SUGARCANE YIELD RESPONSES OF FOUR CULTIVARS TO THREE PLANTING DATES IN LOUISIANA

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ABSTRACT

Louisiana sugarcane (*Saccharum* spp.) farms are increasing in size thus the period of planting has been extended. Both earlier and later dates are used in an effort to maximize farm efficiency as growers contend with having to plant fields and harvest sugarcane for processing where planting is delayed. This research was conducted to determine if yields of four sugarcane varieties were affected by date of planting in Louisiana. Sugarcane varieties LCP 85-384, Ho 95-988, HoCP 96-540, and L 97-128 were hand-planted in mid-August, mid-September, and mid-October in 2004 and 2005. Shoot number, stalk height, cane yield, theoretical recoverable sucrose (TRS), and sucrose yield were analyzed in the plant-cane and first-ratoon harvests. August planting resulted in 10 and 25 more Mg ha^{-1} of cane compared with planting in September and October, respectively, and 2000 and 3000 more kg sucrose ha^{-1} for plant cane, respectively, across two plant-cane harvests. For cane yield, TRS, and sucrose yield, all varieties responded similarly to planting date. Overall, results suggest early planting increased cane and sucrose yield in the plant-cane crop for the varieties tested but the effects did not transfer to first-ratoon crop suggesting that the effects of early planting were short term.

Keywords: Sugar cane planting time; early planting vigor; Louisiana planting sugar cane

INTRODUCTION

Sugarcane planting in south Louisiana, USA, occurs from August to October. In 2008 more than 158,000 ha were cropped to sugarcane and about 49,000 ha (or 31%) were in plant-cane (Legendre and Gravois, 2009). Garrison et al. (2000) recommended delaying planting until September when seed-cane is up to 0.5 m longer than in August. Shorter seed-cane requires more stalks to plant the same area, resulting in a lower "seed-cane to plant-cane ratio" in a September compared with an August planting (Dufrene, 2009 unpublished growth measurement data). While postponing planting until October results in a greater mean stalk length than in August (Dufrene, 2009 unpublished growth measurement data), the risks of lodging increase compared to September planting. Planting lodged cane increases expenses associated with planting cane, including labor and seed-cane harvest. Additionally, mechanical damage associated with harvesting lodged seed cane can reduce the amount of viable buds. For example, Dafa'alla and Hummeida (1991) reported that harvesting seed cane damaged 4% of buds and mechanical planting decreased bud germination by an additional 10%. Moreover, the onset of sugarcane milling in late-September or early-October limits the availability of equipment and labor for planting.

August planting resulted in higher plant-cane yields of cane and sucrose across varieties LCP 85-384, HoCP 85-845, and HoCP 95-555 (released for planting in Louisiana in 1994, 1994, and 2006, respectively) compared with September or October planting (Viator et al., 2005a). Increases ranged from 2 to 5 Mg cane ha^{-1} and from 350 to 800 kg sucrose ha^{-1}. In another study, optimal sucrose yields for plant cane were observed for varieties CP 70-321 (released in 1979), LHo 83-153 (released in 1992), and HoCP 85-845 at August planting (Viator et al., 2005b). Sucrose yield of August-planted cane averaged 14.4 Mg ha^{-1}, compared with cane planted in

September (12.4 Mg ha^{-1}) and October (11.4 Mg ha^{-1}). The increase in sucrose was partially attributed to higher cane yields (Mg ha^{-1}) for CP 70-321, LHo 83-153, and HoCP 85-845, which yielded between 12 to 21 Mg more cane ha^{-1} in August than in October. Sucrose concentration in plant cane was 3 to 6 g kg^{-1} higher in August-planted cane compared with cane planted in September or October. Varieties LHo 83-153 and HoCP 85-845 showed the greatest difference (10 to 14 g kg^{-1}). The planting date effect, however, was not consistent with all varieties, as LCP 85-384 and CP 79-318 did not respond to planting date. For ratoon crops, the only parameter affected by planting date was sucrose yield for HoCP 85-845 which produced more sucrose when planted in October (13.8 Mg ha^{-1}) as compared to August (12.7 Mg ha^{-1}) (Viator et al., 2005b). The ratoon crop of CP 70-321, LHo 83-153, CP 79-318, and LCP 85-384 produced the same amount of sucrose across planting date (Viator et al., 2005b). New sugarcane varieties have been released commercially in Louisiana. It is unknown if current varieties respond to planting date.

