To the Graduate Council:

I am submitting herewith a thesis written by Michael A. Cherry entitled "An Economic Analysis of Three Alternative Harvesting, Curing, and Market Preparation Production Systems for Burley Tobacco Using Container-Type Methods." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Agricultural Economics.

S. D. Mundy

S. D. Mundy, Major Professor

We have read this thesis
and recommend its acceptance:

Billy J. Stevens

Robert M. Ray

Accepted for the Council:

L Evans Roth

Vice Chancellor
Graduate Studies and Research

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AN ECONOMIC ANALYSIS OF THREE ALTERNATIVE HARVESTING, CURING, AND MARKET PREPARATION PRODUCTION SYSTEMS FOR BURLEY TOBACCO USING CONTAINER-TYPE METHODS

A Thesis

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Michael A. Cherry

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ABSTRACT

The objectives of this study were to determine and compare the labor and equipment requirements for selected nonconventional methods of harvesting, curing, and market preparation of burley tobacco. A comparative cost analysis of three nonconventional production systems at selected output levels and wage rates, as well as any other advantages and disadvantages of the nonconventional methods, were also presented.

The production process for producing burley tobacco was divided into component production stages based on similarity of labor tasks and cooperative interaction of labor and equipment in completing a particular activity or set of tasks. The procedure involved collection, description, computation, and analysis of data surrounding the harvesting, curing, and market preparation stages of the three nonconventional burley production systems.

A budgeting technique was used to compare input requirements and costs of the selected production methods. Total costs of the three stages of production at selected wage rates and output levels were computed. The walk-priming system was the least-cost system at output levels below 21,000 pounds, or seven barn cures, and had lower capital investment costs than both the ride-priming and once-over systems. Primarily because of lower variable costs than both the ride-priming and walk-priming systems, the once-over system was the least-cost alternative at all output levels above seven barn cures.

An output of 9,000 pounds, or three barn cures, was required before the walk-priming system had lower total costs of production for the harvest-through-market preparation stages than the conventional method of burley production. An output of 12,000 pounds was required for once-over and 18,000 pounds for ride-priming before total costs were below that for the conventional harvest-through-market preparation stages of production.

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CHAPTER I

INTRODUCTION

Increasing cost of production has become a major problem for tobacco farmers. Over the last 10 years, costs of production have risen in general, but the increasing cost of labor has been particularly critical. The increasing cost of labor has directed attention toward development of technologies which may relieve the tobacco producer from his dependence upon relatively large amounts of unskilled labor. For example, mechanical harvesters and curing facilities have been developed and introduced to tobacco producers, especially in the production of flue-cured tobacco.

A few burley tobacco producers have examined and farm-tested mechanical harvesters and harvesting aids which have been developed to reduce the amount of labor required in flue-cured tobacco production. Mechanical harvesting methods may be divided into two categories: (1) multiple-pass harvesting techniques capable of making more than one trip through the field and, therefore, priming leaves as they become ripe at various stalk positions and (2) single-pass harvesters which remove all leaves from the stalk during one trip through the field.

Technological developments in the curing process of tobacco may also offer a savings in labor costs for the tobacco farmer. Several types of bulk-curing barns are presently used by flue-cured tobacco producers. These bulk barns are of metal construction, equipped with furnaces which force controlled air through perforated metal floors in

order to cure the tobacco. The possibility of general acceptance of these recently developed technologies in the production of flue-cured tobacco and their introduction into burley tobacco production have become of interest to people throughout the tobacco industry.

I. PROBLEM

Recently, several economic and institutional changes have affected the burley industry. The more crucial ones have been those factors contributing to the increased cost and scarcity of farm labor. The minimum wage law was extended to agriculture in 1966 through the Fair Labor Standards Act. Although many tobacco farms were too small to be covered by minimum wage regulations, wages paid on large farms have helped to drive farm wage levels up. More importantly, increased industrialization throughout the "burley belt" and other parts of the nation as well have led to new opportunities for labor. Many people in the burley tobacco industry feel the most important change leading to tobacco mechanization came in 1971. Until 1971, burley tobacco producers were restricted to fixed acreage allotments. In order to maximize net profit, the burley tobacco producer attempted to maximize output on his fixed acreage allotment. In April of 1971, growers voted to convert acreage allotments into poundage quotas based on the historical yield of the farm. The lease ane transfer of the poundage quotas between growers within the same country were also approved. This provision had very important implications for burley producers. With the possibility of more concentrated allotments, burley production could benefit from economies of size with better utilization of machinery and other inputs.

Burley tobacco has traditionally been marketed by a process of tying the cured leaves in "hands" and placing them on baskets. In 1976, a limited number of specified farmers in Kentucky and Tennessee were allowed to market their burley tobacco by placing the leaves untied in sheets and bales.[1] Additional research is currently being conducted by the Department of Agricultural Economics and Rural Sociology at The University of Tennessee concerning the market preparation of burley tobacco in baled form. Acceptance of loose-leaf marketing by the burley industry may contribute eventually to the adoption of labor-saving technologies in the harvesting and curing stages of production.

This study is an economic analysis of three nonconventional methods of harvesting, curing, and market preparation of burley tobacco. The three nonconventional methods utilize harvesting and curing technologies that have already been introduced into flue-cured tobacco production.

II. OBJECTIVES OF THE STUDY

The objectives of this study were:

1. To determine and compare the labor and equipment requirements for selected nonconventional methods of harvesting, curing, and market preparation of burley tobacco.

2. To present a comparative cost analysis of three harvesting, curing, and market preparation methods at selected levels of output

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[1] D. R. Humberd and S. D. Mundy, "Burley Tobacco--Loose Leaf or Tied?" Tennessee Farmer (July, 1977), p. 8.

and wages.

3. To determine and compare any other advantages and/or disadvantages of the three harvesting, curing, and market preparation methods.

III. REVIEW OF LITERATURE

Systems analysis, as used in this study, is a method of examining a production process by breaking the process into its functional component parts. French, Sammett and Bressler (1956) laid out systems analysis in an applied framework in their study of economic efficiency in the pear-packing industry. Ramsey (1977) used this framework in his economic analysis of three nonconventional harvesting-curing systems using rack-type bulk-curing barns with burley tobacco. He found with less than five acres of output, nonconventional rack-type harvesting-curing systems exceeded the total costs of conventional methods of harvesting, curing, and market preparation. Some other studies applying systems analysis to production processes were found and relied upon. For example, Mundy (1970) used this technique in a comparative study of five machine methods of transplanting tobacco. Gray (1975) applied systems analysis to six alternative socio-economic data information systems for Tennessee.

Although few studies concerning the efficiency and performance of harvesting systems have been conducted on burley tobacco, many such studies have been performed with the harvesting, curing, and market preparation of flue-cured tobacco. For example, Thompson, Jordon and Ward (1975) examined four harvesting systems for flue-cured tobacco.

Their study included an examination of the once-over harvester on low profile tobacco as well as a multiple-pass harvesting aid using container-type bulk-curing barns. Hubbard and Hardee (1970) used a budgeting technique to specifically analyze once-over harvesting of flue-cured tobacco in South Carolina. Chappell (1977) also analyzed once-over and multiple-pass systems for flue-cured tobacco in North Carolina. His study included using the once-over harvester as a final primer after the stalk had been hand primed one or two times.

Several other studies were referred to, but the Thompson, Chappell and Hubbard studies were the only ones cited which referred to technologies specifically analyzed in this study for burley tobacco. Other studies examined to better understand the economic analysis involved were: (1) An Economic Analysis of Alternative Systems for Harvesting and Bulk-Curing Flue-Cured Tobacco (May and Chappell, 1972); (2) Cost Comparisons of Five Different Tobacco Harvesting Systems in South Carolina (Jordan, 1972); and (3) Cost Comparisons of Mechanized Harvesting and Curing of Flue-Cured Tobacco in the Piedmont Region of Virginia (Coffey, Smith, and Pratt, 1977). Although these studies were concerned with rack-type harvesting-curing systems, the methodology was similar and supported the other studies.

CHAPTER II

PROCEDURE

An economic-engineering technique was used to compare the relative efficiencies[2] of three alternative technologies by deriving specific cost functions for each alternative technology considered. The production process of burley tobacco was divided into component production stages based on similarity of labor tasks and cooperative interaction of labor and equipment in completing a particular activity or set of tasks. A production substage was defined as the divisible operations which collectively form a single stage of the production process. The harvesting, curing, and market preparation stages of the burley tobacco production process were analyzed at the stage and process levels. The harvesting production stage was also examined at the substage level of operation. The substages in curing and market preparation were not analyzed.

The feasibility and rate at which technologies are adopted are determined by a number of factors. When these factors are measured in quantitative values, budgets may be computed to express the economic characteristics of each technology. Composing a budget begins with a description of the physical input-output relationships comprising the

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[2]For the purpose of this study, efficiency was considered a relative concept by which alternative production systems could be compared. The most efficient production process was that alternative which either maximized returns for a given set of inputs or minimized costs for selected outputs.

production process. Once these relationships are determined, input prices and cost functions are determined for each alternative technology. Cost measurements for each stage of production provide a basis for comparing the costs of alternative production systems and for development of total costs for each system.

To determine input-output relationships for the production process, some method of measurement must be employed. This study utilized engineering data as well as time and motion studies as methods of determining input-output relationships so that costs could be measured. Budgets were prepared showing resource requirements in terms of 3,000- and 2,400-pound units of cured burley tobacco for the three production systems. For the purposes of this study, a production system was defined as one unique process of harvesting, curing, and market preparation of burley tobacco.

I. DESCRIPTION OF HARVESTING STAGES

As previously mentioned, the harvesting stage was analyzed at the substage level for the three nonconventional production systems. Three alternative methods of harvesting burley tobacco were examined, one for each production system. These methods were: (1) riding-priming of the leaves utilizing a multiple-pass harvesting aid with conveyors to deposit leaves in the curing container; (2) walk-priming the leaves and manually filling a tractor-drawn container; and (3) once-over harvesting using a one-row harvesting machine mounted on a tractor. The once-over harvesting alternative was unique to the other harvesting alternatives in that it was a single-pass system; whereas, the ride-priming and walk-priming

were multiple-pass systems. Once-over harvesting also required low profile type tobacco[3] for the mechanical harvester to operate effectively. The multiple-pass production systems were not restricted to a low-profile type of burley tobacco. Common to each production system was the use of a container-type trailer. This consisted of a four-wheeled trailer specifically designed to carry a 4.38 feet by 6 feet by 3.5 feet metal container which houses the leaves during the curing stage.[4] Each barn was capable of holding up to eight containers per barn cure.

