Post-release variety testing has been a core feature of SASRI’s activities over the last 40 years. This paper reviews the value added from such activities with regard to variety adoption and return on industry investment. Sugarcane post-release testing is unique to South Africa and to date has been conducted separately from the plant breeding project. The testing network engages grower co-operators in a participatory approach. Examples of how knowledge exchange activities have influenced variety adoption trends are illustrated. The contribution of trials to variety adoption is illustrated through a survey of extension specialist opinions. Current limitations to variety adoption are discussed in relation to existing efforts and future plans. Estimates of genetic gains calculated from post-release trials will be presented and used to determine economic impacts of slow variety adoption. A comparison with production data from commercial estates shows that variety trials are good predictors of commercial performance. Examples of specific variety adaptabilities identified through trials highlight the complementary nature of post-release testing to the plant breeding project. The contribution of this testing network to the rationalisation of industry breeding strategies is discussed. A robust trial database allows for regular data mining exercises aimed at addressing key agronomic questions for the industry. Trial numbers and varieties per trial show increasing trends, highlighting the increasing need for local knowledge of variety performance and recognition of value derived. In recognition of such value and the need to sustain activities, post-release testing has been incorporated into the core activities of the plant breeding programme.

Keywords: post-release trials, sugarcane, variety adoption

Introduction

The South African Sugarcane Research Institute (SASRI) has conducted post-release variety testing (PRVT) activities within the discipline of Agronomy, independently of the core plant breeding (PB) project since the early 1970s. The main objectives of PRVT were to compare performance of released varieties in environments beyond those tested during selection, and to test performance over more ratoon crops (breeding trials are usually harvested over plant plus three ratoon crops only). Such trials were primarily driven by demand for variety information in a particular area, e.g. uncertainty around variety suitability to soil type, harvest age, frost prone areas, harvest season and waterlogging. The overall purpose of PRVT was to unpack the specific agronomic management of varieties to allow for more refined recommendations to growers. Over time, the PRVT activities at SASRI evolved into a stand-alone project known as the Variety Evaluation Project (VEP), which became part of the Variety Improvement project portfolio at SASRI. This change was geared towards a closer integration of the project with the core PB project. The latest defined objectives of the VEP are:
• To evaluate variety agronomic performance across a range of agro-climatic zones and management practices (knowledge generation); and
• To make information available and continually provide the industry with latest variety recommendations (knowledge exchange).

Experimental methods

The current PRVT network consists of grower-managed, on-farm trials. Trials are established on request, varying in number, specific conditions targeted, number of varieties tested, and frequency of establishment in the different regions. In most cases, demand for a trial is based on a certain critical mass of new varieties being available to justify a new trial. This unstructured, unbalanced approach brings with it many challenges with respect to multi-environment trial (MET) data analysis and interpretation. Conventional experimental designs are used (e.g. randomised complete block designs) together with other routine scientific methodologies. Trial results are communicated to grower groups through extension specialists, who play a key role in establishment and monitoring of trials and interpretation of results. Knowledge exchange events involving the project scientist, extension and growers are regularly held at trial sites. Trial data is collated into a database that is regularly analysed for key variety and agronomic trends.

Rationale for a review

For each of the current PB selection programs, METs are conducted in the final selection stages. The objective of final stage METs is to evaluate genotype x environment (GxE) interactions in target environments that characterise a region. Ideally, these METs must be representative of the target region and must discriminate variety performance differently (i.e. provide different information on relative variety performance) (Gauch, 1992). For many years it was assumed that the above criteria were sufficiently met by the existing MET networks. However, a series of GxE studies revealed possible redundancies of testing sites and suggested the need to improve testing efficiencies (Ramburan et al., 2012a, 2012b). In this regard, the efficiencies of PRVT have also been questioned, in light of the similarities between the testing networks. Indeed, if final stage METs in the PB project were well-distributed, representative of all target environments, and had good discriminating ability, then there would be no need for PRVT. Hence, in an effort to improve efficiencies in light of industry austerity measures, questions have been raised about the effectiveness and necessity for PRVT beyond the routine final stage PB trials. It was therefore necessary to review the value added by PRVT to guide further decisions about integration of these activities within the core breeding program to further improve efficiency. Additionally, the contribution of PRVT to variety adoption and realisation of genetic gains was unclear, and evidence of this link was lacking in the industry. As a result, this review seeks to address the following questions/issues:

1) Is PRVT contributing to adoption beyond that contributed by plant breeding activities alone?
2) Is PRVT adding value in terms of identifying niches, generating new agronomic knowledge on variety management, and complementing breeding?
3) Are post-release variety trials good predictors of commercial performance?
4) What is the industry return on investment for PRVT?
5) Are there other benefits or spin-offs related to post-release testing?
6) What are the challenges and opportunities for continued PRVT?

Materials and methods

Database records of trial numbers, yields, and variety numbers per trial over the past ten years were analysed to identify operational trends within the VEP. In an attempt to evaluate effectiveness of knowledge exchange events, the timing and nature of information presented
at different events were associated with variety adoption trends in a qualitative manner. This analysis was conducted to evaluate whether information and trial results presented in certain years could be linked to changes in variety disposition in the years that followed. Records of actual presentations and handouts utilised at grower events were examined, and key trial results from such materials were associated with variety adoption trends in the mill supply area (MSA).

To determine whether PRVT was contributing to adoption beyond that of conventional PB trials, extension specialists in different regions were surveyed. The contribution of PRVT to the identification of specific variety adaptabilities (niches) was assessed through the analysis and illustration of individual trial results. These examples are used to illustrate the value of PRVT in environments not routinely covered by breeding trials. To determine the effectiveness of PRVT at predicting commercial performance, varietal production data from two mill supply areas were compared with trial data obtained in the same areas in the preceding years. The return on investment for PRVT was estimated by calculating the research costs of establishing and running a standard variety trial, and comparing these costs to the potential benefit of the variety replacement. A single variety trial located approximately 100 km from the SASRI research station was used as a case study for this. Finally, the associated benefits, challenges, and opportunities of PRVT are discussed in the context of a research and knowledge exchange environment.

Results and Discussion

Contribution to adoption trends

Results from variety trials are regularly presented to growers at various grower events, which include field days at variety trial sites, or information days where trial results/variety characteristics are formally presented and discussed. Over the past few years, there has been a marked increase in the number of annual grower events focusing on varieties (Figure 1). It should be noted that these are events involving the VEP project manager and which have an exclusive variety focus. Other events, arranged at a local level by the local Extension Specialist are also routinely conducted, in addition to other published sources of variety information.

![Figure 1. The number of variety-related grower events conducted in the industry from 2008 to 2016. These events involve direct participation of the VEP project manager and involve presentation and discussion of trial results from the project.](image)

The objectives of grower events are to showcase the performance of new varieties and in doing so, promote adoption. The link between grower events and variety adoption are illustrated in the examples that follow. The bar charts in Figure 2 are examples of trial results presented at two successful grower events held in the Pongola mill supply area (MSA) in October 2008 with 25 grower attendees, and in February 2009 with 20 grower attendees. The results illustrated the superior performance of variety N41 in trials harvested early (a) and late (b) in the milling season. It is proposed that the rapid adoption of N41 in the region after 2008
(Figure 2c) was associated with these results being presented at these grower events. It is very plausible that timing of the grower events, the nature of the results presented, and the adoption patterns of N41 are linked. This is especially considering that N41 was initially released for rainfed conditions in the southern parts of the industry, and only gained popularity in the northern irrigated region (Pongla) after further PRVT trials.

Figure 2. Examples of trial results presented at grower events in Pongola in 2008 and 2009, showing the superior performance of N41 both early (b) and late (a) in the harvesting season (bar charts). The proposed/suggested impacts of those events on the adoption of N41 in the Pongoal mill area following the events are illustrated in the variety disposition trends, showing the percentage of total cane delivered and/or the percentage of area planted to different varieties (different data sources were combined) (c).

The bar charts in Figure 3 are extracts from a presentation given at a large grower event held in the Umfolozi MSA in April 2013. These trial results illustrated the superior performance of N36 (Figure 3a) and N41 (Figure 3b) in the area, relative to the standard N19. It is believed that the presentation and discussion of these results of trials in the area, together with results from trials in other areas were contributing factors to the increased adoption of N41 and N36 in Umfolozi after 2013 (Figure 3c).

Figure 4 (a,b,c) shows extracts from presentations given at grower events in the midlands region during 2011 and 2012. Each bar chart represents a different trial. The results showed the wide adaptability and superior performance of N48 at different midlands sites compared
with the standards N12 and N31. In the years following the communication of these results at grower events, there was a marked increase in the adoption of N48 in the region (Figure 4d).

