AN ECONOMIC ANALYSIS OF HARVESTING SYSTEMS FOR FLUE-CURED TOBACCO

William D. Givan and Fred C. White*

More types of harvesting systems are used in flue-cured tobacco than any other crop produced in the United States. As recently as the early 1950's most of the crop was harvested entirely by hand, requiring up to 250 hours of labor per acre just for the harvesting operation. During the past 20 years, various mechanical and semi-mechanical harvesting systems have gained acceptance. Capital and labor requirements differ for each system. As a result growers tend to apply the system especially adopted for specific size of operation and type and amount of available labor.

This paper is concerned with the factors affecting the use of labor for the harvest of flue-cured tobacco. More specifically, it examines factors affecting labor inputs in harvesting tobacco and uses this information to develop average cost data for specified harvesting systems.

HARVESTING SYSTEMS

Although less than 20 percent of flue-cured tobacco acreage was harvested entirely by hand in 1972, most of the remaining acreage was harvested with non-mechanical methods. Perhaps less than 2,000 mechanical harvesters are in operation during 1975. As these harvesters require substantial capital outlay and are best suited for very large tobacco acreages, they are not included in this analysis.

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*Respectively, Agricultural Economist, CED-ERS, USDA stationed at the University of Georgia and Assistant Professor, Department of Agricultural Economics, University of Georgia, Athens, Georgia.

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Harvesting methods differ primarily by three factors: 1) how the tobacco leaves are pulled from the stalk, 2) how and where the leaves are prepared for curing, and 3) the type of curing barn used. With all non-mechanical harvesting methods, the leaves are pulled from the stalk by hand. The individual pulling the leaf either walks through the field and places the leaf on a trailer, or pulls the leaf while riding a harvesting (priming) aid. Approximately 35 percent of the tobacco acreage is harvested with some type of priming aid [2].

If the leaves are to be cured in conventional barns, they are prepared for curing by tying them to sticks, either by hand or with a tying machine. The tying machine ties the leaves together on the stick. If bulk racks are used, the leaves are placed in the racks by hand, either in the field or at the barn.

Traditionally, flue-cured tobacco has been cured in wooden (conventional) barns, which require the leaves to be placed on sticks (a time consuming process). In the 1960's the bulk barn, which requires a larger capital outlay but less labor, was introduced. Metal racks in the bulk barns are used for holding leaves for curing. Placing leaves in the racks and their removal from the racks requires less labor than tying the leaves on sticks. Consequently, the use of these barns results in a substantial saving of labor.

Labor use per acre for harvesting and preparing leaves for market varies widely by type of system. On the average, the bulk barn system uses about 100 hours of harvest labor per acre; the tying machine system uses about 184 hours per acre, and the conventional system (all harvest operations done by hand) uses 240 hours per acre [3].

LABOR PRODUCTIVITY

As tobacco harvesting is a labor intensive operation, the relationship of labor productivity to size and type of harvest system is an important determinant of the cost function. Since an accurate specification of this relationship is required, the factors affecting labor use for each harvesting system are examined in detail.

Carley suggested that labor use was inversely related to mechanization [1]. However, economies in size may be achieved very quickly as size of operation increases. Also, the number of primings and the yield per acre were expected to affect labor use; higher yields would reduce labor requirements per pound of tobacco harvested, while more primings would increase labor requirements.

Reynolds found that to offset rising wage costs, managers use more careful worker selection, better training, better incentive systems, better supervision, some capital-labor substitution, and efforts to reduce waste of supplies and materials [4, pp. 111-113].

Given identical equipment, working methods and supervision, the productive potential of labor can vary by category of workers, depending on physical strength, on motivation and on education and training [4, p. 50]. Tobacco farmworkers can be grouped into three broad categories: family workers, regular hired workers and seasonal hired workers, which can exhibit varying levels of productivity. Hired workers in tobacco production are employed on a highly seasonal basis and are not overly compensated, indicating that they are likely to be poorly motivated [4, 5].

Labor Data and Methodology

An on-farm survey of nearly 1,100 tobacco producers was conducted in the fall of 1972 to measure labor inputs for the various types of tobacco harvesting systems and determine the organization of tobacco production units. Survey results indicate that the amount of labor used for harvesting and preparing leaves for market varies by harvesting system, and that much variation exists within each of these systems [2].

To explain this variability, the effects of various factors on labor productivity were quantified in a regression analysis in which the dependent variable was specified as hours of labor used to harvest 1,000 pounds of tobacco. While one would not expect labor needs of some jobs associated with tobacco harvest to vary by size of operation, it was suspected that an analysis of labor use based on individual observations in a regression rather than average data would measure some variables affecting labor use that have not been apparent in the past. Data for farms with one acre or less of tobacco were excluded. The mean and standard deviation of the independent variables are shown in Table 1.

