Title:
Impact of nitrogen fertilization and the soil type on the quality and yield of sweet sorghum juice

Author:
Holou, Roland A, University of Missouri - Columbia
Stevens, Gene, University of Missouri - Delta Center

Publication Date:
05-28-2009

Series:
The Proceedings of the International Plant Nutrition Colloquium XVI

Publication Info:
The Proceedings of the International Plant Nutrition Colloquium XVI, Department of Plant Sciences, UC Davis, UC Davis

Permalink:
http://escholarship.org/uc/item/9t33w04g

Additional Info:
This data was collected in 2008. I will repeat it this year (2009) before I publish the final version.

Keywords:
Sweet sorghum, biofuel, ethanol, juice

Abstract:
Because of the growing need of finding alternative fuel, interest is increasing in biofuel crops such as sweet sorghum. Unfortunately, many challenges such as the input cost must be overcome before this plant can be sustainably and profitably used for biofuel production. One way to lower the input cost is through nitrogen fertilization management. To test how sorghum respond to N fertilization, M81E variety used was. The experiment was carried out in three types of soil (clay, sand, and Tipton loam) in Portageville (South Missouri). Seven N rate were applied i.e. (0, 22, 45, 67, 90, 112, and 135 kg/ha) with four repeats. Sorghum was harvested 5 months after planting. Data was collected on biomass production, juice yield, water content, pH, density, sugar yield. SAS was used to determine the differences between treatments. The biomass is highly affected by the soil type (P<.0001), and not by N rate. The amount of water accumulated in sorghum stalk in related to the soil type (P<.0001) and unlike the water content, to the N rate applied (P=0.01). The density of sorghum juice does not depend on the N rate (P=0.34) but instead on the soil type (P=0.02). The pH of sorghum juice does not depend either on the soil type (P=0.13) or on the N rate (P= 0.19). The volume and weight of juice obtained depends on both the soil type (P<.0001)

and the N rate (P<0.03). The sugar yield depends on both the soil type (P<.0001) and the N rate (P= 0.02).

Introduction

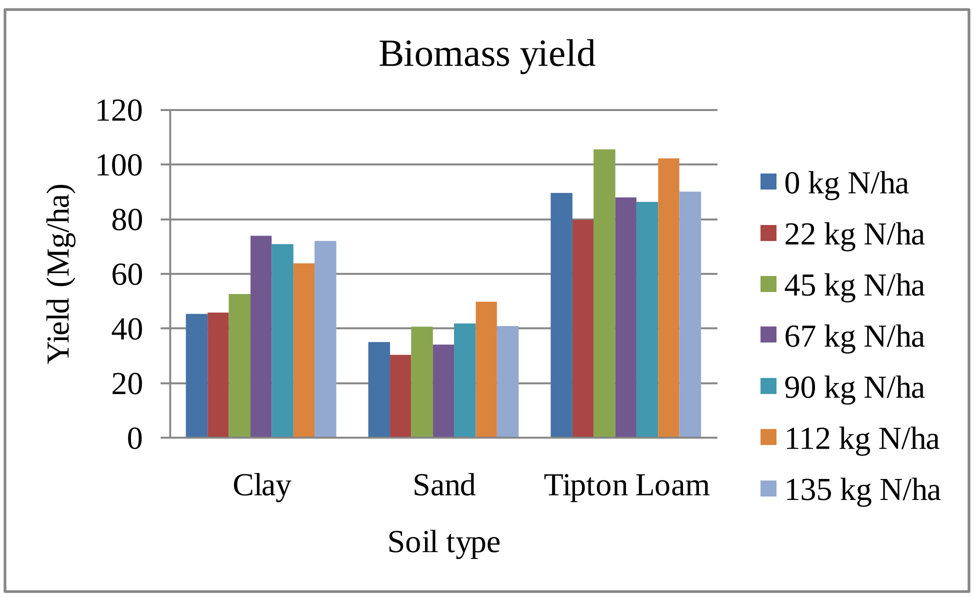
Because of the growing need of finding alternative fuel, interest is increasing in biofuel crops such as sweet sorghum (*Sorghum bicolor*). Unfortunately, many challenges must be overcome before this plant can be sustainably and profitably used for biofuel production; challenges such as the input cost vs. the output yield in biofuel. One way to lower the input cost is through nitrogen fertilization management. Indeed, nitrogen appears as the most applied and crucial fertilizer that greatly affects plant growth and therefore sorghum's use for biofuel production. Today, very little research has been done to test how nitrogen fertilization really affects the production of ethanol from sweet sorghum grown in the field. As sorghum juice is the targeted feedstock for ethanol production from sorghum, the aim of this research is to prove how N affects the yield and the quality of that juice.

