Irrigation Frequency and Cotton Yield in Short-Season Cotton Systems

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Abstract

We tested the hypothesis that small frequent irrigations during the July cotton peak fruiting stage would result in better fruiting and higher cotton yields than the same amount of water applied less frequently. Over three years under a short-season production system, irrigation intervals of every 5-d with 42 mm of water applied at each irrigation increased cotton lint yield by 5-11% compared to irrigation intervals of 10- and 15-d with 80 and 130 mm of water applied at each irrigation, respectively. The results show that small, frequent furrow irrigations during cotton fruiting are highly effective in reducing water deficit during critical growth stages and improved lint production in a short-season cultural system. Soil salt content in the top 15 cm of soil was not increased after three years of study.

Introduction

Drip irrigation to deliver frequent but small amounts of water has been demonstrated to efficiently meet cotton water requirements when grown under full-season cotton production systems in the arid southwestern United States (Buck et al., 1988; Radin et al., 1992). Radin et al. (1989) demonstrated that daily drip irrigation in mid-season, when heavy cotton fruit loads occur, increased midday leaf water potentials as compared to furrow irrigation at longer time intervals. The results suggested that mild plant water stress during heavy fruiting as a result of long time intervals between irrigations contributes to root system deterioration. A subsequent study showed that seed cotton yields were increased when one or two supplemental furrow irrigations were applied during peak cotton fruiting cycles (Radin et al., 1992). The authors concluded that doubling the number of furrow irrigations during the short period of peak cotton fruiting, without significantly changing the total water amount applied, could achieve much of the benefits of drip irrigation in a full-season cotton production system.

A regulatory pink bollworm, *Pectinophora gossypiella* (Saunders), program mandating 1 September cotton treatment with a defoliant or plant growth regulator, and 1 November plowdown of shredded cotton stalks was initiated in the Imperial Valley, CA in 1989 (Weddle et al., 1990) The program changes cotton growing from long-season to short-season management. We conducted studies to investigate the potential of short-season cotton yield enhancement through shorter interval furrow irrigations during the boll-filling (July) growth stage without increasing the water amount applied.

Materials And Methods

Cotton cv. 'Deltapine 5461' was planted and the field furrow irrigated (70 mm) on 20 March 1989, 7 March 1990, and 20 March 1991. Additional irrigations of 90 mm were applied at each of the following dates: 19 April, 8 and 24 May, and 6 and 19 June in 1989; 26 March, 11 and 25 April, 10 and 24 May, and 6 and 21 June in 1990; 18 April, 8 and 24 May, 7 and 21 June in 1991. These irrigations were initiated when loss of leaf turgidity became visible in the afternoon. The plant populations each year were 64,600 plants ha^{-1}. Pesticides were not used in the three year study.

The experimental design for each year was a randomized complete block with nine replicates. Each plot was four rows wide, spaced 1 m apart, and 35 m long. Four rows remained unplanted between plots with 9 m alleys between the ends of plots to prevent water infiltration between plots in soil fissures. The location of the study in the field of each plot remained the same in all 3 years. Three different irrigation treatments were designed to deliver the same amount of water during the month of July but applied (1) at 5-d intervals for six times with 1 unit each, (2) at 10-d intervals for three times with 2 units each, and (3) at 15-d intervals with 3 units each. The shortened interval irrigation treatments were initiated on 3 July in 1989, 2 July in 1990, and 1 July in 1991. All three irrigation interval treatments were initiated simultaneously.

Seed cotton was hand harvested from 4 m row in each of two center rows of each plot to determine the treatment effects on yields. At the completion of the three year study, three soil samples of 0-15 were taken from each plot from the tops of plant beds, in the furrows, and in the middle at the side of beds to determine the influence of irrigation frequency on soil salt content. Electrical conductivity of samples was determined with a conductivity bridge (Model RC 16B2, Beckman Instrument, Inc., Fullerton, CA 92634) (Diagnosis and Improvement of Saline and Alkali Soils, USDA Agric. Handbook No. 60, 1954).

Lint yields were analyzed each year and also analyzed in combinations of two (1989 and 1990) and three years. Means were separated with orthogonal comparison (MSTATC Microcomputer Statistical Program, MSU, East Lansing, MI, 1988).