Factors affecting labor use were obtained for those harvest systems using walking primers and those using riding primers. While it is realized that bulk barns have caused a substantial reduction of labor use, the small number of bulk barns prohibited a sole classification of bulk barns. As a result the present classification was used to determine if these systems and the accompanying techniques realize a different harvest labor use. The effect of bulk barns and other semi-mechanization means are accounted for in the regression coefficients.

Table 1. Mean and Standard Deviation of Variables in Regression[a/]

Variable	Unit	Mean	Standard Deviation
Wage rate	$ per hour	1.427	.325
Tobacco acreage	acres harvested	9.390	9.078
Number of primings		5.992	1.167
Tobacco yield	1,000 lbs. per acre	1.888	.409
Machine tie	proportion of production	.358	.443
Bulk barns	proportion of production	.038	.190
Family labor as a percentage of total labor for harvesting	percentage	34.422	26.975
Region 16		.201	.401
Region 17		.263	.440
Region 18		.302	.389

[a/] Based on 1972 survey data

Average Productivity

The analysis indicates that labor needs for harvesting systems with walking primers could be reduced, on the average, 21 hours per 1,000 pounds of tobacco by using a tying machine or 61 hours with a bulk barn (Table 2). The large reduction associated with bulk barns results from not tying the leaves on sticks. The coefficient for yield was negative indicating that less labor per 1,000 pounds of tobacco is required on high yielding tobacco acreage. The wage rate was also negatively related to labor needs; each 10¢ increase in hourly wage was associated with a reduction of 1.5 hours used to harvest 1,000 pounds of tobacco, other things equal. The significant regression coefficient for the inverse of tobacco acreage indicates some degree of economies in productivity accruing from increases in size of production unit at relatively low acreage (10 acres or less). The change in value of labor is small when compared to total harvest costs.

The productivity of labor is also analyzed for the various tobacco producing regions. Much of the flue-cured tobacco is produced in four economic

Table 2. Regression Equations Explaining Hours of Labor Required to Harvest 1,000 Pounds of Tobacco

Variable	Unit	Regression Coefficient by Harvest System[a/]		
		Walking primer	Riding primer	Mixed system
Constant		164.20	108.09	96.25
Wage rate	$ per hour[b/]	-15.61	-13.80	
		(4.44)	(5.38)	
Inverse of tobacco acres	acres	48.71	58.64	196.50
		(7.56)	(10.84)	(60.35)
Number of primings		9.61	9.89	8.49
		(1.24)	(1.14)	(2.44)
Tobacco yield	1,000 pounds per acre of tobacco harvested	-42.65	-36.33	-31.84
		(3.50)	(3.67)	(10.85)
Machine tie	proportion of production	-21.95		
		(3.28)		
Bulk barn	proportion of production	-61.30	-25.37	-32.00
		(8.65)	(5.73)	(1.70)
Family labor as a percentage of total harvest labor	percent		-.23	
			(.06)	
Region 16		-9.43		
		(5.71)		
Region 17		-13.10	15.91	
		(5.89)	(3.28)	
Region 18		-34.31		-19.87
		(5.79)		(9.65)
R^2		.50	.45	.44

[a/] Standard deviation is shown in parenthesis below coefficient

[b/] Based on 1972 wage rate

sub-regions: Georgia (Region 29), North Carolina-South Carolina Pee-Dee Lumber River area (Region 16), North Carolina Coastal Plain (Region 17), and Virginia-North Carolina Piedmont (Region 18). The equations are structured to measure labor use in Georgia with the differences in labor use for the other regions being determined by the coefficients of the dummy variables for each region. Regions 16, 17, and 18 harvest a larger proportion of their tobacco by walking primers than in Georgia and have become relatively efficient in these harvesting methods, thus explaining the negative coefficient for these areas.

The regression equation explaining labor needs for riding primers reveals that wage rate, tobacco yield, and bulk barns are all negatively related to labor requirements. Region 17 appeared to be least efficient relative to other regions in its use of riding primers, which may indicate why a smaller percentage of the tobacco in this region is harvested by riding primers.

HARVESTING COSTS

Cost Data and Methodology

Reliable cost functions may be determined by budgeting from relevant production and price data, or by observing cost and volume data from a sample of operating firms. Budgeted data are acceptable if the coefficients are accurate, and observed cost and volume data are acceptable if they are based on accurate data from a representative sample of firms in the industry under study. Both survey and budgeting techniques were used in this study to estimate average cost of harvesting tobacco with various harvesting systems. This analysis assumes that all costs are incurred with the choice of a particular system; for example any existing barns are fully depreciated.

