THE DEVELOPMENT OF NEW SUGARCANE VARIETIES AT THE LSU AGCENTER

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ABSTRACT

The primary objective of the Louisiana State University (LSU) Agricultural Center’s (AgCenter) sugarcane (Saccharum spp. hybrids) variety development program is to develop improved varieties for the Louisiana sugarcane industry. Each year, 300 to 600 crosses are made at the sugarcane breeding facilities of the LSU AgCenter’s St. Gabriel Research Station at St. Gabriel, Louisiana. This begins a process of selection, advancement, and testing spanning a period of 12 years culminating with the release of new sugarcane varieties for Louisiana’s sugarcane growers and processors. Although the main goal of the program has never changed, procedures and techniques have evolved and improved over the years. This paper will document and outline the procedures and techniques used by personnel in the LSU AgCenter’s sugarcane variety development program.

INTRODUCTION

The development of improved sugarcane varieties has been a major factor in sustaining a competitive sugarcane industry in Louisiana. Sugarcane breeding efforts in Louisiana are the result of cooperative efforts among three organizations: the LSU AgCenter, the United States Department of Agriculture – Agricultural Research Service (USDA-ARS), Sugarcane Research Unit, and the American Sugar Cane League. Both the LSU AgCenter and the USDA-ARS Sugarcane Research Unit conduct commercial sugarcane breeding programs in Louisiana. The American Sugar Cane League, Louisiana’s sugarcane grower’s and processor’s organization, contributes through financial support and personnel who assist in the outfield testing stage and have primary responsibility for seed increase on grower farms. The cooperative efforts are outlined in the Three-way Agreement of 1978.

The ultimate goal of sugarcane breeding is to develop genetically improved varieties that have a positive impact on the sugar industry. Significant progress has been made in Louisiana in improving sugarcane varieties, particularly with regard to high sucrose content and earliness to maturity (Breaux, 1984). Following the release of LCP 85-384 (Milligan et al., 1994) in 1993, Louisiana’s sugar industry achieved a substantial increase in cane yield and ratoon crop longevity. Increases in the levels of resistance to sugarcane mosaic virus (Breaux, 1985), sugarcane smut (Ustilago scitaminea Sydow), (Chao et al., 1989; Chao et al., 1990), and rust (Puccinia melanocephala H. And P. Syd.) have also been achieved. More recently in the early 1990’s, sugarcane leaf scald [Xanthomonas albilineans (Ashby) Dowson] disease was found in Louisiana and progress is being made toward breeding new varieties with resistance to this disease.
Some researchers have also proposed breeding for ratoon stunting disease (Clavibacter xyli subsp. xyli) resistance (Miller et al., 1996; Comstock et al., 1997). Sugarcane diseases are controlled almost exclusively through the use of resistant varieties (Breaux, 1985; Benda, 1987).

The release of LCP 85-384 has increased the acreage planted to varieties susceptible to the sugarcane borer [Diatraea saccharalis (Fabricius)]. Increases in the levels of resistance to the sugarcane borer (Bessin et al., 1990; Reagan and Martin, 1989) should be addressed in future variety releases as a means of decreasing insecticide usage to decrease the potential of sugarcane borer resistance to insecticides.

Each year about 400,000 viable sugarcane seed are produced during the crossing season at the LSU AgCenter’s sugarcane variety development program. Due to greenhouse capacity and land constraints at the St. Gabriel Research Station, only 100,000 of these can be used, with the remaining seed placed in cold storage for possible future use. Planting of seed in the greenhouse begins a 12-year process of selection, advancement, and testing that will hopefully provide a new sugarcane variety for Louisiana’s sugar producers. Table 1 outlines the various stages of the LSU AgCenter’s sugarcane variety development program and the number of clones in each stage as shown by the most recent variety release L 97-128. The following discussion will cover sugarcane crossing through variety release.

CROSSING

Hybridization of sugarcane in Louisiana is difficult because it does not flower naturally in Louisiana because of cool fall temperatures. The ability to produce true sugarcane seed from crosses made in Louisiana was demonstrated in the early 1950's under the leadership of Dr. St. John Chilton of the LSU Plant Pathology and Crop Physiology Department. He developed photoperiod treatments that induced sugarcane flowering, making sugarcane crossing and the production of true seed possible in Louisiana.

The first step in variety improvement is accomplished by hybridization (Breaux, 1987; Heinz and Tew, 1987). All crossing is done at the greenhouse complex at the St. Gabriel Research Station. The breeding population consists of varieties of proven parental value and advanced experimental clones. To ensure that a broad genetic base (Deren, 1995 and Birding and Roach, 1987) is maintained in the Louisiana sugarcane breeding population, promising hybrids of Louisiana varieties are crossed among themselves, with foreign commercial varieties, and with promising wild-derived near commercial hybrids involving Louisiana varieties and related Saccharum species acquired from the USDA-ARS basic breeding program at Houma, Louisiana.

Photoperiod facilities are used to induce sugarcane to flower in Louisiana before cool fall temperatures arrive (Figure 1). To begin the photoperiod process, vegetative nodal cuttings of varieties that will be used as parents in the upcoming crossing campaign are planted in greenhouse trays in October. Large containers (38 liter) are filled with a
mixture of one part field soil, one part washed sand, and one part peat moss. The nodal cuttings of new parents are transplanted into the containers during the month of January. The containers are kept in the greenhouse until April and then moved to the photoperiod carts.

Sugarcane is an intermediate-day plant that will flower in response to gradually increased night lengths. Flowering is induced by imposing differential photoperiod treatments (June-September) prearranged to synchronize the flowering of all the sugarcane clones intended for use as parents in the breeding campaign. Clones are placed on photoperiod carts and assigned photoperiod regimes according to flowering type. Photoperiod treatments in the LSU AgCenter’s sugarcane variety development program begin on May 31st each year. Sugarcane clones that have difficulty flowering are given a longer (41 days vs. 35 days) induction treatment (12 hour 30 minute) and longer decline period (one minute per day). Thus, sugarcane clones flower in Louisiana beginning in mid-September through mid-November before cold temperatures inhibit flowering. The response to photoperiod treatment is heritable (Imran et al., 1988). This approach has produced a high degree of flowering in the LSU AgCenter’s sugarcane crossing program.

In early August, air layers (marcots) are placed on the lower portion of the stalk to allow for rooting to develop (Figure 2). Milled sphagnum moss is used to fill the air layers. Rooting within the air layers begins within the first week. The air layers enable stalks to be cut from the containers and taken into the crossing house. Miller and Tai (2000) and Dunkleman and Legendre (1982) showed the improved seed production from flowering sugarcane stalks that have been air layered compared to stalks maintained in weak acid solutions.

Tassels that emerge during September through mid-November are used for crossing in the crossing house located at the St. Gabriel Research Station (Figure 2). Crossing is conducted in isolation cubicles, which prevents pollen contamination between crosses (Figure 3). Up to three female clones are placed in the same crossing cubicle with a single male clone. Female clones are determined by their absence or small quantity of pollen produced. Some selfing does occur in sugarcane, but McIntyre and Jackson (2001) found selfing, under Australian conditions, ranged from 0 to 17.6 %, with most of the crosses exhibiting zero or low levels of selfing. Optimum pollination conditions are maintained by the heating, venting, and humidifying systems in the crossing greenhouse.

Crossing decisions are based upon expected progeny performance using an additive genetic (midparent) model (Berg et al., 1986; Wu, 1987; Gravois et al., 1991). Cross performance based on nonadditive genetic variation is accounted for by information derived from the cross appraisal test and the percent of clones advancing through the different stages of the breeding program. Priority is given to crosses where the progeny are expected to have no major faults. In the areas of both disease and sugarcane borer resistance, susceptible by susceptible crosses are avoided. Information for crossing is maintained as a Microsoft Access database. The database also is useful for entering all tassels available for the crossing that particular day along with a pollen
rating. The database provides all possible crossing combinations along with yield, disease and sugarcane borer ratings, and seed inventory.

A limited sample of the progeny of each experimental cross is planted and established in the field as single stools for a cross appraisal test. Those crosses with high frequencies of desirable offspring are deemed "proven." Those crosses that give low frequencies of desirable offspring are deemed "failed." In the seedling selection stage, emphasis is placed on proven crosses by utilizing family selection. Failed crosses are avoided. During the crossing year using L 97-128 as a selection example, a total of 234 crosses were made (Table 1). Typically, 350-550 crosses are made each year. Hurricane Andrew damaged the crossing facilities in 1992 limiting the number of crosses produced.

SEEDLING STAGE

The seedling stage of the program begins in December with germination tests. Metal flats (38 cm x 61 cm) are sterilized with a solution of chlorine bleach and water, filled with about 2.54 cm of potting soil (MetroMix 350™), wet thoroughly, partitioned into six equal cells, and covered with sterilized transparent plastic lids. One-half gram of fuzz from each cross is spread evenly in the cells of the metal flats. Each cell planted is labeled with its corresponding cross number. After one week, a germination count is recorded for each cross. The germination count is used both to calculate the amount of viable seed available of each cross and the amount of fuzz needed to plant a metal flat containing 700 seedlings. Each cross will then be planted as either experimental or proven. Experimental crosses are limited to half trays or 350 seedlings, whereas proven crosses may have 700 seedlings or more.

At the beginning of January, seed is germinated in the greenhouse. A mixture of seven parts sterilized field soil, three parts milled sphagnum moss, and one part washed sand is sterilized and placed in sterilized metal flats to a depth of 5 cm (Figure 4). The metal flats that will contain experimental crosses are divided in half. All metal trays are then leveled, wet, covered, and placed on heated sand-filled benches where they will be planted. The fuzz is weighed according to germination tests and spread evenly on the surface of the soil (Figure 5). The trays are watered, covered with a thin layer of screened, sterilized soil mixture, watered again, and covered with sterilized plastic lids. The covered metal flats serve as a greenhouse within a greenhouse, which in January, is pertinent to timely germination. Once the seed are germinated, the metal flats are monitored closely for moisture and developing disease symptoms. As the seedlings grow, they are clipped to reduce competition allowing all seedlings in the tray to develop.

During the first week of February, plastic foam trays with 128 (3.8 cm by 3.8 cm) cells are filled with potting mix (Metro-Mix 350™). Prior to filling trays, super phosphate, fritted trace elements and lime are added to the potting mix. To each bag of Metro-Mix 350™ (0.79 m³), 0.907 kg of superphosphate, 0.45 kg of lime, and 3 g of fritted trace elements is added. Water is added to the mixture prior to placing in the trays. Seedlings are transplanted into the trays, one per cell. Because a two-row planter is utilized in the field, multiples of two trays per cross are planted. All experimental crosses
are two trays, whereas proven crosses may consist of as many as ten trays. Along with the general population of seedlings, a cross appraisal test is planted.

Transplanting continues through the month of February until the greenhouse is filled to capacity. The seedling greenhouse at the St. Gabriel Research Station can hold up to 108,000 seedlings. The seedlings are watered daily, clipped, and fertilized with a 22-22-22 (kg/ha) mixture weekly through the month of March. Approximately, 11.3 kg of the 22-22-22 mixture is added to a tank containing 113.6 liters of water. This solution is then added to the water stream at a ratio of 100 parts water to 1 part fertilizer solution. All of this is done utilizing the traveling overhead spray boom. The seedlings will remain in the greenhouse until the second week of April at which time they are transplanted to the field.

