

RELEASE OF SUGARCANE VARIETIES IN SOUTH AFRICA

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Abstract

One of the core functions of the South African Sugarcane Research Institute (SASRI) is to develop improved varieties for the South African industry. This process involves between 11 and 15 years of testing, selection and advancement through a five-stage selection programme, before a final decision is taken regarding commercial release. Variety release decisions have an enormous impact on growers, millers and the industry as a whole. These decisions also affect the breeding and selection programmes, in that changing needs and threats in the industry must be taken into account. Good communication and understanding between all involved in this process is crucial to sustaining a competitive sugarcane industry. This paper outlines the variety release procedure at SASRI, highlights some concerns, and reviews how other sugar industries approach variety release.

Keywords: sugarcane, varieties, variety release committee, selection

Introduction

One of the core functions of the South African Sugarcane Research Institute (SASRI) is to develop improved varieties for the South African industry. This is achieved through the breeding, selection and release of sugarcane varieties that are adapted to the major agroclimatic environments of the sugarcane producing area. Significant progress has been made in South Africa in developing improved sugarcane varieties since the establishment of SASRI in 1925, particularly with regard to levels of disease resistance (Bailey *et al*, 1994).

The development of improved varieties has been a major factor in sustaining a competitive sugar industry in South Africa. Following the release of NCo376 in 1955, the South African sugar industry achieved a substantial increase in sugar yield and number of ratoon crops (Nuss, 2001). More recently, the release and adoption of 'N' varieties have also contributed to this improvement (McIntyre and Nuss, 1998; McIntyre *et al*, 1994; Redshaw and Nuss, 2001).

It can be argued that selection and release decisions made by SASRI have served the industry well. The variety release procedure followed by SASRI, however, has been in place for the past few decades. Although the goal has not changed, procedures and techniques have evolved over the years. The dynamics and politics of sugar industries both locally and internationally has also changed, and it is possibly time to review the variety release decision-making process.

Variety selection and release procedure

Crossing of two selected parents is the first step in producing and selecting a new variety. All crossing is done in the glasshouse facilities at SASRI because sugarcane does not produce seed naturally in South Africa. Each year about 1500 crosses are made during the crossing

season (May to August). Seed from these crosses is sown in the glasshouse to produce about 250 000 seedlings (potential new varieties). These seedlings are assigned to the SASRI research stations in the five major agroclimatic regions of the industry for field testing. Field testing, selection and advancement through a five-stage selection programme takes between 11 and 15 years, depending on the age of harvest in a particular region (12 to 24 months). Table 1 outlines the various stages of the SASRI selection programme and the number of varieties in each stage. The number of varieties is reduced at each stage, and the survivors are tested in larger plots in which their performance can be evaluated more reliably. At later stages of selection, replication is used to reduce and classify environmental variation, and trials are also done at several off-station sites. At present the main criteria for selection in the plant breeding selection programme are sucrose yield and resistance to pests and diseases. Decisions on which varieties to advance to the next stage are made by staff in the Plant Breeding Department at SASRI. Inputs from the Pathology and Entomology Departments on disease and *Eldana saccharina* (eldana) ratings respectively, are used in the selection process.

One or two varieties will survive this process in each of the five selection programmes to reach the final propagation stage, and these varieties are proposed to the Variety Release Committee (VRC) for bulking on co-operator farms. The VRC is a multidisciplinary team consisting of plant breeders, pathologists, entomologists, extension and senior managers. The VRC meets annually in June and is chaired by the assistant director of SASRI. No growers, millers or their representatives are on the VRC. After approval by the VRC, the Local Pest Disease and Variety Control Committee (LPD&VCC) will then receive a list of varieties approved for their area, and have to decide whether or not to bulk these varieties. Seedcane is delivered to the relevant LPD&VCC in October/November for planting on co-operator land, which should have been out of cane production for a minimum of six months. Co-operators in each area are registered with the Department of Agriculture.

