Breeding new sugarcane varieties with enhanced ratooning ability

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Abstract
Sugarcane crop-cycle length and yield are largely determined by the ratoon crops and drive economic returns for farming operations. A number of factors affect ratooning ability (RA – the percent of the second-ratoon crop yield to the plant-cane crop yield). The transition from manual harvest to mechanized harvest in many industries has had a negative effect on RA, and most agree that the variety component is the key to improving RA. Thus, it is paramount that sugarcane breeding programs set RA as a high priority. Reported broad-sense heritabilities for RA are generally low; accordingly, some breeding programs employ family-selection strategies to enhance selection. A few breeding programs have reported other useful statistics that have shaped selection strategies for RA, such as: genetic and genotype-by-environment variance component structure; genetic advance values; genetic correlation among traits among crops. However, there is a general paucity of data driving the selection strategy for RA for many sugarcane breeding programs. Introgression breeding efforts have improved RA in some sugarcane industries and offer the necessary genetic variation to exploit through the selection process. The goal of this report is to detail the experiences and progress of sugarcane breeding programs for developing varieties with improved RA.

Key words
Sugarcane, ratooning ability, heritability, breeding, variety development

INTRODUCTION
Sugarcane (Saccharum spp. interspecific hybrids) is a member of the grass family, and the life cycle of the plant is perennial, a growth habit that persists for many growing seasons. In sugarcane industries around the world, this perennial growth habit is referred to as ratooning. A sugarcane crop cycle consists of the first crop, referred to as a plant-cane crop, and a varying number of subsequent ratoon crops. After the normal production cycle is completed, the crop is ploughed out and replanted by vegetative seed-cane cuttings to begin the cycle anew. The length of the crop cycle and productivity of the ratoon crops are important aspects determining a sound economic return in a sugarcane-farming operation because of the high costs associated with planting.

Early sugarcane production focused upon clones from Saccharum officinarum L (2n = 80). The more useful clones were generally high in sucrose content and low in fiber content, but disease prone with poor RA. Sugarcane breeding programs were initiated to improve upon the deficiencies of these early foundation clones. Modern sugarcane varieties (2n = 100-130) possess a complex genetic structure that resulted from a series of natural interspecific hybridizations in the wild and/or controlled hybridizations within sugarcane breeding programs (D’Hont et al. 1996). The major contribution is from S. officinarum, followed by contributions from S. spontaneum, S. sinense, and S. barberi to lesser and varying degrees. This complex genetic structure indicates the importance of interspecific introgression efforts done to improve many sugarcane traits including RA of newly released varieties (Jackson et al. 2014).

RA is affected by many aspects of sugarcane culture (Soopramanien 1996), but most would agree that the variety component has a major effect. Accordingly, sugarcane breeding programs place priority on RA when developing varieties for local industries. The objective of this paper is to review breeding strategies for RA of a few sugarcane breeding programs.
LOUISIANA

The temperate climate for growing sugarcane in Louisiana differs from most other areas and poses a unique challenge for developing varieties with improved RA. A plant-killing freeze and dormancy period can be expected each year in Louisiana. Varieties must survive the winter, re-establish in the spring, and produce a profitable crop within a 7-9 month time frame.

Louisiana has obtained new sugarcane varieties in a number of ways, with the first via importation from other sugarcane-growing areas. The second effort was the development of a commercial sugarcane-breding program. The lack of positive genetic variation to exploit through selection led to the establishment of an introgression breeding effort whose first target was mosaic resistance. Clones (initially US 56-15-8) of *S. spontaneum* were targeted to broaden the genetic base among parents in Louisiana (Dunckelman and Breaux 1971; Jackson et al. 2014). The first benefit of the introgression breeding effort was the release of LCP 85-384 (Milligan et al. 1994), which was grown on 91% of the state's cane area by 2004. One ancillary benefit, in addition to mosaic resistance, was improved RA. Upon its release, LCP 85-384 produced 29% and 55% greater cane yield than the leading commercial variety CP 70-321 in the first- and second-ratoon crops, respectively, LCP 85-384 and subsequent variety releases have extended the crop cycle in Louisiana from 3-4 crops to 4-5 crops. For 2011-2015, the average crop cycle consisted of 30.2% plant cane, 29.8% first-ratoon, 27.5% second-ratoon, and 12.5% third-ratoon and older crops. By comparison, the typical sugarcane crop cycle in the 1940s consisted of 40-45% plant cane, 40-45% first-ratoon, and 10-20% second-ratoon crops (Efferson 1947). In Florida for the 2014 and 2015 crops, the average crop cycle consisted of 33.4% plant cane, 32.2% first-ratoon, 28.4% second-ratoon, and 6.0% third-ratoon and older crops (VanWeelden et al. 2016).

