BURLEY HARVEST MECHANIZATION
AND CURING PROGRESS AND OPTIONS

AN OVERVIEW OF
HARVESTING, HANDLING
& CURING DEVELOPMENTS

by the

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BURLEY HARVEST MECHANIZATION AND CURING PROGRESS AND OPTIONS

Burley mechanization research has been underway throughout the burley states for many years on harvesting, housing, curing, stripping, and marketing burley tobacco. Notable improvements include:

- harvesting aids that reduce the worker drudgery and increase the productivity with attachments for multi-function operations (transplanting, cultivating, spraying, side dressing, and vegetable harvesting).
- burley harvesting machines that relieve drudgery and improve the labor efficiency and safety of harvesting and provide for field curing.
- alternative air-cure barn and field structure designs for labor-saving housing, improved ventilation and curing control, and cost efficient construction.
- cable-hoist handling and housing methods that offers a reduction in worker-hours, crew size, and drudgery.
- loose-leaf packaging options that reduce the labor by 40% and the cost of stripping and marketing burley by five to seven cents per pound.

Ongoing challenges include:

- successful development of functional and economically feasible automatic or semi-automatic harvesting machines for burley with appropriate handling and curing techniques.
- developing a high capacity multi-grade and cost effective stripping machine.
- continued development and enhancement of field curing facilities and techniques.

Our burley mechanization efforts have focused on maintaining a stalk harvested natural air cured product of high quality and profitability with reduced labor and drudgery.

The potential for leaf harvesting and bulk curing methods for burley has been extensively researched and evaluated. The results show an alteration of the cured tobacco leaf which results in a less desirable and less useful product. Such reduction in quality could seriously erode the superiority of U.S. burley in the domestic and world market.

Many efforts have been made by the Biosystems and Agricultural Engineering Department to significantly improve stalk harvesting, housing, and stripping equipment and methods. Major efforts of recent years have focused on integrated systems of stalk harvesting, housing and curing, stripping, and

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An automated harvester with metal frames and a towed harvester with wire-strung wooden frames have resulted from these efforts. Other efforts have been devoted to build-your-own field sprayers, stripping machines capable of three grades and optimum selection, management, and use of mechanized systems. Additional work focused on a spearing machine to enhance stick harvesting methods.

Some harvesting systems will require a significant initial investment and will be suitable for larger enterprises or through cooperative and/or custom operator arrangements. Other harvesting systems will offer a combination of mechanized methods and worker assistance to achieve harvest. Field curing techniques will be advantageous with some of these harvesting systems. Advanced stripping machines may or may not be capable of maintaining the traditional oriented leaf requirements.

Future air-cure barns must be labor efficient, cost effective, and compatible with potential mechanized handling and housing methods. Suitable existing barns could be converted to new labor saving methods. Any newly built barns must be built economically and according to recommended designs for labor-saving features, mechanical housing potential, dependable curing and flexibility. The 1-worker cable-hoist housing method has proven very workable and competitive for converting conventional barns or building new ones.

Durable plastic covered field structures with manual or mechanized housing offer a curing option at one-fourth or less of the cost of a typical barn and equivalent curing along with 50-90 percent labor reduction for housing. Portable frames with plastic covers for field curing offer compatible handling and curing techniques for some harvesting systems. Any producer interested in labor-saving improvements or new curing facility construction should obtain the latest information available and review it for potential on-farm benefits.

The following two pages illustrate various stick- and notch-type harvesting, handling and curing options beyond the traditional methods that have been in trial use or under various stages of development and adoption. The articles following provide an overview of these options and perceived systems. Producer inquiries and comments are welcomed on these methods, ideas and developments.
BURLEY HARVESTING, HOUSING & CURING OPTIONS

ALTERNATIVES FOR A TRANSITION FROM THE PRESENT TO THE FUTURE

HARVEST ------> ------> ------> ------> ------> ------> CURE

STICK METHODS

MANUAL CUT  FIELD WILT  LOAD  HAUL  CONV. BARN

2-TIER PARTIALLY ENCLOSED

FIELD CURING STRUCTURES

PORTABLE FRAMES  TRACTOR FORKLIFT  WAGON  OPEN INTERIOR BARN

CABLE HOIST BEAM TRAILER-CARRIERS  CABLE HOIST BARN

CANTILEVER-BEAMS W/HYD. TRAILER-CARRIER  FIELD STRUCTURE 1-TIER, PL. COVERED
STICK HARVESTING MACHINES:

