Irrigation Efficiencies and Lint Yields of Upland Cotton Grown at the Maricopa Agricultural Center, 1993

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Abstract

The computer program AZSCHED, with weather data obtained from AZMET, was used to schedule irrigations for a yield trial of early season Upland Cotton (DPL 20) at the Maricopa Agricultural Center. Cotton lint yields were compared between plots from five treatments involving five irrigation efficiencies (50%, 65%, 75%, 90% and 110%). As in previous years, a potassium bromide tracer was applied to select areas in each plot to monitor the movement of water and nitrates down the soil profile. The total amount of fertilizer as nitrogen applied in two split applications and sidedressed was 100 #/a. The total amount of water applied to the plots ranged from 42.7" for 50% to 26.6" for 110% (deficit) irrigation efficiency. The plots were harvested on October 5, 1993. There was a significant difference in lint yield between the irrigation efficiency treatments. The 50% irrigation efficiency treatment produced 1190 # lint/acre while the 110% efficiency produced 883 # lint/acre.

Introduction

Water is a limited resource in the desert Southwest and as such, is a major cost associated with agriculture. As cities grow, there will be more competition for the limited amount of water available. Conservation from both the agricultural and urban communities will be necessary to meet the demand for water in the future.

One method of conserving agricultural water is to increase irrigation efficiency. Enough water should be applied to a field to meet the consumptive use of a crop and leach salts out of a root zone. An irrigation efficiency of 100% would supply enough water for the consumptive use of the crop, but would not provide the additional water needed for leaching salts. Less efficient irrigations would provide the additional water needed to leach salts past the root zone.

Once the water is leached past the root zone, it has the potential to enter the ground water supply. The potential for ground water contamination is a concern from a regulatory point of view. Fertilizer, such as nitrates, move through the soil profile with the flow of water. Nitrates not utilized by the crop move past the root zone and may enter the ground water supply. Leaching is also a concern financially. How much water is required to leach salts? Water lost to leaching is a loss of money, but it is necessary for long term crop production.

This yield trial compares the lint yield of DPL 20 grown under five irrigation efficiencies. Nitrate movement down the soil profile will be monitored at the end of the growing season.

Materials and Methods

A randomized complete block design was used to compare lint yields of DPL 20 grown under five irrigation efficiencies (50%, 65%,75%,90% and 110%). With three replications and 5 different treatments, there were a total of 15 plots.

The field was prepared by ripping, discing and laser leveling. Preseason soil samples showed little residual nitrogen (about 6ppm), so 50 #N/acre was applied before bed preparation (Doerge et.al 1991). This rate was slightly higher than the most conservative application recommended (30#N/acre) but was consistent with recommended rates On April 9 1993, DPL 20 was planted into these beds at a rate of 10 # of seed/acre. At this time, Potassium Bromide (KBr) was applied to selected areas in the 15 plots.

Each plot was 390' long and six (40") beds wide. The first irrigation was on April 15, 1992. Nine additional irrigations were scheduled during the growing season up to August 11th. Irrigation amounts were based on the AZSCHED computer program. Water was measured and applied by the use of an in-line meter and gated pipes.

Based on petiole nitrate analysis, ammonium sulfate was sidedressed to the crop at a rate of 50# N/a on June 30 1993. Defoliant was applied on September 14, 1992 and the crop was harvested on October 5, 1993. The two middle rows of each plot were harvested for yield. Subsamples of seed cotton from each plot were taken to determine lint yield.

After harvest, soil samples were taken to a depth of 15' in the areas of each plot where KBr was applied. These samples will be analyzed to determine the depth of bromide and nitrate movement in the soil profile.

Results and Discussion

Results and data of the yield trial are presented in Figures 1 and 2 and Table 1.

The amount of water applied to the newly planted field averaged 5 acre-inches (Figure 1). This was the minimum amount of water needed to wet the soil after planting. The first irrigation amount has varied from 3" up to 10" in previous years (Sheedy and Watson 1992,1993) depending upon the type of seedbed preparation and the consequent volume of water required to adequatly moisten the seedbed. The following two irrigations (post-planting irrigations 1 and 2) were 1" in excess of the AZSCHED recommendation but this was needed so the water would uniformly fill the furrow. The remaining irrigations were based on AZSCHED recommendations, for each desired efficiency. However, the first five irrigations exceeded the AZSCHED estimated ET (evapotranspiration) since it was not possible to apply less than 2" of water per irrigation.

