Mechanical characterization of switchgrass using microindentation

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Motivation and Objectives

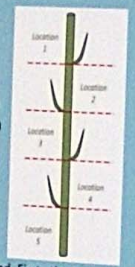
- Switchgrass, a perennial grass, is a good biomass crop for biofuel production.

Objectives:

- Determine the mechanical properties depending on the phenotype of the specimen and find the correspondence between the inner structure and the mechanical properties.
- Establish an effective way to test tillers and determine the best samples for producing biofuels.

Material

The stem of switchgrass is divided into different internodes. Five locations were selected for measurements with location 5 closer to the bottom.



The cross section appeared to be hollow, the first layer is mostly made of cellulose whereas the inner layer is highly lignified.

Two groups of switchgrass have been tested. First, the tests were performed on regular switchgrass (specimens obtained from the green house) and then switchgrass with high and low lignin have been tested (specimens from the field).

Method

Micro-indentation tests were performed by using a Bose Electroforce 3200® in quasi static mode. The test has been performed using displacement control. From the force displacement curves, the reduced modulus and hardness of the material can be obtained from the following equations:

$$E_r = \frac{S}{2}\frac{\sqrt{\pi}}{A}$$

S: stiffness, slope of the unloading curve
A: area, obtained by using the function area and the value of h_c

$$H = \frac{P_{max}}{A}$$

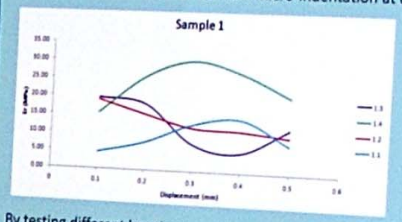
P_{max}: maximum load
A: area, obtained by using the function area and the value of h_c

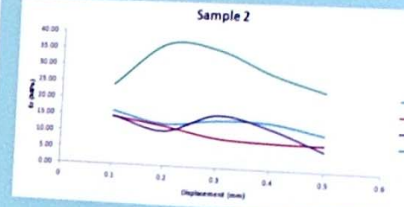
Conclusions

- Micro-indentations tests showed the difference of modulus according to the stem internode and to the indentation depth.
- It has also been shown that the [illegible] used to identif[illegible]

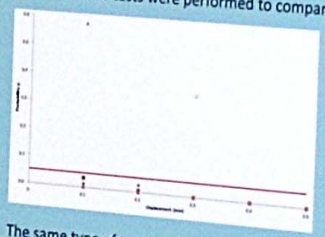
Results

The elastic modulus is obtained from micro-indentation at different depths and at specific location on the tiller.





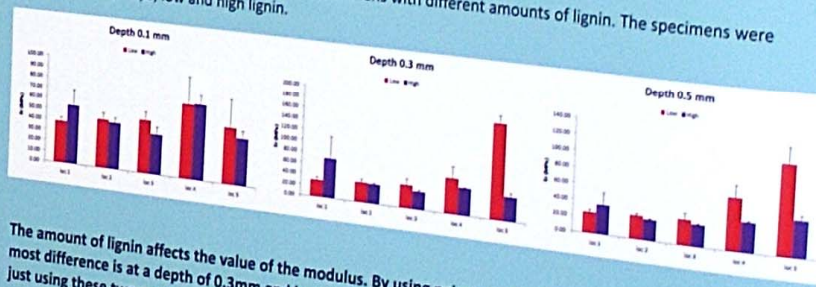
By testing different locations, we can see that the modulus is dependent to the location of the indentation. By comparing two samples, we can see that the behavior is the same. The modulus is changing with the indentation d
A change of the slope can be observed which can be due to the geometry of the specimen.
Paired student's tests were performed to compare the modulus between each location and each indentation depth



By comparing the modulus between each location at the sam
indentation depth, we can observe that $p<0.05$ which means
that the values are significantly different.
The same behavior appears when we compare the modulus a
different depth for a same location.

From these results, we can say that the location and the depth of indentation affects the value of the modulus.

The same type of test has been performed on specimens with different amounts of lignin. The specimens were divided in two groups, low and high lignin.



The amount of lignin affects the value of the modulus. By using paired student's test, it has been observed that the most difference is at a depth of 0.3mm and location 5. So the next step will be to reduced the number of tests by just using these two parameters in order to be able to identify more samples in a shorter time.