Placing Date and Harvest Maturity Impact on Biofuel Feedstock Productivity and Quality of Sweet Sorghum Grown under Temperate Louisiana Conditions

K. J. Han,* M. W. Alison, W. D. Pitman, D. F. Day, M. Kim, and L. Madsen

ABSTRACT
Sweet sorghum \([\text{Sorghum bicolor (L.) Moench}]\) is recognized as a promising biomass energy crop for meeting the increasing demand for bioenergy feedstocks. Field experiments were conducted at sites in northern and southern Louisiana for 2 yr to assess planting date and harvest maturity effects on yield from primary plantings and ratoon crops. The cultivar M81-E was evaluated using a split plot arrangement of treatments in randomized complete block designs. Planting date from mid-March to early July was the primary plot treatment. Harvest maturity at the early heading (EH) or hard dough (HD) stage was assigned as the subplot treatment. A range of planting dates from mid-March to early June produced substantial yields of biomass and fermentable sugar with appropriate harvest maturity and could support sugar mill operation for up to three additional months. However, sweet sorghum planted in early May and harvested at the HD stage produced 30 to 210% more fermentable sugar than other tested planting dates and maturity combinations. Ratoon crop production was not dependable showing inconsistent tiller growth with resultant low biomass yields. Correlation coefficients of sugar yield with biomass or other quantitative agronomic characteristics were higher than 0.79, while that with brix was only 0.32 \((P < 0.0001)\). Production management in Louisiana from long season cultivars such as M81-E based on a single harvest 150 to 160 d from planting at the HD stage can provide more biomass and fermentable sugar than can production management targeting a ratoon crop.

Louisiana has a long history of sugar production, and the existing infrastructure for sugar production from sugarcane has the capability of supporting a biofuel industry based on fermentable sugar. Because sugarcane is primarily harvested between November and February, the operation of the current sugarcane processing infrastructure can be extended by including alternative biofuel feedstock such as sweet sorghum (Kim and Day, 2011). In July 2008 “The Advanced Biofuel Industry Development Initiative” (Act no. 382) was signed into law in Louisiana to provide funding support for a network of small advanced biofuel manufacturing facilities. In addition, existing electrical power generation facilities in central Louisiana are capable of using biomass materials as an energy source and have been seeking material for utilization in this process. These facilities all require adequate supplies of biomass feedstocks for success. Sweet sorghum has been targeted as a biofuel feedstock in Louisiana because of its capability of producing sugar-enriched juice and biomass within 160 d of planting. The culvivar M81-E was shown to produce high yields of both fermentable sugar and cellulosic biomass (Ricaud and Arceneaux, 1990; Tew et al., 2008; Han et al., 2012).

Preliminary research comparing the energy balance between production input and ethanol output indicated sweet sorghum was just behind sugarcane in efficiency (Da Silva et al., 1978). Sweet sorghum has been proposed as a more flexible crop to grow in a rotation because of its short crop duration ranging from 100 to 120 d (Prasad et al., 2007). Some highly productive, slow maturing sweet sorghum cultivars, however, may not be suitable for crop rotation in sugarcane-based systems. Late maturing varieties such as the cultivar M81-E have potential on sites not in sugarcane rotations, with particular promise for soils with lower production potential, which are not suitable for some more intensively managed crops. Biomass can be available for harvest in Louisiana at least by late August and continuing until immediately before the first killing frost to supply feedstock for mill operation. Sweet sorghum shares the same polyphyletic racial origin of grain sorghum within the subspecies \(\text{bicolor}\) (Ritter et al., 2007), which is adapted to a broad range of environmental conditions with a production range covering a large part of the United States. The crop can produce up to 90 Mg ha\(^{-1}\) of fresh biomass with 72% of the weight as juice containing relatively high levels of fermentable sugars (Tew et al., 2008). Sweet sorghum has primarily been grown in small areas for syrup production, so few producers are familiar with sweet sorghum as a cropping option. It is imperative to understand the impact of production practices before viable cropping systems can be developed on a wide scale.

Sweet sorghum sugar accumulates from anthesis to physiological maturity of grain and interactions of genotype...