There was a significant difference in lint yield due to the different irrigation efficiencies (Figure 2, Table 1). Lint yields ranged from 883 #/acre to 1190 #/acre for the 110% and 50% irrigation efficiencies. The crop grown under higher irrigation efficiencies (90% and 110%) was irrigated with less water and produced less seed cotton and lint. More water was applied to the crop with less efficient irrigations and, of course, the crop produced more seed and lint. A significant increase in lint yield occurred between the 90% and 75% irrigation efficiencies (between 33.2" and 35.7" of water applied). Higher yields were obtained when more than 35.7" of water was applied to the crop, but the increases were only small and insignificant. In this field, the amount of irrigation water in excess of 35.7" was unnecessary. When compared with the 50% irrigation efficiency, almost nine acre-inches of water was saved by irrigating at 75% efficiency. Lint yields were substantially reduced when less than 35.7" of water was applied to the crop.

It should be noted that the irrigation efficiencies actually attained were somewhat different from those attempted, as shown in Table 1. This was due primarily to the inability to more completely control the irrigations. A minimum amount of about 2 inches of water was required to be applied to the crop in order to get the water completely across the field. A maximum amount of about 6 inches could not be exceeded without eroding and overflowing field borders and/or drowning the crop. These two constraints prevented us from applying as much water as needed to achieve the lowest efficiency of 50%, and from applying as little water as needed to achieve the highest efficiencies of 90% and 110%, without creating even more extreme stress conditions during the middle of the season. The difficulty of achieving the very high irrigation efficiencies of 90% and 110% (which in reality is a planned irrigation deficit, rather than a "true efficiency"), highlight the fact that early season irrigation control is crucial to optimizing irrigation efficiencies

A second comment should be made about the irrigation efficiencies and their calculation. We calculated irrigation efficiencies by dividing the AZSCHED Consumptive Use estimates by the total water applied. Other approaches could include (1) estimating Consumptive Use from volumetric water contents derived from neutron probe data, (2) calculating efficiencies solely from in season irrigations and view the applied water as that amount needed to replace the amount used by the crop for consumptive use between the first irrigation and the last irrigation, effectively ignoring the amount of water stored in the root zone by the first irrigation and the amount of consumptive use between the last irrigation and defoliation. We chose, rather, to account for irrigation water stored in the root zone from the first irrigation and to account for crop consumptive use for the entire season up through defoliation. Our rationale was that this most closely reflected the long term approach cotton producers need to use for optimum production and crop budget considerations.

The strong yield response to the additional water applied to the 50%, 65% and 75% irrigation efficiency treatments, compared with the lower water application rates at the 90% and 110% irrigation efficiency treatments, appears to be somewhat indicative of the determinant nature of the DPL 20 variety. When compared with yields of the indeterminant variety, DPL 90, in past years, underirrigation appears to have a more critical impact on the determinant variety. A comparison study is planned for 1994 to evaluate this hypothesis.

Bromide data analyzed for previous crop years (1991 and 1992), indicate that irrigation water applied at the beginning of the season generally remained in the root zone after the first irrigation. However, some movement below the root zone did occur by the end of the season. This year, the amount of water required to refill the root zone to a depth of five feet was approximately 6 to 9 inches, based upon preseason soil sample data and in season neutron probe data. Since the average amount of irrigation water applied with the first irrigation was 5 inches, we would also expect that this year no applied irrigation water was lost below the root zone (5 feet) from the first irrigation. Further, the excess water applied during the first four irrigations would likely only fill the root zone. Therefore, we do not expect any significant loss of water or nitrogen below the root zone resulting from the first four irrigations in this field. We do expect leaching losses to occur throughout the remainder of the season, consistent with the amount of applied water for each treatment.

Soil samples were taken to a depth of 15' and are being prepared for analysis of bromide to determine the depth of water movement down the soil profile. Once the analysis is complete, the amount of water leached past the root zone can be estimated for each of the five irrigation efficiencies.

References

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Doerge,T.A., Roth, R.L., Gardner, B.R. 1991. Nitrogen Fertilizer Management in Arizona. University of Arizona, College of Agriculture. Extension Bulletin 191025.

Figure 1.