During March and early April, seed bed preparations are underway in the field. Rows (1.8 m wide) are cultivated, and a pre-plant fertilizer of liquid 17-50-50 (kg/ha) is incorporated into the center of the row. The rows in the field are rotor-tilled and leveled to accommodate the two-row mechanical planter (Figure 6). This planter travels in a serpentine fashion across the field. Cross changes are clearly marked with wooden stakes. Immediately after transplanting, a water tank is used to water the seedlings sealing in moisture to ensure the plants survival (Figure 7). Herbicides are applied to reduce competition of weeds. Atrazine (508 g a.i./ha) and pendimethalin (508 g a.i./ha) are applied after the first watering and water is reapplied after the herbicide is applied to aid in incorporation. Watering continues daily until adequate rainfall occurs. Counts are made of the number of seedlings planted in the field. Two to four weeks later, the number of seedlings surviving the transplanting operation also is counted. Afterwards, standard cultural practices typical for Louisiana sugarcane production are practiced (Legendre, 2001). For L 97-128, a total of 50,827 seedling were transplanted to the field, with 49,655 surviving transplanting, and 43,852 surviving the winter and established as first ratoon seedlings. In 2004, a total of 92,598 seedlings were planted in the field (Table 1).

SEEDLING SELECTION AND ESTABLISHMENT OF FIRST LINE TRIALS

Beginning in the early 1990’s, a cross appraisal test was planted each year in an area near the general seedling population to assess family performance (Milligan and Legendre, 1991; Chang and Milligan, 1992; Tai et al., 2003). For each cross, paired rows were planted with 16 seedlings per row. Each cross is replicated twice. Data is collected in the first ratoon crop.

Prior to 1999, cane yield was estimated for each cross. All of the surviving stools were counted in the first-ratoon crop. A stalk count was taken in each plot, and 10 randomly chosen individual stools were measured to estimate stalk height and stalk diameter. Assuming a stalk density of 1.0 g/cm³, estimated cane yield per stool was calculated. Based on the results of the cross appraisal, inferior crosses were dropped from selection during the fall.
Beginning in 1999 when a sugarcane combine harvester and weigh wagon were made available, the cross appraisal was mechanically harvested and weighed. Surviving stools are counted, and an average cane yield per stool is calculated. These plots are visually evaluated prior to selection. This evaluation is then used as a guide to those crosses that will have the most emphasis placed upon them and those crosses that will be avoided completely.

Because of the importance of ratooning ability of a clone and the poor repeatability of plant-cane seedling traits to first-ratoon performance in Louisiana, initial selection is done in the first-ratoon seedling crop. Therefore, no selection is practiced in the plant-cane seedling population, which is harvested in early December and allowed to over-winter. An over-wintering count is made in the first-ratoon seedlings, giving an indication of the cold hardiness of a particular cross. Before selection begins in early September, the lower leaves of the plants are removed with a leaf extracting machine, which is a converted two row soldier harvester equipped with large extractor fans. This results in a clean row middle giving the selection personnel an unobstructed view of each stool on the row. Cross changes are then located and marked by tying highly visible flagging ribbon across the common middle of the two rows of the cross. Selection is done during September and proceeds as described by Breaux (1972); Gravois et al. (1990); Gravois et al. (1991). One exception is that stalks are topped at the third fully emerged leaf and not at 1.8 m.

First line trial plots are established by first opening row furrows for planting. In 2001, first line trial plot lengths were increased to serve as indirect selection for stalk height. The plots along these rows are marked every 3.05 m and clones advanced from the seedling population are established as single row plots. Stalks are placed in the furrow consistently at the same end of the marked plots across the field. Check varieties are interspersed throughout the first line trials. Since stalk length varies in the selected clones, plot length will vary accordingly. Plot length may range from approximately 1.5 m to 2.4 m. This allows for indirect selection of plant height. For L 97-128, a total of 2,990 experimental clones were established in the first line trial stage (Table 1).

