August 1996 D.A.E. RESEARCH REPORT NO. 703

ESTIMATED COSTS OF SOLDIER AND COMBINE SUGARCANE HARVESTING SYSTEMS IN LOUISIANA

Michael E. Salassi
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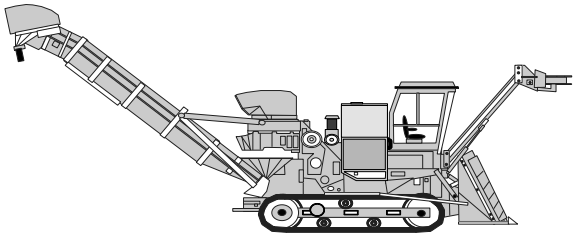

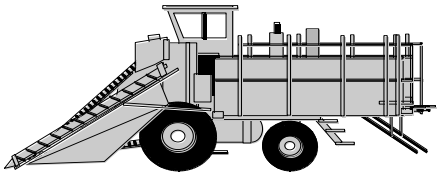

Louisiana State University
Agricultural Center
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Abstract

Soldier (wholestalk) harvesting of sugarcane has been the predominant method of harvesting sugarcane in Louisiana for many years. With the short harvesting season and frequently wet harvesting conditions found in the state, this type of harvesting system has proven to be a very flexible and suitable system. Combine (billet) harvesters have the ability to recover more of the sugarcane in the field, compared to soldier harvesters, particularly in fields with lodged sugarcane. This report quantifies some of the differences in machinery requirements, performance rates, and estimated costs of operating soldier and combine sugarcane harvesting systems in Louisiana.

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by

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ESTIMATED COSTS OF SOLDIER AND COMBINE SUGARCANE HARVESTING SYSTEMS IN LOUISIANA

Michael E. Salassi and Lonnie P. Champagne[1]

INTRODUCTION

Sugarcane is a major agricultural commodity in Louisiana. In 1995, more than 800 producers in 21 parishes in the state cultivated 400,890 acres of sugarcane, the largest sugarcane acreage ever grown in Louisiana (*1995 Louisiana Summary: Agriculture and Natural Resources*). An estimated 368,820 acres were harvested for sugar, with a total of 10,585,420 gross tons of cane produced. In terms of total crop value of major agricultural crop enterprises in Louisiana, the 1995 sugarcane crop ranked second behind cotton with a total value of over $449 million.

Soldier (wholestalk) harvesting of sugarcane has been the predominant method of harvesting sugarcane in the field for many years. Although soldier harvesting technology has progressed from one-row to two-row wholestalk harvesters, the basic harvesting method has remained unchanged. The harvester cuts whole stalks of sugarcane and lays them in piles on the ground. These piles are then burned to remove leaves and other trash, then loaded into wagons to be hauled directly to the mill by tractors or hauled to a transloading site to be later loaded onto trucks. With the short harvesting season and frequently wet harvesting conditions found in the state, this type of harvesting system has proven to be a very flexible and suitable system for sugarcane producers in Louisiana.

In the 1950's, sugarcane producers in Australia began experimenting with combine, or chopper, sugarcane harvesters (Churchward and Belcher). These harvesters would cut sugarcane stalks into 12-14 inch billets, remove extraneous matter, and deposit the billets into wagons running beside the harvester. The original combine harvesters were designed to cut burned sugarcane, as were the wholestalk harvesters. In the 1970's, considerable attention in Australia was being focused on developing a combine harvester which would harvest green sugarcane (Churchward and Poulsen). A primary advantage of harvesting green sugarcane is that the harvester deposits extraneous organic matter in a layer on the field. This contributes to moisture conservation, weed control, and cost savings in cultivation.

In the United States, as sugarcane harvesting methods in Florida switched from hand harvesting to mechanical harvesting in the late 1980's and early 1990's (USDA, *Sugar and Sweetener Situation and Outlook Report*), it was the combine harvesting technology, and not wholestalk harvesting, which was adopted. The sugarcane industry in Texas, although considerably smaller than Louisiana or Florida, also utilizes the combine harvester system.

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One of the major advantages of the combine harvester is the high percentage of cane recovery in the field, particularly in lodged or down sugarcane, compared to soldier harvesters. This ability to deliver more of the sugarcane in the field to the mill has recently caused some producers in Louisiana to seriously consider switching from soldier harvesters to combine harvesting systems. This report quantifies some of the differences in machinery requirements, performance rates, and estimated costs of operating soldier and combine sugarcane harvesting systems in Louisiana.

DATA AND PROCEDURES

Sugarcane harvesting and hauling cost estimates presented in this report are developed with the aid of a spreadsheet-based sugarcane harvesting cost model (Champagne and Salassi). This model estimates fixed and variable costs of soldier (wholestalk) and combine harvesting systems under both direct haul and transloading situations from detailed farm-specific information provided by the user. Information entered into the model includes: (1) farm sugarcane acreage and tonnage; (2) number of days available for harvest; (3) distribution of sugarcane tonnage (yield) across acreage on the farm; (4) estimated capacities, performance rates, and hours of operation for sugarcane harvesting and hauling equipment; (5) queuing times in the field, at the loading site, and at the mill; and (6) distance from farm to mill.

Purchase prices and performance rates of one-row and two-row soldier harvesters, combine harvesters, and loaders are obtained from a survey of machinery dealers in the sugarcane production areas of Louisiana conducted in the fall of 1995. Purchase prices of various types of wagons used in conjunction with combine harvesters are also obtained from this primary data source. Fixed and variable costs of tractors used in hauling sugarcane from the field to the transloading site or to the mill are obtained from Department of Agricultural Economics and Agribusiness, L.S.U. Agricultural Center, estimates (*Projected Costs and Returns - Sugarcane, Louisiana, 1996*). Diesel fuel is charged at 67 cents per gallon. Interest on average investment is charged at a real rate of 6.4 percent. Field labor was charged at a rate of $6 per hour while harvester operator labor was charged at a rate of $10 per hour.

A representative farm situation typical of sugarcane farms in south Louisiana is used in analyzing the costs of the alternative harvesting systems. This representative farm consists of 1,000 acres of harvestable sugarcane with a harvest season length of 75 days. The average cane tonnage in the field, across the entire farm, is assumed to be 30 tons per acre. This yield level is approximately equal to state average sugarcane yield per harvestable acre over the past few years. In order to simulate realistic harvesting conditions, the following distribution of tonnage across the farm's acreage is assumed:

Percent of farm acreage	Tonnage range
35%	less than 25 tons/acre
25%	25 to 35 tons/acre
25%	greater than 35 tons/acre (straight)
15%	greater than 35 tons/acre (lodged)
100%	

This assumed tonnage distribution is used to represent harvesting conditions which a producer might incur across all harvestable acres on a farm. Tonnage per acre can vary by crop age (plantcane versus stubble crop cane) as well as by sugarcane variety. Variation in sugarcane tonnage across the farm influences the capacity of the soldier harvester in terms of the tons of sugarcane it can harvest per hour of operation. The performance rate of a two-row soldier harvester can typically range from 90 to 140 tons per hour, depending upon the tonnage per acre of sugarcane in the field. In relatively light tonnage fields (less than 25 tons per acre), a two-row soldier harvester can harvest 120 to 140 tons of sugarcane per hour. As the tonnage per acre increases, the tons per hour which a two-row soldier harvester can harvest declines down to the 90 to 110 tons per hour range. The capacity of a combine harvester, cutting one row of sugarcane at a time, is more stable at approximately 55-60 tons per hour, regardless of the tonnage per acre of sugarcane in the field.

