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REGISTRATION

Cultivar

Registration of 'Ho 07-613' sugarcane

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Abstract

'Ho 07-613' (Reg. no. CV-208, PI 699606) sugarcane (an interspecific hybrid of *Saccharum officinarum* L., *S. barberi* Jeswiet, *S. spontaneum* L., and *S. sinense* Roxb. amend. Jeswiet) was selected and evaluated by scientists at the USDA-ARS, working cooperatively with the Louisiana State University Agricultural Center and the American Sugar Cane League, Inc. It was released to growers in Louisiana in 2014. The cultivar was tested across the crop cycle (plant cane and first and second ratoon) at 12 farm locations and compared with 'HoCP 96-540', the most widely grown cultivar in Louisiana during that time. The plant-cane sucrose yield (Mg ha^{-1}) of Ho 07-613 was equivalent to HoCP 96-540, and sucrose content was significantly higher. Ho 07-613 has moderately early maturity and poor mature-stalk cold tolerance. The cultivar is resistant to smut and *Sorghum mosaic virus*, tolerant of ratoon stunt, and moderately resistant to brown rust and leaf scald. It is moderately resistant to the sugarcane borer, *Diatraea saccharalis* (F.), and moderately responsive to glyphosate ripener. Ho 07-613's high yield potential, low fiber, and disease resistance make it a useful addition to existing commercial sugarcane cultivars in Louisiana.

1 | INTRODUCTION

Sugarcane (interspecific hybrids of *Saccharum* spp.) is a globally important crop for sugar and fiber. It is currently grown commercially in over 90 countries, with nearly 28 million ha harvested annually (FAOSTAT, 2019). Sugarcane is primarily a tropical crop, but in Louisiana, the crop is grown under temperate conditions where it is subjected to annual subfreezing temperatures (approximately 29°38′ N and 31°17′ N). In addition to environmental stressors, the crop is negatively affected by disease, insects, and weed pests. Sugarcane cultivars in the region have an average life span of 10 yr before they succumb to shifts in biotic pressure (Gravois & Bischoff, 2008). To maintain economical production of the crop and ensure high-yielding replacement cultivars are available, breeding efforts are constantly underway through the Louisiana Cultivar Development Program (LCDP). This program is made up of cooperators from the USDA-ARS Sugarcane Research Unit in Houma, LA (SRU), the Louisiana State University Agricultural Center (LSUAC), and the American Sugarcane League of the U.S.A. (AMSCL), who have been working together under a virtually unchanged formal agreement since 1926.

The SRU established a germplasm enhancement program (Basic Breeding Program) in 1956 to systematically introgress

Abbreviations: AMSCL, American Sugarcane League of the U.S.A.; LCDP, Louisiana Cultivar Development Program; SRU, Sugarcane Research Unit; SSR, simple sequence repeat; TRS, theoretical recoverable sucrose.

traits for disease resistance into elite commercial clones through a modified backcrossing program (Dunckelman & Legendre, 1982). This well-established program has been integral to the success of the Louisiana sugarcane industry because it has led to increased ratooning ability, stress tolerance, and disease resistance in modern-day cultivars. Wild relatives of sugarcane, for example, *S. spontaneum*, are naturally resistant to many biotic and abiotic stressors; however, they possess negative traits such as low sugar and high fiber. Selection of clones suitable for use as parents in the commercial breeding program is a long-term effort because it takes multiple iterations of backcrossing to eliminate undesirable traits, maintain traits for adaptability, and produce clones with commercially acceptable levels of sugar and fiber (Hale et al., 2013). Research to identify molecular markers to make breeding more efficient is underway, but the crop is genetically complicated with high ploidy levels, polygenic inheritance, and aneuploidy, making marker development difficult (Costet et al., 2012; D'Hont et al., 1995; Khan et al., 2013; Lakshmanan et al., 2005). Despite the long-term nature of introgression breeding and the difficulties surrounding marker development in sugarcane, within the past decade, new cultivars have been released to growers at a rate of nearly one per year.

The cultivar 'Ho 07-613' (Reg. no. CV-208, PI 699606) was officially released to Louisiana growers in the summer of 2014. The release of Ho 07-613 sugarcane provides Louisiana growers with cultivar possessing characteristics necessary for sustained cultivation including high sucrose yield, early maturity, low fiber, and good disease resistance.

2 | METHODS

2.1 | Crossing and early-stage selection

Ho 07-613 was selected by researchers from the USDA-ARS, SRU at Houma, LA, from a cross between the female parent HoCP 00-905 and the male parent 'HoCP 96-540' (Tew et al., 2005). The cross was made at the SRU in 2002. Both parents have pedigrees rooted in the SRU's sugarcane germplasm enhancement program (Basic Breeding Program), which after multiple generations of backcrossing, were used as parents in the commercial cultivar development program (Dunckelman & Legendre, 1982). A chronological summary of the crossing, selection, and evaluation of Ho 07-613 is outlined in Table 1. The early stages began with the selection of seedlings and ended with the cultivars receiving permanent names (assignment numbers). A detailed summary of early-stage selection can be found in Tew et al. (2009). The male parent, HoCP 96-540, is a mid-maturing cultivar with high sugar and cane yields. It was a highly successful cultivar in Louisiana that was grown on the majority of the state's acreage from 2007 to 2016 (Anonymous, 2014; Gravois & Bischoff, 2008; Legendre & Gravois, 2007). HoCP 00-905 is an experimental clone that was never commercially released.

