Utilizing Canopy Light Interception/yield Potential Data to Improve Management of Almond

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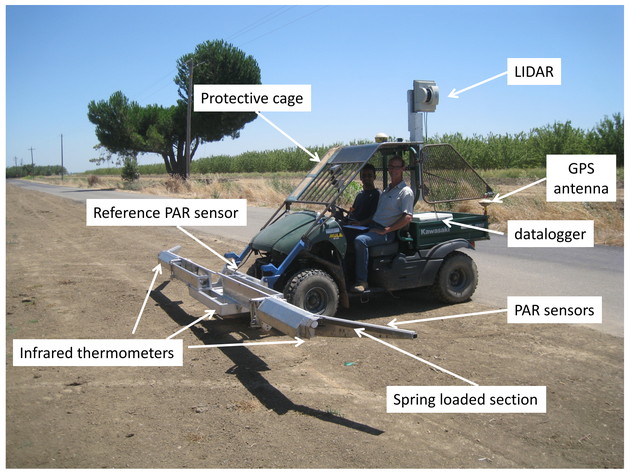


Introduction:

The mobile platform lightbar has now been in use for seven years and has proved useful for evaluating productivity in almond. An iPhone app for measuring midday canopy light interception has been developed as an outgrowth of this project and is currently on trial with farm advisors and select growers.

Objectives:

•Objective 1) The first component of this project involves using the mobile platform lightbar to measure light interception and corresponding yield in almond orchards throughout the almond growing area of California. 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 Figure 1) as well as to use these data to investigate the relationship between productivity and productivity per unit light intercepted.

•Objective 2) The Second objective was to complete calibration of the iPhone app for measuring midday canopy PAR interception and release it on a trial basis to farm advisors and select growers.

Results:

•Objective 1. The mobile platform lightbar was utilized in a total of 21 almond orchards in 2017. Data collected has provided a rough upper limit to productivity in almond with the best orchards able to produce about 50 kernel pounds for each 1% of total incoming midday canopy photosynthetically active radiation (PAR) that is intercepted or potentially about 4000 kernel pounds at 80% PAR interception. Figure 1 shows the data from all years summarized into 6 different categories. The best orchards in trial have produced in the good range over multiple years.

One of the goals in 2017 was to investigate diurnal light interception patterns. Fig. 2 shows data for diurnal light interception (as measured with iPAR iPhone app) for a normal and high density almond orchard. The normal density orchard intercepted at a fairly constant level over the day (Fig. 2b) while interception in the high density orchard drops off at midday (due to the need to have enough space to drive a bankout wagon down the row middles). When the light interception is integrated through the day (by multiplying hourly PAR interception x PAR falling at that time). These data suggest that the high density planting may be able to make up some of the lack of interception at midday by higher interception in late morning and early afternoon.

Fig. 3 shows diurnal interception for adjacent north/south versus east/west oriented orchards with Nonpareil (50%), Aldrich (25%) and Butte (25%) in a hedgerow configuration at a spacing of 15' x 25'. When light intereception is integrated through the day, it appears that the east/west hedgerow may be slightly more efficient (100% for north/south versus 105% for east/west.

only peak at about 11-12 years).

The pattern of light interception in spacing trial in Stanislaus County is shown in Fig. 4. The interception has been deceasing since about year 11 but it appears that the decrease has slowed in the higher density planted treatments while it is continuing to decline in the widest spacing (Fig. 4).

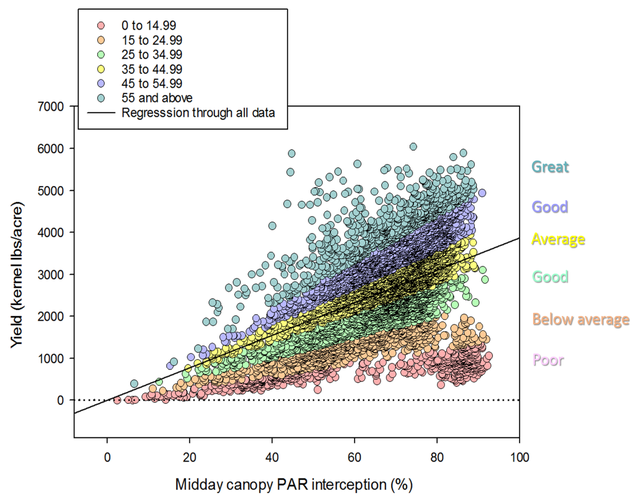


Figure. 1. Midday canopy photosynthetically versus yield for data for all years. Black regression line shows average for all data. The best orchards in our trials have produced in the good range over 3 or more years.

