Published online: 30 July 2021

DOI: 10.1002/plr2.20136

Journal of Plant Registrations

REGISTRATION

Cultivar

Registration of 'L 11-183' sugarcane

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Assigned to Associate Editor Jorge da Silva.

Registration by CSSA.

Abstract

'L 11-183' (Reg. no. CV-200, PI 698200) sugarcane (interspecific hybrid of *Saccharum* spp.) was derived from a cross between HoCP 92-624 as the female and 'LCP 85-384' as the male parent. Early-stage clonal selection by researchers at the Louisiana State University Agricultural Center led to the assignment of a permanent cultivar number in 2011. The cultivar was further evaluated cooperatively with scientists from the USDA–ARS and the American Sugar Cane League. L 11-183 was jointly released to the Louisiana sugar industry on 11 May 2018. L 11-183 was released because of its high yield potential compared with 'HoCP 96-540' and 'L 01-299', two of the most widely grown cultivars in Louisiana at the time. In the final testing stage, data were collected from across 12 locations and three crops (plant cane and first and second ratoons) with multiple crop-years within locations. Combined across locations and crops, L 11-183 accumulated 5% more cane yield than HoCP 96-540 but 4% less than L 01-299. Sucrose yield in L 11-183 was comparable to that of L 01-299 but 3% greater than that of HoCP 96-540. The new cultivar is resistant to smut, moderately resistant to leaf scald, *Sugarcane yellow leaf virus*, and ratoon stunting, moderately susceptible to brown rust and *Sugarcane mosaic virus*, and susceptible to the sugarcane borer.

1 | INTRODUCTION

Modern sugarcane cultivars (*Saccharum* spp.) are derived from interspecific hybridization between two major *Saccharum* species, namely *S. officinarum* ($2n = 80$, $x = 10$) and *S. spontaneum* ($2n = 40–128$, $x = 8$), made in the late 19th to early 20th centuries in Coimbatore, India, and Java, Indonesia. *Saccharum officinarum* (also known as "noble cane") is the sugar-producing species, while *S. spontaneum*, the wild species, is poor in sugar production but resistant to various biotic and abiotic stresses. Until the end of the 19th century, most cultivated sugarcane was the vegetatively propagated noble canes. The simultaneous discovery of sexual fertility in

Abbreviations: LSU AgCenter, Louisiana State University Agricultural Center; PCR, polymerase chain reaction; SSR, simple sequence repeat

Barbados and the devastating effects of sereh disease in Java around the turn of the 20th century prompted hybridization attempts between clones of *S. officinarum* and *S. spontaneum* (Arceneaux, 1965). The hybrid progeny together with a naturally occurring hybrid 'Kassoer' were repeatedly backcrossed to clones of *S. officinarum* to minimize the negative effects of the wild germplasm, a process termed *nobilization*. The restoration of the high-sugar-producing types was easily achieved, starting from the BC_2 generation, perhaps because *S. officinarum*, the recurrent parent, transmitted the somatic chromosome number to its progeny (Bhat & Gill, 1985; Bremer, 1961). However, pairing during meiosis remains complex in cultivated sugarcane hybrids, with unsystematic pairing frequencies ranging from 0 to 40% resulting from differential affinities of homologous and homeologous chromosomes (Jannoo et al., 2004). Consequently, cultivated sugarcane are aneuploids with about 100–130 chromosomes, of which about 80% originate from *S. officinarum*, 10–20% from *S. spontaneum*, and 10% are recombinants (D'Hont et al., 1995; Piperidis & D'Hont, 2001). Sugarcane genotypes are predominantly outcrossing, highly heterozygous, and maintained by vegetative propagation (Gravois et al., 2010).

Nobilization in sugarcane is perhaps the best example of the contribution of wild germplasm to the genetic improvement of an economically important crop. Nobilization stabilized productivity because of increased disease resistance, ratooning ability, and stress tolerance such as flooding and/or cold weather (Roach, 1972). Only a few clones were involved in the original nobilization events, and modern cultivars are mostly multigenerational descendants of the original backcross populations, which makes the genetic base of cultivated sugarcane narrow (Arceneaux, 1965; Berding & Roach, 1987). The background of most sugarcane cultivars in the mainland United States can be traced back to 17 founder clones (Deren, 1995).

To address issues related to the narrow genetic base of cultivated sugarcane and the potential vulnerability of the crop in the Louisiana sugar industry, a basic breeding program was established in late1950s by the USDA–ARS Sugarcane Research Unit at Houma, LA, with a main objective to broaden the genetic base of sugarcane and, in particular, genes for sugarcane mosaic resistance. The establishment of this program was prompted by the fact that mosaic disease contributed to the near collapse of the Louisiana sugarcane industry in the 1920s and had resurfaced as a problem with the release of 'NCo 310' in 1954 (Abbott et al., 1961). It was only through the cultivation of the resistant interspecific cultivars that mosaic was eliminated as a major disease of sugarcane in Louisiana by the late 1990s.

The first success from the basic breeding program was the release of 'LCP 85-384' (Milligan et al., 1994). When LCP 85-384 was released, the new cultivar provided an unprecedented boost in yield (20–25%) and ratoon crop longevity (from two to four ratoon crops) compared with cultivars grown at the time (Gravois & Bischoff, 2008). The release of LCP 85-384 also helped usher in the transition from whole stalk harvesters to combine chopper harvesters. LCP 85-384 was the leading sugarcane cultivar grown in Louisiana from 1998 to 2007, occupying 91% of the sugarcane acreage in 2004 (Legendre & Gravois, 2007). Susceptibility to brown rust (caused by *Puccinia melanocephala* Syd. & P. Syd) caused its downfall (Legendre & Gravois, 2007). Its success as a parent has led to the release of several high-yielding cultivars including 'L 01-299' (Gravois, 2018), which is now the leading cultivar in Louisiana, occupying 56% of the Louisiana sugarcane acreage in 2019. LCP 85-384 is also a parent of 'L 11-183' (Reg. no. CV-200, PI 698200).

The release of L 11-183 is a continuation of the legacy of the LSU AgCenter sugarcane cultivar development program. The new cultivar will serve as another excellent choice for Louisiana sugarcane producers.

Core Ideas

- L 11-183 is a new sugarcane cultivar developed for the Louisiana sugar industry.
- L 11-183 was released because of its high yield potential compared with other cultivars.
- Disease resistance was also improved in L 11-183 compared with other cultivars.
- L11-183 is not an early maturing cultivar nor can it withstand freezing temperatures.
- The new cultivar will serve as an excellent choice for Louisiana sugarcane producers.

2 | METHODS

2.1 | Crossing and early-stage selection

A summary of the breeding and selection activities leading to the release of L 11-183 is given in Table 1. A detailed description of the LSU AgCenter sugarcane cultivar development program was provided by Bischoff & Gravois (2003). All early-stage activities, from crossing through selection in the second clonal line trial stage, were conducted at the Sugar Research Station in St. Gabriel, LA (30°15′13″ N, 91°6′5″ W). L 11-183 was derived from one of two crosses (XL06-306 or XL 06-323) made at the Sugar Research Station in St. Gabriel, LA, in 2006 between HoCP 92-624 as the female and LCP 85-384 as the male parents. Figure 1 shows five generations of the pedigree of L 11-183. The female parent,