2.2 | Nursery trials with estimated yield

Replicated on-station nursery cultivar trials were planted at the USDA-ARS Ardoyne Research Farm near Schriever, LA, the LSUAC's Sugar Research Station in St. Gabriel, LA, and the LSUAC's Iberia Research Station in Jeanerette, LA, in 2007. A randomized complete block design with two replications was used at each location. Plots consisted of single 1.8-m-wide rows that were 4.9 m long with a 1.2-m gap between plots along each row. Data were collected in the plant-cane, first-ratoon, and second-ratoon crops. In 2008, replicated off-station nursery yield trials were established on grower fields at Newton Cane Co., Inc. in Bunkie, LA, Melancon Farm in Breaux Bridge, LA, and Westfield Plantation in Paincourtville, LA. From this stage onward, SRU and LSUAC clones were tested alongside one another and were evaluated by researchers from the three participating institutions (SRU, LSUAC, and AMSCL). Trials were harvested in the plant cane through third-ratoon crops. The plots for these trials were single 1.8-m-wide rows that were 6.1 m long with a 1.2-m alley between plots along the rows. The number of harvestable stalks was determined in August of each year by hand counting each plot in duplicate. For each plot, 10 sugarcane stalks were hand-cut at ground level, knife-stripped to remove leaves, and topped above the meristem. Stalk weight (kg) was estimated by weighing the 10-stalk bundle, and stalk weight was multiplied by stalk population to estimate cane yield (Mg ha^{-1}). Juice from the 10-stalk sample was extracted using a three-roller crusher mill for juice extraction. Brix and optical rotation (Z°) were determined in the juice quality laboratory by refractometer and polarimeter to determine total soluble solids and sucrose content in each sample, respectively. Data obtained from these trials included stalk population (stalks ha^{-1}), mean stalk weight (kg), sucrose content (g kg^{-1}), cane yield (Mg ha^{-1}), and sugar yield (Mg ha^{-1}).

2.3 | Infield trials

Ho 07-613 was planted in mechanically harvested yield tests, locally referred to as infield trials, on silt loam soils at Sugarland Acres, Inc. in Youngsville, LA, at Blackberry Farms in Vacherie, LA, and at the USDA-ARS Ardoyne Research farm near Schriever in 2008. Trials were harvested in the plant-cane through second-ratoon crops. The plots for infield trials were two adjacent 1.8-m wide rows that were 7.3 m long with a 1.2-m alley between plots. The experimental design for each of these trials was a randomized complete block design with

TABLE 1 Summary of the stages of development, evaluation, and eventual release of commercial sugarcane cultivar Ho 07-613

Location	Stage	Year planted	PC	1R	2R	3R
Houma	Crossing	2002				
Schriever	Seedlings	2003		2004		
Schriever	First line	2004	2005			
Schriever	Second line	2005	2006	2007		
St. Gabriel	Nursery	2007	2008	2009	2010	
Schriever	Nursery	2007	2008		2010	
Jeanerette	Nursery	2007	2008	2009	2010	
Bunkie	Nursery	2008	2009	2010	2011	
Breaux Bridge	Nursery	2008	2009	2010	2011	
Paincourtville	Nursery	2008	2009	2010	2011	2012
Vacherie	Infield	2009	2010	2011	2012	
Youngsville	Infield	2009	2010			
Schriever	Infield	2009	2010	2011	2012	
St. James	Outfield	2010, 2011, 2012	2011, 2012, 2013	2012, 2013	2013	
Labarre	Outfield	2010, 2011, 2012	2011, 2012, 2013	2012, 2013	2013	
Napoleonville	Outfield	2010, 2011, 2012	2011, 2012, 2013	2012, 2013	2013	
Edgard	Outfield	2010, 2011, 2012	2011, 2012, 2013	2012, 2013	2013	
St. Martinville	Outfield	2010, 2011, 2012	2012, 2013	2012, 2013	2013	
Jeanerette	Outfield	2010, 2011, 2012	2011, 2012, 2013	2012, 2013	2013	
Baldwin	Outfield	2010, 2011, 2012	2011, 2012, 2013	2012, 2013	2013	
Plaquemine	Outfield	2010, 2011, 2012	2011, 2012, 2013			
Schriever	Outfield	2010, 2011, 2012	2011, 2012, 2013	2012, 2013	2013	
Raceland	Outfield	2010, 2011, 2012	2011, 2012, 2013	2012		
Centerville	Outfield	2010, 2011, 2012	2011, 2012, 2013	2012, 2013	2013	
New Roads	Outfield	2010, 2011, 2012	2011, 2012, 2013	2012, 2013	2013	

Note. PC, plant cane; 1R, first ratoon; 2R, second ratoon; 3R, third ratoon.

two replications. Prior to harvest, a 10-stalk sample was hand-cut as described earlier. Cane from each plot was mechanically harvested using a chopper harvester and weighed in a single-axle, high-dump wagon equipped with electronic load cells. Harvested cane weights from each plot were used to calculate cane yield. Samples were transported to the sucrose analysis laboratory at the USDA-ARS Ardoyne Research Farm near Schriever, where they were shredded in a prebreaker (Cameco Industries Inc.). Juice was expressed from a 1-kg subsample in a core press applying a force of 211 kg cm^{-1}. The remaining fibrous residue was weighed and then dried at 66 ˚C for 72 h to obtain moisture content of the fibrous residue and to determine the percentage of fiber in the cane. Brix and optical rotation were measured in the laboratory to determine sucrose content. Theoretical recoverable sucrose (g kg^{-1}) was estimated as described by Legendre (1992) based on sucrose and fiber content. Stalk weight was estimated based on a 10-stalk hand-cut sample.

2.4 | Outfield trials

Outfield cultivar trials are the final stage of testing in the LCDP. The trial sites were selected to provide a broad representation of the Louisiana sugarcane growing area, including two principal soil types (silt loam at six locations and clay at five locations). Light soil trial sites included Bon Secour Plantation near St. James, Brunswick Plantation near Labarre, Glenwood Plantation near Napoleonville, T. Lanaux and Son Farm near Edgard, Levert-St. John Plantation near St. Martinville, and Ronald Hebert Farm near Jeanerette. Heavy-soil sites included Adeline Planting Company near Baldwin, Al Landry Farms near Plaquemine, Magnolia Plantation near Schriever, Mary Plantation near Raceland, Frank Martin Farms near Centerville, and Alma Plantation near New Roads. The experimental design for each of these trials was a randomized complete block design with three replications. Plot size in outfield trials was two adjacent 1.8-m-wide rows that were 15.2 m long with a 1.5-m alley between plots. Ten-stalk samples were collected prior to harvest as described above to determine stalk weight and for a juice quality analysis. For juice quality analysis, samples were crushed in a three-roller mill as described for the nursery trials. Plots were mechanically harvested and weighed following procedures used in the infield trials. One hundred and sixty-six mechanically harvested outfield trials (35 plant cane, 21 first ratoon, and 10 second ratoon) were evaluated at 12 locations across southern Louisiana from 2011 through 2013.

2.5 | Disease and insect evaluations

2.5.1 | Mosaic

Sorghum mosaic virus and *Sugarcane mosaic virus* cause mosaic disease on sugarcane in the continental United States. In Louisiana, *Sugarcane mosaic virus* is rarely observed, even in spreader trials where experimental lines are monitored among interspersed rows of susceptible cultivars. The virus causing mosaic symptoms in experimental plants was determined using reverse transcription-polymerase chain reaction analysis (Grisham & Pan, 2007). When releasing cultivars for the Louisiana sugarcane industry, resistance to *Sorghum mosaic virus* is weighed heavily. Therefore, released check cultivars are all at least moderately resistant to the disease. Experimental clones showing symptoms of the disease are quickly dropped from the program.

2.5.2 | Smut and leaf scald

Ho 07-613 was evaluated in inoculated field trials at the USDA-ARS Ardoyne Research Farm in Schriever and the LSUAC's Sugar Research Station in St. Gabriel for susceptibility to smut [caused by *Sporisorium scitamineum* (Syd.) M. Piepenbr., M. Stoll & Oberw.] and leaf scald [caused by *Xanthomonas albilineans* (Ashby) Dowson]. The artificially inoculated trials were conducted as described by Tew et al. (2009).

2.5.3 | Brown rust and orange rust

Cultivar trials were observed during the spring and summer periods when the conditions for brown rust development from natural infection by *Puccinia melanocephala* H. and P. Sydow were favorable. Visual observations of both brown and orange rust [causal organism *P. kuehnii* (Kruger) E. Butler] were made. Orange rust was first observed in Louisiana in 2012 (Grisham et al., 2012).

2.5.4 | Ratoon stunting disease

The effect of ratoon stunt (caused by *Leifsonia xyli* subsp. *xyli*) (Evtushenko et al., 2000) on Ho 07-613 was determined in field experiments as described by Grisham et al. (2009). Infection levels based on the number of colonized vascular bundles (CVB) and effects on yield were determined each fall for three crop cycles including 2010–2012, 2011–2013, and 2012–2014, each consisting of plant-cane, first-ratoon, and second-ratoon crops.

2.5.5 | Sugarcane borer

Ho 07-613 was evaluated for its response to the sugarcane borer, *Diatraea saccharalis* (F.) (Lepidoptera: Crambidae), infestation. The sugarcane borer is an important pest of sugarcane throughout the Americas and the most important insect pest of sugarcane in Louisiana. Procedures for evaluating cultivars for sugarcane borer resistance are those reported by White et al. (2008). Evaluations of Ho 07-613 for response to sugarcane borer were conducted in 2011, 2012, and 2013.

