UC DAVIS
DEPARTMENT OF PLANT SCIENCES

Development and Testing of a Mobile Platform for Measuring Canopy Light Interception and Water Stress in Almond

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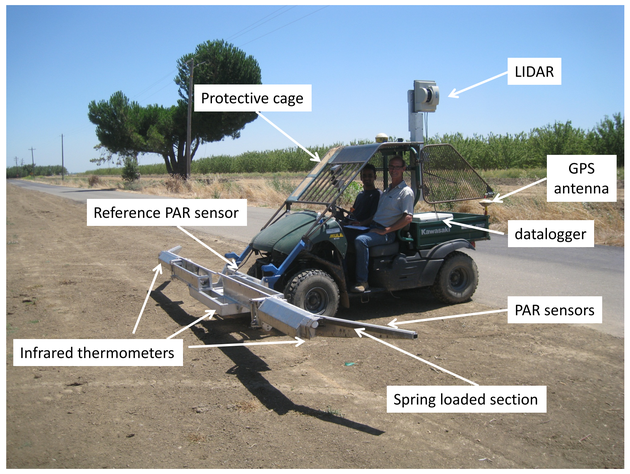

Introduction:

Data collected by the authors over the past several years has provided a rough upper limit to productivity in walnut and almond based on the percentage of the available midday canopy photosynthetically active radiation (PAR) that is intercepted. However, most of the data that was collected previously had limitations due to the difficulty in collecting light interception data with a hand lightbar.

We have outfitted a mobile platform (Kawasaki Mule) with the 2nd generation light bar that is able to measure light across an entire row (up to 32 feet wide). The photo below shows the 2nd generation mobile platform and lists some of the equipment included.

Objectives:

Objective 1- Use the mobile platform mounted lightbar to measure light interception and relate that to yield data from the same area in almond orchards throughout the almond growing area of California.

Objective 2- A mobile sensor suite as well as a continuous leaf monitor were developed and evaluated to predict plant water status by measuring the leaf temperature of nut trees and grapevines. See Poster #46 for details on Objective 2.

Objective 3- Complete and release a working version of the iPhone app to calculate canopy light interception

Materials and methods:

Objective 1- Continue running the lightbar in almond orchard sites throughout California to better define the relationship between light interception and yield. Sites were selected across the almond growing area of California for studying the light interception yield relationship. An attempt was made to get sites that were relatively productive for their age and whenever possible, sites were utilized that were parts of other ongoing studies where yield data was already being collected as part of the original study. The sites where the mobile platform was used to collect PAR data are listed in Table 1.

The goal of this aspect of the work is to help establish the upper limit to the light interception/yield relationship for almond (shown in **Fig. 1**) and to use this information to analyze orchard performance.

Objective 2- This aspect of the work is described in Poster #46.

Objective 3- Continue developing and refining the iPhone app for assessing midday canopy PAR interception.

Results:

Objective 1. The Mule lightbar was utilized in a total of 20 almond orchards in 2014. Data collected with the mobile lightbar has provided a rough upper limit to productivity in almond and walnut based on the percentage of the available midday canopy photosynthetically active radiation (PAR) that is intercepted (**Fig. 1**). The relationship has continued to prove valid with the best orchards being capable of alternating around the diagonal line

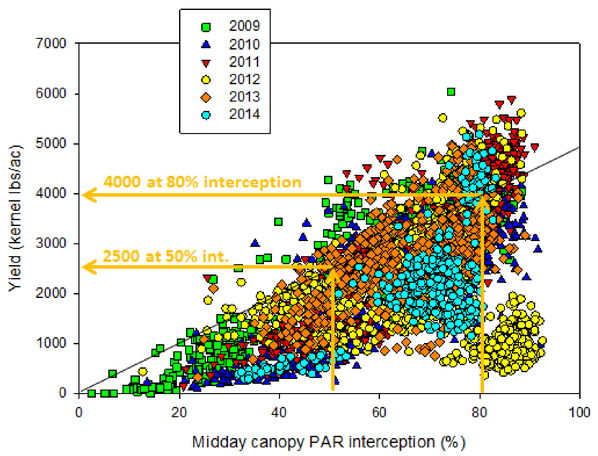

Fig. 1. Midday canopy photosynthetically active radiation (PAR) interception versus yield for almond sites from 2009 to 2014. Data set for 2014 is only partial since all samples had not been processed at the time the poster was created.