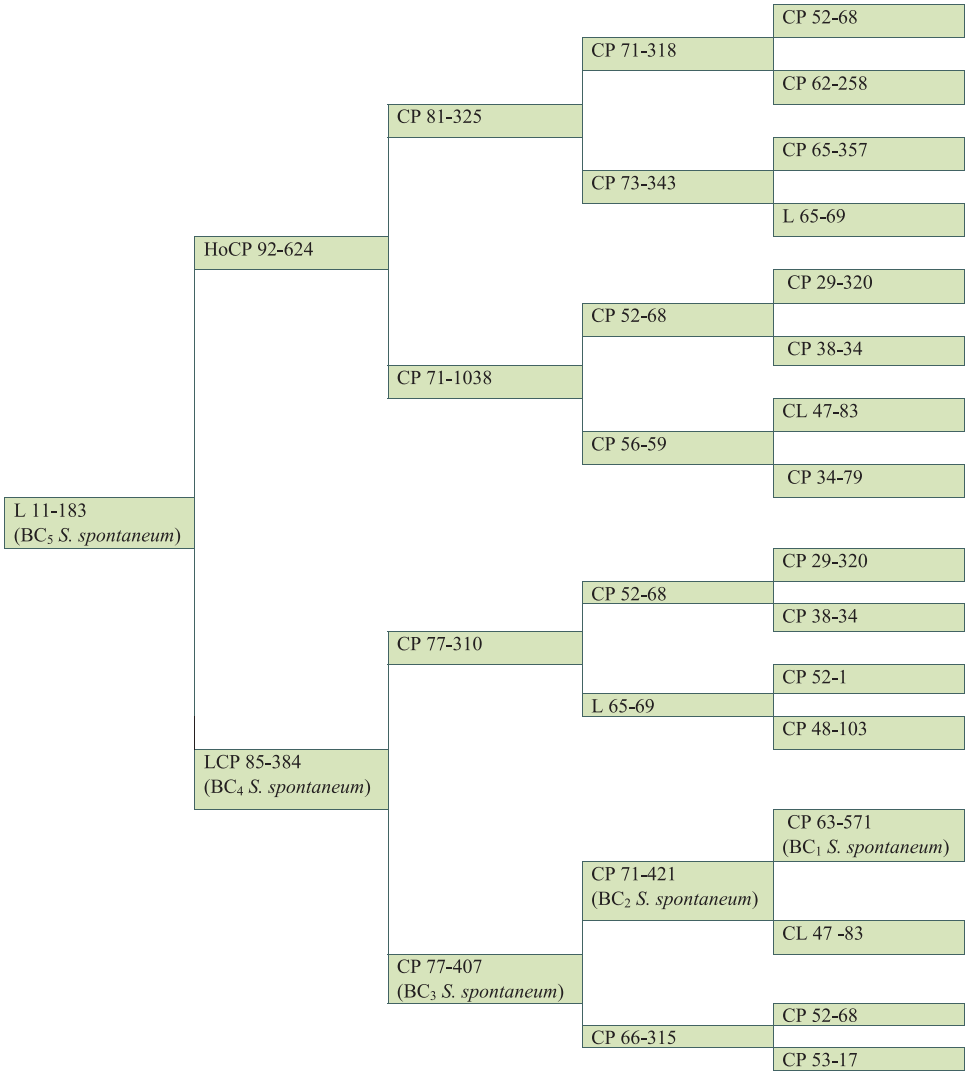

FIGURE 1 Five-generation pedigree of L 11-183

HoCP 92-624, is a proven parent in our crossing program. HoCP 92-624 advanced up to the final testing stage of selection (outfield) but was dropped from active testing because of its propensity to lodge (Edwis Dufrene, personal communication, 2018). The male parent, LCP 85-384, is a BC_4 progeny of the *S. spontaneum* clone US 56-15-8, a clone collected from Thailand for use in broadening the genetic base among sugarcane parents used for crossing in Louisiana.

True seed from the HoCP 92-624 × LCP 85-384 cross were germinated in the greenhouse in January 2007 and transplanted to the field in April 2007. A total of 84,307 seedlings, representing 178 crosses, were transplanted to the field. Seedlings were planted on two adjacent rows at 0.40 m between seedlings and 1.8 m between rows with a 1.2-m alleyway separating each cross. Check cultivars were raised in the greenhouse as "one-bud setts" in trays and transplanted to several locations in the field along with the seedlings. The seedlings were harvested in December of 2007 (no data collected) and allowed to overwinter, and selection occurred in the first ratoon crop in 2008.

Individual seedlings were selected for advancement to the first clonal line trial stage in September 2008. Selection was practiced on 51,867 seedlings that overwintered, among which 1,415 were from the HoCP 92-624 × LCP 85-384 cross. Individual seedlings were visually appraised for lodging, stalk number, stalk height, stalk diameter, and insect and disease resistance. Acceptable seedlings were then checked for presence or absence of pith and/or tube, and those containing pith were dropped from further consideration. Two stalks of the selected seedlings were cut, tied, and taken out of the field and evaluated for juice Brix (%), an indicator of sucrose content. Juice was sampled from the bottom midway point of the stalks using a hand punch, and juice Brix was estimated using an Atago 3810 (PAL-1) Digital Pocket Refractometer. This value was compared with that of the juice Brix of the check cultivars. Seedlings judged to be inferior in juice Brix were

TABLE 1 Summary of the breeding and selection activities leading to the release of L 11-183

Year	Stage
2006	Cross made in October at the Sugar Research Station, St. Gabriel, LA
2007	True seed germinated and seedlings transplanted into the field
2008	Selection in first-ratoon seedling crop (advanced to first line trial)
2009	Selection in plant-cane first line trial (advanced to second line trial)
2010	Selection in plant-cane second line trial (advanced to increase plots)
2011	Assignment in first-ratoon second line trial; on-station nursery trials planted (St. Gabriel,Schriever, and New Iberia, LA)
2012	Plant-cane on-station nursery trials harvested; off-station nursery trials planted (Melancon Farm, Cecilia, LA; Westfield Plantation, Paincourtville, LA; Newton Cane Co., Bunkie, LA); infield trials planted Vacherie and Erath, LA
2013	First ratoon on-station nursery trials harvested; plant-cane off-station nursery and infield trials harvested
2014	Second-ratoon on-station nursery trials harvested; first-ratoon off-station nursery and infield trials harvested; outfield trials planted
2015	Second-ratoon off-station nursery and infield trials harvested; plant-cane outfield trials harvested
2016	Third-ratoon off-station nursery and infield trials harvested; first-ratoon outfield trials harvested
2017	Second-ratoon outfield trials harvested
2018	Cultivar released 10 May 2018

discarded. A total of 2,623 of these two-stalk samples were retained for planting into the first clonal line trial stage, of which 179 were from the HoCP 92-624 × LCP 85-384 cross. The first clonal line trial stage was planted to non-replicated, single-row plots measuring 1.8 m in length with a 1.2-m alleyway between plots. Multiple single-row plots of check cultivars were also planted in the trial.

The first clonal line trial was selected in the plant cane crop in 2009. Plots were visually appraised for lodging, stalk number, stalk diameter, and stalk height and insect and disease resistance. Acceptable clones, when compared with check cultivars, were later evaluated for pith and/or tube. Six stalks of the selected clones were cut, carried out of the field and used to evaluate juice Brix as described above. Six stalks of the selected clone were used to establish the second clonal line trial stage. A total of 341 clones were advanced to the second clonal line trial stage, of which 37 were progeny of the HoCP 92-624 × LCP 85-384 cross.

The second clonal line trial plots consisted of single rows measuring 4.9 m long. Multiple single-row plots of check cultivars were interspersed in the trial. Clones were selected from the plant cane crop of the second clonal line trial plots in 2010 and used to establish two increase plots, one on clay (heavy-textured) soil and the other on a sandy (light-textured) soil. To accomplish this, the experimental clones were first visually appraised for vigor by judging for the following traits: lodging, stalk number based on counts, stalk diameter, and stalk height as well as disease and insect resistance. Clones judged to be adequate for these characteristics when compared with check cultivars were then evaluated for pith and/or tube. A random 10-stalk sample was hand cut from plots of clones that were deemed acceptable. The samples were stripped (clean cane) of the leaves and used to estimate stalk weight (kg) and sucrose content (Mg kg^{-1}) at the Sugar Research Station sucrose laboratory. Sucrose content was analyzed via near-infrared spectroscopy using SpectraCane 400 (for automation) integrated with a Bruker Matrix-F Fourier-transform near-infrared spectrometer (Bruker Optics). The cane sample was first shredded with a Dedini laboratory disintegrator (Dedini S/A Indústrias de Base) and the sample presented through the near-infrared field by automated conveyor belts. Traits measured included fiber content, juice Brix, and optical rotation (Z°), which were used to estimate sucrose content (Gravois & Milligan, 1992; Legendre, 1992). Cane yield (Mg ha^{-1}) was estimated as the product of stalk weight (Mg $stalk^{-1}$) and stalk number (stalks ha^{-1}). Sugar yield (Mg ha^{-1}) was then estimated as the product of cane yield and sucrose content. Two six-stalk bundles from experimental clones, judged to be acceptable for the above traits when compared with the checks, were cut and used to plant the two increase plots. Increase plots consisted of single rows measuring 4.9m long. Of 119 clones advanced to increase plots in 2010, nine were from the HoCP 92-624 × LCP 85-384 cross.

Experimental clones still active (planted in increase plots) in the second clonal line trial were evaluated again in the first ratoon cane crop in 2011 as described above. The corresponding clones in the two increase plots were also evaluated in the plant cane crop in 2011 using similar methods as described above. The corresponding clones in the first clonal line trial plots were also evaluated in 2010 in the first ratoon cane crop, using a six-stalk sample to estimate stalk weight and to analyze for quality traits including fiber content and sucrose content. Data accumulated from all trials and stages were used to advance experimental clones to the on-station nursery trial stage. It is also at this point that experimental clones were assigned a permanent cultivar name. L 11-183, for example, denotes that the cultivar was bred and selected by the LSU AgCenter sugarcane improvement program (L), and was assigned a clone number (183) in 2011 (11). The numbers 1–499 have historically been reserved for clones selected by the LSU AgCenter program. Of 34 clones assigned in 2011,

five were from the HoCP 92-624 × LCP 85-384 cross. The female parent, HoCP 92-624, was involved in the parentage of 11 clones that were assigned in 2011.