Varieties in bulking are considered by the VRC for release to certain areas of the industry. The bulking plots are inspected for trueness to type and freedom from serious diseases three to four times by the LPD&VCC inspection teams and by SASRI pathology staff. A report on the findings of the LPD&VCC teams and pathology staff for each bulking plot is compiled and presented for deliberation at the VRC meeting. While varieties are in bulking, further/final results of variety trials, and entomology and pathology screening trials are collected and collated, and are presented at the VRC meeting for consideration. Although the release of a new sugarcane variety depends largely on its sucrose yield and its resistance to pests and diseases, other agronomic characteristics are also considered. Following approval for release by the VRC, the LPD&VCC makes the final decision on whether the variety will be released.

All varieties must be certified for planting in terms of government regulations (Anon, 2000). The South African Sugar Association (SASA) is responsible for publishing a notice in the Government Gazette that specifies the varieties of cane approved for planting in each control area or part of the area. Growers are not allowed to plant varieties that have not been approved by SASA and gazetted for planting in their area. Seedcane is also controlled in that growers are not permitted to sell or otherwise dispose of any seedcane without the prior approval of the LPD&VCC that has jurisdiction over the land on which the cane is grown (Anon, 2000).

Table 1. Summary of the SASRI selection programme.

Selection stage	No. varieties per station and total	Trial design	No reps	No crops	Selection rate (%)	Selection criteria	
Seedlings NURSERY	50 000 x 5 250 000	Potted seedlings	F a m i l y	1	70	Visual assessment of vigour. Freedom from diseases	
Stage 1 SINGLE STOOLS	35 000 x 5 175 000	Replication of families		1	11	Mean sucrose per family.	
Stage 2 SINGLE LINES	4 000 x 5 20 000	8 m row		2	10	Sucrose yield – plant and (estimated) ratoon Family performance from cross summary	Acceptable sucrose content Freedom from naturally occurring diseases and pests, and from agronomic defects
Stage 3 OBSERVATION TRIAL	400 x 5 2 000	2 x 8 m row	2	1	15	Plant cane sucrose yield Northern irrigated region – smut screening trial	
Stage 4 PRIMARY VARIETY TRIAL	60 x 5 300	5 x 8 m row (gross plot)	3	3	30	Plant cane sucrose yield (reselect in second ratoon) Smut/mosaic/eldana screening trials	
Stage 5 SECONDARY VARIETY TRIAL	20 x 5 100	As above - 3 off-station trials per region	3	3	5	Compilation of all yield and pest/disease results Yield stability or specific adaptability	
FINAL PROPAGATION	1 – 2 5	0.8 ha				Grower acceptance Resource Optimisation establish further trials	

Concerns with the present procedure

The process of developing a variety can be compared to the flow of water through a pipe. The pipe has filters at certain points (selection stages and release meetings) and its diameter is reduced at each filter. Individuals or committees control the filter points. The downfall of this system is when the control points are not consistent with each other and with that of the end user. A common and shared vision between the decision makers and the end users is of utmost importance.

Variety release decisions have an enormous impact on growers, millers and the industry as a whole. Although the VRC's variety release recommendations are considered and approved by the SASA Council, no growers, millers, or their representatives are involved in decision-making in the final stages of selection or in VRC meetings. Growers and millers should be more involved in making the decisions that affect them financially, and also share the responsibility for the consequences of those decisions.

Variety development is a multi-disciplinary, long and costly process. Long-term forward planning and strategising are necessary to effectively breed and select varieties that will be released 10 to 15 years in the future. This suggests a need for strategy ('what if?') workshops within the industry, where all players involved in breeding, selection and release, and the end-users of varieties will be present and which will take place at regular intervals.

Another issue in variety release is the question of risk. The reduction of risk comes at a cost to the industry. Some decisions are made without full understanding of the implications and risk. The consequences of:

- reducing the time of the selection process (stages and/or years)
- reducing the costs of variety development

- selecting varieties based on an economic index (e.g. releasing a high yielding variety that is highly susceptible to eldana)
- investing in basic research (e.g. molecular genetics of sugarcane)
- not planning for the future (e.g. alternate uses of sugarcane)

need to be communicated and appreciated by everyone involved and dependent on variety development.