An example of an orchard is the orchard site for the McFarland Variety Trial (described on Poster #45). The diagonal arrows in Fig. 2 show the direction the yield is changing from year to year and the small number inside the arrow

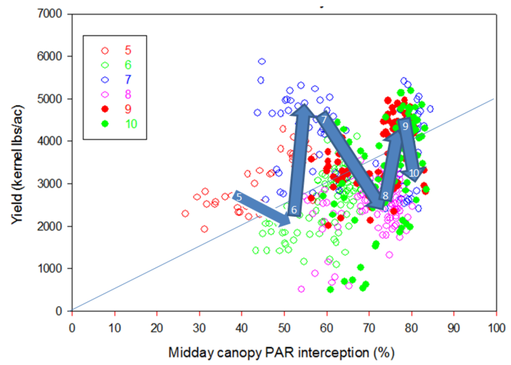

Fig. 2. Midday canopy photosynthetically active radiation interception (PAR) versus yield by year at the McFarland Variety Trial. Arrows indicate direction of average yield from year to year and numbers on arrows indicate orchard age.

indicates the orchard age from 5-10 years of age. You can see that as canopy size is increasing the yields go above and beyond the diagonal line. In Fig. 3, the yield per unit PAR intercepted is plotted out against orchard age. You can see in

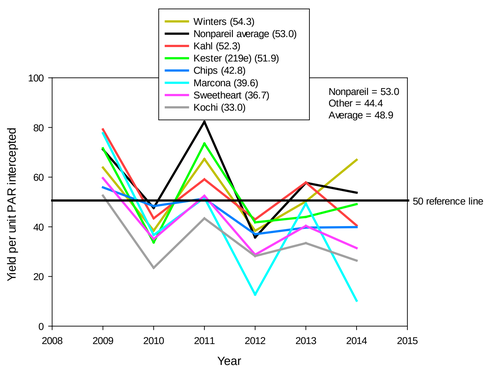

Fig. 3. Yield per unit PAR intercepted by treatment and variety or selection for 2009-2014 seasons at the McFarland variety trial.

this figure that there is a tendency toward alternate bearing in this orchard with most varieties being in the same pattern. Winters, Nonpareil, Kahl and Kester (2-19e) have all averaged above the 50 line for the past 6 years. This shows that this is a productive orchard for it's age and canopy size. Very few orchards in the study are able to stay consistently above this line.

Another way we are using these data is to look at what happens to orchard light interception and productivity with different pruning treatments, tree spacing, irrigation treatments, etc. An example for a trial in Stanislaus County (Roger Duncan Poster #55) with a 22 foot row spacing and tree spacing varying from 10, 14, 18 and 22 feet down the tree row (Fig. 4). The peak in PAR interception at 11

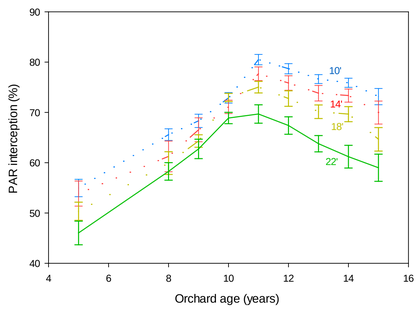

Fig. 4. PAR interception for the 5th through 15th year for Nonpareil trees in a trial in Stanislaus County spacing trial

years of age is typical for almond orchards in our trial. The spacing did not seem to impact this decline nor did the pruning treatments (data not shown). This phenomenon is worthy of further investigation.