Figure 3. Examples of trial results presented at a grower event at Umfolozi in April 2013. The bar chart on the left (a) shows the superior performance of N36 under rainfed conditions, while the figure on the right (b) shows superiority of N41 under irrigated conditions, relative to N19. The suggested impacts of these results on uptake of N36 and N41, and removal of N19 are illustrated in the disposition Figure (c).

It is acknowledged that the above approach to gauge the impact of communicating trial results to growers is subjective. Nevertheless, the trend of increased adoption of a variety following the communication of trial results depicting its superiority, is apparent. Similar trends were also observed in the Amatikulu and Felixton mill supply areas (not shown). It should be noted that trial results are also shared with the grower communities through the local extension specialists in the form of newsletters or grower study groups. Therefore, such grower events do not contribute in isolation, but rather, set the scene and act as triggers for continuous knowledge exchange where the specifics of the variety recommendations are discussed further.
Figure 4. Examples of trial results presented at grower events in the midlands in 2011 and 2012 (a, b, c). The bar charts illustrate the superior performance of N48 relative to N12 and N31 at different midlands sites. The timing of grower events and the suggested impacts of presenting these results on the adoption of N48 are shown (d).
Survey results

A survey was used to evaluate if post-release testing was contributing to variety adoption beyond that contributed by plant breeding activities alone. In this respect, it is important to note that the plant breeding project does not involve any knowledge exchange activities with growers on a routine basis. Data that is generated from breeding trials are used in release decisions, and in preparation of information sheets at release. Any subsequent refining of recommendations are derived from PRVT. Therefore, a key question was whether PRVT results were essential to adoption, or if growers were satisfied with plant breeding trial results alone. In general, extension specialists rated the importance of post-release trials as being moderately important to absolutely essential (Figure 5). The lower score in the Lower South Coast may be linked to the lack of trials (both post-release and breeding trials) in these areas historically. In these areas, variety adoption has occurred primarily through word of mouth. It is interesting to note that the variety dispositions in these areas still lack diversity and this could be linked to the lack of variety trials in the area.

Figure 5. Responses of extension specialists to the question, “How important have post-release trials been in encouraging adoption of new varieties in your area?” Ratings range from 1 (Not important at all) to 10 (Absolutely essential).

Are PRVT trials good predictors of commercial performance?

Figure 6 are examples of trial results presented to Mpumalanga growers at grower events in 2008 and 2009. These results were from trials that were harvested and concluded in the early 2000s. The results show the consistent superior performance of variety N36 compared with the standard variety N25. The timing of the grower events, and the (proposed) impacts on adoption of N36 in the area are shown in Figure 7, once again highlighting the importance of communicating trial results to improve variety adoption. The actual commercial yields achieved with variety N36, compared with N25 and N14 (another standard variety) from 2008 to 2014 are illustrated in Figure 8 (data from the RCL Ltd. production database). This example provides evidence that varietal performance in trials have direct impacts on adoption, and more importantly, such performance is reflected in commercial yields.

A second example shows an extract of a trial result presented at various grower field days in the coastal region of the industry (Figure 9a) until 2012. The result showed the superior performance of variety N41 relative to N12, which was the dominant variety in the coastal region at the time. Figure 9b shows the mean commercial performance of N41 and N12 from coastal sugar estates from 2013 to 2016. Once again, this demonstrates that PRVT trials are
good predictors of commercial performance. Such verification of variety trial results can only be conducted with accurate production data, which is unfortunately not readily available in the industry. Moving forward, more examples of the associations between trial and commercial performance will be gathered to add further grower confidence in trial results.

Figure 6. Mean RV yields from three separate variety trials showing the superior performance of N36 compared with N14 and N25.

Figure 7. Timing of two separate grower events that highlighted the superior performance of N36 in the Komati region, and the proposed impacts of those events on the adoption (% area planted) of N36.
Identifying specific adaptations and complementing breeding

One of the key objectives of PRVT is to test varieties over a wider range of conditions than those tested during selection, and in so doing, identify specific adaptabilities. The intention is to complement breeding by identifying niche environments for varieties, thereby encouraging more widespread variety usage. To this end, the VEP is continually generating new variety recommendations that would not have been derived from reliance on plant breeding trials exclusively. A few examples of these are described below.