The representative farm used in this study is assumed to be located 5 miles from the mill. Distance from the mill affects the cost of sugarcane harvesting and hauling systems in situations where the sugarcane is hauled to the mill by farmer-owned tractor and wagons (direct haul systems). In this situation, a farm located a further distance away from the mill could require a larger investment in tractors and wagons in order to have sufficient hauling capacity necessary to keep the combine harvester operating the required number of hours per day to meet the daily mill quota of the farm. If an empty tractor and wagon unit is not available to operate beside the combine harvester to collect billeted cane exiting the harvester, the combine must stop operation and wait until an empty tractor and wagon arrives at the field.

For purposes of this study, distance from farm to mill does not affect the costs of harvesting and hauling sugarcane under situations where the sugarcane is hauled by custom-hired truck and trailers. In this situation it is assumed that the farm is able to hire the sufficient number of trucks per day required to haul the farm's daily mill quota. For farms which use custom-hired trucks and trailers to haul their harvested sugarcane to mills located great distances from the farm, the availability of trucks and turnaround time at the mill could be limiting factors which determine the amount of sugarcane acreage a single combine harvester could reasonably harvest per day.

Since the harvesting and hauling operation of cutting and transporting the cane from the field to the mill is a multistage process, the time required in each stage affects the overall performance and cost of the system. For the representative farm situation analyzed in this study, the following assumptions are used: (1) queuing in the field by self-dumping wagons (time spent turning and waiting for loading) - 5 minutes; (2) distance from the harvested field to the transloading site or highway - 0.5 miles; (3) queuing at the loading site (time spent by wagons waiting to unload - 8

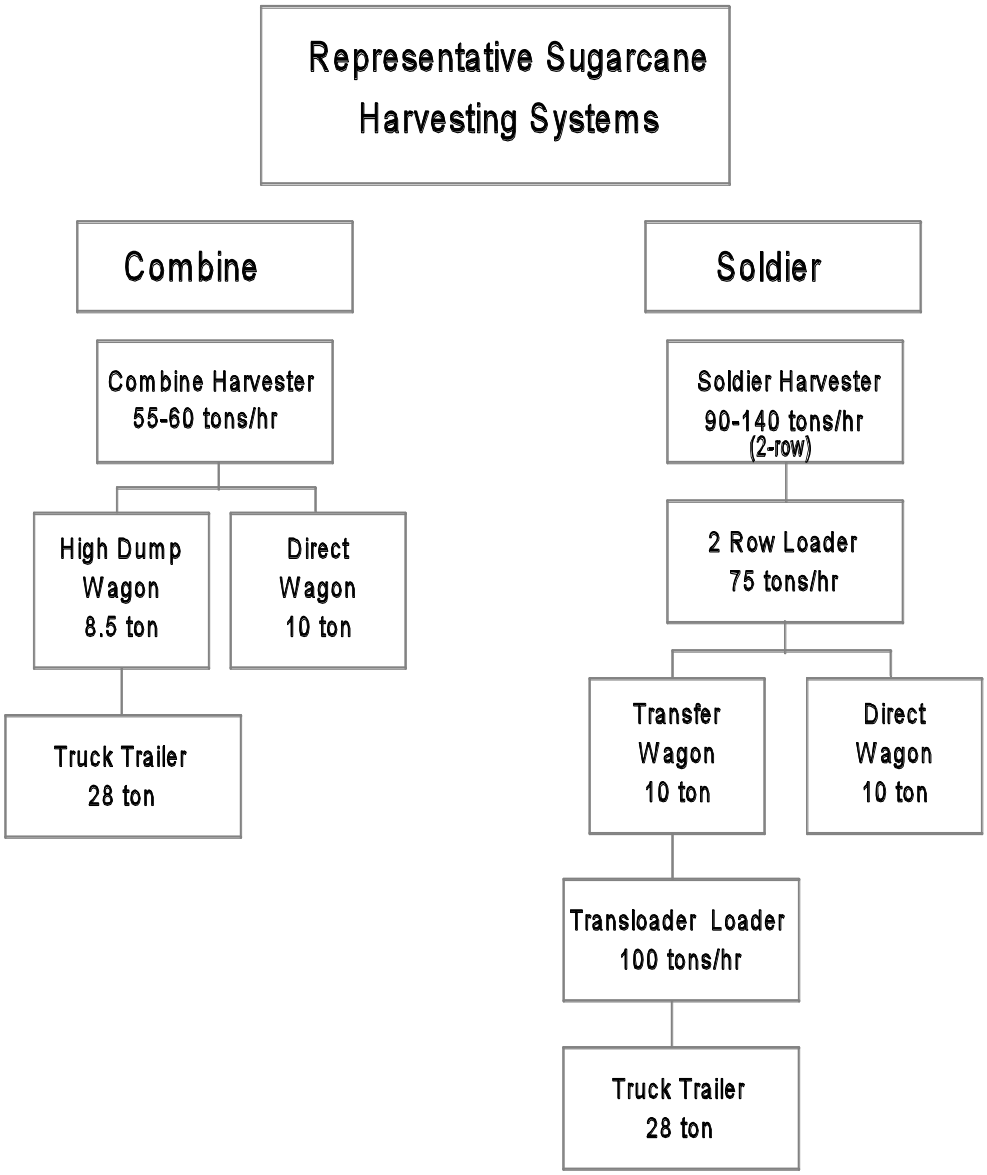
minutes; and (4) queuing and unloading at the mill for direct haul tractors and wagons - 15 minutes. These particular time and distance assumptions are chosen to represent a hypothetical situation which could exist for a sugarcane farm and are not intended to represent an average situation across sugarcane farms in the state. For many sugarcane farms, which harvest fields of sugarcane dispersed throughout a given locality and which may haul harvested sugarcane to more than one mill, these time and distance parameters can vary greatly from field to field as well as from day to day for a single farm.

HARVESTING SYSTEMS

The two-row soldier harvesting system is the most common type of sugarcane harvesting system currently being used in Louisiana. Sugarcane harvested by this type of system is hauled to the mill by both tractors and wagons as well as trucks and trailers. One-row soldier harvesters are also used by some farms. A description of the equipment used by two-row soldier and combine harvesting and hauling systems is depicted in Figure 1. A two-row soldier harvester can harvest 90-140 tons of cane per hour, depending upon tonnage in the field and the percent of lodged or down cane. After the harvested cane is burned to remove leaves and other extraneous matter, a loader is used to load the cane stalks into wagons pulled by tractors which will deliver the cane to the mill for grinding or to a transloading site on the farm for later transfer to truck and trailer.

With a combine harvesting system, a loader and transloader is generally not needed. A tractor pulling some type of self-dumping wagon runs parallel in the field beside the harvester. The combine cuts one row of cane per swath at a rate of about 55-60 tons per hour. Sugarcane stalks are cut into 12-14 inch billets and loaded into the wagon by means of a loading elevator, mounted on the combine, which can be positioned to load cane billets on either side of the harvester. An extraction fan system on the harvester strips and removes leaf material and other extraneous matter from the sugarcane prior to loading into wagons. These wagons then either haul sugarcane directly to the mill or dump sugarcane directly into truck and trailers. Due to the lower performance rate of the combine harvester compared to a two-row soldier harvester, the hours of combine operation needed to harvest a given amount of acreage is about twice the time required for a soldier harvester. If sufficient wagons and/or trucks are available to allow the combine harvester to continue the harvest operation in order to meet the farm's daily mill quota, a transloader is not needed. However, if sufficient hauling units are not available, some type of on-farm storage of cane, such as a bin, is needed to avoid or minimize the amount of time a harvester would have to wait for an empty wagon to continue harvesting. In this case, a transloader is required to reload cane from the on-farm storage bin into wagons or trailers for shipment to the mill.