2.2 | Replicated yield trials

Replicated on-station nursery trials were conducted from 2012 to 2014, in the plant cane through to the second ratoon cane crop, at the Sugar Research Station in St. Gabriel, LA, the USDA–ARS Ardoyne Farm in Shriver, LA (29°44′42″ N, 90°49′4″ W), and the Iberia Research Station in Jeanerette, LA (29°54′59″ N, 91°40′21″ W). Six stalks obtained from increase plots were used to plant single-row plots that were 4.9m long. The experimental design was a randomized complete block design with two replications. Millable stalk number counts of each plot were made in early August. During this process, plots were also observed and notes taken for characteristics such as lodging, stalk height, and insect and disease resistance. At harvest, a random 10-stalk sample was hand cut from each plot, stripped of the leaves, and used to estimate stalk weight, fiber content, and sucrose content as described above. Cane yield was estimated as the product of stalk number and stalk weight divided by 1000. Sugar yield was estimated as the product of cane yield and sucrose content.

Data accumulated on experimental clones from previous stages and in the plant cane crop of the on-station nursery trial (visual appraisal) were considered in deciding which experimental genotypes to advance to two concurrent (off-station nursery and infield) stages in 2012. This included data from the second ratoon crop of the second line clonal trial stage and the first ratoon crop of the increase plots. Of the 10 clones advanced to the off-station nursery and infield stages, two were from the HoCP 92-624 × LCP 85-384 cross. Off-station and infield trials were conducted from 2013 (plant cane) through 2016 (third ratoon crop).

Off-station nursery trials were conducted at three locations: Newton Cane Inc., Bunkie, LA (30°95′32′′ N, 92°18′26′′ W), Michael Melancon Farm in Cecilia, LA (30°20′11″ N, 91°50′52″ W), and Joel Landry Farm in Paincourtville, LA (29°59′28″ N, 91°3′35″ W). Off-station nursery trials consisted of single-row plots measuring 6.1m long, each planted with eight stalks. The experimental design for each trial was a randomized complete block design with two replications. Stalk number, stalk weight, cane yield, sucrose and fiber contents, and sucrose yield were estimated as described for the on-station nursery trials.

Infield trials were planted at two locations: Blackberry Farms, Vacherie, LA (30°0′40″ N, 90°43′10″ W) and Donny Vallot Farms, Erath, LA (29°95′83′′ N, 92°3′60′′ W). Two-row plots, each measuring 7.6m long, were planted with a total of 20 stalks. The experimental design was a randomized complete block design with two replications. Cane yield in the infield trial stage was measured using a combine harvester and a high-dump weigh wagon equipped with load cells to record cane weight. Both rows were harvested and weighed, and the plot weights were used to compute cane yield. At harvest, a 10-stalk sample was hand cut and used to measure fiber content and sucrose content by the pre-breaker press method (Legendre, 1992).

The final testing stage, the outfield stage, was planted in 2014 and tested through 2017 (second ratoon crop) across 12 southern Louisiana locations before L 11-183 was considered for release. Additional data were collected in 2018. Six of the 12 locations were considered light-textured, whereas the other six were considered heavy-textured soil types. Outfield trials consisted of two-row plots measuring 15.2 m long with three replications. Stalks were planted at a rate of two stalks placed side by side with an overlap of 10% at the end of the two stalks. The distance between plots within a row (alleyway) was 1.5m. These trials were conducted in cooperation with scientists from the USDA–ARS, the American Sugar Cane League, and the LSU AgCenter. L 11-183 was one of five experimental cultivars entered by the LSU AgCenter sugarcane cultivar development program into the outfield test. Outfield trials were harvested similar to the infield trials. No burning was done before harvest. Laboratory analysis for quality characteristics were performed at the USDA–ARS laboratory facility using core laboratory methods (Gravois & Milligan, 1992; Legendre, 1992). Experimental cultivars that make it into the outfield trial stage are considered active and as such, data were collected on these clones from previous trial stages. Outfield trial data were reviewed every year along with data from previous trial stages, and clones that continued to perform well were replanted into the outfield trial stage.

Different cultivars were cultivated in the Louisiana sugar industry at different times during the development of L 11-183. Therefore, different cultivars were used for comparison with L 11-183 at different trial stages during its development. HoCP 96-540 (Tew et al., 2005) was the most popular cultivar during the development of L 11-183, but it succumbed to infection by brown rust and was superseded by L 01-299 by the time L 11-183 was released in 2018. Therefore, comparisons focused on L 01-299 (the leading cultivar) and HoCP 96-540 (the second leading cultivar).

2.3 | Maturity, ripener, and freeze tolerance trials

Maturity tests were conducted to determine levels of sucrose accumulation in experimental cultivars throughout the harvesting and milling season, which typically lasts from September to December but sometimes extends into January. The maturity profile of a clone can be important in determining the harvest schedule. Maturity tests were conducted by

researchers at the USDA–ARS Sugarcane Research Unit at Houma, LA. Plots were two rows, 10 m long, and replicated four times. A 10-stalk sample (five from each row) was taken monthly from the plant cane crop and biweekly from the first ratoon crop to monitor for sucrose accumulation. The analysis was performed at the USDA–ARS laboratory.

Plant growth regulators ("ripeners") have traditionally been used in Louisiana to enhance sucrose content in early-season harvested sugarcane. The ripener test was conducted at the Sugar Research Station in St. Gabriel, LA. The trial was planted as single-row, 10-m-long plots, each replicated four times. The ripener, glyphosate (RoundUp PowerMax II) at 0.21kg acid equivalence ha^{-1}, was applied in the plant cane crop on 12 Sept. 2017 and samples taken for laboratory analysis after 32 d. A 10-stalk sample was cut from each plot and processed at the Sugar Research Station sucrose laboratory.

Because sugarcane is grown under temperate climatic conditions in Louisiana, freezing temperatures can occur before the crop is harvested. Severe freezing temperatures, especially when followed by warm weather, can cause the cane to die and the sucrose to deteriorate. A freeze-tolerance test was conducted at the USDA–ARS Sugarcane Research Unit in Houma, LA, to determine freeze-tolerance characteristics of experimental cultivars after freezing. The test consisted of three-row plots, measuring 10m long, in a randomized complete block design with four replications. A 10-stalk sample was taken from the center row of the plant cane crop every week for 5 wk following subfreezing temperatures on 1 and 17 Jan. 2018 and analyzed at the USDA–ARS sucrose laboratory.

2.4 | Disease and insect reactions

The reaction of L 11-183 to endemic diseases and pests of importance to sugarcane in Louisiana was determined from observations in performance trials, propagation and distribution plots, and from controlled tests in artificially inoculated greenhouse and field trials.

To screen for resistance to smut (caused by *Sporisorium scitamineum* Syd. & P. Syd.), stalks from clones to be tested were stripped of leaves and dipped in a suspension of 5×10^6 smut teliospores ml^{-1} for 10 min and then planted immediately. Six stalks of each clone were used to plant a 4.9-m plot, with three replicates. The percentage of stalks with smut whips was determined in the plant cane crop and based on these data, a rating was assigned relative to the performance of commercial checks (standards) in the trial.

Screening for resistance to leaf scald [caused by *Xanthomonas albilineans* (Ashby) Dowson] used the same plots as for smut. Healthy plants not affected with smut within each plot were used for the test. The leaf whorl of the shoot was clipped by hand and the cut surface sprayed immediately with a freshly prepared suspension of *X. albilineans* taken from 10-d-old cultures and adjusted to approximately 10^8 colony-forming units ml^{-1}. Clones were visually inspected for leaf scald symptoms approximately 2 mo later, and a rating based on symptom severity was assigned.