2.6 | Maturity test

Sugarcane Research Unit personnel assessed the maturity profile of released cultivars and near-released clones in plant-cane and first-ratoon maturity tests at the USDA-ARS Ardoyne Research Farm near Schriever, LA. To assess maturity, 15-stalk samples were obtained every 4 wk from plant-cane tests and every 2 wk from first-ratoon tests to determine the natural accumulation of sucrose throughout the harvest season. Clones were planted in randomized complete block designs with three replications. Individual plots consisted of three adjacent rows 13.7 m in length with a 1.2-m alley between plots.

2.7 | Freeze tolerance test

Frequently, the Louisiana sugarcane crop is exposed to freezing temperatures during the harvest season. The economic effect of a freeze event will vary depending on the timing, intensity, and duration of a freeze. It is important to be aware of cultivar responses to freezing temperatures when establishing a harvesting schedule. In Louisiana, freezes tend to occur late in the season as winter approaches, and more cold tolerant cultivars can be left for late-season harvest with less threat of crop loss (Hale et al., 2016). Furthermore, in the event of an early-season freeze, growers need to be aware of which cultivars are most vulnerable to low temperatures and harvest these immediately. Freeze-tolerance trials involving commercial and near-commercial cultivars are planted annually on a clay soil at the USDA-ARS Ardoyne Research Farm near Schriever, LA. These tests are planted in a randomized complete block design with three replications. Individual plots consist of four adjacent, 1.8-m-wide rows 13.7 m in length with a 1.5-m alley between plots. Two cultivars, 'LCP 85-384' (Milligan et al., 1994), representing good stalk freeze tolerance, and 'TucCP 77-42' (Mariotti et. al. et al., 1991), representing poor stalk freeze tolerance, are included as controls. Freeze-tolerance trials are only sampled if a damaging freeze occurs. A damaging freeze does not typically occur until temperatures are sustained below −3 °C for several hours, and the degree of damage can be affected by environmental factors besides temperature. Indications of damage include changes in juice optical rotation (sucrose), pH, titratable acidity, and dextran formation (Legendre et al., 1985), which are determined on a weekly basis following a freeze event. Ho 07-613 was planted in the 2012 freeze test at the Ardoyne Research farm and harvested in the plant cane in January 2014.

2.8 | Chemical ripener tests

Glyphosate (Roundup WeatherMax, Monsanto) was applied as a sugarcane ripener at 200 g acid equivalent ha^{-1} to five commercial sugarcane cultivars and Ho 07-613 to determine the effect on theoretical recoverable sucrose (TRS). The study was conducted in Schriever during the summers of 2016 and 2017 at the USDA-ARS Ardoyne Research Farm. The experimental design was a split-plot factorial arrangement of ripener treatments and cultivars with four replications. Whole plots included two levels of ripener treatments and an untreated control, and subplots consisted of five different cultivars randomly assigned within each whole plot. Ripener treatments were broadcast-applied on 23 Aug. 2016 and 24 Aug. 2017 over the top of erect sugarcane using a 2.7-m-wide handheld CO_2 pressurized spray boom equipped with nine nozzles and XR8001 flat-fan nozzle tips. The spray boom was calibrated to deliver 94 L ha^{-1} at 136 kPa at a speed of 4.8 km h^{-1}. Individual plots measured 1.8-m wide by 9.1-m long and were machine harvested 49 d after treatment using a chopper harvester. The chopper harvester unloaded billets onto a high-dump weigh wagon equipped with a hydraulic driven sample basket that was used to collect approximately 7 kg of billets from each plot. Each billet sample was barcoded for tracking purposes and billets were crushed using a three-roller mill to extract juice. The extracted juice was analyzed for Brix (percentage by weight of soluble solids) and pol (percentage of apparent sucrose by weight) using a refractometer and saccharimeter, respectively. Theoretical recoverable sucrose was calculated as described by Chen and Chou (1993).

2.9 | Anatomical, botanical, and molecular descriptors

Plant descriptors for sugarcane in USDA-ARS GRIN system (http://www.ars-grin.gov/npgs/descriptors/sugarcane) were used as a guide. These guides were used to describe the canopy, dewlaps, ligule, auricle, leaf sheath, rind color, wax, and internodes.

The molecular identity of Ho 07-613 was defined with 144 DNA fragments or alleles amplifiable by 21 pairs of microsatellite (simple sequence repeat [SSR] primers) using a high throughput procedure (Pan et al., 2007). The nucleotide sequence of these SSR primers can be found in Pan (2006).

2.10 | Statistical analyses

Plant-cane and ratoon yield data were analyzed using PROC MIXED in SAS (Version 9.1) (SAS Institute, 2002) with cultivar as the fixed variable and year, location, and replication and their interactions as random variables. Maturity and freeze tolerance data were also analyzed using PROC MIXED. Least square means were generated for each cultivar and were separated using the PDIFF option ($P = .05$). For ripener tests, theoretical recoverable sucrose data were analyzed using the PROC MIXED procedure, where cultivar, treatment, and cultivar × treatment interaction were considered fixed effects and replication was random. Analysis was run by year. The statistical assumptions of constant variance and normal distribution were not violated; therefore, data were not transformed. Means were separated at the .05 level of significance using the PDIFF option (Saxton, 1998).

