performed in the olive orchards, and the recommendations of the Integrated Olive Crop Protection (Mendes & Cavaco, 2017) are followed, as well as the Crop Fertilization Manual (Calouro, 2022). Based on European Space Agency Sentinel-2 NDVI data for both rainfed and irrigated areas, three sampling units per variety were identified, each consisting of three olive trees. Field measurements and vegetative growth calculations were performed as illustrated in Figures 1 and 2, according to the methodology described by Del Río et al. (2005). For statistical analyses, the monthly average of NDVI values was calculated. Subsequently, the monthly average indices were correlated with vegetative growth parameters using linear regression analyses.

1. Vegetative Measurements
(Before Start of New Annual Cycle)



2 . Derived Variables (Del Rio et al., 2005)

1. Canopy Surface (m²)

$$CS = \pi\,(H \times D_m) \qquad D_m = \frac{D_1 + D_2}{2}$$

Where:
Cs = Canopy Surface Area (m²)
H = Canopy Height (m)
D_m = Mean Canopy Diameter (m)

D_m is the mean canopy diameter, calculated from two perpendicular measurements of the canopy diameter.

Top View (Example)

2. Canopy Volume (m³)

$$V = \frac{\pi\,(D_m \times D_m) \times H}{6}$$

Where:
V = Canopy Volume (m³)
H = Canopy Height (m)
D_m = Mean Canopy Diameter (m)

3.Trunk Cross-Sectional Area (cm²)

$$AST = \pi\left(\frac{P}{2\pi}\right)^2$$

Where:
P = Circumference (cm) (Measured around the trunk)
AST = Trunk cross-Sectional area (cm²)

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Del Río, C., Caballero, J. M., García-Fernández, M. D., Tous, J., Romero, A., & Plana, J. (2005). Vigor. In L. Rallo, D. Barranco, J. M. Caballero, C. Del Río, A. Martín, J. Tous, & I. Trujillo (Eds.), *Variedades de olivo en España* (pp. 245–256). Mundi-Prensa.

Mendes, F., & Cavaco, M. (2017). *Proteção integrada da cultura da oliveira*. Direção-Geral de Alimentação e Veterinária.

FUNDING: The project 0100_TID4AGRO_4_E is co-financed by the European Regional Development Fund (ERDF) through the INTERREG VI-A Spain-Portugal (POCTEP) 2021-2027 program of the European Commission.

RESULTS

3. Remote Sensing Data
(Sentinel – 2 Satellite System)

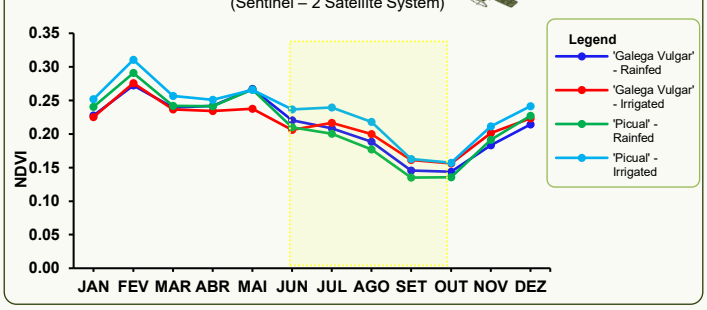
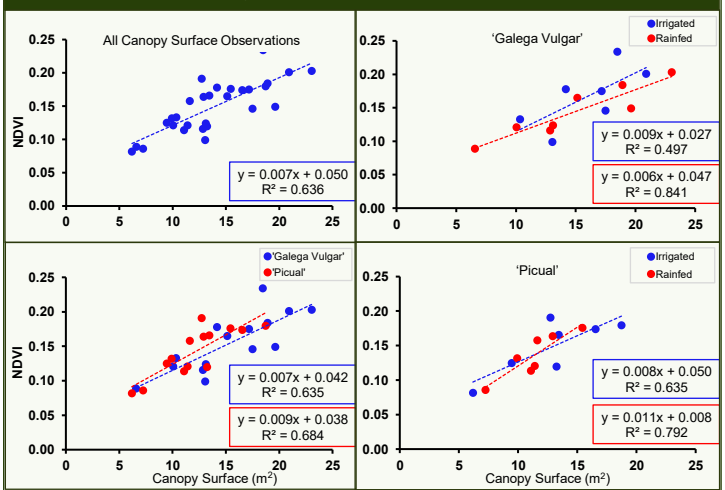


Figure 3. Temporal trends in monthly mean NDVI values over the past five years (2020 – 2025).

Canopy Surface (m²) *vs.* NDVI (October)



More Correlation (R^2) Values

Orchard	Variety	Water Regimes	NDVI (October) *vs.* Canopy Height (m)	Canopy Diameter (m)	Canopy Volume (m^3)	Trunk Cross-Sectional Area (cm^2)
Olive Orchard	N/A	N/A	0.555	0.584	0.616	0.667
	'Galega Vulgar'	N/A	0.555	0.622	0.637	0.686
		Irrigated	0.303	0.588	0.552	0.544
		Rainfed	0.859	0.607	0.796	0.854
	'Picual'	N/A	0.695	0.550	0.585	0.674
		Irrigated	0.717	0.521	0.535	0.719
		Rainfed	0.732	0.588	0.732	0.800

Note: N/A, not applicable; values with $R^2 > 0.7$ were highlighted in yellow.

CONCLUSION

- Summer conditions reduced herbaceous vegetation interference, allowing olive tree canopies to dominate the NDVI signal.
- NDVI showed strong correlations with vegetative growth parameters, demonstrating its potential as an indirect indicator of olive tree vigor.
- The strongest correlations were observed under rainfed conditions, particularly for the 'Galega Vulgar' variety.
- These findings highlight the potential of NDVI integration into olive grove monitoring and precision agriculture management strategies.

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Funding: Partners: