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IntelliGin – A Ginning Revolution from Process Control Technology

Gordon Williams spread his files across the table in front of him. As product manager for IntelliGin, it was his responsibility to develop the marketing plan for Zellweger Uster's latest product. They were planning on a 1998 product introduction but in April of 1997, they had yet to settle on a marketing plan. Marketing IntelliGin presented a unique challenge because although the technology would be sold to cotton gins, the cotton farmers would end up paying for it. However, everyone in the supply chain could benefit from it. His marketing team was to meet shortly to discuss once again their approach to this marketing problem.

IntelliGin is another in a series of technological solutions developed by Zellweger Uster, a Swiss-owned company that is an industry leader in technical instrumentation and process control in the textile industry. They have been proactive in developing HVI technology (high volume instrumentation) applied to fiber analysis in the spinning industry and have addressed numerous quality control issues for textile manufacturers. IntelliGin is a natural progression of process control technology to the cotton ginning business. With IntelliGin, a cotton ginner would be able to gin to buyer specifications, retaining more marketable fiber of a higher quality for the farmer-client. Initial reports from the two IntelliGin test sites look very promising. The process control technology returns amounts as high as $35 per bale to farmers (Greene, 1998).

Gordon surveyed the industry analysis and thought about the current cotton situation. Cotton farmers have faced a cost-price squeeze for several years. Poor crop years in several areas, the impact of foreign cotton production and imports

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on domestic cotton prices, and production expenses often exceeding $500 per acre had many farmers moving acreage out of cotton and into alternative row crops.

Recent technological advances had eased some of the pressure on cotton farmers, however. Genetically engineered cotton varieties that are resistant to some types of pest pressure and/or are tolerant of less expensive herbicides had helped reduce the cost of producing cotton. Eradication of the boll weevil in many locations had also reduced insecticide applications for many producers.

Ordinarily, gains as high as those reported by the test gins sell themselves, but the IntelliGin technology is expensive. The system at Servico Gin, one of the test sites, had cost $250,000 and they had to make another $200,000 of improvements and modifications to their existing equipment. At these levels of new investment, only the largest, most solvent, and most efficient gins would be able to afford to purchase the technology outright.

Gordon decided to review the benefits of IntelliGin throughout the cotton market one more time before the rest of his marketing team arrived for their meeting. He wanted to have a firmer proposal for the product introduction to which the rest of the team could react.

What Is Process Control?

Each stage of the ginning process carries an expense and a potential loss in turnout, the percentage of cotton harvested that is baled and sold as lint. Turnout of lint typically averages less than 30% of raw cotton harvested from the field. The balance is composed of cottonseed, trash, moisture, and lint waste that cannot be marketed for spinning. Each drying and cleaning process removes fiber and weight from the ginned cotton and can also reduce fiber quality. The application of process control to the ginning process reduces the amount of loss to the system. “The idea is to minimally process cotton to its optimal quality,” says Bobby Greene, general manager of Servico Gin in Courtland, Alabama.

Cameras and moisture sensors measure cotton color, leaf content, and moisture characteristics before, during, and after the ginning process. If these cotton measurements fall outside of their desired ranges, a computer automatically adjusts the ginning process. Adjustments can be made every six seconds. For example if moisture content falls too low, the temperature in the dryer would be reduced. If leaf content is determined to be within satisfactory ranges, then the cotton is not sent through additional lint cleaners, thus preserving yield and quality. Every time cotton is processed, fiber length, quality, and quantity are sacrificed.

The premium process control system is monitored and controlled by computer. Valves that control the flow of cotton through the ginning process are opened and closed automatically by computer, depending on the input from the monitoring

Table 1. Example Gains to Farmer Yields from IntelliGin

Content	*Without IntelliGin*	*With IntelliGin*
	pounds	
Seed Cotton	1,800	1,800
Marketable Cotton	480	530
Cottonseed	710	710
Linters and Motes	90	80
Trash and Moisture	520	490

sensors. A less expensive system would exclude the computer-controlled valves. The computer software would simply alert the gin operator to current cotton condition. The gin could then be stopped, adjusted manually, and quickly restarted. The cost to the gin for improvements and modifications using the manual system could be reduced to about $35,000 per gin to get ready for the IntelliGin system. That cost would be in addition to any payment to Zellweger Uster for IntelliGin.