Breeding for Ratooning Ability

Managing parents that are used for crossing is the first step necessary for improving RA, but there are no reported narrow-sense heritability values (single-plot basis) for RA for sugar yield and cane yield were low (H = 13.4% and H = 17.0%, respectively) as reported by Milligan et al. (1996) where RA was defined as the second-ratoon crop yield as a percentage of the plant-cane crop yield. In Louisiana, parental populations did not possess the positive genetic variation necessary to exploit during selection; therefore, new sources of favourable genetic variation were sought. On average in Louisiana, about 90% of parents for the commercial breeding program are obtained annually from a recurrent selection breeding strategy, and the remainder are obtained from the introgression breeding program. Initial selection of clones for use as parents is based on their performance in advanced stage selection trials. Subsequent decisions on retention or discard of parents are based on advancement of progeny clones through the early stages of the program and performance of progeny in family selection trials. Newly introduced recurrent parents are often not well characterized for RA, which adds an element of cost and risk.

Initial selection for RA occurs in the seedling stage (Bischoff and Gravois 2004). Selection is done in the first-ratoon crop because correlation among families in plant-cane and first-ratoon crops in the seedling stage was low (r = 0.41, two-year study, unpublished data). Mechanical harvesting of the plant-cane crop and subsequent overwintering serve as the first environment for applying selection pressure to improve RA. In the first-ratoon crop, family selection is a key aspect of selection for RA. Families that ratoon well and produce high biomass are selected or weighted prior to mass selection on individual clones.

The next selection stages are unreplicated first and second clonal line trials with plot sizes of 1 row 1.8 m, and 1 row 4.9 m, respectively. Selection is focused on traits such as Brix, stalk weight, and stalk population, which have higher broad-sense heritability values than RA. Selection to advance clones is done in the plant-cane crop of the first line trials, and additional data on these original selection is collected in the first-ratoon crop. In the second line trials, selection to advance clones is done in the first-ratoon crop, and additional data on these original selections is collected in the second-ratoon crop.

The next stages are replicated yield trials where the number of testing sites increases. Clay soil sites provide a challenging environment that help identify clones with enhanced RA. Another management tool for variety trials in Louisiana is early harvest because varieties in Louisiana tend to produce fewer ratoon crops with less yield when harvested in the first third of the harvest season (Ricaud and Arceneaux 1986). Yield trials are harvested through to the third-ratoon crop where possible.

Another important aspect of the Louisiana program is the selection of appropriate comparison or check varieties, especially varieties with superior RA. After its release, LCP85-384 served as the primary check variety, and the flow of experimental clones through the breeding program slowed. That can be a daunting proposition, but it is the natural ebb and flow of any
sugarcane breeding program. Now the primary check variety is L01-299 (Gravois et al. 2011), a progeny of LCP85-384. Much like its paternal parent, L01-299 has excellent RA with excellent production into the third- and fourth-ratoon crops.

Guidance for the current selection strategy in Louisiana was provided in part by Milligan et al. (1990a,b) and Milligan et al. (1996). Stalk number in the younger crop was the only trait significantly correlated with ratoon-crop cane yield \( r = 0.56 \), which suggested that selection of experimental clones with high stalk population in the younger crops would enhance cane yield in older crops. Second-ratoon cane yield could be predicted by first-ratoon crop cane yield. However, the best improvement of second-ratoon cane yield was realized by selection in the second-ratoon crop. Genetic advance estimates suggest that selection to improve a particular crop’s yield component value is most effective when performed within that crop and commonly shows the most potential for improvement in older crops. Cane yield was the most important determinant of sucrose yield and became increasingly important in determining sucrose yield in older ratoon crops. Stalk number was the primary determinant of cane yield and became more important in determining cane yield in older ratoon crops.