Results and Discussion

The three-year averages for the amounts of water applied at each irrigation during July irrigation treatments were 42, 81 and 130 mm for 5-, 10- or 15-d irrigation intervals, respectively (Table 1.). Total amounts of water applied during July in the three years ranged from 243 to 260 mm. Although total amount of water delivered to plots under each irrigation treatment interval varied during the three-year study, the yield advantage of the shorter interval irrigation during the peak cotton fruiting period in July was evident.

Cotton lint yield difference in plots receiving irrigations at 5-d intervals were 5 to 6% higher in 1989 and 1990 compared to 10- and 15-d interval (Table 2). The results were consistent and were statistically significant when the 2 years data were combined. Lint yields from plots receiving 5-d interval irrigations in 1991 were significantly higher than lint yields from plots receiving irrigations at 10- or 15-d irrigation intervals. Additionally, average lint yields for the three year study showed that cotton plants irrigated at 5-d intervals during July yielded over 7.0% more lint than plants irrigated at 10- or 15-d intervals. Lint yield from plants receiving irrigation at 10-d intervals was not significantly different from plants irrigated at 15-d intervals.
The consistent yield increase of the 5-d irrigation interval treatment during each year is particularly interesting and significant, because cotton plants during the three years experienced extreme environmental conditions each year. In 1989, "leaf burn" (Chu et al., 1991) affected cotton growth in July; in 1990, no extreme growing conditions were encountered; however in 1991, epidemic outbreaks of a new strain of sweetpotato whitefly *Bemisia tabaci* (Gennadius), occurred in July which caused premature cotton defoliation (Brown, 1992).

Salt content of cultivated soils in the southwestern desert is generally high and of particular concern in crop production. Furrow irrigation practices leach salt from soil improving crop growing conditions. A considerably lower water volume more frequently applied could aggravate soil salinity problems by bringing salt to top soils through evaporation. This could be a consideration on low water volume but more frequent irrigations. However, there was no evidence for increased salt accumulation in top 15 cm soils under the conditions of our study.

Results of investigations evaluating the concept of frequent but small amounts of water in furrow irrigation throughout the entire cotton growth and production period, as opposed to high volume delivery of water at longer intervals, or use of automated drip irrigation programmed in response to the evapotranspiration of plants, have suggested that significant increases in cotton yields can be obtained (Radin et al. 1992). The results of our study show that more frequent irrigation with reduced water volume during peak cotton fruiting can also be beneficial in increasing cotton yield in short-season cotton systems. This is particularly significant in view of the increasing interest in short-season cotton for earliness, more efficient crop management with less input and more efficient pest management, and development of optimal yields with increased profits.

References

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Table 1. Average and total amounts of water applied at 5-, 10- and 15-d intervals in July during a three-year study from 1989 to 1991 at Brawley, CA.

Irrigation interval (days)	Year 1989	1990	1991	Mean
	---------- mm ----------			
5	44 (264)+	42 (252)	40 (240)	42 (252)
10	93 (279)	76 (228)	74 (222)	81 (243)
15	135 (270)	153 (309)	102 (204)	130 (260)

\+ Denotes amount of water each time and total in parenthesis.

Table 2. Effect of irrigation intervals in July on cotton lint yields at Brawley, CA.

Irrigation intervals (days)	Lint Yield				
	1989	1990	1989-90 Mean	1991	1989-91 Mean
	kg ha^{-1}				
5	883 a*	1896 a	1389 a	1778 a	1519 a
10	808 a	1805 a	1306 b	1614 b	1409 b
15	843 a	1787 a	1315 b	1608 b	1413 b

* Means in a column with different letters differ significantly (Student-Keuman-Keul's Multiple Range Test, $P \leq 0.05$).

Table 3. Effect of irrigation frequency on the 0-15 cm soil salinity at Brawley, CA - 1991

Variable	EC25†
	$dS \times 10^3 m^{-1}$
Irrigation interval	
5-day	3.59 a‡
10-day	3.71 a
15-day	4.16 a
Location in field	
Top of bed	6.27 a
Side of bed§	2.46 b
Furrow	2.74 b

† Electrical conductivity at 25°C.
‡ Means of a variable in a column within with different letters differ (orthogonal comparison ($P \leq 0.05$).
§ In the middle between top of bed and furrow.