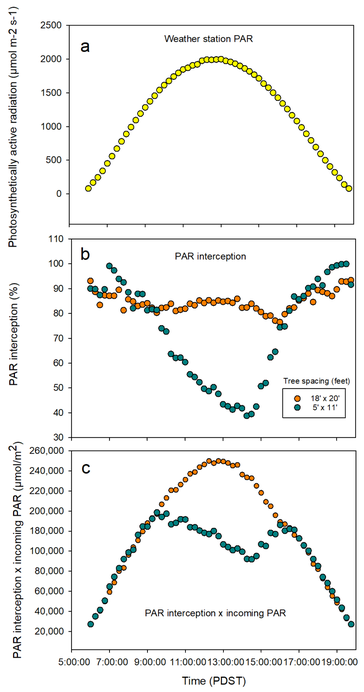


Figure 2. Diurnal PAR (a), diurnal PAR interception (b) and diurnal integrated interception over day (c) for normal density orchard (18' x 20') and high density (5' x 11') spacing orchards.

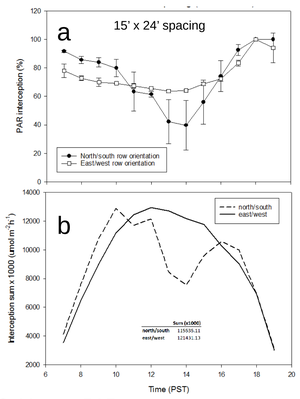


Figure 3. Midday PAR interception over day (a) and integrated interception over the day (b) for north/south versus east/west row orientation. Varieties are Nonpareil, Aldrich and Butte.

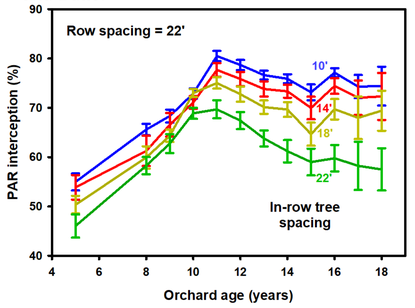


Figure 4. PAR interception for the 5th through 18th year for Nonpareil trees in a trial in Stanislaus County spacing trial

Objective 2- The iPAR iPhone application is able to estimate canopy light interception from photographs of the orchard floor shadows. Fig. 5 and 6 show screen shots and output from the iPAR iPhone app. Fig. 7 shows data from (a) the mule light bar versus hand processed images of orchard floor shadows using ImageJ, (b) mule light bar versus the iPAR app with some bad points included (with a wet drip irrigation pattern impacting results), and (c) the same data with the bad points removed. The relationship between the mule light bar data and the iPAR app are good as long as all the factors listed below are taken into account.

- Take photos of ground shadows within one hour of solar noon
- Avoid branches hanging down into view of orchard floor
- Avoid taking photos when shortly after irrigation when the wetted pattern is distinc
- Take at least 5-10 photos that span variability of orchard
- Process images in polygon delimited by 4, 6 or 9 tree trunks
- Image is processed by flattening view and converting to black and white pixels
- User can choose to discard or reprocess problematic images
- Output can be sent to a report on the screen as well as to an emailed PDF file
- App provides estimate of yield potential based on canopy size
- This can eventually be used as an aid to estimating nitrogen and water needs

Data on midday canopy light interception collected with the modified mobile platform suggests that there are a number of potential uses for this technology. The first is for providing a baseline for assessing how an orchard is performing relative to other orchards of similar age and variety. Another is for separating out the effects of rate of canopy growth from productivity per unit canopy light intercepted by different clones or

