Can vine canopy nitrogen status be assessed non-destructively?

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Introduction

Nitrogen (N) is an essential macronutrient for vine health, as well as grape and wine quality. Vine N status is most commonly obtained through petiole sampling and elemental analysis for nitrogen concentration. However, this method is expensive, destructive and labor intensive. Therefore, a rapid and simpler method of estimating vine nitrogen status would be advantageous.

Remote sensing is utilised by several agricultural industries to aid decision-making. The GreenSeeker is a commercial hand-held sensor, which measures the normalised difference vegetative index (NDVI) and has been successful in quantifying the nitrogen status of several agricultural crops (Basyouni et al. 2016; Zhang et al. 2017). Near infra-red (NIR) spectroscopy has numerous applications, including leaf N estimation of horticultural crops. Therefore, it may also be effective for vine leaf N estimation.

This study aims to determine whether the GreenSeeker and NIR spectroscopy are effective non-destructive methods for determining vine N concentration. Data was collected over two seasons (2017-18, 2018-19) in Pinot Noir and Chardonnay varieties in the Coal River Valley, Tasmania.

Aims

• To determine whether the GreenSeeker (NDVI) or NIR spectroscopy can be used to predict vine canopy nitrogen status in comparison to elemental analysis for nitrogen concentration (scientific standard)

• To compare the effectiveness of two forms of NIR spectroscopy (benchtop Bruker MPA-11 FT-NIR analyser & portable ARC-optix FT-NIR rocket) to determine vine leaf nitrogen concentration (dry versus fresh leaf samples)

Results

• Using multiplicative scatter correction (MSC) and partial least square analysis, the benchtop Bruker FT-NIR spectral data allowed for the strongest model (RMSE: 0.104, \( r^2 = 0.94 \)) to be developed with the ability to predict leaf nitrogen concentration (Fig. 1). This was done using an independent validation data set.

• The portable ARC-optix FT-NIR spectral data could also be used to develop a strong model (RMSE: 0.205, \( r^2 = 0.76 \); Fig. 2). This was done using MSC and 1st derivative pre-processing and cross-validation (20 segments). However, interference due to water variability resulted in spectral variation, and therefore, a comparably weaker model.

• The GreenSeeker (Trimble Agriculture) emits visible red light and NIR light, which is absorbed and reflected back to the sensor by the leaves. The reflected data is used to calculate the NDVI

• The FT-NIR rocket spectrometer (ARC-optix) uses an internal light source and fibre optic cable to take measurements. A laptop or tablet is linked up and provides the spectral data on specialised software

Conclusions

• The benchtop FT-NIR spectral data allowed the creation of a strong model, suggesting that it can be reliably utilised as a cheaper alternative to elemental analysis for vine N prediction

• Data from the portable FT-NIR also developed a promising nitrogen prediction model

• As the portable NIR can be used in-field and is more affordable, further data should be collected to potentially strengthen the model for commercial use

• The GreenSeeker could not be effectively used to predict vine canopy N content

Near infra-red (NIR) spectroscopy has the ability to assess vine leaf nitrogen content non-destructively

Figure 1. Model obtained using the benchtop Bruker MPA-11 FT-NIR analyser with elemental analysis (N%). RMSE: 0.104, \( r^2 = 0.94 \).

Figure 2. Model obtained using the portable ARC-optix FT-NIR rocket with elemental analysis (N%). RMSE: 0.205, \( r^2 = 0.76 \).

Figure 3. Correlation between GreenSeeker NDVI vine canopy data and nitrogen (%) obtained from elemental analysis in (a) 2017/18 and (b) 2018/19 season