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

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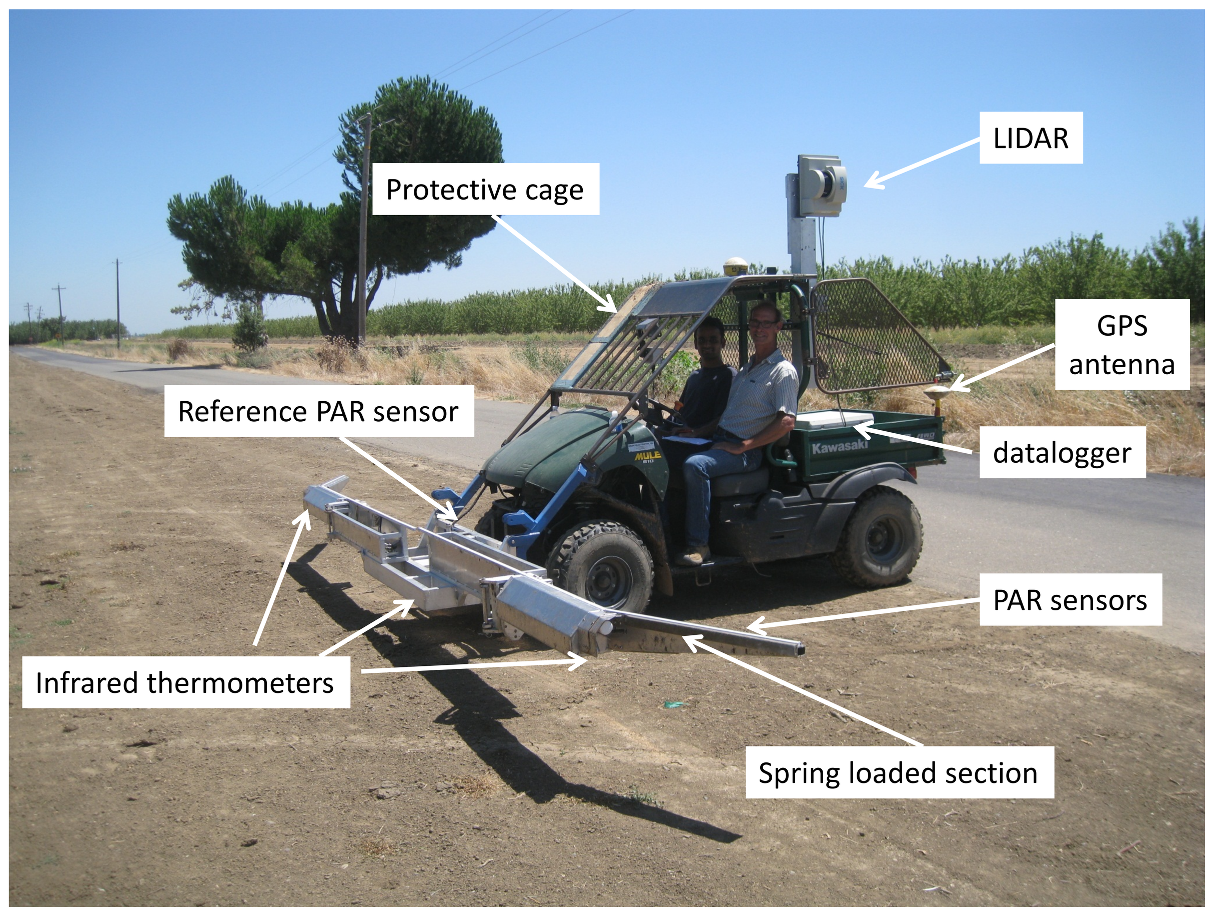
Introduction:

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 light bar.

A mobile platform light bar was designed to automate the collection of canopy light interception data (see photo below). The second generation mobile platform that is able to measure light across an entire row (up to 32 feet wide) driving at a speed of about 6-7 mph.



Objectives:

Objective 1) Use the second generation mobile platform light bar to measure light interception and relate that to yield data from the same area 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.

Objective 2 The Second objective in 2012 was to continue utilizing and analyzing data from the plant water status sensing portion of the project. The sensor suite was refined/improved in 2011 and 2012 to consist of an infrared thermometer (with a narrower field of view for more precise measurements), PAR sensor, ambient temperature, humidity, and wind speed sensors.

