EVALUATION OF IRRIGATION INTERVAL ON HIGH PLAINS COTTON PRODUCTION WITH LEPA SYSTEMS

James P. Bordovsky and William M. Lyle
Texas Agricultural Experiment Station
Lubbock/Halfway, TX

Abstract

Two experiments were conducted in the Texas High Plains to determine the effect of irrigation interval with Low Energy Precision Application (LEPA) on cotton lint yield at several levels of water availability. High frequency, light irrigations are required by LEPA to maintain dikes and prevent runoff. Results show LEPA irrigation at intervals down to 2 days did not reduce yield as one might expect in a high evaporative environment. Rather, 2 and 3-day intervals were beneficial in the production of cotton lint particularly at very deficit levels of irrigation.

Introduction

The low energy precision application (LEPA) irrigation concept was developed to maximize the use of seasonal rainfall and increase irrigation efficiencies in arid and semi-arid areas. It was targeted to areas experiencing declines in water availability due to dropping water tables, dwindling surface supplies, or supply decline from other socio-economic reasons (Lyle and Bordovsky, 1981). The LEPA concept requires retention of all applied irrigation water and was designed to be independent of soil intake rate due to the relative high-volume water applications to small areas. This normally requires soil surface manipulation (furrow diking) possibly combined with stubble or residue management to increase surface storage capacity. Proper LEPA management requires frequent irrigations with amounts smaller than traditional delivery systems to reduce degradation of surface modifications and prevent runoff.

High frequency irrigations during the growing season are impractical with most delivery systems. Furrow irrigation requires relatively large quantities of water delivered at infrequent intervals to maintain distribution efficiency. Center pivot systems equipped with spray nozzles also require high irrigation volumes to minimize spray and soil surface evaporation losses caused by high wind speeds and low relative humidity in semi-arid areas. LEPA typically wets less than 40 percent of the soil surface and channels water into narrow bans in the bottom of alternate furrows, thus reducing opportunity for evaporative losses even with light-frequent irrigations. Also, evidence exists that there are benefits to high frequency cotton irrigation. Low volume drip irrigation systems have resulted in increased cotton yields due to increased frequency of application (Radin et al., 1989). Whether these benefits are due to reduced soil evaporation loss associated with the delivery system or due to a physiological response to frequent wetting of the plant is not clear.

A series of experiments were conducted in 1986 through 1988 in which cotton was irrigated at intervals from 3 to15 days by the LEPA method. An additional experiment was conducted from 1995 to 1998 with cotton irrigated at intervals from 1, 2 and 3 days. In both trials, irrigation frequency was independently evaluated at irrigation levels ranging from near 40 to 100 percent of peak evaporative demand. The latter experiment restricted quantities by limiting pumping rates to 0.1, 0.2, and 0.3 inches/day. The purpose of this paper is to summarize cotton yield response to LEPA irrigation at intervals ranging from 1 to 15 days at different levels of water availability.

Procedures

These studies were conducted at the Texas Agricultural Experiment Station at Halfway, Texas on an Olton loam (fine, mixed, thermic *Aridic Paleustolls*) soil with very low permeability (0.1 inch/hr) and a slope of 1% or less. Irrigations were applied to alternate diked furrows by the LEPA method with a modified linear irrigator (Bordovsky, et al., 1992). Furrow dikes were maintained in all furrows to capture rainfall and retain applied irrigation water. Dikes were removed in non-irrigated furrows in early August to facilitate crop termination and harvest. Preplant irrigations with LEPA raised profile water content to approximately 85 percent of field capacity prior to planting based on neutron readings. Paymaster 145 and HS26 cotton varieties were planted in the 1986-88 and 1995-98 experiments, respectively. Normal cultural practices were used to control weed and insect pests. Areas (26.2 row-ft) were harvested by hand within each replicate of all treatments. Yield samples were ginned with the small TAES gin stand at Lubbock. Cotton lint yield was determined for each treatment.

1986 to 1988 Experiment

Irrigations were applied at intervals of 2, 4, 8, and 12 days in 1986 and 3, 6, 9 and 18 days in 1987 and 1988. To make multiple year statistical comparisons of the yield data, interval treatments in 1986, 1987, and 1988 were grouped as 3-day (irrigated every two or three days), 5-day (every four or six days), 9-day (every eight or nine days), and 15-day (every 12 or 18 days). Cotton evapotranspiration (ET) was estimated from daily weather data measured near the test site using a modified Penman equation and a locally derived crop coefficient. The base irrigation amount (1.0BI) was determined by subtracting rainfall from the cumulative crop ET since the last irrigation. The four irrigation quantity treatments were fractions of BI and ranged from very deficit to full irrigation (0.4BI, 0.6BI, 0.8BI, and 1.0BI). Additional treatments received preplant irrigations only (DRY) and were used a checks. All

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treatments were replicated four times. Irrigations began at the "first bloom" cotton growth stage unless delayed by rainfall. Irrigations were terminated within three days of the last 15-day irrigation each year. All quantity treatments received identical volumes of seasonal irrigation each year.