Mosaic is a historically important disease of sugarcane in Louisiana. Mosaic can be caused by two viruses, *Sugarcane mosaic virus* or *Sorghum mosaic virus* of which the latter is the more prevalent strain found on sugarcane in Louisiana. Several evaluation trials were monitored for the development of symptoms of mosaic from natural spread of virus inoculum until the cultivar was released in 2018. The smut and leaf scald trial described above was also used to screen for natural spread of mosaic by aphid vectors of the virus. In the trial, mosaic-infected clones were interspersed (one row per two rows of experimental cultivars) to act as a close source of inoculum for spread by migrating aphids. An artificial inoculation test was also conducted jointly by researchers from the LSU AgCenter and the USDA–ARS Sugarcane Research Unit. Inoculum consisted of virus-infected symptomatic leaves macerated with 1 kg tissue in 4 L of 0.01 M potassium phosphate buffer at pH 7.5, with the homogenate filtered through cheesecloth. Carborundum was dusted onto leaves prior to inoculation. Thirty-day-old plants raised in Styrofoam flats in the greenhouse were inoculated by rubbing the leaves with a scouring pad dipped in the inoculum. Each clone was represented by six plants. Plants were observed for mosaic symptoms for about 48 d. Presence of the virus causing mosaic symptoms was confirmed in symptomatic plants by researchers at the USDA–ARS Sugarcane Research Unit at Houma, LA, using reverse transcription-polymerase chain reaction (RT-PCR) analysis.

For brown rust and orange rust [caused by *Puccinia kuehnii* (Kruger) E. Butler], observations were made in performance trials over several years during the spring and summer months when the conditions for rust development from natural infection were favorable, and resistance ratings were assigned based on symptom severity on young leaves.

Reaction of L 11-183 to *Sugarcane yellow leaf virus* (SCYLV) was determined by researchers at the USDA–ARS Sugarcane Research Unit at Houma, LA, in a natural spread test that included interspersed (3:1 ratio of experimental rows to spreader row) rows of infected plants. *Sugarcane yellow leaf virus* rarely produces visual symptoms until late in the growing season. Therefore, random leaf samples from the experimental cultivars were assayed by RT-PCR for infection by SCYLV (Grisham et al., 2010).

Reaction of L 11-183 to ratoon stunting [caused by *Leifsonia xyli* subsp. *xyli* (Davis et al. 1984) Evtushenko et al. 2000] was assessed by researchers at the USDA–ARS Sugarcane Research Unit. Seed cane of experimental cultivars were cut using a cane knife dipped in a suspension of *L. xyli* subsp. *xyli* cells and then planted in field trials. Susceptibility was based on the percentage of vascular bundles in stalks colonized

by the bacterium. Colonization levels were determined using tissue-blot immunoassay (Grisham & Hoy, 2017). Yield loss trials planted using infected versus non-infected (hot water treated) seed cane were also used to assess susceptibility as described by Grisham et al. (2009).

The resistance/susceptibility rating of L 11-183 to sugarcane borer, *Diatraea saccharalis* (F.) (Lepidoptera: Crambidae), was assessed in the plant cane (2018) and first ratoon cane (2019) crops at the Iberia Research Station. The rating was established by comparing borer infestation on L 11-183 relative to sugarcane cultivars with known levels of susceptibility or resistance according to Wilson et al. (2020). Trials were conducted under enhanced pest pressure, and data collection followed the methods of White et al. (2008) and Wilson et al. (2020). Data from both trials were analyzed together using generalized linear mixed models in SAS. Means were separated within years using Tukey's HSD.

2.5 | Botanical and molecular characterization

The botanical descriptions for L 11-183 were recorded using the plant cane crop in late August 2018 at approximately 170–180 d after spring emergence. The descriptions were based on 10 stalks taken from the middle row of a three-row plot that was 7.3 m long. The stalks were taken from the middle row to minimize the effect of environmental factors such as direct sunlight on stalk color. Quantitative measurements were based on an average of 10 stalks, morphological characteristics were according to Artschwager & Brandes (1958), and color was described based on Munsell Color (1977).

For the molecular characterization, 12 simple sequence repeat (SSR) markers known to generate maximum polymorphism among Louisiana clones (Parco et al., 2011) were used for fingerprinting to confirm the parentage of L 11-183 and to distinguish it from other commonly grown sugarcane cultivars in Louisiana. Polymerase chain reaction was performed as described above (Khan et al., 2013). Briefly, genomic DNA (50 ng) of L 11-183, its parents (HoCP 92-624 and LCP 85-384), and eight current Louisiana commercial sugarcane cultivars was used as templates in 10-µl PCR reactions containing 1× PCR buffer, 2.5 mM $MgCl_2$, 0.2 µM dNTP mix, 0.4 unit of Taq DNA polymerase (Promega), and 0.75 µM of each primer using a thermal profile of initial denaturation at 95 ˚C for 5 min, 35 cycles at 95 ˚C for 15 s, 58 ˚C for 15 s, and 72 ˚C for 30 s, and a final extension at 72 ˚C for 5 min. The PCR products were resolved in a 13% polyacrylamide gel using a HEGS electrophoresis apparatus (Nihon Eido). The gels were stained using ethidium bromide and visualized and documented in a Kodak Gel Logic200 gel documentation system (Carestream). The amplified fragments were manually scored as 1 for presence and 0 for absence. In addition, L 11-183 was screened for the presence of the brown rust resistance gene, *Bru1*, as described by Parco et al. (2014).

2.6 | Statistical analyses

Data were analyzed using the Proc Mixed procedure in SAS v. 9.4 (SAS Institute). Multilocation trials were analyzed by year (crop-year), with cultivars considered as fixed effects and locations and replications considered as random effects in the model. Least square means were generated for each cultivar, and pairwise differences between means were separated using the PDIFF option ($P = .05$). The data were also analyzed to determine the effect of soil type on cultivar performance, with cultivars and soil types considered as fixed effects and locations (nested within soil types) considered as random effects in the model. The slice option was used to partition cultivar and soil type effects from their interaction term, which provided a significance test ($P = .05$) of cultivar performance between soil types. Data from the 2018 third ratoon crop were excluded from the analyses because only five locations were harvested. Clustering based on the genetic similarity among the sugarcane clones including L 11-183 was analyzed using the Unweighted Pair Group Method with Arithmetic Mean module of the software NTSYS-pc v. 2.21 (Rohlf, 2000).

3 | CHARACTERISTICS

3.1 | Replicated yield trials

Results from replicated on-station yield trials conducted from 2012 to 2014 are shown in Table 2. As stated above, during the early stages of selection, HoCP 96-540 was considered the standard check cultivar; however, by the time L 11-183 was released in 2018, HoCP 96-540 was superseded by L 01-299 for two reasons. HoCP 96-540 succumbed to rust infection and L 01-299 tended to be very productive in the ratoon crops. In the plant cane crop, L 11-183 was not significantly different from any cultivar in sugar yield, cane yield, and sucrose content except 'L 99-226' (Bischoff et al., 2009), which had higher sucrose yield primarily because it was significantly higher in sucrose content. 'L 99-226' and 'HoCP 00-950' (Tew et al., 2009) are often included in tests to serve as the standard check cultivars for sucrose content. The results were generally similar in the first and second ratoon crops, except that L 11-183 had significantly higher sucrose content than HoCP 96-540 in the first and higher sugar yield and cane yield in the second ratoon crops. Except for L 99-226, which recorded significantly higher values for stalk weight in all crops, no significant differences were found between L 11-183 and the other cultivars for this trait. L 99-226 is among the highest in stalk weight among the

TABLE 2 Summary of on-station nursery trials conducted at three southern Louisiana locations from 2012 to 2014

Cultivar	Sugar yield	Cane yield	Sucrose content	Stalk weight	Stalk number
	Mg ha^{-1}		g kg^{-1}	kg	stalks ha^{-1}
Plant-cane crop means, 2012					
L 11-183	12.66	92.8	136.0	1.06	88,392
HoCP 96-540	12.52	91.5	137.0	1.13	81,102
L 99-226	16.55 +	111.2	149.0 +	1.35 +	82,973
L 01-299	12.65	90.8	139.0	0.98	92,689
L 03-371	13.67	100.2	136.0	0.92	109,134 +
HoCP 04-838	14.39	101.8	141.0	1.02	100,537
First-ratoon cane crop means, 2013					
L 11-183	13.56	106.0	128.5	1.01	105,771
HoCP 96-540	12.13	99.3	122.0 −	1.03	96,613
L 99-226	15.40	114.6	134.5 +	1.18 +	97,735
L 01-299	14.29	112.1	128.0	0.88 −	127,822
L 03-371	14.40	111.2	130.0	0.94	117,731
HoCP 04-838	12.87	98.0	131.5	0.85 −	116,048
Second-ratoon cane crop means, 2014					
L 11-183	9.59	83.6	115.5	0.82	103,715
HoCP 96-540	6.15 −	58.3 −	106.0	0.83	69,142 −
L 99-226	12.92 +	111.2 +	118.0	1.15 +	95,679
L 01-299	11.53	102.0	116.0	0.88	116,609
L 03-371	10.35	90.1	116.0	0.83	108,200
HoCP 04-838	9.99	86.1	118.0	0.79	108,946

Note. Values within a column that are significantly ($P = .05$) higher or lower than that for L 11-183 are denoted by + or −, respectively.

cultivars grown in Louisiana (Bischoff et al., 2009). Similar to other cultivars, the stalk weight of L 11-183 decreased in the older (ratoon) crops. Stalk number was significantly higher in L 11-183 than in HoCP 96-540 in the second ratoon but was equivalent to that of other cultivars in the older ratoon crops. Similar results were obtained in the off-station and infield trials conducted from 2013 (plant cane) through 2016 (third ratoon crop), especially when comparing L 11-183 with HoCP 96-540 (data not shown).