Self-Propelled Mechanical Priming Aid (RP)

Primers with this system of harvesting rode on four seats suspended below the main platform. This allowed four rows to be primed simultaneously. Each primer placed a small handful of leaves between two V-belts directly above and slightly forward of his seat. The V-belts carried the leaves to the platform where they fell onto two flat-belt conveyors which carried the leaves to the container-trailer located at the rear of the harvesting aid. The driver of the harvesting aid occasionally distributed the leaves evenly in the container throughout the harvesting process. This was done without stopping the harvesting operation when the rows were ridged properly so that the harvester essentially self-steered for short distances.

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[3]Low profile tobacco is topped lower than normal height in order that increased uniformity in the cured leaves might be obtained.

[4]All specifications concerning the bulk-curing barn and containers, such as the container dimensions were obtained from Long Manufacturing Company, Tarboro, NC.

The container-trailer was supported by a forklift attached to the rear of the harvesting aid. When the container was 1/2 to 2/3 full of uncured tobacco, a metal screen was flipped into the container. The screen held the leaves in place during the curing stage. When the container was full of uncured tobacco, the trailer was hydraulically lowered to the ground. The hauling crew replaced the full container-trailer with an empty container-trailer, and the harvesting operation continued. The full container-trailer was transported by tractor to the barn where the container was removed from the trailer and loaded into the barn by the hauling crew. After the full container was loaded into the barn, an empty container located near the barn was loaded onto the trailer. Seven laborers were required in this harvesting stage: four primers, one harvesting aid driver, and two workers hauled container-trailers and loaded the containers into the bulk barn. Harvesting equipment requirements included the self-propelled priming aid, one tractor, and two trailers.

Walk-Priming (WP)

This production system did not utilize any mechanical priming aids or harvesters. One container-trailer was pulled by a medium horsepower tractor into the field. Priming required four workers who hand-primed the tobacco and manually loaded the leaves into the container traveling in a skip row or at the side of the field. The hauling crew transported a second tractor pulling a container-trailer into the field to replace the full container-trailer. A complete exchange of tractor and container-trailer was made so that trailer exchange between tractors

was not necessary. The priming operation was not interrupted by container-trailer exchange with the WP system as it was with the RP system. Seven laborers were required in this harvesting stage: four primers, one tractor driver in the field, and two men to haul trailers and load containers into the barn. This method of harvesting required two tractors and two trailers.

Once-Over Harvester (OOH)

The once-over harvester was tractor mounted and stripped all leaves from the stalk in one priming. The harvester consisted of two main components: the defoliator and the transport belts. As the stalk entered the harvester, the leaves were removed by a downward motion of the defoliator. The leaves were conveyed by the transport belts to the container which rode on a trailer behind the tractor. A medium horsepower tractor was sufficient to power the once-over harvester. The maximum field speed was limited by the defoliating operation of the harvester and field conditions.

This stage of production involved four workers: the harvester tractor driver, one man to ride on the trailer to distribute the leaves, and two men to haul trailers to and from the field and load containers into the barn. Equipment requirements for the OOH harvesting stage consisted of three tractors, one for the harvester, and two tractors for transporting trailers to and from the field. Four trailers were required for this harvesting stage, given the farm production system assumed in this study.

The once-over system differed from both of the multiple-pass systems in the hauling and trailer exchange substages. The hauling crew

transported two container-trailers to and from the field in the OOH system; whereas, only one container-trailer was transported per trip in the multiple-pass systems. Two tractors were also required in the once-over hauling and trailer exchange substages. One tractor with a container-trailer remained at the side of the field while another container-trailer was filled with tobacco as it was pulled behind the once-over harvester. The harvesting crew filled both containers and performed the task of exchanging both of the trailers from the harvester to the hauling tractor. The hauling crew brought two empty container-trailers into the field pulled in tandem by a third tractor. The hauling crew took the second tractor and two container-trailers to the bulk barn to be loaded. These operations were repeated in two-trailer units until the barn or barns were loaded. Several combinations of labor and equipment were possible in the harvesting stage, but the combination outlined above was believed typical and was examined in this analysis.

Description of Barn Loading Substage

The substage operation of loading the containers into the barn was the same for all three harvesting methods and was performed by the hauling crew. When the container was full of uncured tobacco, the trailer was placed approximately 15 feet from the front of the barn. An electric hoist was attached to the center of the sides of the container, and the container was lifted vertically so that the trailer could be removed. The container was lowered to the ground where two workers inserted approximately 90 steel rods through the sides of the container. These rods held the leaves in place during the curing stage.

The two hoist hooks were then relocated at the top sides of the container so that the container could be lifted from its horizontal position to a vertical position. The container was lifted into the air, and the container, which has wheels, was lowered onto rails mounted on the floor of the barn. The hoist was unhooked from the container, and it was pushed manually into the barn.

II. DESCRIPTION OF THE CURING STAGE

After the containers were loaded into the bulk barn, the curing stage began. The barn observed in this study was an eight-container bulk-curing barn. The bulk barn had a steel base with exterior aluminum siding and interior plywood walls. An oil or gas furnace provided the heat while a squirrel cage blower fan powered by an electric motor forced the heated air through a perforated metal floor. The bulk-curing barn held eight containers with an inside capacity of 1,576 cubic feet.

The farmer adjusted the heat and humidity levels inside the barn throughout the curing period, which usually averaged about 7 days. The farmer was required to adjust these controls daily throughout the curing period.

III. DESCRIPTION OF THE MARKET PREPARATION STAGE

When the tobacco was cured and in proper case, the containers were unloaded from the barn. To unload the tobacco from the containers, a hoist was used to lower the container to the ground. The hoist was relocated to the sides of the container so that the container could be flipped to a horizontal position, reversing the loading procedure. The

steel rods were removed by hand so that when the container was returned to the vertical position, the leaves would fall from the bottom of the container to the surface below. The leaves were then packed manually in sheets to a weight of approximately 200 pounds per sheet. Four laborers were used in the market preparation stage.

IV. DATA COLLECTION

Data on labor, machine, and equipment requirements were collected on the three harvesting, curing, and market preparation stages. The once-over harvesting system was observed on a farm in Graham County, North Carolina, in 1976. The multiple-pass priming aid was observed on one farm in Jefferson County, Tennessee, and on one in Blount County, Tennessee, in 1976. Labor and machine requirements were obtained using a combination of recorded observations and judgment. Stop watches were used to record time requirements for substage operations and elapsed times for each stage of production. A description of the production process was recorded in the field, and notes were taken on various aspects of the production process.

Three stages of production were included in the production process. The harvesting stage was composed of four substage operations. Labor and machine requirements for each substage operation were recorded and summed to obtain labor and machine requirements for the harvesting stage. The input requirements for the curing and market preparation stages were not recorded by substage operations. A substage breakdown of the curing and market preparation stages was not performed because labor and machine requirements were the same for each alternative.

The same type of bulk-curing barn was used on each of the three farms observed during the study period. It had a curing capacity of approximately 3,000 pounds of cured tobacco which would be somewhat greater than the average per acre yield of burley tobacco. Therefore, input requirements were stated in 3,000-pound units and then prorated into 2,400-pound units to give a perspective to input requirements per acre. Data concerning initial cost of harvesting, curing, and market preparation equipment were obtained from the manufacturer.

V. LIMITATIONS OF THE DATA

Although once-over and multipass harvesters using container-type bulk-curing barns were introduced into flue-cured tobacco production a few years ago, their use in burley production has been quite limited. Therefore, observations were limited to three farms with the same crew being used on the Blount County and Jefferson County, Tennessee, farms. On each farm observed, the laborers were not familiar with mechanical harvesting operations. This precipitated more down time and labor inefficiencies in the production process than would have occurred with a more experienced crew. However, several barnings were observed at each location allowing judgments to be made on the regularity of these inefficiencies.

VI. UNDERLYING ASSUMPTIONS

1. Each alternative was assumed to have a feasible solution.

A comparative cost analysis was used to determine an optimum solution from among the three production systems. Holding total revenue

and yield per barn constant, the optimum solution was that alternative which had the lowest total cost of production for a given output. Smith (1964) stated that net revenue is maximized when the difference between total revenue from sale of the product and total cost due to resources used in producing the product is maximized. Current assumptions concerning bulk-cured tobacco reflect the belief that quality of the cure is inferior to conventionally cured tobacco. This would indicate that bulk-cured tobacco would be discounted in price, and, therefore, total revenue would not be constant between conventional and nonconventional methods. An analysis of breakeven price discounts between bulk-cured and conventionally cured tobacco was, therefore, included in this study.

2. Average variable costs were held constant across the selected output levels. That is, no economies or diseconomies enter in as volume is varied.

3. The physical characteristics of the production stages were given and constant as described. Fixed and variable inputs, usually labor and equipment, were combined to produce a specific output.

VII. BURLEY TOBACCO YIELD AND QUALITY

Quality of cured tobacco was assumed to be equal among the three nonconventional production systems. Therefore, price and total revenue were constant for a given output. The assumption that quality was constant was important and should be noted. As mentioned previously, questions have been raised as to quality differences between conventional and bulk-cured tobacco. There may also be quality differences among the nonconventional harvesting methods. Two basic harvesting techniques were

studied: multiple-pass and single-pass systems. The single-pass production system removed all leaves from the plant at one time while the multiple-pass production systems removed selected leaves by stalk position. With variation in the quality of leaves from different stalk positions, constant total revenue per barn may no longer be a valid assumption.

The yield, in pounds of cured tobacco per barn, was assumed to be 3,000 pounds and equal across alternatives. Average yield was determined from observation of the yields of cured leaf per barning on the farms observed and from rated capacity as given by the barn manufacturer.