FIRST LINE TRIAL SELECTION AND ESTABLISHMENT OF SECOND LINE TRIALS

First line trial selection begins in August with a visual rating of the plots. Plots are rated on a 1-9 scale with five being the mean of the check plots that are planted in certain areas of the field. Plots rating inferior to the check plots are rated a six or greater and discarded. Visual symptoms of disease and insect problems are also noted at this time. Based on the severity of these pest problems, these clones may also be discarded. Clones may be discarded for small diameter, low stalk population, lack of height, and excessive lodging.

In late-September, tags are printed corresponding to those clones that were rated as acceptable. The remaining clones are then re-evaluated by observing the presence or absence of both pith and/or a tube (hollow core in the stalk center). Disease and insect
problems, yield components, and lodging are re-evaluated. Six stalks are cut from those clones deemed acceptable, bundled, tagged, and carried from the field. The selected clones are then tested for Brix, and standards are set based upon check varieties planted within the first line trials. Those clones having acceptable Brix are then advanced and planted in second line trials, which have single-row plots that are 4.9 m long with 1.2 m alleys separating each clone. Check varieties are replicated four to eight times depending on how many are advanced to this stage. For L 97-128, a total of 650 clones were established as second line trials (Table 1).

SECOND LINE TRIAL SELECTION AND ESTABLISHMENT OF THE INCREASE STAGE

Second line trial plots are counted for millable stalks in late July or early August. Those clones having adequate stalk number, stalk diameter, and stalk height when compared to check varieties are then evaluated for pith and/or tube, diseases, and insect problems (sugarcane borer primarily). In Louisiana, stalk number has been shown to be more important than stalk weight in determining cane yield and is weighted in greater proportion for indirect selection for cane yield (Gravois et al., 1991; Milligan et al., 1996). Milligan et al. (1996) also showed that selection for high stalk number in younger crops, such as plant-cane, was highly correlated to ratoon crop cane yield.

Two six-stalk bundles of selected clones are cut and planted in two, single-row, 4.9 m increase plots. One increase plot is planted on a heavy soil site, and the other increase plot is planted on a light soil site. Check varieties are replicated three times at each increase test site. The increase plots will serve as a seed source after permanent assignments are made in the corresponding first-ratoon second line trial stage. Data also will be collected from the increase plots for the plant-cane through second ratoon crops. Data also is collected from the plant-cane second line trial plots by estimating cane yield from a millable stalk count and a 10-stalk sample that is used to estimate stalk weight and analyzed for sucrose content. Sugar yield is estimated based on the product of cane yield and sucrose content. The plant-cane second line trial plots are usually harvested in late November or early December. The corresponding clone in the first-ratoon first line trial stage also is harvested in late October, and stalk weight and sucrose content are determined. Second line trials are harvested through the second ratoon crop, and first line trials are harvested through the first ratoon crop. For L 97-128, a total of 403 clones were established in the Increase Stage (Table 1).

ON-STATION NURSERIES

In the first-ratoon crop of the second line trials, clones are counted and assessed for disease and insect problems in late July and early August. During October, those plots having adequate stalk population are again checked for pith and/or tube, diseases, and sugarcane borer problems. The remaining clones, along with check varieties, are sampled to obtain an estimate of stalk weight and sucrose content. All available data, including current and previous years, are assessed, and a final list of assignment
candidates is formulated. The candidates are then viewed a final time when permanent assignment numbers are assigned.

The candidate varieties assigned in the LSU AgCenter and USDA-ARS commercial sugarcane breeding programs are designated by the abbreviations:

“L” if seed originates at St. Gabriel, Louisiana with clonal selection efforts in St. Gabriel, Louisiana;

“LCP” if seed originates at Canal Point, Florida with clonal selection efforts in St. Gabriel, Louisiana;

“LHo” if seed originates at Houma, Louisiana with clonal selection efforts in St. Gabriel, Louisiana;

“Ho” if seed originates at Houma, Louisiana with clonal selection efforts in Houma, Louisiana;

“HoL” if seed originates at St. Gabriel, Louisiana with clonal selection efforts in Houma, Louisiana; and

“HoCP” if seed originates at Canal Point, Florida with clonal selection efforts in Houma, Louisiana.

