Adoption of Water-Related Technology and Management Practices by the California Avocado Industry

Julie Escalera, Ariel Dinar and David Crowley

We conducted a survey to examine factors that influence adoption of water-saving technologies and management practices by avocado producers in California who face scarce water quantity and deteriorated quality conditions. The research showed that location of orchard, high field landscape variability (irrigation complexity), and cost of water were among the main factors influencing adoption of irrigation technology and water management practices.

Multiyear drought in California has forced growers to re-evaluate water use in agricultural production. Avocado is one of the most water-intensive orchard crops, requiring approximately 50 gallons of water per pound of fruit. The recent 2009–2014 drought in California, along with anticipated decreases in high-quality irrigation water drive the adoption of water conservation practices, but the available technologies and management practices are not yet fully adopted by all growers. In this article, we report the results of a survey that was carried out to examine the socioeconomic and management factors associated with adoption of water conservation practices.

Prior research has shown that growers based their adoption decisions on farm operation complexity, financial risks, water quality, and cost of production. Other factors that influence adoption decisions are grower education, experience, use of University of California Cooperative Extension (UCCE), and farm size. To examine the importance of these factors for adoption and conservation decision-making by avocado growers, we collected information on these factors across representative farms and growing conditions in California. We estimated regression models to evaluate marginal contributions of the various factors.

California avocados, which account for 90% of production in the U.S., are commercially grown in six California counties: Orange, Riverside, Santa Barbara, San Luis Obispo, San Diego, and Ventura (Figure 1). Avocado production covers an area of nearly 52,000 acres and is managed by about 5,000 grower operations. Avocado growers have to manage highly saline and/or high-chloride water, interruptions to water delivery, mandatory reductions in water use, and rising cost of water.

Expenses on water represent the highest share of total production cost, suggesting that proper management of