L 11-183 was tested in the outfield stage in the plant cane (2015) through the third (2018) ratoon crops (Table 3). L 11-183 was replanted into the outfield trial every year it remained active as an experimental clone. Consequently, 4 yr of plant cane, 3 yr of first ratoon, 2 yr of second ratoon, and 1 yr of third ratoon crop data were available from the outfield testing stage (Table 3). L 11-183 produced significantly more sugar yield in the plant cane, first, second, and third ratoon crops than HoCP 96-540 but significantly less sucrose yield than L 01-299 and several commercial cultivars in the second (L 01-299 and 'HoCP 09-804' [Todd et al., 2019]) and third (L 01-299, HoCP 09-804, and 'HoCP 04-838' [Todd et al., 2018]) ratoon crops. L 11-183 yielded significantly more cane yield than L 01-299 in the plant cane but significantly less than L 01-299 in the remaining crops. Only one other commercial cultivar (HoCP 09-804) produced significantly more cane yield than L 11-183 in the third ratoon crop. In the plant crop, L 11-183 produced significantly more sucrose content than HoCP 96-540, L 01-299, and HoCP 04-838 but significantly less sucrose content than HoCP 00-950. In the first ratoon crop, L 11-183 produced significantly more sucrose content than HoCP 96-540 and HoCP 04-838. In the second and third ratoon crops, the sucrose content for L 11-183 was comparable to that of HoCP 96-540 but significantly less than that of the other commercial cultivars. Stalk weight was significantly higher in L 99-226 than in L 11-183 in all crops except the plant cane crop. Compared with the other commercial cultivars, L 11-183 had stalk weight that was either similar or significantly higher than that of the other cultivars.

Stalk number is an important trait in sugarcane in Louisiana as it is considered an indicator of ratooning ability. Although stalk number and stalk weight both influence cane yield, stalk number is easier to visualize and appraise during selection and is cheaper to measure. When planted as whole stalk, L 11-183 establishes quickly and produces significantly more stalks (plant cane) than HoCP 96-540 and as many stalks as L 01-299 (Table 3). However, the cultivars L 01-299, 'L 01-283' (Gravois et al., 2010), and HoCP 09-804 are considered to have excellent ratooning ability because of their ability

TABLE 3 Summary of outfield trials conducted at 12 southern Louisiana locations from 2015 to 2018[a]

Cultivar	Sugar yield	Cane yield	Sucrose content	Stalk weight	Stalk number
	Mg ha^{-1}		g kg^{-1}	kg	stalks ha^{-1}
Plant-cane crop means, 2015–2018 (34) [b]					
L 11-183	10.77	73.1	147.5	1.09	67,798
HoCP 96-540	10.23 –	72.6	141.0 –	1.21 +	61,139 –
L 99-226	10.48	69.5	150.5	1.31 +	53,624 –
HoCP 00-950	10.58	67.5 –	157.5 +	1.03	64,845
L 01-283	10.25 –	68.6 –	149.5	0.92 –	75,607 +
L 01-299	10.07 –	69.7 –	144.5 –	1.01 –	70,114
HoCP 04-838	10.56	73.3	144.0 –	0.98 –	75,987 +
Ho 07-613	11.00	74.0	149.0	1.09	68,764
HoCP 09-804	10.50	71.1	148.0	0.84 –	85,276 +
First-ratoon cane crop means, 2016-2018 (23)					
L 11-183	9.68	64.1	152.0	0.91	71,618
HoCP 96-540	8.87 –	60.8	147.0 –	0.95	64,672 –
L 99-226	9.68	62.3	156.5 +	1.07 +	58,638 –
HoCP 00-950	8.58 –	53.6 –	162.5 +	0.79 –	66,041 –
L 01-283	9.55	61.9	155.0 +	0.77 –	81,149 +
L 01-299	10.20	67.7 +	151.5	0.83 –	81,616 +
L 03-371	8.99	58.5	154.5	0.83 –	70,346
HoCP 04-838	9.07 –	61.6	148.0 –	0.80 –	76,738 +
Ho 07-613	9.30	60.1 –	155.5 +	0.91	65,863 –
HoCP 09-804	9.51	62.5	153.0	0.69 –	89,845 +
Second-ratoon cane crop means, 2017-2018 (11)					
L 11-183	7.60	54.7	140.5	0.80	71,354
HoCP 96-540	6.78 –	49.3 –	138.0	0.96 +	63,343 –
L 99-226	7.82	52.5	148.5 +	0.73	55,861 –
HoCP 00-950	7.37	46.9 –	157.5 +	0.69 –	64,746
L 01-283	8.33	55.1	151.0 +	0.73	80,544 +
L 01-299	8.77 +	61.0 +	144.5 +	0.73	84,937 +
L 03-371	7.74	52.2	149.0 +	0.68 –	72,632
HoCP 04-838	7.60	52.9	143.5	0.76	78,377
Ho 07-613	6.89	46.4	149.0 +	0.62 –	62,535 –
HoCP 09-804	8.36 +	56.7	147.5 +	0.80	91,802 +
Third-ratoon cane crop means, 2018 (5)					
L 11-183	7.36	61.6	122.0	0.93	67,874
HoCP 96-540	5.13 –	45.2 –	118.0	1.02	44,360
L 99-226	7.97	63.7	129.5 +	1.17 +	55,086
HoCP 00-950	8.75	61.9	139.5 +	0.86	72,470
L 01-283	8.69	66.4	133.5 +	0.84	79,202
L 01-299	10.82 +	84.2 +	129.5 +	0.80	106,573 +
HoCP 04-838	9.13 +	68.8	132.5 +	0.90	77,311
Ho 07-613	5.98	44.7 –	134.5 +	0.92	50,059 –
HoCP 09-804	10.10 +	75.7 +	134.0 +	0.72 –	106,495 +

Note. Values within a column that are significantly ($P = .05$) higher or lower than that for L 11-183 are denoted by + or –, respectively.

[b]Numbers in parentheses represent the total number of trials in which L 11-183 was harvested. L11-183 was replanted into the outfield trial every year that it remained active as an experimental cultivar, hence the difference in number of trials within each crop. Also, due to unforeseen circumstances, not all 12 locations or crops within a location were harvested, hence the disparity with the expected number of locations or crops.

TABLE 4 Summary of outfield trials conducted at six light- and six heavy-textured soil locations in the Louisiana sugar industry

Cultivar	Sugar yield	Cane yield	Sucrose content	Stalk weight	Stalk number
	Mg ha^{-1}		g kg^{-1}	kg	stalks ha^{-1}
Light-textured soil type					
L 11-183	10.38	74.9	139.1	1.04	73,024
HoCP 96-540	8.48 –	63.3 –	134.3 –	1.05	61,516 –
L 99-226	8.84 –	60.3 –	147.3 +	1.11 +	54,680 –
HoCP 00-950	8.39 –	54.9 –	154.2 +	0.82 –	67,120 –
L 01-283	9.92	68.9 –	145.4 +	0.86 –	81,875 +
L 01-299	10.28	74.1	140.0	0.90 –	84,937 +
HoCP 04-838	9.72	69.9 –	140.4	0.89 –	79,881 +
Ho 07-613	8.83 –	60.6 –	146.4 +	0.95 –	64,172 –
HoCP 09-804	10.25	71.0	145.3 +	0.77 –	94,651 +
Mean	9.42	66.5	143.6	0.93	73,540
Heavy-textured soil type					
L 11-183	9.53	65.6	146.2	1.00	66,840
HoCP 96-540	8.10 –	58.7 –	137.5 –	0.96	62,221
L 99-226	7.72 –	51.8 –	148.9	0.93 –	58,112 –
HoCP 00-950	7.13 –	45.0 –	158.5 +	0.73 –	61,689
L 01-283	8.88	59.0 –	150.4 +	0.78 –	76,688 +
L 01-299	9.05	63.0	144.2	0.86 –	75,168 +
HoCP 04-838	8.26 –	58.2 –	142.2	0.81 –	72,876 +
Ho 07-613	7.86 –	52.6 –	149.3	0.82 –	64,648
HoCP 09-804	8.97	60.8	148.01	0.73 –	84,154
Mean	8.35	57.2	147.3	0.84	69,154
Test (Pr > *F*) of cultivar mean difference between light- and heavy-textured soil types					
L 11-183	.19	.07	.18	.46	.21
HoCP 96-540	.62	.35	.52	.14	.88
L 99-226	.09	.10	.75	.00 *	.48
HoCP 00-950	.05	.06	.41	.12	.27
L 01-283	.10	.05	.32	.12	.27
L 01-299	.05	.03 *	.41	.42	.04 *
HoCP 04-838	.02 *	.02 *	.71	.14	.14
Ho 07-613	.13	.12	.58	.02 *	.92
HoCP 09-804	.04 *	.04 *	.59	.45	.03 *

Note. Soils in the Louisiana sugar industry are classified into two broad categories, namely light- and heavy-textured soils. Values within a column that are significantly ($P = .05$) higher or lower than that for L 11-183 are denoted by + or –, respectively.

