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Variation in corn stover composition and energy content with crop maturity

L.O. Pordesimo[a,*,1], B.R. Hames[b], S. Sokhansanj[c], W.C. Edens[d,2]

[a]Deptment of Biosystems Engineering and Environmental Science, The University of Tennessee, 2506 E. J. Chapman Dr., Knoxville, TN 37996-4531, USA
[b]National Renewable Energy Laboratory, National Bioenergy Center, 1627 Cole Blvd. Golden, CO 80401-3393, USA
[c]Oak Ridge National Laboratory, Environmental Sciences Division, Oak Ridge, TN 37831-6422, USA
[d]Department of Biosystems Engineering and Environmental Science, The University of Tennessee, 2506 E. J. Chapman Dr., Knoxville, TN 37996-4531, USA

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Abstract

How to harvest and process corn stover to maximize its quality as a fuel or industrial feedstock and minimize material losses are compelling issues in the industrial utilization of corn stover. The objectives of this investigation were to evaluate the variation in the chemical composition and energy content of aboveground components of the corn plant over time and to evaluate how composition changes after grain physiological maturity is reached and the plants are weathered while undergoing further field drying. Above ground biomass distribution and composition of two almost identical corn cultivars (Pioneer 32K61 and 32K64 Bt) were studied from an estimated 2 weeks before corn kernel physiological maturity until 4 weeks after the grain had already reached a moisture content suitable for combine harvesting. Compositional analysis of corn stover fractions gathered over the course of maturation, senescence, and weathering using NIR spectroscopy showed (1) a rapid drop in soluble glucan, (2) increase in lignin, and (3) increase in xylan. By day 151 after planting, about when grain from surrounding non-test plots was harvested at about 15.5% moisture, composition of the different fractions remained fairly constant. Since product yield in fermentation-based biomass conversion processes is proportional to the structural carbohydrate content of the feedstock, timing of stover collection and the proportion of anatomical fractions collected affect the quality of corn stover as fermentation feedstock. Since the energy content of corn stover anatomical fractions is shown to remain fairly constant over time and

*Corresponding author. Tel.: +1 301 504 8450; fax: +1 301 504 9466.
E-mail address: pordesil@ba.ars.usda.gov (L.O. Pordesimo).
[1]Present address: Instrumentation and Sensing Laboratory, USDA-ARS Beltsville Agricultural Research Center, Bldg. 303, BARC-East, Beltsville, MD 20705, USA.
[2]Present address: Middle Tennessee Electric Membership Corporation, 555 New Salem Rd., Murfreesboro, TN 37129, USA.

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from one plant to another (16.7–20.9 $kJ\,g^{-1}$), insofar as combustion processes are concerned, it apparently makes little difference which part of the plant is used, or at what time the material is harvested.

Keywords: Corn stover; Stover anatomical fractions; Chemical composition; Energy content; NIR spectroscopy

1. Introduction

It has been put forward that corn stover can be a strategic feedstock for both bioenergy and bio-based industrial products because of its abundance and proximity to existing grain-to-ethanol conversion facilities [1–3]. Key issues that need addressing are how to harvest and process corn stover to maximize its quality as a fuel or industrial feedstock, minimize material losses, and improve handling efficiencies. Development of strategies/systems for the postharvest handling of corn stover involves quantifying corn stover biomass over time after physiological maturity of the grain has been reached and evaluating its distribution in different stover morphological fractions. Data on the chemical composition and energy content of the different corn stover fractions around the time of corn kernel physiological maturity is needed as well for process design, such as in the timing of harvest for grain and stover and in evaluating seggregated processing of the different stover fractions.

Plant material consists mainly of cellulose, hemicellulose, lignin, ash, protein, lipid, pectin, soluble sugars, and phenolic compounds [4]. Cellulose, hemicellulose, and pectic polysaccharides, classifications based on chemical composition and solubility properties in various solvents, are structural polysaccharides contained in plant cell walls [5]. The cellulose and hemicellulose fractions can be converted into energy and chemicals through direct combustion, pyrolysis, or biological conversion. Sugars in the plant vegetative material occur as storage polysaccharides such as starch, fructans, some mannans, and important amounts of gums and mucilages. In straw specifically, cellulose and xylan are the predominant components [6] with smaller amounts of polysaccharides containing mannose and galactose and probably pectic components occurring also.

The objectives of this investigation were to evaluate the variation in the chemical composition and energy content of the aboveground components of the corn plant over developmental time and to evaluate how composition changes after grain physiological maturity has been reached and the plants are weathered. Such investigation will give some insight into the fate of chemical components in the stover fractions during the course of maturation and senescence. Moreover, the compositional data obtained aids in the valuation of corn stover and its fractions for different end uses (e.g. combustion or industrial fermentation). Similar studies have been undertaken to assess the value of corn plants as forage [4,7–9]. Hence, these studies were terminated at grain physiological maturity and only overlap moderately with this work.

2. Materials and methods

2.1. Test material

Corn planted in a 0.40-ha field at The University of Tennessee, Knoxville Experiment Station, Plant Sciences Farm was taken as the test material in this study. The soil in this field was Sequatchie loam, which is a deep, well-drained alluvial soil on the first terrace of the Tennessee River. The field was divided into 32 plots measuring $9.2 \times 6.1\,m^2$ laid out on a 4×8 grid. A column consisted of four plots each separated by a 2.1-m alley. A genetically engineered Bt cultivar, Pioneer[3] 32K64, and its conventionally bred parent cultivar, Pioneer 32K61, served as the treatments and each was

[3]Trade names are provided for the sake of factual reporting. The University of Tennessee neither guarantees nor warrants the standard of the product and the use of the trade name implies no approval of the product to the exclusion of others.