This project has resulted in the ability to analyze grower orchards as well as to assess variable treatments in research studies that has not been possible in the past.

Objective 3- The iPAR iPhone application is able to estimate canopy light interception from photographs of the orchard floor shadows. Fig. 5 shows a flow chart desgram describing the iPAR iPhone app..

The photos need to be taken within one hour of solar noon at an angle such that 4 or more tree trunks are in view. Branches hanging down in front of the orchard floor shadow image or tall weeds can cause problems. The user should take at least five pictures that cover the range of variation in canopy cover in the orchard. If there is a lot of variability, more photos are required to get a good estimate.

The application is calibrated to estimate the PAR for almond using the percentage of the ground covered by shadows. To process the images the user manually positions the polygon on the section delimited by 4, 6 or 9 tree trunks, and then enters the number of trees spaces that this polygon has covered. The image is then processed by first flattening the perspective of the image and then estimating how many pixels in the image are in the shade. The user can decide if a particular image has been successfully processed. If not, the image can be reprocessed or discarded.

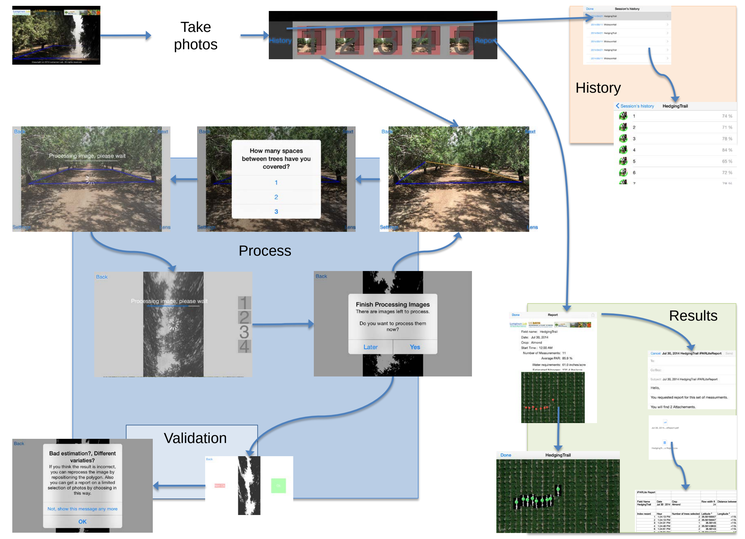

Fig. 5. Flow chart showing iPhone application image capture and processing.

The application sends results in a pdf as well as comma separated file formats to a provided e-mail address. In the pdf file the user can check all the pictures and the processed images with the estimated PAR. A map is also created showing the location of the images. In the .csv file the user has all the information from the orchard, location name, tree spacing and row spacing, the estimated PAR value, coordinates of the pictures and the number of trees covered by each image. Every record will also show the threshold value where brightness values do not correspond to a shaded pixel.

Based on canopy light interception data provided by the app, an estimate of yield potential is provided. The yield per unit light intercepted (yield divided by light interception) can be used to compare productivity of different varieties. Fig. 2 shows the yield per unit light intercepted for the varieties and selections from a variety trial in McFarland over 6 years. This figure, along with the statistics not shown, suggests that there are differences in productivity per unit light intercepted among varieties. This is likely due to tree height differences. If the previous year yield is known, this information can be used to more accurately predict this years yield based on the light interception. The plan is to incorporate nitrogen and water needs into the app based on ongoing work.

Current and future uses of this technology:

- Investigate light interception/yield relationship (ongoing)
- Adjust treatments for relative canopy area in any type of study such as pruning trials (ongoing)
- Evaluate performance of new cultivars- separate out effect of faster tree growth versus higher productivity per unit canopy light interception (ongoing)
- Investigate role of orchard floor temperature on food safety risk
- Evaluate impacts of different pruning and training treatments on light interception and productivity
- Aid in assessing value of orchards

Acknowledgements

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