Labor requirements for various harvesting systems and selected acreages were generated from the regression equations on labor productivity. For each harvesting system, the regression equation was solved for a given acreage using average values for other independent variables; then the acreage was incremented 1 unit from 1 to 30 acres with a solution obtained for each acreage. The average wage rate was then multiplied by the labor requirement to determine the labor cost for harvesting 1,000 pounds of tobacco.

The tobacco labor costs were combined with budget data to compute the average costs for harvesting various acreages of tobacco. Annual fixed and variable costs were calculated for each item of equipment used in the various harvesting systems (Table 3). The operating capital and labor data were used in a budget cost simulator to compute the average cost per 1,000 pounds of tobacco for 1 to 30 acres.

Cost Analysis

In this analysis the harvesting costs for farms with small tobacco acreages was high for all systems (Table 4). Systems using various means of semi-mechanization had especially high costs at low acreages. Costs per acre for walking primers dropped rapidly up to 4-6 acres and thereafter tended to "level out". For systems using riding primers, the costs per acre decreased rapidly up to 10 acres.

In general, systems using riding primers had lower per unit costs at levels greater than 10 acres than did systems using walking primers. Also at high acreages, bulk barns, in most instances were more efficient than were conventional barns. When riding primers were used, the lower costs obtained with the hand tie system compared with the machine tie system can likely be accounted for by the relative efficiency of riding systems in Region 29 (Georgia).

Table 3. Fixed and Variable Costs Used in Analysis[a/]

Fixed Costs	Purchase cost (dollars)	Capacity (acres)	Years of life (years)
Bulk barn	7,300	7.0	12
Conventional barn	3,200	4.5	25
Tying machine	2,200	30	10
Priming aid; self propelled (used with conventional barn)	5,500	30	10
Priming aid; tractor drawn; bulk rack	3,150	30	10
Tobacco wagons	700	30	10
Tobacco bulk trailers	1,230	30	10

Insurance and taxes = 3 percent of average value
Interest on machinery = 9 percent

Variable Costs	
Item	Cost
Fuel for bulk barn	6.55¢ per pound
Fuel for conventional barn	7.38¢ per pound
Electricity for bulk barn	33.72 per acre
Sticks and twine for conventional barn	22.00 per acre
Tractors (2)	4.13 per hour
Priming aid; bulk barn	5.50 per acre
Priming aid; conventional barn	10.85 per acre
Tobacco wagon	1.40 per acre
Bulk trailer	2.65 per acre
Tying machine	1.80 per acre

[a/] Based on 1975 prices

Table 4. Harvesting Cost per 1,000 Pounds of Tobacco by Harvesting System and Selected Acreages[a/]

Acres	Walking Primers						Riding Primers					
	Hand tie	Rank	Machine tie	Rank	Bulk barn	Rank	Hand tie	Rank	Machine tie	Rank	Bulk barn	Rank
	Dol.		Dol.		Dol.		Dol.		Dol.		Dol.	
1	775.96	1	1017.63	2	1238.16	4	1176.56	3	1408.95	5	1415.60	6
2	548.34	1	654.06	2	731.66	4	687.09	3	804.23	6	785.09	5
3	472.47	1	532.87	3	562.82	4	523.93	2	602.66	6	574.92	5
4	434.53	1	472.27	4	478.41	5	442.35	2	501.87	6	469.84	3
5	418.36	3	442.50	5	427.76	4	389.99	1	446.99	6	406.79	2
6	413.07	4	428.15	6	393.99	3	374.73	2	415.05	5	364.75	1
8	406.47	5	410.22	6	367.04	3	344.42	2	375.14	4	325.14	1
10	402.50	6	399.45	5	363.07	4	326.23	2	351.19	3	311.72	1
15	397.21	6	385.10	5	357.79	4	310.98	2	319.25	3	293.83	1
20	394.57	6	377.93	5	355.14	4	289.86	2	303.29	3	284.88	1
25	392.98	6	373.62	5	353.56	4	282.58	2	293.71	3	279.51	1
30	391.93	6	370.75	5	352.50	4	277.73	2	287.32	3	275.94	1

[a/] Based on 1975 input prices except labor price which is average labor wage reported in 1972 survey of tobacco farms

The least-cost harvesting system depends on several factors, with two of the most important factors being wage rate and size of operation. Using costs and labor requirements for the average producer, systems using walking primers were least-cost systems only at less than 6 acres with a low wage rate (Figure 1). With higher wage rates but less than 6 acres, the least-cost system was a riding primer with hand tying and conventional barn. Riding primers and bulk barns were most efficient above 6 acres at all wage rates.

CONCLUSIONS

The declining availability of farm labor and rising wage rates have forced many tobacco producers to examine the feasibility of increased harvest mechanization. For the producers to more accurately evaluate these alternatives, the present study estimated labor requirements and harvesting costs for various harvesting systems. A regression model was used to account for individual farm situations rather than using average labor use. The model indicated that economies of labor resulting from size occur primarily at low acreages. Increases in wage rates reduce labor use, as do tying machines and bulk barns. Decreased labor use per pound also occurs with an increase in yields.

