

AGRONOMIC AND ECONOMIC EVALUATION OF ULTRA NARROW ROW COTTON PRODUCTION IN ARIZONA IN 1999

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Abstract

An experiment was conducted at the University of Arizona Maricopa Agricultural Center, Maricopa, Arizona in 1999 to compare and evaluate agronomic and economic differences between Ultra Narrow Row (UNR) and conventional cotton row spacing systems with respect to yield, fiber quality, earliness potential, plant growth and development, and production costs. Row spacing was 10 and 40 inches for the UNR and conventional systems, respectively. Two varieties were evaluated within each row spacing, Sure Grow 747 (SG 747) and Delta Pine 429RR (DP 429RR). Lygus populations were extremely high in the Maricopa, Arizona region in 1999 which resulted in poor fruit retention from early through mid-season. As a result of poor boll load through mid-season, the UNR plots were irrigated and grown later into the season than desired along with the conventional cotton in order to set and develop a later season boll load. The mean lint yield averaged across row spacing was significantly greater ($P=0.05$) in the UNR row spacing at 1334 lb/A than for the conventional row spacing at 1213 lb/A. SG 747 produced 1426 and 1337lb/A of lint in the UNR and conventional systems, respectively. DP 429RR produced 1242 and 1089 lb/A of lint in the UNR and conventional systems respectively. Fiber grades were all 21 or 31 in both UNR and conventional systems. Micronaire was 4.9 or less in both varieties within the UNR system. Micronaire was high at 5.3 in the conventionally produced SG 747 resulting in discount but was acceptable at 4.7 in the conventionally produced DP 429RR. Length and strength measurements met base standards in all cotton variety and row spacing combinations. Neither the conventional or the UNR cotton production systems were profitable due primarily to high chemical insect control costs and early season boll loss. However, UNR production costs were lower by \$0.09 per pound than in the conventional system on a cash cost basis and \$0.14 per pound lower when considering total costs including variable and ownership costs.

Introduction

Low cotton prices, increasing production costs, and increasing uncertainty regarding government commodity support programs are seriously challenging the economic viability of the Arizona cotton industry. Beyond pursuing effective marketing strategies, producers can not control cotton prices and have varying degrees of success in influencing government commodity support programs. However, a promising strategy for overcoming this economic

challenge is to identify production practices that increase yield or reduce cost. From a practical standpoint, identifying and implementing production practices that increase yield or reduce costs within the conventional cotton production system will be difficult. In contrast, ultra narrow row (UNR) cotton production is of commercial interest because of its potential to reduce costs while still producing acceptable fiber quality and yield.

UNR cotton production is defined as cotton production using row spacing of 20 inches or less and plant populations greater than 100,000 plants per acre. The theorized advantage of UNR cotton is the increased light capture and photosynthetic efficiency that maximizes carbohydrate production for boll initiation and growth early in the season. The UNR cotton production system was tried in Arizona in the 1970's but was abandoned due to the inability to control weeds and manage cotton plant height. In recent years, UNR cotton has been the subject of renewed interest in the South and South Eastern regions of the United States cotton belt. The availability of selective over-the-top herbicides, transgenic herbicide resistant cotton varieties and plant growth regulators have enabled research and have allowed grower experience to increase and gain momentum. In Arizona prior to 1998, no recent commercial or research evaluation of UNR cotton production was conducted.

The objectives in a UNR cotton production system are to promote early fruiting, control vegetative growth, and reduce input costs by enhancing earliness. The UNR system has the potential to promote fruit set on lower than usual fruiting branches and set a limited number of bolls on fewer fruiting branches per plant at high plant populations compared to the fruiting patterns in conventionally planted densities of cotton. The ability to produce economically viable yield and fiber quality on fewer fruiting branches per plant can reduce the length of the season and reduce costs by eliminating late season water, insect pest control, and fertilizer inputs required for conventional cotton production. Additional savings are realized in UNR systems due to the lower cost of cotton strippers compared to spindle pickers and the lower cost of harvest. The objective of an experiment initiated in 1999 was to compare conventional and UNR cotton production systems with respect to yield and fiber quality, earliness potential, plant growth and development, and production costs.