The year of assignment and selection number follows each abbreviation with candidate varieties made at the LSU AgCenter using 1 through 499 and candidate varieties assigned at the USDA-ARS using 500 through 999.

The newly assigned series is planted at three on-station nursery locations. These nurseries are located at research stations in various areas of the sugarcane belt. Multi-location and multi-year testing is important to address genotype-by-environment interactions that are prevalent in sugarcane (Kang and Martin, 1987; Milligan et al., 1990; Milligan et al., 1990; Gravois and Milligan, 1992). Beginning in 1985, nurseries have been planted at the St. Gabriel Research Station - St. Gabriel, Louisiana; the Iberia Research Station - Jeanerette, Louisiana, and at the USDA-ARS Sugarcane Research Unit’s Ardoyne Farm - Chacahoula, Louisiana. All nurseries consist of two replications of single-row plots that are 4.9 m long. These on-station nurseries represent the first time the new clones are exposed to different environments. Data (sugar yield, cane yield, sucrose content, stalk weight, and population) are collected on plant-cane through third-ratoon crops.

OFF-STATION NURSERIES AND INFIELD TRIALS

The next two concurrent stages of the variety development program include off-station nurseries and infield tests. The off-station nurseries were initiated in the early 1990’s by planting tests at three additional locations that are different from the on-station nurseries. In 1998, two additional infield (machine harvested) locations were added. The off-station nurseries and infield trials are located on commercial farms in five different areas of the sugarcane belt. The experimental clones are planted and harvested by the sugarcane breeders, but the cultural practices followed through harvest are those used by that particular grower on whose farm the test is planted. This results in the sugarcane clones being subjected to unique environments. It is at this point of the breeding program
that experimental sugarcane clones from both the LSU AgCenter and the USDA-ARS commercial sugarcane variety development programs are planted in the same nursery or trial. Personnel from both the LSU AgCenter and the USDA-ARS meet at these locations to plant, evaluate, count, and harvest these sugarcane tests.

The off-station nurseries consist of two replications of single-row plots that are 6.1 m in length; whereas the infield tests have two replications with plots consisting of two rows that are 7.3 m long. Plot size was changed in the off-station nurseries in 2000 based on the results of Bischoff et al. (2001) who showed significant decreases in experimental error by changing the 4.9 m plot lengths to 6.1 m. The off-station nurseries are hand-harvested, and a 10-stalk sample is obtained from each plot. Estimated yields are calculated as mentioned above.

The infield tests represent the first time mechanical combine harvesting is utilized. The infield plots are harvested with a combine, and the harvested sugarcane is weighed with a wagon that is fitted with three load cells under a wagon that can hold up to 3.2 Mt (Figure 8). The entire two row plot is weighed for estimating cane yield. A 15-stalk sample is hand-cut from the plots and taken to the laboratory for both a sucrose and fiber analysis (Gravois and Milligan, 1992). Sugarcane clones with fiber content that exceed 13.5 to 14.0 % are dropped from the program. Cane yield is estimated from the plot weights, and sugar yield is calculated as the product of cane yield and sucrose content. The plant breeders, plant pathologists, and entomologists closely monitor all variety trials for diseases and insect pests.

In addition to monitoring variety nurseries and trials, smut, leaf scald, and sugarcane borer nurseries are planted with the newly assigned clones and any clones remaining in the later selection stages. A smut and leaf scald nursery is planted in an isolated area of the St. Gabriel Research Station. Stalks of experimental clones are dip-inoculated in a smut spore suspension and planted in a three replication nursery in single row (4.9 m) plots. Ratings (1-9) for smut susceptibility are based on the percentage of smut-infected stalks within the plots, and rating intervals are adjusted based on the infection levels of check varieties within the nursery. Ratings 1-3 are considered resistant, 4-6 moderately susceptible, and 7-9 highly susceptible. The smut nursery also is used to inoculate smut-free stalks with the leaf scald pathogen. Leaf scald is rated based on a qualitative assessment of inoculated leaf necrosis and systemic symptom development with death of the top being the most severe case. Ratings of 1, 3, 5, 7, and 9 are assigned for highly resistant, moderately resistant, moderately susceptible, susceptible, and highly susceptible reactions.

