15. Mechanization

Mike Boyette
Professor of Biological and Agricultural Engineering
Grant Ellington
Extension Associate—Biological and Agricultural Engineering

Burley mechanization efforts continue to focus on both harvesting machines and cured-leaf removal systems to reduce the hard work and improve labor efficiency. As burley tobacco production continues to expand into nontraditional areas of North Carolina (the piedmont and coastal plain), more opportunities arise to assist with implementing mechanization. Many growers in the nontraditional areas have no burley infrastructure or previous experience and are not limited to set methods of harvesting, curing, or market preparation. The traditional harvesting of burley tobacco requires intensive hand labor, resulting in a significant cost to the grower. Also, many new burley growers are also flue-cured tobacco growers who depend heavily upon mechanization for harvesting. As more mechanization options are becoming available, especially with harvesting machines, growers can choose equipment that will work best for their particular acreage and location. Because the cost of the harvesting equipment varies, some devices will be better suited for larger growers. As growers and equipment manufacturers continue to gain experience with existing and new machinery, improvements will be made to increase overall efficiencies. In this chapter we describe some of the new machinery to increase your awareness of recent developments in burley mechanization and commercially available equipment.

Commercial Burley Harvesters

Traditional harvesting requires spiking five to eight plants onto a stick and handling the plants and sticks. The 30- to 35-pound sticks are handled multiple times during loading and transporting from the field to the barn. Compared to traditional harvesting operations, commercial harvesters offer a major advantage—they require a limited number of workers to cut and remove the plants from the field. A tractor operator is required for the harvester, and two additional drivers are needed to transport the field trailers. The machines eliminate most of the drudgery and significantly reduce the harvesting time required per acre. As might be expected, the time required to hang the plants will be significantly greater than the time it takes to cut, notch, and load the plants in the field with any type of harvester. Based on feedback from a limited number of growers, 8 to 10 workers may be required to maintain a continuous harvesting operation when using the wire-frame curing structures.

The Kirpy Machine

The Kirpy machine is a unique burley harvester developed by a French equipment manufacturer (Figure 15-1). The harvester is designed to mount on a tractor's three-point hitch. It is powered by the tractor power take-off (PTO). The single-row machine uses a large diameter saw to cut the plant slightly above the ground. Once the stalk is cut, a modified steel chain with metal spikes grips the plant and conveys it in the upright position. The spikes penetrate the stalk and convey the plant as the chain travels along a sheet metal track. A notching saw is also incorporated that cuts a 45-degree notch at the base of the stalk, which is required to hang the plants onto any of the wire-frame curing structures. After notching, the plant is conveyed until it reaches the track end, where it is released onto a field trailer that is pulled adjacent to the harvester. The notching saw can also

Figure 15-1. Kirpy harvester

be disengaged or removed if the grower uses sticks for hanging the plants. Approximately 20 harvesters were sold in the united States this past year throughout the expanding burley production area.

Numerous field days were conducted during 2006 to provide opportunities for growers to view the harvester in operation. Suggested manufacturer capacity is approximately one-fourth to one-third acre per hour, depending on plant population and tractor ground speed. In order for the plants to be conveyed in the upright position, the conveyor chain speed and tractor ground speed must be synchronized. Also, the conveyor track width should be properly adjusted to maintain the stalks in an upright position when conveyed. This ensures that the notch will be correctly aligned when the stalks pass through the notching saw. Plants that are leaning result in problems during the notching process and consequently will not hang properly on the curing structure.

The recommended tractor ground speeds are 0.6 to 1.0 miles per hour. Therefore, the tractor used to operate the harvester should be capable of maintaining a very slow ground speed to properly synchronize the conveyor speed. The conveyor speed can be adjusted with a needle valve incorporated in the hydraulic controls. The conveyor width can be manually adjusted for different sizes of tobacco, but the more uniform plant size and field conditions are, the better the machine performance will be. Contact your Extension agent for details concerning a U.S. distributor.

Marco Harvesters

A more sophisticated commercial harvester designed to incorporate the portable curing frames was built originally by Powell Manufacturing Co. and most recently by Marco Manufacturing. The harvester cuts the plant, cuts the 45-degree notch, and conveys the plant to workers on the machine who hang the plant onto the portable frames. The advantage of this system is that workers handle the plant only once until curing is completed. Due to the increased automation, this harvester requires a greater investment than the carrier unit and single-row cutter-notcher and may only be cost effective for growers with many acres of burley. The frame cost and quantity required per acre, however, would be similar for both systems.

A smaller version of the burley harvester without the portable rack-handling mechanism was recently built by Marco Manufacturing (Figure 15-2). This machine cuts, notches, and conveys the plant and is also mounted on a three-point hitch. The machine utilizes a gripper or sticker chain to carry the plants onto a wide flat-belt conveyor. The plants are then conveyed and discharged onto a field trailer pulled adjacent to the machine. One advantage of the sticker chain is its ability to continuously accommodate different size stalks that may be encountered during operation. A limited number of machines were built and tested this past season.