VIII. SEASONAL OUTPUT CAPACITY

The harvest season in East and Middle Tennessee usually lasts approximately 10 weeks, beginning in late July and ending about the first of October. Although normal machine utilization during the harvest season would probably be less, an assumed maximum of 60 hours per week was used for the 10-week period. An allowance for rain was estimated at 13 days. This was the average number of days' rain has occurred during the harvest season at the Knoxville Weather Station over the last 20 years.[5] After the adjustment for rainy days, seasonal harvest capacity was based on a 470-hour harvest period. The seasonal poundage capacity for each production system was computed by dividing the 470-hour harvest season by the elapsed time per barn. Labor was assumed to

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[5]U.S. Weather Service, U.S. Department of Commerce, McGhee Tyson Airport Weather Station, Knoxville, Tennessee.

be the limiting factor in determining harvest season capacity. A single labor crew was assumed to be at each location for the harvest season and the farmer possessed unlimited capital. Thus, he was capable of expanding the curing stage without limitation.

CHAPTER III

LABOR, EQUIPMENT, AND COST COMPARISONS OF THE THREE ALTERNATIVE PRODUCTION SYSTEMS

In order to compare costs of production for the three nonconventional production systems, labor and equipment requirements were determined for the harvesting, curing, and market preparation stages. Based on the labor and equipment requirements for the three nonconventional production systems, a comparative cost analysis was performed. The labor wage rate was assumed to be $2.50 when variable costs for the three nonconventional production systems were computed, although the wage rate was varied later in the analysis. Equipment used in the three production stages consisted of equipment used exclusively in tobacco production and joint-use equipment. Joint-use equipment was considered to be any equipment which was used in some enterprise other than burley tobacco production. The tractors used in each of the production systems were assumed to be the only joint-use equipment.

I. LABOR REQUIREMENTS

The labor requirements for the stage and substage operations of harvesting, curing, and market preparation were defined in the following equation:

1. $L = H + (C + M)$

where:

L = total labor requirements in man-hours per unit of output for

each production system where output was in pounds of cured leaf ready for market;

H = man-hours per unit of output for the harvesting stage;

C + M = man-hours required per unit of output for the curing and market preparation stages, which were the same for each production system.

Labor requirements for the harvesting stage represented the only difference in total labor requirements among the three alternative production systems. The harvesting stage was examined in each of four substage operations. The harvesting stage and its substage operations were represented by the following equation:

$$2.\quad H = H_p + H_r + H_h + H_l$$

where:

H = man-hour requirements per unit of output for the harvesting stage;

H_p = man-hour requirements per unit of output for general preparations;

H_r = man-hour requirements per unit of output for the priming substage operation;

H_h = man-hour requirements per unit of output for exchanging empty container-trailers for full container-trailers and transporting them to and from the barn;

H_l = man-hour requirements per unit of output for loading containers of uncured tobacco into the bulk barn and loading empty containers on trailers.

Table 1 lists the labor requirements in man-hours per 3,000-pound and 2,400-pound acre for the production stage and substage operations of the three production system alternatives. Labor requirements for the stage and substage operations were based on: (1) time and motion data, (2) field data from other studies, particularly the Ramsey study, and (3) judgment.

Many factors affect the production of burley tobacco. For instance, the quality of the tobacco in the field may affect the rate at which the tobacco can be harvested. Also, variations in land characteristics, management abilities, and general organizational structures may affect the amount of labor required in the production process. Man-hour requirements in Table 1 include a 20 percent positive adjustment to cover such factors which may increase labor requirements in the production process.[6]

Results of the labor requirements for the harvesting substages indicate the location of the various requirements in the harvesting stage. The general preparation substage includes the amount of labor to prepare harvesting machinery and other equipment, assemble laborers, and move them into the field to begin the priming activities. The WP system required 0.8 man-hours for general preparation, while both the RP and OOH systems required 1.0 man-hours. An additional 0.2 man-hours of labor were needed in the once-over and ride-priming systems to prepare

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[6]The 20 percent adjustment was judged appropriate after consulting Associate Professors S. D. Mundy and Robert M. Ray of the Department of Agricultural Economics and Rural Sociology, The University of Tennessee, Knoxville.

Table 1. Labor Requirements in Man-Hours Per 3,000-Pound Barn and Per 2,400-Pound Acre of Cured Burley Tobacco for Three Nonconventional Harvesting, Curing, and Market Preparation Production Systems

Labor Stage and Substage Operations	Output Classification	Multiple-Pass Harvesting		Single-Pass Harvesting
		Self-Propelled Mechanized Aid (RP)	Walk-Priming (WP)	Mechanized Once-Over (OOH)
Total harvest-through-market preparation	3,000-lb. barn	107.7	100.0	37.1
	2,400-lb. acre	86.2	80.0	29.7
Production stage: harvesting (H)	3,000-lb. barn	85.9	78.2	15.3
	2,400-lb.	68.7	62.6	12.2
Harvesting substages: general preparation (Hp)	3,000-lb.	1.0	0.8	1.0
	2,400-lb.	0.8	0.6	0.8
Priming (Hr)	3,000-lb.	73.0	67.0	7.5[a]
	2,400-lb.	58.4	53.6	6.0[a]
Hauling and trailer exchange (Hh)	3,000-lb.	6.8	5.3	1.7[b]
	2,400-lb.	5.4	4.2	1.3[b]
Loading container into barn (Hl)	3,000-lb.	5.1	5.1	5.1
	2,400-lb.	4.1	4.1	4.1
Production stage: curing (C)	3,000-lb.	5.0	5.0	5.0
	2,400-lb.	4.0	4.0	4.0
Production stage: market preparation (M)	3,000-lb.	16.8	16.8	16.8
	2,400-lb.	13.4	13.4	13.4

[a]Includes time of trailer exchange in field. [b]Hauling time only.

the mechanical harvesters for field operation.

The harvesting substage H_r was the labor required to prime a 3,000-pound barn of cured burley tobacco. For the multiple-pass systems, this substage represented only priming of leaves. Labor requirements for substage H_r in the OOH system included priming requirements and labor to exchange trailers in the field. Trailer exchange man-hour requirements were included in the priming substage for the OOH system because the harvesting crew was responsible for the operation. The largest variation in man-hour requirements between multiple-pass and single-pass systems occurred in the priming substage. Once-over harvesting required 7.5 man-hours for priming and trailer exchange, while the ride-priming and walk-priming systems required 73 and 67 man-hours, respectively. Tobacco priming, excluding trailer exchange for the once-over system, required 5.7 man-hours.

Labor tasks for the substage H_h include transporting trailers loaded with uncured tobacco to the barn, transporting empty container-trailers to the field, and trailer exchange. As was previously stated, the time of trailer exchange was included in the priming substage for the OOH system. Therefore, only hauling requirements were represented by H_h for the OOH system. Distance from the barn to the field was assumed to be 0.25 miles. Hauling times were calculated based on field observations of the hauling operation and adjustments for the .025-mile distance. Because of the longer time requirements for trailer exchange, the RP system required more man-hours in the H_h substage than the WP system. The container-trailer had to be hydraulically lowered to the

ground from the platform to exchange trailers in the RP system. Total man-hours involved in the H_h substage for the RP system were 6.8, as opposed to the WP man-hour requirement of 5.8 where the exchange was simply tractor-trailer unit exchange. The once-over system required 1.7 man-hours to transport trailers to and from the field. This was about half the man-hour requirements for the multiple-pass systems because the tractor driver pulled two container-trailers at once making a total of four trips to and from the field per barning. The multiple-pass systems each required eight hauling trips, or one container per trip.

After the loaded container-trailers were parked at the bulk barn, the harvesting substage H_1 began. Labor tasks for this substage included loading the container into the barn and then loading empty containers onto trailers. Each of the three production systems required 5.1 man-hours for this substage because tasks and number of laborers were identical among the systems.

The curing and market preparation stages were also identical with respect to tasks and required labor. The curing stage was spread over a 7-day period, requiring a total of 5.0 man-hours to cure a bulk barn. The farmer was required to check and adjust the heat and humidity controls each day until the tobacco was cured. The labor requirements for the market preparation stage were calculated using a four-man crew taking an elapsed time of 4.2 hours or 16.8 man-hours to unload and place 3,000 pounds of cured tobacco in sheets.

II. EQUIPMENT REQUIREMENTS

Table 2 lists the average equipment requirements in hours of use per 3,000-pound barn and 2,400-pound acre for each production system. Averages were classified by work activity. Each machine was assumed to be operating if it was required to be at a certain location. Table 2 also includes the type and amount of equipment needed for each production system.

Hours of use for equipment used in the priming substage varied from the elapsed time of the harvesting stage by the time required to load the final container into the barn. This was .2 hours for the multiple-pass systems and .5 hours for the single-pass or OOH system. The greater requirement for the OOH system occurred because two containers were loaded at once rather than one.

The RP system required 3.4 hours of tractor time hauling tobacco to the barn and trailer exchange in the field, 0.7 hours more than the 2.7 hours required for the WP system. This difference was due to the extra time required for the container-trailer exchange in the RP system. The OOH system required four hauling trips utilizing two 40 pto (horsepower at power take-off) tractors. Hours of use per tractor were 1.8 hours or a total of 3.6 hours for the transporting and trailer exchange substages.

The task of loading containers filled with tobacco into the barn required the use of an overhead rail and hoist. The process was the same for the three production systems, requiring 2.6 hours to load eight containers into a bulk barn.

Table 2. Work Activity, Equipment Used, and Average Equipment Operating Hours Required Per 3,000-Pound Barn and Per 2,400-Pound Acre of Cured Burley Tobacco for Three Harvest-Through-Market Preparation Production Systems

Work Activity	Alternative[a]	Equipment Used	Hours Per 3,000-lb. Barn	Hours Per 2,400-lb. Acre
Priming	RP	Self-propelled priming aid, 2 bulk tobacco trailers	14.6	10.7
	WP	40 pto[b] tractor, 2 bulk tobacco trailers	13.4	9.3
	OOH	40 pto tractor with mounted once-over harvester, 4 bulk tobacco trailers	4.1	3.0
Transporting trailers and trailer exchange	RP	40 pto tractor	3.4	2.5
	WP	40 pto tractor	2.7	1.9
	OOH	Two 40 pto tractors	1.8 ea.	1.3 ea.
Loading barn	RP, WP, OOH	Overhead rail and hoist	2.6	1.9
Curing	RP, WP, OOH	Eight container bulk curing barn with gas furnace	180	144
Market preparation	RP, WP, OOH	Overhead rail and hoist	4.2	3.3

[a]The alternative harvesting methods are represented in the following manner: mechanical priming aid (RP), walk-priming (WP), and once-over harvesting (OOH).

[b]The abbreviation "pto" is used for horsepower at power take-off throughout the study.

The production stage of curing the tobacco in the bulk barn required 7 days or 168 hours. An extra 12 hours of barn time were added for loading and unloading. The process of market preparation was also the same for the systems. The overhead rail and hoist were used for 4.2 hours during removal of the containers from the barn and packing the cured leaf in sheets. The general preparation substage was excluded from Table 2 because no equipment was required.

III. ASSUMPTIONS UNDERLYING COST ANALYSIS

Budgets were computed to determine the least-cost method among the three production system alternatives analyzed in this study. Each budget consisted of variable and capital costs. All variable costs were computed linearly with volume of output, while capital costs were computed for a selected number of barn cures at 3,000 pounds of cured tobacco per barn load. Total variable and capital costs were summed for each of the production systems over a range of outputs up to and including seasonal capacity of the production systems. Average total costs were determined for the selected output levels using these costs. Costs comparisons between the methods were than made at a fixed wage rate of $2.50 per hour. Average wage rates were assumed to be the same for each system. This was based on the assumption of homogeneity of labor from the standpoints of skill, quality, and physical exertion required. Field observations of the systems substantiated this assumption. Wages and volume of output were later varied, and the total costs of each system at selected output levels were then compared.

The labor tasks involved in each of the systems were not specifically assigned to either sex. The task of distributing the harvested leaves in the container for the once-over system required the most physical exertion but could be accomplished by either sex. No qualifications were made concerning age, except for the leaf distributing task in the once-over system, which a child probably could not accomplish.

IV. VARIABLE COSTS

Variable costs consisted of labor and equipment costs which varied linearly with volume of output. Appendix Table A-1 lists the equipment operating costs per hour of use. These costs were combined with labor costs using a $2.50 per hour wage rate to obtain average variable costs per barning and per acre for each production system.

Labor Costs

Labor costs, listed in Table 3, were computed using a $2.50 wage rate and the man-hour requirements given in Table 1, page 21. Therefore, variation in labor costs of each production stage corresponded to the variation in man-hour requirements for the production systems. Labor costs per 3,000 pounds for the three stages of production were $92.75 for the OOH system, $250 for the WP system, and $269.25 for the RP system. A reduction in labor costs of $157.25 was possible when the once-over harvesting system was compared to the walk-priming system. An even greater reduction in costs occurred when the OOH system was compared to the RP system. This difference amounted to $176.50 per 3,000-pound barn.

Table 3. Labor Costs Per 3,000-Pound Barn and Per 2,400-Pound Acre of Cured Burley Tobacco for Three Harvest-Through-Market Preparation Production Systems Using $2.50 Per Hour Wage Rate

Labor Stage and Substage Operations	Output Classification	Multiple-Pass Harvesting RP	Multiple-Pass Harvesting WP	Single-Pass Harvesting OOH
Total harvest-through-market preparation	3,000-lb. barn	269.25	250.00	92.75
	2,400-lb. acre	215.40	200.00	74.20
Production stage: harvesting	3,000-lb.	214.75	195.50	38.25
	2,400-lb.	171.80	156.40	30.60
Harvesting substages: general preparation	3,000-lb.	2.50	2.00	2.50
	2,400-lb.	2.00	1.50	2.00
Priming	3,000-lb.	182.50	167.50	18.75
	2,400-lb.	146.00	134.00	15.00
Transporting and trailer exchange	3,000-lb.	17.00	13.25	4.25
	2,400-lb.	13.60	10.60	3.40
Loading container into barn	3,000-lb.	12.75	12.75	12.75
	2,400-lb.	10.20	10.20	10.20
Production stage: curing	3,000-lb.	12.50	12.50	12.50
	2,400-lb.	10.00	10.00	10.00
Production stage: market preparation	3,000-lb.	42.00	42.00	42.00
	2,400-lb.	33.60	33.60	33.60

The principal cost advantage of the OOH system is found in the priming substage for labor costs. The labor cost for the priming substage of the OOH system was $18.75 per 3,000-pound barn, $148.75 less than walk-priming and $163.75 less than ride-priming.

Equipment Operating Costs

Equipment operating costs per barn and per acre appear in Table 4. Equipment operating hours located in Table 2, page 25, were multiplied by the per-hour operating costs of the machines from Table A-1. The harvesting production stage required machinery with operating costs in the priming and hauling substages. The H_p and H_1 substages were excluded from Table 4 because no machinery was required which had operating costs.

The RP system had significantly higher operating costs in the priming substage than the other systems. This was due, in part, to the operating costs of the self-propelled priming aid. It operated at a per hour cost of $3.30 as opposed to $2.74 for the tractor with side-mounted once-over harvester and $2.01 for the 40 pto tractor used in the WP system. The self-propelled priming aid also required more field use time. The combination of these two factors led to equipment operating cost of $48.18 for the priming substage for the RP system. The WP system did not require any mechanical priming equipment other than the tractor which transported the container-trailer through the field. Therefore, operating costs per hour were lower than the once-over harvester, but more time was required in the priming substage. The faster speed at which the once-over harvester completed the priming

Table 4. Equipment Operating Costs Per 3,000-Pound Barn and Per 2,400-Pound Acre of Cured Burley Tobacco for Three Harvest-Through-Market Preparation Production Systems

Production Activity[a]	Classification	Multiple-Pass Harvesting		Single-Pass Harvesting
		RP	WP	OOH
		dollars		
Total harvest-through-market preparation	3,000-lb. barn	200.81	178.15	164.26
	2,400-lb. acre	160.65	142.52	131.41
Production stage: harvesting	3,000-lb.	55.01	32.35	18.46
	2,400-lb.	44.00	25.88	14.77
Harvesting substages: priming	3,000-lb.	48.18	26.93	11.23
	2,400-lb.	38.54	21.54	8.98
Hauling, trailer exchange, and loading barn[b]	3,000-lb.	6.83	5.42	7.23[c]
	2,400-lb.	5.46	4.33	5.78[c]
Production stage: curing	3,000-lb.	145.80	145.80	145.80
	2,400-lb.	116.64	116.64	116.64

[a]The production activities not included were: (1) harvesting substage--general preparation and (2) production stage--market preparation.

[b]Combined harvesting substages hauling and loading barn.

[c]Includes operating costs for two 40 pto tractors.

substage led to lower total operating costs than the WP system.

The operating costs of the curing stage consisted of gas and electrical usage costs required to operate the bulk-curing barn. Fuel and electrical consumption and associated costs appear in Table A-1. Total operating cost to cure one 3,000-pound capacity barn was $145.80.

Average Variable Costs

Average variable cost was the sum of labor and equipment operating costs which increased linearly with volume of output, given the assumptions of this study. As mentioned earlier, no economies or diseconomies were assumed to occur as output increased although many combinations of equipment and labor were possible for each system under consideration. Table 5 shows the average variable costs for each stage and substage operation.

The OOH single-pass system had lower labor and equipment operating costs than either of the multiple-pass systems. Therefore, differences in average variable costs between the systems appear more pronounced in Table 5. Again, an examination of the priming substage reflects the major cost difference among the harvesting alternatives.

V. CAPITAL COSTS

Capital costs included depreciation, interest, insurance, repairs, and maintenance on all equipment used for tobacco production. The tractors used in each of the production systems were considered joint-use inputs. Allocation of joint costs were based on hours of use in tobacco production. Tractor capacity was assumed to be 600 hours per year with

Table 5. Average Variable Costs Per 3,000-Pound Barn and Per 2,400-Pound Acre of Cured Burley Tobacco for Stage and Substage Operations of Three Alternative Harvesting, Curing, and Market Preparation Systems

Stage and Substage Operation	Output Classification	Multiple-Pass Harvesting		Single-Pass Harvesting
		Self-Propelled Mechanized Aid (RP)	Walk-Priming (WP)	Mechanized Once-Over (OOH)
		dollars		
Total harvest-through-market preparation	3,000-lb. barn	470.06	428.15	257.01
	2,400-lb. acre	376.04	342.52	205.61
Production stage: harvesting	3,000-lb.	269.76	227.85	56.46
	2,400-lb.	215.81	182.28	45.17
Harvesting substages: general preparation	3,000-lb.	2.50	2.00	2.50
	2,400-lb.	2.00	1.60	2.00
Priming	3,000-lb.	230.68	194.43	29.98
	2,400-lb.	184.54	155.54	23.98
Hauling and trailer exchange	3,000-lb.	23.83	18.67	11.48
	2,400-lb.	19.06	14.94	9.18
Loading container into barn	3,000-lb.	12.75	12.75	12.75
	2,400-lb.	10.20	10.20	10.20
Production stage: curing	3,000-lb.	158.30	158.30	158.30
	2,400-lb.	126.64	126.64	126.64
Production stage: market preparation	3,000-lb.	42.00	42.00	42.00
	2,400-lb.	33.60	33.60	33.60

470 hours available for tobacco harvesting at season capacity. Annual capital costs for equipment used exclusively for the three stages of the tobacco production process are listed in Table A-2.

Average Capital Costs at Seasonal Capacity

Capital costs consist of the cost of ownership of capital equipment. Capital costs of joint-use equipment were computed assuming use at maximum seasonal capacity. On the other hand, capital cost of equipment used exclusively in tobacco production such as the bulk barn did not vary with level of output. Additional bulk barns were required as output increased at increments of seven barn cures which was the curing capacity of each bulk barn per season. Capital costs of the joint-use tractors were based on hours of use and varied linearly with volume of output. At seasonal capacity, tractors were assumed to be used for 470 hours in the harvest stage of burley tobacco production.

Average capital costs at seasonal capacity appear in Table 6. Annual capital cost of equipment was fixed to the machine, not to the units of output. Therefore, average capital cost of equipment used exclusively for tobacco production decreased as total output increased because fixed cost was spread over more units of output as output increased up to seasonal capacity.