Variety release procedure in other industries

Cenicaña - Colombia

Sugar milling companies in the Cauca Valley cultivate 70% of the sugarcane area. The remaining 30% is cultivated by independent growers. Regional variety trials are planted in the areas controlled by the mills, so they have the opportunity to be the first to get in contact with a new variety and to initiate its propagation and commercial use.

Cenicaña's scientists, essentially those who are working with the Variety Improvement Programme (VIP), such as geneticists, breeders and phytopathologists, have the responsibility for selecting varieties through the initial selection stages. In the later stages personnel from the sugar mills and all members of the Variety Committee are invited to participate in selection. The Variety Committee, in addition to the scientists of the VIP, comprises the heads of the Agronomy Departments at each mill and two independent growers (13 in total).

There is no Variety Release Committee as such. The Variety Committee approves varieties for planting in a specific agro-ecological zone. The members of the Committee do not vote for any variety, but they qualify them, and each member's opinion is taken into account to help in the final decision. The Committee does not have a person who presides over a meeting. Each meeting is hosted by a mill and always starts in the field visiting the varieties and ends at an appropriate venue for a final discussion.

Varieties are selected according to their productivity in a specific environment, in terms of cane production per hectare, sucrose content, resistance to diseases and other traits. Cenicaña is making an effort to select varieties not only for productivity but using an economic index.

Mauritius Sugar Industry Research Institute (MSIRI) - Mauritius

Breeders are responsible for reviewing the performance of and promoting varieties in early and final stage trials, agronomic trials, advanced multiplication nurseries, planting in observation plots and rapid *in-vitro* multiplication.

Three regional committees (North/West, Centre/East, South) made up of planters, their representatives, agronomists on large estates and researchers, evaluate promising varieties in trials and larger observation plots twice during the year (at establishment stage and pre-harvest stage). This is a participatory approach to breeding. The aim of these committees is to enable planters to get acquainted with the promising varieties before release, and to provide additional observation to breeders for decision-making. The committees do not substitute for the formal Cane Release Committee (CRC). An Annual Meeting of the Regional Committees is held prior to the meeting of the CRC, and observations made by growers during the field visits over the year are reviewed.

The CRC is made up of 17 members, which include major stakeholders and other representatives. Breeders prepare a booklet which is sent to members of the CRC before the annual meeting. The booklet includes notes on the candidate varieties proposed for release, and detailed data from all trials with their respective standards. The Director of MSIRI is the Chairman of the CRC. The Head of Department (HOD) Breeding reviews the agronomic performance of proposed varieties in a formal presentation and the HOD Pathology reviews the disease reaction of the candidates, which is followed by a debate. The decision to release a variety and restrictions, if any, is reached by consensus.

The CRC is a consultative body emanating from the Board of Agriculture to which it submits its recommendations for approval. After the Ministerial proclamation, the variety is gazetted. No indication is attached as to the region for cultivation. This has already been stated in the documents provided to the CRC and is approved taking into consideration agronomic performance and disease reactions. The region specified for a variety and its harvest data are elaborated in the recommendation sheets of the MSIRI. These are updated yearly after the meeting of the CRC and on feedback received from trials and planters.

BSES Limited - Australia

Selection meetings are held annually in each region, as early as possible after the previous season's data have been analysed. The selection meeting is normally run by the Variety Officer and is attended by the Programme Leader Plant Improvement, a breeder, a pathologist, regional plant breeding technicians, an Area Development Manager and Extension Officers. In some cases, Distribution Agents and/or industry members are invited. The meeting decides on new 'Accelerated Varieties' and the fate of previously 'Accelerated Varieties', including release, maximum propagation, long hot water treatment in preparation for maximum propagation, and holding or discarding.

For varieties that the meeting believes should be released, the Variety Officer prepares a 'Q application' in which all trial data, disease and other information, propagation amounts and history are reported. In the meantime, the breeder in charge organises an 'Industry Meeting' of millers and growers. This is achieved through a group called the 'Regional Planning and Advisory Committee' (RPAC), which have been set up in each region. The breeder presents all relevant data to this group and they either endorse or reject the release.

