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Abstract

A field trial was conducted at the Maricopa Agricultural Center to observe the effects of four irrigation efficiencies (65%, 75%, 85%, and 95%) on the lint yield produced from two upland cotton varieties (DP 5409 and SG 125). Nitrogen requirements for the crop were determined using pre-season soil samples and in-season petiole samples in conjuction with crop monitoring data collected at weekly intervals. AZSCHED was used as a guide to the irrigation timing and amount of water applied during the season. The actual irrigation efficiencies obtained were less than what was targeted. The end season results were 59, 62, 62, and 68 %, respectively. This is due in part to the inherent inefficiency of irrigations in the early season. This year there was a lint yield response to the different irrigation efficiencies, but no difference in yield between the two varieties. Lint yields were significantly lower in the 95 % irrigation efficiency plots. Lint Yields ranged from 1058 and 1109 # lint/acre (DP5409 and SG125 at 95 %) to 1358 and 1353 # lint/acre (SG 125 and DP5409 at the 85 % irrigation efficiency).

Introduction

Water management and conservation can significantly reduce costs associated with cotton production. Improving irrigation efficiency on any particular field can conserve a large amount of water over the growing season. An efficient irrigation system will provide enough water to meet the growing requirements of the crop without any yield loss due to water stress while also providing enough extra water to leach salts past the root zone.

Increasing the efficiency of irrigations can be a costly and difficult endeavor. In 1991, at the Maricopa Agricultural Center (MAC), the first (pre-)irrigation required up to 10 acre-inches/acre of water to completely wet the seedbed (Sheedy and Watson 1992). In that particular field the soil water holding capacity is 1.6" per foot, so the pre-irrigation water actually saturated the soil profile to a depth of 6'. The residual water present in the soil profile before the pre-irrigation is replaced and becomes unavailable for crop use. The practical root zone of the cotton crop until the first post emergence irrigation is about 2' deep, so the water that saturated the soil from 2' to 6' deep can be considered an excess application of over 6". This excess results in less than 50 % irrigation efficiency.

Reducing the amount of water applied at the first irrigation of the season would save money and reduce the potential for loss of fertilizer salts due to leaching. An increased irrigation efficiency is often the result of an improvement in irrigation application uniformity. We have employed different methods in recent years in attempts to improve the uniformity and efficiency of the first irrigation. In 1990, a tractor was driven up and down the furrows to compact the soil and allow the water to run the length of the field unimpeded by large dirt clods present in the furrows (Scherer et. al. 1991). An increased water flow at the head end of the field was used to improve irrigation efficiency in 1992 (Sheedy and Watson 1993). The use of torpedoes can improve uniformity and thus reduce the amount of water required in an irrigation (Schwankl et. al. 1992). Short runs also allow a more uniform distribution of water across the field. These approaches, of course, apply to a laser leveled field in a basin irrigation setting.

Crop monitoring and plant growth characteristics can be used as a tool to follow the nutrient requirements and the overall health of the crop. Guidelines for different crop characteristics have been available from previous cotton reports (Silvertooth et. al. 1993). These guidelines are independent of the cotton variety grown and provide baselines and thresholds for the expected growth and development of cotton. The observations of Height:Node (H:N) ratios and petiole nitrate analysis are useful in the timing of fertilizer applications. As the season progresses, the nodes above white bloom (NAWB) and the fruit retention are recorded. The number of NAWB's indicate cutout and help in deciding the terminal irrigation (Silvertooth 1994). Regular monitoring of the crop signals trends in crop growth and alerts the grower to needed management decisions as well as provide the basis for these decisions.

In 1995, two upland cotton varieties were grown in a field at MAC. These two varieties were irrigated at four irrigation efficiencies to observe the effect of differing amounts of applied water on the crop growth characteristics and lint yield.

Materials and Methods

A split plot design was used to compare lint yields from DP 5409 and SG 125 grown at four irrigation efficiencies (65%,75%,85% and 95%). For each efficiency, there was a different amount of water applied to the crop at irrigation time. Lower efficiencies, of course had a greater amount of water applied than the higher efficiency treatments. Timing and amount of irrigation was determined by using the computer model AZSCHED.

The previous crop on this field was a pasture of barley used for grazing sheep. Pre-season soil samples showed a need for additional nitrogen fertilizer. In March 3, nitrogen was applied as ammonium sulfate (21-0-0) at a rate of 40 #N/acre. Before preirrigation, torpedoes were used to compact each furrow bottom. On March 23, the field was pre-irrigated with an average of 6 acre-inches of water and on April 5, the upland cotton varieties were planted at a rate of 8-10 # seed/acre.

Each plot was 400' long and six (40") beds wide. Twelve additional irrigations were scheduled during the growing season up to August 20th. On April 28, after emergence, a flash irrigation (2") was applied to the field to prevent desiccation of the seedlings. Other than this unscheduled irrigation, the following irrigations were based on the AZSCHED computer program. Water was measured and applied by the use of an in-line meter and gated poly-pipes.

