



## Harvest Management and Switchgrass Composition

**Purpose:** The purpose of this publication is to evaluate the effects of harvest management on switchgrass composition as a combustion feedstock.

### Harvest Options

Switchgrass for biomass should be harvested once a season after the crop has matured, to allow for stand persistence. Composition of the biomass can be altered by mowing and delayed baling in the fall, or by leaving the crop in the field overwinter. Leaching will remove some undesirable elements, but yield will also be reduced.



Fig. 1. Switchgrass may remain standing or become completely lodged over winter, with many heads and leaves knocked off the plants and lost as yield.

### Biomass Composition

From a combustion standpoint, the ideal grass feedstock would be similar in composition to wood. Concentrations of most elements in grasses decline with plant age, making mature plants more desirable. The most undesirable elements from a combustion standpoint are chlorine (Cl), nitrogen (N), potassium (K), and sulfur (S). Sodium (Na) is just as undesirable as K, but grasses contain very little Na. Total ash content can affect the ash handling ability of a particular combustion appliance. Approximately one half of the total ash content is silica. Silica, in combination with K, affects the ash melting behavior (clinkering) in grasses.

### Soil Fertility

Soil type and inherent soil fertility will impact mineral uptake. Fertilizers contain undesirable elements from a combustion standpoint, in particular N, K and Cl. An advantage of warm-season grasses like switchgrass over cool-season grasses is that they only require a modest level of N fertilization to produce optimum yields. Fertilization with KCl should be minimized, as grass plants exhibit luxury uptake of both of these elements far in excess of plant requirements.



Fig. 2. Switchgrass overwintered in the field will result in some leaching of undesirable elements, but this will increase the chances of soil contamination, particularly in a wet spring.

### Methods

A field of 'Nebraska' switchgrass and a field of 'Cave-in-Rock' switchgrass, both located at the Cornell Mt. Pleasant research farm, were used for this research. Switchgrass was mowed and baled in the late fall, mowed in late fall and baled in spring, and mowed and baled in the spring over four growing seasons (Bioenergy Information Sheet #10). Treatments were randomized and each replicate consisted of two 13' adjacent swath widths. The two swaths in each replicate were raked into one windrow for baling. All mowing was at 3-4" stubble height. Bales from all field replicates (total of 15) were cored and samples were analyzed for minerals, gross energy content (BTU), N, fiber, and ash content.

## Results

Data was analyzed using SAS PROC MIXED with years and replicates considered random effects. Nebraska switchgrass matured earlier than Cave-in-Rock and Nebraska was significantly higher in fiber and lignin, and lower in K and ash than Cave-in-Rock. Cultivar was confounded with field. Fields were on the same soil type, separated by only a few hundred feet. Marginal, stony soil with a relative rough soil surface resulted in occasional significant soil contamination of bales, with the highest ash content exceeding 9%.

Table 1. Average content of switchgrass baled in the fall (Fall), overwintered in windrows and baled in spring (Winter), and mowed and baled in the spring (Spring), over 4 growing seasons. Treatments followed by the same letter are not significantly different (P=0.05).

Variable	Fall	Winter	Spring
Ash, %	3.48a	3.07ab	2.68b
Cl, %	0.075a	0.054b	0.052b
K, %	0.59a	0.14b	0.09b
N, %	0.84a	0.72ab	0.62b
S, %	0.067a	0.053b	0.045b
BTU, per lb	8237b	8268ab	8302a
ADF, %	52.1b	57.4a	58.1a
NDF, %	80.8b	85.8a	87.2a
Lignin, %	9.19b	10.59a	10.41a
P, %	0.12a	0.07b	0.05c
Ca, %	0.38a	0.35ab	0.31b
Na, ppm	89a	67b	55b
Al, ppm	105b	389a	291ab
Fe, ppm	164b	557a	358ab
Ti, ppm	0.74c	3.11a	2.22b

Although fall-baled switchgrass was significantly different in composition of most components compared to spring-cut grass, only some of these are important for combustion. The differences found in total ash, fiber, lignin, BTU, P, Ca, Na, Al, Fe, and Ti will have minimal impact on combustion. Differences in Cl, N, K, and possibly S between fall and spring bales will have a significant impact on combustion and emissions.

### Soil Contamination of Biomass

Aluminum, Fe and Ti are found in most soils in significant quantities. Titanium is not taken up

by grasses, Al uptake is minimal (<50 ppm), and Fe uptake is limited. For all bales, the range in Al was 36 to 1894 ppm, the range in Fe was 47 to 3237 ppm, and range in Ti was 0.01 to 10.5 ppm. The lowest Al, Fe, and Ti concentrations were all found in the same spring-cut bale in 2011, representing a minimum of soil contamination. Based on Al, Fe, and Ti concentrations, soil contamination of the feedstock is most likely for grass overwintered in windrows, and least likely for fall-baled switchgrass.

### Summary

Maximum switchgrass yield occurs in the fall, but biomass quality for combustion can be improved by overwintering the biomass in the field. Spring-baled switchgrass has increased chance of soil contamination, but has lower concentrations of components problematic for combustion. Economically it may not be practical to lose 15 to 50% of fall yield (Bioenergy Information Sheet #10) in order to harvest a higher quality combustion feedstock the following spring.

### Additional Resources

Cherney, J.H. and K.M. Paddock. 2013. Overwintering Switchgrass in the Field in NYS. Bioenergy Information Sheet #10. [www.grassbioenergy.org](http://www.grassbioenergy.org).

Cherney, J.H. K.M. Paddock, Q. Ketterings, M. Davis, and D.J.R. Cherney. 2013. Grass Biomass Composition as Influenced by Fertility. Bioenergy Information Sheet #13. [www.grassbioenergy.org](http://www.grassbioenergy.org).

Cherney, J.H. and V.K. Verma. 2013. Grass Pellet Quality Index: A Tool to Evaluate Suitability of Grass Pellets for Small Scale Combustion Systems. Applied Energy 103:679-684.

### Acknowledgments

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For more information



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