Field Trailers

With both types of commercial harvesters, the number of trailers required will depend on the trailer capacity. A small trailer of 16 feet or less will be filled quickly with loosely stacked plants. Some growers are using 40-foot cotton trailers for additional capacity. One solution developed by a local grower is to fabricate removable bulk handling bins that are incorporated onto the trailer. Instead of numerous trailers, only a few are needed and many bins are fabricated. The filled bins can be removed from the trailer in the field or at a central location, such as the curing structure. In terms of trailer capacity, the packing or loading density for uniform average-size plants is approximately four to five plants per square foot of area. The area is determined by the length of the trailer and the depth of

Figure 15-2. Marco burley harvester

the bulked plants. For example a 16-foot trailer with plants piled 3 feet deep would result in approximately 240 plants (16 times 3 times 5). Regardless of the capacity, the harvesters can load the trailers significantly faster than workers can unload them.

Plant Cutting and Notching Devices

The concept of notching the base of the plant to hang it from a wire grid system was developed some years ago in Maryland and exported to Europe. Carolina Industries manufactures a toolbar-mounted cutter-notcher based on a similar unit developed by the University of Kentucky (Figure 15-3). The single-row machine simultaneously cuts a 45-degree notch in the stalk near the base and cuts the plant down. The notch depth is approximately half the diameter of the stalk.
The notch is cut using a 7-inch and a 6.25-inch saw blade assembled together. Stacking the blades together, thereby doubling the thickness, results in a tapered notch that is widest on the stalk surface and narrower near the stalk center. The tapered notch allows the worker to hang the plant onto the wire with ease, but the notch grips the wire tightly enough to keep the stalk from bouncing off the wire during transport through the field. To cut the plant completely, a 10-inch saw

Figure 15-3. Carolina Industries cutter-notcher

blade was used. The cutter and notcher blades are driven by a single hydraulic motor powered by the tractor's remote hydraulic outputs.

Portable Notching Saw

A portable notching saw was developed at NC State University to assist growers who cut the plants manually or by some mechanical method other than the cut-and-notch machinery. Regardless of how the plants are cut, if the portable frames or high-tensile wire curing structures are to be utilized, a notch is required in each stalk. The portable notching saw is direct-driven by a hydraulic motor and uses the same blade assembly as on the cutter-notcher. This device can be mounted in any position and is operated from the tractor's remote hydraulics. A centering linkage is also incorporated into the notching saw that ensures the notch depth is correct regardless of the stalk diameter. An electric unit was also developed to operate from a 120-volt power source and eliminate the use of a tractor (Figure 15-4). The major difference is the notching saw blades are powered by a ¾-horsepower electric motor. The hydraulically operated portable notching saw is commercially available, but it can be fabricated locally if a grower has the resources. Contact your Extension agent for plans to build both portable notching saw configurations.

Figure 15-4. Electric-motor-driven portable notching saw

High-Tensile-Wire Curing Structures

Some growers are beginning to develop low-cost and low-maintenance field curing structures that utilize high-tensile wire for hanging and curing the plants. Various construction methods and materials are being used. All structures incorporate, as they should, some type of plastic cover to protect the tobacco from the wind and rain. Although weather conditions greatly affect the cure quality, growers can manage curing to some degree by raising and lowering the plastic, which controls the drying rate.

Most of the low-cost structures use single wire strands that span support posts (Figure 15-5). The wires are spaced across the structure in 6-inch increments, and the plants are typically spaced 6 inches apart along the wire. The resulting plant density is approximately four plants per square foot, which is recommended for adequate ventilation. The length of these low-cost structures varies from 100 to several hundred feet, depending on the space availability. The height of the field structures should be sufficient to ensure the tip leaves are 6 to 12 inches above the ground.

When constructing these types of field structures, do not exceed the tensile strength of the wire. This is critical. Typically, 12.5 gauge high-tensile wire is used that has a wire diameter of approximately 0.095 inches and a tensile strength of 180,000 pounds per square inch (psi). The wire support-post spacing and amount of sag allowed will determine the tensile stress in each wire. For a given support-post spacing, the wire tension force increases as less wire sag is allowed under load. This tension force should not exceed the wire capacity, which is approximately 1,370 pounds for 12.5 gauge wire. Figure 15-6 is a plot of the wire sag at mid-span in relationship to the support-post spacing. The wire sag is the greatest at mid-span or half the distance between the posts. The green plants are assumed to weigh approximately 8 pounds, and a factor of safety of 2 is used. The factor of safety decreases the allowable tension force to 685 pounds (1,370 divided by 2).

The solid line in Figure 15-6 represents the wire sag for a given post spacing that results in a tension force of 685 pounds. Anything above the solid line is under-stressed and anything below is overstressed, which may result in exceeding the wire capacity. For example, if the support posts are spaced 12 feet apart, a wire sag of approximately 5 inches will result in a tension force of 685 pounds. In this example, a wire sag of greater than 5 inches would decrease the tension force, but a sag of less than 5 inches would over-stress the wire.