Farmer Benefits

Cotton production is a high-expense, risky sector of agriculture. Many farmers have struggled to profit from cotton over the past few years, rarely covering total costs of production and sometimes not even covering cash costs of production. IntelliGin offers an opportunity for farmers to effectively increase marketable yields of cotton lint, attain higher prices for their cotton, and lower per unit break-even costs of production.

USDA estimates that an average of 1,800 pounds of seed cotton from the farm field is required to get a 480-pound bale of cotton lint that is marketable. Of the remaining weight, 520 pounds is trash (sticks, dirt, boll husks, etc.), 710 pounds is whole cottonseed that is marketed to oil mills and as livestock feed, 70 pounds is linters (fibers too short to weave or spin), and 20 pounds is motes (fibers used for industrial uses). The percentage composition of these outputs from seed cotton will vary across gins due to ginning efficiencies and the trash content of the seed cotton coming into the gin. Stripper cotton (using a harvest technique that strips the whole plant rather than picking the bolls) will have a higher trash content than cotton that is harvested with a cotton picker. A ginning process that removes only the required amount of trash and maintains fiber length through minimal cleaning will preserve a higher percentage of the 1,800 pounds of seed cotton for marketable lint, reducing the losses to trash, linters, and motes.[1] An example is presented in Table 1.

Because cotton ginned under process control will not be too dry, additional weight from water content will remain in the same physical quantity of cotton, improving yields, which are measured by weight. Similarly, if cotton is not over-cleaned, more cotton fiber will be left to market. These two improvements in the ginning process can translate to an increase of as much as 50 additional pounds of cotton marketed per bale above the old ginning technology (Greene, 1998). The result is a 10% increase in marketable farm yields simply through the ginning process.

Cotton ginned with process control also has improved quality characteristics. The percentage of short fibers and "neps" is lower and fiber quality in general is more consistent. Neps are small snarled masses or clusters of fibers that will appear as defects in finished cloth. Any improved quality characteristics may reduce quality discounts farmers have received in the past, perhaps improving the cotton price received by two cents per pound. More importantly, the textile mills have expressed enough interest in improved cotton quality to pay additional premiums for cotton ginned using this technology. The result may also mean an additional two cents per pound is received for mill-direct contracts from gins using IntelliGin.

Gin Benefits

Cotton gin profitability has also followed that of the cotton farmers, depending primarily on cotton yields. The number of cotton gins in the United States fell 30% between 1988 and 1997, from 1,645 gins to 1,153 gins. Ginning charges have also fallen about $2.50 per bale over that period of time. IntelliGin offers an opportunity for improved cotton gin financial performance in addition to improved farm-level profitability. Because many gins are farmer-owned or are part of farmer-cooperatives, increased gin profitability may eventually be returned to the farm patrons.

There are few direct benefits to the cotton gins resulting from process control. The primary benefit is the attraction and retention of an expanded customer base. If cotton gins can demonstrate that they can make farmers more money with IntelliGin, then those gins ought to be able to increase profits.

There will be some direct benefits to the gins, however. If fewer cleanings are used and lower dryer temperatures are maintained, then there will be modest savings in fuel and electricity usage. Most importantly, if farm marketable yields are increased 10% through process control, then that means there will be 10% more finished bales ginned each year, increasing revenues from ginning fees that are based on a per bale basis. Any additional customer base will also add to annual gin output. Because gins will be adding value to farmer-owned cotton through more efficient ginning, they should also be able to extract some payment from farmers for that service.

