2005

Biomass Harvest and Densification

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Abstract
Research and development of harvesting and transportation systems to efficiently and economically move corn stover from the field to biomass processing facilities has been ongoing for the past several years. To accomplish this, simple and effective equipment that allows rapid collection of large quantities of stover must be developed, without significant interference of other harvest operations. The primary emphasis of this work has been on innovative single-pass corn and stover harvesting systems, which have both economic and technical advantages for bioconversion processes. The two fundamental issues that must be addressed are (1) the development of biomass harvesters and supporting equipment for field operations and (2) densification of the harvested material to minimize transportation costs.

Keywords
Agricultural and Biosystems Engineering

Disciplines
Agricultural Science | Agriculture | Bioresource and Agricultural Engineering

Biomass Harvest and Densification

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Introduction

Research and development of harvesting and transportation systems to efficiently and economically move corn stover from the field to biomass processing facilities has been ongoing for the past several years. To accomplish this, simple and effective equipment that allows rapid collection of large quantities of stover must be developed, without significant interference of other harvest operations. The primary emphasis of this work has been on innovative single-pass corn and stover harvesting systems, which have both economic and technical advantages for bioconversion processes. The two fundamental issues that must be addressed are (1) the development of biomass harvesters and supporting equipment for field operations and (2) densification of the harvested material to minimize transportation costs.

Materials and Methods

Two different harvest systems have undergone development and testing during the past year at the Ag Engineering/Agronomy Research Farm. The first machine, shown in Figure 1, is a modified Claas head mounted on a New Holland TV145 bidirectional tractor. This machine incorporates a head that collects the entire corn plant and separates the stover and ear corn like a normal corn head. The stover is then processed by a rotary blade, similar to a lawn mower, under each row unit, collected with an auger, and further processed with a hay processor acquired from Vermeer Manufacturing Company. After the stover is chopped, it is recombined with the ear corn and transported by a paddle type conveyor into a trailer for transport.

The concept behind this system is incorporation of ear corn into the stover to increase the bulk density for transport. Field processing stover to a smaller particle size will help increase the bulk density of corn stover; however, to achieve a legal load, based on weight limits, a density of approximately 11 lb/ft^3 is required. Only with extremely large compaction pressures can this bulk density be achieved without including the ear corn.

Other advantages of this system include lower harvest equipment investment, due to the elimination of the combine for corn and simplified field logistics with only one material stream leaving the field. However, the mixture of ear corn and chopped stover requires stationary batch separation at the processing facility with the current regulation of grain handling.

The second system developed during the past season is a stover processing and conveying system attachment to a John Deere 9750 STS combine as shown in Figure 2. The machine incorporates a John Deere 653A whole-crop head that collects the entire plant, which is then fed though the combine. This harvester then threshes and separates the grain as normal, except that the material other than grain (MOG) to grain ratio is significantly higher than for a conventional corn head. The MOG is then chopped by a rotary slicer taken from a production baler. The chopped stover and cobs are then transitioned into a blower and spout from a forage harvester and transferred into a transport trailer.

The tractor-mounted system was able to achieve a bulk density of approximately 8 lb/ft^3

compared with a density of about 3.5 lb/ft^3 on the combine attachment system. Further laboratory studies were conducted to establish baseline density information. Corn plants were hand harvested at the Ag Engineering Research Farm and cut to different lengths. Compaction studies of samples of known volume and mass were conducted using a Sintech MTS test machine. The results indicated that the first 10 lb/in.^{2} of load applied to the sample did the majority of the compaction, while subsequent higher loads resulted in much lower marginal increases in sample density. Compaction studies were conducted to evaluate the effects of cut length, moisture contents, and inclusion of ear corn in the sample.

Conclusion

The stover bioprocessors have demonstrated that any soil or foreign material in the collected sample greatly reduces production efficiency. This has led the research to focus on the single-pass harvest systems shown in Figures 1 and 2, which keep the stover above the ground rather than simply baling windrowed stalks on the ground after harvest. The relatively low value of stover, estimated at $30/dry ton, requires the use of low cost harvest equipment that does not significantly decrease the rate of corn harvest or increase the labor demand. It is critical to remember that whatever in-field stover processing is done, it must reduce the overall cost of the transport or conversion systems to be beneficial.

Figure 1. Modified Claas head.

Figure 2. Stover attachment for a John Deere combine.