Capital costs for the harvesting stage are represented in two harvesting substages in Table 6. The 40 pto tractors were the equipment assigned capital costs in the hauling and barn-loading substages; these substages were combined in Table 6 to represent the capital costs for the tractor used at seasonal capacity. No capital equipment was required in

Table 6. Average Capital Costs at Capacity Per 3,000-Pound Barn and Per 2,400-Pound Acre of Cured Burley Tobacco for Three Harvesting, Curing, and Market Preparation Production Stages[a]

Labor Activity	Output Classification	Multiple-Pass Harvesting		Single-Pass Harvesting
		Ride Priming	Walk-Priming	Once-Over
		dollars		
Total harvest-through-market preparation	3,000-lb. barn	365.48	302.92	290.34
	2,400-lb. acre	292.38	242.33	232.27
Production stage:[b] harvesting	3,000-lb.	79.31	43.73	24.06
	2,400-lb.	63.44	34.98	19.25
Harvesting substages: priming	3,000-lb.	58.90	25.6	11.26
	2,400-lb.	47.12	20.48	9.00
hauling, trailer exchange and loading barn[c]	3,000-lb.	20.41	18.13	12.80
	2,400-lb.	16.33	14.50	10.24
Production stage: curing	3,000-lb.	244.79	221.71	227.78
	2,400-lb.	195.83	177.37	182.22
Production stage: market preparation	3,000-lb.	41.38	37.48	38.50
	2,400-lb.	33.10	29.98	30.80

[a]Seasonal capacities were computed using elapsed times for the harvesting stage and a 470-hour harvest season. Elapsed times and seasonal capacities in 3,000-pound barn cures were: ride priming with an elapsed time of 14.8 hours and a seasonal capacity of 31.7 barn cures; walk priming with an elapsed time of 13.4 hours and seasonal capacity of 35 barn cures; once-over harvesting with an elapsed time of 4.6 hours and seasonal capacity of 102.2 barn cures.

[b]Harvesting substage, general preparation, excluded.

[c]Combined harvesting substages hauling and loading barn.

the general preparation substage. Hence, this substage was excluded from Table 6. The priming substage included capital costs of all equipment used to prime tobacco. Each of the multiple-pass systems had higher average capital costs than the single-pass system. This was due, in part, to the large difference in seasonal harvest capacity between the multiple- and single-pass systems as shown in footnote "a" of Table 6. The relatively high capital cost of $79.31 for the priming substage in the RP system resulted from the higher capital cost and lower seasonal capacity of the self-propelled priming aid. The WP system required no mechanical harvester and, thus, had the lowest annual capital costs. The increased seasonal harvest capacity of the OOH system overcame a higher annual capital cost. Therefore, OOH had the lowest average capital costs of the production system alternatives.

Differences in average capital costs for the curing stage alternatives resulted from inefficient use of barn capacity for the last barning. Each barn was capable of curing seven 3,000-pound barn loads in one harvest season. The WP system had a seasonal capacity of 35 barn cures. This required five barns used at optimum efficiency. The RP system had a seasonal capacity of 31.7 barn cures requiring five barns. Therefore, one barn was not used at full capacity since total cure capability of five barns was 35 cures. The OOH system used 15 barns at seasonal capacity. Capital cost for the overhead rail and hoist was charged to the market preparation stage although the rail and hoist were also used for the loading substage. Differences among the alternatives in average capital costs for the market preparation stage also resulted from differences in seasonal harvest capacity.

Average Total Costs at Seasonal Capacity

Average total cost at seasonal capacity was defined to be the sum of average variable cost and average capital cost at seasonal capacity. Average total costs are listed in Table 7. The average total cost for the once-over harvesting system was $547.80 per 3,000 pounds of cured burley tobacco. Average total cost for the OOH system was $176 less than the WP system and $285 less than the RP system for the three stages of production. The walk-priming system had an average total cost of $723.82 at capacity. This cost was $108.98 less than the average total cost of $832.80 for the ride-priming system.

The principal advantage of the OOH system occurred in lower labor costs in the priming substage. Average total cost for the priming substage of the once-over harvesting system was $41 per 3,000-pound barn at seasonal capacity. Average total costs at seasonal capacity for the RP and WP priming substages were $289 and $220, respectively. Costs for the priming substage were 86 percent lower for the OOH system compared to the WP system. Average total cost for the harvest-through-market preparation stages was 34 percent lower for the OOH system as compared to the RP system and 25 percent lower compared to the WP system.

Table 7. Average Total Cost at Seasonal Capacity Per 3,000-Pound Barn and Per 2,400-Pound Acre of Cured Burley Tobacco for Three Harvesting, Curing, and Market Preparation Production Stages

Labor Activity	Output Classification	Multiple-Pass Harvesting		Single-Pass Harvesting
		Ride-Priming	Walk-Priming	Once-Over
		dollars		
Total harvest-through-market preparation	3,000-lb. barn	832.80	723.82	547.80
	2,400-lb. acre	666.24	579.05	438.24
Production stage: harvesting	3,000-lb.	349.07	271.58	80.77
	2,400-lb.	279.25	217.26	64.61
Harvesting substage: general preparation	3,000-lb.	2.50	2.00	2.50
	2,400-lb.	2.00	1.60	2.00
Priming	3,000-lb.	289.58	220.03	41.24
	2,400-lb.	231.66	176.02	32.99
Hauling and trailer exchange[a]	3,000-lb.	44.24	36.80	24.28
	2,400-lb.	35.39	29.44	19.42
Loading container into barn	3,000-lb.	12.75	12.75	12.75
	2,400-lb.	10.20	10.20	10.20
Production stage: curing	3,000-lb.	400.80	373.86	386.53
	2,400-lb.	320.64	299.08	309.22
Production stage: market preparation	3,000-lb.	82.93	78.38	80.5
	2,400-lb.	66.34	62.70	64.4

[a]Includes average capital costs for tractors for total harvesting stage.

CHAPTER IV

AN ANALYSIS OF COSTS AND RETURNS UNDER VARIOUS PHYSICAL AND ECONOMIC CONDITIONS

I. LEAST-COST METHOD AT SELECTED OUTPUTS AND A $2.50 PER HOUR WAGE RATE

Average total costs for selected outputs at a wage rate of $2.50 per hour were calculated and are listed in Table 8. Output in Table 8 is in terms of barn cures. One barn has a capacity of seven barn cures per season. Average total costs are listed for each barn cure for the first two bulk barns. For each of the succeeding barns, average total costs are given at maximum barn efficiency. Minimum efficiency was considered to be use of the barn for one barn curing while maximum efficiency was considered seven barn cures per bulk barn. These alternative output levels for the first two barns indicate costs at a scale of operation at some level less than seasonal capacity. Discontinuities occurred in the average total cost curves as each additional bulk barn was added to increase output up to seasonal harvest capacity. The addition to capital costs from adding successive bulk-curing barns was constant among the three production systems.

The WP system was least cost among the production systems through the first seven cures of the first bulk barn. The WP system required less capital investment than the RP and OOH production systems but required more labor than the OOH system. Average total cost is essentially

Table 8. Average Total Cost at Selected Output Levels and a $2.50 Wage Rate for the Three Harvest-Through-Market Preparation Burley Tobacco Production Systems

Number of Barns	Number of Barn Cures (per season)	Ride-Priming	Walk-Priming	Once-Over
		----------dollars per barn cure----------		
1	1	4,193	2,529[a]	3,638
	2	2,342	1,498*	1,957
	3	1,724	1,154*	1,396
	4	1,416	982*	1,116
	5	1,231	879*	948
	6	1,108	810*	836
	7	1,019	761*	765
2	8	1,180	951	930*
	9	1,173	897	830*
	10	1,042	854	799*
	11	992	818	752*
	12	950	789	712*
	13	915	764	678*
	14	884	743	650*
3[b]	21	865	737	609*
4	28	817	734	591*
5	35	804	732	579*
10	70	(more than capacity)		553*
15[c]	102			564*

[a]The least-cost alternative is denoted by an asterisk.

[b]Average total cost for barns 3 through 10 is calculated at barn capacity.

[c]The 15th barn is used for only four barn cures due to the seasonal capacity of the once-over harvester.

equal for the WP and OOH systems at the seventh barn cure. Beginning with employment of the second barn at minimum efficiency and continuing to capacity, the OOH system became the least-cost method. This was due to the labor advantage of the OOH system, which exceeded the additional capital costs beginning with utilization of the second bulk-curing barn. The RP system was never least cost and had the highest average total cost at all output levels. The RP system required more labor and had higher capital cost at each output level.

II. LEAST-COST METHODS AT SELECTED OUTPUT LEVELS AND WAGE RATES

Total costs are listed in Table 9 for selected output levels and wage rates. Total costs at each output level and wage rate were based on labor requirements listed in column 4 of Table 9 and "All Other Costs" (column 5). "All Other Costs" consist of fixed annual capital costs, plus variable equipment operating costs and joint capital costs. Labor costs were computed at a wage level of $2.00 per hour and increased at $.50 intervals to a maximum of $3.50 per hour. All variable costs increased linearly with output. Output units were in terms of number of barn cures per season with one bulk barn capable of seven cures per season. Total cost figures were computed for most output levels (in whole barn cures) for the first two barns. Total costs for the remaining barns were computed assuming the barns were utilized up to seasonal harvest capacity.