However, gins will lose mote income. When cotton is ginned, some cotton fibers are removed with the trash. That cotton's fiber length is too short to be used in spinning, but the short-fiber cotton can be salvaged and sold as motes for industrial uses such as furniture stuffing. Because IntelliGin preserves additional fiber in marketed cotton, some of that amount will no longer be available for sale as motes or linters. The market price for motes is about 8 cents per pound.

The gins will also have the burden of additional investment in the IntelliGin product line and any improvements to the gin that are required in order to utilize the process control technology. Many gins will find this investment infeasible, because the additional charges to farmers necessary to pay for the technology will be far greater than farmer benefits from process control. In addition, some gins may have to absorb the initial year's cost of the technology to demonstrate its value to farmers before passing an additional gin charge on to the farmers. Since some customers may remain skeptical regardless, gins may also have to offer the option of standard ginning without process control to their customers.

Finally, cotton gins with integrated cotton warehousing operations may find efficiencies arising from their newfound ability to group cotton by quality designations in storage. Such grouping will allow the placement and recovery of individual cotton bales at lower costs, and to group shipments of similar quality cotton to purchasers interested in consistent quality. Bobby Greene estimates savings in his warehouse operation of $6 per bale.

The ability to provide high-grade cotton of consistent quality in an organized fashion also makes cotton processed by gins using IntelliGin attractive to mills interested in direct-mill contracts. However, mills will probably not be interested in marketing contracts for small amounts of cotton coming from small gins.

Which Gins Will Benefit?

The significant expense of IntelliGin process control means that only large, well-managed gins will be able to afford that technology. In 1997, 38% of the cotton gins in the United States processed fewer than 10,000 bales. It is unlikely that any additional capital investment would be profitable for those gins, much less an investment of the magnitude of IntelliGin.

Zellweger Uster will have the capability of installing IntelliGin in only a handful of gins in 1998, gradually increasing the number over the next few years. Early adopters may gain an advantage over competitor gins, but only if cotton farmers recognize an economic advantage of ginning with the process control system and are willing to pay a higher price for the service.

Gins that develop ties with the textile mills will also benefit indirectly from process control. If farmers are able to increase their price received through mill-direct marketing contracts negotiated through the cotton gins using process control technology, those gins will be able to attract and retain market share in their associated cotton production regions.

Changes In Industry Structure

Zellweger Uster recognizes that there will be significant structural changes in the cotton industry as a result of the process control ginning technology. While it is unlikely that these structural changes will affect Zellweger Uster directly, their business depends on healthy cotton production and marketing sectors.

Even moderate adoption of process-controlled ginning will have several industry effects. Increased cotton marketings resulting from this shift in the supply curve will put more domestic crop on the market depressing farm level prices. Many cotton farms are already experiencing a cost-price squeeze. For those farmers unable to take advantage of the process control gin technology, other row crops may become more attractive relative to cotton, leading to offsetting shifts backward in supply.

Farmers that take advantage of IntelliGin products will have more crop to market. In addition, increased cotton quality and integration with the textile mills through contractual arrangements will improve prices received by farmers. Cotton merchants who currently buy cotton from farmers and sell to the mills will become a less important part of the marketing channel.

In 1992, merchants handled 65% of U.S. cotton sales. Cooperatives handled 25 percent with some of those sales being redirected through merchants later in the marketing stream. Brokers and mill buyers handled only 5% of the sales in 1992. With increases in direct-mill sales resulting from process-controlled ginning, marketing margins formerly associated with merchant services will become available to farm producers and textile manufacturers (Figure 1).

Increased cotton quality and consistency will reduce costs at the textile mills. Improved consistency will reduce costs in the "laydown" of cotton during the yarn-spinning phase in the production of textiles. Laydown is the organization and optimal combination of cotton bales of different fiber characteristics in order to manufacture a yarn of consistent quality. In addition, fewer neps will mean fewer problems for the mills in the spinning and weaving of quality cotton goods. Cost reductions at the mill-level will improve the efficiency and competitiveness of the U.S. textile sector.

