CORRELATION BETWEEN REMOTE SENSING DATA AND STRAWBERRY GROWTH AND YIELD

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INTRODUCTION

With the impending phase-out of methyl bromide, alternative fumigants and production practices are under evaluation for management of soilborne pests. Remote sensing technology has been employed in an effort to better characterize the influence of these alternative production practices on plant growth parameters and how they relate to yield. Remote sensing measures specific wavelengths of light that are reflected from the leaves of plants in the field. In addition to light in the visible spectra, light in the near infrared spectrum (NIR, which is not visible with the naked eye and is reflected by the plant) is measured as well. The amount of NIR reflectance is related to the biomass (leaf area) of the plant and the plant's vigor; larger plants with more leaves will reflect more NIR light than smaller plants, just as healthy vigorous plants of a given size will reflect more NIR light than diseased or stressed plants the same size. The NIR reflectance from a plant can change over time as it encounters stress (such as disease), which can then be used to assist in the identification of a problem with the plant prior to the onset of visual symptoms. Reflectance data can be measured with a multispectral radiometer and used to calculate a vegetation index (such as a Normalized Difference Vegetation Index; NDVI), which has been found to be correlated to plant size, vigor and yield in some crops. While collection of this type of data can be done while walking through the experimental plots, it can also be accomplished by aerial photography using a digital camera, thereby allowing for evaluation of entire fields rather than just smaller test plots.

In order to fully interpret the data collected from aerial images it is important to understand the relationship between the physical characteristics of the plants on the ground and vegetation index in the aerial image.

Assessment of plant size

Given that plant growth can be influenced by fumigation or production practices and this in turn is related to the amount of NIR light reflected by a plant, it would be important to be able to nondestructively determine plant biomass and leaf area during the season. To accomplish this a Tetracam ADC-2 digital camera was used for taking pictures of the plants because it collects images in the green, red, and NIR spectra (the NIR is important as it eliminates shadows in the canopy). The camera system was mounted on a PVC pipe frame and calibrated by taking pictures of a ruler. For taking pictures of the plants, the frame was placed on the bed parallel with the bed top. The images were processed and the amount of the plant canopy (expressed as % canopy coverage) in the picture frame determined

using the software that came with the camera. The individual plants were then harvested and actual leaf area of each plant was determined with a WinDias system. Fresh and oven dry weights were determined as well. Regression analysis of data collected during the production season was used to determine the relationship between the analysis of the digital images and plant growth parameters.

The results indicated there was a good correlation between % canopy coverage and actual leaf area of individual plants ($r^2 = 0.898$ for Aromas, Fig. 1), however, due to differences in plant architecture the slope of the regression lines was different among cultivars (Fig 2, $r^2 \geq 0.9$ for all cultivars). Similar results also were observed for fresh and oven dry weights of the plants.

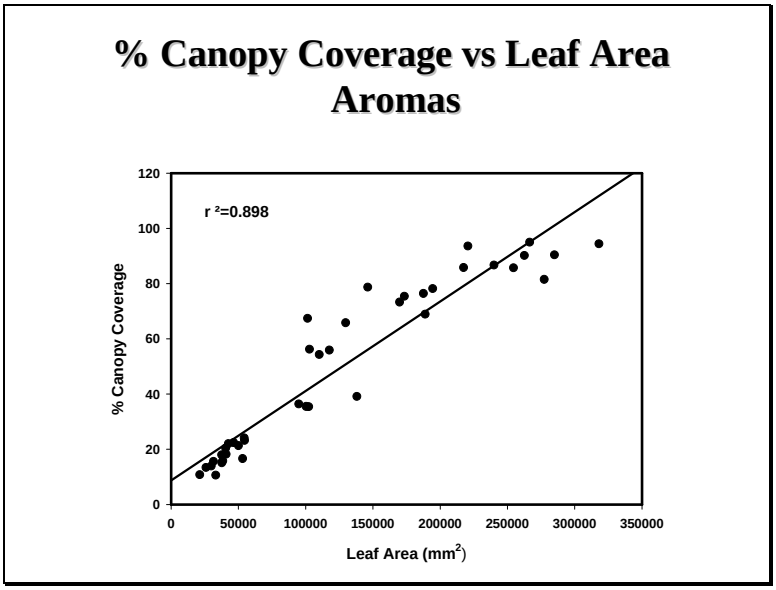

Fig. 1.

