DEFICIT IRRIGATION APPROACHES FOR PIMA AND ACALA COTTON

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Abstract

Irrigation water availability is declining and costs are increasing for cotton producers in the irrigated west. As water supplies on some farms become highly restricted, cotton growers are looking to water management practices that include reducing water application amounts that result in yields that are less than maximum production. The pressure chamber has been documented to be an effective indicator of crop water stress and was found to be highly effective in establishing irrigation deficit treatments in this study. While crop responses to irrigation deficits varied between production seasons, we successfully established and quantified differential water stress treatments and monitored crop performance responses associated with a consistent range of water regimes for commercial Acala type Upland cottons, *Gossypium hirsutum*, and Pima cotton, *Gossypium barbedense*. Pima and Acala cottons exhibit similar trends in yield responses to cotton, but when deficits are severe, the shorter flowering period Acala types generally perform better on a relative scale, whereas Pima cotton types perform better under modest irrigation deficits and when excessive irrigation water is applied. Our results support the idea that western US cotton growers can make use of deficit irrigation approaches using tools that allow them to manage and minimize risks associated with yield decline when water supplies are limited.

Introduction

Though western states often benefit from favorable peak season growing conditions, cotton production systems require significant irrigation inputs to satisfy crop water demand with typical in-season water requirements ranging from 640 to 840 mm (25 to 33 inches) annually for peak yield. This does not include water that is required for the leaching of salts and water lost due to inefficiencies in the irrigation delivery system. The portion of the crop budget dedicated to irrigation can also range from 10 to 35 percent of total inputs depending on the irrigation water and delivery system costs which in turn depend primarily upon irrigation district and/or pumping costs. Efforts to explore and improve water management on farm also meets critical resource management needs as environmental and municipal water demands grow.

Because of cottons ability to adapt to changing environmental conditions by exhibiting some drought tolerance characteristics, it is a crop that lends itself to modification of its soil water regime depending on crop development phase and existing climatic conditions. Previous water management studies have generally demonstrated cottons inability to adapt to high water stress events early in the season, however when the crop is hardened by modest stress events prior to a high stress event, productivity responses were decreased as harvest index and yield increased. Further work is needed to increase our understanding of controlled deficit irrigation responses in cotton and the interactions that come from a varied genetic resource base. Because both Pima and Upland types of cotton are commercially important to western agricultural systems, we developed studies to contrast the response of the more determinate Acala cotton types with the indeterminately growth habit of Pima cotton types.

Materials and Methods

Long-term studies were conducted at the University of California West Side Research and extension Center on deep and well-drained Panoche clay loam soils. Cotton varieties planted included the predominant Acala and Pima cotton variety being grown in the San Joaquin valley. From 1997 to 2006, plot location varied within a one quarter mile radius with generally small differences in soil type and soil water storage. Each year, three to four irrigation treatments were imposed in a randomized complete block design with irrigation management regime assigned as the main effect. Each cotton variety was grown on 4-1 m beds approximately 90 m in length with each irrigation/variety combination replicated 4 times. Each irrigation event was scheduled using a pressure chamber with the optimum irrigation treatment developed according to UC cotton production guidelines. The excessive water treatment included one additional late season irrigation following the ideal termination treatment, while one to two irrigations were withheld on the deficit irrigation treatment(s). Applied irrigation water was measured on each treatment using propeller type flow meters mounted to aluminum gated pipe while crop water stress was measured by using the pressure chamber to measure mid-day leaf water potential on a weekly basis. Following crop emergence, soil water was monitored weekly in each plot using neutron scatter technology with steel access tubes read every 30 cm to a depth of 240 cm. The crop was grown using production management practices that work to achieve optimum yield. A plant growth regulator (Mepiquat Chloride) was applied most years to the optimum and excessive irrigation treatments according to UC guidelines while no PGR's were used on deficit irrigated cotton.

Table 1. Typical in-season irrigation treatment application amounts and dates in acre inches/acre. All treatments received an 11.2 inch pre-irrigation on Jan. 4, 2000.