The WP system had the lowest total costs among the alternatives at the $2.00 and $2.50 wage rates for output levels up to one barn used at

Table 9. Total Costs of Three Harvest-Through-Market Preparation Production Systems for Burley Tobacco at Selected Wage Rates and Output Levels

Number of Barns	Number of Barn Cures (per season)	Alternative	Input Requirements: Labor (man-hours)	Input Requirements: All Other Costs (dollars)	Total Cost at Selected Wage Rates[a]: 2.00	2.50	3.00	3.50
					dollars			
1	1	RP	108	3,923	4,138	4,193	4,246	4,300
		WP	100	2,279	2,479*	2,529*	2,579*	2,629*
		OOH	37	3,545	3,619	3,638	3,656	3,675
	2	RP	215	4,144	4,575	4,683	4,790	4,898
		WP	200	2,495	2,895	2,995	3,095	3,195
		OOH	74	3,728	3,876	3,914	3,951	3,988
	3	RP	323	4,365	5,011	5,173	5,334	5,496
		WP	300	2,711	3,311	3,461	3,611	3,761
		OOH	111	3,911	4,134	4,189	4,245	4,300
	4	RP	431	4,586	5,448	5,665	5,878	6,094
		WP	400	2,927	3,727	3,927	4,127	4,327
		OOH	148	4,094	4,391	4,465	4,317	4,613
	5	RP	539	4,807	5,884	6,156	6,423	6,692
		WP	500	3,143	4,143	4,393	4,643	4,893
		OOH	186	4,227	4,648	4,741	4,834	4,926
	6	RP	646	5,028	6,320	6,647	6,967	7,289
		WP	600	3,356	4,556	4,859	5,156	5,456
		OOH	223	4,460	4,905	5,017	5,128*	5,239*

Table 9, continued

Number of Barns	Number of Barn Cures (per season)	Alternative	Input Requirements: Labor (man-hours)	Input Requirements: All Other Costs (dollars)	Total Cost at Selected Wage Rates[a]: 2.00	2.50	3.00	3.50
					dollars			
	7	RP	754	5,249	6,757	7,134	7,511	7,888
		WP	700	3,575	4,975	5,325	5,675	6,025
		OOH	260	4,703	5,223	5,343	5,483	5,613
2	8	RP	862	7,284	9,008	9,439	9,870	10,301
		WP	800	5,605	7,205	7,605	8,005	8,405
		OOH	297	6,700	7,294	7,443*	7,591	7,740
	9	RP	969	7,505	9,443	9,928	10,412	10,897
		WP	900	5,821	7,621	8,071	8,521	8,971
		OOH	334	6,883	7,551*	7,718	7,885	8,052
	14	RP	1,508	8,610	11,626	12,380	13,134	13,888
		WP	1,400	6,901	9,701	10,401	11,101	11,801
		OOH	519	7,798	8,836	9,096	9,355	9,615
3[b]	21	RP	2,262	12,519	17,042	18,171	19,304	20,435
		WP	2,100	10,223	14,422	15,473	16,523	17,573
		OOH	779	10,837	12,395	12,785	13,173	13,564
4	28	RP	3,016	15,343	21,374	22,880	24,389	25,897
		WP	2,800	13,547	19,147	20,547	21,947	23,347
		OOH	1,039	13,941	16,019	16,538	17,057	17,577
5	35	RP	3,770	18,706	26,245	28,130	30,015	31,900
		WP	3,500	16,872	23,872	25,622	27,372	29,122
		OOH	1,299	17,029	19,626	20,275	20,925	21,573

Table 9, continued

Number of Barns	Number of Barn Cures (per season)	Alternative	Input Requirements: Labor (man-hours)	Input Requirements: All Other Costs (dollars)	Total Cost at Selected Wage Rates[a]: 2.00	2.50	3.00	3.50
					----------dollars----------			
10	70	OOH	2,594	32,249	37,437	38,733	40,031	41,328
15[c]	102	OOH	3,896	47,790	55,581	57,528	59,476	61,424

[a]A change in the least-cost alternative for a given wage rate as output increased is denoted by an asterisk.

[b]Total cost for barns 3 through 10 is calculated at barn capacity.

[c]The 15th barn is used for only four barn cures due to the seasonal capacity of the once-over harvester.

capacity. At wage rates of $3.00 and $3.50 per hour, the WP system was least cost up to the sixth barn curing for the first bulk barn. An asterisk marks the output level at which a system becomes least cost for a particular wage rate. Once the OOH system became least cost, it continued to be so up to seasonal capacity. Although the WP system had the lowest total cost at barn capacity for the first bulk barn at wage rates of $2.00 and $2.50, its advantage was not substantial. At the $2.00 wage rate, the WP system's total cost was $248 less than the OOH system. At the $2.50 wage rate, the difference was $28 per barn at barn capacity. On a comparative basis, total costs should be considered equal for one barn used at barn capacity for the WP and OOH systems. However, at this output level, WP required 700 man-hours while OOH required 260 man-hours. Availability of labor should be considered when comparing the two systems.

Finally, the RP system required more labor and capital costs than the other systems for all output levels in Table 9. However, the primers were able to ride and prime which made the task of priming much easier on the labor crew as compared to the WP system.

III. BREAK-EVEN INPUT PRICE RATIOS AT SELECTED OUTPUTS

An isoquant-isocost analysis was performed using the data from Table 9 to determine if a selected production system ever became least cost at a selected output and input price ratio. Column 4, "Labor," and column 5, "All Other Costs," found in Table 9 served as the horizontal and vertical axes in a two-dimensional, isoquant-isocost diagram. Each production output level or isoquant consists of the numerical values in

these two columns. However, not all of the alternatives at each output level were on the isoquant. The RP system was never least cost because it required higher labor requirements and all other costs than either of the other production systems for all output levels.

The isoquant, if drawn, would consist of a series of connected, straight lines where each line connects two adjacent points that meet the qualifications for being on the isoquant. The slope of the straight line connecting each pair of points represents the rate of substitution of all other costs for labor between the two production systems. For the purposes of this study, the rate of substitution was defined as $\Delta C/\Delta L$, where the difference (ΔC) in value of all other costs between two systems was divided by the difference (ΔL) in labor requirements between the systems at the same output level. The slope of the isoquant was negative in the economically relevant range. The least-cost point was where the isocost line was just tangent to the isoquant. The point of tangency was where the rate of substitution was less than or equal to the negative inverse price ratio of labor and all other costs. In notational form, the least-cost criterion between any two adjacent points on the isoquant was:

$$\frac{\Delta C}{\Delta L} \leq -\frac{P_L}{P_C}$$

The rates of substitution between the production systems are listed in Table 10. Because the RP system had both higher labor requirements and higher other costs than the other alternatives, a positive

Table 10. Break-Even Wage Rates Between Two Alternative Harvest-Through-Market Preparation Production Systems for All Possible Combinations of Any Two Alternatives[a]

Number of Barns	Number of Barn Cures (per season)	WP-OOH	RP-WP[b]	RP-OOH
1	1	-20.09	+	+
	2	-9.78	+	+
	3	-6.36	+	+
	4	-4.64	+	+
	5	-3.61	+	+
	6	-2.93	+	+
	7	-2.56	+	+
2	8	-2.17	+	+
	9	-1.88	+	+
	10	-1.63	+	+
	11	-1.44	+	+
	12	-1.28	+	+
	13	-1.14	+	+
	14	-1.02	+	+
3	21	-0.46	+	+
4	28	-0.22	+	+
5	35	-0.07	+	+

[a]The alternative harvesting methods are represented in the following manner: mechanical priming aid (RP), walk-priming (WP), and once-over harvesting (OOH).

[b]Positive signs represent an economically irrelevant rate of substitution since the break-even wage rate would be negative.

rate of substitution implying negative break-even wage rates resulted. Therefore, a positive sign was placed under each column representing comparisons involving the RP system. The P_C was assumed to be 1.00 so that each rate of substitution for each output level represented the wage rate at which the two systems became equal in cost. As mentioned earlier, the labor intensive WP system was least cost up through seven barn cures. The wage rate required for the two systems to be equal in cost at seven barn cures was $2.56. At an output of seven barn cures, the total cost varied by $28 at the $2.50 wage rate. At output levels below seven cures, higher wage rates were required for the two systems to be equal in cost. The break-even wage rate between the OOH and WP systems decreased at output levels above seven cures to a low of $0.07 at an output level of 35 barn cures or seasonal harvest capacity for the WP system. For example, at an output level of 14 barn cures, a wage rate of $1.02 would be required for the labor intensive walk-priming system to be equal in costs to the OOH system. As output increased to 35 barn cures, a wage rate of $0.07 per hour would be necessary for walk-priming to be equal in costs to once-over harvesting. A comparison of outputs above 35 barn cures was not made because the WP system was limited to 35 barn cures per season.

IV. VARYING LABOR AND COST REQUIREMENTS TO REACH LEAST COST

Labor and equipment requirements for the three production systems were based on a limited number of observations. This led to judgmental decisions involving these requirements in the budgeting analysis. For example, the assumptions that no error occurred in determination of labor

and equipment requirements or that labor quality was homogeneous among all farms were judgmental decisions. Any violation of these assumptions could affect the cost status of a particular system. In the preceding section, an isoquant-isocost approach was used to determine rates of substitution among the systems assuming no error of measurement or judgment in the budgeting analysis. A similar approach was taken in this section while assuming a constant price ratio of -2.50, but varying the rate of substitution. For each output level or isoquant, there were three isocost lines, one for each production system. Only one isocost line touches the isoquant at a point which was least cost among the alternatives for that output level at a given wage rate. The two remaining isocost lines may be moved to the least-cost point by either reducing labor cost with all other costs remaining constant or reducing all other costs while labor cost remains constant. Although the least-cost point could be reached by reducing both labor and all other costs simultaneously, this analysis was concerned with reducing one input while holding the other constant. By varying the rates of substitution in the isoquant-isocost approach, the determination of percentage reductions in labor or all other costs necessary to bring a production system to the least-cost point was possible.

