Evaluation of Irrigation Termination Affects on Upland Cotton, 1997

J.C. Silvertooth and E.R. Norton

Abstract

A single field study was conducted in 1997 at the Maricopa Agricultural Center (1,175ft. elevation) to evaluate the effects of three dates of irrigation termination on the yield of a common Upland cotton variety (DP NuCOTN 33b). Planting date was 9 April (668 HU/Jan 1 86/55° F thresholds. Three dates of irrigation termination (IT1, IT2, and IT3) were imposed based upon crop development into cut-out. The earliest irrigation termination date, IT1 (7 August) was made as early as possible in an attempt to provide sufficient soil-water such that bolls set at the end of the first fruiting cycle would not be water stressed and could be fully matured. The second termination (IT2) date was 20 August, and provided one additional irrigation over IT1. The final (IT3) date was 17 September, which was staged so that soil moisture would be sufficient for development of bolls set up through the last week of September and provide full top-crop potential. Lint yield results revealed no differences among any of the IT treatments. Mirconaire values increased slightly with later IT dates.

Introduction

One of the advantages associated with a cotton (*Gossypium spp.*) production system in an irrigated desert region such as Arizona, is the availability of a relatively long growing season, or a reliable supply of abundant heat units (HU). Traditionally, cotton production systems in the low (elevation) desert regions of Arizona (<2,000 ft. above sea level) have employed a long, full season approach. Such a long, full season approach would commonly involve a February or March date of planting with final irrigations being applied in September or October (depending on local conditions). Production over this period would include a completion of the first, or primary fruiting cycle, a cut-out period (hiatus in blooming), followed by a second fruiting cycle or top-crop. Accordingly, long season, indeterminate varieties were usually best suited to this type of production system. This is one of the reasons that Pima (*G. barbadense* L.) has been well adapted to this region.

In recent years, reduced or shorter season production systems, utilizing a smaller portion of the total available growing season have become increasingly attractive to Arizona cotton growers. The principle incentives associated with the interest in a reduced season approach include primarily insect pest pressures from pink bollworm (*Pectinophora gossypiella* (Sanders)) and whitefly (*Bemisia tabaci* (Gennadius)), and increasing costs of production (i.e. irrigation water). The inclement weather patterns associated with the summer monsoon season, which causes an increase in humidity (dew point temperatures), night temperatures, and a resulting increase in fruit loss and abortion on the crop also serve to limit yield potentials.

Overall, the objective with a reduced season approach to cotton production in the irrigated southwest is to achieve the highest degree of efficiency possible. To do so requires an identification of the point of diminishing returns with respect to a cotton crop. This is based on the assumption that yield potentials decline with time in the later stages of the growing season due to natural crop senescence, shorter day lengths, and cooler weather conditions (lower rates of HU accumulations).

Recent research in Arizona has attempted to address this issue by comparing a reduced season approach to that of a more traditional long, or full season system (Silvertooth et al., 1989; Silvertooth et al., 1990; Silvertooth et al., 1991; Silvertooth et al., 1992; and Silvertooth et al., 1993; Silvertooth et al., 1994; Unruh et al., 1995; Silvertooth and Norton, 1996; and Silvertooth and Norton, 1997). Summarizing this work, Unruh and Silvertooth (1997) reported on 12 site-years of data in Arizona comparing various planting and irrigation termination date combinations. The overall results from these studies revealed a most pronounced improvement in yield from an early date of planting and a generally small increase in yield from a late irrigation termination date. Comparing early and late IT treatments with an early date of planting, Unruh and Silvertooth (1997) found an average increase of 83 and 118 lbs. of lint/acre for DPL 90 and Pima S-6, respectively. Large increases in lint yield from a later IT were observed, but usually under conditions of very poor fruit retention over the primary fruiting cycle (up to cut-out).

Strategies associated with IT timing have been developed from the earlier studies previously mentioned. From that work it has been found that 600 HU (86/55 ° F thresholds) are required to develop a late season boll from a bloom to a full sized, hard boll when fiber length development is complete (Silvertooth et al., 1996). Approximately 400 additional HU are then required to complete boll maturation and opening, for a total of 1,000 HUs needed for boll development from bloom to open boll. Therefore, IT treatments are best structured to accommodate development of bolls intended for harvest to the point of full fiber development (600 HU post-anthesis). This commonly translates to a period of approximately 21 days in southern Arizona in August and September. Accordingly, adequate soil moisture must be maintained throughout this three week period for the last set of bolls intended for harvest. The exact IT date will therefore vary depending upon soil water holding capacities, amounts of water applied per irrigation, weather conditions, and crop condition. For example, if bolls set up to the point of cut-out are designated as those intended for harvest, final irrigations should be made so that adequate soil moisture is maintained for a three week (600 HU) period beyond the time of cut-out. The development of a top-crop usually requires irrigation and pest control for four to six weeks beyond cut-out, which for many systems equates to approximately an extra acre-foot of irrigation water and appropriate pest control to protect the developing fruit load.