1st Irrig.	2nd Irrig.	3rd Irrig.	4th Irrig.	5th Irrig.	Total Applied In-Season
6/28 6.8"					6.8 Ac/in
6/15 5.6"	7/19 6.2"				11.8 Ac/in
6/15 5.6"	7/19 6.2"	8/17 5.5"			17.3 Ac/in
5/26 7.3"	6/28 6.8"	7/19 6.2"	8/17 5.5"	9/8 3.9"	29.7 Ac/in

Results and Discussion

Optimum irrigation timing for cotton depends on a combination of many factors including atmospheric water demand, soil water availability, active rooting depth and root density. On high water holding capacity soils in the San Joaquin Valley the optimum timing for the first irrigation generally ranges from 45 to 65 days after planting and occurs within the first three weeks of June. Imposing water deficits in cotton by delaying the first seasonal irrigation from -1.5 MPa to -1.8 MPa results in reduced vegetative growth noticeable prior to first flower but does not always result in reduced productivity or quality. While UC Guidelines indicate post bloom irrigation be initiated on or before plant LWP's reach -1.8 MPa, the data developed here suggest that in some years LWP can briefly go as high as -2.0 to -2.2 MPa with having a significant impact on yield. This is particularly true for stress events that occur after the peak flower production period. In commercial Acala cotton types this usually occurs approximately three weeks after first bloom and four weeks after first bloom in Pima cotton.

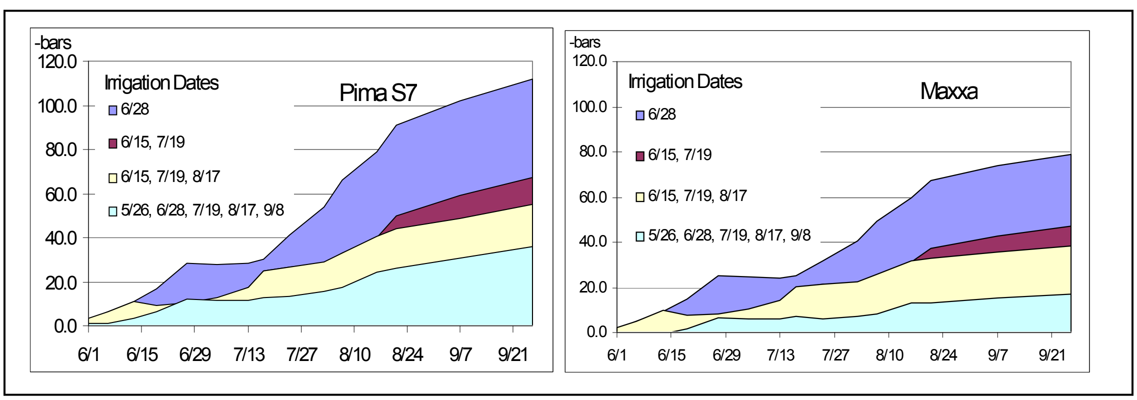

Fig 1. Accumulated weekly LWP (-10 bar baseline) from June 1 to Sept. 26th 2000.

Yield responses to water deficits were not completely consistent from year to year and between cotton types. Deficit irrigation treatments in 1997, 1999, and 2000 performed particularly well from a production standpoint, with significant yield declines during 1998 and 2002. The primary difference in these production years was the earliness of crop development with delayed first bloom occurring in the 1998 and 2002 seasons. The university guideline treatments consistently performed better than the deficit irrigation treatments and equally as well as the excessive irrigation treatment. When severe water deficits were imposed, Acala cotton performed marginally better than the

Pima types while Pima performed better than the Acala types in the moderate water deficit treatment. These results appear to be consistent with previous data that indicate commercial Pima varieties can exhibit superior drought tolerance when compared to Acala types but as a result of the extended boll production period, Acala can perform better when water is severely limited.

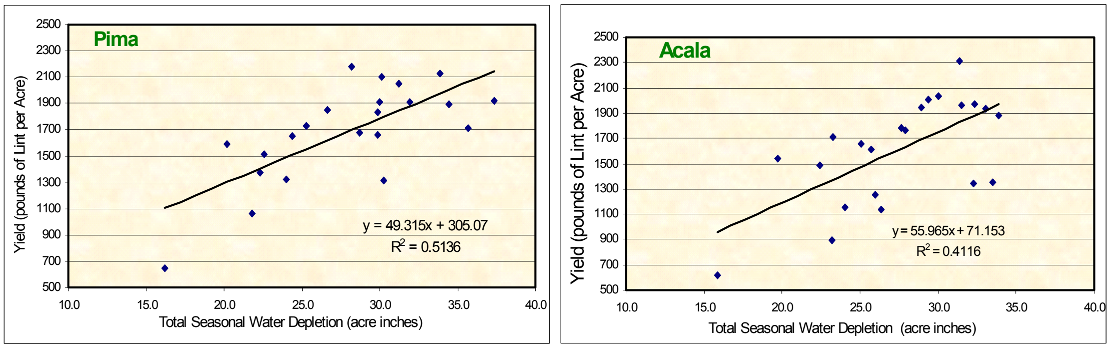

Fig 2. Total seasonal water depletion measured by neutron probe from 1997 to 2000, 2002, and 2006 for Pima and Acala Cotton.

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