The absolute and percentage reductions required to bring a production system which was not least cost to the least-cost point at selected output levels are listed in Table 11. An examination of the necessary percentage reductions was helpful in determining the stability of the choice of the least-cost system in the presence of possible estimation error. As the percentage reduction required to bring a

Table 11. Absolute and Percentage Reductions in Labor Costs or in All Other Costs Other Than Labor of the Three Alternative Burley Production Systems Required to Move the Total Cost to the Least-Cost Level or Least-Cost Isocost Line[a]

Number of Barns	Number of Barn Cures (per season)	Alternative[b]	ΔL Required to Reach Least-Cost (man-hours)	ΔC Required to Reach Least-Cost (dollars)	$\frac{\Delta L}{L} \times 100$ (percent)	$\frac{\Delta C}{C} \times 100$ (percent)
1	1	RP	665.6	1,664	6,180	42
		WP	0	0	0	0
		OOH	443.6	1,109	1,195	31
	2	RP	675.2	1,688	313	41
		WP	0	0	0	0
		OOH	367.6	919	495	24
	3	RP	684.8	1,712	212	39
		WP	0	0	0	0
		OOH	291.2	728	261	19
	4	RP	695.2	1,738	161	38
		WP	0	0	0	0
		OOH	215.2	538	145	13
	5	RP	705.2	1,763	131	36
		WP	0	0	0	0
		OOH	139.2	348	75	8
	6	RP	723.6	1,788	96	35
		WP	0	0	0	0
		OOH	63.2	158	28	4

Table 11, continued

Number of Barns	Number of Barn Cures (per season)	Alternative[b]	ΔL Required to Reach Least-Cost (man-hours)	ΔC Required to Reach Least-Cost (dollars)	$\frac{\Delta L}{L}$ X 100 (percent)	$\frac{\Delta C}{C}$ X 100 (percent)
	7	RP	723.6	1,809	96	63
		WP	0	0	0	0
		OOH	11.2	28	4	0
2	14	RP	1,116	2,790	74	32
		WP	346	865	25	13
		OOH	0	0	0	0
3	21	RP	2,154	5,386	95	43
		WP	1,075	2,688	51	26
		OOH	0	0	0	0
4	28	RP	2,537	6,342	109	41
		WP	1,604	4,009	57	30
		OOH	0	0	0	0
5	35	RP	3,142	7,856	83	42
		WP	2,139	5,347	61	32
		OOH	0	0	0	0

[a]Notation: ΔL = reduction in labor requirements
ΔC = reduction in all other costs
L = initial labor in man-hour requirements at a certain output
C = total value of all other costs at a certain output

[b]The alternative harvesting methods are represented in the following manner: mechanical priming aid (RP), walk-priming (WP), and once-over harvesting (OOH).

production system to the least-cost level increases, the greater the confidence that can be placed in the choice of the least-cost system. In other words, when the percentages are high, the presence of some adjustment errors would probably not affect the choice of the least-cost system. For example, at the output level of seven barn cures, the percentage reduction in labor requirements was 96 percent for the RP system and 4 percent for the OOH system to reach the least-cost level. At this level of output, little confidence should be placed in the WP system being the least-cost system because only a 4 percent reduction is required for labor and a 0.6 percentage reduction in capital for the once-over harvesting method to be equal to the least-cost system. As output increases, the stability of the choice of the OOH system as the least-cost alternative becomes more reliable since percentage changes for the RP and WP systems also rise.

V. BREAK-EVEN TOBACCO PRICE DISCOUNTS BETWEEN NONCONVENTIONAL AND CONVENTIONAL HARVEST AND CURING SYSTEMS

Up to this point in the budgeting analysis, quality of tobacco at each output level and, hence, total revenue were assumed to be equal among the nonconventional harvesting systems and conventional harvesting. A basic question with respect to mechanical harvesting and bulk curing of burley tobacco has been the quality of the cured tobacco. Market indications at the time of this research were that bulk-cured tobacco would be less acceptable than conventionally cured tobacco. Hence, an assumption was made that bulk tobacco price would be discounted relative to conventionally cured tobacco. An analysis was performed to determine

the market price per pound that the nonconventional systems may be discounted and still break even in comparison to conventional harvest and curing when the same wage rate of $2.50 per hour was used for all inputs. Costs were assumed to be the same for all stages of production up to the harvesting stage for all nonconventional and conventional harvest and curing. Table A-3 lists the costs per 3,000 pounds of cured burley tobacco for conventional harvest and curing. It was assumed that no economies or diseconomies of size existed for the conventional system so that costs increased linearly with output. Conventionally cured tobacco was assumed to receive the standard price to which the nonconventional systems were compared.

Break-even discounts are listed in Table 12 for each of the nonconventional production systems. At less than three barn cures (9,000 pounds) per annum, costs of all nonconventional methods exceed the cost of the conventional system, and, therefore, no comparison was made. The walk-priming system becomes least cost at an output of three barn cures. The market price the farmer receives per pound may be discounted $0.002 at this output level and still receive the same net revenue as would be obtainable through conventional harvest and curing. Similar comparisons may be made at other output levels. Using the first barn at a capacity of seven barn cures for the once-over harvesting system allows the farmer to receive a price discounted $0.132 per pound less than the price of conventionally cured tobacco. This represents a total cost difference of $2,774 between the once-over system and the conventional system. Similarly, at an output of 14 barn cures per season, the farmer could receive $0.139 less per pound using the walk-priming system and retain the same net revenue on his tobacco.

Table 12. Break-Even Market Price Discounts for Nonconventional Harvesting Systems as Compared to Conventional Harvesting and Curing of Burley Tobacco

Number of Barns	Number of Barn Cures (per season)	Ride-Priming	Walk-Priming	Once-Over
		cents per pound		
1	3		0.2	
	4		5.9	1.5
	5		9.4	7.1
	6	1.7	11.7	10.8
	7	4.7	13.3	13.2
2	8	1.7	7.0	7.7
	9	1.9	8.8	10.1
	10	3.9	10.2	12.0
	11	5.6	11.4	13.6
	12	7.0	12.4	14.9
	13	8.2	13.2	16.1
	14	9.2	13.9	17.0
3	21	9.8	14.1	18.4
4	28	11.4	14.2	19.0
5	35	11.9	14.3	19.4
10	70			20.2
15	102			19.9

CHAPTER V

SUMMARY AND CONCLUSIONS

I. SUMMARY

The harvesting, curing, and market preparation stages require approximately 74 percent of the total labor requirements using conventional production methods of burley tobacco.[7] Farm labor shortages and increased wages for farm labor have stimulated the need for new methods of tobacco production. Several nonconventional methods of harvesting, curing, and market preparation of tobacco have been developed. Most of the new technologies have been concentrated in the flue-cured tobacco areas. Three nonconventional harvesting, curing, and market preparation production systems used in flue-cured tobacco production with possible potential for application to burley tobacco were examined in this study. These methods were: (1) ride-priming of the leaves (RP) utilizing a multiple-pass harvesting aid with conveyors to deposit leaves in the curing container; (2) walk-priming the leaves (WP) and manually filling a tractor-drawn container; and (3) once-over harvesting (OOH) using a one-row harvesting machine mounted on a tractor. The once-over harvesting alternative was unique to the other production alternatives in that it was a single-pass system; whereas, the ride-priming and walk-priming were multiple-pass systems. The objectives of the study were to determine

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[7] Labor requirements were obtained from the Farm Planning Manual of the Agricultural Extension Service of The University of Tennessee.

and compare the labor and cost requirements of the three nonconventional systems and to examine the effects of wages and volume of output on costs.

II. DATA COLLECTION

A budgeting technique was used to compare costs of production at alternative output levels for the three nonconventional harvesting, curing, and market preparation systems. Labor and equipment data were obtained on two farms in east Tennessee and one farm in western North Carolina. Due to a limited amount of field data, some judgment estimates were made concerning certain labor and equipment requirements after consulting with agricultural economists and with agricultural engineers at The University of Tennessee at Knoxville.

The basic unit of measurement throughout the study was in terms of a barn output of 3,000 pounds of cured burley tobacco. Data were also presented on the basis of a 2,400-pound acre.

III. RESULTS

The crew size of the three nonconventional production systems was four for the single-pass once-over production system, while both multiple-pass production systems required seven laborers each. Total labor requirements per 3,000-pound barn varied from 37.1 man-hours for the once-over production system to 107.7 man-hours for the ride-priming production system for harvesting, curing, and market preparation.

Equipment requirements were the same for the curing and market preparation stages among the three alternative production systems. The

ride-priming production system required more investment in capital equipment used exclusively in the production process than either walk-priming or once-over harvesting. Capital investment for equipment for the harvesting stage ranged from $1,360 for the walk-priming system to $10,406 for the ride-priming production system.

Average variable costs for the three nonconventional harvesting, curing, and market preparation systems ranged from a low of $257.01 for the once-over production system to $470.06 for the ride-priming system. Major differences in average variable costs occurred in the priming substage. The average variable costs for the priming substage of the once-over system was $29.98. This was $200.70 less than the ride-priming system and $164.45 less than the walk-priming system.

Average capital costs were computed at the seasonal output capacity of each production system. The two multiple-pass production systems had seasonal capacities of 31.7 barn cures for the RP system and 35 barn cures for the WP system, respectively. The single-pass OOH system had a seasonal output capacity of 102.2 barn cures. Although the once-over system had higher capital costs than the walk-priming system, average capital costs at seasonal capacity were lower for the once-over system because its seasonal output capacity was greater. Thus, capital costs were spread over a greater number of barn cures. The ride-priming system, which had the highest capital costs and lowest seasonal capacity, had the highest average capital costs.

Average variable costs and average capital costs were summed to obtain average total costs at seasonal capacity. Therefore, a similar cost pattern resulted with the once-over system having the lowest average

total costs of $547.80 per 3,000-pound barn curing and the ride-priming system having the highest average total costs of $832.80 per 3,000-pound barn curing. Average total costs were then computed at selected output levels up through seasonal capacity at a constant wage rate of $2.50 per hour. The walk-priming system had the lowest average total cost through seven barn cures. Beginning with the eighth barn cure, the once-over system had the lowest average total cost up to its seasonal capacity.

Total costs of the three nonconventional systems were then computed at selected output levels while varying the wage rates from $2.00 to $3.50. The ride-priming system was never least cost at any selected wage rate or output level. The walk-priming was least cost at lower output levels for all wage rates examined. At the $2.00 wage rate, the lowest rate considered, the OOH system became least cost at an output level of nine barn cures. As wage rates increased, once-over harvesting became least cost at lower output levels. Total costs at the $2.50 wage rate for seven barn cures, or one barn used at its annual capacity of 21,000 pounts of cured tobacco, was $5,325 for walk-priming; $5,353 for once-over harvesting; and $7,134 for ride-priming.

IV. CONCLUSIONS

The once-over harvesting system was the most advantageous production method from the standpoint of higher seasonal capacity and lower labor requirements when compared to the two multiple-pass production systems. The walk-priming system had the relative cost advantage over ride-priming and once-over harvesting at less than seven barn cures at

the $2.50 wage rate. At an output level of seven barn cures, walk-priming and once-over harvesting became essentially equal in total cost. At output levels greater than seven barn cures, the once-over system had a lower total cost. The walk-priming system had a lower capital investment in harvesting equipment but was more labor intensive than the once-over harvesting method. This was the reason for the lower total cost of the WP system at less than seven barn cures.