Finally, the number and size of gins remaining after the introduction of IntelliGin will be different. Smaller gins will not be able to compete for customers with larger gins with modern ginning technology. Some small gins will remain, ginning family cotton or continuing to service a small but loyal customer base. However, yield and price advantages associated with process control advances

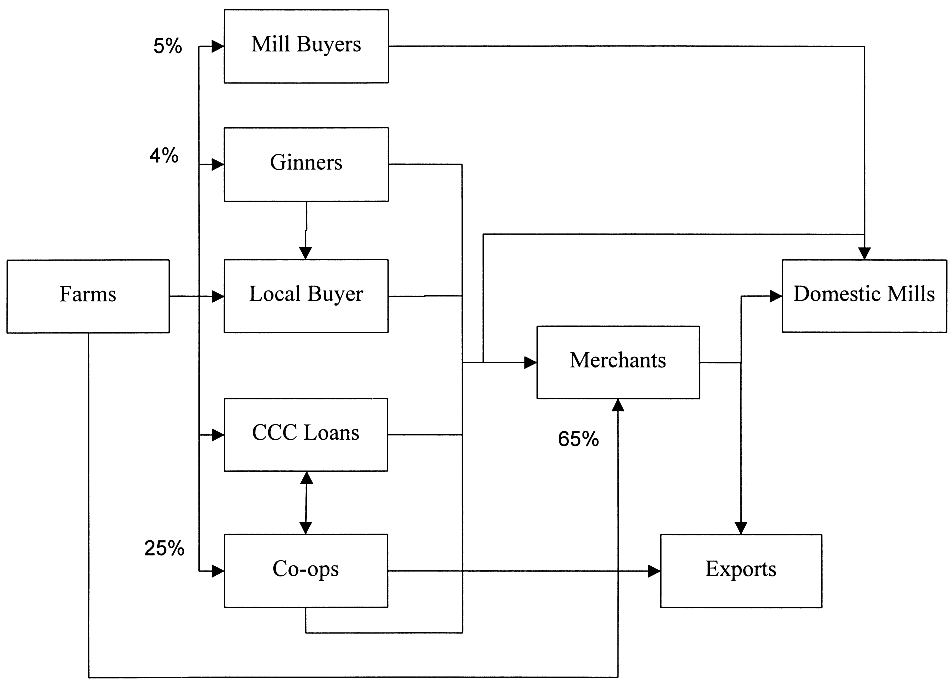

Figure 1. The Cotton Marketing Chain

will jeopardize the survival of most small cotton gins, and the farmers that use them.

ADDITIONAL COTTON MARKET INFORMATION

There are several other factors affecting the future of the U.S. cotton industry that must be considered by potential investors in IntelliGin. The removal of direct government price supports and acreage restrictions for field crops has increased acreage flexibility for all crops. Temporary and permanent shifts in and out of cotton acreage increase local uncertainty about cotton production in some regions, directly affecting the production base of some gins. There is significantly more price uncertainty for cotton producers, as well. Increased risk and reduced government support of farms has also transferred risk-bearing responsibility to producers. Farmers unable to manage or withstand downside price risk may mean that cotton acreage in certain regions is at risk, affecting total cotton available for ginning.

Cotton also faces increased competition from synthetic fibers. Cotton steadily improved its market share of mill use of fibers from a low of 25.1% in 1984 to 32.1% in 1993. However recent years have seen a surge in use of synthetic fibers putting increased downward pressure on the demand for cotton. Competition among alternative fibers is expected to remain strong in the future.

Finally, international trade plays an important role in the determination of farm prices of cotton. Although the U.S. usually exports over a third of its domestic cotton production, it is an importer of cotton products. Foreign cotton production, exchange rates, and the stability of foreign economies all have a significant impact on domestic cotton prices. For example, the price of cotton fell over 5 cents per pound in April, 1998 due to an unexpected sale of about one million bales of cotton by China.

