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The costs of cotton harvesting systems in the Mississippi Delta

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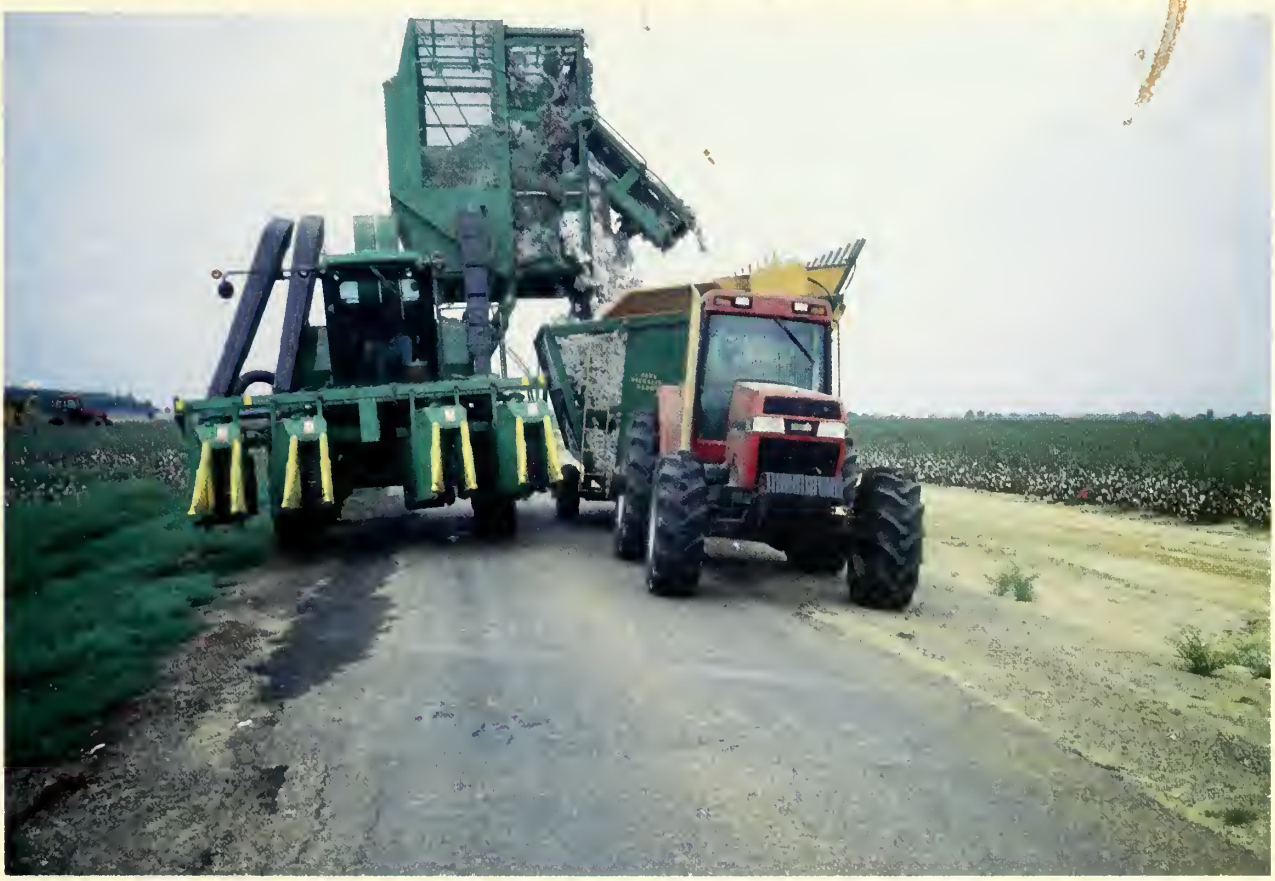

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The Costs of Cotton Harvesting Systems in the Mississippi Delta

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Introduction

The harvesting component of cotton production is complex and expensive. Managing the production of a cotton crop to achieve an early and timely harvest can lead to improved returns [9, 10]. An economic evaluation of cotton harvesting must consider production techniques and the resulting effect on yields, maturity, and timeliness of harvest. In recent years, evaluations have focused on these factors while taking the organization and means of the harvest as given. However, there have been significant technological changes in cotton harvesting and handling during the past two decades.