Ammonium sulfate was side dressed to the crop at a rate of 45# N/a on May 10 and July 6. Defoliant was applied on September 8 and the crop was harvested on October 13. The two middle rows of each plot were harvested for yield. Subsamples of seed cotton from each plot were taken to determine lint yield and gin turnout.

Observations of plant growth characteristics were taken on a weekly basis to monitor the growth and development of the cotton crop. Petiole samples were analyzed for nitrates at MAC with use of an ion selective electrode. Height to node ratios and fruit retention levels were also recorded at the same time.

Results and Discussion

Results and data of the yield trial are presented in Table 1 and Figures 1 thru 5.

Lint Yield (Table 1)

There was significant difference in lint yield due to the irrigation efficiencies, but there was no difference in lint production between the two cotton varieties DP 5409 and SG 125. The difference in yield was limited essentially to the 95 % irrigation efficiencies vs the other three efficiencies. The largest amount of lint produced was from SG 125 (1358 # lint/acre) when irrigated at a 85 % irrigation efficiency, and the least amount of lint produced was from DP 5409 (1058 # lint/acre) when irrigated at a 95 % irrigation efficiency. The difference in the amount of water applied between these twoefficiencies is less than four inches but the end result is a significant loss in lint yield. When lint yields between these two varieties at the same irrigation are compared there is no difference between SG 125 and DP 5409. The greatest irrigation efficiency that could be maintained on this field in 1995 without a reduction in lint yield was 62%. Any greater efficiency (less water) would have, and in fact did, result in a significant decrease in lint production.

Irrigation Efficiencies (Figures 1 and 2)

The timing and amount of water applied during the season was determined by using the program AZSCHED. The total amount of water applied varied according to the irrigation efficiency that was targeted. Less efficient irrigations resulted in more water applied to the crop than irrigations with a higher efficiency. The irrigation efficiency treatments were 65 %, 75 %, 85 %, and 95 %. The bar graph below shows the irrigation efficiencies obtained from this field in 1995. Irrigation efficiencies were calculated as crop evapotranspiration (Et) ÷ amount of water applied.

Figure 1 shows a summary of irrigation efficiencies in the field.

1. End of season (weighted average) irrigation efficiency was calculated from 1995 seasonal Etc ÷ total applied water.

As a comparison, the in-season irrigations have been split into two separate categories: before layby and after layby. The efficiency of each individual irrigation was calculated. Then an average of these efficiencies was calculated for each of these categories.

2. The average of each irrigation efficiency at each irrigation before layby (non-weighted average).

3. The average of each irrigation efficiency at each irrigation after layby (non-weighted average).

The first calculation shows the results of the targeted irrigation efficiencies. The highest efficiency obtained was 68 % (Table 1) and this was supposed to be the 95 % treatment. The closest obtainable irrigation efficiency was the 65 % treatment (actual=59 %). Overall, the irrigation efficiencies for this year's field could not be achieved. This is due mainly to the inefficiency of early season irrigations as seen from Figure 1 : # 2 and Figure 2. For all treatments, the efficiencies of irrigations before layby averaged 30 %. The constant cultivation and tillage practices early in the season require a larger amount of water to be applied to the field. In addition, the amount of water needed to replenish the soil profile is often so little (~ 1") that an excess amount water must be applied to ensure an adequate distribution of water to the entire field regardless of irrigation treatment. After layby, irrigation efficiencies increase significantly (Figure 1 : # 3, Figure 2). This is due to a smooth furrow bottom which allows the irrigation water to be applied more accurately and efficiently. As for this field in 1995, the maximum total irrigation efficiency achieved was ~68%.

Crop Monitoring (Figures 3, 4, and 5)

Cotton petioles were collected at weekly intervals for preparation of nitrate analysis. Height to node ratios and fruit retention levels were obtained at the same time. Fertilizer applications were timed in accordance with petiole nitrate levels and height to node ratios (Figures 3,4, and 5). Height to node ratios as well as fruit retention levels remained well within the upper and lower thresholds during the season, so there were no great shifts between vegetative or stressed growth. Although petiole nitrate levels were low from the mid season on, no ill effect was noticed in the fruit retention levels or height : node ratios. Even though inflammatory comments were made and panic started to set in, no additional fertilizer was applied after July 7 1995. Overall, the results from crop monitoring indicated this to be the correct decision, and the yields were quite respectable for this year. Because of the tight control on inputs, a plant growth regulator application was unnecessary.