The Marketing Decision

There were several pricing alternatives from which Gordon might choose. The first alternative is to sell the technology outright to interested gins. This arrangement is particularly appealing to firms attempting to commercialize new technologies because of the fact that transaction costs are minimized and more importantly, risk incurred by Zellweger Uster is mitigated. The major disadvantage of this type of transactional arrangement is that the gins are forced into substantial up-front costs associated with renovations that are necessary to ensure smooth transition to the new ginning processes. In addition, there is the inherent tradeoff for Zellweger Uster between getting the full price up front and foregoing the opportunity for potentially higher future income streams.

An alternative pricing strategy would be to license the technology to participating gins for a set price per bale ginned. That strategy would most likely allow additional gins feasible access to the technology, but would shift production risk from the gins to Zellweger Uster. Should cotton production (supply) in areas surrounding participating gins be affected negatively by drought, insect/disease infestations, etc., then the revenue generated by ginning would decline as well. In addition, the high costs of initial renovations are still incurred by the participating gin, possibly limiting the number of gins that could afford to adopt the technology.

Another possibility would be to market a less-sophisticated (manual) version of the process control system that would have lower initial startup costs for the participating gins. Under this alternative, an up-front installation charge ($40,000) would be assessed and then a licensing fee would be collected on a per-bale basis. While this system would not take advantage of the full extent of the technology's capabilities, it does potentially allow more gins to feasibly adopt the new technology.

Regardless of the alternative pricing arrangement used by Zellweger Uster, the firm is still faced with "selling" the technology to farmers because the gins would ultimately pass the technology cost on to the farmers in the form of higher ginning charges. Without fully convincing the farmers of the benefits of using process control ginning technologies, they will simply opt to have their cotton ginned in the traditional manner, eliminating any economies of scale that gins may have experienced.

Gordon was leaning toward a pricing strategy for the less-sophisticated, manual control version involving an up-front payment by the gin and a per-bale "licensing fee" for the process control after that. There is still some concern, however, that this pricing strategy assumes too much production risk for the company. In addition, this pricing strategy locks out many gins because Zellweger Uster may not recover the installation cost quickly enough from smaller gins.

Gordon felt prepared for his meeting. He was comfortable with his inclination toward the licensing fee pricing plan. He needed more input from his team on location and target markets, though. He hoped the rest of his team was prepared to address these issues.

Acknowledgement: The authors wish to acknowledge the helpful comments of Carl Anderson, Bobby Greene, and Gordon Williams.

Notes

1. Servico Gin recently has averaged 1,550 pounds of seed cotton to get a 500-pound bale of marketable lint. Of the remainder, 235 pounds is trash, 760 pounds is whole cottonseed, 70 pounds is linters, 30 pounds is motes, and 25 pounds of moisture loss.

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Appendix

A teaching note and a spreadsheet file containing the following tables are available from the authors.

Table A-1. Cotton Costs and Returns

Item	United States 1995	United States 1996	Southeast 1995	Southeast 1996	Delta 1995	Delta 1996	Southern Plains 1995	Southern Plains 1996	Southwest 1995	Southwest 1996
Revenue										
Cotton	$ 340	$ 384	$ 406	$ 537	$ 467	$ 566	$ 192	$ 189	$ 589	$ 635
Cottonseed	49	71	58	94	61	72	26	39	109	152
Total, Gross Value of Production	389	455	464	631	528	639	219	228	699	786
Financial Costs										
Total Variable Cash Expenses	298	299	308	308	364	367	213	214	589	593
Total Fixed Cash Expenses	62	59	58	55	69	65	45	43	128	122
Total Cash Expenses	360	358	366	363	432	433	258	257	716	715
Gross Value of Production Less Cash Expenses	28	96	99	267	96	206	(39)	(29)	(18)	71
Economic Costs										
Total Cash Expenses Less Interest	340	339	341	340	405	407	247	247	673	674
Capital Replacement	55	56	66	68	78	79	33	32	82	84
Opportunity Cost of Operating and Non-Land Capital	28	28	31	31	33	32	21	20	46	46
Land	46	48	34	36	77	81	26	27	77	81
Unpaid Labor	34	31	23	24	22	24	29	30	48	49
Total, Economic Costs	502	501	496	499	616	623	356	357	926	933
Residual Returns to Management and Risk	$(113)	$ (46)	$ (32)	$ 132	$ (88)	$ 15	$(137)	$(128)	$(227)	$ (147)
Harvest-Period Price ($/lb)	$0.70	$0.65	$0.75	$0.75	$0.75	$0.72	$0.67	$0.60	$0.70	$ 0.63
Yield (lb/planted acre)	486	591	542	715	623	786	287	315	842	1,007