Figure 1. Sugarcane Combine and Soldier Harvesting Systems



EQUIPMENT PERFORMANCE AND COST ANALYSIS

Estimated measures of sugarcane harvesting and loading equipment performance rates are listed in Table 1. The tonnage harvested per hour by wholestalk harvesters varies depending upon the tonnage of sugarcane in the field. In relatively light cane (<25 tons per acre), a one-row soldier harvester can harvest about 60 tons per hour. As the tonnage level in the field increases, the tons of cane per hour which a one-row harvester can handle decreases, particularly in heavy cane (>35 tons per acre) which is lodged. The same relationship holds for two-row soldier harvesters with tonnage per hour ranging from 140 tons per hour in light cane down to 90 tons per hour in heavy, lodged cane.

The acres per hour estimates for one-row and two-row soldier harvesters are based on an average farm yield of 30 tons per acre. For simplicity, an assumption is made in this study that the average yield of cane harvested per day is equal to the average yield of cane across the entire farm. This assumption is made in order to minimize the impact on harvesting and hauling cost of harvesting all heavy tonnage fields or all light tonnage fields on a given day. In reality, acres per hour estimates for soldier harvesters should be somewhat higher in light cane and lower in heavy cane than the estimates shown hear. However, the average performance rates of wholestalk harvesters used on a specific farm across an entire harvest season should be about the same as the average performance rates used in this study, assuming similar distribution of sugarcane yields on the farm.

Combine harvesters cut one row of sugarcane per swath at a relatively constant rate of about 55-60 tons per hour. A performance rate of 56 tons per hour is assumed in this study. This translates into a harvest capacity of 1.87 acres per hour in 30 ton per acre cane or about 0.54 hours per acre. One-row and two-row loaders, used to load wholestalk sugarcane after it has been burned to remove leaves and other extraneous matter into wagons for transport to mill or transloading site, are assumed to handle 50 and 75 tons of sugarcane per hour, respectively. A transloader, used to load wholestalk sugarcane in truck and trailers, is assumed to handle 100 tons of sugarcane per hour. Maximum hours of operation per day are assumed to be 8 hours in this study for all harvesters and loaders, except for a combine harvester which is assumed to operate no more than 10 hours per day.

Estimated costs of soldier and combine harvesters are shown in Table 2. These estimates are based on purchase price, fuel consumption, repair cost, salvage value, and estimated useful life assumptions listed in Appendix Table 1. Variable costs per hour of operation are estimated to be about $32 per hour for one-row soldier harvesters, $44 per hour for two-row soldier harvesters, and $49 per hour for combine harvesters. Variable costs shown in Table 2 represent fuel, labor, and repair and maintenance costs associated with the operation of sugarcane harvesters. Estimates of repair and maintenance costs, based on standard assumptions for similar type harvesting equipment, are calculated as a percentage of the purchase price incurred over the entire useful life of the machine. Harvesters are assumed to be in use on the farm for their entire useful life. Fixed costs include estimates of economic depreciation and interest on average investment (a measure of opportunity cost). Total annual depreciation costs are estimated using

Table 1. Estimated Performance Rating for Sugarcane Harvesters and Loaders				
	Tons/hour	Acres/hour[1]	Max. hours[2]	Hours/acre
1-Row Soldier Harvester:				
a. <25 tons/acre	60	2.00	8	0.50
b. 25-35 tons/acre	50	1.67	8	0.60
c. >35 tons/acre (straight)	40	1.33	8	0.75
d. >35 tons/acre (lodged)	30	1.00	8	1.00
2-Row Soldier Harvester:				
a. <25 tons/acre	140	4.67	8	0.21
b. 25-35 tons/acre	130	4.33	8	0.23
c. >35 tons/acre (straight)	110	3.67	8	0.27
d. >35 tons/acre (lodged)	90	3.00	8	0.33
Combine Harvester	56	1.87	10	0.54
1-Row Loader	50	1.67	8	0.60
2-Row Loader	75	2.50	8	0.40
Transloader	100	3.33	8	0.30

[1] Estimate based on an average farm yield of 30 tons/acre. Assumption is made that the average yield of cane harvested each day is equal to the yield across all acreage harvested. In reality, acres/hour estimates for soldier harvesters should be higher in light cane and lower in heavy cane than the estimates shown hear, although the average across the farm over the entire harvest season will remain about the same.

[2] Maximum hours of operation per day assumed in this analysis.

Table 2. Estimated Costs of Sugarcane Harvesters			
Cost:	1-Row Soldier Harvester	2-Row Soldier Harvester	Combine Harvester
Variable Costs per hour:			
Fuel Cost	$4.56	$4.96	$6.03
Repair and Maintenance	$17.50	$29.17	$33.00
Labor Cost	$10.00	$10.00	$10.00
Total Variable Cost / hour	$32.06	$44.12	$49.03
Fixed Costs per hour:[1]			
Depreciation	$15.75	$26.25	$27.00
Interest on Avg. Investment	$6.16	$12.32	$10.56
Total Fixed Cost / hour	$21.91	$38.57	$37.56
Total Annual Fixed Cost	$13,146	$19,285	$22,536

[1] These fixed costs per hour estimates are based on estimated hours of annual use and years of useful life from Appendix Table 1.

Table 3. Estimated Costs of Sugarcane Loaders			
Cost:	1-Row Loader	2-Row Loader	Transloader
Variable Costs per hour:			
Fuel Cost	$2.75	$3.69	$3.22
Repair and Maintenance	$6.69	$12.81	$6.72
Labor Cost	$10.00	$10.00	$10.00
Total Variable Cost / hour	$19.44	$26.50	$19.94
Fixed Costs per hour:[1]			
Depreciation	$8.25	$15.38	$8.40
Interest on Avg. Investment	$3.23	$6.01	$2.63
Total Fixed Cost / hour	$11.48	$21.39	$11.03
Total Annual Fixed Cost	$6,886	$12,833	$4,136

[1] These fixed costs per hour estimates are based on estimated hours of annual use and years of useful life from Appendix Table 2.

the straight-line method. Interest on average investment is calculated using a real interest rate of 6.4 percent. Projected fixed costs estimates range from about $22 per hour for one-row soldier harvesters to about $38 per hour for two-row soldier and combine harvesters, respectively. Fixed cost estimates per hour as well as total annual fixed cost, shown in Table 2, are based on expected hours of useful life. Total annual fixed costs are divided by actual hours of annual use to obtain estimates of actual fixed costs per acre and per ton reported in the following section of this study.

Variable and fixed cost estimates for loaders and transloaders used in harvesting wholestalk sugarcane are shown in Table 3. Variable costs per hour of operation are estimated to be about $19 per hour for a one-row loader, $26 per hour for a two-row loader, and $20 per hour for a transloader. Similar assumptions are made regarding estimates of repair and maintenance costs, as described above for harvesters. Projected fixed cost per hour of operation are estimated to be about $21 per hour for a two-row loader and about $12 per hour for a one-row loader and a transloader. These fixed cost per hour estimates are multiplied by expected hours of annual use, over the life of the machine, to obtain estimates of total annual fixed cost. Actual fixed cost estimates per acre and per ton, included in the following section, are based on actual hours of annual use. Purchase price and estimated useful life assumptions for sugarcane loaders are shown in Appendix Table 2.