Figure 1. Distribution of Avocado Orchards in California Included in the Survey

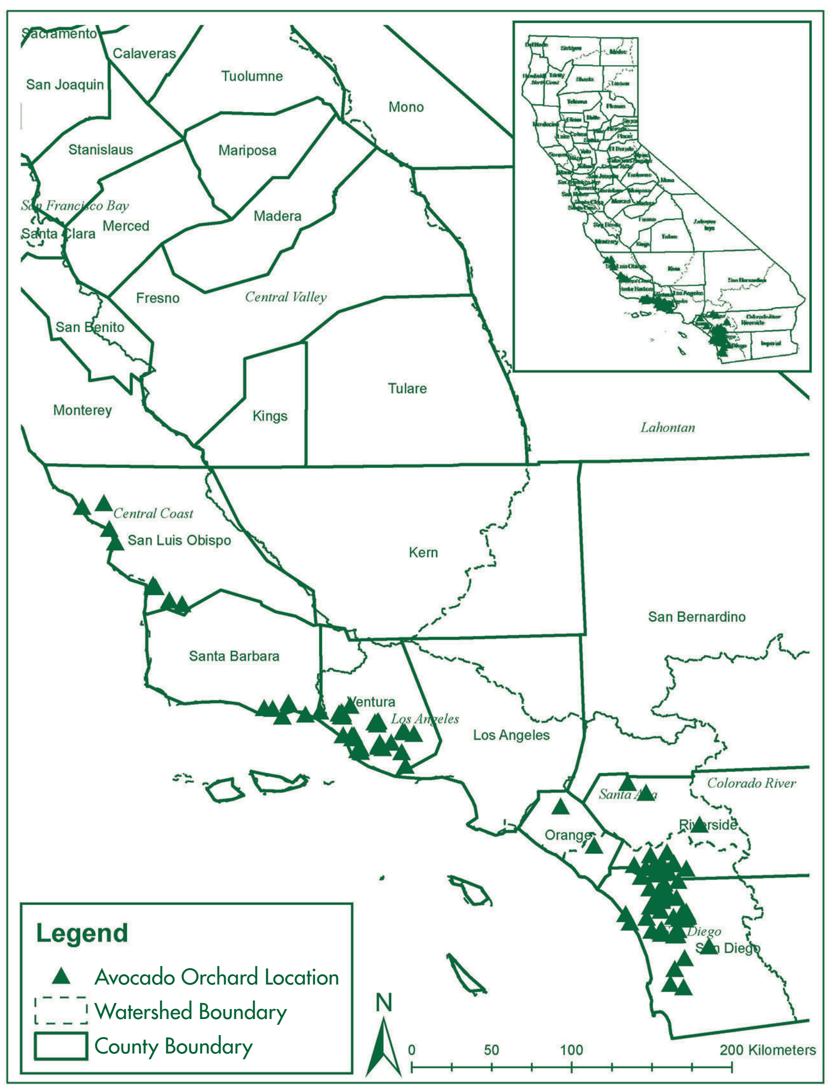
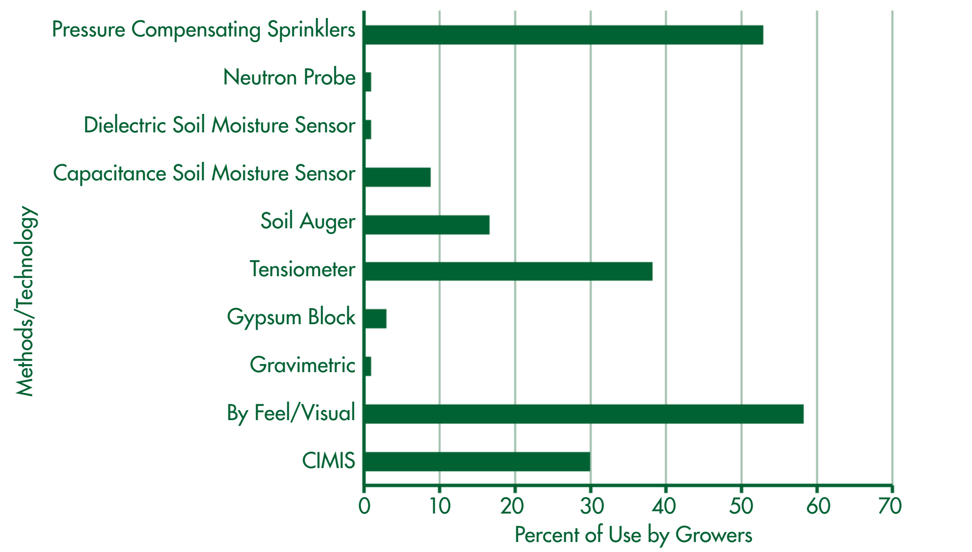


Figure 2. Methods Used by CA Avocado Growers to Determine When to Irrigate



this input is critical for profitability. To date, there is no research on avocado production under water scarcity or on the determinants of adoption with respect to water-saving practices or response to decreasing water supplies and qualities. Due to severe drought and limited quality of agricultural irrigation water in areas such as San Diego County, the results of this research are timely and essential for guiding policy to enable growers to withstand continued years of drought.

Many water management technologies are available to growers and are in use by some (Figure 2). Data from our survey show that only 50% of California avocado growers use soil moisture monitoring technologies to manage irrigation. Gypsum blocks and tensiometers are the most commonly used soil moisture technologies by all farmers. They are inexpensive and easy to use. In our study, we found that among avocado growers, only 3% use gypsum blocks and 38% use tensiometers for irrigation management.

Our hypothesis was that socioeconomic factors (age, education, gender), rather than cost or management structure, largely influence adoption of water-saving technologies. Our approach was to develop a theoretical model where adoption is a function of socioeconomic, agroecological, and informational factors as described below.

Literature Review

Interruption in supply of water quantity and deteriorated quality can cause reduced yields, death of trees, and damage to soil chemistry and structure. Although not evaluated on avocado crops, other survey studies (detailed information on the individual studies is available from the authors) suggest that drought conditions lead growers of annual crops to adopt modern water-saving technologies.