3 | CHARACTERISTICS

3.1 | Replicated yield trials

3.1.1 | Infield testing

Infield testing in the LCDP program is the first stage where yields are estimated through mechanically weighing plots as opposed to estimating from stalk numbers and average stalk weight. Ho 07-613 was planted in infield tests at three locations in 2008 and two locations in 2009. The Sugarland Acres test in Youngsville was plowed by the grower following the plant-cane crop, so no ratoon data was obtained from this test. In the plant cane, Ho 07-613 had higher stalk number and sucrose content (g kg^{-1}) than HoCP 96-540 (Tew et al., 2005) (Table 2). Sugar yield of Ho 07-613 was numerically greater than that of HoCP 96-540, but differences were not significant. This cultivar had lower fiber than all of the check

TABLE 2 Summary of 'Ho 07-613' sugarcane cultivar compared with commercial control cultivars in infield variety trials

Cultivar	Sugar yield	Cane yield	TRS		Stalk weight		Stalk population		Fiber	
	Mg ha^{-1}		g kg^{-1}		kg stalk^{-1}		no. ha^{-1}		%	
Plant cane[a]										
Ho 07-613	12.8	93.9	136.0		1.1		49,428		11.8	
HoCP 96-540	11.0	86.5	128.0	−	1.2		40,365	−	12.6	
L 99-226	13.6	97.7	139.5		1.4	+	42,981	−	12.4	
L 99-233	11.8	95.4	123.5	−	0.9		60,017		15.0	+
HoCP 00-950	12.3	88.3	140.0		1.0		49,179		12.9	
L 01-283	11.6	84.7	136.5		0.9	−	55,564		11.8	
First ratoon										
Ho 07-613	10.6	77.5	136		0.9		88,044		11.0	
HoCP 96-540	9.8	75.3	131		0.9		80,813		11.8	
L 99-226	12.2	88.9	136		0.9		95,600		12.3	+
L 99-233	10.8	87.8	122	−	0.9		99,225		14.1	+
HoCP 00-950	10.5	72.8	144		0.8		92,019		11.8	
L 01-283	10.9	79.5	137		0.7	−	111,318		11.2	
Second ratoon										
Ho 07-613	7.4	25.6	259		1.9		66,644		10.9	
HoCP 96-540	7.9	27.5	255		1.66		82,372		11.7	
L 99-226	7.8	27.1	262		1.99		69,105		12.0	
L 99-233	7.7	28.3	242		1.71		82,232		14.2	+
HoCP 00-950	10.0	30.8	292		1.68		91,552		11.5	
L 01-283	8.5	28.1	271		1.5		92,963		12.1	

Note. Yield estimates that are significantly higher or lower ($P = .05$) than estimates for Ho 07-613 are noted with a "+" or "−," respectively.
[a]Plant cane means from three trials harvested in 2010; first ratoon means from two trials harvested in 2011; second ratoon means from two trials harvested in 2012.

cultivars and significantly lower than 'L 99-233' (Gravois et al., 2009) in all crops (Table 2).

3.1.2 | Outfield testing

Ho 07-613 was planted in outfield trials beginning in 2010 (Table 3). Results from these outfield trials are found in Table 3. Ho 07-613 is a cultivar that performs best in the plant-cane crop. Its plant-cane and first-ratoon sucrose content (g kg^{-1}) were significantly higher than HoCP 96-540 and L 01-299, and its sugar yield (Mg ha^{-1}) was numerically, but not significantly, higher in plant cane. High sugar recovery is attributed, in part, to the low fiber content of the cultivar. While low fiber content enhances sucrose recovery, it also causes the cultivar to lodge easily and become brittle when recumbent. In ratoon crops, Ho 07-613 had significantly less sugar and cane yield (Mg ha^{-1}) than L 01-299. Finally, the stalk weight of HoCP 07-613 was equal to or greater than the other standard cultivars with the exception of HoCP 96-540 in the first ratoon and 'L 99-226' in all three crops.

3.2 | Disease and insect reactions

Disease reactions of Ho 07-613 are shown in Table 4. Ho 07-613 is resistant to smut and mosaic and moderately resistant to brown rust and leaf scald. Although moderately susceptible to *L. xyli* subsp. *xyli* infection, Ho 07-613 is tolerant to infection and shows little yield loss. Orange rust has not been observed on Ho 07-613 in Louisiana; however, infection was observed in small plots in Florida (W. Davidson, personal communication, 9 June 2017).

3.3 | Sugarcane borer

Based on the average of three borer evaluations, Ho 07-613 was significantly more resistant to the sugarcane borer, *Diatraea saccharalis* (F.), than the susceptible standards 'L 03-371' (Gravois et al., 2012) and 'HoCP 00-950.' Ho 07-613 sustained significantly fewer damaged internodes than the susceptible standards L 03-371 and HoCP 00-950 (Tew et al., 2009) (Table 5), but it produced significantly more adult moths (indicating more moths reached maturity) in plant cane

TABLE 3 Yield components for 'Ho 07-613' compared with commercial control cultivars in outfield cultivar trials