Estimated costs of representative sugarcane hauling systems are shown in Table 4. These cost estimates are based on purchase price and estimated useful life assumptions listed in Appendix Tables 3 and 4. Variable and fixed cost estimates for each representative hauling system include costs for both tractor and wagon. Two hauling systems are included to haul wholestalk and billeted sugarcane directly to the mill and two hauling systems are included to haul wholestalk and billeted sugarcane from the field to a transloading site or waiting truck/trailer. Estimates for transfer systems include costs for one tractor and one wagon while estimates for direct systems include costs for one tractor and two wagons. Estimated costs are higher for the transfer and direct hauling systems associated with the combine harvester, primarily due to the higher purchase price and estimated repair and maintenance costs of billet wagons. Variable and fixed hauling costs per hour estimates range from $18 to $24 and $10 to $17 per hour, respectively.

HARVESTING SYSTEM COST COMPARISON

Direct Haul Systems

Estimated costs for a one-row soldier harvesting system with sugarcane hauled directly from field to mill by tractors and wagons are shown in Table 5. Under the assumptions of an average farm tonnage of 30 tons per acre, hauling distance of 5 miles to the mill, and a maximum harvester operation of 8 hours per day, it would require 2 one-row harvesters, 2 loaders, and 4 tractor/wagon units in order to harvest and haul the farm's daily quota of 400 tons. Each one-row harvester and loader would operate for 4.4 hours per day. Each of the 4 tractor/wagon units

Table 4. Estimated Costs of Sugarcane Hauling Systems

Cost:	10-Ton Transfer Wagon & 106-130 HP Tractor[1]	10-Ton Direct Wagon & 131-155 HP Tractor[2]	8.5-Ton Self-dump Wagon & 106-130 HP Tractor[3]	10-Ton Billet Wagon & 131-155 HP Tractor[4]
Variable Costs per hour:				
Fuel Cost	$4.56	$5.43	$4.56	$5.43
Repair and Maintenance	$7.33	$8.94	$10.94	$12.41
Labor Cost	$6.00	$6.00	$6.00	$6.00
Total Variable Cost / hour	$17.89	$20.37	$21.50	$23.84
Fixed Costs per hour:[5]				
Depreciation	$6.39	$8.08	$8.00	$10.96
Interest on Avg. Investment	$3.85	$4.84	$4.40	$5.76
Total Fixed Cost / hour	$10.24	$12.92	$12.40	$16.72
Total Annual Fixed Cost	$6,131	$8,015	$7,593	$10,363

[1] Representative hauling system used to haul wholestalk sugarcane from the field to a transloading site for later transfer to truck/trailer (1 tractor and 1 wagon).

[2] Representative hauling system used to haul wholestalk sugarcane directly from the field to the mill (1 tractor and 2 wagons).

[3] Representative hauling system used to haul combine harvested (billet) sugarcane from field to truck/trailer (1 tractor and 1 wagon).

[4] Representative hauling system used to haul combine harvested (billet) sugarcane from field to mill (1 tractor and 2 wagons).

[5] These fixed costs per hour estimates are based on estimated hours of annual use and years of useful life from Appendix Tables 3 and 4.

Table 5 - Estimated Total Costs for a 1-Row Soldier Harvesting and Hauling System, Direct Haul to Mill by Tractors/Wagons

Farm Size and Tonnage:		**Daily Requirements:**	
Acres:	1000 acres	Mill Quota:	400 tons/day
Tons:	30,000 tons	Acres harvested/day:	13.33 acres
Tons/acre:	30.0 tons		

	Equipment		
Operation	**Number of units**	**Hours per unit**	**Hours per day[2]**
Cutting	2	4.4	8.8
Loading	2	4.4	8.9
Direct Wagons[1]	4	7.6	30.5
Burning	1	2.0	2.0

	Variable System Cost[3]			**Total System Cost[4]**		
Operation	**Total**	**Per acre**	**Per ton**	**Total**	**Per acre**	**Per ton**
Cutting	$21,237.10	$21.24	$0.71	$47,529.10	$47.53	$1.58
Loading	$12,959.11	$12.96	$0.43	$26,731.11	$26.73	$0.89
Subtotal	$34,196.21	$34.20	$1.14	$74,260.21	$74.26	$2.48
Direct Wagons	$46,536.11	$46.54	$1.55	$76,410.03	$76.41	$2.55
Burning	$1,949.33	$1.95	$0.06	$2,638.58	$2.64	$0.09
Total	$82,681.65	$82.68	$2.76	$153,308.82	$153.31	$5.11

[1] Each direct wagon unit includes one tractor and two wagons.
[2] Number of units multiplied by daily hours of operation per unit.
[3] Variable system cost includes costs for fuel, repair and maintenance, and labor.
[4] Total system cost includes variable and fixed costs.

would operate for 7.6 hours per day. Variable cost for this type of system is estimated to be about $83 per acre, or $2.76 per ton. Total system cost (variable plus fixed cost) is estimated at about $153 per acre, or $5.11 per ton.

System requirements and estimated costs for a two-row soldier system are shown in Table 6. In order to cut 400 tons of sugarcane per day, 1 two-row harvester would be required, operating 3.7 hours per day. A single two-row loader would also be required, operating 5.3 hours per day. Four tractor/wagon units would be required, each operating 7.0 hours per day. Estimated variable cost of this system is determined to be about $67 per acre, or $2.24 per ton. Total system cost is estimated at $128 per acre, or $4.26 per ton.

With a 400 ton quota, one combine harvester would have to operate 7.1 hours per day (Table 7). Combine machines currently available can harvest only one row of sugarcane per swath. Four tractor/wagon units would be needed to haul the cane directly to the mill. Each tractor/wagon unit would operate for an estimated 7.4 hours per day. The variable cost of operating this particular harvesting and hauling system is estimated to be about $81 per acre, or $2.71 per ton. This estimated cost is higher than the costs for a two-row soldier system. The cost of operating a combine harvester is estimated to be about $4-$5 per acre higher than the costs of operating a two-row soldier harvester and loader. The biggest difference in cost is the higher estimated cost of wagons used with a combine system. This higher cost results in higher estimates for repair and maintenance costs as well as for depreciation and interest costs. Total combine system cost is estimated to be about $143 per acre, or $4.77 per ton.

Transfer Systems

Required equipment and estimated costs of a one-row soldier harvesting system with the sugarcane transferred to truck/trailer units for hauling to mill is shown in Table 8. With a 400 ton daily quota, 2 one-row harvesters and loaders would be required, as in the direct haul system. Each harvester and loader would operate approximately 4.4 hours per day. Three transfer tractor/wagon units would be needed to haul the sugarcane to a transloading site and one transloader would be required to transfer sugarcane to truck/trailer. Each tractor/wagon unit would operate approximately 7.9 hours per day and the transloader would operate approximately 4.0 hours per day. Estimated variable cost for this system is determined to be about $74 per acre, or $2.46 per ton. Total system cost, including fixed costs, is estimated at $136 per acre, or $4.54 per ton.

For two-row soldier harvesting systems, 1 two-row harvester and 1 two-row loader would be required. The harvester would require about 3.7 hours of operation in the field to harvest 400 tons per day. Three transfer tractor/wagon units would be needed to haul sugarcane from the field to the transloading site. Each tractor/wagon unit would operate for approximately 7.0 hours per day. One transloader would transfer the sugarcane into truck/trailers. Variable cost for this system is estimated to be about $59 per acre, or $1.97 per ton (Table 9). Total system cost is estimated to be about $3.73 per ton ($112 per acre).