Additional findings in the literature suggest that orchard growers are willing to adopt water-saving technologies if they anticipate a combination of benefits from various improvements, such as savings in energy and water. Modification of irrigation technologies, management practices, and cropping patterns to create ‘technology bundles’ was also observed. Such bundling provides flexibility in handling extreme climatic and water supply changes.

Several studies report that the management structure of the farm, and its size and between-field landscape variability, play an important role in on-farm adoption of water technologies. Growing high-cash crops and crops that are sensitive to water quality (salinity) and soil properties affect the adoption of water efficient irrigation technologies.

A recent study by Genius et al. quantified the role of information transmission in promoting agricultural adoption and diffusion through extension services and social learning in the case of olive production. Findings suggest that socioeconomic variables such as age, experience, and education had a significant impact on a farmer’s adoption behavior and that extension agents and other farmers are the primary source of technology information for farmers. As Tey and Brinda found, not only is the existence of that information important for adoption, but realizing the benefits from the information is important as well.

Theoretical Framework

Based on the works reviewed earlier, we suggest a model that captures the behavioral relationship of grower adoption of irrigation technology and management practices under water scarcity and deteriorated quality. We consider socioeconomic variables such as age, education, experience, cost of inputs, and management structure of the farm as one set of variables. Location of the orchard, farm size, within plot variation of landscape, and soil properties are considered agroecological variables and may have fixed effects on adoption. Location can determine water quality and cost, as well as climatic factors involved with irrigation management

We consider the use of UCCE services, the California Avocado Commission, and interaction with other growers as sources of information. We asked growers where they went for information on specific topics, how often they use those sources, and the level of importance they attribute to those sources. Table 1 provides a summary of the variables we considered and their expected impact.

Empirical Application

Data collection was carried out during 2012–2013, using a survey instrument comprised of 71 questions (available from authors). We received 123 responses, which corresponds to nearly 2% of the avocado growers in California. Table 2 shows the distribution of number of growers and the acreage studied in each county. Data were analyzed using Logit and Ordinary Least Squares (OLS) regressions within the statistical package STATA.

The dependent variable in the adoption model was defined as either the use of a water-conserving irrigation technology (e.g., tensiometer, California Irrigation Management Information Systems (CIMIS)), or a water-saving management practice (e.g., frequency of using soil moisture equipment, testing irrigation for salinity, getting a water audit to improve distribution uniformity, and use of management response to water shortages). The independent variables in the adoption model are described in Table 1, based on the literature reviewed.

Table 1. Variables Affecting Adoption of Irrigation Technologies and Hypotheses Regarding Their Impact

Determinant of Adoption	Variables Used	Hypotheses Regarding Impact on Adoption
Socioeconomic factors	Operator age, years of experience, formal education, ownership type, cost of water, tenure (ownership)	Older growers may be less likely to adopt; growers with more years of experience, higher formal education, larger operations, and with higher cost of water will be more likely to adopt irrigation technologies and irrigation management practices.
Agroecological factors	Farm size, location of farm, soil properties	Growers who are full-time operators, with larger farm size, and located in areas with decreased water supplies will be adopters of irrigation technologies and irrigation management practices.
Informational factors	Use of Cooperative Extension, California Avocado Commission, and growers. Importance placed on information collected from each source.	Growers who use informational factors such as UCCE, and place a high level of importance on these factors, will be more likely to use irrigation technologies and water-saving practices than growers who do not use information factors or place low importance on them.

Discussion

This survey showed that several factors influenced the adoption of water-saving technologies by avocado growers in California. The most important factors were owner's age, location of orchard, high field variability (irrigation complexity), cost of water, and information collected from UCCE and growers. Growers in Riverside or San Diego County were more likely to adopt water-saving technologies and apply water-related management practices than those in the other counties. Growers within these two counties were also more likely to use CIMIS as a tool for irrigation scheduling and to take advantage of free water audits to improve water use. Also, compared to other counties, they made more management decisions regarding the long-term water management of their orchard such as stumping trees, cutting off water, and removing trees.