Methodology

An experiment was conducted at the University of Arizona Maricopa Agricultural Center (MAC) in 1999 using a complete block, split-plot design with four blocks. The main plot factor was row spacing, either 10 or 40 inch, and the subplot factor was cotton variety, either Sure Grow 747 (SG 747) or Delta Pine 429RR (DP 429RR). Since the subplots were 20 feet wide by 800 feet, each main plot was 40 feet wide by 800 feet which was the length of the field. The varieties were chosen based on their potential to mature early and on the use of different over-the-top weed control programs, either Staple (pyrithiobac) on SG 747 or Roundup Ultra (glyphosate) on DP 429RR.

Ammonium sulfate was broadcast applied prior to planting at a rate of 200 pounds per acre (A) (42 pounds of nitrogen/A). The conventional or 40 inch row spacing subplots (approximately 4 acres) were treated prior to bed formation with Prowl 3.3 (pendimethalin) at a rate of 2.4 pints/A. The herbicide was applied in 23 gallons of water per acre (GPA) at 30 psi using flat-fan TeeJet XR8004VK nozzles in a boom mounted on a field cultivator operated at 6.1 mph equipped with three ranks of s-tines that incorporated the herbicide immediately after spraying. The conventional plots were then listed, mulched, and beds were shaped in preparation for planting. In the UNR main plots, the Sure Grow-Staple subplots were treated with 2.4 pints of Prowl/A. However, in the Delta pine 429RR-Roundup Ultra subplots, two rates of Prowl were compared to an untreated area 50 feet long by 20 feet wide in order to evaluate the feasibility of using a Roundup Ultra only post-emergence weed control program. An area 75 by 20 feet was treated at a rate of 1.8 pints of Prowl 3.3/A and the remaining subplot area (approximately 675 feet by 20 feet wide) was treated at a rate of 2.4 pints/A. The Prowl was applied in 13.5 GPA at 20.5 psi with a tractor-mounted sprayer traveling at 4.3 mph equipped with a 20 foot boom using XR8003VS nozzles. The herbicide was incorporated about 30 min after application using a field cultivator operated at 6.1 mph equipped with three ranks of s-tines. The UNR plots were dry planted on the flat in borders (10 inch rows) using a seeding rate of 33 pounds per acre with a set of 10 John Deere 71 unit planters mounted on a double tool bar. The conventional plots were dry

planted using a seeding rate of 12 pounds per acre with a single seed line per bed using a John Deere 6300 Max Emerge planter. Irrigation was initiated on April 29 to germinate the seed. The conventional plots received surface applied furrow irrigation water in every other furrow. The UNR plots were sprinkler irrigated using a solid set, hand moved, system in order to eliminate soil crusting and insure a high rate of seedling emergence and good stand uniformity. The sprinkler irrigation was a non-conventional practice and was cost prohibitive on a commercial basis but was implemented to avoid non-uniform, low density stands for experimental purposes. The remaining in-season UNR main plot irrigations were surface applied. Stand counts made on June 2 were 44,000 and 115,000 plants/A in the conventional and UNR plots, respectively.

