Planting Method Affects Stalk Size in Sweet Sorghum

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Increasing global demands for sources of alternative energy that do not compete with food have led to research into alternative crops as well as novel uses for by- or co- products. Sweet sorghum (*Sorghum bicolor* (L.) Moench) is ideal because the stalks contain high concentrations of sugars that can be fermented into ethanol and it can be grown on marginal land where water is limiting. Many varieties produce ample seed heads that can be used like grain sorghum in the production of ethanol, and seed can also be used for animal feed. The bagasse that remains from pressing sweet sorghum to obtain the juice can be used as forage or ensiled for livestock.

Current efforts to grow sweet sorghum for biofuels in Arizona focus on maximizing biomass and sugar yields and optimizing the harvest window in order to supply sufficient feedstock to processing facilities. Varieties tested have been either bred for the southeastern United States (harvested at 140 to 160 days after planting) or for Texas to be harvested around 100 to 110 days after planting. Our previous work has shown that as intra-row plant density decreases, stalk diameter and weight increase. Thicker stalks contain more juice and are sturdier, but the greater biomass can be challenging to transport and process. This experiment was designed to further explore the relationship between planting density and stalk diameter.

Materials and Methods: Seeds of eight varieties (Table 1) were sown on June 6, 2014, mechanically ('normal') and manually ('hills'). Normal rows were planted with a tractor-driven grain drill at 18 seeds m^{-1}. Hills were planted as a cluster of three to five seeds every 0.5 m. In this split-plot design, planting method or arrangement was the main plot and variety was the sub-plot, with five replications. Each variety was harvested 30 days after half of the plants were flowering (Table 1). Smith was not harvested due to severe lodging. A 3.05 m section from each of the two middle rows (of four row plots) was cut manually at the soil line and weighed to obtain field (plot) weight. A subsample of 15 stalks was weighed with and without leaves and panicles (seed heads). Stem diameters were measured before stalks were passed through a roller mill and juice collected and weighed. Juice samples were analyzed in the laboratory by High Performance Liquid Chromatography (HPLC) with a refractive index detector (RID). Theoretical yields of biomass, sugar, juice, and ethanol per hectare were calculated. Statistical analyses were performed with JMP using the 'Fit Y by X' platform to obtain p-values from Analysis of Variance (ANOVA). If results were significant at $\alpha=0.05$, pairs were compared with Tukey's Honestly Significant Difference (HSD).

Table 1: Varieties planted and their harvest dates

Variety	Harvest Date	Days after planting
TX09022	September 24	110
Sugar T	October 25	141
TX09055	November 1	148
Cowley	November 11	158
M81E	November 11	158
Hodo	November 15	162
Mer 74-2	November 22	169
Smith	NA	NA

Results: For all varieties, stem diameters in hills were significantly greater than those in the normal rows. Weights of the 15-stalk subsamples and juice as well as grams of sugar were also significantly higher for the hill arrangements (Table 2). Leaves and panicles of plants in the hills were also heavier, suggesting greater leaf area and potential seed yield (Table 2). However, results for field weight show no difference between planting treatments (data not shown). Plants in normal rows were smaller but there were more of them per area. Because of the thicker and heavier stalks, predicted yields for juice, sugar, and ethanol are all higher for hill arrangements (Table 3).

Table 2: Mean stalk data

Parameter	Hill (n=23)	Normal (n=22)
Wt. 15 stripped (kg)	11.74 ± 3.09 a	7.63 ± 2.31 b
Wt. juice (kg)	4.07 ± 1.30 a	2.28 ± 0.89 b
Sugar in 15 stalks (g)	688.26 ± 284.13 a	364.45 ± 142.37 b
Stem diameter (mm)	26.20 ± 4.70 a	22.46 ± 3.53 b
Wt. leaves & seeds (kg)	2.23 ± 0.63 a	1.45 ± 0.40 b

Table 3: Calculated yields

Parameter	Hill (n=23)	Normal (n=22)
Biomass (kg ha^{-1})	94039.1 ± 4181.5 a	88222.0 ± 4275.5 a
Juice (kg ha^{-1})	27493.5 ± 9091.2 a	21975.8 ± 7136.0 b
Sugar (kg ha^{-1})	4571.1 ± 1455.7 a	3539.5 ± 1338.9 b
Ethanol (L ha^{-1})	2657.6 ± 840.5 a	2057.8 ± 778.4 b

Conclusions: While it is not feasible to plant manually from a labor perspective, the increase in yields are substantial over traditional, mechanized planting. One solution could be to engineer a planter that drops seeds in groups. This would require rethinking cultural practices, but one crop that produces sugar, grain, and biomass on marginal land not used for human food production is a very economical use of finite resources. This experiment is being repeated in 2015.

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