Hence, in nearly every stage of the Louisiana sugarcane breeding program, crop cycle evaluations have been extended without lengthening the variety development cycle. To identify experimental clones with improved RA in older crops, selection is best done in the oldest crop of the crop cycle. The Louisiana breeding program holds fast to comparisons with key check varieties that possess improved RA. These strategies, along with a long term commitment to introgression breeding, have been paramount to success in extending the sugarcane crop cycle for the Louisiana sugar industry.

**SOUTH AFRICA**

RA is important in South Africa where the crop is planted on hilly terrain prone to erosion. Good RA is desirable to recover planting costs and the high cost of irrigation infrastructure in irrigated regions. Therefore, varieties that achieve fewer than 10 ratoon crops (the average number of ratoon crops) are not preferred by growers.

**Breeding for Ratooning Ability**

The breeding programs were designed to develop varieties with high RA where RA is defined as high cane yield in first- and second-ratoon crops as a percent of the plant-cane crop. Experimental clones with high stalk populations (Zhou and Shoko 2012) are given priority in early stage selection. Programs have five selection stages, of which the last four stages assess experimental clones in the ratoon crops. The final stage trials are harvested in the plant-cane and two or three ratoon crops where experimental clones advanced must possess similar or higher levels of RA than check cultivars. Cultivars NCo310, NCo376 and N12 have produced up to 20% higher cane yield than the population mean in the second-ratoon crops in plant-breeding trials.

Studies on genotype by crop-year variance components (GC) for cane yield showed significant trends for all breeding populations in South Africa (Zhou et al. 2012). The proportion of GC to total variance was highest for the coastal and Midlands than the irrigated breeding program. Further studies of released varieties (Ramburan et al. 2013) showed lower decline in yield with ratoons among varieties developed for irrigated regions. Other studies (Zhou 2015) showed that relative performance of clones in the plant-cane crop was a poor predictor \( r = 0.45 \) of relative ratoon-crop cane yield, compared with first-ratoon \( r = 0.78 \) to second-ratoon crops.

The future will focus on traits for early stage and indirect selection for RA. The heritability of RA will be investigated with the aim of determining selection gains. Investigations into variability for RA in seedling populations are underway and will be used to test the potential for family evaluation and selection. Family evaluation would further be used to evaluate parental effects and estimate breeding values of parents for RA with the aim of using the results to identify high RA for incorporation in the parental population for crossing. The South African program also has an on-going introgression breeding effort where a primary focus will be improving RA.

In 2015-2016, less than 10% of the sugarcane crop was mechanically harvested, but it is anticipated that mechanized harvest will increase to 30% of the land area in the near future. In anticipation, sugarcane breeders are taking an indirect approach whereby lodging and ratooning of experimental clones are evaluated under trash blankets as an indicator of suitability to mechanized harvest. Projects have been initiated to better assess the sugarcane breeding effort as it relates to increased mechanized harvest.
BRAZIL

Sugarcane production is concentrated in the central-south (90% of production) and northeast (10% of production) regions of Brazil. The cultivated area of sugarcane is about 9 Mha for 2015-2016. Mechanical harvesting began in mid-1980s, and currently, about 88% of the sugarcane in the central-south region is mechanically harvested, which negatively affected RA of sugarcane due to increased soil compaction and damage to the stools. Until the early 1970s, the crop cycle averaged four crops. For the 2015-2016 crop, the average crop cycle consisted of 15.8% plant-cane, 19.3% first-ratoon, 21.3% second-ratoon, and 43.5% third-ratoon and older crops.

Breeding for Ratooning Ability

Three major sugarcane breeding programs develop new varieties for Brazil. This review will focus upon the RIDESA program, which has developed sugarcane varieties grown on 68% of the cultivated area in Brazil. Crosses are made at the Federal University of São Carlos. The variety development process starts with approximately 300,000 seedlings and is a 17-year process from crossing to commercial release. Both family selection and subsequent mass selection is practiced in seedling populations in the first-ratoon crop. To increase the genetic variability of germplasm banks, germplasm exchange agreements have been established. New germplasm should contribute alleles for important traits, such as sugar content, biomass yield, and RA.

Yield trials are harvested for three and four crops at multiple sites. Cane yield is estimated from plots that are mechanically harvested to better assess ratoon-crop yield. Sugarcane breeding programs face new challenges to develop varieties suited for mechanized harvest and, at the same time, to extend the average crop cycle. This challenge has been met with sugarcane variety releases, such as RB867515 and RB966928, which are widely grown and have improved ratoon-crop yields (Table 1).