In-season irrigation, nitrogen fertility, and insect populations were managed similarly in the UNR and conventional main plots but weed control and plant growth management were different. In season irrigation was initiated on June 11 and was done approximately every 14 days until irrigation was terminated on August 19. Nitrogen applications were managed by collecting petiole samples weekly from 8 June through 16 August. Ammonium sulfate was side dressed in the conventional plots to provide 92 lb/A of in-season nitrogen for a total season amount of 134 lb N/A. Urea ammonium nitrate (UAN 32) was applied in irrigation water in the UNR plots to provide 108 lb/A of in-season nitrogen for a total season amount of 150 lb N/A. Insect scouting for whitefly (*Bemisia tabaci*), pink bollworm (*Pectinophora gossypiella*), lygus (*Lygus hesperus*), and bollworm (*Heliothis spp.*) was initiated on June 16. University of Arizona recommended sampling methods and treatment thresholds were used. Insect pest populations were extremely large at this site in 1999 resulting in 13 individual foliar insecticide applications during the season. In addition, Temik (aldicarb) was side dressed at a rate of 10 lb/A in the conventional plots. The UNR DP 429RR subplots were treated with Roundup Ultra at 1 quart/A plus spray grade ammonium sulfate at 8.5 lb/100 gal. The UNR SG 747 subplots were treated with Staple at 1.8 ounces/A plus 0.5% (v/v) non-ionic surfactant on May 27 when the cotton was at the 3 to 4 true leaf growth stage. The herbicides were applied in 24 GPA at 35 psi and 3.2 mph using 11 XR8003VS nozzles and one OC-06 nozzle (on the end of the boom) on a tractor mounted boom that extended about 20 feet beyond the side of the tractor. Since weed pressures within the experiment were low, no additional herbicides were applied in the UNR plots. Cultivation of the conventional plots during the season controlled the few weeds that escaped the pre-plant Prowl application and no additional herbicide was applied. PIX PLUS (mepiquat chloride) was applied 5 times for a total of 48 ounces/A in the UNR plots in contrast to 2 applications totaling 28 ounces/A in the conventional plots.

Plant height, total number of nodes, and boll retention by node were measured on October 18 in order to evaluate the effect of row spacing and variety on boll distribution. Both the UNR and conventional main plots were defoliated on September 30 using a three component tank mix of 0.1 lb of Dropp 50WP (thidiazuron), 1.5 pints of Def 6 (sodium chlorate), and 2.0 pints of Prep (ethephon) per acre. The UNR plots were treated with an additional 2.0 pints of Starfire (paraquat)/A on October 22 in order to desiccate the cotton and facilitate stripper harvest. On October 27, the conventional plots were harvested using a Case IH 1822 spindle picker and the UNR plots were harvested with a John Deere 7455 equipped with a 14 foot S and H broadcast stripper header. Cotton from each variety subplot in each block was weighed separately using portable field scales placed under the tires of a cotton trailer. The four replicates of each UNR or conventional variety subplot were combined in separate trailers and ginned at a local commercial gin. Each trailer was ginned separately with remnants from each trailer put aside in order to obtain an accurate commercial gin turnout on each variety and system configuration. Each full bale was sampled by the gin in a commercial manner and sent to the USDA Cotton Classing Office in Phoenix, Arizona for grade and High Volume Instrument (HVI) classing.

Results and Discussion

The primary objectives of UNR cotton production are to reduce season length and decrease input costs. Unfortunately, these objectives were not achieved in this experiment. Lygus populations were extremely high in the Maricopa, Arizona region in 1999 and lygus feeding resulted in poor fruit retention from early through mid-season, the period during which boll set must be maximized, particularly in the UNR system. Presumably, secondary pest

populations also increased once lygus control applications were initiated. Thirteen foliar chemical applications were made to control lygus, pink bollworm, bollworm, whitefly, and other target insects (Table 1). The average node of the first harvestable boll was 10 and 13 for SG 747 and DP 429RR, respectively, in the UNR system (Table 2). The low fruit retention or boll load from nodes 6-12 in the UNR system indicates the loss of earliness or the potential to reduce season length which was vital for achieving cost reductions. The majority of the boll load occurred on nodes 13-24 for both row spacing systems independent of variety. The UNR and conventional systems in the experiment were equally affected by the high insect populations. As a result of poor boll load through mid-season, the UNR main plots in the experiment were irrigated and grown later into the season than desired along with the conventional cotton in order to set and develop a later season boll load.

