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Assessment of the complementarity between field observations and multispectral UAV imaging for optimized cover crop management in viticulture: Towards a comprehensive approach to the functioning of agroecological practices

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## Introduction

The evolution of agroecological systems introduces greater complexity in cultivated fields, challenging both traditional and modern observational networks and methods. These include remote observations, e.g. aerial data collection, proxidetection, e.g. crowdsourcing, and direct in situ measurements. The digital transition is continually producing vast amounts of data, enhancing our understanding of agroecosystems when used effectively (Ingram and Maye, 2020), both within and surrounding agricultural plots. As a result, the increasing availability of digital tools is transforming the role of on-farm experimentation (OFE) in contemporary agriculture (Lacoste et al., 2021). With this backdrop, this study aims to assess whether there is redundancy or complementarity between field measurements and UAV imaging throughout the growing season, and to determine the efficacy of UAV imaging in the management of service crops in viticulture.

## Materials & Methods

An experiment was conducted over three years (2019-2022) at the Domaine du Chapitre (France) on a vineyard plot (*Vitis vinifera* Syrah), divided into three blocks. The experiment aimed at comparing 6 service crops termination strategies, combining two termination periods (early and at grapevine budbreak) and three termination methods (mowing, roller-crimper, mowing + tillage). Several indicators were assessed to evaluate the water stress (predawn leaf water potential), vigor (pruning weight) of the grapevine, as well as to monitor service crops development through biomass and LAI measurements. In 2021-2022, alongside field measurements, auxiliary data were collected on 10 dates, from service crops emergence to grapevine flowering, using multispectral sensors mounted on a UAV. All the aerial imagery were processed using Agisoft Metashape software. The same products were obtained in the pre-processing step: orthoimage, digital elevation model, digital surface model, normalized digital surface model (nDSM). A series of indicators were calculated, including the geometric characteristics of the vines canopy, the biovolume of inter-row vegetation cover and spectral indices. To assess the quality of UAV-derived indicator estimates, correlation analyses were used to explore the precision and robustness of the relationship between manual measurements and indicators from multispectral imagery. A spatio-temporal complementarity table is used to provide a detailed assessment of data complementarity at different growth stages and to highlight potential correlations and divergences between UAV and direct field indicators.

## Results & Discussions

Analysis of the data collected over the three-year experiment revealed a significant complementarity between field measurements and multispectral UAV imagery (Figure 1). We looked at the relationship between field measurements indicators and UAV-derived indicators. For instance, we assumed a strong indicator relating to water stress in vines (predawn leaf water potential vs NDVI or tree row volume). The results showed promising correlations between variations of both manual and UAV-derived indicators. In addition, it was observed that estimates of inter-row vegetation cover biovolume, obtained from the nDSM, closely matched field measurements, thus confirming the accuracy of UAV imagery in estimating vegetation cover crop biomass. To extend this analysis, a spatio-temporal complementarity table was drawn up, enabling a detailed assessment of the interaction between field measurements and data acquired by UAV, depending on the vine block and phenological stage under

consideration. The results confirmed the complementary nature of the measurements obtained by different methodologies, but also highlighted the importance of combining these data for accurate and informed farm monitoring and management.