HARVESTING AID(S)

SPEARING MACHINE

NOTCHING METHODS

ECONOMY NOTCHING-CUTTING

TOWED HARVESTER  WOODEN  FORKLIFT (2000#)  FIELD CURING
WIRE-STRUNG FRAMES

AUTOMATED HARVESTER  METAL FRAMES  FORKLIFT (2400#)  FIELD CURING
HIGH CAPACITY, FULLY AUTOMATED HARVESTING OF BURLEY TOBACCO

Work began in 1981 to develop a fully automated system for harvesting burley tobacco. The goal was to develop a high capacity system which would totally eliminate the need for the grueling manual tasks which have been a way of life for two centuries. The result has been the development of a system which enables two operators to harvest approximately 4-5 acres per day. This eliminates approximately 85% of the labor currently required to harvest burley tobacco.

The Council for Burley Tobacco gave the first major boost to our program by providing funds for the construction of a new machinery research laboratory. Beginning in 1983, Philip Morris U.S.A. has provided major support for this effort by means of sizeable grants.

The system which has been developed is centered around a self-propelled harvester which is automatically guided down a row being harvested. Plants are cut off near the ground and grasped near the base of the stalk between two aggressive gripper chains, conveyed up a 45 degree incline and inverted before the spacing between them is reduced. After being inverted, the leaves hang down along the stalk and are much less likely to be broken. Also, the only mechanical contact with plants is near the base of the stalk, so that most of the leaves detached are the least valuable.

After being inverted, plants pass between opposed stacks of cutter blades and receive a 1/2 inch wide notch on each side near the base. Notched plants are then placed into continuous slot receivers which are 12" apart in 8' x 14' portable curing frames. Plant spacing within the receivers is 3" giving a plant density of 4 plants/ft\(^2\). Each portable frame holds 448 plants, therefore 14 to 17 frames are required per acre, depending on field plant population. The harvester is equipped with a mechanism which dispenses and fills portable curing frames from a storage magazine which holds 6 frames.

Filled curing frames are off-loaded in the field and moved to a nearby sodded area via a tractor and front-end loader. After approximately one week of wilting, portable frames are covered by waterproof material. The tobacco then remains in the covered portable frames until curing is complete.

The experimental system has been subjected to field testing since 1985. Mechanical losses occur due to both; a) failure to place a notched plant in the curing frames, and b) detachment and loss of leaves. Losses of the first type have averaged approximately 3% and leaf loss has been approximately twice that of conventional harvesting, ranging between 1% and 7% of total harvestable leaves. It should be noted, however, that most leaves lost by the mechanical harvester are the least valuable ones nearest the ground.

Mechanically harvested tobacco has been cured in portable curing frames under waterproof covers during 1987-90 and compared to conventionally harvested tobacco cured in a barn. There was virtually no difference in the average quality of tobacco cured under the two methods, however, in a dry curing season (1987) tobacco cured better in mechanically filled and covered frames whereas, in a humid curing season (1989) the reverse was true.

Various economic analyses have indicated the automated system could be competitive with building new barns for a production system of around 100 acres or for a custom operation for this size or larger.

Work has been done to develop a high capacity system for removing cured leaves from stalks and separating them according to maturity level. A mechanical system to remove cured stalks from the
portable curing frames would thus make it possible to automate both the harvesting and market preparation operations.

**MACHINE HARVESTED WIRE STRUNG FRAME SYSTEM**

A commercial version of the harvester from the wire-strung portable frame system was produced by Powell Manufacturing Co., Inc. of Bennettsville, SC, for a few years. The commercial harvester was based primarily on the experimental harvester developed by engineers from the Department of Biosystems and Agricultural Engineering, with modifications for using a wire-strung portable frame designed by Mr. Steve Hunt of Quality, Kentucky. The harvester cuts the plants, makes a 45 degree notch near the base of the stalk, and conveys the plants to workers stationed in a standing position on the machine, who then hang the plants on wire-strung portable frames. The filled frames are handled in the field with a tractor-mounted front-end loader. These frames of tobacco are cured in the field under waterproof covers.