Table 6 - Estimated Total Costs for a 2-Row Soldier Harvesting and Hauling System, Direct Haul to Mill by Tractors/Wagons

Farm Size and Tonnage:		**Daily Requirements:**	
Acres:	1000 acres	Mill Quota:	400 tons/day
Tons:	30,000 tons	Acres harvested/day:	13.33 acres
Tons/acre:	30.0 tons		

	Equipment		
Operation	**Number of units**	**Hours per unit**	**Hours per day[2]**
Cutting	1	3.7	3.7
Loading	1	5.3	5.3
Direct Wagons[1]	4	7.0	27.8
Burning	1	2.0	2.0

	Variable System Cost[3]			**Total System Cost[4]**		
Operation	**Total**	**Per acre**	**Per ton**	**Total**	**Per acre**	**Per ton**
Cutting	$12,274.68	$12.27	$0.41	$31,559.68	$31.56	$1.05
Loading	$10,599.00	$10.60	$0.35	$23,432.00	$23.43	$0.78
Subtotal	$22,873.68	$22.87	$0.76	$54,991.68	$54.99	$1.83
Direct Wagons	$42,467.38	$42.47	$1.42	$70,285.50	$70.29	$2.34
Burning	$1,949.33	$1.95	$0.06	$2,638.58	$2.64	$0.09
Total	$67,290.39	$67.29	$2.24	$127,915.76	$127.92	$4.26

[1] Each direct wagon unit includes one tractor and two wagons.

[2] Number of units multiplied by daily hours of operation per unit.

[3] Variable system cost includes costs for fuel, repair and maintenance, and labor.

[4] Total system cost includes variable and fixed costs.

Table 7 - Estimated Total Costs for a Combine Harvesting and Hauling System, Direct Haul to Mill by Tractors/Wagons

Farm Size and Tonnage:		**Daily Requirements:**	
Acres:	1000 acres	Mill Quota:	400 tons/day
Tons:	30,000 tons	Acres harvested/day:	13.33 acres
Tons/acre:	30.0 tons		

	Equipment		
Operation	**Number of units**	**Hours per unit**	**Hours per day[2]**
Cutting & loading	1	7.1	7.1
Direct Wagons[1]	4	7.4	29.6
Burning	1	2.0	2.0

	Variable System Cost[3]			**Total System Cost[4]**		
Operation	**Total**	**Per acre**	**Per ton**	**Total**	**Per acre**	**Per ton**
Cutting & loading	$26,266.07	$26.27	$0.88	$48,802.07	$48.80	$1.63
Subtotal	$26,266.07	$26.27	$0.88	$48,802.07	$48.80	$1.63
Direct Wagons	$52,993.19	$52.99	$1.77	$91,599.96	$91.60	$3.05
Burning	$1,949.33	$1.95	$0.06	$2,638.58	$2.64	$0.09
Total	$81,208.59	$81.21	$2.71	$143,040.61	$143.04	$4.77

[1] Each direct wagon unit includes one tractor and two wagons.

[2] Number of units multiplied by daily hours of operation per unit.

[3] Variable system cost includes costs for fuel, repair and maintenance, and labor.

[4] Total system cost includes variable and fixed costs.

Table 8 - Estimated Total Costs for a 1-Row Soldier Harvesting and Hauling System, Transfer to Truck/Trailer

Farm Size and Tonnage:		**Daily Requirements:**	
Acres:	1000 acres	Mill Quota:	400 tons/day
Tons:	30,000 tons	Acres harvested/day:	13.33 acres
Tons/acre:	30.0 tons		

	Equipment		
Operation	**Number of units**	**Hours per unit**	**Hours per day**[2]
Cutting	2	4.4	8.8
Loading	2	4.4	8.9
Transfer Wagons[1]	3	7.9	23.7
Transloader	1	4.0	4.0
Burning	1	2.0	2.0

	Variable System Cost[3]			**Total System Cost**[4]		
Operation	**Total**	**Per acre**	**Per ton**	**Total**	**Per acre**	**Per ton**
Cutting	$21,237.10	$21.24	$0.71	$47,529.10	$47.53	$1.58
Loading	$12,959.11	$12.96	$0.43	$26,731.11	$26.73	$0.89
Subtotal	$34,196.21	$34.20	$1.14	$74,260.21	$74.26	$2.48
Transfer Wagons	$31,751.20	$31.75	$1.06	$49,295.54	$49.30	$1.64
Transloader	$5,980.80	$5.98	$0.02	$10,116.40	$10.12	$0.34
Burning	$1,949.33	$1.95	$0.06	$2,638.58	$2.64	$0.09
Total	$73,877.54	$73.88	$2.46	$136,310.73	$136.31	$4.54

[1] Each transfer wagon unit includes one tractor and one wagon.

[2] Number of units multiplied by daily hours of operation per unit.

[3] Variable system cost includes costs for fuel, repair and maintenance, and labor.

[4] Total system cost includes variable and fixed costs.

Table 9 - Estimated Total Costs for a 2-Row Soldier Harvesting and Hauling System, Transfer to Truck/Trailer

Farm Size and Tonnage:		**Daily Requirements:**	
Acres:	1000 acres	Mill Quota:	400 tons/day
Tons:	30,000 tons	Acres harvested/day:	13.33 acres
Tons/acre:	30.0 tons		

	Equipment		
Operation	**Number of units**	**Hours per unit**	**Hours per day**[2]
Cutting	1	3.7	3.7
Loading	1	5.3	5.3
Transfer Wagons[1]	3	7.0	21.0
Transloader	1	4.0	4.0
Burning	1	2.0	2.0

	Variable System Cost[3]			**Total System Cost**[4]		
Operation	**Total**	**Per acre**	**Per ton**	**Total**	**Per acre**	**Per ton**
Cutting	$12,274.68	$12.27	$0.41	$31,559.68	$31.56	$1.05
Loading	$10,599.00	$10.60	$0.35	$23,432.00	$23.43	$0.78
Subtotal	$22,873.68	$22.87	$0.76	$54,991.68	$54.99	$1.83
Transfer Wagons	$28,173.60	$28.17	$0.94	$44,020.62	$44.02	$1.47
Transloader	$5,980.80	$5.98	$0.20	$10,116.40	$10.12	$0.34
Burning	$1,949.33	$1.95	$0.06	$2,638.58	$2.64	$0.09
Total	$58,977.41	$58.98	$1.97	$111,767.28	$111.77	$3.73

[1] Each transfer wagon unit includes one tractor and one wagon.

[2] Number of units multiplied by daily hours of operation per unit.

[3] Variable system cost includes costs for fuel, repair and maintenance, and labor.

[4] Total system cost includes variable and fixed costs.

A combine harvesting system transferring sugarcane directly into truck/trailer would require 1 combine harvester and 3 transfer, self-dumping tractor/wagon units, each operating about 7.1 hours per day. Variable cost for this system is estimated to be about $62 per acre and total cost is estimated to be about $106 per acre (Table 10). With a 30 ton per acre average yield, these costs translate to per ton costs of $2.08 and $3.54, respectively.

FACTORS AFFECTING THE FEASIBILITY OF COMBINE HARVESTERS

The cost estimates for combine and soldier sugarcane harvesting systems presented above are based on a specific set of assumptions relating to both the operating performance of the various harvesting units which make up the total system as well as specific farm characteristics in terms of sugarcane acreage and tonnage per acre. Changes in these or other factors result in changes in the estimated costs of the respective systems on both a 'per acre' and a 'per ton' basis. This section of the report discusses some the more important factors which influence the actual costs which might pertain to a particular farm situation.