The introduction of module builders in the early 1970's has impacted seed cotton handling and ginning [1, 11]. A 1984 study discussed potential impacts of four-row harvesters, but was largely speculative [2]. The increased use of four-row pickers since 1985 has also been associated with an increase in the use of boll buggies in the Delta. A boll buggy is a tractor-towed cotton basket and serves the same function as a grain cart when combines are used to harvest crops.

Performance rates (the time required to harvest one acre, measured in hours per acre) of these more advanced cotton harvesting systems have not been updated in the Mississippi Agricultural and Forestry Experiment Station/Mississippi Cooperative Extension Service (MAFES/MCES) cost of production estimates since 1975 [3, 4, 5, 6, 12]. Thus, an in-depth study of cotton harvesting systems in the Mississippi Delta was initiated in 1988. The purpose of this paper is to provide physical and economic data to cotton producers for decision making relative to cotton harvesting.

Methodology

To meet the objectives of the study, much information had to be collected and analyzed. First, the harvest operations on a sample of cotton farms were observed to obtain data from which performance rates could be calculated. Second, 16 harvesting systems were developed to allow comparisons of old and new technology. Third, the costs of each of these representative cotton harvesting systems were estimated. These components are discussed in the following sections.

Performance Rates

MAFES contracted with the Mississippi Agricultural Statistics Service to provide enumerators to assist in collecting cotton harvesting data. Enumerators spent at least one day with each of 42 growers collecting data. Detailed data concerning the time associated with each component of the harvest was obtained and are shown in Table 1. From the 42 farms, observations were made on 104 cotton pickers, 68 module builders, 13 boll buggies, and numerous trailers. Data from these observations were organized and used to compute average first-pick performance rates for each harvest system. Also, information was collected about the number and job description of personnel involved, distance to gins, ginning rates, length of harvest day, and harvest dates, (Appendix Table 1).

The performance rate for second pick was not observed in this study. Second pick performance rates were calculated by adjusting published performance rates with observed turn time, turn row time, dump time, and down time. Farmers reported two dumps per day for second pick, and this figure was used to develop second pick performance rates.

Harvesting Systems

The systems analyzed in this study were not actual systems found on farms. Most observed systems had a mixture of two-row pickers of various ages. All but

Table 1. Components of harvest cycle observed.

Number	Item
1	Picking
2	Travel to dump site
3	Dump, trailer
4	Dump, module builder
5	Dump, boll buggy
6	Return to field
7	Clean (picker, heads, etc.)
8	Breakdown
9	Other (lunch, rest stop, etc.)
10	Turn time

three farms using four-row harvesters were also using two-row harvesters. This study was designed to allow cost comparisons between various cotton harvesting systems, with emphasis on alternative picker ages and seed cotton handling equipment. Sixteen harvesting systems were developed and represent old and new technology for both two-row and four-row pickers.

Data were obtained from two-row cotton pickers ranging in age from 1972 models to 1988 models. The two-row pickers were divided into three groups: those manufactured before 1982, those manufactured from 1982 to 1985, and those manufactured from 1986 through 1988. Trailers and module builders were used on farms having two-row pickers, but boll buggies were not used on these farms.

A specific attempt was made to include numerous four-row pickers in this study, because observed performance rates for these machines operating in Mississippi have not been available. Field observations of 23 four-row cotton pickers were obtained, constituting 22.1 percent of all machines in this study. An unpublished study of farm organization and structure in the Delta area of Mississippi conducted in 1989 found that 17.6 percent of all cotton pickers were four-row machines.