Once the RPAC has agreed to the release, the Q application is sent to the Chief Executive Officer (CEO) of BSES for approval and allocation of a Q number. When all Q numbers for the year have been allocated, a letter is sent to the Director-General Queensland Department of Primary Industries and Fisheries (QDPI&F) under the CEO's signature requesting approval of the varieties under the Sugar Industry Act, and including the appropriate disease resistance reports. Since BSES Limited has become incorporated, the QDPI&F has taken on the role of approving varieties (at the request of BSES Limited). This is done purely on the basis of resistance to certain diseases (e.g. leaf scald and Fiji leaf gall) and is granted for different Pest Quarantine Areas. This is done mainly to control varieties where growing them could endanger an entire region.

Once QDPI&F approval is obtained, distribution of the variety can take place. However, with the advent of BSES Limited taking out Plant Breeder's Rights (PBR) on varieties and signing up growers with PBR Licence Agreements, BSES Limited has to be very careful controlling varieties prior to release and needs to ensure that the application for PBR is at a stage that such a distribution will not compromise PBR.

Louisiana State University (LSU) AgCenter - Louisiana

Sugarcane breeding efforts in Louisiana are the result of cooperative efforts among three organisations: the LSU AgCenter, the United States Department of Agriculture – Agricultural Research Service (USDA-ARS) Sugarcane Research Unit, and the American Sugar Cane League (ASCL). Both the LSU AgCenter and the USDA-ARS Sugarcane Research Unit conduct commercial sugarcane breeding programmes in Louisiana. The ASCL, which is Louisiana's sugarcane grower's and processor organisation, contributes through financial support and personnel who assist in the outfield testing stage. They have primary responsibility for the seed increase on grower farms and manage distribution to other growers following release. The cooperative efforts are outlined in the Three-way Agreement of 1978 (Bischoff and Gravois, 2004).

The advancement of varieties through the initial stages of the LSU AgCenter and USDA-ARS selection programmes is left primarily to the respective scientists. The two selection programmes combine for the final selection stages (i.e. LSU AgCenter and USDA-ARS varieties are planted in the same nurseries and trials on growers' farms). At this stage all newly assigned and previously assigned varieties are given an active status. Each August a variety committee meets to determine the disposition of an active variety. The LSU AgCenter, USDA-ARS and the ASCL each have a vote. Unanimous votes are not discussed, while non-unanimous votes are discussed. Either the USDA-ARS or LSU AgCenter will take a lead in defending their varieties. Afterwards, data is collected only on the set of active varieties for the upcoming harvest. If a variety makes it through second ratoon data collection in the outfield variety trials, it will be considered for release.

The Louisiana Sugarcane Variety Release Committee comprises variety development personnel from the LSU AgCenter, USDA-ARS and the ASCL. The committee meets during the spring after the second-ratoon harvest of the final testing stage is complete and the data compiled. Mill managers have typically chaired the committee. A field visit is not part of the agenda for the meeting, as the fields are visited regularly prior to the meeting. Data summaries are presented and discussed by the three agencies. Each agency has a single vote. Two votes are necessary for the release of a new sugarcane variety. When a new variety is released, a notice of release is sent out to sugarcane growers, who can then order seedcane of the new variety from the secondary increase stations. Tissue culture derived seedcane is available the year after release from private seedcane companies (Bischoff and Gravois, 2004).

Agronomy Research and Variety Testing Unit - Barbados

The variety release process is fairly simple in Barbados - only about 8000 hectares of cane is grown and half of that is under one management company.

Final yield trials are all conducted on farms. Following these trials the Selection Officer recommends several promising varieties, which are then offered for expansion on farms. The final evaluation is therefore made by farmers interested enough to take up this offer.

There is an annual Variety Recommendation meeting to which all cane farmers on the island are invited. The data for existing varieties and new varieties are presented and discussed. Recommendations are made for planting varieties or withdrawing older varieties for three rainfall areas (high, intermediate and low), each divided into soil conditions (shallow and deep) rather than specific soil types.