*The difference in a cultivar's performance between the light- and heavy-textured soil was significantly different from 0 at the .05 level.

to retain comparatively high numbers of stalks in the ratoon crops (Table 3). The stalk number of L 11-183 was significantly less than that of HoCP 09-804 in all crops, the stalk number of L 01-299 in all crops except the plant cane crop, and the stalk number of L 01-283 in all crops except the third ratoon. Averaged across 51 samples, the fiber content of L 11-183 was 11.8%, which was slightly lower than that of L 01-299 (12.0%). Field observations throughout the selection and testing process revealed L 11-183 to be no more susceptible to herbicides commonly used for weed control in sugarcane than either HoCP 96-540 or L 01-299.

To simplify the cultivar selection and testing process, soil types in the Louisiana sugar industry are classified into two broad categories, light- and heavy-textured soils (Table 4). Louisiana sugarcane growers have generally reported less profitability on heavy- than light-textured soils. This agrees with the results of this study, where cultivars performed better under light- than heavy-textured soils for most traits except sucrose content (Table 4). Heavy-textured soils are estimated to occupy about 30–35% of the industry (Herman Waguespack, personal communication, 2018). Both soil categories are present on some large farming enterprises.

Profitability could be increased by developing and deploying cultivars adapted to specific soil types. However, due to lack of resources, there has been no deliberate attempt by the cultivar development program to breed and select sugarcane cultivars adapted to a specific soil type. This explains why cultivar performance between the light- and heavy-textured soils did not differ significantly for most of the cultivars (Table 4). Averaged across six light soil locations, L 11-183 produced significantly more sugar and cane yield than HoCP 96-540, L 99-226, HoCP 00-950, and 'Ho 07-613'; more cane yield than HoCP 04-838; more sucrose than HoCP 96-540; heavier stalks than L 01-283, HoCP 00-950, L 01-299, HoCP 04-838, Ho 07-613, and HoCP 09-804 and, more stalks than HoCP 96-540, L 99-226, HoCP 00-950, and Ho 07-613. L 11-183 produced significantly less sucrose than the two standard sucrose checks (L 99-266 and HoCP 00-950) as well as L 01-283, Ho 07-613, and HoCP 09-804. The results from the heavy-textured soil locations were mostly similar as for the light-textured soil locations, with L 11-183 performing better than the same group of cultivars and for the same traits. Therefore, L 11-183 is suitable for cultivation on both soil types when compared with the other cultivars.

3.2 | Maturity, ripener, and freeze tolerance trials

In Louisiana, sugarcane is grown in a temperate climate where plant-killing freezes and dormancy periods are expected to occur every year, and the plants must survive the winter, reestablish in the spring, and produce a profitable crop within 7–9 mo (Gravois et al., 2016). Under severe freezing conditions, plants tend to die and the stored sucrose begins to deteriorate. Consequently, earlier starting dates for sugarcane harvesting are now more common in Louisiana. The application of plant growth regulators (ripeners) is also necessary to enhance sucrose content levels in early-harvested cane. Results from the maturity trials are presented in Table 5, whereas Table 6 compares the effect of ripener on L 11-183 relative to other Louisiana cultivars. The results from the maturity tests were consistent across crops and years; therefore, only the results averaged from the plant cane crops are presented. HoCP 00-950 is considered an early-maturing cultivar in Louisiana (Tew et al., 2009). At the earliest harvest dates in September, L 11-183 had accumulated significantly less sucrose content than HoCP 00-950, L 01-283, Ho 07-613, and HoCP 04-838 but similar levels of sucrose compared with HoCP 96-540 and L 01-299 (Table 5). By accumulating 40% more sucrose by the last harvest date in November, L 11-183 had sucrose content not significantly different from that in HoCP 96-540, L 01-299, HoCP 04-838, and HoCP 04-804 but significantly less than that in HoCP 00-950, L 01-283, and Ho 07-613. Therefore, L 11-183 cannot be considered an early-maturing cultivar and could benefit from ripener application depending upon its response. At 32 d after ripener application, the increase in sucrose content for L 11-183, L 01-299, Ho 07-613, and HoCP 09-804 was 10.7, 13.8, 7.2 and 22.9%, respectively (Table 6). Therefore, the response of L 11-183 was rated moderate compared with the other cultivars in the trial.

In 2018, Louisiana experienced freezing temperatures on 1 January (−5.0 ˚C) and 17 January (−7.9 ˚C) that lasted for longer than 24 h. Sucrose content decreased significantly for every cultivar and, on average, decreased by 40% across all cultivars between the 3–31 January sampling dates (Table 7). The least amount of decrease in sucrose content was recorded by HoCP 04-838, the freeze tolerance check (Todd et al., 2018), and the largest decrease in sucrose content was exhibited by 'TucCP 77-042' (Mariotti et al., 1991), whereas the response for L 11-183 fell in the middle. Similarly, the least amount of change in pH and titratable acidity (g/L) (basic to acidic) was recorded in HoCP 04-838, while L 11-183 was

TABLE 5 Maturity test (harvest dates) comparing sucrose content of L 11-183 with eight commercial cultivars averaged across the plant cane crops during the 2016 and 2017 seasons

Cultivar	Sucrose content [b]			Increase [a]
	Sept.	Oct.	Nov.	
	g kg^{-1}			%
L 11-183	108	135	152	40.7
HoCP 96-540	103	130 –	150	43.5
HoCP 00-950	137 +	154 +	164 +	25.0
L 01-283	125 +	145 +	158 +	30.6
L 01-299	102	130 –	149	43.5
HoCP 04-838	119 +	141 +	152	30.6
HO 07-613	125 +	148 +	161 +	33.3
HoCP 09-804	128 +	145 +	152	22.2
Avg.	118	141	155	34.3

Note. Cultivars with values that are significantly higher or lower ($P = .05$) than that of L 11-183 are denoted by a + or −, respectively. Harvest dates were 26 Sept. 2016 and 25 Sept. 2017, 24 Oct. 2016 and 23 Oct. 2017, and 21 Nov. 2016 and 20 Nov. 2017.

[a]Increase in sucrose content between September and November.

TABLE 6 Effect of Roundup PowerMax II applied at 0.37 kg ha^{-1} on enhancing sucrose content in L 11-183 and three commercial cultivars of sugarcane in Louisiana

Cultivar	Untreated	Treated	Increase
	g kg^{-1}		%
L 11-183	104	115	10.7
L 01-299	104	117	13.8
Ho 07-613	129	138	7.2
HoCP 09-804	112	137	22.9

[a]Treatments applied 12 Sept. 2017 and hand harvested 10 Oct. 2017.

TABLE 7 Post-freeze changes in sucrose content of L 11-183 and eight cultivars in the plant-cane crop following subfreezing temperatures on 1 Jan. (−5.0 ˚C) and 17 Jan. (−22.1 ˚C) 2018

Cultivar	Sucrose content					Rank	Change[a]	
	3 Jan.	10 Jan.	19 Jan.	24 Jan.	31 Jan.		Difference	%
	g kg^{-1}							
L 11-183	131.5 A	124.0 AB	119.0 B	103.0 C	81.0 D	5	−50.5	−38.6
TucCP 77-42	117.5 A	106.0 B	97.5 C	87.0 D	50.5 E	9	−67.0	−56.9
HoCP 96-540	127.0 A	117.5 B	115.5 B	105.0 C	85.0 D	2	−42.0	−33.0
HoCP 00-950	134.5 A	124.0 B	126.0 AB	105.5 C	76.5 D	8	−58.0	−43.2
L 01-283	130.5 A	111.5 BC	119.0 AB	100.0 C	80.0 D	3	−50.5	−38.4
L 01-299	130.5 A	116.5 B	110.0 BC	99.5 C	74.0 D	7	−56.5	−43.4
HoCP 04-838	129.0 A	112.0 B	113.5 B	109.5 B	90.5 C	1	−38.5	−29.7
Ho 07-613	134.0 A	123.0 B	121.0 B	105.5 C	83.5 D	4	−50.5	−37.6
HoCP 09-804	134.0 A	116.5 B	119.5 B	103.5 C	78.0 D	6	−56.0	−41.8
Average	129.5 A	116.5 B	115.1 B	102.5 C	77.5 D		−52.0	−40.1

[a]Values within a row accompanied by different letters are significantly ($P = .05$) different from each other.
[b]Change in sucrose content between the initial and final sampling dates.