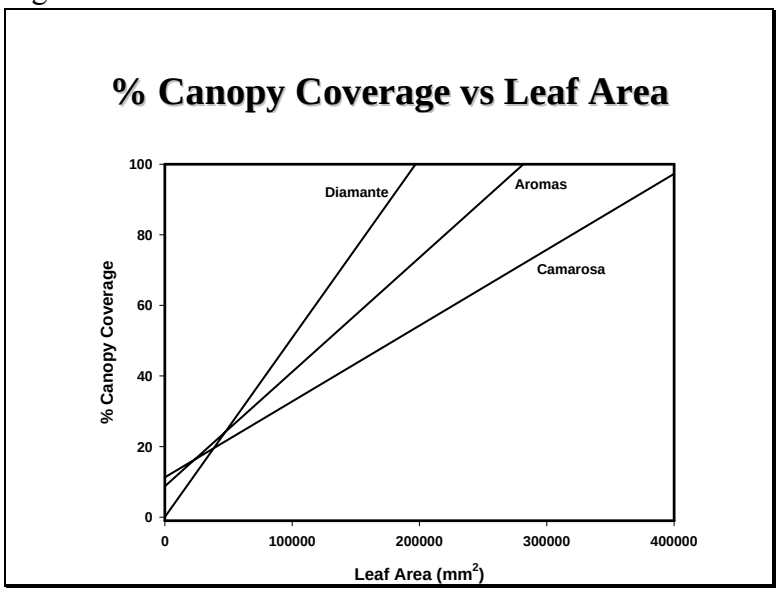

Fig. 2

Correlation between plant size and NDVI from aerial images
In an effort to evaluate the relationship between plant size and vegetation index determined with the aerial images, 212 sites in a production field (cv. Camarosa) were marked with flags and their position determined by GPS. Percent canopy coverage was determined at 4-6 week intervals (corresponding to taking the aerial images). Aerial imagery (0.5 meter spatial resolution) was collected every 4-6 weeks of the harvest season with a 12% and 56% reflectance calibration tarp deployed to enable comparison of imagery collected on different dates. The processed images were georeferenced and the vegetation index for each of the 212 sites extracted (the single pixel that corresponded to the GPS position and each adjacent pixel). Regression analysis was then used to determine the relationship between canopy size and the NDVI from the aerial image.

The results indicated a strong positive correlation between the two sets of data (r^2=0.918).