The system requires a tractor driver, a two- to four-member hanging crew and a tractor-loader operator for best efficiency. The advantage of this system as compared to the conventional system is that simultaneous harvesting and hanging means the plant is handled by hand only once. The heaviest unit to be handled by the workers is a single plant.

The plants are hung on a 6" by 6" wire grid. The frames should be covered during the first week of curing. Management of the side covering is dependent upon weather. Tobacco cured on the portable frames has consistently shown quality equivalent to conventionally cured burley.

After modifications and corrections typical of developing a new machine, the machine showed a smooth flow of tobacco with few conveyor jams and few inadequate notches. Our experience and farmer experience with the commercial machines indicate capacities of 2 acres per day are attainable.

The harvester design permits an empty frame to be placed on the harvester using the front-end loader while the harvester is operating. The empty frame is then moved into filling position as soon as the filled frame is removed from the machine by the tractor loader and operator.

Financial support for the development of this harvester and frame system was provided initially by Philip Morris, U.S.A. and later by U.S.D.A. Agricultural Research Service funds.

**BURLEY TOBACCO HARVESTING AID**

A one-man burley tobacco harvesting aid has been developed that permits the operator to harvest tobacco from a seated position on the machine. The machine was designed to fulfill four criteria:

1) The machine is self-steering. Once the machine is steered onto the row it will steer itself along the row freeing the operator's hands for spearing the tobacco onto a conventional wooden stick.

2) The operator is seated for comfort and ease of operation.

3) The machine is mechanically simple to enhance mechanical reliability and to hold down cost.
4) The stick is left standing in the field as with hand-cutting.

Harvesting burley tobacco with this machine is basically a three-step process. The machine cuts the plants with a circular saw as it steers itself along the row. The operator takes the plants directly from the saw and spears them onto a wooden stick as in hand-harvesting. When the stick is filled with plants, the operator can easily stand the filled stick on the row without leaving his seat.

The machine was not designed to significantly improve the rate of harvest. Rather, the machine was designed to ease the physical labor involved. Thus, harvesting tobacco with the harvesting aid is considerably easier but only about 25 to 30% faster than hand-harvesting. The machine exhibits marked simplicity yet performs those functions necessary to allow one person to efficiently harvest burley tobacco with reduced effort.

Financial support was provided by the Council for Burley Tobacco from funds contributed by tobacco producers.

Four Star, Inc. of College Grove, Tennessee was licensed several years ago to produce and sell the machine. Acceptance of this machine was generally good by several producers in certain areas and years. A few operators experienced some difficulty in adjusting to the machine's spearing procedures and learning to properly set the filled sticks onto the stick row.

Mr. Gerry Giles of nearby Chapel Hill, TN, developed a similar machine with a low platform where one or two workers could stand and spear (spike) the plants onto a stick as they were handed back by the front worker near the cutting saw.

**TOBACCO SPEARING MACHINE**

The widespread interest among tobacco producers for equipment to help stick harvesting methods prompted a renewed effort to develop a stalk spearing ("spiking") machine. An objective was to keep such a machine as simple as possible by having one worker riding at the front to grasp plants as they are cut, rotate them 90 degrees, and place them onto an adjacent horizontal chain conveyor. A mechanism then automatically conveyed and impaled ("spears", "spikes") the plants onto a wooden stick via a "floating spear" mechanism held by three sets of hydraulically operated opposed cam arms.

A design capacity of one plant every two seconds was an objective. Trials achieved about 200-240 sticks per hour for short time operation by workers in good tobacco conditions.

The spearing mechanism was mounted on a self propelled chassis with a 12.5 hp gasoline engine and various hydraulic drive, steering and operational components.

Progress to date has been very successful as the machine accomplished the fundamental objective of spearing plants onto the stick with a high degree of accuracy. Mechanical durability and performance with the varied field and plant conditions has been very good.

