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Dry Matter Losses During Storage of Switchgrass Biomass

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Summary

Future supplies of renewable fuels may come from thermo-chemical processing of forage biomass. For accurate estimates of biomass supply, these biomass-processing plants will need to know how much biomass is lost during storage. Losses of dry matter from switchgrass (*Panicum virgatum* L.) biomass stored in large round bales were determined in two 6-month storage periods. Dry matter losses estimated from changes in volumetric density averaged 19% during the first storage period (October 1991 to April 1992). Dry matter losses estimated from changes in bale weight averaged 12.8% during the second storage period (August 1992 to February 1993), in which bale weight decreased linearly at 0.42 lb/day.

Introduction

Switchgrass has been selected by the U.S. Department of Energy as a model species for developing the technology for herbaceous biomass feedstock production of synthesized ethanol or other liquid fuels (McLaughlin 1993). Switchgrass for biomass is foreseen as being harvested with conventional hay-handling equipment. The most likely storage package will be in large round bales (Cundiff 1993). Biomass conversion plant operators will need to know the potential losses during storage of biomass before processing. Thus the objective of this study was to determine the feedstock quality of 'Alamo' switchgrass for conversion to ethanol and thermo-chemical products and the effect of storage on that quality. Switchgrass was packaged into large round bales at two dates and stored unprotected for 6 months.

Procedures

We used a 6-year-old stand of Alamo switchgrass on the Alan Koemel Ranch 11 mi south of Stephenville, Texas. The switchgrass was on a Frio clay loam soil, which is a bottomland soil of moderate to high native fertility. No fertilizers or pesticides were applied during the study. In 1991 (Harvest 1), the switchgrass had been grazed by beef steers from June to late July. The switchgrass was cut with a windrower to a 6-in. stubble on 3 Oct. 1991 and allowed to field-dry for 5 days. Switchgrass was baled with a larger round baler into bales 4-ft in diameter by 5-ft long. Estimated weight was 700 lb/bale. Eight bales were made and transported to the Texas A&M University Agricultural Research and Extension Center at Stephenville. Dry matter yield, morphological stage (Sanderson 1992), and density (TAPPI 1985; method T-258-OM-85) were determined at harvest. Bulk samples (200 lb) of the windrowed biomass were sent to the National Renewable Energy Laboratory (NREL) for chemical analysis.

In 1992 (Harvest 2), a 2.5-acre area of switchgrass was fenced off to exclude grazing animals and was cut on 15 August and allowed to field-dry for 3 days. Twelve bales of switchgrass were made and transported to the research center on 18 August. At each harvest, six thermocouples were placed into each of four bales, three on one end and three on one side. For Harvest 1, temperature was monitored daily for 28 days, then weekly until April 1992. For Harvest 2, temperature was monitored daily for 60 days, then weekly until February 1993. Thermocouples were calibrated at 32 and 212 °F before insertion into the bales and at the end of each storage period. During the first storage period, the electronic thermometer (EXTECH model 40131K) failed and was replaced with an Omega model HH23 electronic thermometer. All thermocouples were recalibrated with the new electronic thermometer at that time.

Bales were sampled with a "Penn-State" bale corer every 2 weeks for 10 weeks after baling, then monthly until the end of storage. Four cores were taken to a 24-in. depth and composited by bale. Dry matter and volumetric density were determined on each composited sample. Selected bales were destructively sampled with a chain saw at 3.25, 6.5, 13, and 26 weeks of storage. A 2-in. slice was taken from the end of the bale and another 2-in. slice was taken at 18 in. into the bale. These samples were sent to NREL for analysis. The depth of the weathered layer was measured at the 3, 6, 9, and 12 o'clock position on the destructively sampled bales. At each destructive sampling date during Harvest 2, samples were taken of the weathered material from the top and bottom of the bales and of the unweathered core. Dry matter and volumetric density were determined on these samples.

Keywords: round bales / biomass / switchgrass / storage losses.

Bales were weighed at the start of Harvest 2 and at each destructive sampling date. The bales were weighed with an electronic load cell (Sensortronics model 60001 3K load cell) and a digital indicator. Biomass samples were taken at each weigh date to adjust bale weights to a 100% dry matter basis. A reference weight was used to calibrate the load cell at each date.

At Harvest 2, two bales were placed into large galvanized tanks to enable collection of rainfall runoff water. The bales were placed on a fiberglass grating to prevent contact of the bale with the metal tank. Shields were placed around the bale to exclude excess rainfall. Samples of rain and bale runoff water were collected after each rainfall event and sent to NREL for analysis.

Daily maximum and minimum temperature and relative humidity and daily rainfall were recorded at the weather-monitoring station near the research center. The station was located about 1 mi from the bale storage site.