References

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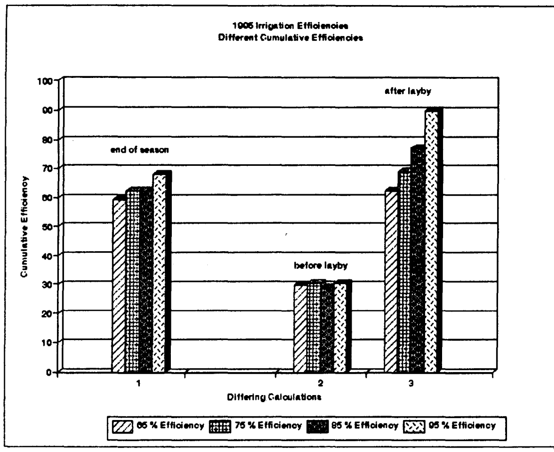
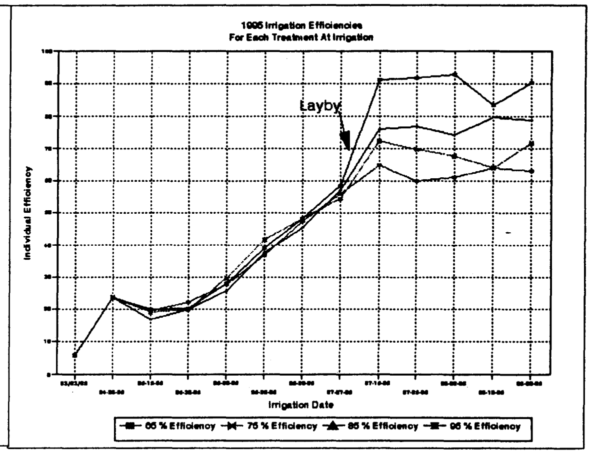
Table 1. Yield and Water Data for Each Treatment and Variety

Variety and Irrigation Efficiency	In-Season Irrigation (inches)	Rain (inches)	Average Total Applied Water	1994 Actual Irrigation Efficiency	AZSCHED Estimated Consumptive Use	Lint Yield* (#/acre)
SG 125 - 85 %	44.9	1.1	46.0	62 %	28 "	1358 a
DP 5409 - 65 %	47.3	1.1	48.4	59 %	28 "	1353 a
SG 125 - 75 %	45.0	1.1	46.1	62 %	28 "	1315 a
DP 5409 - 85 %	44.9	1.1	46.0	62 %	28 "	1305 a
SG 125 - 65 %	47.3	1.1	48.4	59 %	28 "	1295 a
DP 5409 - 75 %	45.0	1.1	46.1	62 %	28 "	1245 ab
SG 125 - 95 %	41.1	1.1	42.2	68 %	28 "	1109 b
DP 5409 - 95 %	41.1	1.1	42.2	68 %	28 "	1058 b

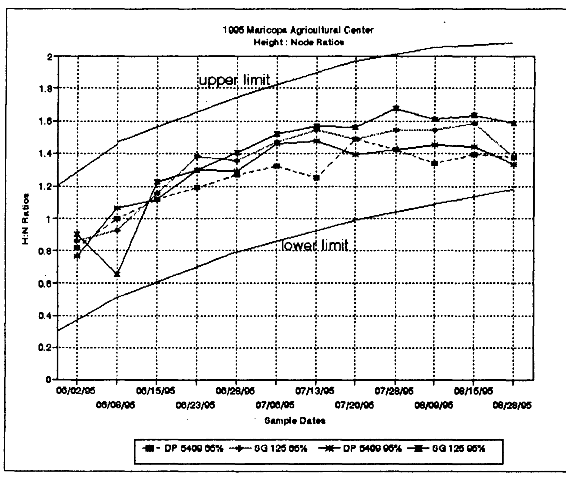
* Values followed by the same letter are not significantly different at the 5 % probability level. LSD=193.
** Values followed by the same letter are not significantly different at the 5 % probability level. LSD=122.

Figures 1 and 2. 1995 Seasonal Irrigation Efficiencies





Figures 3 and 4. Height:Node Ratios and Fruit Retention Levels for DP 5409 and SG 125.



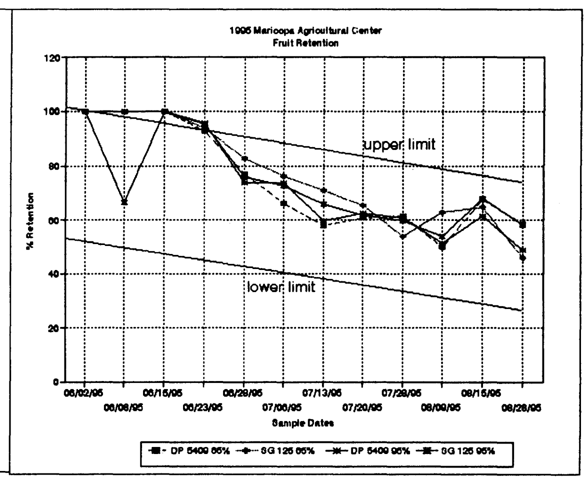


Figure 5. Petiole Nitrate Results for DP 5409 and SG 125 for the 65 % and 95 % Irrigation Efficiencies.