Evaluation of Date of Planting and Irrigation Termination on the Yield of Upland and Pima Cotton

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ABSTRACT

Three field experiments were conducted in 1989 in Arizona to evaluate the response of Upland and Pima cotton to two dates of planting and two dates of irrigation termination. Planting dates ranged from as early as 22 February in the Yuma Valley (150 ft. elevation) to 4 May at Marana (2,000 ft. elevation). Dates of irrigation termination ranged from 27 July in the Yuma Valley to 8 September at Maricopa and Marana. Based upon the final lint yield, planting date provided a significant main effect within two of the three experimental locations (Yuma Valley and Marana). At the Maricopa location, there was a significant effect on yield due to date of irrigation termination with both 30-inch- and 40-inch-row Upland cotton experiments, resulting in differences of 167 and 157 lbs. lint/acre, respectively, by extending two irrigations (approximately 12 acre-inches) past 10 August to 8 September. The Pima experiment at Maricopa was similar with a significant ($P \leq 0.05$) response to two additional irrigations (approximately 12 acre-inches) of 184 lbs. lint/acre. Return from additional lint yield must be considered against additional costs (water, insect control, etc.), as well as possible quality losses from insect infestations.

INTRODUCTION

Arizona cotton (Gossypium spp.) growing areas, for the most part, have a potentially long growing season. Based on long-term historical averages, locations such as Yuma Valley, Litchfield Park, and Coolidge will accumulate 4,121, 4,149, and 4,038 H.U. (heat units with 86/55 F thresholds), respectively, from 1 April to 1 October. Traditionally, at the lower elevations in the state (below 2,000 ft.) the cotton growing season has been extended in excess of 200 or 250 days in an effort to make use of the available season (heat units) and strive for maximum absolute yield potentials. However, there are many factors to consider with regard to pursuing long, full season cotton production versus the use of an earlier termination of the crop and a shorter season production scenario. The relative merits of a short- versus full-season production has been discussed and debated within the Arizona cotton industry for many years. Important factors considered have always included the use of cultural production practices in conjunction with biological constraints of certain insect pests in an effort to achieve greater control over these pests; the conservation of major inputs such as water, fertilizer, and insecticide costs due to an earlier crop termination; and the preservation of high quality cotton lint (Farr, 1989; Silvertooth and Terry, 1989). These have always been important considerations, but factors such as high water costs in many areas, and the threat of diminished quality due to late season insect infestations, such as whitefly, have created additional incentive to cotton growers to consider a shorter season management approach than may have been traditionally practiced.

With this general background, and drawing from earlier research work with date of planting experiments and irrigation termination experiments, a project was initiated in 1989 with the objective of developing agronomic guidelines adaptable across a range of conditions in Arizona (basically below 2,000 ft. elevation) for pursuing an optimization of Upland (G. hirsutum L.) and Pima (G. barbadense L.) cotton production. Planting dates were chosen with one date close to an optimum (based on weather conditions and earliest date of planting research) and a second date slightly past an optimum point. This was due to the fact that highest yields often are obtained with more indeterminate varieties, which also respond to delays of planting past an optimum period with substantial declines in yield potential and increased vegetative tendencies (Silvertooth, et al, 1989). The dates of irrigation termination were selected with the initial date of termination being imposed at a time after cut-out in the Upland crop, so that bolls set prior to cut-out could be matured with adequate soil-water available through that period. That estimate requires a projection of time (heat units) needed to mature the fruit in question, the water-holding capacity in the soil, and then the amount of irrigation water needed to maintain available soil water over that period. The first date of termination with the Pima crop must be somewhat more subjective or arbitrary due to a more sustained flowering and fruiting phase, and often no distinct cut-out. Thus, this must be adjusted based upon the season and the fruiting pattern of the crop. The second date of termination is to be directed towards usually two additional irrigation events past the early termination, allowing for more boll set and development as would occur with the development of a "top crop" or second fruiting cycle as in the case of the Upland crop.

METHODS

Four field experiments were initiated in the spring of 1989 on The University of Arizona Agricultural Centers (Yuma Valley, Maricopa, and Marana) to evaluate the effects of planting date and irrigation termination date on the quality of lint, yield, and impact on insect management, on both Upland (Gossypium hirsutum L.) and Pima (G. barbadense L.) cotton. For each experiment, there were two dates of planting and two dates of irrigation termination imposed on both species of cotton (Table 1). In all experiments, Deltapine 90 and Pima S-6 were the Upland and Pima varieties used. Treatments were arranged with planting dates as mainplots, irrigation termination dates as subplots, and varieties (species) as sub-subplots for a split-splitplot within a randomized complete block design with four replications in all experiments. Experiments with 40-inch row spacings were established at all locations, with a single experiment with 30 inch row spacings established at the Maricopa location only, due to equipment availability. In all experiments, the sub-subplots, subplots, and main-plots were eight, 16, and 32 rows wide, respectively, and were continuous through the entire irrigation run (length of the field).