The results of these projects have shown that in general, optimum agronomic yields can often be achieved with a reduced season approach, providing that a reasonable level of fruit retention (FR) is maintained through the completion of the first fruiting cycle (cut-out). If overall FR levels (accounting for the first two fruiting positions of all fruiting branches) are greater than approximately 40% at cut-out, we have found that extending irrigations and pest control several weeks beyond cut-out to accommodate a top-crop (second fruiting cycle) will yield a range of approximately 50 to 160 lbs. lint/acre above an early IT set to complete boll development established at cut-out. This commonly requires additional irrigations four to six weeks beyond the earliest IT. On the other hand, if FR is low at cut-out (40% or less), a much greater increase in yield can possibly be realized (200 to 400 lbs. lint/acre) from a later IT. The questions concerning top-crop potentials, the point of diminishing return, and optimizing yield and profit in Arizona appear to be a perennial part of the Arizona cotton industry. Therefore, the questions associated with IT remain critical in the management of an irrigated cotton crop toward optimal efficiencies and profit to the operation.

The objective of this study was to further investigate the issue of IT management and the subsequent effects on the growth, development, and yield of a common Upland (Gossypium hirsutum L.) variety. Continual development of research information relative to this issue is important for the development and refinement of recommendations provided by the University of Arizona Cooperative Extension.

Methods and Materials

This study was conducted in 1997 at the Maricopa Agricultural Center (1,175 ft.) on a Casa Grande sandy loam soil. The experimental design was a three treatment randomized complete block design with four replications. The treatments consisted of three IT dates, designated as IT1, IT2, and IT3. Each plot consisted of 8, 40 inch rows that extended the full length of the irrigation run (600 ft.). The entire study area was dry planted and watered-up on 9 April 1997 with DP NuCOTN 33b. All inputs such as fertilizer, water, and pest control were managed on an as-needed basis.

A complete set of plant measurements were collected from all plots on 14 day intervals. Measurements taken included: plant height, number of mainstem nodes, first fruiting branch, total number of aborted sites (positions 1 & 2), number of nodes above the top (1st position) fresh flower (NAWF), canopy closure, and number of blooms per unit area. Climatic conditions were also monitored using an Arizona Meteorological network (AZMET) site located on the station.

Field monitoring information indicated crop progression into the later stages of the first fruiting cycle by the week of 4 August. Therefore, the IT1 plots were provided the last irrigation on 7 August, as early as possible to accomplish complete fiber length development for bolls set the week of 4 August. IT2 provided one additional irrigation over IT1 and provided a means to determine if IT1 was made too early. Plots associated with IT3 were given the last irrigation on 17 September in manner consistent with supporting a complete top-crop development. All in-season irrigations were provided on an as-need basis, based on soil moisture evaluations on approximately 10 day intervals. The center 4 rows from each plot were harvested on 3 December to obtain seedcotton estimates. Gin turn-out averages for each treatment were used to calculate lint yield. Lint samples were subjected to complete HVI analysis.

Results

Crop vigor, as noted by height to node ratios (HNR) shown in Figure 1, were observed to be relatively low (below the middle baseline developed in Arizona (Fletcher et al., 1994; Silvertooth, 1994; and Silvertooth et al., 1996) in this study early in the season. In early bloom (~1500 HUAP) HNRs improved and were close to the normal baseline levels. Fruit retention (FR) levels (Figure 1) were low very early in the season but improved by peak bloom. FR retention levels dropped substantially between 2400 and 2800 HUAP, which was near cut-out. This drop in FR coincided with the arrival of monsoon weather conditions, an increase in humidity, as indicated by dewpoint temperatures > 55 °F. This pattern of FR was common for many fields in central AZ in 1997. FR levels were approximately 45% as the crop reached cut-out. Crop vigor was strong in the IT3 plots that were supported with irrigations and pest control for top-crop development.

Lint yield results are shown in Table 1. Lint yield differences were not found to be significant ($P \leq 0.05$) among any IT treatment. Therefore, gains in yield were not realized by pursuing a top-crop. Average micronaire values for the IT1 plots was 4.3, and increased with later terminations with values of 4.4 and 4.6 for IT2 and IT3, respectively.

These results are consistent with earlier work on this topic (Silvertooth et al., 1989; Silvertooth et al., 1990; Silvertooth et al., 1991; Silvertooth et al., 1992; and Silvertooth et al., 1993; Silvertooth et al., 1994; Unruh et al., 1995). A yield increase of up to approximately 140 lbs. lint/acre are common from top-crops developed from fields with satisfactory FR levels (approximately 45% FR) at the completion of the first fruiting cycle, which was experienced in this same experiment in 1995.

