Objectives and Rationale

Optimal fruit production potential can only be achieved when every single tree is contributing optimally. Production variation among trees is a result of differences in tree volume, vigour, flower density and set potential. The aim of this study was to establish to what extent inter-tree variability can be quantified and visualized using remote sensing (RS) technologies and to develop an easy to use guideline that will indicate the feasibility of using different RS data sources and techniques to assess variability.

Methods

A range in situ measurements relating to soil, blossom, vigour, and yield were taken in three Fuji Kiku apple orchards in Grabouw. The measurements were interpolated to produce variability maps. They were also quantitatively compared to remotely sensed data ranging from 1 cm RGB drone to 60 m multispectral (13-band) satellite imagery. Several techniques used to find relationships (models) between the imagery and the observed measurements. The resulting models were applied to the imagery to produce predicted inter-tree variability maps. The maps were compared to yield measurements to improve our understanding of the impact of inter-tree variance on production.

Key Results

The measured inter-block and inter-tree variability was generally high, with minimal correlation among most in situ variables. None of the simple (univariate) regression models comparing individual in situ variables to individual RS variables were strong ($R^2 > 0.7$), although a relatively strong ($R^2 = 0.65$) relationship between blossom cluster count and fruit mass was noted. When the in situ data were compared to remotely sensed data, regression modelling and machine learning classification did not produce useful results. However, some of the target variables (e.g. TCSA, tree height, fruit growth, and fruit size) were modelled to a high accuracy when random forest regression modelling was used.

Key Conclusion of Discussion

The study showed that the factors contributing to yield are multifaceted and cannot be modelled with any single variable. Remotely sensed data and machine learning regression can be used to model inter-tree variations, but only to a limited degree. In general, drone imagery produced poor results compared to the satellite imagery. Specifically, the lower (10-60 m) Sentinel-2 imagery frequently produced stronger models, not necessarily because it contains more information, but rather because the higher resolution imagery contains too

much variation and noise (e.g. shadows). However, high resolution imagery is beneficial for certain applications (more detail in the discussion section of the full PDF report). In situ measurements and observations remain the basis for production practices.

Take Home message for Industry

Quantifying inter-tree variability is challenging because the measured variability (e.g. fruit mass at first pick) is too high to model with a limited number of samples (e.g. 30 trees).