Procedures for plant growth measurements were initiated early in the season and carried out on regular 10- to 14-day intervals through the month of August. Measurements taken within each distinct plot included: plant heights and number of mainstem nodes for 10 consecutive plants, and flower numbers (fresh blooms) per 25 row feet samples (0.002 acre). Nitrogen fertility status was monitored in season by use of NO_3^--N analysis of cotton petiole samples. Irrigation and other management factors were provided on an as-needed basis.

Yield measurements were made using a two-row mechanical picker, harvesting the entire center four rows of each sub-subplot unit. Samples from each plot were analyzed for quality factors.

RESULTS

Yuma

Analysis of variance of yield data from Yuma revealed no significant differences (P \ 0.05) due to the main effects for planting date or irrigation termination date, or for an interaction term in the case of Pima (Tables 2 and 3). The same was true for the Upland cotton, except for a significant main effect due to planting date. In the latter case, means for Upland lint yield (lbs/acre) averaged across dates of irrigation termination were 1732 and 1463, respectively, for the 22 February and 16 March dates of planting. It is also worth noting that the Yuma experiment experienced a severe storm on 27 July. Wind speeds up to 80 mph were recorded at the Yuma Valley Agricultural Center for over an hour period, with rainfall amounts of approximately 2 inches. The resulting damage left the plants with a seriously diminished canopy in terms of photosynthetic capacity. Subsequent irrigations provided to the second irrigation termination date were not as potentially beneficial to late season development of the crop under these circumstances as they may have been otherwise. Therefore, it is not surprising to find that the earlier planting date (22 February) had a significant yield advantage over the 16 March planting date. This is particularly true under the early season weather conditions which prevailed in 1989, being very conducive to early season fruiting and crop growth.

Maricopa

Yield results for the 30- and 40-inch Upland experiments are shown in Tables 4 and 5. In general, the longer production periods (earlier planting and later termination) produced higher total yields (Table 4), but the only significant main effect experimentally was due to irrigation termination date. There was also a very close relationship in yield between the 30- and 40-inch row systems with corresponding planting and termination date combinations (Table 4). Table 5 outlines the Upland yield results due to irrigation termination date for both 30 and 40 inch row systems, averaged over planting dates.

Differences in yield obtained from an additional 12 acre-inches of water due to later termination, are translated into monetary terms by use of $0.60/pound price of short staple cotton lint. Financial benefit would then be dependent upon the costs of water, insect control, and inputs needed to sustain the crop, as well as fixed cost considerations. The early termination in this case (and all experimental cases) is due to bolls set up to cut-out. The second termination date was obviously able to promote the development of a second fruiting phase or top crop to some extent.

Whitefly infestations characteristically develop to high levels late in the season, and the damage to the lint, as a result of the honeydew excrement, is another important consideration in terms of irrigation termination of the crop. This is true for both Upland and Pima cotton. The Pima yields for both termination dates are shown in Table 6, averaged over both planting dates. Differences in yield and lint value estimates also are provided, with $1.00/pound of ELS lint used for comparison of the two termination dates. Similar to the Upland cases, the differences in termination represented approximately 12 acre-inches of water. The impact on quality is of paramount concern in the case of Pima cotton, particularly in light of late season whitefly populations. However, it is well demonstrated in Table 6 why Pima cotton is very often grown in a full season scenario due to its more indeterminate nature than Upland cotton, and the late season yield enhancement that is possible.

Marana

The yield results from Marana are shown in Tables 7 and 8. The only significant ($P \leq 0.05$) main effect was for planting date, for Pima cotton only. Therefore, yields are averaged over termination dates and listed for both Upland and Pima in Table 8. The difference in yield and associated estimates in value for Upland in this case must be regarded with caution due to lack of significance due to planting date, termination date, or interaction terms. However, for the Pima results, the earlier (14 April) planting date expressed a clear advantage over the later (4 May) planting date. This is not surprising in that 1989 was an exceptionally good season for early crop development and yield expression. These results also support several years of research evaluating date of planting effects at Marana and other locations (Silvertooth, et al, 1989). The later planted crops in this study were taller at season's end, and much more vegetative in structure than the earlier planted areas, which is another characteristic noted by earlier date of planting studies.

SUMMARY

Explicit or clear-cut guidelines from these 1989 results are not in order for statewide recommendations at this point. However, for cotton growers facing the increasing pressures of increasing water costs and late season insect pest infestations, the incentives for consideration of earlier termination may be in order. These experiments do indicate the possibility of optimizing cotton yields by using an early (optimum) planting date, managing for an early fruit set (with the help of good weather), and pursuing management towards full yield potential through the first fruiting cycle (prior to cut-out).

A similar set of experiments will be conducted in 1990 at the same locations as 1989. The addition of several years' data in conjunction with other similar research projects will provide a better basis for grower consideration in an effort to achieve greatest efficiency in Arizona cotton production. Quality aspects (which are forthcoming for the 1989 experiments) are being accumulated for final summary.