1995 to 1998 Experiment

Decisions related to irrigation initiation, termination, quantities, and the integration of rainfall were based on the comparison of calculated and target soil water contents as well as irrigation delivery rates (Bordovsky and Lyle, 1996). Calculated soil water content (estimated field content) was determined daily using local irrigation and effective rainfall amounts and regional ET and heat unit (dd60) data obtained from the South Plains PET network. Target soil water content was 85 percent field capacity from emergence to peak bloom (1480 heat units), declined linearly to 40 percent field capacity at 2080 cumulative heat units, and was held at 40 percent field capacity for the remainder of the irrigation season. Irrigations were initiated if calculated soil water (field conditions) were less that target water content. Irrigation delivery rates of 0.1, 0.2, and 0.3 inch/day limited application amounts. These quantities correspond to 1/4-mile pivot flow rates of 233, 470, and 700 gpm and represent pumping rates of 1.9, 3.8, and 5.7 gpm/acre. Plots were irrigated on 1, 2, and 3-day intervals. Irrigations were terminated with the maturity of upper bolls or at the beginning of a significant cooling trend. The field experiment included five replicates of the 9 treatments (3 intervals x 3 irrigation capacities) plus preplant only irrigated checks.

Results

These tests were conducted in the northern (and coolest) part of the Texas High Plains cotton growing region. Weather conditions known to retard cotton plant and fiber development are possible and have a significant impact on lint yield. Growing seasons during the 1986 to 1988 experiment were wetter and slightly cooler than during the 1995 to 1998 experiment. Average annual rainfall from May through September was 15.5 and 10.7 inches for the respective experiments compared to the historical average of 12 inches. Average annual heat unit accumulation during the first 130 days following emergence was 1844 heat units (dd60) in the earlier test period compared to 1905 heat units in the latter period. Figure 1 compares cotton lint yield from the two time periods as affected by total seasonal irrigation. Yields result are from LEPA irrigation at 3-day intervals. During the 1986-88 period, cotton yields responded negatively to increased irrigation, while during the 1995-98 period, larger irrigations resulted in higher lint yield. The change in irrigation scheduling protocol between the two periods may have helped prevent the negative effects of over irrigation in the latter test period, however, most of the difference in yield is attributed to the weather. These data support the hypothesis that cotton lint yields can be reduced if irrigation quantity is not carefully controlled in geographic areas that have a predominantly short growing season.

1986 to 1988 Experiment

As time between irrigations was reduced, average lint yield increased at all deficit quantity treatments below 0.8BI. Figures 2 through 5 show lint yield as a function of irrigation interval at each of four irrigation quantities. The 3-day treatments average 11 irrigations per growing season and the 15-day treatments averaged 3 irrigations per growing season. At the 0.4 BI quantity, which averaged 3.1 inches of seasonal irrigation per year, yields increased by 8.5 percent when irrigations occurred every 3 days with amounts of approximately 0.3 inch/application compared to irrigations every 15 days with amounts of 1.0 inch/application. At 0.6BI, which averaged 4.8 inches of seasonal irrigation per year, yields increased by 7.3 percent, and at 0.8 BI, which averaged 6.4 inches per year, yields increased by 13.4 percent when irrigations were applied every 3 verses 15 days. These yield increases, however, were not statistically significant ($P<0.05$, Duncan) except at 0.8BI. At the 1.0BI quantity, 15-day yield was 843 LB/acre compared to 3-day yield at 836 LB/acre.

1995 to 1998 Experiment

Average cotton lint yields resulting from irrigation intervals of 1, 2 and 3 days, are given in Figure 6, 7 and 8. There were no statistically significant ($P<0.05$, Duncan) yield differences due to irrigation interval when the irrigation capacity treatment equaled or exceeded 0.2 inch/day. Average yields were virtually identical for all 0.2 inch/day capacity treatments at 1091, 1077, and 1088 LB lint/acre for the 1, 2 and 3-day intervals, respectively. At the 0.3 inch/day irrigation capacity, 3-day interval yields were slightly higher at 1156 LB/acre than either the 1 or 2-day interval at 1113 and 1101 LB/acre, respectively. However, when capacity was severely limited (0.1 inch/day), irrigation every 2 days resulted in a significantly higher cotton lint yield at 978 LB/acre than either the 1 or 3-day treatments at 897 and 911 LB lint/acre.