The sorghum variety used was M81E. The experiment was carried out in three types of soil (clay, sand, and Tipton loam) in Portageville (South Missouri). Seven N rate (ammonium nitrate) treatments were applied i.e. (0, 22, 45, 67, 90, 112, and 135 kg/ha) with four repeats. Sorghum was harvested 5 months after planting. Data was collected on biomass production, juice expression, water content, pH, density, sugar content and yield. SAS was used to determine the differences between treatments. Significant differences were assumed for $P \leq 0.05$.

Results

Biomass Yield

There is a highly significant effect of the soil type on both the fresh and dried biomass yield of sweet sorghum ($P<.0001$). The N rate did not significantly affect either the fresh biomass yield ($P=0.06$) or the dried biomass yield ($P=0.27$). The loam soil recorded the highest fresh and dried yield (91.6 Mg/ha and 29.6 Mg/ha) whereas the lowest value was obtained in the sandy soil. The fresh and the dried biomass yield recorded in the sandy soil was 39 Mg/ha and 11.8Mg/ha respectively, which is less than half the value of the loam soil. This suggests that sorghum is sensitive to the nature of the soil under which it is grown.



Water accumulation in stalk

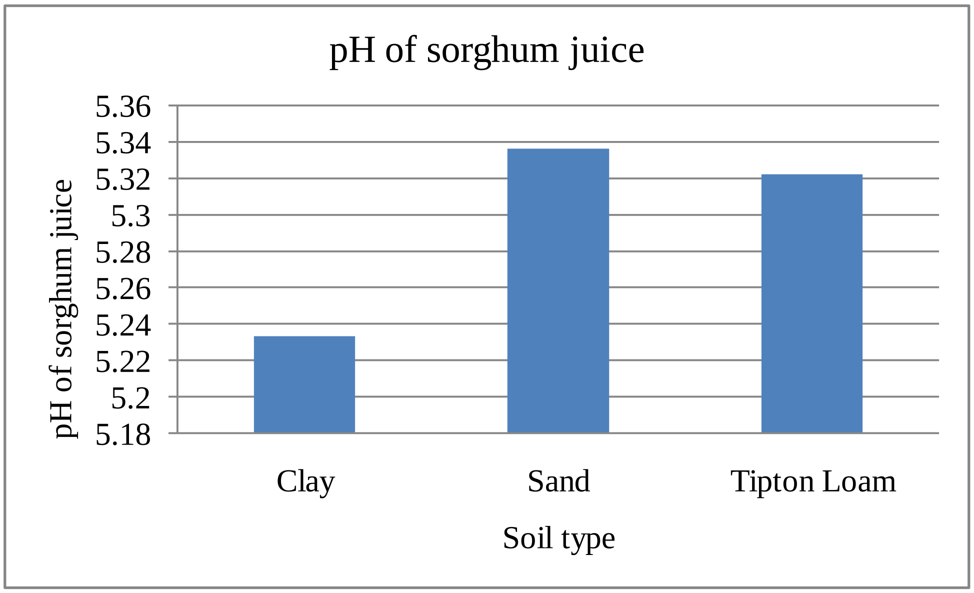
The water content (weight basis) in sorghum stalk is highly affected by the soil type ($P<.0001$) whereas the N rate has no effect ($P=0.89$). The highest water content was obtained in the clay soil (74%) whereas the loam has the lowest value (70%).

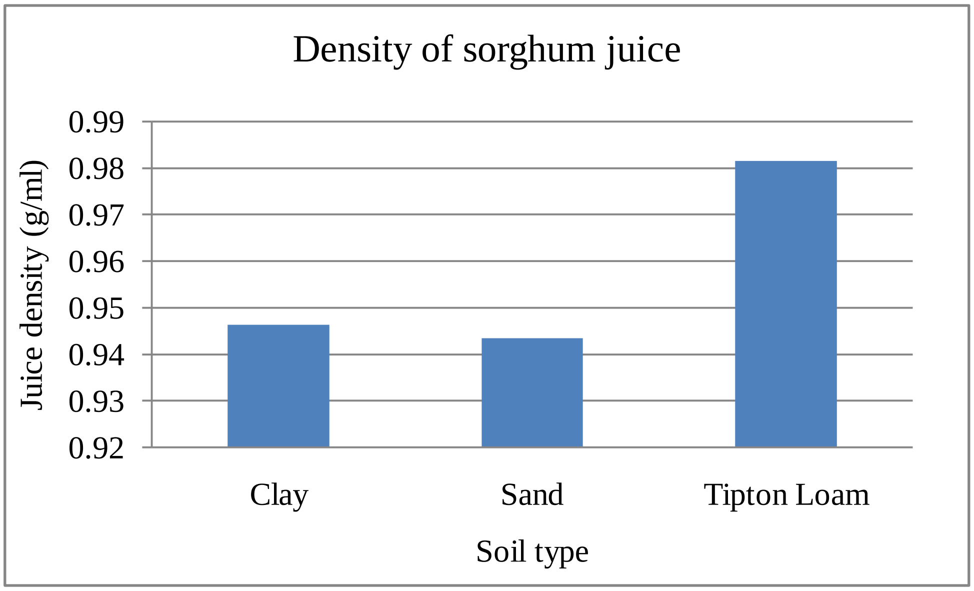
The amount of water accumulated in sorghum stalk in related to the soil type ($P<.0001$) and unlike the water content, to the N rate applied ($P=0.01$). The highest value was recorded in the Tipton loam soil (58 Mg/ha) whereas the lowest value was obtained in the sandy soil (25.2 Mg/ha). In general, the water accumulation in the stalk is proportional to the N rates as if the nitrogen fertilization stimulates the accumulation of water in the stalk.