Table 1. Cane yield (t/ha) across the crop cycle for some important sugarcane varieties grown in Brazil.

<table>
<thead>
<tr>
<th>Variety</th>
<th>Plant-cane</th>
<th>First-ratoon</th>
<th>Second-ratoon</th>
<th>Third-ratoon</th>
</tr>
</thead>
<tbody>
<tr>
<td>SP81-3250†</td>
<td>134</td>
<td>101</td>
<td>85</td>
<td>84</td>
</tr>
<tr>
<td>RB867515</td>
<td>140</td>
<td>113</td>
<td>95</td>
<td>94</td>
</tr>
<tr>
<td>Percent increase</td>
<td>4.5</td>
<td>11.9</td>
<td>11.8</td>
<td>11.9</td>
</tr>
<tr>
<td>RB855156‡</td>
<td>125</td>
<td>103</td>
<td>95</td>
<td>86</td>
</tr>
<tr>
<td>RB966928</td>
<td>139</td>
<td>116</td>
<td>101</td>
<td>90</td>
</tr>
<tr>
<td>Percent increase</td>
<td>11.2</td>
<td>12.6</td>
<td>6.3</td>
<td>4.7</td>
</tr>
</tbody>
</table>

† Comparison is based upon 352 evaluations
‡ Comparison is based upon 42 evaluations.

AUSTRALIA

Sugarcane in Australia is grown along the eastern coastline over a 2,100 km stretch from Mossman in north Queensland (approximately 17°S) to Grafton in New South Wales (approximately 30°S). Over the last 20 years, cane production has averaged 34 Mt at an average 88 t cane/ha.

During a recent review of economic importance of sugarcane traits for the Sugar Research Australia (SRA) breeding program (data not published), the Australian industry has identified RA as one of the most critical issues affecting industry viability and sustainability, and strongly believes that newer varieties do not possess RA at the levels of older varieties. Varieties that ratoon well will result in increased profitability through less frequent planting, increased area of land in production, and reduced loss of soil and nutrients through run-off. According to the review, the current average 1-year crop number in a crop cycle varies from 4 (Burdekin and Southern regions) to 6 (Northern region). This reflects the optimal average economic returns of a crop to growers given the cane yield in the plant-cane crop and the yield reduction rates across the crop cycle. Chapman (1988) reported the average number of ratoon crops for the Queensland area as 4.5 in 1986, up from 2.5 in 1976. In the Burdekin region during 2011-2015, the average harvested crop cycle consisted of 16.2% plant-cane, 20.3% first ratoon, 19.2% second ratoon, and 44.3% third ratoon and older crops. Similarly in the Herbert
region during the same period, the average harvested crop cycle consisted of 15.5% plant-cane, 16.5% first ratoon, 16.0% second ratoon, and 52.0% third ratoon and older crops.

Breeding for Ratooning Ability

Studies on RA in Australia were reported in the early 1990s. Chapman et al. (1992) found that yield reduction in ratoon crops was associated with a reduction in stalk weight but not stalk number. Ferraris and Chapman (1991) looked at bud development in ratooning stubble, and concluded that under favourable conditions this was not a factor in ratoon-crop yields. However, they also suggested that differences in varietal RA would be more pronounced under stressed conditions. Ferraris et al. (1993) suggested that rapid canopy development, increased interception of light in the early development stage, and maintenance of stalk weight through the crop cycle all contributed to better RA. Cane yield in ratoon crops is influenced by genotype, soil conditions including compaction, diseases and pests, weather conditions, harvester damage, and combinations of these factors.

The SRA breeding program contains a three-stage selection strategy. Stage 1 or Progeny Assessment Trials (PAT) are the first stage of selection and are harvested in the plant-cane crop as families with selections taken from the best families in the first-ratoon crop. Selected clones are then assessed over two crops in Clonal Assessment Trials (CAT), and over three crops in late stage Final Assessment Trials (FAT). All trials are harvested and weighed mechanically. The limited number of crops assessed in the selection program and the effect this has on identifying varieties with good RA is often raised.