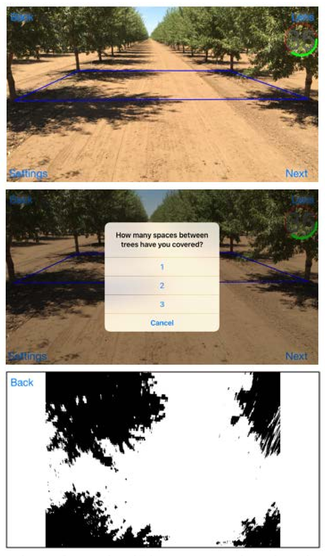


Figure 5. Screenshots from the iPhone app showing (top) image of orchard floor with trapezoid to denote area between 4 tree trunks, (middle) prompt asking if 1,2 or 3 tree spaces were covered, and (bottom) image that has been orthocorrected and converted to a black and white image for pixel counting.

Field name: Joe Martinez Call Menz
Date: Sep 8, 2016 Start Time: 3:29 PM
Crop: Almond
Number of Measurements: 9
Average PAR: 53 %
Water requirements: 37.9 inches
Estimated Nitrogen: 131 - 182 lbs/acre
Yield potential: 1923 - 2671 kernel lbs/acre

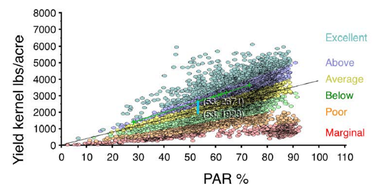
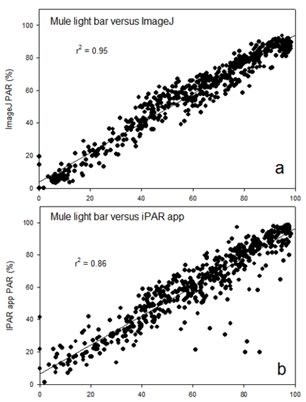


Figure 6. Report generated by the app. The report can also be sent to recipient by email from iPAR app. A more detailed report showing data for each individual photo can also be sent in an Excel file format if desired.



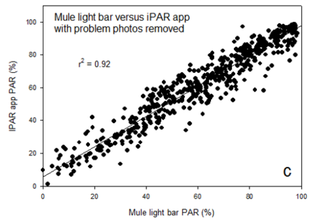


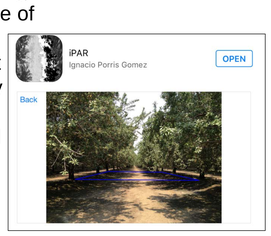
Fig. 7. Photosynthetically active radiation (PAR) interception versus PAR estimated from ground shadows using ImageJ (a), and the iPAR app (b). Points in Fig. 14b on lower right were all from orchards with a wet area around the drip tubing and this caused problems with the photos such that only the wet area was interpreted as shadows. Fig. 14c has these points removed. The recommendation based on this is to not do iPAR photos for several days after irrigation.

ivarieties. The measure of productivity per unit PAR intercepted is proving to be a very useful tool for analyzing orchard performance. A third potential use is for assessing the efficacy of different fumigants by again separating out the effects of canopy size from productivity per unit light intercepted. This information is very useful in evaluating new selections and varieties for their production potential before they reach full canopy size. Additional investigations using this technology include looking at the effect of tree spacing and orchard age on productivity per unit light intercepted. This technology also allows the elimination of canopy size differences from any type of research trial. These data are being used in a wide range of almond research project statewide as well as for providing ground truthing for remotely sensed (aerial and satellite) imagery. Two publications describing the mobile platform light bar are listed at the end of the report.

The iPhone app for estimating light interception was field tested and refined during the 2015-2017 seasons. The output was also compared extensively to estimates of PAR interception from the Mule light bar as well as to images processed manually by ImageJ. It performed well and the iPAR app is currently available in the Apple App Store.

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 (ongoing)
- Aid in assessing value of orchards



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