Juice density and pH

The density of sorghum juice does not depend on the N rate ($P=0.34$) but instead on the soil type ($P=0.02$). As the density of the juice is related to the amount of sugar in the juice, particular attention has to be paid to the soil type under which sorghum is produced when pricing the juice based on volume. The density ranged from 0.94 to 0.98. In general, the juice squeezed from the Tipton loam is denser than that of the sandy and the clay soils.

The pH of sorghum juice does not depend either on the soil type ($P=0.13$) or on the N rate ($P= 0.19$). In general the pH is 5.3.

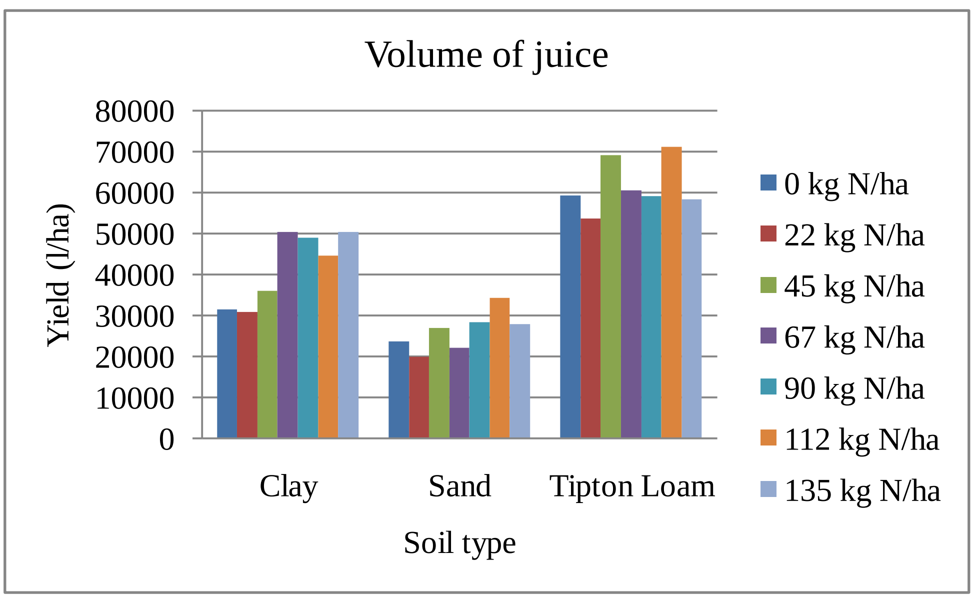




Volume of juice

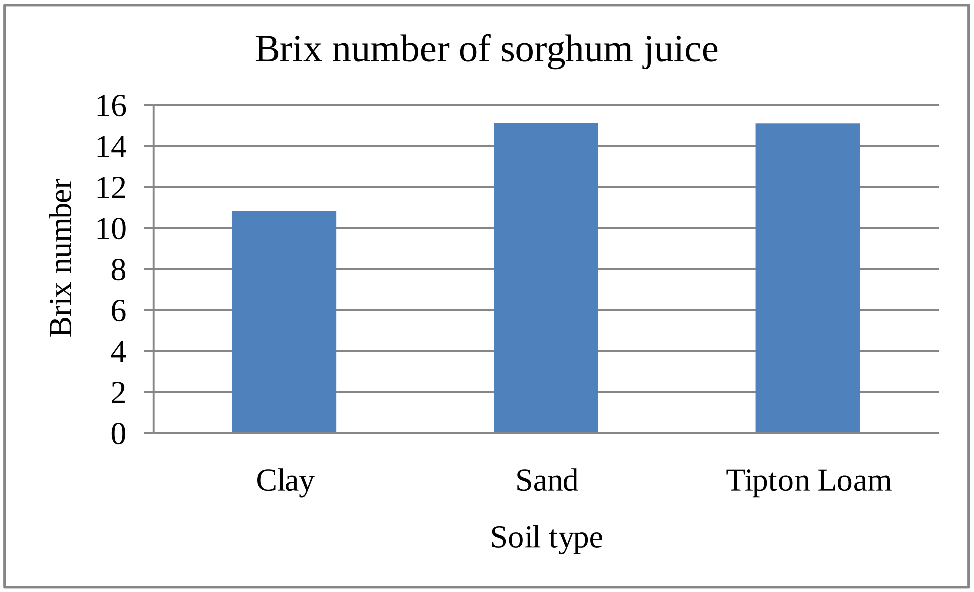
The juice expression is the weight of juice squeezed from a specific weight of stalk. It is not related to N fertilization (P=0.56) but to the soil type (P=0.007).