The rationale for structuring the breeding program in this way, where early stage selection trials are generally not assessed in later ratoons, was driven by studies conducted in the 1990s (Mirzawan et al. 1993; Jackson 1992). In these studies, moderate to high genetic correlations (>0.65) for sugar yield between plant and ratoon crops were identified, and suggested that emphasis would be better placed by testing in more environments, more replication or more genotypes in early stage trials rather than testing for RA. In this way, the majority of poor-performing experimental clones can be rapidly discarded from early stage trials rather than carrying them through in ratoon crops. Another consequence of collecting information on later ratoon crops is the potential increased length of the selection program and time to release of new varieties. Chapman (1988) suggested that superior ratooning varieties could be identified after assessment of first- or second-ratoon crops in the selection program, and that more reliability of a variety’s ratooning potential could be established in third-ratoon crops. In the Southern program recently, Jensen and Parfitt (2015, unpublished data) compared clone rankings from FATs assessed over 3-year and 4-year crop cycles. In this preliminary study based on a limited data set, they found a high correlation (r = 0.99) between the two methods, with some changes in clone ranking in the six top performing clones that could influence the selection of varieties for release to the industry. More trials are planned to confirm this result.

Slow harvester speeds used to harvest selection trials while weighing small plots is another issue raised by the industry as it does not reflect commercial harvesting conditions. A new project has recently been proposed to address these issues of the limited number of crops harvested and slow harvester speeds used in the selection program. The aims of this new project are to:

1) Determine the most profitable number of ratoon crops for each of the regional areas;
2) Define selection criteria for RA and construct selection indices that include these criteria for SRA selection programs
3) Understand the genetic control of cane yield in commercial harvesting;
4) Determine traits useful as indirect selection criteria for RA (i.e. stalk number, stalk weight, fiber physical properties of stalks).

If successful, the outcome of this project will be new selection criteria added the SRA selection index to enable selection of varieties for improved RA.

_Saccharum spontaneum_ is widely recognised as the main contributor of RA traits in modern varieties. Jackson (1994) reported that sucrose content was negatively correlated with traits contributing to RA in early generation introgression populations. Intensive selection within these populations for sucrose content without considering RA may reduce the frequency of favourable specific ratooning characteristics. SRA is screening for early generation introgression clones with good RA traits, particularly under harsh or stressful conditions, and to incorporate these traits into its parent population. A slashing regime will be implemented in this project to see if the time taken to select for RA can be reduced, and whether this method has an effect on the ranking of clones for selection. Stool architecture is also being examined in another project that commenced in 2015, to identify if variation in stool architecture exists in current varieties, whether there has been a change in varieties over time, and finally if there is a link between stool architecture traits and RA of varieties.
MAURITIUS

Sugarcane production occurs from coastal areas to humid uplands, representing more than 80% of the agricultural land. The area harvested was around 52,000 ha with an average yield of 76.53 t cane/ha; the average length of the crop cycle is 12 years. In 1990, about 2% of the area was mechanically harvested, whereas about 42% of the sugarcane was mechanically harvested in 2012. As mechanized harvesting becomes more common, varieties must be developed that are adapted for mechanized harvest, which has a negative effect on RA.

Breeding for Ratooning Ability

In Mauritius, improved RA is a much sought attribute of new varieties. In addition, high tillering and erect growth habit are traits emphasized in selection, especially with the advent of mechanized harvest. At the early selection stages, seedlings are assessed in replicated family trials based on the first-ratoon crop, and the first clonal stage (3-m plots) is systematically stubble-shaved to ensure uniform regrowth in ratoon crops to enhance selection.

Replicated yield trials base selection on the cumulative results of plant-cane, first- and second-ratoon crops, for sugar yield, cane yield, sucrose yield, and fiber content. At the advanced multi-environment selection stages, experimental clones are evaluated in plant-cane and three ratoon crops. Mamet and Domaingue (1999) reported that Stage 3 yield trials could be selected on the basis of plant-cane instead of plant-cane + first-ratoon; Stage 4 yield trials could be selected on the basis of plant-cane plus first-ratoon instead of plant-cane through second ratoon. The program could be shortened by 2 years and conserved resources could be allocated to test varieties in more environments with more replicates, which would improve considerably the efficiency and precision. These recommendations were initially adopted, but more recent studies showed lower association among plant-cane and ratoon crops. Therefore in 2010, the length of the crop cycle was increased in Stage 3 and Stage 4 trials.