USDA, Economic Research Service, Farm Business Economics Report

Table A-2. Number of active cotton gins, by State, 1985/86-1994/95

State	*1988*	*1989*	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*
					Number					
Alabama	82	75	72	70	68	61	58	61	56	51
Arizona	89	89	90	85	81	69	67	63	54	51
Arkansas	129	125	122	138	121	127	111	100	104	94
California	146	148	138	126	121	117	108	109	103	97
Georgia	64	63	59	58	59	61	66	79	79	77
Louisiana	82	81	80	85	77	75	75	75	72	68
Mississippi	210	201	192	181	181	163	156	137	129	127
Missouri	49	48	48	45	41	41	39	35	35	36
New Mexico	28	28	26	22	20	19	19	18	16	16
North Carolina	37	36	39	45	42	41	49	57	54	50
Oklahoma	64	65	63	61	64	61	56	52	45	39
South Carolina	43	41	40	43	6	46	42	40	38	36
Tennessee	76	74	70	69	62	53	50	48	47	41
Texas	543	507	494	472	405	423	404	391	372	360
United States	1,645	1,581	1,533	1,500	1,383	1,357	1,300	1,274	1,204	1,153

U.S. Department of Commerce, Bureau of the Census, Agriculture Division. USDA, National Agricultural Statistics Service, Cotton Ginnings Annual Summary.

Table A-3. Cotton ginning charges, by State, 1985/86-1994/95

State	*1985/86*	*1986/87*	*1987/88*	*1988/89*	*1989/90*	*1990/91*	*1991/92*	*1992/93*	*1993/94*	*1994/95*
						$/bale				
Alabama	37.76	37.04	36.85	36.84	36.67	34.78	35.10	38.11	38.08	38.70
Arizona	40.70	40.33	40.31	41.04	42.15	41.95	41.88	41.49	41.85	42.22
Arkansas	38.94	37.19	38.72	39.31	38.99	37.63	36.20	36.68	38.13	39.46
California	48.91	48.62	48.44	47.31	47.77	46.32	45.54	46.42	42.42	40.49
Georgia	42.89	42.41	42.53	43.06	42.70	41.59	41.04	42.03	41.55	41.76
Louisiana	38.46	37.20	37.41	36.98	36.43	36.84	36.54	36.18	35.17	35.98
Mississippi	36.59	37.16	37.64	38.40	37.42	38.20	36.39	36.50	36.33	37.46
Missouri	37.39	39.76	41.25	42.17	42.19	40.61	38.95	38.71	37.42	39.67
New Mexico	54.26	52.80	55.31	53.43	55.51	56.26	57.33	56.63	56.62	55.88
North Carolina	45.42	45.83	45.72	46.80	45.79	47.81	49.06	50.15	49.12	49.28
Oklahoma	48.57	50.35	50.60	47.74	45.63	50.46	50.47	52.35	50.04	46.97
South Carolina	42.97	42.81	43.04	44.07	46.57	46.59	46.90	46.40	47.89	47.17
Tennessee	38.78	34.69	34.80	35.02	34.59	34.06	34.19	32.70	30.40	35.61
Texas	50.18	52.92	53.81	51.45	51.55	48.47	48.93	50.09	50.34	49.03
United States	44.86	44.91	45.82	45.14	44.26	43.68	42.61	42.50	43.28	42.37

USDA, Economic Research Service, Cotton Ginning Charges, Harvesting Practices, and Selected Marketing Costs.