Farm Size

One factor which has a major influence on the cost of owning and operating any piece of farm machinery is farm size. For self-propelled equipment, such as tractors or harvesters, the variable (or direct) cost per hour of operation is not generally assumed to be a function of the hours of annual use. Stated in other words, the cost of fuel, repairs, and labor per hour of operation would generally be the same for a tractor or harvester regardless of whether that particular machine were used 300 hours per year or 600 hours per year. Fixed costs, however, are directly related to hours of annual use. Since annual fixed costs of owning a piece of farm machinery are incurred regardless of whether or not, or how much, a particular piece of machinery is used during the year, fixed cost per unit can be lowered by using the machine over more acres. As an example, if a sugarcane harvester has the capacity to harvest 1,000 acres of sugarcane over a 75-day harvest season, the fixed cost per acre of owning such a harvester is significantly higher if that harvester is used on only 500 acres per harvest season. As the acres over which a machine is used increases, total annual fixed costs are spread over more units, thus lowering cost per acre.

As an illustration of impact of farm size on fixed cost, the representative farm situation used in estimating comparative system costs, presented earlier in this report, is used here. A sugarcane farm with an average yield of 30 tons of cane per acre and a harvest season of 75 days is assumed. The impact of farm size on system cost per unit is evaluated by varying the daily mill quota. Estimated costs per ton for a combine and 2-row soldier harvesting system for alternative daily quota (farm size) levels is shown in Figure 2. Daily mill quota is varied from 200 tons per day, representing a farm size of approximately 500 acres, up to 800 tons per day, representing a farm size of roughly 2,000 acres. Cost per ton estimates shown in Figure 2

Table 10 - Estimated Total Costs for a Combine Harvesting and Hauling System, Transfer to Truck/Trailer

Farm Size and Tonnage:		**Daily Requirements:**	
Acres:	1000 acres	Mill Quota:	400 tons/day
Tons:	30,000 tons	Acres harvested/day:	13.33 acres
Tons/acre:	30.0 tons		

	Equipment		
Operation	**Number of units**	**Hours per unit**	**Hours per day**[2]
Cutting & loading	1	7.1	7.1
Transfer Wagons[1]	3	7.1	21.3
Burning	1	2.0	2.0

	Variable System Cost[3]			**Total System Cost**[4]		
Operation	**Total**	**Per acre**	**Per ton**	**Total**	**Per acre**	**Per ton**
Cutting & loading	$26,266.07	$26.27	$0.88	$48,802.07	$48.80	$1.63
Subtotal	$26,266.07	$26.27	$0.88	$48,802.07	$48.80	$1.63
Transfer Wagons	$34,277.92	$34.28	$1.14	$54,676.55	$54.68	$1.82
Burning	$1,949.33	$1.95	$0.06	$2,638.58	$2.64	$0.09
Total	$62,493.33	$62.49	$2.08	$106,117.20	$106.12	$3.54

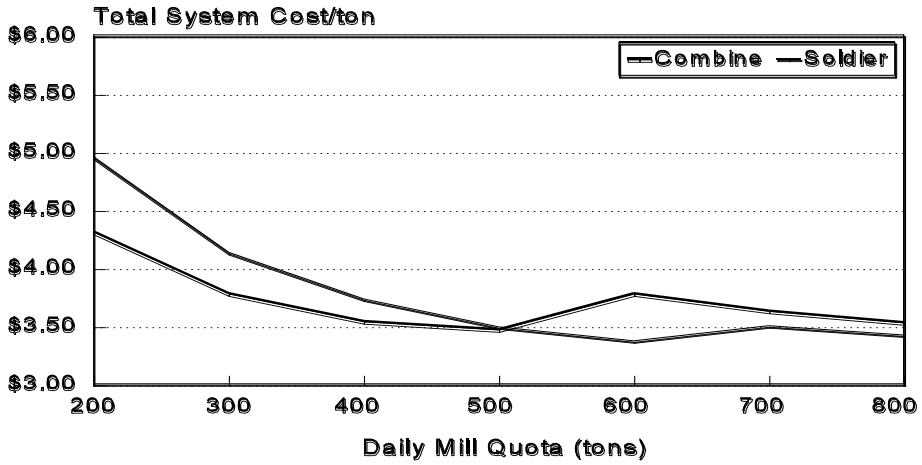
[1] Each transfer wagon unit includes one tractor and one wagon.

[2] Number of units multiplied by daily hours of operation per unit.

[3] Variable system cost includes costs for fuel, repair and maintenance, and labor.

[4] Total system cost includes variable and fixed costs.

Figure 2. Estimated Cost per Ton for Combine and 2-Row Soldier Harvesting Systems With Transfer to Truck/Trailer For Alternative Quota (Farm Size) Levels.

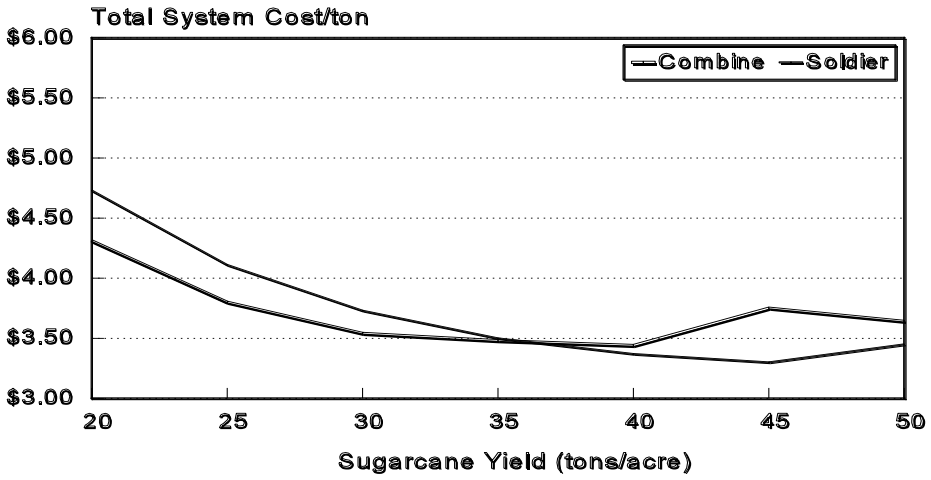


represent the total cost (variable plus fixed cost) of transfer harvesting systems, including tractors and wagons used to transport sugarcane from the field to truck/trailer or transloading site. This illustration assumes that sugarcane is transferred to truck and trailers for transport to the mill. As daily quota increases from 200 tons per day, total system cost per ton decreases. This decrease in cost reflects a decrease in fixed costs, resulting from total annual fixed costs being spread over more acres. This relationship holds for both the combine and the soldier systems.

In this particular example, it is assumed that the combine harvester could be used a maximum of 10 hours per day and the soldier harvester could be used a maximum of 8 hours per day. Cost per ton in Figure 2 decreases for the combine system until a quota level of 600 tons per day (approximately 1,500 acres) is reached, at which point the total system cost increases from $3.47 per ton to $3.78 per ton. This increase in cost is the result of having to add a second combine harvester to the system because the acreage level has risen to the point where a single combine could not harvest the daily quota within the 10 hour per day limit. Adding this second combine increased annual fixed costs of the total harvesting system, thereby increasing the cost per ton. As farm size increases beyond this point, cost per ton of the combine system again decreases, as fixed costs are spread over more acres. If, on the other hand, the combine is used more than 10 hours per day at the 600 ton per day quota level, rather than adding a second combine, total costs per ton would continue to decrease.