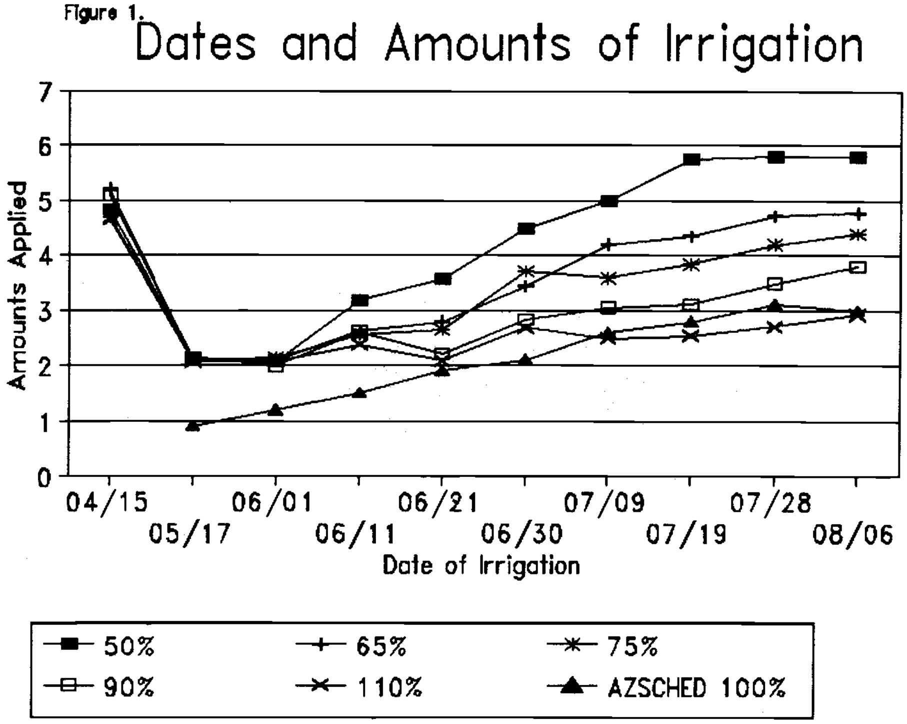

Figure 2.

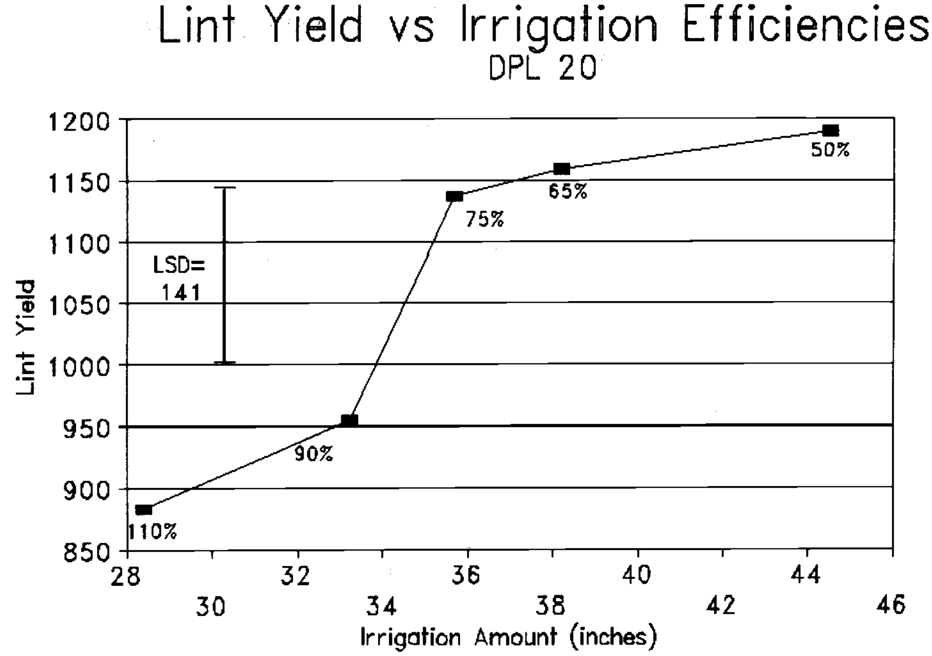

Table 1. Yield and Water Data for Each Irrigation Efficiency

Irrigation Efficiency Attempted	First Irrigation Amount	In-Season Irrigation	Rain	Average Total Water Applied	Actual 1993 Irrigation Efficiency	AZSCHED Estimated Consumptive Use (4/15 to 8/15)	Seed Cotton (#/A)*	Lint (#/a)**
50%	4.8	37.9	1.8	44.5	59	26.4	3126a	1190a
65%	5.2	31.2	1.8	38.2	69	26.4	3071a	1158a
75%	4.7	29.2	1.8	35.7	74	26.4	2903a	1136a
90%	5.1	25.3	1.8	33.2	82	26.4	2512b	955b
110%	4.7	21.9	1.8	28.4	93	26.4	2289b	883b

* Values followed by the same letter are not significantly different at the 5% probability level. LSD=377.
** Values followed by the same letter are not significantly different at the 5% probability level. LSD=141.