The current study evaluates the effects of planting date for varieties HoCP 96-540 (Tew et al., 2005a), Ho 95-988 (Tew et al., 2005b), and L 97-128 (Gravois et al., 2008) using LCP 85-384 as the standard (Milligan et al., 1994). HoCP 96-540, L 97-128, and Ho 95-988 accounted for 52, 19, and 6% of total Louisiana sugarcane acreage planted in 2008, respectively (Legendre and Gravois, 2009). LCP 85-384 comprised 7, 45, and 71% of first, second, and third-plus ratoon cane in 2008 (Legendre and Gravois, 2009). HoCP 96-540 has a substantially lower stalk population and slower emergence relative to LCP 85-384. It was hypothesized that this variety would be more affected by a later planting date than other varieties. L 97-128 is reported to be resistant to brown rust (*Puccinia melanocephela*) (Gravois et al., 2008). Inconsistent plant-cane stands were observed with Ho 95-988, and delayed the release of the variety with planting dates being a suspected cause (Jackson, 2009 personal communication).

MATERIALS AND METHODS

Sugarcane was hand-planted in mid-August, September, and October 2004 and 2005 on a Commerce silt loam (Fine-silty, mixed, nonacid, thermic, aeric fluvaquent) after four-month fallow periods at the USDA-ARS Sugarcane Research Unit's Ardoyne Farm located near Schriever, LA (29°38'11" N, 90°50'25" W). Yearly precipitation for 2004 - 2007 was 1980 mm, 1680 mm, 1150 mm, and 1510 mm, respectively. Cumulative precipitation from May – Oct for 2004-2007 was 1300, 880, 630, and 1060 mm, respectively (LOSC, 2010).

Seedcane for the tests was from the first cutting of heat-treated cane planted the previous year. Sugarcane was planted at a rate of three mature stalks with a 10% overlap, so a six foot stalk would be overlapped by about 7 inches with the next stalks placed down the row. Planted stalks, about 1.5 m in length, were covered with 8 cm of packed soil. A tank-mix containing metribuzin (4-amino-6-*tert*-butyl-4,5-dihydro-3-methylthio-1,2,4-triazin-5-one) at 3.4 kg a.i. ha^{-1} and pendimethalin (*N*-(1-ethylpropyl)-2,6-dinitro-3,4-xylidine) at 2.2 kg a.i. ha^{-1} was broadcast immediately after planting for weed control. Nitrogen [UAN 32% - consists of urea (35%), ammonium nitrate (45%), and water (20%)], phosphorus (diammonium phosphate), and potassium (potash) were applied in mid-April at 135, 34, and 68 kg ha^{-1}, respectively, as an injected band on both sides of the planted cane. Tebufenozide (*N*-*tert*-butyl-*N'*-(4-ethylbenzoyl)-3,5-dimethylbenzohydrazide) at 0.1 kg a.i. ha^{-1} was applied in the summer for sugarcane borer (*Diatraea saccharalis* F.) control when infestations reached thresholds defined by Louisiana State University Cooperative Extension Service (Reagan et al., 2010).

Plot size was 5.4 m wide X 4.9 m in length and consisted of three rows with 1.8 m row spacing. Fully developed stalk populations and heights were determined each year from a 3.1 m section of middle row in each plot in mid-September prior to harvest. A stalk was classified as fully developed if it was at least 1.4 m in length from the soil surface to the youngest dewlap below the whorl. The experiment was conducted two times in adjacent fields with plant cane harvested in December 2005 and 2006 and first ratoon harvested in November 2006 and 2007. Each row was harvested with a chopper harvester. Cane yield (Mg ha^{-1}) was determined using a modified tipper-wagon equipped with electronic load cells and fitted with a billet sampling basket that allowed an operator to catch a sample of billeted cane as it is being transferred from the harvester to the wagon. Theoretically recoverable sucrose (TRS) levels (g kg^{-1}) were assessed using the prebreaker and core press method (Johnson and Richard, 2005; Meade and Chen, 1977). Sucrose yield (kg ha^{-1}) was calculated as the product of cane yield and TRS. Growing degree days (°C) were calculated by averaging the weekly maximum and minimum temperature and subtracting a base temperature calculated for sugarcane leaf emergence (12°C). (Inmam-Bamber, 1994).

The experiment was a split plot design with whole plots consisting of planting dates and split plots consisting of varieties. Four replicates of each treatment were included. Plant cane and first ratoon data were analyzed separately using PROC MIXED (SAS Institute, 2008) with year, date of planting, and variety as fixed variables and replication as a random variable using SAS version 9 software (SAS Institute, Cary, NC). Means of significant effects were separated using the PDIFF option with the SAXTON macro at the P=0.05 level (Saxton, 1998). PROC CORR in SAS was used to evaluate correlations between yield parameters and crop growth measurements.