In spite of the need to grow cotton later into the season than projected, the yield and fiber quality data still provided interesting information. The mean lint yield averaged across row spacing was significantly greater ($P=0.05$) in the UNR row spacing at 1334 lb/A than for the conventional row spacing at 1213 lb/A (Table 3). SG 747 produced 1426 and 1337 pounds of lint/A in the UNR and conventional systems, respectively, and DP 429RR produced 1242 and 1089 lb of lint/A UNR and conventional systems, respectively (Table 4). The difference in yield between varieties was not statistically significant and there was no statistical interaction between variety and row spacing. The fiber quality of stripper harvested UNR cotton is a consistent concern of ginners and textile mills. In this experiment, all UNR grades and fiber quality characteristics were satisfactory (Table 5). Grades were all 21 or 31 in both the UNR and conventional production systems. Micronaire readings were 4.9 or below in both SG 747 and DP 429RR in the UNR system. Micronaire was high at 5.3 in the conventionally produced SG 747 resulting in a discount but was in the acceptable range at 4.7 in the conventionally produced DP 429RR. High micronaire (above 4.9) is becoming an increasing problem in Arizona. SG 747 is an early maturity variety and did have some green bolls in the top at harvest suggesting that excess carbohydrate allocation and cellulose deposition had occurred due to the need to grow an early maturing variety later into the season than is desirable. Length and strength measurements met base standards in all cotton variety and row spacing combinations (Table 5).

Input costs were tracked diligently in order to develop an UNR production budget. The first two budget columns in Table 6 present the actual production costs for the UNR and conventional cotton in the 1999 experiment using actual lint yields. The budgets were separated categorically into growing costs (i.e., cash costs), harvest and post-harvest costs, and ownership costs, and include break even cotton price projections. The budget was categorized specifically to enable producers to substitute personalized data that represents their farm units. Total growing cost or cash cost of the UNR system was \$606.52/A which was \$53.69/A less than the conventional system cash cost of \$660.21/A. UNR growing costs were lower due to lack of cultivation (reduced labor and machinery costs), reduced fertilizer costs, and reduced water costs. These reduced costs more than compensated for increased chemical costs for plant growth control and weed control, and for seed and planting costs that were higher than for the conventional system. Harvest and post-harvest costs were higher for the UNR system at \$234.49 compared to the conventional system at \$217.92 partly due to higher defoliation and ginning costs. The ownership costs were lower in the UNR system at \$295.91 than for the conventional system at \$315.30 due to reduced implement needs (e.g., cultivator and side dress fertilizer injector) and the lower cost of stripper harvesters compared to spindle pickers. Total costs were \$1232.72 and \$1173.60 for the conventional and UNR systems, respectively.

The conditions at the Maricopa Ag. Center in 1999 were atypical of Arizona in many respects, particularly with respect to insect pest pressures. The poor early season fruit retention and high insect control costs, and the additional water costs did not allow us to develop a representative UNR budget based on the data collected in 1999 experiment. However, based on the MAC experiment and observations of other 1999 Arizona UNR plantings, a target UNR production schedule was developed to represent a scenario where pest pressures are more typical and the producer succeeds in capitalizing on an earlier crop with yield developed on ten fruiting branches (Table 7). The target UNR schedule was used to generate the UNR budget shown in the third budget column of Table 6 which can be compared with the current University of Arizona conventional cotton production budget for central Arizona. The yield used in the target UNR and current conventional budgets is the most recent five year state average which in conventional cotton production represents yield developed on about 20 fruiting branches. The validity of any theoretical budget is debatable but the target UNR budget does offer motivation to continue investigating the potential of UNR cotton in Arizona. The growing or cash costs are \$452.94 and \$538.48 for the target UNR budget

and the conventional system, respectively (third and fourth columns, Table 7). The harvest and post-harvest costs are \$217.05 and \$217.68 in the target UNR and conventional systems, respectively, and the ownership costs are \$263.05 and \$325.43 for the target UNR and conventional systems, respectively. According to these budgets and their implied assumptions, cash growing costs would be \$0.39 and \$0.47 per pound for the target UNR and conventional systems, respectively

Summary

While the results of this experiment were unable to document a shorter production season and concomitant cost reduction, there does appear to be valid reasons for continuing UNR research and evaluation in Arizona. Neither the conventional or the UNR cotton production systems were profitable due primarily to extremely high chemical insect control costs and early season boll loss. However, the fact remains that the UNR system produced 121 lb of lint/A more than the conventional system, a 9% yield difference. In addition, the fiber quality and grades of cotton from the UNR system were within acceptable ranges and were comparable or, in the case of micronaire, better than the conventional production system. UNR production costs were lower by \$0.09 per pound than in the conventional system on a cash cost basis and \$0.14 per pound lower when considering total costs including variable and ownership costs. These differences in production costs are based on actual 1999 experimental yields and inputs. Based on the theoretical or target UNR budget, it appears that the potential exists to achieve a UNR cash or growing cost of \$0.39 versus \$0.47 per pound for a conventional system. Estimated or target budgets using five year statewide yields suggest that total production costs including all variable and ownership costs, could be \$0.14 per pound lower for UNR cotton compared to a conventional cotton production system.