TABLE 8 Disease and insect reactions of L 11-183 and other commercial sugarcane cultivars

Cultivar	Mosaic [a]	Sugarcane yellow leaf	Smut	Brown rust	Leaf scald	Ratoon stunting	Sugarcane borer [b]
L 11-183	MS	MR	R	MS	MR	MR	S
HoCP 96-540	R	S	R	S	R	S	S
L 99-226	MR	R	MS	S	MS	S	MR
HoCP 00-950	R	R	R	R	R	S	S
L 01-283	R	S	R	S	R	S	S
L 01-299	R	S	S	R	R	S	R
HoCP 04-838	R	MS	R	R	MR	R	R
HoCP 09-804	S	R	MS	S	MS	MS	MS

Note. R, resistant; MR, moderately resistant; S, susceptible; MS, moderately susceptible.
[a]Mosaic can be caused by two viruses, *Sugarcane mosaic virus* or *Sorghum mosaic virus* of which the latter is the more prevalent strain found on sugarcane in Louisiana.
[b]Reported by Wilson et al., 2018.

either among the highest for change in pH or around the middle for change in titratable acidity (data not shown). The new cultivar L 11-183 is, therefore, predisposed to sustaining moderate to high levels of juice deterioration when exposed to freezing temperatures.

3.3 | Diseases and insect reactions

L 11-183 was found to be resistant to smut, moderately resistant to leaf scald, *Sugarcane yellow leaf virus*, and ratoon stunting disease and moderately susceptible to brown rust and mosaic (Table 8). The mosaic ratings are from inoculated tests. Little to no mosaic was reported in L 11-183 following a survey of multiple increase and distribution plots of the cultivar. Orange rust has not been observed on L 11-183 in Louisiana. Generally, the pathogens of diseases such as smut and ratoon stunting disease are systemic in the stalk before planting, and some level of control can be achieved through a "healthy" seed cane program whereby the seed cane is subjected to a hot-water treatment at 50 ˚C for 2 h (Croft & Cox, 2013). Similar outcomes can be achieved also using apical meristem tissue culture-mediated micropropagation (Hoy et al., 2018).

Reaction to the sugarcane borer indicate that L 11-183 is susceptible to the insect, more like HoCP 96-540 than the resistant cultivar L 01-299 (Wilson et al., 2018). L 11-183 should be considered susceptible to the sugarcane borer. This cultivar will require insecticidal protection in many situations and should not be planted in areas where aerial application is not possible. Field observations indicate that the cultivar is also attractive to yellow sugarcane aphids.

TABLE 9 Botanical descriptions of L 11-183 as determined at the Sugar Research Station in St. Gabriel, LA, in 2018

Trait	L 11-183
Stalk height, cm	241 ± 7.96
Stalk diameter, mm	25.9 ± 1.67
Leaf shape	drooping
Leaf length, cm	154 ± 5.70
Leaf width, cm	2.8 ± 0.24
Stalk bud shape	round
Auricle shape	long lanceolate
Auricle length, mm	13 ± 2.77
Internode	
Length, cm	17.0 ± 2.11
Shape	cylindrical to conoidal
Waxiness	moderate
Growth ring width, mm	3.8 ± 0.41
Root band width, mm	6.5 ± 0.96
Dewlap	squarish deltoid
Ligule shape	crescent with broad lozenge
Leaf sheath	no pubescence on green leaves

Note. Stalk and leaf measurements are reported as means (±standard deviation) averaged across 10 stalks. Stalk height was measured from the ground to the top visible dewlap. Stalk diameter and internode lengths were means taken from the fourth internode above ground level. Growth ring, root band, and bud measurements and descriptions were from the fourth internode above ground level. Leaf measurements were from the top visible dewlap. Auricle and ligule measurements and descriptions were taken from five nodes below the top visible dewlap.

3.4 | Botanical and molecular characterization

The botanical description of L 11-183 following Artschwager & Brandes (1958) is presented in Table 9. The average height and diameter of mature stalks of L 11-183 were 241 ± 7.9 and, 2.59 ± 0.17 cm, respectively. L 11-183 has a drooping canopy similar to that of L 01-299 and HoCP 96-540. The leaf blades are smooth with no pubescence and acuminate in appearance, with an average length and width of 154 ± 5.7 and 2.8 ± 0.24 cm, respectively. The margins on the leaf blade are slightly serrated. The midribs appear concave and whitish in color on the adaxial side and raised and similar in color to the leaf blade on the abaxial side. The outside surface of the leaf sheaths is smooth (no pubescence) and green but with distinctly necrotic margins. Similar to L 01-299, the leaf sheaths of L 11-183 have little to no wax, unlike HoCP 96-540, which has moderate to heavy wax bloom. The leaf sheaths adhere more tightly to the stalk than those of L 01-299. Auricles are prominent on L 11-183. They measure about 1.3 ± .027 cm in length, are long and lanceolate in shape, have no pubescence, and are distinctly necrotic. The ligules are crescent with broad lozenge in shape, are tan to brownish in color, and also have no pubescence. The dewlap of L 11-183 is squarish deltoid in shape with a dark green color.

The stalks of L 11-183 are covered with a moderate to heavy white wax bloom that does not rub off easily. However, L 11-183 is not as waxy as HoCP 96-540. The predominant stem color of L 11-183 under the wax is green with a yellow tint that becomes purple when exposed to direct sunlight. The internodes on the stem are cylindrical to conical in shape and measured 17.0 ± 2.1 cm in length with no bud furrows or growth cracks. The growth ring (intercalary meristem) and root band measured 0.38 ± 0.04 and 0.65 ± 0.01 cm, respectively, with minimal root primordia present. The buds of L 11-183 are located just above the leaf scar, lack pubescence, are round with a central germ pore, and have a yellowish green color. They are raised above the surface of the root band but do not project above the growth ring. There is a prominent wax ring below the leaf scar measuring about 1.0 ± 0.02 cm.

Similar to L 01-299 and HoCP 96-540, controlled photoperiod treatments are usually required to induce L 11-183 to flower in Louisiana. L 11-183 flowers easily, on average within 82 ± 5 d (Daigle & Kimbeng, 2018). L 11-183 tends to produce less pollen than L 01-299 and HoCP 96-540, two abundant pollen producers. Accordingly, L 01-299 and HoCP 96-540 have predominantly been used as males, whereas L 11-183 is used as a female for crossing in the LSU AgCenter sugarcane cultivar development program.

The parentage and identity of L 11-183 was confirmed by several alleles generated by SSR primers (Figure 2). For example, an ~760-bp fragment amplified by CA119212 was present in L 11-183 and its female parent HoCP 92-624 but absent in the male parent LCP 85-384. This fragment also distinguished L 11-183 from other sugarcane cultivars except HoCP 04-804. Similarly, one fragment amplified by SCES0792 was present in L 11-183 and its male parent LCP 85-384 but absent in the female parent HoCP 92-624. This fragment was unique to L 11-183 along with LCP 85-384 and L 01-299. Another allele generated by SCES0890 was present only in L 11-183 and its male parent LCP 85-384. Although no fragment was uniquely present or absent in L 11-183, several combinations of fragments distinguish L 11-183 from the other cultivars.

Cluster analysis using alleles generated with SSR primers grouped the cultivars into two major clusters, I and II (Figure 3). L 11-183 grouped with its female parent HoCP 92-624 in a sub-cluster IA at 78% similarity. The male parent LCP 85-384 was in the same cluster as L 11-183 at 59% similarity and also close to the sub-cluster IB containing 'L 12-201' and HoCP 96-540 (Figure 3). HoCP 96-540 is a progeny of LCP 85-384, and L 12-201 is a progeny of HoCP 96-540.

