THE PRESENT AND FUTURE OF ALFALFA HARVESTING EQUIPMENT

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ABSTRACT

Changes in alfalfa harvest are continuing. The adoption of disc mowing units will soon outpace the sales of sickle cutterbar units. Large forage harvesters and big square bales are systems rapidly adopted by larger alfalfa operations to satisfy capacity requirements. The application of field robotics by NASA affiliates may make driverless, operator supervised harvesters a reality in the early next century.

Key Words: alfalfa, machinery, harvesting, equipment, robotics

INTRODUCTION

Our historical harvest system for alfalfa as either hay or silage has been accomplished with reciprocating sicklebars, rakes, small square balers, and pull-type forage harvesters. Today a multitude of equipment is available which is a combination of past practices (mower-conditioners) or larger, faster cutting units (self-propelled windrowers) and harvesting units (large bale packages - round and square) and S.P. harvesters. A few of the trends in North American forage harvesting are discussed with a possible scenario under development by the National Aeronautics and Space Administration (NASA).

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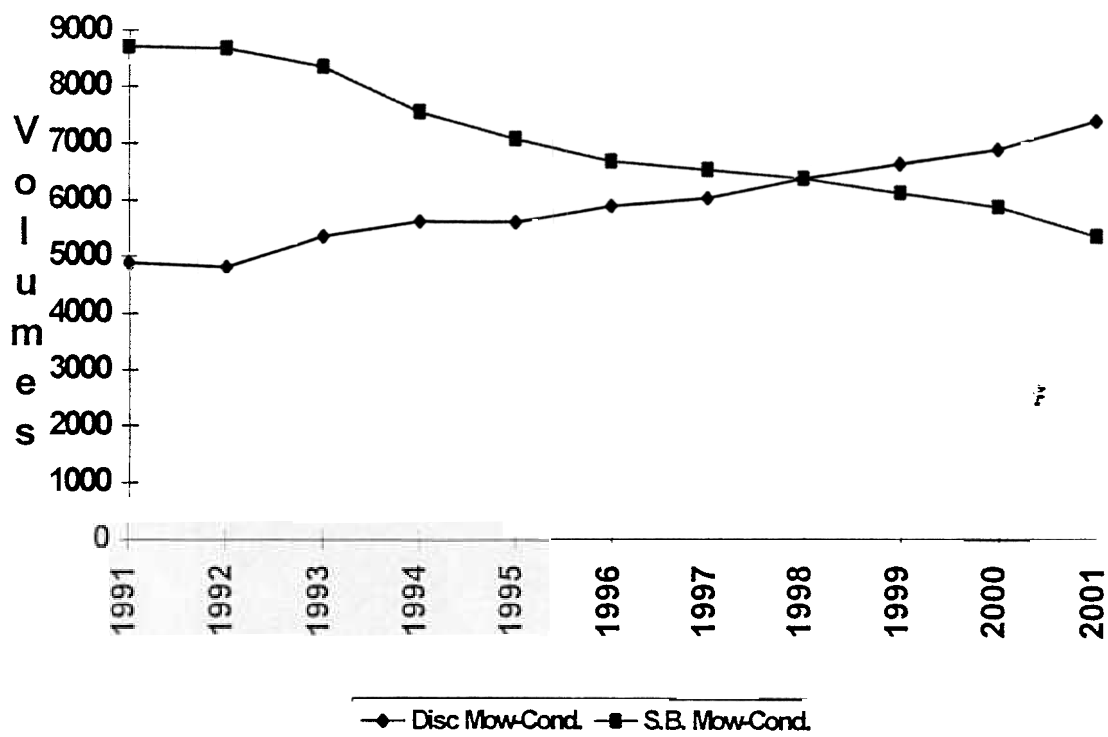
CUTTING PROCESSES AND TRENDS

The reciprocating sickle as a plant cutting device has been with us since 1833 when Obed Hussey combined the reciprocating knife and slotted guard. This design remains relatively unchanged except for the use of heat-treated forged guards instead of wood, and speed and durability has increased substantially. We have moved from pull or mounted mowers, to mowing and pulling a crusher; to today's 18 foot cut pivot tongue mower conditioner. This traditional cutting principle is being pressured by the improvements and performance of the disc mowing system. The advantage of these disc cutting systems are — speed and performance. Today's typical sicklebar can operate 4 to 5 mph before "stripping" or crop stubble overrun occurs. The disc cutterbar operating at 3,000 rpm can cut at 2 and 3 times the ground speed — if you can stay on the operators platform of the propelling cutting device! The disc cutting principal developed in Europe was first used in grass crops and has rapidly (and unexpectedly?) gained popularity with legume growers. The reason is "the disc will cut anything". The trend (Figure 1) shows an industry mower-conditioner prediction. The number of disc mower conditioners equals the sicklebar units in 1998 and exceeding by about 1/3 in 2001. The growth of disc cutting has a downside of increased power but has largely been a "no problem".