The four-row pickers observed were 1981 through 1988 models. There were no four-row pickers found on farms that used cotton trailers exclusively. All 13 boll buggies observed in the study were being used in support of four-row pickers.

Harvesting Costs

The total cost of a harvesting system is defined as the sum of variable and fixed costs that are incurred while cotton is picked, handled, and hauled to the gin. Variable costs are comprised of repairs and maintenance, diesel fuel, and labor. Fixed cost was estimated as the annuity value of the initial investment over the machine's economic life at an annual interest rate of 10 percent. The costs of first and second picks are calculated separately and added together to derive total cost per year. This total cost is divided by acres picked (first pick only) to arrive at an annual cost per acre.

Before the cost of the cotton harvest system can be estimated, the length of the harvest day must be considered. Data obtained by the field enumerators in this study indicated an average time of 8.76 hours per harvest day. A study reported in 1990 [7] reported 8.71 harvest hours per day at Stoneville, Mississippi, making use of observed weather data for the period September 25 through October 22. This study assumes 8.7 hours per day during first and second picks.

Another important factor is the number of days fit for harvesting during the first pick. The harvest initiation date is influenced principally by planting dates, production practices, and weather during the growing season. Completion of the first harvest is a function of the number of pickers available, their performance rates, and weather. Beginning harvest dates usually vary by at least 2 weeks from the South Delta to the North Delta because of differences in planting dates and accumulated DD-60's. Starting dates for harvesting cotton range from September 15 to October 10 at Stoneville, Mississippi. The use of earlier and faster fruiting varieties has generally resulted in earlier harvesting dates in the Mississippi Delta during the last 10 years.

Research on earliness has shown that higher yields and greater profits are obtained if the first harvest is started by September 25 and completed by October 22 [7]. These 28 calendar days have an average of about 18 days suitable for harvest (days fit), Appendix Table 2. This study uses 18 harvest days as the basis for determination of total cotton harvesting costs.

Each machine is assumed to have a known economic life (measured in hours of use). Annual hours available for first pick are derived by multiplying hours per day by days of picking. This number, divided by the performance rate, gives the number of acres that are assumed to be harvested during first pick. It is assumed that second pick is performed on one-half of the first-pick acres. Annual hours of use during second pick are derived by multiplying second-pick acres by the performance rate. The total of first-pick and second-pick annual hours of use divided into lifetime hours of use determines the economic life (in years) of the machine.

Repairs and maintenance over the life of each machine are assumed to be a specified portion of the initial investment. Dividing this amount by years of life gives the annual cost estimate for repairs and maintenance. Annual fuel cost is determined by multiplying the annual hours of use by the fuel use rate (gallons per hour) by the price of diesel fuel ($0.90 per gallon).

Labor use for seed cotton handling differed greatly from farm to farm. Full-time, or permanent, laborers are utilized throughout the farming year to operate tractors and harvesters. In addition to the picker operator, most farmers reported one other permanent laborer used primarily for spotting trailers and assisting in picker cleaning and maintenance. If module builders are included in the system, the module operator is a permanent laborer. If a boll buggy is included in the handling system, this laborer is also considered to be a permanent employee. Temporary labor is employed only during the harvest

season to assist in loading and tromping trailers, picking up spilled cotton, and staging and covering modules. The number of temporary laborers varied widely from farm to farm. However, two temporary laborers per farm are assumed in this study. Wage rates used in this study are as follows: picker operator, $6/hour; temporary labor, $4/hour; permanent labor, $6/hour; and supervisor, $10/hour. Each type is paid for 11 hours per day.