Results and Discussion

Biomass yield in October 1991 was 5,780 lb dry matter/acre, and in August 1992 was 6,553 lb dry matter/acre. Dry matter at cutting was 45.6% in 1991 and 42.1% in 1992. Dry matter at baling was 91.3% in 1991 and 96.3% in 1992. Mean morphological stage at cutting was 35 (seeds matured and shattering) in 1991 and 28.9 (inflorescence fully exserted) in 1992. Because the biomass was baled at less than 10% moisture, no heating from microbial growth was observed (data not shown). Volumetric density of the biomass at baling in Harvest 1 averaged 0.52 lb/cu ft and 0.42 lb/cu ft after 6 months of storage. In Harvest 2, density at cutting was 0.59 lb/cu ft; at baling it was 0.55 lb/cu ft and averaged 0.51 lb/cu ft after 6 months of storage. The depth of the weathered layer did not change much during the first 6-month storage period and averaged 7.1 in. (Fig. 1). In contrast, the depth of the weathered layer increased quadratically during the second 6-month storage period (Fig. 2) and was 3-in. at the end of 6 months. Biomass in the weathered layer had an average volumetric density of 0.25 lb/cu ft after the first 6-month storage period. At the end of the second 6-month storage period, the volumetric density of the bottom weathered layer averaged 0.43 lb/cu ft. Bale weight declined linearly during the second 6-month storage period (Fig. 3). Dry weight loss averaged 12.8% during the 6 months.

Total runoff collected from the bales in Harvest 2 was 220 gal during September 1992 until February 1993. Rainfall during that period was 15.2 in. Peak runoff volumes of 31.3 and 25.6 gal occurred on 11 Sept. 1992 and 14 Dec. 1992, when rainfall was 2.5 in. for the 24-hr period.

Biomass and runoff water samples will be analyzed by the National Renewable Energy Laboratory. New studies during 1993-94 will address dry matter losses during storage, runoff water quality, and biomass losses during harvest and transport.

Acknowledgment

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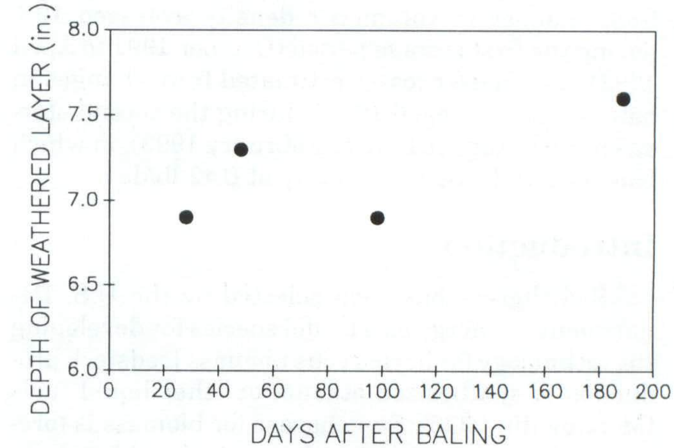

Figure 1. Depth of the visibly weathered layer in switchgrass large round bales during 6 months of storage (October 1991 to April 1992).

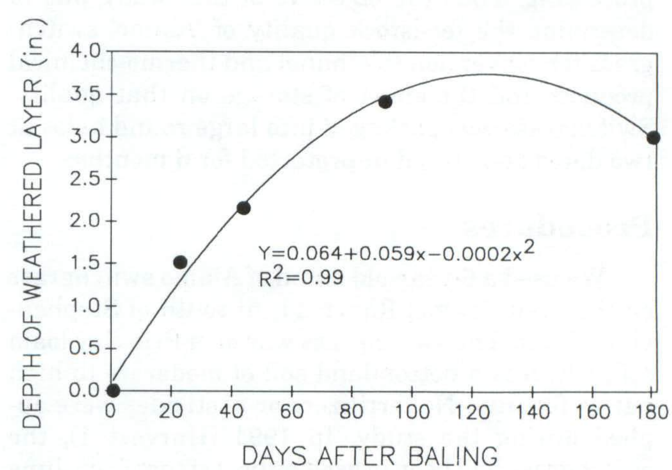

Figure 2. Depth of the visibly weathered layer in switchgrass large round bales during 6 months of storage (August 1992 to February 1993).

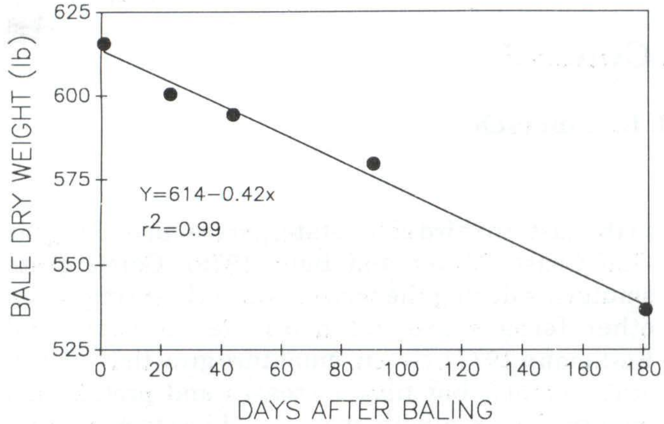

Figure 3. Dry weight of large round bales of switchgrass during 6 months of storage (August 1992 to February 1993).

Literature Cited

Cundiff, J.S. 1993. Fuel cropping in the Piedmont. Oak Ridge National Laboratory, Miscellaneous Report. Oak Ridge, TN. 313 p.

McLaughlin, S.B. 1993. New switchgrass biofuels research program for the southeast. p. 111-115. *In* Proc. 1992 Annual Automotive Technology Development Contractor's Coordination Meeting, 2-5 Nov. 1992. Dearborn, MI.

Sanderson, M.A. 1992. Morphological development of switchgrass and kleingrass. Agron. J. 84:415-419.

TAPPI Official Test Methods. 1985. Basic density and moisture content of pulpwood. T.258. Technical Association of the Pulp and Paper Industry. Atlanta, GA.