Summary and Conclusions

In order to maintain soil surface modifications that prevent irrigation runoff, LEPA requires more frequent irrigation than what is practical with either spray or furrow systems. The primary concern with high frequency irrigation has been increased opportunity for extreme soil-surface evaporation losses in our semi-arid environment. Experiments conducted from 1986 to 1988, which were wetter than normal, and from 1995 to 1998, which were dryer than normal, show LEPA irrigation at intervals of 2 or 3 days is not harmful, but rather, beneficial in the production of cotton on the Southern High Plains. When irrigating with quantities of less than the evaporative demand of the crop, decreasing the time between irrigations down to 2 days increased lint yield. Lint yield increases associated with the reduction in irrigation interval may be attributed to more efficient nutrient uptake, reduction in root regeneration after a dry periods, more optimum water-oxygen environment in the root zone, or other factors. However, at the 1-day interval, soil surface evaporation apparently depleted such a high portion of the small daily irrigation amount (0.1 inch/day) that yields were reduced regardless of benefits to the root environment. Generally, differences among interval treatments decreased as seasonal irrigation amounts increased.

Acknowledgments

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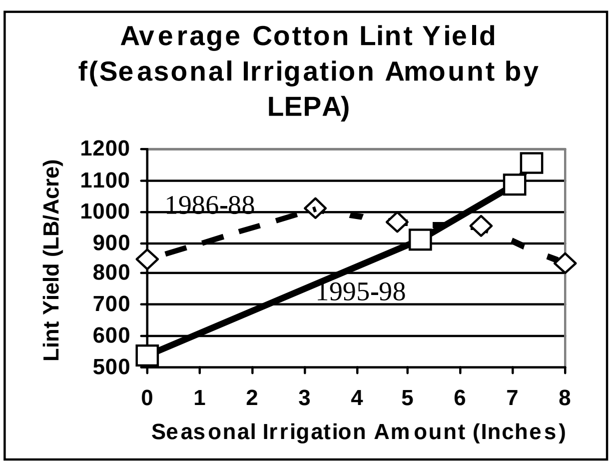

Figure 1. Comparison of average annual cotton yields from 1986 to 1988 and from 1995 to 1998 as a function of seasonal irrigation quantity delivered by LEPA at 3-day intervals.

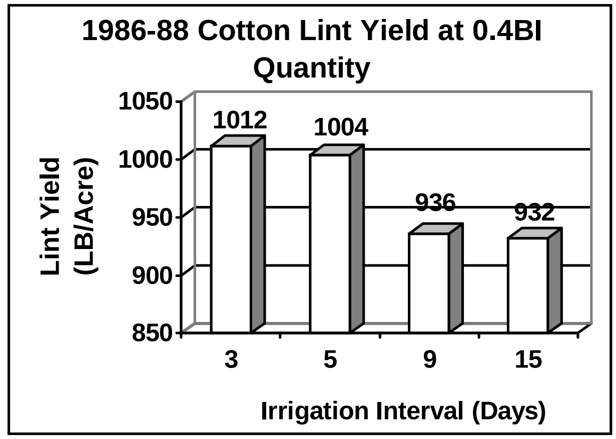

Figure 2. Average cotton lint yield resulting from LEPA irrigation at 3, 5, 9 and 15-day intervals at the 0.4BI quantity in 1986 to 1988.

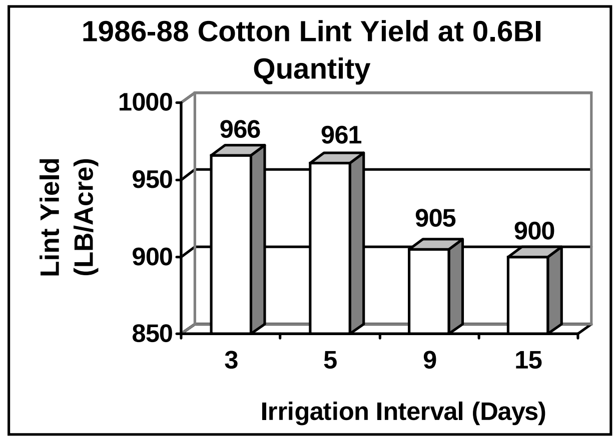

Figure 3. Average cotton lint yield resulting from LEPA irrigation at 3, 5, 9 and 15-day intervals at the 0.6BI quantity in 1986 to 1988.

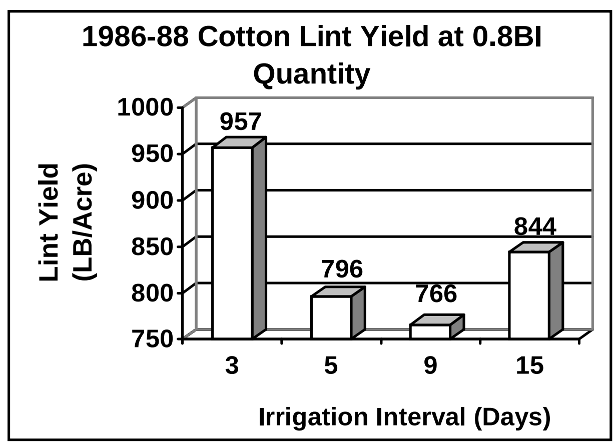

Figure 4. Average cotton lint yield resulting from LEPA irrigation at 3, 5, 9 and 15-day intervals at the 0.8BI quantity in 1986 to 1988.