Field handling of seed cotton is done through some combination of trailers, module builders, and boll buggies. Farmers in this study dumped the first hour's picking and one to three additional dumps per day on trailers if the module was tied up. Trailer use associated with systems having both modules and boll buggies was slightly lower. All producers cooperating in this study reported sufficient trailers to handle 4 to 6 days of harvest. Many of the trailers were never needed, as usual trailer turn around from the gin was reported to be 36 to 48 hours. The number of trailers provided for each system is sufficient to handle 2.25 days of that portion of harvest which is dumped on trailers. For systems with trailers only, this constitutes the entire harvest for 2.25 days.

Each module builder and boll buggy has a tractor operating with it during the entire day. Two hours of tractor use per day are added to those systems using trailers only. Every 2 days, a trailer is hauled to the gin by a pickup truck. The hauling cost is assumed to be $0.30 per mile for a 16-mile round trip. Modules are assumed to be picked up by the gin at no cost to the producer. Gin rebates for modules are not included in this study. Information concerning purchase price, repair cost percent, lifetime hours of use, and fuel use rates that were used in this study are presented in Appendix Table 3.

Results

Seed cotton handling systems used by producers in the Delta area of Mississippi are extremely varied, ranging from complete dependence on trailers to the use of module builders, boll buggies, and a harvesting supervisor directing activities with radios. The most common handling system observed in the study utilized module builders and trailers for two-row or four-row harvesters. As previously stated, the use of boll buggies was observed only at farms using four-row harvesters.

The observed speed of two-row pickers ranged from 2.1 to 3.2 miles per hour for older pickers and from 2.3 to 3.5 miles per hour for newer pickers. The performance rates for the three age groups of two-row pickers and associated cotton handling equipment are presented in Table 2. Newer harvesters are able to pick more acres per time period than older machines, and thus have lower (more efficient) performance rates. The data also indicate that the inclusion of module builders in the cotton handling system improves (lowers) performance rates. This improvement is greater for newer harvesters.

Table 2. Performance rates of 2-row cotton pickers, three age groups and various cotton handling systems.

Item	Before 1982	1982-1985	After 1985
	hours per acre		
First pick			
Trailers	0.68	0.56	0.55
Modules and trailers	0.65	0.52	0.50
Modules, boll buggies and trailers	N.O.[1]	N.O.[1]	N.O.[1]
Modules, trailers and supervisor	N.O.[1]	N.O.[1]	0.47[1]
Second pick[3]	0.44	0.36	0.35

[1] Not observed.
[2] Two observations.
[3] Derived from published speeds and modified by observed turn time, turn row time and down time. All cotton dumped on trailers.

The observed speed of four-row pickers averaged about 3.2 miles per hour for older pickers and about 3.65 miles per hour for newer pickers. The performance rates of four-row pickers in two age categories are presented in Table 3. Again, newer machines are more efficient than older machines. The use of boll buggies also improved performance rates of four-row cotton pickers.

Once performance rates are estimated, it is possible to determine the acres that any given picker can harvest in one day or during a given season. Information for three classes of two-row pickers with

Table 3. Performance rates of 4-row cotton pickers, two age groups and various cotton handling systems.

Item	1981-1986	After 1986
	hours per acre	
First pick		
Trailers	N.O.[1]	N.O.[1]
Modules and trailers	0.26	0.25
Modules, boll buggies and trailers	0.24	0.22
Modules, boll buggies, trailers and supervisor	N.O.[1]	0.20[2]
Second pick	0.17	0.15

[1] Not observed.
[2] Two observations.
[3] Derived from published speeds and modified by observed turn time, turn row time and down time. All cotton dumped on trailers.

two cotton handling systems and two classes of four-row pickers with two cotton handling systems is presented in Table 4. The acreage harvested in 18 harvest days is used to represent a long-run average situation in this analysis. The components of the first 12 harvest systems that were developed are reported in Table 5. The cost estimates for these 12 systems are presented in Table 6. A discussion of each system follows.

Table 4. Acres harvested during first pick.