For the soldier system shown in Figure 2, total system cost per ton of sugarcane harvested decreases from $4.95 per ton at a quota level of 200 tons per day down to $3.37 per ton at 600

Figure 3. Estimated Cost per Ton for Combine and 2-Row Soldier Harvesting Systems With Transfer to Truck/Trailer For Alternative Sugarcane Yield Levels.



tons per day. At the 700 ton per day level, a second loader must added to the system, thus increasing total costs. However, the cost per ton decreases at the 800 ton level due to decreasing fixed costs per ton.

This example illustrates the point that the cost per acre or cost per ton of a particular harvesting system will be lowest if that system is used at, or as close to as possible, its maximum capacity. Given the short harvest season which exists for sugarcane in Louisiana, some excess harvester capacity may be warranted to cover situations where harvesting may have to be halted due to wet conditions or other factors. However, the efficient use of harvesting machinery means that a producer must weigh the benefit of having excess harvesting capacity to make up for down time during the harvest season with the higher fixed cost of having that excess capacity.

Tonnage per Acre

Similar to the influence of increasing acreage on the total cost per ton of sugarcane harvesting systems, higher yields per acre will also decrease fixed cost per ton. This is shown in Figure 3. Total costs per ton for combine and soldier harvesting systems transferring to truck and trailer are estimated for alternative tonnage per acre levels. Total combine system costs decrease from $4.31 per ton at 20 tons per acre down to $3.44 per ton at 40 tons per acre. At the 45 ton per acre level, a second combine harvester is added to the system as the 10 hour per day limit is reached with only one combine. For the soldier system, estimated system costs are

$4.73 per ton at 20 tons per acre and decrease to $3.30 per ton at the 45 ton per acre level. At 50 tons per acre, a second loader is added to the soldier system increasing total costs. Estimated costs per ton decrease in this example for the same reason costs per ton decreased when the harvester is used over more acreage. As tonnage through the harvesting system increases, either due to more acreage or higher tonnage per acre, fixed costs per ton will decline until the point is reached where additional machinery must be added to the harvesting system.

An additional point must be mentioned here regarding sugarcane harvester recovery rates. Recovery rates refer to the percentage of sugarcane in the field which the harvester or harvesting system is able to harvest and deliver to the mill. One of the primary advantages of the combine harvester is its ability to harvest sugarcane, particularly heavy tonnage or lodged cane, with very high recovery rates. In field tests conducted in 1995, sugarcane recovery rates for combine and soldier systems were very similar in light to moderate cane which was relatively erect in the field (Richard). However, in fields with heavy tonnage cane with some degree of lodging, recovery rates for the combine harvester were significantly higher than for the wholestalk harvester. In addition, there is also assumed to be lease spillage of billeted sugarcane on highways during transport to the mill than currently exists with wholestalk harvested sugarcane.

This difference in recovery rate also has an impact on the actual, or realized, cost per ton of a particular harvesting system. Cost estimates presented in this report are based on the implicit assumption that the farm has an average yield of 30 tons per acre and 100 percent of this tonnage is harvested and hauled to the mill. This assumption is made primarily to estimate the total amount of equipment and time required to harvest and haul the tonnage of sugarcane actually in the field. As the recovery rate of a particular harvesting system decreases from 100 percent, costs per ton will generally increase. The impact of varying recovery rates on actual cost per ton of sugarcane harvesters is illustrated in Table 11. Estimated variable and fixed cost per acre of a combine and two-row soldier harvester is estimated to be $48.80 and $31.56 per acre, respectively. These costs are based on an assumed sugarcane tonnage level of 30 tons per acre in the field. Realized cost per ton for owning and operating a combine harvester varies from $1.63 per ton, at a recovery rate of 100 percent, to $3.25 per ton, at a recovery rate of 50 percent. Cost per ton for a two-row soldier harvester varies from $1.05 per ton to $2.10 per ton over the same recovery range.

Across the farm, over an entire harvest season, or on a particular field which has light to moderate tonnage with little or no lodged cane, recovery rates for combine and soldier harvesters should be very similar, approximately in the 90 to 95 percent range. In these situations, actual harvesting system costs will be very similar to the estimates presented in this report, for similar farm situations. However, in fields which have very heavy tonnage cane or severely lodged cane, the recovery rates for a combine harvester are generally expected be much higher than what might exist with soldier harvesters. In these situations, total costs per ton of combine harvesting systems should be significantly lower than soldier systems because a substantially higher percentage of the cane in the field is actually being delivered to the mill.

Table 11. Impact of Sugarcane Recovery Rate on Harvester Cost per Ton		
Total Harvester Cost[1]	Combine Harvester	2-Row Soldier Harvester
(A) Total cost per acre[2]	$48.80	$31.56
(B) Total cost per ton[3]:		
Recovery rate[4]:		
100% (30 tons/acre)	$1.63	$1.05
90% (27 tons/acre)	$1.81	$1.17
80% (24 tons/acre)	$2.03	$1.32
70% (21 tons/acre)	$2.32	$1.50
60% (18 tons/acre)	$2.71	$1.75
50% (15 tons/acre)	$3.25	$2.10

[1] Total harvester cost includes variable and fixed costs for the harvester only.

[2] Estimate based on an average farm yield of 30 tons/acre in the field.

[3] Total cost per acre divided by tons per acre recovered.

[4] Percentage of sugarcane tonnage in the field actually recovered by the harvester.

When deciding whether to switch from a soldier system to a combine system, a producer should consider the tonnage and harvestability of the sugarcane varieties which will be planted on the farm in the near future. Depending upon the variety mix and other factors, such as soil type, distance to the mill, etc., some farms may achieve lower per ton costs by switching completely to a combine system, particularly if a majority of the acreage on the farm is planted in heavy tonnage varieties. When considering the flexibility of the soldier system, the most cost efficient harvesting system for a particular farm may be to maintain the soldier harvesting system and utilize a combine harvester to harvest lodged sugarcane. In this situation, the additional cost of a combine harvester could be minimized by sharing the investment with one or two other farms or having the lodged sugarcane custom harvested with a combine.

Availability of Hauling Units

One factor to consider in evaluating the feasibility of a sugarcane harvesting system, either soldier or combine, for a particular farm situation is the availability of hauling units, including tractor/wagons and truck/trailers. The current soldier harvesting system used in Louisiana cuts and lays whole stalks of sugarcane in heap-rows which are then burned to remove leaves and other

extraneous matter. The sugarcane is later loaded into wagons or trailers and hauled to the mill. This type of system also allows for field storage of harvested sugarcane. As a result, this type of harvesting system provides considerable flexibility in that the harvester can operate independently of the loading and hauling operations.

Combine harvesters are different than soldier harvesters in two important aspects. First, combine harvesters can currently cut roughly 55-60 tons of cane per hour. This is about half the performance of a two-row soldier harvester. As a result, it will take more hours per day for a combine harvester to cut a given daily quota of sugarcane than would be required by a two-row soldier harvester. Secondly, a tractor and wagon must run beside the combine to collect the billeted sugarcane exiting the combine. Therefore, a farm would need to have enough tractors and wagons to keep the combine operating in the field the required time to cut the daily quota. In addition, if the farm's sugarcane is being hauled long distances to a mill by truck and trailer, situations could arise where the combine would have to stop harvesting and wait for an empty truck to arrive. In such situations, some type of on-farm storage facility for billeted sugarcane may be required.