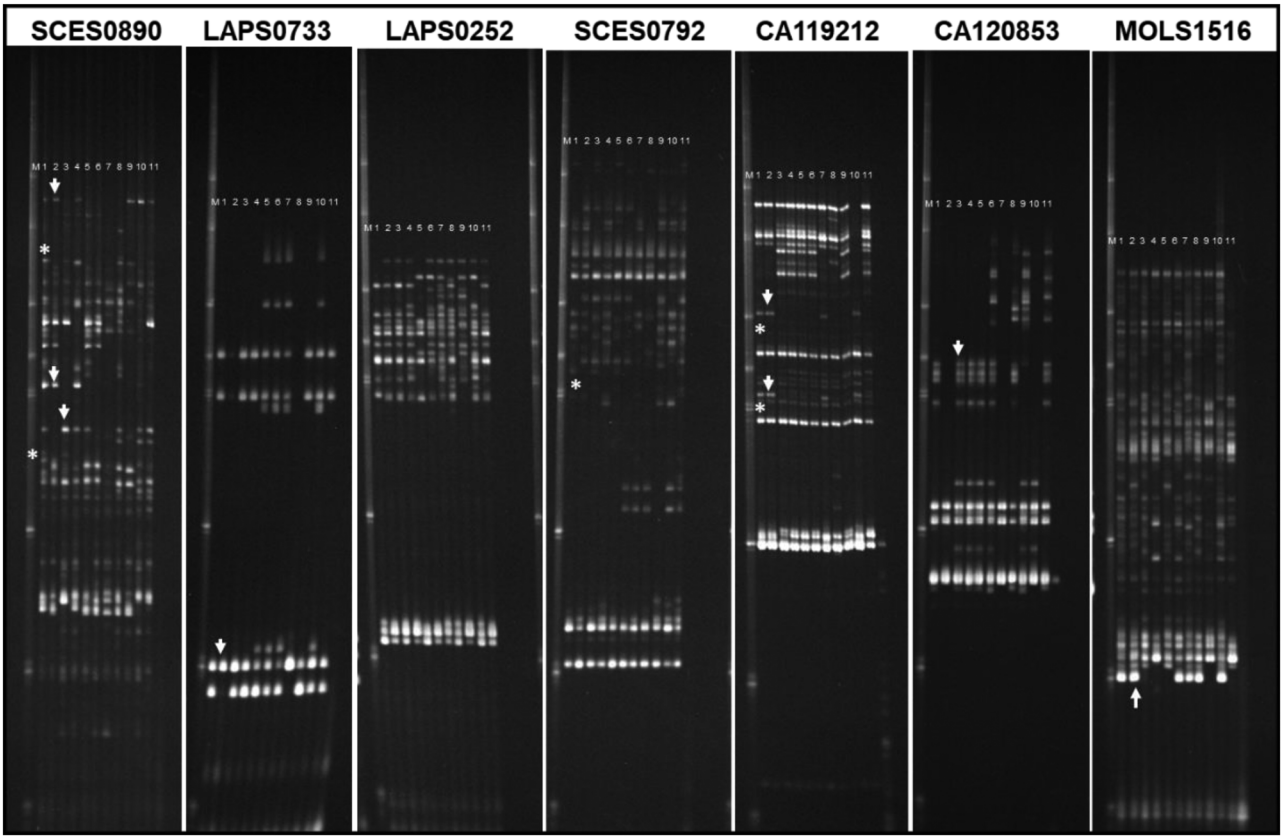

FIGURE 2 Representative gel picture showing simple sequence repeat (SSR)-generated alleles confirming the parentage (represented by arrowheads) and shared uniqueness (represented by asterisks) of L 11-183. M = 1-kb DNA ladder, 1 = L 11-183, 2 = HoCP 92-624, 3 = LCP 85-384, 4 = HoCP 96-540, 5 = L 01-299, 6 = L 01-283, 7 = HoCP 09-804, 8 = HoCP 04-838, 9 = Ho 12-615, 10 = Ho 13-739, 11 = L 12-201

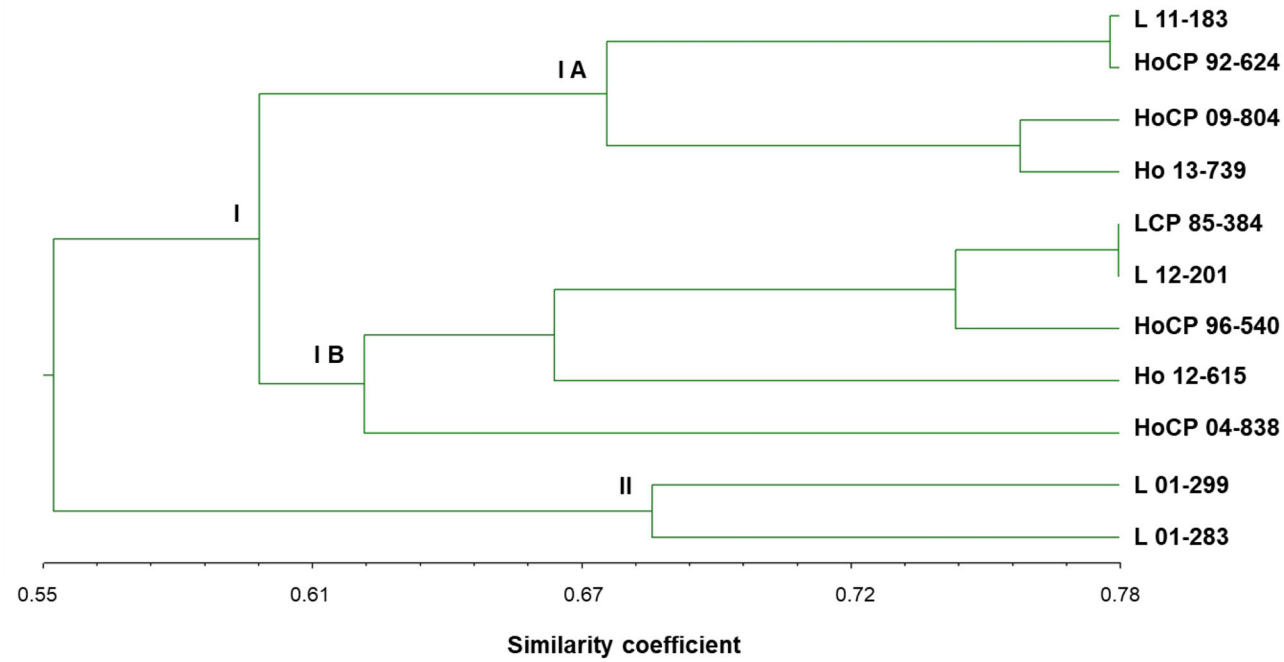

FIGURE 3 Dendrogram showing L 11-183 in the same subcluster as its female parent HoCP 92-624 and placed in the same cluster but a different subcluster containing the male parent LCP 85-384

4 | AVAILABILITY

Small quantities of seed cane (vegetative stalks) for research purposes may be obtained at the LSU AgCenter, Sugar Research Station, where L 11-183 will be maintained for at least five years from the date of this publication. Seed cane for commercial plantings can be obtained from the American Sugar Cane League of the U.S.A., Inc. It is not anticipated that a plant patent will be sought for L 11-183.

ACKNOWLEDGMENTS

L 11-183 was developed with financial support from the LSU AgCenter and the American Sugar Cane League. During the course of its development, personnel (too numerous to mention) from the Sugarcane Variety Development Programs of the LSU AgCenter, USDA–ARS, and American Sugar Cane League participated in a cooperative effort toward the release of L 11-183. All are gratefully acknowledged.

AUTHOR CONTRIBUTIONS

M. J. Pontif: Conceptualization, Data curation, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing-original draft, Writing-review & editing; C. A. Kimbeng: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing-original draft, Writing-review & editing; K. P. Bischoff: Data curation, Investigation K. A. Gravois: Conceptualization, Data curation, Funding acquisition, Investigation, Methodology, Writing-review & editing; C. M. LaBorde: Data curation, Investigation, Resources, Validation; G. L. Hawkins: Data curation D. R. Sexton: Data curation, Investigation, Methodology J. W. Hoy: Data curation, Methodology, Resources, Validation, Writing-review & editing; N. Baisakh: Data curation, Formal analysis, Investigation, Writing-review & editing; B. E. Wilson: Data curation, Investigation, Methodology, Resources, Validation, Writing-review & editing; A. J. Orgeron: Data curation, Investigation, Methodology, Validation, Writing-review & editing; J. R. Todd: Data curation, Investigation, Methodology, Resources, Validation, Writing-review & editing; H. L. Waguespack: Data curation, Investigation.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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How to cite this article: Pontif MJ, Kimbeng CA, Bischoff KP, et al. Registration of 'L 11-183' sugarcane. *J Plant Regist*. 2021;*15:*447–462. https://doi.org/10.1002/plr2.20136