Continual investigation into this issue is valuable for the validation and refinement of University of Arizona Extension guidelines and recommendations. Each season growers address this question in many fields across Arizona. University of Arizona comments and recommendations are distributed regionally on a weekly basis based upon current conditions (Brown et al., 1992; Brown et al., 1993; Brown et al., 1994; Fletcher et al., 1994; Silvertooth, 1994; Brown et al., 1995; Brown et al., 1996; and Brown et al., 1997). Further validation and demonstration of these techniques on grower-cooperator fields have also been conducted in recent years (1993-1996) which are also extremely valuable in the refinement at a production level. These demonstrations have provided results that are very consistent with experiment station projects.

In the current economic climate, improving production efficiencies are critical to the survival of cotton farms in Arizona. With a crop like cotton (perennial and indeterminate growth habit), in a climate such as we have in Arizona, the identification of the point of diminishing returns is an important point of consideration for the efficient management of the crop. This must be addressed on a field by field basis for accuracy. However, information from studies such as this provide the basis for understanding the conditions that provide the greatest probability of realizing a yield increase from late season or top-crop production.

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Table 1. Lint yield means for each irrigation termination treatment, DP 33b, Maricopa, AZ, 1997.

Irrigation Termination Date	Lint Yield lbs. Lint/acre
Trmt 1 (7 August)	1813 a
Trmt 2 (20 August)	1771 a
Trmt 3 (17 September)	1840 a
LSD†	NS
OSL‡	0.1315
C.V. (%)§	2.25

*Means followed by the same letter are not significantly different according to pairwise comparisons using a Fisher's LSD.

† Least significant difference

‡ Observed significance level

§ Coefficient of variation

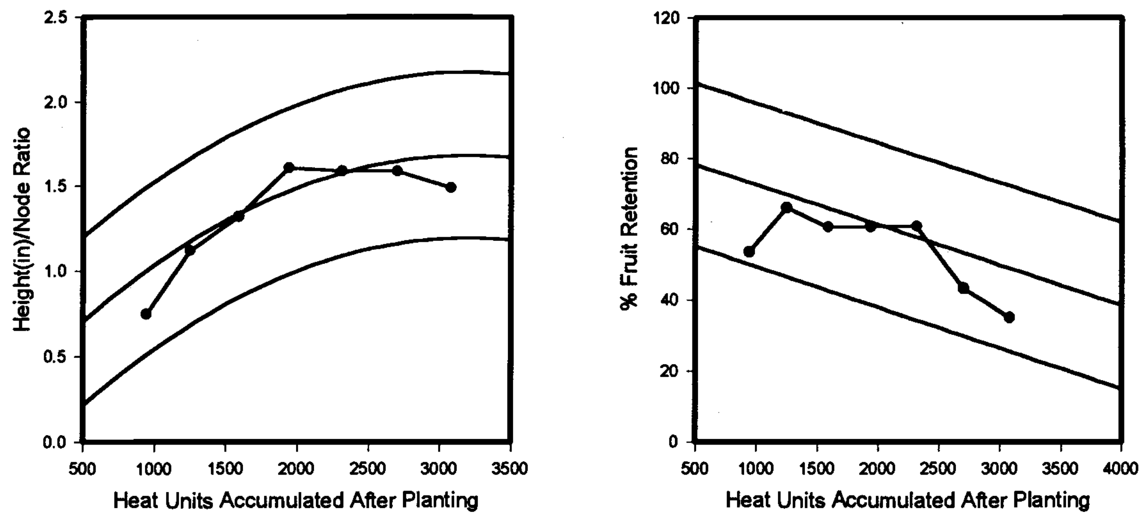

Figure 1. Height to node ratio and fruit retention levels, irrigation termination study, MAC, 1997.

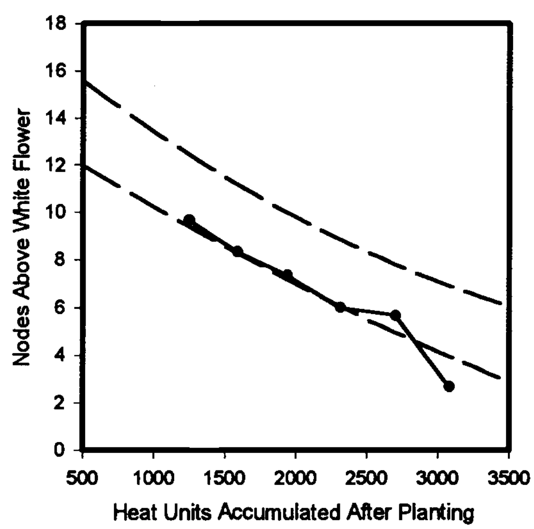

Figure 2. Nodes above top white flower (NAWF), irrigation termination study, MAC,1997.