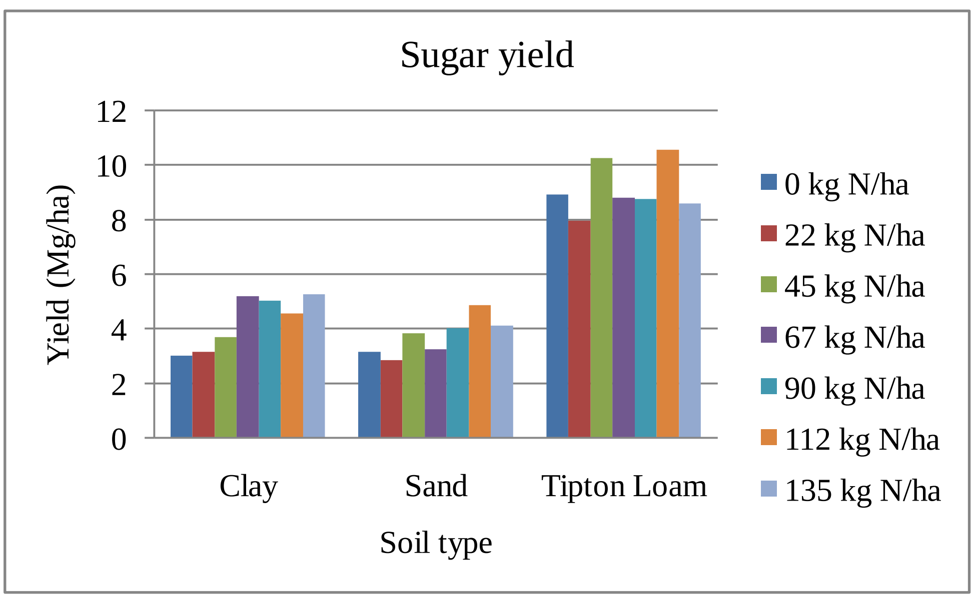
The volume of juice obtained depends on both the soil type (P<.0001) and the N rate (P=0.03). The weight of the juice followed the same pattern, with highly significant differences observed with soil type (P<.0001) and significant difference with N rates (P=0.02). So, N fertilization increases the ability of sorghum stalk to accumulate more juice instead of converting the photosynthates into cellulose. The juice squeezed from the Tipton loam was 61,542.8 l/ha compared to 26,231 l/ha obtained in the sandy soil. The clay soil yield is two thirds that of the loam soil. In the Tipton loam soil, the highest juice yield was obtained with 45 kg N/ha, whereas in the sand soil and the clay soil, the highest juice yields were recorded under 112 kg N/ha and 67 kg N/ha respectively.



Sugar content and yield

Sucrose, the main sugar in sorghum juice, can be estimated using the Brix refractometer. The Brix number is significantly affected by the soil type ($P<.0001$) but not by the N rate ($P=0.43$). So, the quality of sorghum juice does not depend on the N fertilization. The lowest value was obtained in the clay soil (10.8) whereas the highest value is recorded in the sandy soil (15.12) and the Tipton loam (15.11).





Considering the Brix number, the sugar (mainly sucrose) yield can be calculated by multiplying the Brix by the weight of the juice. By doing so, it appears that the sugar production depends on both the soil type (P<.0001) and the N rate (P= 0.02). The Tipton loam yielded almost three times as much (9.1 Mg/ha) as the sandy soil (3.7 Mg/ha) and twice the clay soil (4.2 Mg/ha). Multiple comparisons between soil types showed no significant difference between the clay and the sandy soil whereas a significant effect was observed between either of them and the Tipton loam (P <.0001).

Conclusion

Although the total biomass yield of sorghum does not depend on the N rate applied, the juice production, and the sugar yield showed significant differences between N rates. Although sweet sorghum is N efficient, in order maximize ethanol yield while using it for biofuel production, a great attention needs to be paid to the soil type and N fertilization.