Cultivar	Sugar yield		Cane yield		TRS		Stalk weight		Stalk population	
	Mg ha^{-1}				g kg^{-1}		kg stalk^{-1}		no. ha^{-1}	
Plant cane[a]										
Ho 07-613	10.7		75.0		143.5		1.1		70,111	
HoCP 96-540	10.3		74.8		138.0	–	1.1		67,788	
L 99-226	10.6		72.4		146.5	+	1.3	+	57,299	–
HoCP 00-950	10.2		68.5	–	149.5	+	1.0	–	72,604	
L 01-299	10.5		75.5		138.0	–	1.0	–	77,334	+
L 03-371	10.3		69.7	–	148.0		1.0	–	72,402	
HoCP 04-838	10.7		76.4		140.0	–	1.0	–	77,920	+
First ratoon										
Ho 07-613	9.8		66.1		149.0		0.9		68,470	
HoCP 96-540	9.8		69.0		141.0	–	1.0	+	65,003	
L 99-226	9.8		66.1		149.5		1.2	+	54,741	–
L 99-233	9.4		67.2		140.0	–	0.8	–	80,868	+
HoCP 00-950	9.9		64.5		155.0	+	0.8	–	73,380	
L 01-299	10.9	+	76.6	+	143.5	–	0.9		82,153	+
L 03-371	9.0	–	60.9	–	147.0		0.9	–	68,843	
HoCP 04-838	9.9		69.0		143.5	–	0.8	–	80,378	+
Ho 05-961	9.7		65.9		147.0		0.9		71,977	
Second ratoon										
Ho 07-613	8.3		58.0		144.0		0.8		72,414	
HoCP 96-540	8.0		59.4		133.5	–	0.9		67,818	
L 99-226	8.2		56.7		145.0		1.0	+	58,870	–
L 99-233	8.5		61.6		136.5	–	0.8		83,964	+
HoCP 00-950	8.8		57.8		151.5		0.8	–	77,900	
L 01-283	9.1	+	63.8	+	143.0		0.7	–	91,612	+
L 01-299	10.5	+	75.9	+	138.0	–	0.8	–	99,554	+
L 03-371	8.5		60.3		142.0		0.8		74,638	
HoCP 04-838	8.6		62.5		137.5	–	0.7	–	86,173	+
Ho 05-961	9.0	+	63.6	+	141.5		0.8		77,430	

Note. Yield estimates that are significantly higher or lower ($P = .05$) than estimates for Ho 07-613 are noted with a "+" or "–," respectively.
[a]Plant cane means from 33 trials conducted from 2011–2013; first ratoon means from 21 trials conducted 2012–2013; second ratoon means from 10 trials conducted in 2013.

TABLE 4 Disease response of 'Ho 07-613' compared with other cultivars

Cultivar	Mosaic	Smut	Brown rust	Leaf scald	Ratoon stunt
HoCP 96-540	R	R	S	R	R
L 99-226	MR	M	S	MR	M
HoCP 00-950	R	R	MR	R	S
L 01-283	R	R	MS	R	S
HoCP 04-838	R	R	R	MR	R
L 01-299	R	S	R	MR	S
Ho 07-613	R	R	MR	MR	T

Note. R, resistant; MR, moderately resistant; S, susceptible; MS, moderately susceptible; T, tolerant.

than the susceptible standard (greater than 2.5 stalk^{-1}). These data indicate that Ho 07-613 is moderately resistant to the sugarcane borer. Evaluations in Texas indicate that Ho 07-613 is moderately resistant to Mexican rice borer (Wilson et al., 2016).

3.4 | Maturity tests

Theoretical recoverable sucrose was measured every 2 wk during the 2013 harvest season (August–December) to determine maturity levels of Ho 07-613 as compared to other commercial cultivars. This cultivar matured earlier in the season than the leading commercial cultivar HoCP 96-540, but later

TABLE 5 Mean percent bored internodes and number of adult moths produced in yield reduction studies conducted in 2011, 2012, and 2013 at the USDA-ARS Ardoyne Research Farm near Schriever, LA

Cultivar	Bored internodes[a]		Adult moths[b]	
	%		no.	
2011				
HoCP 96-540	6.4		0.8	
L 99-226	4.1		0.3	
L 01-283	4.7		0.8	
Ho 02-113	0.0		0.0	
L 03-371 (S standard)	11.4		3.0	
HoCP 04-838 (R standard)	0.9		0.5	
Ho 05-961	7.5		1.5	
Ho 07-613	4.8	–	2.5	+
2012				
HoCP 91-555	6.5		1	
HoCP 00-950 (S standard)	7.9		1.3	
HoCP 04-838 (R standard)	1.7		0.3	
Ho 05-961	2		0.3	
Ho 07-613	3.1	–	1	
2013				
L 01-299 (R standard)	3.4		0.3	
L 03-371 (S standard)	10.2		1.8	
Ho 07-613	3.5	–	1.5	
HoCP 09-804	4.9		0.8	

Note. R, resistant; S, susceptible.
[a]A minus sign indicates that Ho 07-613 is significantly (.05) lower in percentage bored internodes than the susceptible standard for that year.
[b]A plus sign indicates that Ho 07-613 produced significantly (.05) more moths than the resistant standard for the year.