Although the ride-priming system had higher total cost at all output levels, primers in this production system were able to ride on the machine as they primed the leaves. This factor may be very influential in obtaining and retaining farm labor thorughout the harvest season.

The total costs for conventionally harvesting, curing, and preparing 2,400 pounds of cured burley tobacco for market was $786.54 with 250.6 man-hours required at $2.50 per hour and $159.54 for all other costs.[8] These costs were prorated into units of 3,000 pounds in order to conform to the basic units used in this study. Thus, total costs for conventional harvest-through-market preparation at the 3,000-pound level was $1,161.46. If the total cost of the conventional system is increased linearly, cost comparisons between conventional and the three nonconventional systems are possible. The WP system had lower total cost than the conventional method at an output level of four barn cures

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[8]All costs for conventional tobacco harvesting through market preparation were supplied by Dr. H. Walch of Extension Agricultural Economics and Dr. R. Ray of the Department of Agricultural Economics and Rural Sociology, The University of Tennessee, Knoxville, or were obtained from the Farm Planning Manual supplied by the same.

(12,000 pounds annually). The OOH system became least cost when compared to the conventional method at five barn cures. The ride-priming system became lower in total costs than the conventional method at an output of 12 barn cures.

Where labor is readily available, walk-priming may be a feasible alternative to conventional harvesting at higher output levels. The WP system had the advantage of leaf selection which was not possible in the once-over system.

The capital costs were lower for the walk-priming system than the other nonconventional systems because no mechanical harvester or priming aid were required. The main disadvantage of the walk-priming system was the more difficult labor tasks involved in field priming. With larger acreages this factor could be very important, depending on the availability of labor. The ride-priming method had higher labor and capital costs than the other nonconventional systems. As previously mentioned, the main advantage of the ride-priming system was that laborers were able to ride as they primed the leaves. The once-over system had lower capital costs than the ride-priming but higher capital costs than the walk-priming system. The higher capital costs for the once-over system were offset by lower labor requirements.

The once-over production system had a much higher seasonal capacity, lower labor requirements, and lower capital costs than the ride-priming system. At all output levels above seven barn cures, it was the least-cost method at the $2.50 wage rate. These advantages make the OOH system attractive to the farmer who has problems in obtaining

labor and has a large number of acres. The once-over production system is a single-pass system. All leaves were removed from the stalk in a single pass. More managerial emphasis would have to be placed on a sucker control program, uniform plant heights, and uniform ripeness of the leaves.

Before deciding on which type of production system to use, a farmer should consider several factors: (1) the availability, quality, and cost of labor; (2) the capital position of the farm operation; (3) the risks associated with marketing bulk-cured tobacco; and (4) alternative uses of building and equipment. For example, bulk barns might be used for grain storage.

V. IMPLICATIONS

A break-even market price discount analysis was performed based on cost of production. The purpose of this analysis was to suggest how much less per pound a producer could receive for bulk-cured burley tobacco under each of the nonconventional methods as compared to conventional harvesting, curing, and market preparation and have net revenue remain constant. This analysis was included in the study because at the present time there exists a doubt as to the market acceptability of bulk-cured burley tobacco. Many people associated with the tobacco industry feel that bulk-cured burley tobacco is inferior and, thus, less acceptable than tobacco which has been cured by the conventional method. Also, bulk-cured tobacco is cured in loose-leaf form making the conventional methods of marketing in tied "hands" a labor problem for bulk-cured tobacco. Although limited marketing of loose-leaf burley tobacco has been

conducted on a trial basis, the acceptance by the tobacco industry of this method of marketing burley tobacco is not a reality at this time. The acceptance of loose-leaf marketing is one important factor in determining the future of mechanical harvesting and bulk-curing of burley tobacco.

The United States world share of burley tobacco production has declined steadily over the last 12 years. In 1965 the United States world share of burley production was 70.9 percent. In 1977 this figure had declined to 47 percent.[9] The price support system of tobacco in the United States tends to create a higher price for U.S. tobacco in relation to world market prices. The United States has historically retained its share of the world market because of high leaf quality. As evidenced by the decline in the United States world share, foreign tobacco has steadily become more acceptable on the world market. Increased foreign competition could intensify the need for greater economic efficiency in domestic burley production. As a result, changes in the industry that could lead to the acceptance of new technologies and institutional arrangements could occur.

An acceptance of bulk-cured burley tobacco in the market may lead to changes throughout the tobacco-producing industry. A large amount of the burley tobacco produced in this country is still raised in small allotments. In 1976 the average number of pounds marketed per burley

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[9]These figures were obtained from Robert Miller, U.S. Department of Agriculture, Commodity Economics Division, Economic Research Service, Washington, D.C., January, 1978.

tobacco producer in Tennessee was 2,300 pounds.[10] Mechanization, which requires larger acreages to be economically feasible, may require changes in allotment leasing or sale. For example, intercounty or even interstate leasing and/or sale of allotments may be considered. Many farmers with small allotments may be forced out of tobacco production and will have to seek other income alternatives to replace lost income from tobacco.

A number of mechanical production systems are available to tobacco producers which were not included in this study. The tobacco combine is one mechanical harvester which was not examined in this study. Also, combining or modifying the production systems may be considered. For example, the once-over harvester may be used as a final priming method for upper-stalk tobacco after the leaves had been previously hand-primed. Several combinations of equipment and labor are possible. Each farm and farmer has individual characteristics which may make a particular production technique more acceptable.

Further research involving changes in the other stages of burley tobacco production may be necessary for the economic acceptability of bulk-cured burley tobacco. For example, changes in the plant bed and transplanting stages which complement mechanical harvesting may lead to improvements in the production process. Further increases in production efficiency in the production process might be obtained by using several tobacco varieties on a farm with different maturity dates. Also,

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[10]Average number of pounds marketed per burley tobacco producer in Tennessee was estimated by Ernest Hill of the Tennessee State Agricultural Stabilization and Conservation Service office.

staggered transplanting dates and uniform transplant size and quality are production practices that may lead to better utilization of seasonal barn capacity and increases in leaf quality. Production practices conducive to mechanical harvesting and bulk-curing methods may have to be followed in each stage of the production process in order to obtain acceptable leaf quality and maximum production efficiency in the tobacco production process.

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APPENDIX

Table A-1. Equipment Operating Costs Per Hour of Use in Harvesting and Curing Burley Tobacco[a]

Type of Equipment	Description	Cost/Hour (dollars)
Tractor	40 pto gasoline	2.01
Priming aid	Self-propelled gasoline engine	3.30
Once-over harvester	Tractor-mounted harvester	0.73
Bulk barn[b]	Long model 1133 bulk curing with LP gas furnace	.81

[a]These costs include fuel, lubrication, oil, and grease. Repairs were included in the operating costs of the tractors, priming aid, and once-over harvester. The operating costs of the tractors and priming aid were supplied by The University of Tennessee Agricultural Extension Staff.

[b]Operating costs of the bulk barn were computed by the author. Costs per hour were based on estimated average fuel consumption supplied by Long Manufacturing, Inc. One barn cure was estimated to consume 1000 kilowatt hours of electricity at a rate of 2.38 cents per kilowatt hour. Fuel consumption was based on 230 gallons of LP gas at 49 cents per gallon. The electrical rate was supplied by Knoxville Utilities Board; the gas rate was supplied by Holston Gases, Inc., both of Knoxville, Tennessee.

Table A-2. Estimated Purchase Price, Expected Life, and Annual Capital Cost of Equipment Used Exclusively in the Three Harvest-Through-Market Preparation Systems for Burley Tobacco

Equipment	Estimated Purchase Price[a] (dollars)	Expected Useful Life (years)	Annual Capital Cost[b] (dollars)
Once-over harvester and mounting kit	5,735	10	1,050.51[c]
Self-propelled priming aid with conveyor system	9,046	10	1,639.12
Bulk tobacco trailer	680 ea.	10	124.43
Bulk curing barn with LP gas furnace	9,433[d]	12	1,552.01
Overhead rail, hoist, and loading accessories	1,427	10	262.37

[a]All quoted prices were obtained from Long Manufacturing, Inc.

[b]Annual capital cost was computed using the following:

$$\text{Interest} = \frac{\text{initial cost + salvage value}}{2} \times 7.5\%$$

(Salvage value was assumed to be 10% of new cost).

$$\text{Depreciation} = \frac{\text{initial cost - salvage value}}{\text{life in years}}$$

$$\text{Repairs and maintenance} = \frac{\text{40\% of initial cost}}{\text{life in years}}$$

Insurance costs were supplied by Farm Bureau Insurance Services, Knoxville, Tennessee.

[c]Repairs for the once-over harvester and self-propelled priming aid were included in the per hour operating costs computed in Table A-1.

[d]This price includes the price of eight bulk curing containers and the electrical component kit for the barn.

Table A-3. Total Costs Per 3,000 Pounds of Cured Burley Tobacco for Conventional Harvesting, Curing, and Market Preparation of Burley Tobacco[a]

Cost Classification	Total Units Required Per 3,000 lbs.	Cost Per Unit (dollars)	Cost Per Barn Cure (dollars)
Labor	313.5 hours	2.50	783.75
40 pto tractor (fixed cost)	10 hours	1.39	13.90
40 pto tractor (variable cost)	5 hours	2.01	10.05
Barn (depr. & repairs)[b]	1 barn		225.00
Barn insurance[c]			91.26
Tobacco sticks[d]	2,500 sticks		37.50
			1,161.16

[a]Basic costs were obtained from the Agricultural Extension Service Farm Planning Manual on a 2,400-pound acre and prorated for 3,000-pound unit costs.

[b]Assumes $6,760 barn depreciated over 30 years and used for tobacco 6 months per year.

[c]Insurance cost was obtained from Farm Bureau Insurance Services, Knoxville, Tennessee.

[d]Cost prorated over a useful life of 8 years.

VITA

Michael A. Cherry was born in Nashville, Tennessee, on June 2, 1952. He graduated from Overton High School in Nashville, Tennessee, in June 1970. He received his Bachelor of Science from Middle Tennessee State University.