COMPARING DIFFERENT VINEYARD SAMPLING DENSITIES AND PATTERNS FOR SPATIAL INTERPOLATION OF INTRINSIC WATER USE EFFICIENCY

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Abstract:

Context and purpose of the study - The need to rationalize agricultural inputs has recently increased interest in assessing vineyard variability in order to implement variable rate input applications, so-called 'precision viticulture'. In many viticultural areas globally, precision viticulture is already widely used such as for selective harvesting and variable rate application (VRA) of inputs such as irrigation and/or fertilizer. Robust VRA relies on having a geostatistically accurate map (of one or more vineyard attributes) requiring high sampling densities, which can be cost- and time-prohibitive to obtain. Previous work on spatial interpolation using kriging have upscaled ground-based measurements, but such upscaling strategies are applicable only when vineyard conditions are spatially continuous and satisfies the assumption of second-order stationary processes. Alternatively, mixed models that combine kriging and auxiliary information, such as the regression kriging (RK) method, are more instructive for spatial predictions. In order to improve prediction accuracies, it is therefore necessary to incorporate additional information to achieve accurate spatial patterns with low error. Here, we used a hybrid approach where information derived from multiple sources – point (ground-based) and high resolution remote sensing (aerial, continuous) – was used to spatially interpolate leaf-level intrinsic water use efficiency (WUE_i) in a South Australian Shiraz vineyard to improve the prediction accuracy and lower the error estimates of *WUEi*.

Material and methods – We utilised a upscaling approach where aerial imagery was used to improve the accuracy of spatially-interpolated ground-based measurements to obtain a reliable geostatistical (kriging) model with respect to error rates. We also compared different sampling densities and distributions; gridded vs. stratified sampling distribuitions were compared viz. upscaling UAV images in order to obtain a geostatistically accurate estimate of WUE_i. Relationships between UAV altitude and number of ground sampling points were obtained vs. kriging error rates. To the best of our knowledge, this is the first study reporting on the spatial prediction of WUE_i from multiple data sources.

Results – The integration of UAV images with ground data of WUE_i effectively improved the spatial accuracy of WUE_i through the RK technique. We found that kriging WUE_i based on stratified sampling had a lower interpolation error compared to gridded sampling. We found that gridded sampling error rates increased more rapidly with increasing flight altitude (or higher ground spatial distance) than stratified sampling. Our findings could help viticulturists to rapidly develop highly accurate spatial maps of vine performance parameters.

Keywords: Grapevine, kriging, water use efficiency, UAV, geostatistics, sampling distribution.