As you might suspect, the farther apart the support posts are spaced to maintain a given wire sag, the greater the strength required in the wire. Also, excessive wire sag can result in the plants sliding down the wire and bunching together, especially during periods of high wind. Experience in Kentucky recommends avoiding a wire sag greater than 4 inches. Plants that do not maintain the proper spacing may result in curing problems. Based on the graph, spans exceeding 12 feet are not recommended due to the tension force required to maintain a minimum amount of wire sag.

Another major concern of these types of field structures is bracing the end posts. The tension developed in each wire is transferred back to the end posts and supports. Typically, guy wires, brace members, or both are used to support the end post. The guy wires will need to resist the tension load developed by all the individual wires minus the load carried by the end post. The end-post load is not easily determined, and it is affected by many variables. Therefore, assume that the guy wires must be of adequate strength to carry the entire load.

Consider this example: A field structure that is 16 feet wide with a 6-inch wire spacing supports 33 wires total. If the support posts are 12 feet apart with a mid-span wire sag of 5 inches, the tension force in each wire is approximately 685 pounds (Figure 15-6). The total load

Figure 15-5. High-tensile-wire curing structure

supported by the end posts and guy wires is approximately 22,605 pounds (685 times 33). This example demonstrates the large amount of force that can be exerted onto the end post. Also, the load exerted on the middle end post may be twice the load exerted on the outer posts. Therefore, the middle end post may need additional bracing. Fortunately, the load exerted on the support members will decrease as the plants dry.

Experience has shown that mobile home ground anchors may not be suitable for bracing the end posts. Mobile home anchors are typically rated at a holding capacity of a few thousand pounds. The industrial type screw anchors similar to those used to support utility poles are a better alternative. These larger-capacity anchors come in various rod diameters and lengths and may be installed by hand or machine. As an example, for a given soil type, the holding strength for an industrial screw anchor is approximately three to four times that of a mobile home anchor.

The soil type will have a great effect on the holding strength of any anchor used. Regardless of the anchor used, the angle measured between the guy wire and the ground should be minimized to decrease the tension load. As the angle increases, the tension load carried by the guy wires will increase accordingly. An angle of 45 degrees or less between the guy wire and the ground should be targeted. It is also rec-

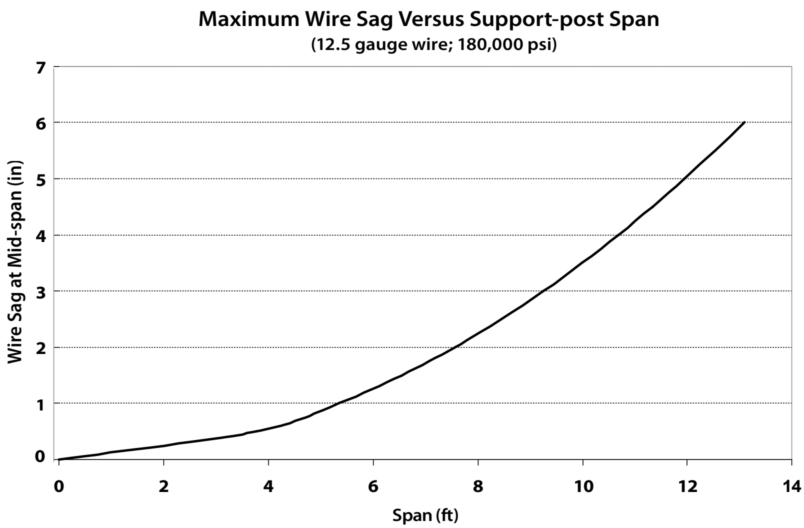

Figure 15-6. Mid-span wire sag versus support-post span

ommended that the ground anchor be installed at the same angle as the guy wire so the anchor shaft is aligned with the guy wire load.

Cured-Leaf Removal Aids

Removing the cured leaves from the burley tobacco stalk is very labor intensive and accounts for approximately half of the total labor cost. The leaves are typically removed manually and segregated into different stalk positions for market preparation. To increase worker productivity and efficiency, a simple stripping aid was developed at NC State University based on similar devices developed by growers in Kentucky and Tennessee (Figure 15-7).

The stripping unit consists of a light steel frame and a conveyor with holders or cups for the stalks. The stalk holder allows a worker to use both hands to remove the leaves, which increases worker productivity. The conveyor frame height is also adjustable to minimize worker effort during removal of the tip leaves. Conveying the stalk past the stationary workers reduces both the time and physical effort required to remove the leaves. A variable speed electric motor drives the conveyor, which allows workers to vary the conveyor speed and consequently the stalk output rate. Although capacities can vary, a stripping unit should easily convey 10 to 12 stalks per minute. Such a simple leaf-removal aid can reduce the labor requirement by 50

Figure 15-7. Stripping aid

percent. Some growers have developed their own aids using flue-cured stringing machines or other conveying equipment, but the concept is the same. Commercial units are available. If you are interested in fabricating your own device, contact your Extension agent for plans.

A large-capacity prototype burley stripping machine is under development, but detailed information or availability is not known at this writing in December 2006. This machine is being designed to automatically remove the cured leaves and separate them into the desired grades or stalk positions. If the design capacity is achieved, then this unit will significantly decrease the labor requirement for market preparation.