A sugarcane borer nursery is planted annually in areas of the state known to have high infestation levels. Experimental clones are planted in a four replication nursery in single row (4.9 m) plots. During the summer growing season, insecticides are applied on the ground to control predators so that more consistent sugarcane borer infestation levels will occur. No other insecticides are applied to the nursery. Stalk counts are made in August each year. At the end of the growing season (November or December), 15-stalk
samples are cut from each plot. Percent bored internode data are taken, and entrance and exit holes are noted to indicate adult survival on a per hectare basis.

OUTFIELD TESTING

Experimental sugarcane clones introduced to the outfield testing stage are planted as seed increase plots around the edges of the most recently planted test. The number of clones introduced to outfield testing is approximately 15. Outfield testing procedures have been outlined by Fanguy and Garrison (1982). Prior to 2000, plot size for outfield testing was three rows that were 9.8 m long with a 1.5 m alley. This plot size accommodated single-row mechanical whole-stalk harvesting. Now the plot size for outfield testing is two rows that are 15.2 m long with a 1.5 m alley. The change in plot size was to accommodate the change to combine harvesting. Combine harvesting and the calculation of cane yield is done in the same manner as the infield tests. One notable change in the move to combine harvesting from whole stalk harvesting is the reduced CV's for cane yield estimates, which also improves both sugar and cane yield estimates (Bischoff et al., 2001).

Early each summer, plant pathologists and breeding program personnel assess the outfield tests for mosaic, which is recorded as a percentage of shoots exhibiting symptoms. Experimental clones exhibiting severe mosaic are dropped from the variety development program.

SEED INCREASE

At the same time that experimental sugarcane clones are introduced to outfield testing, the same set of clones is also sent to each of three Primary Increase Stations. Seed increase is the primary responsibility of the American Sugar Cane League, and general seed increase procedures have been outlined by Lauden (1971). Experimental clones are obtained from both the LSU AgCenter and USDA-ARS sugarcane variety development programs. A special hot-water treated (50°C for 2 hours) nursery of clones to be increased is established at each breeding program’s experiment station. Each fall, personnel from the American Sugar Cane League obtain 25 stalks of each clone to plant each of the three Primary Increase Stations. One of the more recent changes to the seed increase programs was the testing for RSD and sugarcane yellow leaf virus prior to introduction to the three Primary Increase Stations. Each of the 25 stalks is tested for the presence of RSD, and samples collected from plots are tested for sugarcane yellow leaf virus. Stalks testing positive for RSD or sugarcane yellow leaf virus are not used as seed increase planting material at the Primary Increase Stations. If an experimental sugarcane clone remains active in the sugarcane breeding program, the clone will be increased twice after being introduced on the primary increase station. Afterwards, the clone will be sent out to 44 secondary increase stations where it will be increased once before release to the industry.

VARIETY RELEASE
After second-ratoon data is collected in the outfield testing stage, an experimental sugarcane clone is eligible for release. A meeting is called for the Louisiana Sugarcane Variety Release Committee, which is comprised of variety development personnel from the three agencies: LSU AgCenter, USDA-ARS, and the American Sugar Cane League. The committee meets during the spring after the second-ratoon harvest is completed and data compiled. Data summaries are presented and discussed among the three agencies. Each agency has a single vote. Two votes are necessary for the release of new sugarcane variety. If a sugarcane variety is released, a notice of release is sent out to sugarcane growers who can then order seed cane of the new variety from the secondary increase stations. Tissue culture derived seed cane is available the year after release from private seed cane companies.