Materials and methods

Objective 1- 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 where ever 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 the table below. Yield data was collected from the same rows using a new load cell and GPS equipped weigh trailer.

Objective 2- Work was continued utilizing and analyzing data from the plant water status sensing portion of the project (Fig. 1). The improved sensor suite was used to measure stress on sunlit and shaded leaves and these data were compared to midday stem water potential measurements with the pressure chamber.

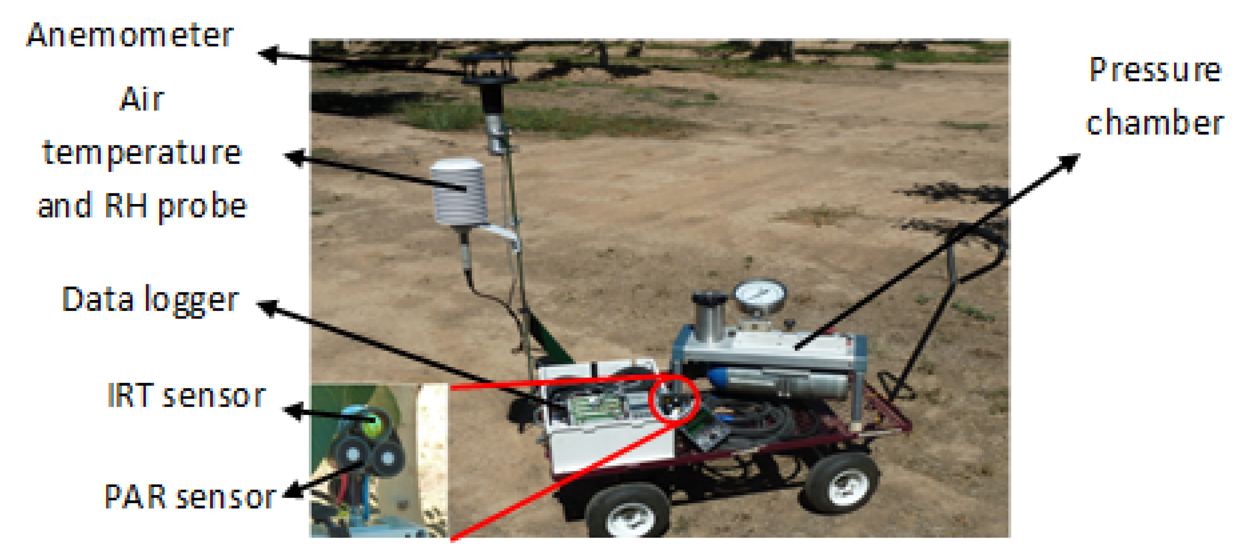


Fig. 1. Mobile sensor suite and pressure chamber used during data collection in an almond orchard.

Results and Discussion

Objective 1. Data for all almond light bar sites for the 2009-2011 season (and partial dataset for the 2012 season) are shown in Fig. 2. The solid line is the level of yield that we have found can be sustained at a given level of light interception. In general, an orchard that is substantially above this line in one year will be substantially below it in the next year. The very best orchards will be producing near this line.

Results to date suggest that almond orchards can potentially produce up to 50 kernel pounds per acre of yield for each 1% of the total midday light intercepted. This would result in a yield potential of 4650 kernel pounds per acre at 93% midday light interception. However, due to food safety concerns, we would recommend orchards be limited to about 80% midday light interception which would result in a yield potential of 4000 kernel pounds per acre to balance optimum yield with food safety and orchard management goals.