RESULTS AND DISCUSSION

There were no significant planting date by variety interactions (Table 1) indicating that all varieties responded similarly to planting date. Combined over varieties, planting date significantly impacted plant-cane yields (Table 1). Data indicated planting cane in August resulted in higher cane and sucrose yields for all varieties (Table 1, 2). Planting cane in August resulted in 10 and 25 additional Mg of cane ha^{-1} as compared to September and October planting, respectively. Sucrose concentrations (TRS) in cane were similar across planting time with an average of 110 g kg^{-1} (Table 2). Higher plant-cane yields for August planting resulted in a 2000 and 3000 kg ha^{-1} increase in sucrose yield over September and October, respectively (Table 2). Previous research indicated that not all varieties responded to early planting (Viator et al., 2005b). One of the varieties that has had consistent yields across August, September, and October planting dates was LCP 85-384. However, this current study revealed substantial effects of planting date on LCP 85-384 as well as the more recently released varieties. One explanation for its change in reaction to planting date is that LCP 85-384 has lost vigor and yield potential since becoming susceptible to brown rust (Hoy, 2005). In tropical climates, stresses do not always lead to yield loss because the extended growing season (>12 months) allows sugarcane plants to compensate with additional growth. With reduced plant vigor, LCP 85-384 may have lost its compensatory ability to overcome stresses associated with management practices, such as early planting and use of ripeners.

Stalk height of plant-cane differed by year, variety, and planting time (Table 1). Stalk height was affected by planting time when analyzed by variety and across year but only for Ho 95-988 (data not shown). The tallest Ho 95-988 observed was planted in September (236 cm) as compared to August (221 cm) or October (224 cm), thus the height change did not explain the planting date yield effect. Stalk height was not different across varieties for planting date within each year (Table 3). Planting time only affected stalk number in the October 2004 planting (Table 4). Delaying planting until October resulted in a 15% decrease in stalk numbers as compared to the August-September average (Table 4).

First-ratoon cane yields were similar across varieties and planting dates (Table 1). First-ratoon cane yields for the 2004 and 2005 plantings averaged 110 Mg ha^{-1} in 2006 and 102 Mg ha^{-1} in 2007, respectively (Table 5). First-ratoon TRS levels were also not affected by planting date.but were higher in 2007 (257 g kg^{-1}) than in 2006 (217 g kg^{-1}) (Table 6).

Time of planting affected cane yields in the plant-cane crop, but not TRS levels; hence sucrose yields primarily reflected differences in cane yield (Table 1). Results were similar to other data that showed no difference in TRS with respect to planting date for whole-stalk planted LCP 85-384, HoCP 95-555, and HoCP 85-845 (Viator et al., 2005a). In the present study for plant cane, sucrose yield, cane yield, and TRS levels were similar for each variety. In a previous study, August planting produced optimal sucrose yields for CP 70-321, LHo 83-153, and HoCP 85-845, but not for LCP 85-384 and CP 79-318 (Viator et al., 2005b).

Earlier crop establishment may lead to more heat units prior to first killing frost. Growing degree days (°C) for the period of time between planting month (August, September, or October) and December in 2004 were 1560, 1070, and 620, respectively, and in 2005 were 1530, 1000, and 500, respectively. The earliest freeze dates recorded for each newly planted crop were -3°C (December 2004) and 0°C (February 2006) (LOSC, 2010). The higher amount of heat units accumulated for the August planting could have led to the seed cane becoming a net photosynthetic sink. Research in tall grass prairie demonstrated that if grazed big bluestem (*Andropogon gerardii*) is allowed to regrow ungrazed for 6 weeks before a killing frost, the total nonstructural carbohydrates (TNC) were higher than for continuously grazed prairie (Owensby et al., 1977). The later planted cane may emerge and generate leaf area but the depleted TNC in the planted section of the stem is not replaced in belowground storage before the first killing frost. The plant goes into dormancy without an adequate supply of carbon to begin growth the next season (Owensby, 2010 personal communication). Moreover, maximum plant vigor was linked to end-of-season carbohydrate reserve in desert perennial grasses (Coyne and Cook, 1970).