REFERENCES


Table 1. The stages of the LSU AgCenter’s sugarcane breeding program and the number of clones per stage as demonstrated by the release of L97-128.

<table>
<thead>
<tr>
<th>Year</th>
<th>Stage</th>
<th>Number in Stage</th>
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<tbody>
<tr>
<td>1992</td>
<td>Cross made at the St. Gabriel Research Station</td>
<td>234</td>
</tr>
<tr>
<td>1993</td>
<td>Seedlings planted into the field; surviving; over-winter to establish as first ratoon</td>
<td>50,827; 49,655; 43,852†</td>
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<td>1994</td>
<td>Selection in first-ratoon seedling crop (advanced to first line trials)</td>
<td>2,990</td>
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<td>1995</td>
<td>Selection in plant-cane first line trials (advanced to second line trials)</td>
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<td>1996</td>
<td>Selection in plant-cane second line trials (advanced to increase plots)</td>
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<td>1997</td>
<td>Assignment in first-ratoon second line trials</td>
<td>56</td>
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<td></td>
<td>On-station nurseries planted (St. Gabriel, Houma, New Iberia)</td>
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<tr>
<td>1998</td>
<td>Plant-cane on-station nurseries harvested</td>
<td>26</td>
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<td></td>
<td>Off-station nurseries planted (Westfield, Stoute’s, Gonsoulin)</td>
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<td>1999</td>
<td>First-ratoon on-station nurseries harvested</td>
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<td></td>
<td>Plant-cane off-station nurseries harvested</td>
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<tr>
<td></td>
<td>Introductions of experimental clones planted at outfield test sites</td>
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<td></td>
<td>Introduce experimental clones to three ASCL primary increase stations</td>
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<td>2000</td>
<td>Second-ratoon on-station nurseries harvested</td>
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<td>First-ratoon off-station nurseries harvested</td>
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<td>Outfield tests planted</td>
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<td>First increase of experimental clones on primary increase station</td>
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<td>2001</td>
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<td>Plant-cane Outfield tests harvested</td>
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<td>Second increase of experimental clones at primary increase stations</td>
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<td>2002</td>
<td>Third ratoon off-station nurseries harvested</td>
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<td>First-ratoon Outfield tests harvested</td>
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<td>Seed of experimental clones sent to 44 secondary increase stations</td>
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<tr>
<td>2003</td>
<td>Second-ratoon outfield tests harvested</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Replant experimental clones on secondary increase stations</td>
<td></td>
</tr>
<tr>
<td>2004</td>
<td>Variety release meeting</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>New variety distributed by ASCL from Secondary Increase Stations</td>
<td></td>
</tr>
</tbody>
</table>

† The number of seedlings planted to the field, the number surviving transplanting, and the number that successfully over-wintered.
Figure 1. Rail carts with sugarcane clones two weeks prior to the initiation of photoperiod treatments at the St. Gabriel Research Station.
Figure 2. The sugarcane crossing house is located at the St. Gabriel Research Station. The sugarcane clones on the right have been induced to flower in the photoperiod house. Air layers (marcots) were placed on the clones in mid-August and flowering is just beginning as the picture was taken in mid-September. The crossing house is white-washed to help reduce high early fall temperatures in the greenhouse.
Figure 3. Crossing is done in isolation cubicles. Each stalk is tagged for identification. Note the marcots, which are watered daily.
The seedling germination trays are being prepared. The lids are placed over the seed once planting is done to ensure a warm and moist environment for optimum germination.
Figure 5. Seed is spread over the soil surface to begin the germination process.
Figure 6. Transplanting sugarcane seedlings at the St. Gabriel Research Station.
Figure 7. Watering newly planted sugarcane seedlings at the St. Gabriel Research Station. Cross changes are delineated by orange wooden stakes.
Figure 8. Combine harvesting of an infield test and obtaining cane weights with a weigh wagon fitted with load cells and a device to record the weight. The weigh wagon was designed by Cameco located in Thibodaux, Louisiana.