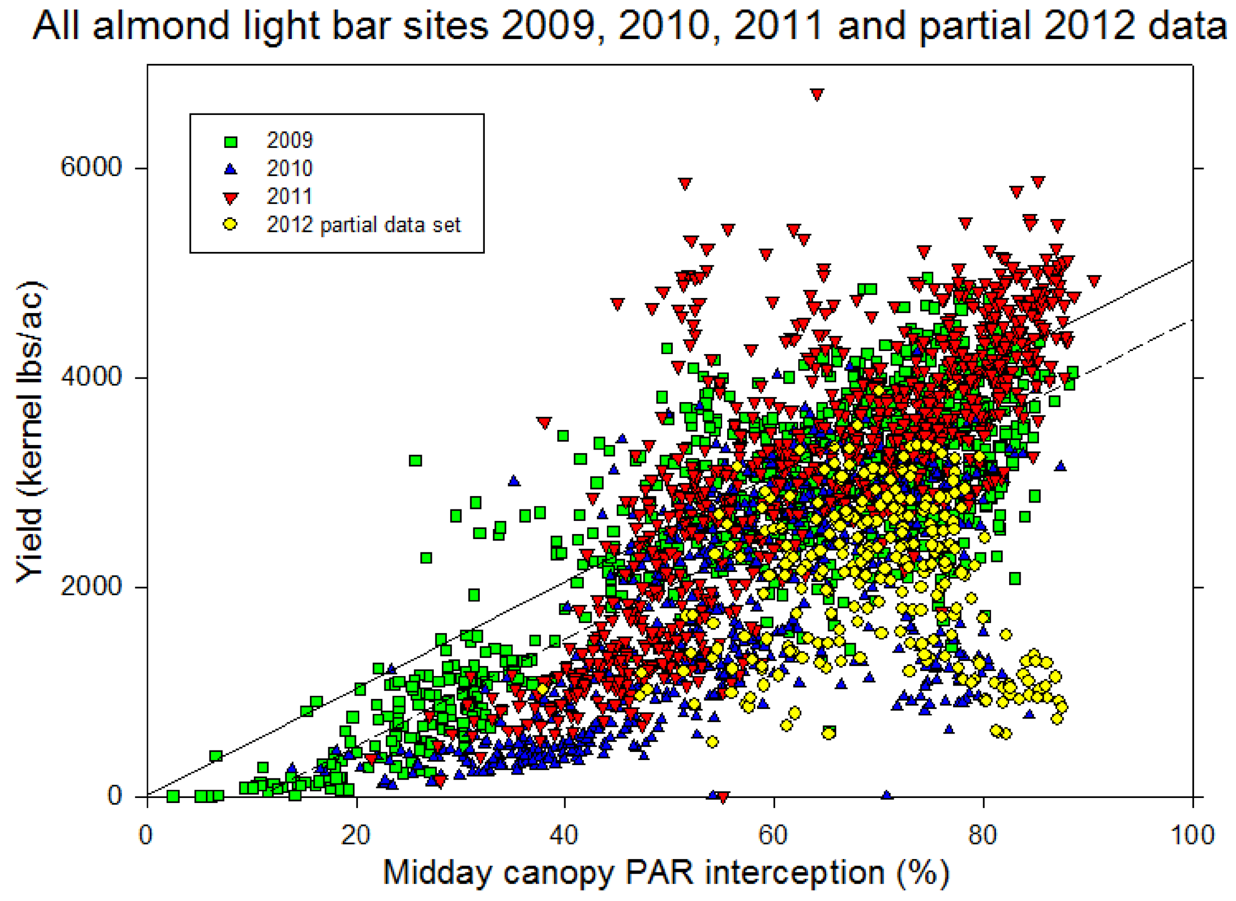


Fig. 2. Midday canopy photosynthetically active radiation (PAR) interception versus yield for all almond light bar sites for 2009 to 2012. Data set for 2012 is not complete since all samples had not been processed .

Objective 2) The mobile sensor suite was extensively tested in 2011 and 2012. The tests revealed that the sensor suite can be used to detect midday stem water potential in almonds. Measurements were done on sunlit and shaded leaves. The stepwise selection based multiple linear regression (MLR) models yielded coefficient of multiple determination values of 0.88 for almonds when shaded leaf temperature was used to develop the model. Moreover, two classification techniques, stepwise discriminant analysis (SDA) and canonical discriminant analysis (CDA) were used to identify stressed and unstressed trees. When these three methods were used for plant water stress classification (as stressed and unstressed) we found that: in almonds, critically wrong errors (i.e., stress trees being classified as unstressed trees) were 8.1, 8.8, and 9.0% respectively for MLR, SDA, and CDA methods. Over-irrigation errors (i.e., unstressed trees being classified as stressed trees) were 10.6, 5.5, and 8.0% respectively for MLR, SDA, and CDA methods. These results suggest that these methods may be useful for detecting irrigation thresholds in almond using shaded leaves.

Acknowledgements

This work was supported by the Almond Board of California, the USDA-ARS Pacific Area-Wide Pest Management Program for Integrated Methyl Bromide Alternatives, and USDA SCRI Grant CA-D-BAE-2082-OD- Precision Canopy and Water Management of Specialty Crops Through Sensor-based Decision Making