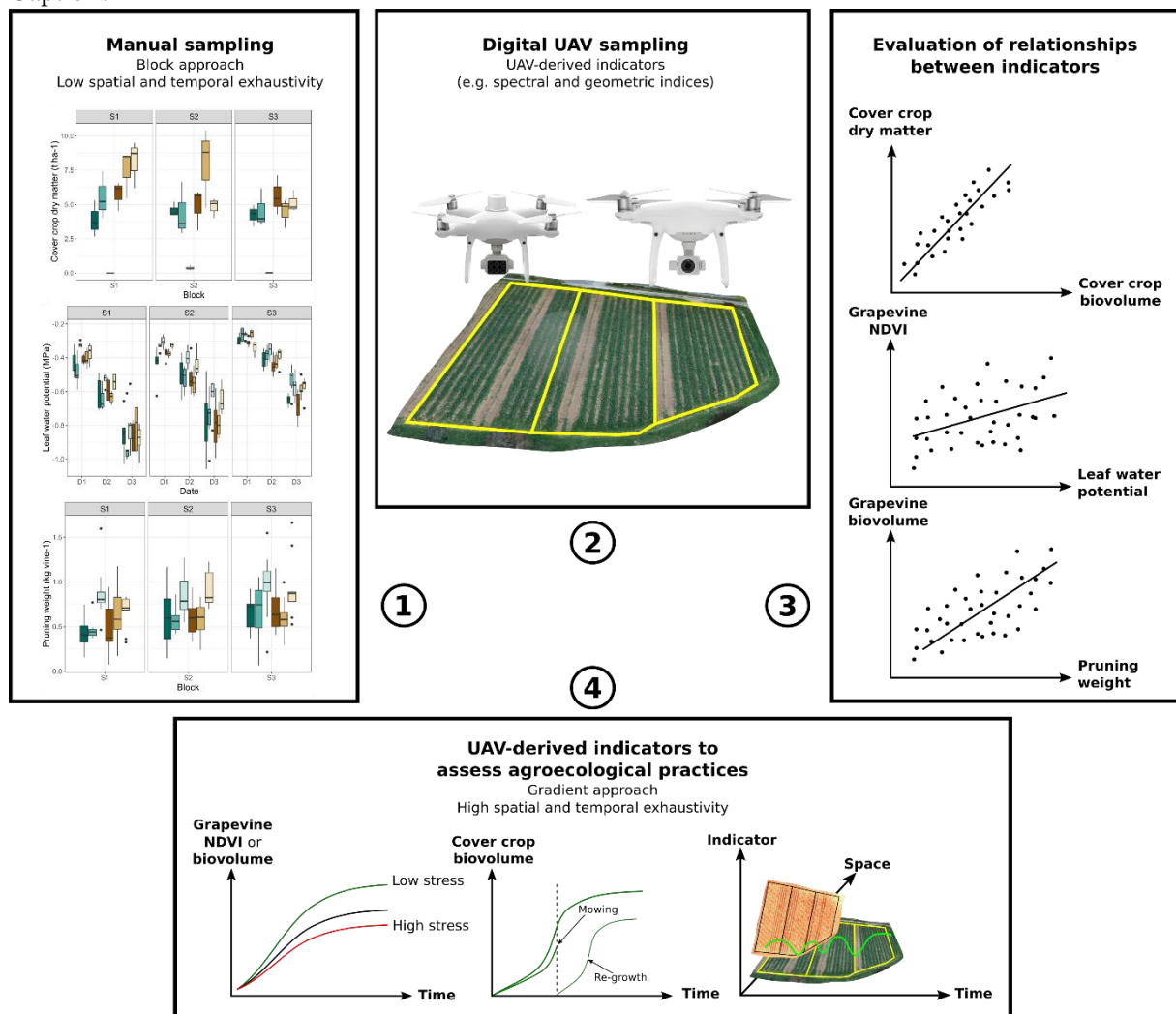
## Conclusions

This study illustrated the role of multispectral UAV imagery in refining cover crop assessment and opening new perspectives for cover crop adaptive management in viticulture. As a result, the growing availability of digital tools offers unprecedented prospects for designing new experimental models in agroecology, making it possible to reimagine the role of the OFE and bring out innovative practices for optimized management of cover crops in viticulture. In this perspective, exploring the synergy between advanced digital tools and the Ecosystem Services functional Spatial Unit offers promising horizons for redesigning on-farm spatial experiments.

## References

- Ingram, J., Maye, D. 2020 What Are the Implications of Digitalisation for Agricultural Knowledge?, *Frontiers in Sustainable Food Systems*, 4, 66.
- Lacoste, M., Cook, S., et al. 2021 On-Farm Experimentation to transform global agriculture, *Nature Food*. 3, 11–18.

## Captions



**Fig.1** A four-step framework to combine field observations and UAV-derived data to assess cover cropping practices in agroecological viticulture