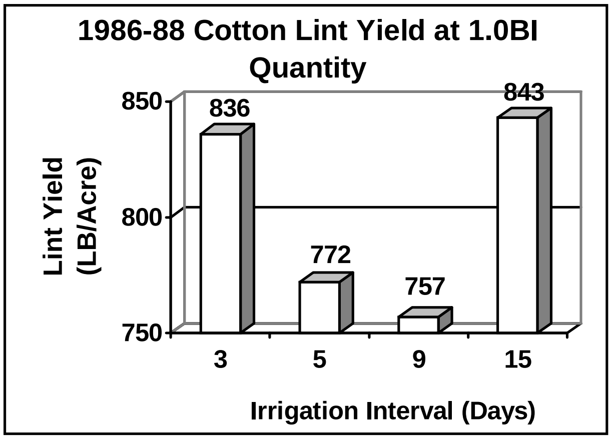

Figure 5. Average cotton lint yield resulting from LEPA irrigation at 3, 5, 9 and 15-day intervals at the 1.0BI quantity in 1986 to 1988.

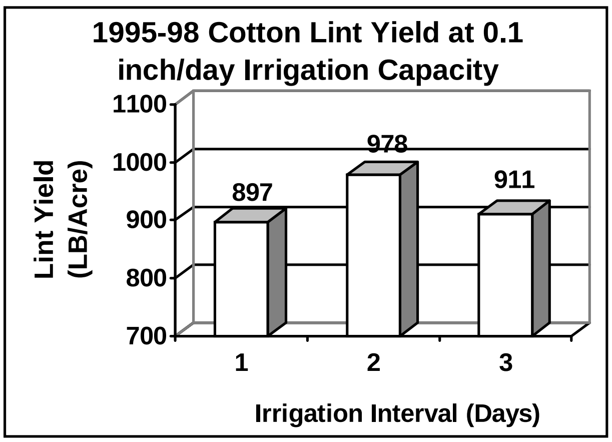

Figure 6. Average cotton lint yield resulting from LEPA irrigation at 1, 2, and 3-day intervals at the 0.1inch/day capacity in 1995 to 1998.

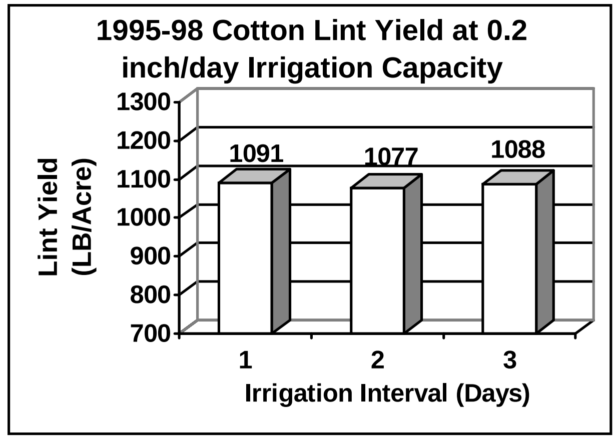

Figure 7. Average cotton lint yield resulting from LEPA irrigation at 1, 2, and 3-day intervals at the 0.2inch/day capacity in 1995 to 1998.

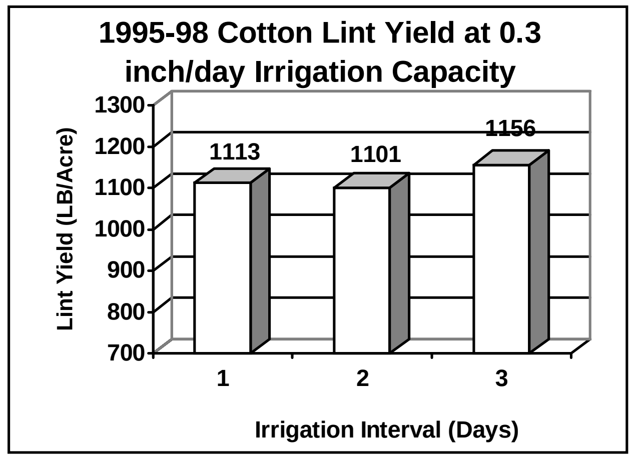

Figure 8. Average cotton lint yield resulting from LEPA irrigation at 1, 2, and 3-day intervals at the 0.3inch/day capacity in 1995 to 1998.