MOWER CONDITIONER TRENDS
(FIGURE 1)



CROP CONDITIONING

The use of crushing rolls to process the legume by smashing and splitting the hollow stem has become the standard of design for pull-type mower conditioner and self-propelled windrowers. Crop is processed and deposited on the ground in a wide swath or compressed windrow. Geographic preference, climate, and end use as silage or hay tend to dictate the choice between swath and windrow. The humid areas are laying wide swaths to maximize solar and exposed surface drying. The more arid areas tend toward windrows to reduce bleaching of the alfalfa to obtain a high value green bale. A developing phase of crop conditioning is that of intensive conditioning and maceration.

INTENSIVE CONDITION

The European market is seeing manufacturers develop "intensive conditioning" for their typical grass forage crops. Intensive is the mechanical treatment that significantly breaks and abrades the plant but has minimum stem lengths of nine inches. The disruption of the waxy surface is the objective as well as some cell rupture. The resulting reduced drying time can allow silage operations to begin in 4 to 6 hours.

MACERATION

The severe mechanical treatment of forage such that cell rupture occurs can be referred to as maceration. This high degree of crop treatment has three apparent advantages:

1. Faster drydown - rapid moisture loss has the potential to get alfalfa to silage moisture is 2-3 hours. Baling moisture is attainable in 6-8 hours.
2. Better ensiling - the increased surface area allows rapid lactic acid bacterial growth and has apparently improved the ensiling process.
3. Improved feed value - up to 10% increased energy/food value.

It is the latter potential of increased food energy that will really drive the maceration process to widespread acceptance.

The severe crushing techniques reduce fiber length and separate most of the leaves from the stem base. The potential exists for very high field losses when this material is laid back on the crop stubble. This is addressed by compressing the material into a mat and depositing it on the stubble. This process of high pressure compacting of the crop flow "knits" the loose fibers together so the resultant crop is cohesive and after a short drying period, becomes suitable for harvest as silage or dry day.

The machinery to macerate/mat is being investigated by such North American organizations as the University of Wisconsin (in cooperation with the U.S. Dairy Forage Research Center), the University Laval in Quebec (with Agriculture Canada) and the Prairie and Agriculture Machinery Institute in Manitoba (PAMI). The future of maceration is still developing but the ultimate acceptance will depend on cost, convenience, and performance.

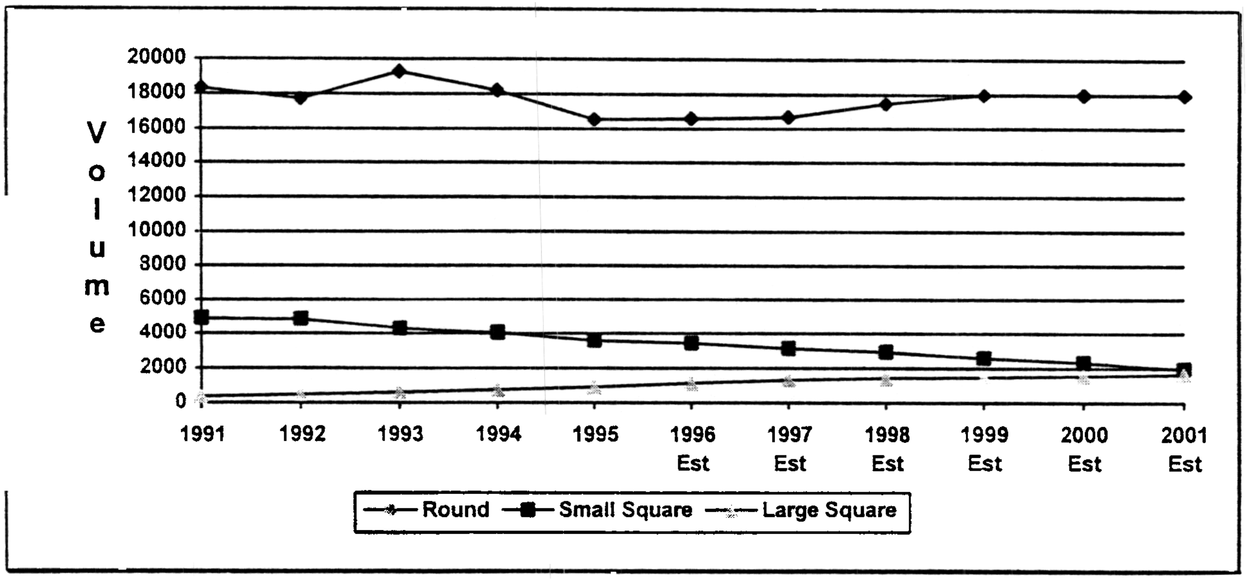
SILAGE

Alfalfa harvested as silage and stored in traditional vertical or horizontal (pit) silos have been in use for some time. Alternatives such as the ag bag and round bale silage are regionally popular.