Table A-4. Number of active gins, 1997

									State									
Bales Ginned	*US*	*AL*	*AZ*	*AR*	*CA*	*FL**	*GA*	*KS**	*LA*	*MS*	*MO*	*NM*	*NC*	*OK*	*SC*	*TN*	*TX*	*VA**
1–2,999	119	9	4	7	2		2		6	12	0	6	3	24	6	1	37	
3,000–4,999	96	7	7	7	0		1		7	4	2	2	2	4	5	1	47	
5,000–6,999	98	7	3	5	4		3		7	11	4	0	2	4	3	1	44	
7,000–9,999	125	8	2	6	4		3		4	18	6	4	2	4	5	8	51	
10,000–14,999	211	9	4	21	15		14		18	30	8	2	12	1	7	14	56	
15,000–19,999	124	3	4	14	5		10		7	17	7	2	9	0	4	6	36	
20,000–39,999	277	7	23	23	46		25		18	31	8	0	18	1	6	9	62	
40,000+	93	1	4	11	21		19		1	4	1	0	2	1	0	1	27	
All Gins	1,153	51	51	94	97	4	77	1	68	127	36	16	50	39	36	41	360	5

*Individual gin data withheld.
USDA, National Agricultural Statistics Service, Cotton Ginnings, 1997 Summary, May 1998. <http://usda.mannlib.cornell.edu/>
County data also available.

Table A-5. Cotton marketing year average price received by farmers ($/lb)

	State																
Year	*US*	*AL*	*AZ*	*AR*	*CA*	*FL*	*GA*	*KS*	*LA*	*MS*	*MO*	*NM*	*NC*	*OK*	*SC*	*TN*	*TX*	*VA*
1987	0.64	0.65	0.66	0.64	0.70	0.63	0.62	0.58	0.63	0.64	0.66	0.66	0.62	0.58	0.59	0.63	0.60	0.62
1988	0.56	0.53	0.57	0.54	0.65	0.52	0.55	0.47	0.55	0.54	0.54	0.62	0.54	0.47	0.54	0.54	0.52	0.54
1989	0.64	0.64	0.66	0.63	0.72	0.65	0.65	0.57	0.64	0.63	0.65	0.70	0.63	0.57	0.66	0.63	0.59	0.63
1990	0.67	0.69	0.69	0.66	0.77	0.68	0.69	0.58	0.66	0.65	0.65	0.71	0.69	0.63	0.68	0.66	0.63	0.69
1991	0.57	0.57	0.60	0.57	0.67	0.55	0.60	0.53	0.53	0.55	0.60	0.55	0.59	0.49	0.60	0.54	0.54	0.59
1992	0.54	0.56	0.53	0.56	0.61	0.56	0.56	0.50	0.53	0.53	0.53	0.59	0.57	0.47	0.56	0.53	0.49	0.55
1993	0.58	0.57	0.58	0.57	0.66	0.56	0.60	0.52	0.58	0.58	0.53	0.61	0.58	0.50	0.61	0.59	0.54	0.57
1994	0.72	0.69	0.71	0.68	0.80	0.72	0.73	0.74	0.69	0.72	0.66	0.72	0.73	0.68	0.72	0.70	0.70	0.72
1995	0.76	0.73	0.76	0.73	0.84	0.80	0.76	0.73	0.73	0.74	0.70	0.81	0.78	0.73	0.80	0.75	0.75	0.73
1996	0.71	0.71	0.70	0.72	0.77	0.69	0.73	0.64	0.68	0.70	0.68	0.75	0.74	0.64	0.74	0.71	0.67	0.72

USDA, National Agricultural Statistics Service, Agricultural Prices

Table A-6. Acres harvested (1000s)