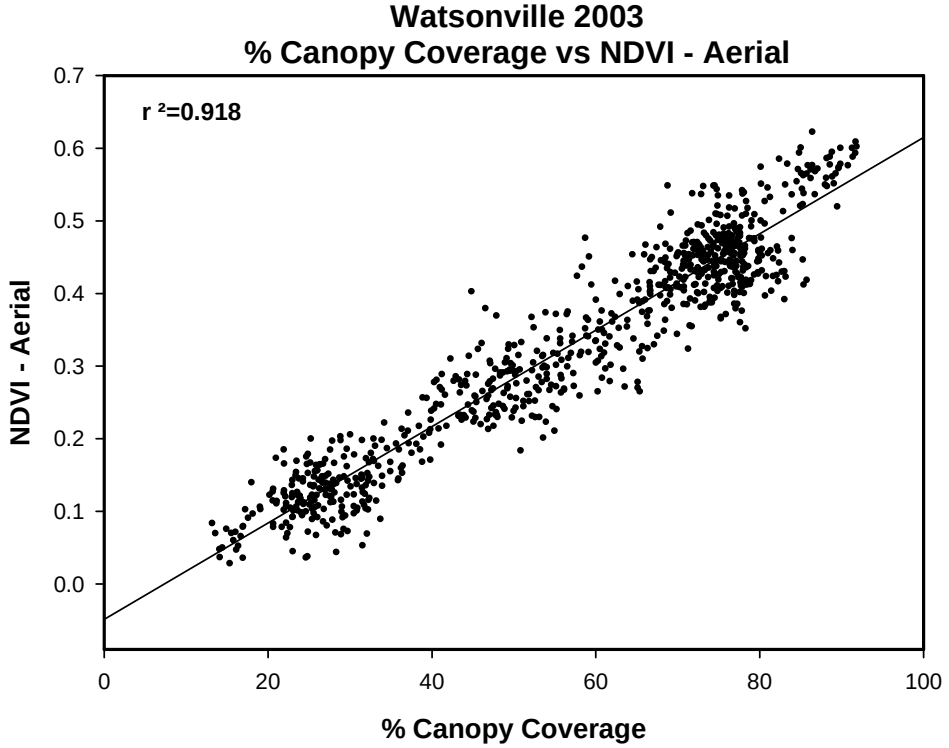

Fig. 3. The relationship between % canopy coverage for 212 sites in a field and the vegetation index from the corresponding position in the aerial image for data collected on an approximately monthly basis from March to August (for a total of 848 data collection points).

The effect of field topography on the relationship between % canopy coverage and NDVI determined from aerial images
Some of the production fields in central coastal California are located on the slopes of gently rolling hills. To evaluate if field topography can influence the relationship between % canopy coverage and NDVI from aerial images a region

of a production field was identified that had a slope of approximately 9%. A number of sites were marked out for collecting plant size data using the standard procedure (the camera is parallel to the bed top) and using a bubble level to adjust the frame to a vertical position so the camera is taking a picture in the same orientation as an aircraft mounted camera. Minimal differences in canopy coverage were observed between these two methods for collecting data (Fig. 4), indicating that a field slope of 9% or less likely has a minimal impact on estimation of plant canopy, and hence calculation of vegetation index from aerial images.

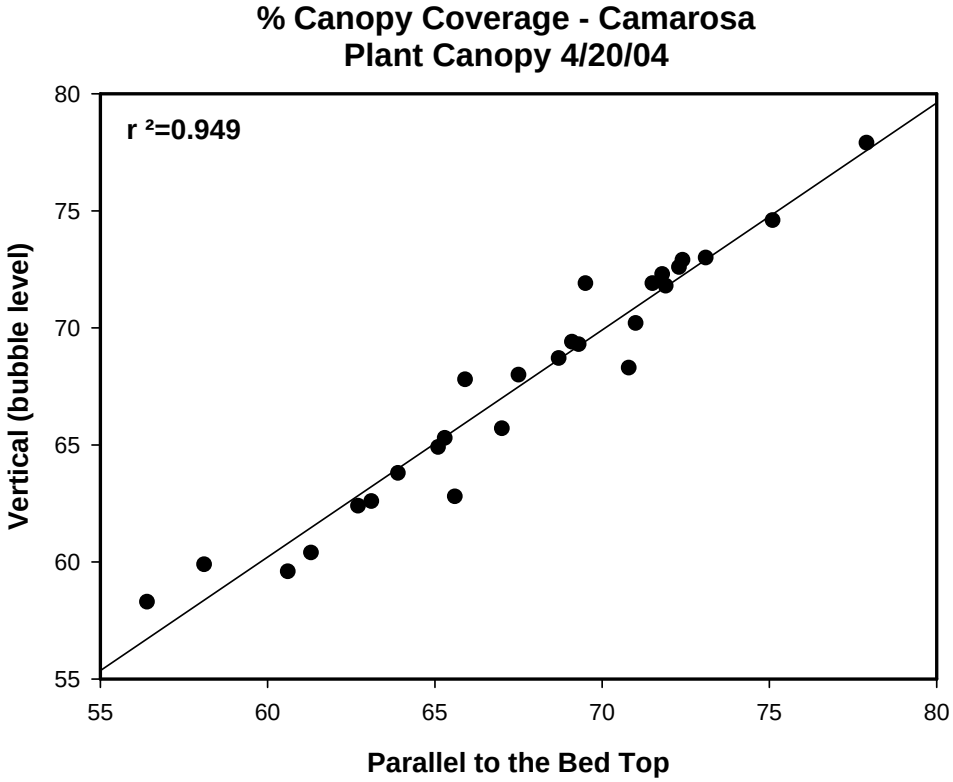

Fig. 4. Relationship between canopy coverage determined when the camera is parallel to the bed top compared to adjusted to a vertical orientation using a bubble level. The test plants were from an area of the field that had an approximately 9% slope.

Relationship between remote sensing data and strawberry yield

Additional data analysis on the relationship between plant growth or vegetation indices and strawberry yield will be discussed.