Simulating representative warm-season grasses under different watering regimes, as an indication of biofuel feedstock production and stability

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WeARE Research Area

Renewable Energy: Using ALMANAC to predict the growth of select grasses in different controlled conditions

Background

Currently, about 3% of our current energy consumption is supported by biofuels. In order to increase this percentage, we must first work out a few of the kinks in biofuel production. First, a sizable amount of land is required for the growth of plants to be used as the biofuel feedstock. However, this land cannot take away from current or potential agricultural yield, nor can it restrict urbanization or city growth. This means that plants grown as feedstock must be adaptable enough to be grown in a variety of less-than-ideal soils and weather conditions. Next, once farmlands for feedstock growth are established, we must also ensure a fairly stable yield output over the course of many years. This means that feedstock plants must be extremely hardy and have a decent lifespan. This study tests eight different potential feedstock grasses in three different rain treatments over the course of four years to see which best meets these requirements.

Objectives

1. Monitor the growth of eight different warm-season grasses in three different rain conditions
2. Find an accurate method of comparison for the yields per year
3. Run ALMANAC simulations for each grass per each rain condition
4. Compare the ALMANAC models to the measured data to discern any reasonable growth trends
5. Determine the grass with the best yield without sacrificing yield stability

Methodology

The majority of this experiment was conducted in a rainout shelter located at the Ladybird Johnson Wildflower Center in Austin. Eight different warm-season grasses native to Texas were chosen; switchgrass, yellow Indian grass, big bluestem, side oats grama, little bluestem, hall's panic grass, blue grama, and black grama. The grasses (starting with 12 of each plant per rain type) were transplanted onto site in 2009 and given 2 years of equal watering for establishment. Starting in 2011, three different rain treatments were given to each plant: low (349 mm/year), mean (885 mm/year) and high (1331 mm/year). Each year, measurements for the width and canopy heights were taken until 2014. A cylindrical volume was calculated for each species per rain treatment per year. Plant growth was also simulated using the ALMANAC modeling system under the same conditions for comparison.

Fig. 1
The rainout shelter layout at the Ladybird Johnson Wildflower Center

Results

The average volumes for the low rain treatment were divided by the average volumes for the mean rain treatment to create a ratio. The same was done for the volumes for the high rain treatments vs the mean. This was done per species, per year. The high/low ratio was made negative so that both ratios could be depicted side by side. Ideally, the low/mean ratio would be less than 1 (meaning that the low rain treatment yielded smaller volumes than the mean), whereas ideally the high/mean ratio would be higher than 1 on similar reasoning. This process was repeated with the data collected using the ALMANAC model. The results can be seen below. One of the grasses, hall's panicgrass, was removed from the study due to the extremely high death rate the last two years.

Fig. 2
The Low/Mean and High/Mean percentages based off the data given by the ALMANAC model
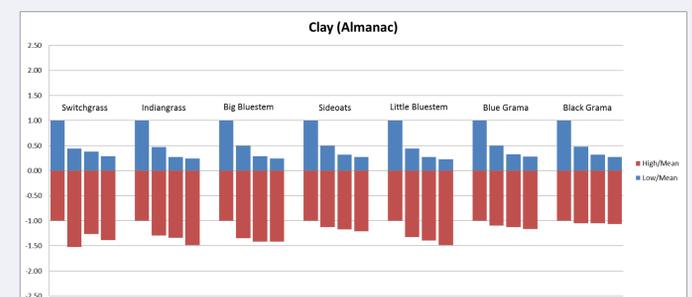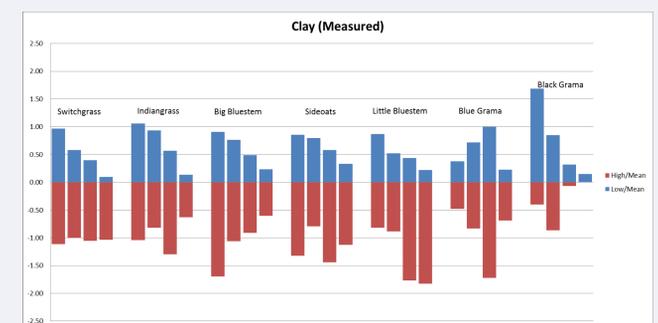

Fig. 3
The Low/Mean and High/Mean percentages based off the data measured in Austin

Conclusions

The ALMANAC data was clearly much more stable than the measured data. This could mean that factors not considered in this experiment created static in the results. Another possibility could be that not enough data was collected to yield sharper results. Despite this, a clear trend is shown between annual rain and plant growthThus, it can be concluded that from the chosen grasses, switchgrass might be the best candidate for feedstock.

Future Plans

To reduce the amount of static in the results, a duplicate experiment with more data points might be useful. A larger pool of species should be tested to ensure the best plant is chosen as feedstock. For some plants with very high mortality rates (such as hall's panicgrass), more tests should be run to determine which factor, if any, led to such a result. And finally, different types of soils should be tested to see its effect on yield.

Acknowledgments

References

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