The use of the round baler as an alfalfa silage harvest system has grown with the improvements to round bale wrappers. Recent designs of round balers include pickup attachments with cutting mechanisms or in baler slicing knives to reduce crop stem length for easier mechanical or animal feedout. The round baler market for North America is expected to remain constant at 18,000 new baler sales per year into the next century (Figure 2).

Baler Industry Trends

(Figure 2)



Large square balers (cross section greater the 2' x 2') are also being designed for silage. Choices for storing these bales are bulk multiple bale stacks covered with plastic and sealed and single bales wrapped in plastic. Although acceptance of large square baleage is limited, the growth may increase significantly as large square bales grow as a harvest means for dry hay. The bale wrappers are now capable of individually wrapping these bales.

Forage harvesters for silage have continued to grow in sophistication. Today's self-propelled units have up to 450 horsepower with very significant harvest capacity. These units include such features as automatic cutterhead knife sharpener, self adjusting shear bars, and crop processing rolls to crack corn kernels.

DRY HAY

The typical small square balers for harvesting dry day with the assorted handling means of bale throwers, bale accumulators and bale wagons is being displaced by the large baler (Figure 2).

The number of large square baler sales is anticipated to reach 2,000 units at the turn of the century. These balers will be the focus of large hay operations and custom operators. Interestingly, the European market has moved to large square balers almost entirely either for hay or straw harvest.

NASA AND ROBOTICS

The National Aeronautics and Space Administrator (NASA) has established a Robotics Engineering Consortium (REC) in Pittsburgh, Pennsylvania. The REC is an entrepreneurial entity dedicated to the development of products incorporating advanced robotics technologies. The applications of robotics include agriculture, construction, mining, excavation, transportation, and space enterprises. In the agricultural sector New Holland has teamed with the REC on project "Demeter" (the Greek goddess of agriculture).

Demeter is the adaptation of NASA planetary rover technology to a New Holland 2550 Windrower. Modification to the 2550 in preparation for the robotics experimentation required adapting the hydrostatic drive to "fly-by-wire" or computer controlled pump displacement for forward, neutral, reverse, or any incremental portion between. The scientists at the REC applied mobile guidance and perception concepts developed on lunar programs such as "Dante", a multi-leg walking machine and "Navlab" an all terrain military vehicle retrofitted to perform general autonomous navigation research.

There is a visual perception system on board with which the windrower "sees" a crop cut line in the field. The defining quality at present is the percent green between the standing crop and the brown stubble of the cut crop. The video camera sees and the computer scans the line of data to determine the junction between cut and uncut crop and then averages or weighs the points to determine machine direction. The windrower is guided at speeds of 4 to 8 mph to about a 3 inch variance from this crop cut line. Other guidance and safety instruments are on board such as GPS for navigation in case of a bare spot in the alfalfa field. An inclinometer checks to see if the machine is placed in a precarious position and a compass system for redundant guidance or the ability to made a plunge cut through the field parallel to a previous cut.

The totally unmanned yet operator supervised windrower is a combination of currently available technology. The unique combination of a cost effective, safety designed system is the challenge. Remember, the unit has to have the capability of recognizing unknown field obstacles (a pickup truck from a wayward driver) and making a decision to stop operation or cut around the problem.

The system of autonomous harvesting will come, but when is hard to say. First steps will likely be as an operator assist option. A possible scenario is CutCruise, the option that allows the operator to align on the crop cut line and engage the automatic mode to offer "hands off" driving. Such things as ability to plunge cut through the field (a parallel cut offset from a previous cut) and end-of-row detector are possible options.

Stepping beyond the operator assist mode are one operator manned unit with CutCruise followed by one or more drone units. These cabless windrowers mimic the speed and performance of the "mother" unit with operator responsibility for quality of cut, mechanical function on power unit, and general field operating conditions.

The ultimate machine is the supervised cabless windrower programmed to cut the northeast eighty acres at 9:15 a.m. on Thursday. As envisioned, this step is "in the future" because we will need a long proven test period to be sure we can avoid someone's stray cow or not be guided by Johnny's stray Nintendo commands.

Choices of equipment were limited to the windrower first because of its single function (cut crop) and differential hydrostatic drive. The more complex adaptation of autonomous operation to combines, tractors, fertilizer spreaders or crop sprayers will come rapidly after the autonomous harvester system is commercialized.

The future is becoming available at a rapid pace and the application of technology to alfalfa is an exciting arena. Faster cutting with disc systems, drying improvements and better feed with maceration, and the application of field robotics to lessen operator fatigue are examples, that are present and future of alfalfa harvesting equipment.