While the results of this experiment were interesting and offered a preliminary look at UNR cotton production, considerable research is needed to develop scientifically sound recommended production practices. Experience with UNR cotton gained in 1999 indicates that research needs to be conducted across all production input categories including variety selection, row spacing, plant population densities, irrigation requirements, nitrogen management, plant growth regulator use and timing, and weed control. In addition, national efforts to market UNR cotton objectively based on actual fiber quality rather than the perception of stripper harvested cotton needs to continue. UNR cotton production appears to have promise in Arizona but should be pursued commercially with healthy skepticism, a basic understanding of the system differences, and a well thought out production strategy.

Table 1. Production input summary for UNR (10 inch) and Conventional (CNV)(40 inch) row spacing at the University of Arizona Maricopa Agricultural Center (MAC) in 1999.

	UNR	CNV
Planting Date	30-Apr	30-Apr
Irrigations	7	7
Nitrogen App.	3	3
PGR App.	5	2
Insecticide App.	13	14
Herbicide App.	2	1
Harvest Date	27-Oct	27-Oct

Table 2. Boll distribution comparison of SG 747 and DP 429RR in UNR and Conventional cotton row spacing in 1999 at the MAC.

	UNR		CNV	
Sample Date:	SG 747	DP 429RR	SG 747	DP 429RR
18 Oct. 1999				
Plant Height	35	41	52	58
Total Nodes	24	31	30	36
Node of 1 st Hvst Boll	10	13	7	11
	Avg. No. Bolls			
Nodes 1-5	0	0	0	0
Nodes 6-12	2	0	4	2
Nodes 13-18	4	3	5	3
Nodes 19-24	1	4	4	5
Nodes 25-30	0	1	0	2

Table 3. Lint yield by row spacing comparison for UNR and Conventional row spacing at the MAC in 1999.

	Main Plots (row spacing)	Lint Yield (lbs./acre)
	UNR	1334 a*
	CNV	1213 b
P		0.0172
% CV		5.84
LSD		91.0

*Means followed by the same letter are not significantly different ($P < 0.05$) according to the LSD test.

Table 4. Lint yield by row spacing by variety interaction in cotton production system experiment at the MAC in 1999.

Subplots (variety)	Main Plots (row spacing)	Lint Yield (lbs./acre)
SG 747	UNR	1426
SG 747	CNV	1337
DP 429RR	UNR	1242
DP 429RR	CNV	1089
P		NS
% CV		5.84

*Means followed by the same letter are not significantly different ($P < 0.05$).

Table 5. Cotton fiber quality for UNR and Conventional row spacing at the MAC in 1999.

Variety	Spacing	Grade	Mic.	Length (100ths)	Length (32nds)	Strength (g/tex)
SG 747	UNR	31(2)* 21(1)	4.9	114	37	27.4
SG 747	CNV	21(2)	5.3	115	37	27.2
DP 429RR	UNR	31(1) 21(1)	4.1	111	36	27.8
DP 429RR	CNV	31(1) 21(1)	4.7	111	36	27.7

*Number of bales.

Table 7. Comparison of a proposed or target UNR production schedule and a typical conventional central Arizona cotton production schedule.

	UNR	CNV
Planting Date	12-Apr	12-Apr
1st Square	17-May	17-May
Total Fruiting Branches	29-Jun (10)	5-Aug (20)
Last Square to Flower	4-Jul	20-Aug
Final Irrigation	25-Jul	3-Sep
Last Flower to Boll	3-Aug	11-Sep
Defoliation	16-Aug	27-Sep
Harvest	6-Sep	25-Oct
Total Days to Harvest	147	196
Total Heat Units (86/55)	3572	4573

Table 6. Cotton production budgets for UNR and Conventional row spacing based on data collected in 1999 at the MAC.