Discussion

Each industry is unique, and it is not surprising that selection and release procedures differ among institutes/industries. The selection and release decisions made by SASRI over the past few decades have served the industry well, and have contributed hugely to the viability of the industry. This success has been due in part to the range of agricultural and scientific skills that SASRI and the VRC apply to this complex decision making process.

Essentially, SASRI's multi-disciplinary VRC has operated for many years as though it were mandated by the industry to make decisions that have a large component of financial risk on behalf of the industry. This places a burden on the VRC and SASRI to be accountable for the success or failure of new varieties released to the industry. It also assumes that SASRI and the VRC staff largely make the same decisions that growers and millers would make. All other industries reviewed have growers and/or millers directly or indirectly involved in selection and release decisions. It is time to reconsider greater involvement of the industry in the entire selection and variety release process in South Africa. The variety release process could be restructured in a number of ways:

- Growers and millers become more involved in the final selection stages and/or VRC decisions.
- Regional committees appraise varieties in final selection stage trials to provide additional information to breeders and the VRC for decision making.
- A multi-disciplinary team, including growers and millers, is formed to develop (and keep current) a single (economic) rating system for releasing varieties. The method places characteristics of varieties into economic perspective and helps to minimise subjectivity in the choice of variety (Inman-Bamber and Stead, 1990).
- Do away with the VRC, and a regional committee (possibly the LPD&VCC) select varieties for bulking and release from the final selection stage of the relevant selection programme (shopping list approach).

Further issues also need to be considered in restructuring the variety selection and release process in South Africa:

Plant Breeder's Rights

Plant Breeder's Rights are the exclusive, commercial rights to registered varieties (Cox *et al*, 2001). A registered variety is one that has a breeder, is distinct, uniform and stable, and has not yet been exploited or has only recently been exploited commercially. It is widely accepted that PBR has led to increased investment in plant breeding of agricultural crops (Cox *et al*, 2001). Since 2000, SASRI has been protecting all new varieties, and currently seven commercial sugarcane varieties (N35 to N42, excluding N38) are protected. This is not presently impacting on the variety release procedure, but could affect the procedure and adoption of new varieties in the future. Australian growers now have to grow BSES registered varieties under contract (Licence Agreement). Growers who choose not to sign a 'service agreement' with BSES Limited are charged a royalty for PBR varieties grown and delivered to the mill (Cox *et al*, 2001).

Time taken by growers to adopt new varieties

Many reasons for slow or non-adoption of varieties can be put forward. According to growers in Mauritius (Pillay, 1999) the main reasons were the lack of information on the performance of new varieties and limited availability of planting material.

Planting a new variety entails a certain amount of risk. This risk, amongst others, can be ascribed to the extent varieties are tested in the selection programme. The implications of further testing on the rate of variety release, the availability of tests for any additional criteria, the provider of additional tests and the costs of additional tests would need consideration. Poor communication between breeders, extension and growers regarding the performance of new varieties could also be a reason for lack of information and increased risk.

The role of tissue culture, transplant nurseries and bulking plots needs to be re-evaluated if planting material availability is a bottleneck in rapid adoption of new varieties, especially in the light of new technologies.

For breeding and selection programmes to be successful in the long term, they must not only produce a steady stream of improved varieties, but also have rapid adoption of these varieties by the industry. While improvements in sugar yield due to breeding are difficult to quantify, 1% per annum is a widely accepted target for plant breeders (Cox and Hogarth, 1993). Hogarth (1976) calculated that the Queensland sugar industry improved yields by 1.9% per annum from 1948 to 1975, and plant breeding was likely to have contributed about half of this increase. The domination of a few varieties in certain regions of South Africa for periods of more than 20 years could be reason for concern. Breeding and selection programmes need to be assessed on a regular basis to determine whether they are still on course and that poor performing varieties are not the reason for poor adoption. A number of criteria can be used to measure progress in a breeding and selection programme.

Conclusion

Continued long term gains through variety development is going to require a constant re-evaluation of techniques and procedures to ensure maximum efficiency, and this will depend on good communication, flexibility and strategic planning by all involved.

Based on international methods and to best serve the needs of the South African industry, a review of the variety release procedures is suggested.

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