Item	Perf. rate	Acres/ 8.7 hr/day	Acres in 18 days
1978 2-row picker + trailers	.68	12.79	230.3
1978 2-row picker, module builder, + trailers	.65	13.38	240.9
1983 2-row picker + trailers	.56	15.54	279.6
1983 2-row picker, module builder, + trailers	.52	16.73	301.2
1988 2-row picker + trailers	.55	15.82	284.7
1988 2-row picker, module builder, + trailers	.50	17.40	313.2
1984 4-row picker, module builder, + trailers	.26	33.46	602.3
1984 4-row picker, module builder, boll buggy, + trailers	.24	36.25	652.5
1988 4-row picker, module builder, + trailers	.25	34.80	626.4
1988 4-row picker, module builder, boll buggy, + trailers	.22	39.55	711.8

Table 5. Components of selected cotton harvesting systems.

System	Picker		No.	No. module	No. boll	Harvest support labor	
Number	Year	No.	trailers	builders	buggies	Perm.	Temp.
2-Row Pickers							
1	1978	2	8	0	0	1	2
2	1978	2	3	1	0	1	2
3	1983	2	10	0	0	1	2
4	1983	2	3	1	0	1	2
5	1988	2	13	0	0	1	2
6	1988	2	3	1	0	1	2
4-Row Pickers							
7	1984	1	3	1	0	1	2
8	1984	1	2	1	1	2	2
9	1988	1	3	1	0	1	2
10	1988	1	2	1	1	2	2
11	1984	2	4	1	1	2	2
12	1988	2	4	1	1	2	2

Systems 1 and 2

These systems utilize two older two-row harvesters. System 1 has eight 12-bale trailers and three laborers for cotton handling, as indicated in Table 5. As shown in Table 6, System 1 can harvest 460 acres during the first harvest. Harvesting the cotton crop was estimated to cost $83.30 per acre when all costs of the system are totaled and averaged over the 460 acres.

System 2 also has two older two-row pickers and three laborers, but one module builder is added and the trailers are reduced from eight to three. This system results in a slight improvement of the performance rate for the old pickers, allowing acres picked to increase to 482 acres. However, about a $4 per acre increase in picking cost is estimated for System 2 as compared to System 1.

Systems 3, 4, 5 and 6

As shown in Table 6, when a module builder is substituted for trailers the total harvest cost per acre declines for 1983 harvesters (Systems 3 and 4) and 1988 harvesters (Systems 5 and 6). The use of a module builder instead of trailers results in improved performance rates for both pickers. Unlike the results for Systems 1 and 2, these improved performance rates result in reduced picking costs per acre. The module builder is able to replace seven trailers in System 3 and ten trailers in System 5. Thus, a greater reduction in per-acre cost is obtained with the 1988 pickers than with the 1983 pickers.

Systems 7 and 8

These two systems have one 1984 four-row cotton harvester instead of two two-row harvesters. System 7 utilizes one module builder and three trailers. System 8 has one module builder, one boll buggy, and two trailers. Farmers with boll buggies reported less need for trailers, and field observations confirmed this. A cost analysis of a trailers-only system with four-row pickers is not included, because no such system was observed on farms surveyed in this study.

The cost of System 8 is almost $8 per acre more than System 7 (Table 6). The addition of the boll buggy improves the performance rate (acres picked increases from 602 to 653 acres), but it also increases per-acre picking costs. When only one trailer is replaced by the

Table 6. Harvest costs per acre, total harvest system (picking and handling).

System number	Number pickers	Picker age	Acres harvested in 18 days	Total harvest cost
2-Row Pickers				*$/acre*
1	2	1978	460.6	83.30
2	2	1978	481.9	87.27
3	2	1983	559.3	89.92
4	2	1983	602.3	87.86
5	2	1988	569.5	92.26
6	2	1988	626.4	84.98
4-Row Pickers				
7	1	1984	602.3	75.50
8	1	1984	652.5	83.31
9	1	1988	626.4	73.36
10	1	1988	711.8	77.49
11	2	1984	1,305.0	67.55
12	2	1988	1,423.6	63.17

Systems 1, 3, and 5 are trailers only.
Systems 2, 4, 6, 7, and 9 are module builders and trailers.
Systems 8, 10, 11, and 12 are module builders, boll buggies, and trailers.

boll buggy (with the additional laborer), the per-acre cost increases.