REFERENCES

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Table 1. Planting dates and irrigation termination dates for each location, 1989.

Location	Planting Date		Irrigation Termination	
	First	Second	First	Second
Yuma Valley	22 February	16 March	27 July	18 August
Maricopa	24 March	13 April	10 August	8 September
Marana	14 April	4 May	23 August	8 September

Table 2. Lint yield means and standard deviations for Upland and Pima, at two dates of planting and two dates of irrigation termination, Yuma Valley, 1989.*

Planting Date	Termination Date	Lint Yield	
		Upland	Pima
		-- lbs lint/acre --	
22 February	27 July	1458 ± 193	962 ± 203
22 February	18 August	1636 ± 282	1114 ± 231
16 March	27 August	1347 ± 408	1045 ± 258
16 March	18 August	1265 ± 119	1004 ± 226
$LSD_{0.05}$		NS	NS

*Harvest completed on 26 October. Main effects due to planting date were significant ($P \leq 0.05$) for planting date only with Upland cotton.

Table 3. Lint yield means of Upland and Pima cotton for two dates of planting, averaged over dates of irrigation termination, Yuma Valley, 1989.

Planting Date	Yield Upland (DPL 90)	Yield Pima S-6
	------------ lbs lint/acre	----------
22 February	1732 A*	1163
16 March	1463 B	1147
$LSD_{0.05}$	220	NS
"Difference"	269	(16)***
Value**	$161.40	($16.00)

*Means followed by the same letter within a column are not significantly different ($P \leq 0.05$) according to pairwise comparisons using a Fisher's LSD.
**Value of lint yield difference based upon $1.00/pound ELS lint, and $0.60/pound price for strict low middling.
***Provides only an estimate, not based upon a real statistical difference.

Table 4. Lint yield means and standard deviations of Upland cotton, at two dates of planting and two dates of irrigation termination, for both 30 and 40 inch row experiments, Maricopa, 1989.*

Planting Date	Termination Date	Yield (DPL-90) 30 inch rows	Yield (DPL-90) 40 inch rows
		-------- lbs lint/acre	-----------
24 March	10 August	1483 ± 41	1439 ± 37
24 March	8 September	1658 ± 28	1619 ± 52
13 April	10 August	1347 ± 132	1461 ± 23
13 April	8 September	1506 ± 48	1596 ± 25

*Main effects due to termination dates were significant ($P \leq 0.05$).

Table 5. Lint yield means of Upland cotton for dates of irrigation termination averaged over dates of planting, for 30 and 40 inch rows, Maricopa, 1989.

Termination Date	Yield (DPL-90) 30 inch rows	Yield (DPL-90) 40 inch rows
	----------- lbs lint/acre ----------	
10 August	1415 A*	1450 A
8 September	1582 B	1607 B
$LSD_{0.05}$	119	28
"Difference"	167	157
Value**	$100.20	$94.20

*Means followed by the same letter within a column are not significantly different ($P \leq 0.05$) according to pairwise comparisons using a Fisher's LSD.
**Value of lint yield difference based upon $1.00/pound ELS lint, and $0.60/pound price for 1-1/16 inch strict low middling.

Table 6. Lint yield means of Pima cotton for two dates of irrigation termination, 40 inch rows, Maricopa, 1989.

Termination Date	Yield (Pima S-6)
	------ lbs lint/acre ------
10 August	950 A*
8 September	1134 B
$LSD_{0.05}$	63
"Difference"	184
Value**	$184.00

*Means followed by the same letter within a column are not significantly different ($P \leq 0.05$) according to pairwise comparisons using a Fisher's LSD.
**Value of lint yield difference based upon $1.00/pound ELS lint.

Table 7. Lint yield means and standard deviations of Upland and Pima cotton for two dates of planting and irrigation termination, 40 inch rows, Marana, 1989.

Planting Date	Termination Date	Yield	
		Upland (DPL 90)	Pima S-6
		----------- lbs lint/acre ----------	
14 April	23 August	1320 ± 38	960 ± 47
14 April	8 September	1324 ± 30	1003 ± 30
4 May	23 August	1249 ± 105	745 ± 166
4 May	8 September	1231 ± 93	838 ± 91

*Main effects due to planting dates were significant ($P \leq 0.05$), for Pima cotton only.

Table 8. Lint yield means of Upland and Pima cotton for two dates of planting, averaged over dates of irrigation termination, Marana, 1989.

Planting Date	Yield	
	Upland (DPL 90)	Pima S-6
	------------ lbs lint/acre ----------	
14 April	1481	981 A*
4 May	1388	791 B
$LSD_{0.05}$	NS	160
"Difference"	(93)***	190
Value**	($55.80)	$190.00

*Means followed by the same letter within a column are not significantly different ($P \leq 0.05$) according to pairwise comparisons using a Fisher's LSD.
**Value of lint yield difference based upon $1.00/pound ELS lint, and $0.60/pound price for strict low middling.
***Provides only an estimate, not based upon a real statistical difference.