TABLE 6 Theoretical recoverable sugar (TRS) per ton of cane for 'Ho 07-613' compared with eight commercial sugarcane cultivars sampled from the plant-cane maturity test conducted at the USDA-ARS Ardoyne Research Farm near Schriever, LA, during the 2013 harvest season

	Harvest dates								Seasonal				
	23 Sept.			21 Oct.			18 Nov.		Average		Rank	Change[a]	Percentage
	TRS, g kg^{-1}												%
Ho 07-613	102.5	BC	c	131.5	BC	b	147.0	BC	a	127.0	ABC	3	44.5	43.4
HoCP 96-540	87.5	D	c	113.0	E	b	141.5	D	a	114.0	C	8	54.0	61.7
L 99-226	85.5	D	c	119.5	DE	b	148.0	BC	a	117.5	BC	7	62.5	73.1
L 99-233	101.0	BC	c	124.5	CD	b	147.5	BC	a	124.5	BC	5	46.5	46.0
HoCP 00-950	121.0	A	c	147.0	A	b	159.0	A	a	142.5	A	1	38.0	31.4
L 01-283	106.0	B	c	138.5	AB	b	151.0	B	a	132.0	AB	2	45.0	42.5
L 01-299	85.0	D	c	114.5	E	b	133.5	E	a	111.0	C	9	48.5	57.1
L 03-371	93.0	CD	c	125.5	CD	b	144.5	CD	a	121.0	BC	6	51.5	55.4
HoCP 04-838	106.0	B	c	130.0	BC	b	144.5	CD	a	127.0	ABC	4	38.5	36.3
Average	98.5		c	127		b	146.5		a	124.0			48.0	48.7

Note. Means followed by the same letter group are not significant (.05). Capital letters read down or within columns, lower case letters read across or within rows.
[a]Change represents the difference in TRS between initial sampling date and final sampling date.

than the fast-maturing cultivar HoCP 00-950 (Table 6). It had a similar maturity curve to 'L 01-283' (Gravois et al., 2010).

3.5 | Freeze tolerance tests

On 6 Jan. 2014, a damaging freeze occurred at the USDA-ARS Ardoyne Research Farm near Schriever. Temperatures dipped below 0 ˚C for 17.5 h, and below −6.1 ˚C for 4.5 h. A minimum temperature of −6.8 ˚C was sustained for 1.5 h. Stalk samples were collected the day after the freeze occurred and weekly thereafter until 21 January (Table 7). All evaluated cultivars suffered some deterioration due to the freeze, with the most cold tolerant, L 01-299, showing a 12% post-freeze reduction in TRS, and the least tolerant, L 99-226, showing a 65% decrease. Of the 10 cultivars evaluated, Ho 07-613 ranked number 7, with a 39% reduction in TRS between samples taken on 7 and 21 Jan. 2014. Based on results from this test, Ho 07-613 is considered moderately susceptible to

TABLE 7 Postfreeze changes in yield of theoretical recoverable sugar (TRS) of 10 commercial cultivars and 'Ho 07-613' in a plant-cane crop following freezing temperatures (−6.8 ° C) at the USDA-ARS research farm in Schriever, LA, in 2014

Cultivar	Harvest dates 7 Jan.	14 Jan.	21 Jan.	Change in TRS		Rank
	TRS, $g\ kg^{-1}$			$g\ kg^{-1}$	%	
Ho 07-613	129	112	79	−50	−39	7
HoCP 96-540	130	111	107	−23	−18	3
L 99-226	135	111	47	−88	−65	10
L 99-233	123	97	47	−76	−62	9
HoCP 00-950	131	115	105	−26	−20	5
L 01-283	128	114	99	−29	−23	6
L 01-299	118	103	104	−14	−12	1
L 03-371	125	109	100	−25	−20	4
HoCP 04-838	119	107	104	−15	−13	2
TucCP 77-42	110	87	57	−53	−48	8

TABLE 8 Comparison of theoretical recoverable sucrose (TRS) in sugarcane in response to glyphosate treatment (GT) compared with nontreated sugarcane (NT). The response of 'Ho 07-613' was compared with four other common sugarcane cultivars. Sugarcane was combine-harvested at 7 wk after glyphosate treatment, and the percentage change in TRS (Δ) between GT and NT sugarcane was determined in 2016 and 2017 at the USDA-ARS Ardoyne Research Farm near Schriever, LA

Cultivar	2016 NT	GT	Δ	2017 NT	GT	Δ	Average 2016–2017 NT	GT	Δ
	$g\ kg^{-1}$		%	$g\ kg^{-1}$		%	$g\ kg^{-1}$		%
HoCP 96-540	129	139	8*	118	129	9*	124	134	9*
HoCP 00-950	134	145	8	150	150	0	142	148	4
L 01-283	132	143	8*	142	134	−6	137	139	1
L 01-299	125	139	11*	127	133	5	126	136	8*
Ho 07-613	128	142	11*	142	137	−4	135	140	3

Note. Glyphosate was applied late 23 Aug. 2016 and 24 Aug. 2017.
*Significant difference (.05) in TRS comparing treated and nontreated sugarcane.

freezing temperatures and is not recommended for cultivation in the colder northern regions of the Louisiana sugarcane industry.