Systems 9 and 10

These systems are similar to Systems 7 and 8 except for the use of 1988 rather than 1984 pickers. Results show that 1988 pickers have lower per-acre costs than 1984 pickers because of improved performance rates (Table 6). Again, performance rates and annual harvest capacity are further enhanced by the use of a boll buggy in place of a trailer. The increased capacity of System 10 over System 9 is still not sufficient to reduce per-acre harvest cost. However, the cost increase is only about $4 per acre. The per-acre cost increases of the more advanced cotton handling systems are greatest when used with older harvesters.

Systems 11 and 12

These two systems utilize two four-row cotton pickers, one module builder, one boll buggy, and four trailers (Table 5). As shown on Table 6, total per-acre harvest costs are significantly reduced (almost $16 per acre between System 11 and 8 and about $14 per acre between System 12 and 10). This per-acre cost reduction is possible because only two additional trailers are required to support the second four-row picker.

Harvest Supervisors with Radios

Enumerators reported that several farms used radios to communicate with cotton picker operators, module builder operators, boll buggy operators, and other support personnel. This communication capacity allowed equipment coordination, which minimized nonpicking time for cotton harvesters. For example, a supervisor might direct a specific harvester to the quickest dump site; i.e., trailer, module builder, or boll buggy. Data obtained by field enumerators indicated improved performance rates where such supervision existed. Four farms using harvest supervisors with radios were revisited. The data obtained from these followup visits confirmed that such systems were able to harvest more acres per time period than those without supervisors and radios.

The cotton handling systems developed in this study require the addition of one supervisor and six two-way radios. Most of the radios were of the citizen's band type, with an average cost of $150 each and an assumed life of 3 years. The results presented in Tables 7 and 8 indicate that more acres can be harvested at a lower cost per acre where such supervision is a part of the system.

Table 7. Components of cotton harvesting systems with a supervisor.

System No.	Picker Yr.	Picker No.	No. trailers	No. module builders	No. boll buggies	Harvest support labor Perm.	Harvest support labor Temp.
2-Row Pickers							
13	1988	2	3	1	0	1	2
14	1988	3	5	1	0	1	2
4-Row Pickers							
15	1988	2	4	1	1	2	2
16	1988	3	5	1	1	2	2

Table 8. Harvest costs per acre, total harvest system using harvest supervisors and radios.[1]

System Number	Number pickers	Picker age	Acres harvested in 18 days	Total harvest cost $/acre
2-Row Pickers				
13	2	1988	666.4	85.55
14	3	1988	999.6	78.46
4-Row Pickers				
15	2	1988	1,566.0	60.54
16	3	1988	2,349.0	55.13

[1] Data to develop this table were obtained from two farms using 2-row harvesters, one farm using a mix of 2-row and 4-row harvesters, and one farm using 4-row harvesters.

Systems 13 and 14

System 13, Tables 7 and 8, is directly comparable with System 6, Tables 5 and 6, except for the supervisor. Despite an increase of 40 acres harvested during the 18-day harvest season, the total cost of System 13 is $0.57 per acre greater due to the added cost of the supervisor.

System 14 has an additional two-row picker and two more trailers. Where three two-row harvesters are used, the addition of the supervisor results in a total harvest cost of $78.46 per acre, or $7.09 per acre less than System 13 and $6.52 per acre less than System 6. The use of a supervisor is more efficient when using more than two harvesters.