CONCLUSIONS

Planting in August resulted in higher sucrose yield in the plant-cane crop than planting in September or October for cultivars HoCP 96-540, LCP 85-384, L 97-128, and Ho 95-988. The difference was due to increases in cane yield, rather than TRS levels. Thus, planting time affected vegetative growth during establishment prior to winter-kill of the top growth and in the spring at the start of the plant-cane growing season. Other yield parameters, including stalk height and stalk number, varied in their response to planting date among cultivars, but no consistent change could explain yield effects. Factors to consider when choosing to plant early include the higher costs associated with cutting more seed cane and the lodging susceptibility of the cultivar later in the season. Based on mechanically-harvested seed cane ($\leq$ 2.13 m using soldier harvester, 1.0 kg stalk^{-1}, 0.4 m shorter stalks in August 2009 than in September 2009 – based on HoCP 96-540) indicate the increase in plant-cane yield of 10 Mg ha^{-1} was worth the extra 3 Mg ha^{-1} of seed cane needed to plant in August as compared to September. These experiments were conducted in spring/summer fallow period in Louisiana and results may differ from succession planting or when following short season rotational crops. Continued research to identify optimum planting times for newly released cultivars is still needed to confirm the findings presented here and to validate hypotheses regarding carbohydrate reserves. If planting has to be delayed, growers should utilize agronomic practices such as shallow planting to encourage the quick emergence and establishment of the crop prior to winter killing temperatures.

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Table 1. Probabilities of F-values of fixed effects from two experiments for cane yield, TRS levels, sugar yield, stalk number, and stalk height for varieties CP 85-384, HoCp 96-540, L 97-128, and Ho 95-988.

Source	Cane yield	TRS*	Sucrose yield	Stalk number	Stalk height
Plant-cane crop					
Year	<0.01	<0.01	<0.01	0.01	<0.01
Variety	0.10	0.22	0.43	0.19	0.03
Year X Variety	0.03	0.97	0.09	0.21	0.02
Date	<0.01	0.51	<0.01	0.24	0.83
Year X Date	0.25	0.37	0.26	0.01	0.84
Variety X Date	0.36	0.32	0.26	0.28	0.25
Year X Variety X Date	0.33	0.89	0.33	0.70	0.04
First ratoon crop					
Year	0.05	<0.01	0.02		
Variety	<0.01	0.02	<0.01		
Year X Variety	0.01	<0.01	0.06		
Date	0.61	0.76	0.73		
Year X Date	0.38	0.03	0.15		
Variety X Date	0.97	0.12	0.68		
Year X Variety X Date	0.03	0.48	0.07		

*TRS = theoretically recoverable sucrose

Table 2. Effects of three planting dates on plant-cane yield in 2005 and 2006 for CP 85-384, HoCP 96-540, L 97-128, and Ho 95-988.

Planting Date	**Sucrose yield**	**Cane yield**	**TRS**†
	kg ha^{-1}	Mg ha^{-1}	g kg^{-1}
August	14000 A*	120 A	110 A
September	12000 B	110 B	110 A
October	11000 C	95 C	110 A

*Means within a column followed by a different letter are statistically different using the Saxton mean separation procedure at P = 0.05.
†TRS = theoretically recoverable sucrose

Table 3. Effects of three planting dates on plant-cane stalk heights in 2005 and 2006 for CP 85-384, HoCP 96-540, L 97-128, and Ho 95-988.

Year	Planting date	Stalk height
		------ cm^{-1}------
2005	August	200 A*
	September	200 A
	October	200 A
2006	August	250 A
	September	240 A
	October	240 A

*Means for each year followed by the same letter are not different using the SAXTON mean separation procedure at the P = 0.05 level.

Table 4. Effects of three planting dates on plant-cane shoot number in 2005 and 2006 for CP 85-384, HoCP 96-540, L 97-128, and Ho 95-988.

Year	Planting date	Shoot number
		------ ha^{-1}------
2005	August	108000 A*
	September	105000 A
	October	91000 B
2006	August	112000 A
	September	111000 A
	October	10500 A

*Means for each year followed by the same letter are not different using the SAXTON mean separation procedure at the P = 0.05 level.

Table 5. Effects of three planting dates on 1st ratoon cane yield in 2005 and 2006 for CP 85-384, HoCP 96-540, L 97-128, and Ho 95-988.

Year	Planting date	Cane yield
		--- Mg ha^{-1} ---
2006	August	117 A*
	September	107 A
	October	107 A
2007	August	101 A
	September	104 A
	October	102 A

*Means for each year followed by the same letter are not different using the SAXTON mean separation procedure at the P = 0.05 level.

Table 6. Effects of three planting dates on 1st ratoon sucrose concentration in 2005 and 2006 for CP 85-384, HoCP 96-540, L 97-128, and Ho 95-988.

Year	Planting date	TRS†
		--- $g\ kg^{-1}$ ---
2006	August	220 A*
	September	220 A
	October	210 A
2007	August	250 A
	September	260 A
	October	260 A

*Means for each year followed by the same letter are not different using the SAXTON mean separation procedure at the P = 0.05 level.

†TRS = theoretically recoverable sucrose