Description	CNV	UNR	UNR	CNV
	Actual	Actual	Target	Current
Area	Maricopa	Maricopa	Maricopa	Maricopa
Management Level	Average	Average	Average	Average
Water Source	Central AZ	Central AZ	Central AZ	Central AZ
Irrigation System	Laser Furrow	Laser Basin	Laser Basin	Laser Basin
Units	Pounds	Pounds	Pounds	Pounds
Yield (units/acre)	1,213	1,334	1,154	1,154
COSTS				
Growing Cost				
	(\$/acre)	(\$/acre)	(\$/acre)	(\$/acre)
Labor	\$97.58	\$88.09	\$66.62	\$78.28
Machine Operation	\$59.82	\$48.96	\$37.63	\$44.35
Irrigation	\$37.76	\$39.13	\$28.99	\$33.93
Chemicals & Application	\$281.00	\$275.21	\$170.69	\$208.10
Fertilizer	\$73.72	\$30.42	\$45.63	\$73.72
Insecticide	\$186.54	\$186.54	\$81.06	\$101.51
Herbicide	\$6.49	\$15.49	\$15.49	\$18.62
Other Chemicals	\$14.25	\$42.76	\$28.51	\$14.25
Machinery Fuel & Repairs	\$63.68	\$52.84	\$49.25	\$52.15
Diesel	\$24.87	\$20.12	\$18.59	\$19.17
Repairs	\$38.87	\$32.72	\$30.66	\$32.98
Irrigation Water w/o Assessment	\$205.50	\$157.50	\$133.50	\$187.50
Seed & Transplants	\$12.45	\$32.88	\$32.88	\$12.45
<i>Total Growing Cost</i>				
	<i>\$660.21</i>	<i>\$606.52</i>	<i>\$452.94</i>	<i>\$538.48</i>
Harvest and Post-harvest Cost				
Labor	\$25.83	\$25.83	\$25.83	\$25.83
Machine Operation	\$17.56	\$17.56	\$17.56	\$17.56
Other Labor	\$8.27	\$8.27	\$8.27	\$8.27
Chemicals & Application	\$29.61	\$36.64	\$36.64	\$28.95
Defoliant	\$29.61	\$36.64	\$36.64	\$28.95
Machinery Fuel & Repairs	\$43.95	\$41.82	\$41.82	\$48.47
Diesel	\$6.09	\$7.35	\$7.35	\$7.12
Repairs	\$37.86	\$34.47	\$34.47	\$41.35
Custom & Other Materials	\$11.77	\$12.79	\$11.19	\$12.86
Ginning & Assessment	\$106.76	\$117.41	\$101.57	\$101.57
<i>Harvest and Post-harvest Cost</i>				
	<i>\$217.92</i>	<i>\$234.49</i>	<i>\$217.05</i>	<i>\$217.68</i>
Operating Overhead	\$15.41	\$15.41	\$15.41	\$15.41
Operating Interest	\$23.88	\$21.27	\$14.95	\$25.58
<i>Total Variable Cost</i>				
	<i>\$917.42</i>	<i>\$877.69</i>	<i>\$700.35</i>	<i>\$797.15</i>
Ownership Cost				
Cash Overhead	\$83.29	\$78.66	\$64.11	\$77.84
Capital Allocations	\$100.96	\$89.17	\$84.82	\$123.35
Land Ownership	\$58.77	\$58.77	\$58.77	\$58.77
Management Services	\$72.28	\$69.31	\$55.35	\$65.47
Total Ownership Costs	\$315.30	\$295.91	\$263.05	\$325.43
Total Costs	\$1,232.72	\$1,173.60	\$963.40	\$1,122.58
BREAK-EVEN PRICE				
to Cover Growing Cost	\$0.54	\$0.45	\$0.39	\$0.47
to Cover Total Variable Cost	\$0.76	\$0.66	\$0.61	\$0.69
to Cover Ownership Cost	\$0.26	\$0.22	\$0.23	\$0.28
to Cover Total Cost	\$1.02	\$0.88	\$0.83	\$0.97

