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LiDAR based porosity and LAI: can we use lidar scanning on one side only?

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INTRODUCTION

Characterisation of the vineyard is a prerequisite for any precision farming approach in which the aim is to adapt cultivation operations to the characteristics of the environment and production objectives. Examples include crop protection by spraying, fertilisation, irrigation, and crop management in terms of quality and quantity. The need for regular phenotyping and in particular physical phenotyping of the crop is emerging as a necessity to further precision viticulture. From this perspective, the total leaf area (TLA, LAI when normalised by ground area) is a major candidate descriptor for site-specific management. Cheraiet et al. (2020 developed a method for automatically calculating the height of vines, their thickness and their apparent porosity as seen from the inter-row from 3D point clouds provided by a mobile 2D LiDAR sensor. Using this work as a foundation, the aim of our research is to develop generic multivariate regression models for predicting TLA from the analysis of the 3D point cloud, throughout the cropping season. The present contribution is a first step in this direction by working on the relation between LiDAR based estimation of the optical porosity of a stratum of vegetation and TLA.

MATERIALS AND METHODS

Acquisitions were made in three different plots called Aglae, Collection and Terre Blanche, at the end of bunch closure phenological stage. These plots were chosen because of their contrasting vigour. Within each plot, two segments corresponding to 1 m in length in the direction of travel and one vine plant, with contrasting vigour were identified. In each of these segments, destructive measurements of the TLA and vegetation scans were carried out using a tractor-mounted terrestrial 2D LiDAR sensor. In order to assess TLA variability, each of the 6 vegetation segments was subdivided into 12 cells (3 heights indexed A, B and C and 4 depths indexed from 1 to 4). In the middle of vegetation (B2&B3), cells were 0.4 m high and 0.15 m deep. A total of 6 scans were taken per segment, one scan of the front and back sides of the vegetation, and four scans of the front side, after successive defoliation of all the cells of a given depth on the vine plant. TLA was predicted from a leaf mass-surface relationship. A linear regression analysis was carried out to assess the performance of the IBR parameter (intercepted beam rate) in estimating TLA before any defoliation. Two linear models were built. The first was made using exclusively LiDAR data from front side scanning, while the second has been optimised using a combination of the front and back sides scanning of the vegetation segment. The number of beams that reach each cell in back-side scanning was used to provide relative weights for cells of depth strata 3 and 4 (farthest from LiDAR when scanning from front side). Instead of using IBR on the whole depth as in (Cheraiet et al. 2020), IBR was calculated for each cell, calculating incoming beams and intercepted beams on a given cell.

RESULTS AND DISCUSSION

The results of the analysis of the TLA data and the LiDAR point clouds show that for several segments (P2, P3, and P4), asymmetry is present between the two sides of the same stock (table 1).

Table 1: Mean values of the TLA and the IBR indicator observed between the two sides of a vegetation segment, and coefficients of variation including both sides.

	TLA			IBR		
	Sum (m²)		CV (%)	Mean		CV (%)
Vegetation segment	Front	Back		Front	Back	
Terre blanche – P1	0.31	0.29	2.8	0.52	0.49	4.2
Terre blanche – P2	0.43	0.56	18.7	0.53	0.59	8.1
Collection – P3	0.69	0.48	24.7	0.84	0.62	21.3
Collection – P4	0.44	0.77	38.3	0.87	0.55	31.9
Petit Verdot – P5	1.21	1.23	0.8	0.72	0.93	17.5
Petit Verdot – P6	1.22	1.08	7.4	0.83	0.91	6.5

Considering asymmetry and higher variability of IBR for depth strata 3 and 4 due to few beams reaching these strata, the interest of developing the optimised linear model and compare it to the one side scanning model was justified. Interpretation of the results of the regression models linking TLA and IBR revealed significant differences between the two predictive models (reference with one side scanning and combination of front and back sides scanning). The TLA correlated only 23% with IBR for the one-sided regression model (Figure 2) and 71% with IBR for the regression model optimised from the combination of the two sides of the same vine segment (Figure 1). Based on this data, it appears that a single variable regression model obtained by scanning only one side of the vegetation presents risks of biased estimate of TLA. The poor ability to predict TLA from IBR in the first model can be explained by a masking phenomenon due to the vegetation present on the outer layers.

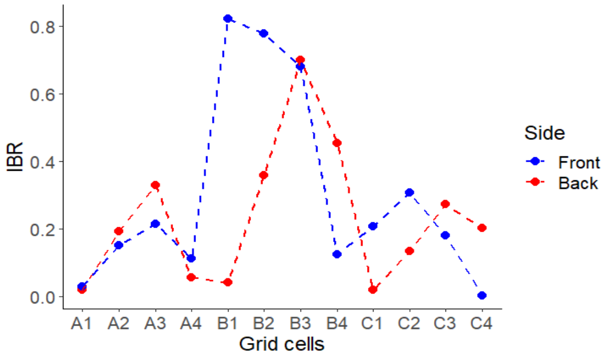

Figure 1: Comparison of IBR values between front and back side acquisitions at the resolution scale of the grid cell

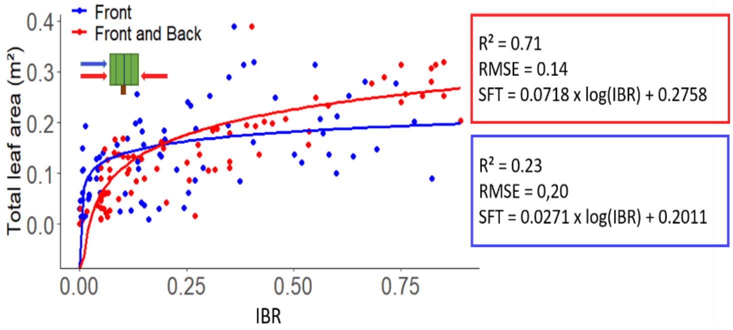

Figure 2: Relationship between the TFI index and the SFT measured on all the vegetation compartments defined by considering all the vegetation segments

Because one-side scanning is much desirable for operational reasons, future research should be devoted to multi-variable prediction models.

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