CONCLUSIONS

RA ranked highly as a priority in all sugarcane breeding programs. The transition from manual sugarcane harvest to mechanized harvest and stress environments has accentuated the need for developing new sugarcane varieties with improved RA.

Resources and program specific statistics guiding selection for breeding new sugarcane varieties with improved RA varied. Stalk number was significantly correlated to RA. Selection in the ratoon crops was most effective for genetic gain for RA in Louisiana and South Africa; however in Australia, moderately high genetic correlations for sugar yield between plant and ratoon crops suggested that emphasis would be better placed by testing in more environments, more replication or more genotypes in early stage trials rather than testing for RA. Comparisons with key check varieties with enhanced RA were important for advancing the goal of improved RA.

Clones of S. spontaneum have provided useful genetic variation for RA and have been successfully exploited in introgression breeding efforts to improve RA. Louisiana, Australia, and South Africa have on-going introgression breeding efforts where improving RA is a primary objective. Breeding for RA is a long term and costly endeavour, but one that has paid large dividends in many sugar industries.

REFERENCES

Production de nouvelles variétés de canne à sucre avec une capacité de repousse améliorée

Résumé. La durée du cycle de culture et le rendement en canne et en sucre sont en grande partie déterminés par les repousses et entraînent des retombées économiques pour les pratiques culturales. Un certain nombre de facteurs lies à l’aptitude à la repousse (AR) - le pourcentage du rendement en 2ème repousse au rendement en vierge. La transition de la récolte manuelle à la récolte mécanique dans beaucoup d’industries a eu un effet négatif sur l’AR et il est généralement accepté que le composant variétal est la solution pour améliorer la performance en repousse. Ainsi, il est primordial que les programmes d’amélioration variétale ciblent l’aptitude à la repousse. Les programmes d’amélioration variétale ont mis en avant d’autres statistiques utiles qui ont contribué à développer des stratégies pour l’AR, comme la variance génétique et l’interaction génotype x environnement; les valeurs génétiques améliorées; la corrélation génétique parmi les traits et les repousses. Cependant, il y a un manque général des données qui déterminent la stratégie de sélection pour l’AR dans un grand nombre de programmes. Les travaux au niveau d’introgression dans des programmes de développement variétal ont amélioré l’AR dans certaines industries et introduisent la variation génétique requise à des fins de la sélection. Le but de ce rapport est d’exposer les travaux et les progrès notés dans des programmes de création de variétés ayant une meilleure aptitude à la repousse.

Mots-clés: Canne à sucre, aptitude à la repousse, héritabilité, amélioration, le développement variétal

Obtención de nuevas variedades de caña de azúcar con mejor habilidad de soqueo

Resumen. La longitud del ciclo de cultivo y rendimiento de la caña de azúcar son determinados en gran medida por los ciclos de corte (socos) y promueve la rentabilidad económica para las operaciones agrícolas. Varios factores afectan la capacidad de soqueo (RA - el porcentaje del rendimiento de los cultivos de segundo sco en relación al rendimiento de la caña plantada). La transición de la cosecha manual para cosecha mecanizada en muchas industrias ha tenido un efecto negativo en la RA, y la mayoría está de acuerdo que el componente varietal es clave para la mejora del RA. Por lo tanto, es fundamental que los programas de mejoramiento de caña de azúcar establezcan la RA como una alta prioridad. La heredabilidad en sentido amplio reportados para la RA son generalmente bajas. En consecuencia, algunos programas de mejoramiento emplean estrategias de selección familiar para mejorar la selección. Pocos
programas de mejoramiento han reportado de otras estadísticas útiles que han dado forma a estrategias de selección para RA, tales como: la estructura de los componentes de varianza genética y genotipo por ambiente; valores de avance genéticos; correlación genética entre los caracteres y entre cortes. Sin embargo, hay una escasez general de datos que impulsen la estrategia de selección para RA en muchos programas de mejoramiento de caña de azúcar. Los esfuerzos de mejoramiento por introgresión han mejorado la RA en algunas industrias y ofrecen la variación genética necesaria para explotarla a través del proceso de selección. El objetivo de este artículo es detallar las experiencias y logros de los programas de mejoramiento de caña de azúcar para el desarrollo de variedades con mejora de la RA.

Palabras clave: Caña de azúcar, capacidad de soqueo, heredabilidad, mejoramiento, desarrollo de variedades