

Title: Site-specific management using remote sensing for detection of abiotic stress in grapes.

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The overall objective of this research is to develop nondestructive monitoring techniques for grape plant stresses before they are currently detected using standard visual techniques. Detection should provide real time information of stresses, which will vary based on location within a site and/or time of year. This will allow the use of management inputs that are both location and time responsive, at a stage that would reduce the adverse impact of a plant stress on crop yield and quality.

During the 2003 growing season we tested whether full spectrum leaf reflectance can detect and quantify plant stresses based on location within the vineyard in *Vitis vinifera* and the French hybrid, Chambourcin, at different stages of growth and development. In 2003, the research vineyard managed by Dr. Stanley Howell's research program and located at the Southwest Michigan Research and Extension Center was used.. Plant material included a variety of wine grapes managed under different trellis systems, at different locations within the research block, and with different crop load/canopy ratios (Table 1.). Data collection included GPS coordinates of sample plants (200 data points), elevation differences of site, leaf reflectance measured at specific stages of canopy and crop development (NB -near bloom, AB -after bloom, NV- near veraison, and NH- near harvest), cluster number, fruitfulness (lb/fruit/node), and crop load (yield/pruning wt on a per vine basis). Data will include reflectance curve analysis for plant stress, spatial analysis of reflectance stress indices, and correlations between treatment/variety and growth parameters on a spatial basis. Full spectrum leaf reflectance curves were analyzed for the following stress indexes:

1. Canopy water stress using the **Water Band Index (WBI)** = $R_{900nm} + R_{978nm}$
2. Efficiency of photosynthesis (a measure of how much light energy is used for photosynthesis) using the **Photosynthetic Reflectance Index (PRI)** = $(R_{531nm} - R_{570nm}) + (R_{531nm} - R_{570nm})$
3. Leaf reflectance after wavelengths absorbed by chlorophyll as an indication of plant stress using the **Red-edge Vegetation Stress Index (RVSI)** = $(R_{714nm} - R_{752nm}) + (2 - R_{733nm})$

Preliminary statistical analysis (results not shown) indicates variety and treatments (trellis system and crop load/canopy ratios) had a significant effect on reflectance indexes. These effects overlay the natural spatial variation that exists within the site. Two points of interest need to be determined when examining the effect of canopy management treatments on a spatial basis. The first task is to determine if there is a spatial continuity (spatial correlation) in the leaf reflectance indexes. The second task is to determine whether the natural spatial variations within the site (slope, soil, microclimate) can be eliminated from the comparisons of grape varieties and treatment to examine the effect of imposed treatments without the variation caused by location within the vineyard. The first task has been the focus of our data analysis thus far .

For all three indexes there is a strong spatial continuity in data distribution in the studied vineyard (Figs. 1, 2, and 3). For all indexes the correlation between data values is the strongest at the minimum separation distance (5m) between points and as the distance between data points increases, the correlation between location and data values decreases. As the spatial relationship diminishes, it gives a positive indication of which detected differences are due to the imposed treatment and not based on the location of the vine within the vineyard.

The results also indicate that over the growing season the strength of the spatial continuity of the individual plant stress indexes vary. For each of the three indexes, spatial continuity is stronger at NB and AB than in the NV or NH (Figs. 1-3). For example in Fig. 2, PRI correlogram values (correlation coefficients) at 5 apart are 0.84 and 0.64 for NB and AB time intervals, respectively. However, at NV and NH time intervals, the values are only 0.37 and 0.50. For WBI, the distance at which the measurements are spatially correlated are only at 5m and 10m for NV and NH and becomes not significant at 20 m. An example of the WBI distributions in the vineyard during NV and NH measurement intervals is shown in Fig.4. The range of spatial correlation for the NB data is much larger, for both PRI and RVS with correlation coefficients statistically significant up to 40 m distances.

The strong correlation in the distribution of the plant stress indexes derived from full spectrum leaf reflectance measurements indicate that there are well defined patterns of variation in water stress, photosynthetic efficiency and overall plant stress across the research vineyard. The patterns are probably caused by variations in topographical features, soil properties, nutrients and moisture availabilities. The impact of these features varies during the growing season, possibly being stronger in the summer than the fall (at harvest), when vines are most vulnerable to fluctuations in water and nutrient status. This would justify the stronger spatial relationships that we observed in the remote sensing indexes during NB and AB versus NV and NH measurement intervals. Further analysis will include whether the natural spatial variations within the vineyard can be eliminated from the comparisons between wine grape varieties and the imposed treatments. We will also test whether this elimination results in more accurate and meaningful estimations of wine grape variety responses to treatment effects. Differences in treatment will then be correlated to plant stress indexes to test if they can be used as a valid indication of canopy status during the growing season.