Systems 15 and 16

Results presented in Table 8 show that the impact of a supervisor on harvest costs where two or more four-row pickers are used is also favorable. System 15, two four-row machines with a supervisor, results in a $2.63 per acre savings when compared with System 12, Table 6, as well as an increase of 142 acres (1,424 to 1,566) harvested. System 16, which uses three four-row harvesters, will require the addition of only one trailer. Unlike the two-row systems without a boll buggy, the use of a boll buggy in the four-row systems negates the addition of two trailers. The use of three four-row harvesters reduces per-acre cost even further from $60.54 per acre for System 15 to $55.13 per acre for System 16. Again, the impact of the supervisor is even greater when more than two four-row harvesters are a part of the system.

Limitations

The absence of boll buggies on farms using two-row harvesters prevented the collection of data on how this cotton handling tool impacts the cotton harvest on these farms. However, after observing boll buggies on farms with four-row pickers, it is expected that a boll buggy will reduce nonpicking time for any harvester and may result in faster dump times for two-row machines. Thus, boll buggies will probably improve performance rates and could reduce total harvest costs for two-row harvesters.

The average dump time for four-row pickers on boll buggies was less than the average dump time on either trailers or module builders. Nonpicking time was considerably less when boll buggies were used. To a slightly lesser extent, the same was true where more than one module builder was used. The boll buggy significantly improved performance rates for systems using one, two, or three four-row pickers. No data was collected where one boll buggy supported four four-row machines. Field observations indicate that three 4-row machines is near the limit of efficient use of a boll buggy.

Fifteen farms used more than one module builder. Turn row time was somewhat less on these farms than on farms with only one module builder. However, quantitative differences were not sufficient to allow meaningful conclusions, due to the variations in ages and sizes of pickers.

Conclusions

Newer cotton harvesters are faster than older machines and thus can harvest more acres per time period. The substitution of module builders and boll buggies for trailers improves the performance rates for both old and new harvesters. However, when two-row pickers are used, cost per acre for the complete harvest system declines with the addition of module builders for newer harvesters, but increases for older harvesters. Systems having one four-row picker exhibit an increased cost per acre when boll buggies are added to both old and new harvesters. However, the addition of one more four-row picker to both old and new systems with a boll buggy will substantially lower per-acre harvest costs. The use of harvest supervisors with radios to direct the harvest may have a place on farms utilizing three or more cotton harvesters. The reductions in per-acre harvest costs will be greatest on large cotton farms using four-row pickers with advanced cotton handling systems.

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Appendix Tables

Appendix Table 1. Miscellaneous data reported by 42 cooperating farmers.

Average number of temporary harvest employees	3.0
Average distance to gin (miles)	6.2
Average gin capacity (bales per hour)	18.0
Average length of harvest day (hours)	
1st pick	8.8
2nd pick	10.5
Average length of harvest season (calendar days)	
1987 - 1st pick	34
2nd pick	18
1988 - 1st pick	32
2nd pick	17
Usual - 1st pick	32
2nd pick	19

Appendix Table 2. Days and hours per day suitable for harvest, Stoneville, Mississippi.

Week	Days	Hours
September 25-October 1	4.74	8.84
October 2-October 8	4.72	8.75
October 9-October 15	4.39	8.66
October 16-October 22	4.04	8.55

Appendix Table 3. Machinery cost factors.

Item	Purchase price	Lifetime use	Repair percent	Fuel use
	$	hours	%	gal/hr
1978 2-Row Picker	47,600	2,000	75	4.5
1983 2-Row Picker	69,200	2,000	75	4.5
1988 2-Row Picker	69,594	2,000	75	4.5
1984 4-Row Picker	118,000	2,000	75	7.5
1988 4-Row Picker	123,000	2,000	75	7.5
Tractor (115-150 HP)	48,855	8,400	52	5.9
Trailer (12 Bales)	3,600	2,400	40	
Module Builder (32 Ft.)	18,000	2,400	80	
Boll Buggy	15,000	2,400	80	
Radio	150	650		

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