	State																
Year	*AL*	*AZ*	*AR*	*CA*	*FL*	*GA*	*KS*	*LA*	*MS*	*MO*	*NM*	*NC*	*OK*	*SC*	*TN*	*TX*	*VA*	*U.S.*
1988	375	349	675	1,335	29	315	1	645	1,190	242	69	124	435	142	530	5,300	3	11,759
1989	322	239	595	1,040	25	260	0	620	1,020	209	55	110	340	118	460	3,750	3	9,166
1990	378	348	750	1,090	36	350	1	790	1,220	235	62	200	370	154	515	5,000	5	11,505
1991	405	359	980	977	49	427	2	820	1,230	327	65	457	380	210	610	5,400	18	12,716
1992	408	323	980	995	50	456	1	870	1,345	328	37	377	315	192	615	3,550	22	10,863
1993	430	315	970	1,045	54	600	1	875	1,300	335	49	385	350	198	615	5,050	23	12,594
1994	455	312	970	1,095	68	875	1	890	1,270	345	50	485	340	223	585	5,150	42	13,156
1995	578	364	1,110	1,165	109	1,490	3	1,075	1,420	453	56	800	315	342	660	5,750	106	15,796
1996	516	356	990	1,159	98	1,336	4	885	1,100	385	69	710	210	282	530	4,136	102	12,868
1997	440	341	940	1,059	99	1,430	14	625	970	375	79	665	190	285	490	5,182	100	13,284

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Table A-7. Yield per acre (pounds)

	State																
	AL	*AZ*	*AR*	*CA*	*FL*	*GA*	*KS*	*LA*	*MS*	*MO*	*NM*	*NC*	*OK*	*SC*	*TN*	*TX*	*VA*	*U.S.*
1988	486	1,190	742	1,015	566	564	373	705	736	607	710	515	334	473	529	472	510	615
1989	571	1,303	687	1,228	557	631	240	672	732	618	698	615	244	626	497	367	498	602
1990	476	1,119	692	1,204	640	555	280	715	728	641	735	631	496	452	461	477	562	632
1991	655	1,201	772	1,252	719	812	347	828	888	630	465	672	303	786	552	419	765	650
1992	731	1,077	823	1,359	701	783	120	717	761	792	616	596	320	565	651	441	621	694
1993	524	1,204	541	1,340	696	586	206	606	572	539	769	535	370	495	425	484	634	601
1994	766	1,203	877	1,191	735	843	480	815	806	856	720	820	349	846	726	458	944	705
1995	409	1,046	635	953	472	625	185	614	622	544	609	479	187	528	527	372	620	533
1996	734	1,150	793	1,145	637	747	492	697	819	737	717	677	306	774	611	511	748	707
1997	600	1,218	883	1,188	655	638	601	756	896	742	638	671	505	674	643	496	667	686

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Table A-8. Bales produced (1,000s)

	State																
	AL	*AZ*	*AR*	*CA*	*FL*	*GA*	*KS*	*LA*	*MS*	*MO*	*NM*	*NC*	*OK*	*SC*	*TN*	*TX*	*VA*	*U.S.*
1988	380	865	1,044	2,824	34	370	1	948	1,825	306	102	133	303	140	584	5,215	3	15,077
1989	383	649	851	2,661	29	342	0	868	1,555	269	80	141	173	154	476	2,870	3	11,504
1990	375	811	1,081	2,734	48	405	1	1,177	1,850	314	95	263	382	145	495	4,965	6	15,147
1991	553	898	1,576	2,548	73	722	1	1,414	2,275	429	63	640	240	344	701	4,710	28	17,216
1992	621	725	1,681	2,817	72	744	0	1,299	2,131	541	48	468	210	226	834	3,265	28	15,710
1993	469	790	1,094	2,918	78	733	1	1,105	1,550	376	78	429	270	204	545	5,095	30	15,764
1994	726	782	1,772	2,717	104	1,537	1	1,512	2,132	615	75	829	247	393	885	4,915	82	19,324
1995	492	793	1,468	2,312	107	1,941	1	1,375	1,841	513	71	798	123	376	724	4,460	137	17,532
1996	789	852	1,636	2,765	130	2,079	4	1,286	1,876	591	103	1,002	134	455	675	4,405	159	18,942
1997	550	865	1,730	2,620	135	1,900	17	985	1,810	580	105	930	200	400	656	5,355	139	18,976

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