In selecting the appropriate system, each producer can use this information, while taking into account his own situation regarding labor efficiency and supply of labor. The budget analysis indicated that tobacco harvested by walking primers and cured in conventional barns is least-cost only at less than 3-4 acres. Bulk barns and priming aids contribute to least-cost harvest systems at higher acreages. Present investment in machinery and barns may be

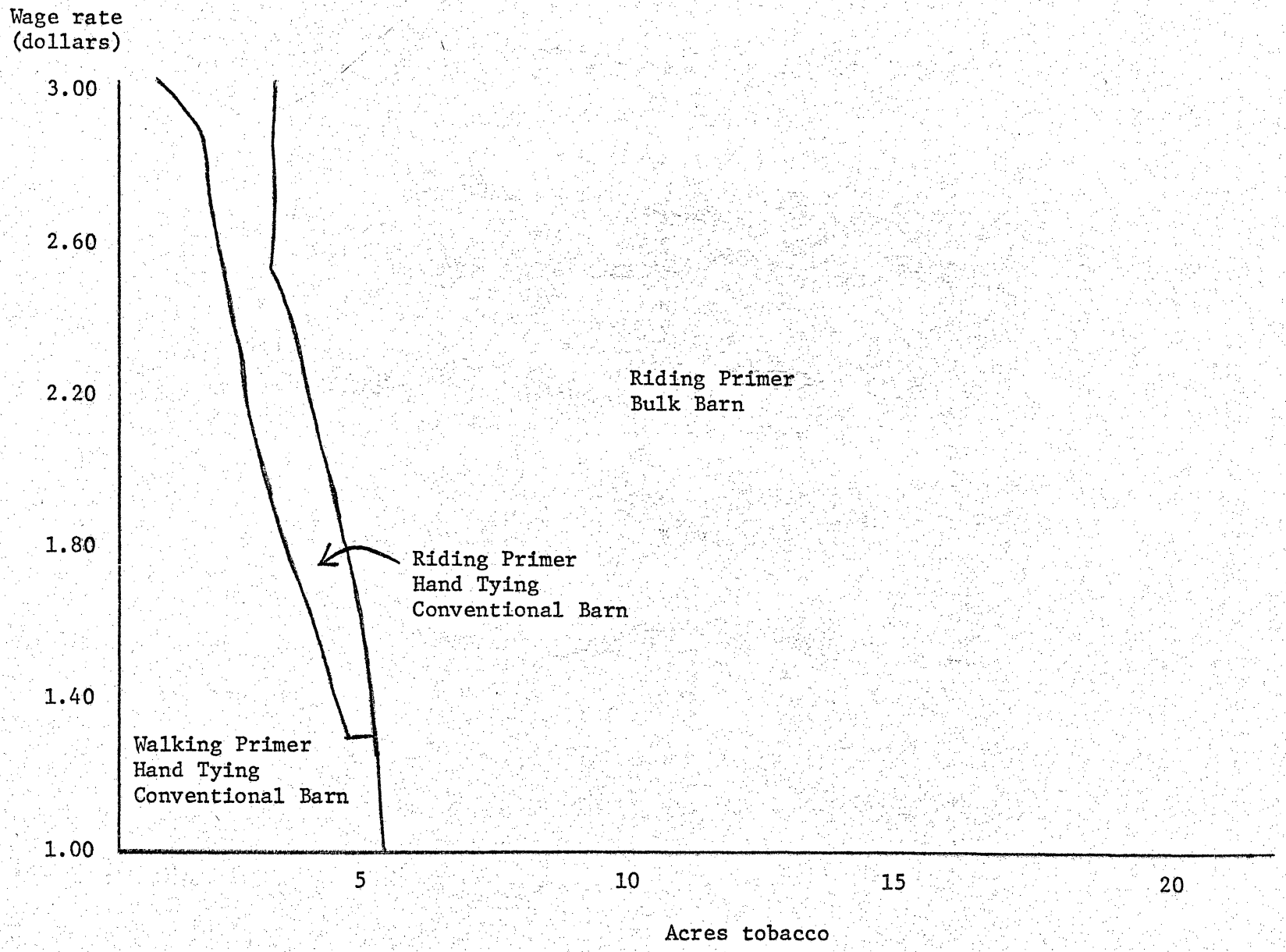

Figure 1. Least-Cost Harvest System by Wage Rate and Acres Tobacco

a deterrent to the purchase of new equipment, however the cost data presented here can be compared to total as well as out of pocket costs of a system presently being used to aid in decision making.

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