Crop Choices with Limiting Water Supplies: Deficit Irrigation and Sensitive Crop Growth Stages

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Introduction

The Central Valley agricultural production area of California, comprising the Sacramento Valley north of the Delta region and the San Joaquin Valley south of the San Francisco Bay Delta, has what is typically described as a Mediterranean climate characterized by cool, wet winters and dry conditions the rest of the year. Recurring droughts are typical. Changes in some irrigated agriculture practices can demonstrate adaptation to drought conditions in the region. An example of a change in irrigation practices during the past 20 years in the western San Joaquin Valley is the large reduction in pre-plant irrigation amounts for many annual crops such as cotton or processing tomatoes. In the heavy, clay loam soil areas of the western San Joaquin Valley, pre-plant irrigation amounts of 25 cm (1 inch = 2.5 cm) were not unusual one or two decades ago, and these applications served to replenish soil water depleted by the prior crop and provide a fairly aggressive leaching fraction. In more recent years, fields that are to be furrow-irrigated during much of the growing season have seen a change to hand-move sprinkler lines for pre-plant and even the first and second irrigations of the growing season. This has increased labor costs and costs for sprinkler lines, but has lowered early season water applications. In many cases it provided greater uniformity of water applications during this part of the growing season, and reduced deep percolation losses that have contributed to shallow groundwater accumulations and problems.

Deficit irrigation

Deficit irrigation management approaches have been developed by researchers, consultants and growers. Many of the best efforts are based on an understanding of impacts of water stress timing and severity on specific physiological processes important to growth or developmental processes. Water stress can impact key developmental processes such as bud formation, pollination, or new shoot development important to extended fruit formation or the following year’s fruiting potential. These efforts have provided agricultural producers with choices to make regarding crop water management under water-limited conditions. For some crops there is a good level of understanding of growth stages or situations most suitable for deficit irrigation and potential impacts on yield and quality, while for other crops more information is needed. Descriptions of deficit irrigation management discussions follow for specific crops.

Acala Cotton (Gossypium hirsutum L. and Pima Cotton Gossypium barbadense L.)

Cotton growth stages considered least sensitive to soil and plant water deficits are early vegetative development, through about seven to eight main stem node stage, and then again after peak flowering and into the early boll opening phase of development. Growth stages found most sensitive to moderate to severe plant water deficits include early flower bud (square) development through the
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early flowering stage, with later flowering and boll development periods intermediate in sensitivity.

A factor with potential to impact deficit irrigation options is the relatively high salt-tolerance of cotton. In comparing crops for suitability for salinized soils, use of degraded irrigation water supplies, or where water supply quantities are inadequate for a full leaching fraction, salt-tolerance can influence water management options.

Alfalfa (Medicago sativa)

In a wide range of irrigation management studies, alfalfa forage yields within climatic zones have been found to be essentially linearly related to crop evapotranspiration (ETc). While crop yields can be impacted at any production location by other constraints to growth, such as insect pressure, soil aeration or salinity issues, and periods of very low or very high temperatures, reductions in irrigation water that produce plant water deficits and reductions in ETc typically will also reduce yields. In studies done across California, a number of options were discussed for consideration under conditions of limited water supplies, including:

- Fully irrigate part of planted alfalfa acreage, and provide little or no water to remaining acreage;
- Fully irrigate for spring and early summer production, reduce or eliminate later irrigations;
- Reduce the number of irrigations between cuttings or decrease applied water per irrigation to reduce total applied water.

However, under conditions of saline irrigation water supplies or with severe water supply limits, these reduced-water application approaches also bring the eventual risk of salt-induced damage or water stress damage to plant survival and yields.

Pistachios (Pistacia vera L.)

Pistachio deficit irrigation management research conducted over a period of years indicated specific growth stages during which deficit irrigation and plant water deficits had greater potential to reduce crop yields or impact nut quality, and less sensitive growth stages that could be targeted if irrigation water supplies are limited. Research indicated that reductions in applied irrigation water according to these recommendations in the San Joaquin Valley could result in reductions in crop water use from about 41 inches to 32 inches, with relatively moderate short-term impacts on yield or nut quality.

An important characteristic of pistachios with potential to impact suitability of the crop for certain agricultural land and water supplies is the greater salinity and boron tolerance of pistachio in comparison with many vegetable or tree crops.

Walnuts (Juglans species, Juglans regia L.)

Fairly extensive work on regulated deficit irrigation of walnuts has occurred in the San Joaquin Valley and Sacramento Valley during the past two decades. The first year of deficit irrigations largely reduced nut size with only minor impacts on in-shell yields. Additional years of deficit irrigation, however, reduced shoot growth, new fruit-bearing wood and fruit number to a greater extent. Over a three-year period of deficit irrigation, walnut size was reduced by stress, and off-grade nut percentages increased, both of which reduced crop value. Upon reinstatement of irrigation at full Etc levels, shoot growth and new fruiting wood responded in previously deficit irrigated trees, and number of nuts and in-shell yields recovered to yield levels measured in fully-irrigated trees in one year with more moderate deficit irrigation and within two years in more severe deficit irrigations.

In established orchards, moderate deficit irrigation during mid-season and late, post-harvest reductions in applied water have potential to save between 6 and 10 inches of applied water with only moderate impacts on current year yield and nut quality, and less impact on shoot development important to the following year’s fruiting potential.

Other factors affecting crop choice

Economic factors, such as the reliance of certain industries that are dependent on reliable output of crops (such as energy crops for biofuel energy facilities, forage and other feed for dairies) can also be important influences on which crops are deemed suitable for deficit irrigation and which industries can best deal with reductions in total production.

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