Operation in Wet Field Conditions

One factor not incorporated into the cost analysis presented in this report, but one which could have a major impact on the feasibilty of combine harvester use in Louisiana, is the impact of wet harvesting conditions on harvester performance and cane quality. Due to the manner in which combine harvesters handle sugarcane in the field, operation of these machines in wet field conditions could result in higher trash and mud levels in the cane delivered to the mill than might otherwise be the case with soldier harvesters. Since combine harvesters must travel over every row in the field, along with a tractor and wagon, there is also the possibility that this increased field traffic could damage head-rows or stubble cane in the row. Furthermore, there is a potentially greater chance of loss of sugar from billeted cane harvested in wet conditions, as a stalk of billeted cane would have a greater number of exposed ends through which sugar could be lost. Although the chance of wet field conditions during harvest will vary from day to day throughout a single harvest season as well as from year to year, its impact on harvester performance and cane quality must not be overlooked.

Determination of a 'Standard Combine System'

Due to the relatively few number of combine harvesters currently in use in Louisiana, no information exists regarding what might emerge as a typical or standard combine harvesting and hauling system used by most producers. The combine harvesting system evaluated in this study represents only one of many possible types of combine system arrangements which could exist in Louisiana. Although the combine harvester itself will be the same, the types of hauling units used in such a system could vary widely. In the analysis presented here, self-dumping billet wagons are assumed to be used to dump billeted cane into trucks and specially designed billet wagons are assumed to be used to haul billeted cane to mills by tractors. Other types of hauling units which could also be used within a combine harvesting system include dumping billets into boxes rather than

wagons and hauling these boxes to mills by truck and trailer, or refitting currently used wagons with some type of screen or mesh to allow these wagons to hold billets. These types of alternative hauling units would generally have somewhat lower costs associated with them, compared to the billet wagons used in this analysis. In addition, the mills would have to make some investment into equipment which would unload the billeted cane into the mill yard.

Billet Planting

A related factor which will also have some bearing on the adoption of combine harvesting is related to the planting of sugarcane. Seed cane in Louisiana has historically been planted as whole stalks of sugarcane. Each stalk of sugarcane planted will contain several joints. Planting recommendations have generally called for a planting rate of three stalks of sugarcane with an overlap of at least two mature joints (*Louisiana Sugarcane Planting Recommendations*). With billeted cane cut into 12-14 inch pieces, each billet of sugarcane would probably average about one joint per billet. In addition, stalks of sugarcane cut into billets would have a greater number of open ends which could be exposed to disease. Although some research on billet planting in Louisiana is currently being conducted, the success of this type of sugarcane planting has not yet been established in the state. This means that farms which harvest millable sugarcane with combine harvesters may still need to harvest their seed cane with wholestalk harvesters.

Summary and Conclusions

Wholestalk (soldier) harvesting of sugarcane has been the predominant method of harvesting sugarcane in Louisiana for many years. Although mechanized sugarcane harvesting in other areas of the United States and the world has switched to the combine, or billet, harvesting system, producers in Louisiana have continued to utilize the soldier harvester. The flexibility and performance of this type of harvesting system has proved to be very suitable for the relatively short, and often wet, harvest season in Louisiana. However, the ability of combine harvesters to deliver more of the sugarcane in the field to the mill has recently caused some producers in Louisiana to seriously consider switching from the soldier harvester to the combine harvesting system. This report quantifies some of the differences in machinery requirements, performance rates, and estimated costs of operating combine and soldier sugarcane harvesting systems in Louisiana.

Since combine harvesters load billeted sugarcane directly into wagons, investment in sugarcane loaders and transloaders, currently used in soldier systems, would not be needed with a combine harvesting system. However, depending upon the particular farm situation, additional investment in equipment related to the hauling operation could offset this investment savings. Purchase prices for self-dumping billet wagons are currently much higher than traditional cane wagons. In addition, if some type of on-farm storage facility for billeted cane would be required, the farm would have investment and operating costs of a transloader as well as sugarcane storage bins or boxes.

Based on cost estimates included in this report, the combine harvesting system does show some cost advantage over the two-row soldier system, particularly in situations where harvested sugarcane is being transferred to truck and trailer for transport to mills. However, the performance rate of combine harvesters, in terms of acres harvested per hour, is much lower than two-row soldier harvesters, requiring the combine to operate more hours in the field per day to harvest the same amount of sugarcane. As a result, a critical factor in the feasibility of combine harvesting systems in Louisiana will be having sufficient hauling units available to keep the combine in operation in order to harvest a farm's daily quota in a timely manner. This will be true for both direct haul and transfer hauling situations. Other factors which will likely influence the feasibility and adoption of combine harvesting in Louisiana include farm size, tonnage per acre, harvester operation in wet field conditions, identification of a standard or typical hauling system for billeted cane, and the feasibility of billet planting. The many factors which influence the actual costs of a sugarcane harvesting and hauling system imply that these costs can vary from one farm situation to another. As a result, sugarcane producers who are considering alternative harvesting systems should evaluate the estimated costs of each system for their particular farm situation.

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Appendix Table 1. Cost Parameters of Sugarcane Harvesters			
Parameter:	1-Row Soldier Harvester	2-Row Soldier Harvester	Combine Harvester
Purchase price	$105,000	$175,000	$180,000
Total useful life (hours)	6,000	6,000	6,000
Estimated useful life (years)	12	12	10
Estimated annual use (hours)	500	500	600
Performance rate (tons/hour)	45	118	56
Average farm yield (tons/acre)	30	30	30
Performance rate (hours/acre)	0.76	0.27	0.54
Fuel use (gallons/hour)	6.8	7.4	9.0
Repair cost percent	100%	100%	110%
Salvage percent	10%	10%	10%

Appendix Table 2. Cost Parameters of Sugarcane Loaders			
Parameter:	1-Row Loader	2-Row Loader	Transloader
Purchase price	$55,000	$102,500	$28,000
Total useful life (hours)	6,000	6,000	3,000
Estimated useful life (years)	10	10	8
Estimated annual use (hours)	600	600	375
Performance rate (tons/hour)	50	75	100
Average farm yield (tons/acre)	30	30	30
Performance rate (hours/acre)	0.60	0.40	0.33
Fuel use (gallons/hour)	4.1	5.5	4.8
Repair cost percent	73%	75%	72%
Salvage percent	10%	10%	10%

Appendix Table 3. Cost Parameters of Wagons Used in Hauling Sugarcane				
Parameter:	5-Ton Transfer Wagon	10-Ton Direct Wagon	8.5-Ton Self-Dump Wagon	10-Ton Billet Wagon
Purchase price	$7,800	$7,500	$18,000	$15,000
Total useful life (hours)	6,000	6,000	5,500	5,500
Estimated useful life (years)	13	13	9	9
Estimated annual use (hours)	472	602	585	611
Repair cost percent	100%	100%	150%	100%
Salvage percent	10%	10%	15%	15%

Appendix Table 4. Cost Parameters of Tractors Used in Hauling Sugarcane					
Parameter:	56-80 HP Tractor	81-105 HP Tractor	106-130 HP Tractor	131-155 HP Tractor	156-180 HP Tractor
Purchase price	$28,500	$42,300	$58,000	$70,250	$81,000
Total useful life (hours)	10,000	10,000	10,000	10,000	10,000
Estimated useful life (years)	16	16	16	16	16
Estimated annual use (hours)	625	625	625	625	625
Fuel use (gallons/hour)	4.2	5.4	6.8	8.1	9.6
Repair cost percent	138%	108%	104%	99%	95%
Salvage percent	10%	10%	10%	10%	10%