3.6 | Chemical ripener tests

In Louisiana, it is common to treat ratoon crops of sugarcane with a ripener to increase the concentration of sucrose early in the harvest season (Dalley & Richard, 2010; Orgeron et al., 2016). The majority of ratoon crops are ripened through application of glyphosate 4–7 wk prior to harvest. Ho 07-613 was tested for its response to glyphosate ripener treatment in 2016 and 2017. Sugarcane TRS response to ripener in this test varied by cultivar and year. Commercial cultivars HoCP 96-540 and L 01-299 are considered to be highly responsive to glyphosate (Orgeron, et al., 2019) and were included for comparison when assessing the response of Ho 07-613. When averaged across 2 yr, TRS for glyphosate-ripened HoCP 96-540 and L 01-299 was 9 and 8% higher than nonripened cultivars, respectively (Table 8). Glyphosate increased TRS for Ho 07-613 by 11% in 2016 but failed to increase TRS in 2017. Of the five sugarcane cultivars tested, ripener application significantly increased TRS only in HoCP 96-540. Response of sugarcane to ripener application is often dependent on environmental conditions prior to and following application. On years where conditions favor natural ripening of sugarcane, there is frequently little or no response of sugarcane to ripener application. In a similar study, Spaunhorst et al. (2019) reported an increase in TRS of 9% in glyphosate-treated Ho 07-613 over the nontreated control.

3.7 | Agronomic, botanical, and molecular descriptors

The canopy of Ho 07-613 is slightly erect and rounded (Gravois et al., 2020). The dewlaps are reddish brown in color

TABLE 9 The simple sequence repeat (SSR) fingerprint of 'Ho 07-613' defined with 144 DNA fragments or alleles amplifiable by 21 pairs of microsatellite primer pairs. The name of the SSR primer pair, allele size (bp), and the presence (+) or absence (–) of each allele are shown

Primer	**SMC119CG**					**SMC1604SA**						**SMC18SA**					**SMC24DUQ**					
bp	106	112	118	128	131	109	112	115	118	121	124	137	140	144	147	150	126	128	131	135	137	142
±	–	+	–	+	–	–	+	+	–	–	–	–	+	+	+	+	+	+	+	+	+	+
Primer	**SMC278CS**									**SMC31CUQ**												
bp	140	153	166	168	170	174	176	178	182	138	150	160	162	163	165	167	171	173	177	179		
±	–	–	+	–	+	+	+	–	–	–	–	–	+	–	–	+	+	+	–	–		
Primer	**SMC334BS**						**SMC336BS**											**SMC36BUQ**				
bp	146	149	151	161	163	164	141	154	164	166	167	169	171	173	175	177	183	112	118	121		
±	+	–	+	–	+	–	–	–	–	+	–	–	+	–	+	+	–	–	+	+		
Primer	**SMC486CG**					**SMC569CS**					**SMC7CUQ**											
bp	224	227	237	239	241	167	170	210	219	222	158	162	164	166	168	170						
±	+	–	+	+	–	–	–	–	–	+	–	+	+	+	–	–						
Primer	**SMC597CS**											**SMC703BS**										
bp	144	148	154	157	159	161	163	164	165	168	174	201	206	208	210	212	214	216	220	222		
±	+	–	–	–	–	+	–	+	+	–	–	+	+	–	+	+	+	+	–	–		
Primer	**SMC851MS**						**mSSCIR66**				**mSSCIR3**											
bp	128	130	132	134	136	141	127	130	132	134	141	145	171	173	175	177	178	180	182	187		
±	–	+	–	+	–	–	–	+	–	–	–	–	–	–	–	+	–	+	–	+		
Primer	**SMC1751CL**					**SMC22DUQ**							**mSSCIR43**									
bp	140	144	147	151	154	125	148	151	154	157	160	163	206	229	233	235	237	239	248	250	252	
±	–	+	+	+	+	–	+	+	+	+	+	–	–	–	–	+	–	+	–	+	+	
Primer	**mSSCIR74**																					
bp	217	220	223	226	229																	
±	–	+	+	–	+																	

and ascending narrow ligulate-shaped (Artschwager, 1951). Auricles are present, and approximately 7-cm length unciform in shape (IUPOV, 2006). Leaf sheath edges are dark reddish purple with margins becoming necrotic with age (Gravois et al., 2020). Leaf sheaths are light green, smooth (no silicate hair), and are loose on the stalk. The exposed rind color on stalks of Ho 07-613 is green becoming darker when exposed to the sun. Wax on the stalks and leaf sheath of Ho 07-613 is heavy, and stalks contain growth cracks. Internodes are slightly narrower in the middle with a concave–convex shape (IUPOV, 2006).

The number of SSR fragments produced per SSR primer pair varied from 3 to 11, and the amplification profile for Ho 07-613 for each of the 21 pairs of SSR primers is shown in Table 9. The reported SSR fingerprint is used to represent the molecular identity of Ho 07-613 when comparing with those of other Louisiana commercial cultivars (Pan et al., 2007).

4 | AVAILABILITY

Small quantities of seed-cane of Ho 07-613 for research purposes will be maintained at the USDA-ARS Sugarcane Research Unit, located at Houma, LA, for five years. It is not anticipated that a plant patent for Ho 07-613 will be sought.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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