Leaf and plant damage were greater than with hand methods. Ways of handling and conveying the brittle, turgid plant to minimize breakage and damage were pursued. One commercial machine was
built by Taylor Manufacturing of Elizabethtown, NC. A tractor mounted and powered version was later built and tested for reduction of the one worker’s manual handling of plants. Work stopped on this version before successful completion.

Financial support was provided by the following support groups:


PLANT NOTCHING-CUTTING DEVICES AND METHODS

The concept of notching the base of a plant and hanging the plant onto a wire was publicly introduced around 1978-1980 by Dr. Claude McKee at the University of Maryland Upper Marlboro Research Station after viewing similar work in France. He and colleagues built a notching and cutting unit on the front of a Gravely walk-behind garden tractor for trials. A one-tier structure with stretched wires was built and evaluated for hanging and curing field-notched plants. The method apparently did not appeal to the Maryland producers at the time as few, if any, on farm systems were built. Dr. McKee’s work spurred the later plant notching and hanging ideas and machines of the 1980s.

The automated harvester and towed notching harvester evolved from this notching and hanging concept. Smaller hi-boy and other walk-behind notching-cutting devices have been built and demonstrated over the years. None of these smaller units have been adopted apparently due to the laborious tasks of stopping to pick up individual plants (although a long hand-held ‘hook’ can be used), the cumbersome nature of handing into a wire framework along the row of cut plants, the transport and curing procedures for such frameworks, economic benefits and harvest rate.

‘Sunburn’ of the tender underside of the leaves of the cut plants has been a detriment to quality when the plants were left to lay on the ground exposed to a bright summer or fall sun for more than 30-60 minutes.

THE CABLE-HOIST TOBACCO HOUSING SYSTEM

The placing of stalk-harvested tobacco into a curing barn ("housing") has been the most laborious and time-demanding of all production practices. Even though only 10% of the total labor is required for this task, workers must manually handle 40,000 to 50,000 pounds of tobacco per acre of harvest. The 30-35 pound sticks are handled several times in loading and transporting from the field to the barn. Much of the laborious work and drudgery involves 4-5 workers standing on tier rails in a barn and handling the tobacco to 25- to 30-foot heights.

Many innovations and techniques have been tried for "mechanical housing" (ropes, cables, pulleys, forklifts, frames, etc.) but none had more than few installations.
The continual search for a workable and economical housing method led to a unique cable-hoist housing system that permits one worker unassisted to house tobacco with a 40 to 50% reduction in labor-hours.

The new system involved:

1. A special wooden beam that holds the equivalent of two rails of tobacco,
2. Modifications to the conventional barn that include removing the tier rails and permanently suspending two small cables from the rafter framework for each two rails of width, or building a new barn to specifications, and
3. Two special hydraulic-powered hoists that lift and position the beam of tobacco into the barn.

Brief features of the cable hoist system are:

- Two-wheel trailer-carriers allow filling of beams in the field and transport to the barn for direct lift-up and maximum labor-saving.
- The 12-foot beam holds 35-40 sticks of harvested tobacco (14' holds 40-45 sticks).
- Each hydraulic-powered host quick-connects to a suspended cable and literally "winds itself up the cable" engaging and "pushing" the beam into position.
- The hoists are controlled through 12-volt valves operated by hand-held "push-button" switches.
- Tier supports need to be far enough apart vertically (5' plus) to prevent the stalk butts of one tier from jamming the tip leaves of another.
- After curing, the beams of tobacco are removed in a reverse manner and lowered for bulking the tobacco.
- Cost data show new barns can be built competitive with conventional barns. Modification can be made to structurally sound conventional barns for using the system.
- The special hydraulic hoist and control design was once built and sold by two Kentucky businesses.
- The hoists can be used in several barns for numerous acres of tobacco and over many years to make the annual cost/acre very economical.
- Over 60 on-farm systems were built and operated.
- Funding for the cable hoist system development in the early 1980s was provided by R. J. Reynolds Tobacco Co.