The share of growers using water audit services in order to improve irrigation efficiency by increasing their distribution uniformity was 52%. Forty-eight percent of growers had to take some action such as stumping trees, cutting off water, or removing trees in order to mitigate reductions in water delivery and quality.

Growers who rated information from UCCE as an important source were more likely to use CIMIS and tensiometers as tools for determining irrigation timing. The average rating for UCCE by growers was 3.4, with zero being not at all important to 5 being extremely important. Growers who placed a high level of importance on information collected through grower-to-grower interactions were more likely to use water audits and CIMIS as a way to conserve water.

Orchard landscape variability had a significant effect on adoption—those with high field variability (e.g., steep slopes, poor soil quality, and irregular shape of irrigated blocks) used tensiometers (32%) and CIMIS (30%), and they had higher responses to having had to make water-saving management decisions such as stumping, etc.

Water price was also important for predicting whether a grower chose to get a water audit or make water-saving decisions. Water prices

Table 2. Avocado Water Use Survey Observations

California County	No. of Growers	Avocado (Acres)
Orange	2	94
Riverside	16	734
San Diego	51	1036
Santa Barbara	12	304
San Luis Obispo	8	151
Ventura	34	1580
Total	123	3899

California avocados account for 90% of production in the United States and many growers face challenges with water supply and quality. This study examines several factors that influence the adoption of water-saving technologies by avocado growers in California.

ranged from $1.26/hcf (one hundred cubic feet) to $3.93/ hcf, with the highest prices reported in San Diego and Riverside Counties.

For managing salinity and leaching, growers who irrigated with groundwater tested their water for salinity. Groundwater and district water chloride values ranged from 84 to 134 parts per million (ppm). (Negative effects of chloride on avocado production can be seen at levels above 75 ppm.) Growers who irrigated their orchards with district water (81%) were less likely to test their water. It may be important to note that water districts provide free water reports to growers.

Conclusions and Policy Implications

This research indicates that orchard location, high landscape field variability (irrigation complexity), and cost of water were among the main factors influencing adoption of irrigation technology and water management practices. These variables are not readily controllable through policy instruments, but the results suggest that growers farming in more arid regions, on slopes, in irregular shaped orchards, or within districts that have a high water cost will be the earlier adopters within the California avocado industry.

In counties such as San Diego, where growers have experienced up to a 30% cut in water deliveries and an increase of up to 130% in water costs, the results seem to coincide with the trend of reductions in water application. Sixty-seven percent of the growers located in San Diego County had to stump, reduce canopy, or remove trees to mitigate the interruption in water supply.

Technologies that can help guide growers when and how much to irrigate are still used at low levels of adoption, although it appears that rising costs of water may influence future adoption of such technologies. We found the role UCCE, in sharing information and educating on these technologies, to be significant and valued by growers. This finding has an important policy implication, as this is one way in which policy can intervene and improve growers' preparedness for water interruptions and deteriorated quality.

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For additional information, the authors recommend:

Genius, M., P. Koundouri, C. Nauges, and V. Tzouvelekas, 2014. "Information Transmission in Irrigation Technology Adoption and Diffusion: Social Learning, Extension Services, and Spatial Effects." *American Journal of Agricultural Economics* 96(1): 328-344. 344. http://ajae.oxfordjournals.org/content/96/1/328.short.

Tey, Y.S. and M. Brindal, 2012. "Factors Influencing the Adoption of Precision Agricultural Technologies: A Review for Policy Implications." *Precision Agriculture* 13(6): 713-730. DOI 10.1007/s11119-012-9273-6. http://link.springer.com/article/10.1007/s11119-012-9273-6.