A FIELD CURING STRUCTURE AND MECHANIZED
HOUSING SYSTEM FOR BURLEY TOBACCO

A field curing structure with a mechanized housing system was developed in the 1980s. The field curing structure had three rows of posts set in the ground to provide columnar strength for the structure. Cross members were set on top of the columns to support the tobacco when it is placed into the structure. The roofing material was spun-bonded polypropylene with a black waterproof coating, which has a three year or longer useful life (Typar®).

The structure was one-tier high and 28' wide. The field curing structure was easy to construct compared to a conventional barn and was well within the construction capabilities of most producers. The structure required about 12 to 13 bents for an acre of burley (28' x 114' to 124'). The cost of the structure was about half that of a conventional barn on a per acre basis, including the cantilever beams.

Wooden beams 14' long were used to hold 50 to 60 sticks of burley tobacco with the sticks extending from each side in a cantilever manner. The empty beams were loaded onto the carrier by two workers for transport to the field. These beams, which weigh about 100 pounds, must be tied down for transport to keep them from bouncing from the carrier. A two-wheeled carrier hauls two beams end-to-end, which gives it a capacity of 100 to 120 sticks per load. The carrier has a tractor-operated hydraulic cylinder for raising and lowering the height of the beams, which allows the beams to be positioned at a convenient height for filling in the field and also permits lifting the filled beams at the curing structure for hanging the beams. After the beams are filled and transported to the structure, the carrier with two cantilever beams in tandem is pulled into the structure where the carrier is used to raise the beams into position for attachment to the framework using wire cable. The carrier is lowered and pulled out of the structure where empty beams are loaded onto the carrier. Two workers can house burley tobacco at the rate of slightly over an acre per day using the system.

The structure can also be tiered to handle tobacco in the conventional manner. Tobacco would be loaded on a conventional wagon or trailer or on a rail wagon for transport to the field curing structure where the tobacco would be hung one tier deep on cantilever tier rails.

Financial support for this developmental work was provided through U.S.D.A. Agricultural Research Service funds.

MINI-HIBOY

A special hi-boy was designed and built to provide sprayer and stick dropping capability. It featured an 18 hp (later upgraded to 24 hp) engine and tricycle mini-hiboy design with hydrostatic drive for primary power and auxiliary hydraulics to power any attachments. Sprayer components included an 8-row boom and 100 gallon water capacity and stick dropping capabilities.

The spray system used components to provide a three-section fold-up 8-row boom for broadcast, over-the-top, or drop nozzle applications. Manual or 12-volt electric solenoid valves enabled control of the boom sections.

The hi-boy power unit has capacity for several hundred sticks and two positions for workers to drop the sticks while the driver operates the hi-boy.
Build-your-own plans were made available for this unit.

Financial and materials support for this equipment development has been provided by White Hydraulics, Spraying Systems Co., and Universal Leaf Tobacco Company, Inc.
MECHANIZED MARKET PREPARATION OF BURLEY TOBACCO

A mechanical system for stripping and grading cured burley leaves was under development for several years. Stalks were held horizontally, with leaves hanging vertically, and inserted (base first) between two feed rollers. Opposed horizontal gripper belts below the feed rollers trapped leaves and pulled them from the stalk. Leaves were deposited from the belts on a rotating platform such that they are aligned for placement into baling boxes.

The rotating carousel platform controlled the operation of the feed rollers via cams and switches. The relative proportion of leaves placed into 3 grades can be adjusted by the operator at any time by moving the carousel dividers.

The stripper/grader was designed for 2 workers. One worker placed stalks into the rollers while the other transfers sorted leaves from the carousel to baling boxes nearby. If design capacity is achieved, the stripper/grader will double the productivity of 2 workers or reduce labor requirement by approximately 50 percent.

Experimental evaluation was done to improve functional reliability. Further development is needed to improve placement of leaves on the carousel and to conveniently dispose of stalks.

Other Burley stripping devices

Several other tobacco stripping devices were built by various entrepreneurs and sold in the 1980s after burley went to the small bale system. An evaluation of the productivity of workers using these machines was conducted and the results summarized in the late 1980s. A copy of the evaluations is on the BAE web site:

www.bae.uky.edu/ext/tobacco

See additional pictorial and summary features of the equipment discussed and other burley harvesting and curing innovations.

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