Figure 10 shows the mean estimated recoverable crystal (ERC) yields (mean of three crops) of varieties from a variety trial in a valley prone to frost (so-called ‘frost pocket’) in the midlands region. The top two varieties, N41 and N36 were never released in the midlands region, yet they were superior yielders in this and other variety trials in frost pockets. As a result, up to 70% of the frost pockets in the midlands region are now planted to N36 and N41. This example illustrates how wider variety testing in the VEP can identify specific adaptabilities and encourage wider variety adoption, beyond the conditions originally intended for.
Figure 10. Mean ERC yields (mean of 3 crops) of varieties from a trial in a frost pocket. Varieties with green bars are those bred and released for the midlands region, and recommended for frost pockets at the time of trial establishment. Varieties N41 and N36 were originally released for coastal growing conditions.

A key consideration affecting variety choice is adaptability to soil types. In this regard, the VEP samples a wider range of soil types than that which is possible in selection trials. Genotype x soil type interactions are regularly observed in VEP trials, and such interactions are routinely reported to growers as refined recommendations. Figure 11 illustrates an example of typical genotype x soil type interactions observed in the midlands region. The standard variety N12 is superior to N37 on low potential grey soils, while N37 is generally superior to N12 on higher potential humic and red soils.

Figure 11. Mean ERC yields from multiple trials of varieties N37 and N12 on different soil types.

Ratooning ability (RA) is one of the most important considerations for growers in the industry, especially given the long ratoon cycles typically observed (between 6 and 10 crops). Perceived poor RA has been a major limitation to variety adoption in the industry. In this respect, the VEP plays an important role in alleviating some of the RA perceptions. The RA trends observed in trials have been regularly presented to growers at various forums over the last few years. Following these targeted efforts, there has been a change in the mindset of growers who seem to have a better appreciation of the greater effects of environment and management on RA. Where obvious cases of differential variety RA are observed, such information is presented to growers in various forums. For example, Figure 12 shows the good RA of variety
N41 in two coastal variety trials. These results (and others not shown) are believed to be key factors that influenced the widespread adoption of N41 in various parts of the industry (Figures 2 and 3).

Figure 12. Examples of ratoon decline trends from trials showing the good ratooning ability of N41 compared with other varieties in trials. The rank changes of N41 between early and late ratoons are of particular interest.

Other benefits of post-release testing

One of the features of post-release trials is flexibility. Trials are managed by growers under commercial conditions and are subject to commercial variations in management. Although this introduces imbalance and inconsistencies in the datasets derived from the trials, it also presents opportunities to gather relevant information on general production factors. The post-release trial database, therefore a valuable resource at SASRI, and has proven to be useful for a number of research questions. For example, unlike selection trials (which require structured, consistent harvesting cycles), post-release trials are harvested over the full spectrum of commercial harvest ages in the industry. This has created an opportunity to evaluate effects of different harvest ages and identify optimal harvest ages for different conditions (Figure 13).

Figure 13. Mean RV yields at different harvest ages in the coastal and midlands regions of the industry, illustrating the suggested optimal ages of 15 and 22 months compared with previously identified 18 and 24 months, respectively. Data for the analysis was extracted from a variety trial database.
Post-release trials are also harvested throughout the milling season, in comparison to selection trials that may need to be harvested at stricter harvest times to minimise genotype x season interactions in some programs. As such, analyses of post-release trials also provide growers with information on best harvest times of different varieties (example not shown).

In a recent drive to improve efficiency, post-release trials have incorporated chemical ripener or nematicide treatments in factorial designs more regularly. Variety interactions with these management factors are regularly observed in trials, and so the intention with these trials is to optimise management of varieties. This is especially important given the fact that nematicides and chemical ripeners are applied as standard practice under certain growing conditions in the industry. An example of a crossover genotype x nematicide interaction is shown in Figure 14.

![Figure 14. First ratoon RV yields of ten varieties in a factorial variety x nematicide trial. Variety N52 was the top performer when untreated, while N55 was the top performer when treated with nematicide.](image)

Post-release trials also serve as confirmation of pest and disease ratings of newly released varieties. In most cases, trials are conducted under commercial conditions with high pest or disease pressure. Additionally, queries from industry regarding the eldana ratings of certain varieties are also regularly addressed through an analysis of post-release trial data. For example, industry recently proposed a downgrade of the eldana rating of N48 to susceptible. An analysis of post-release trials confirmed that the variety still responds to eldana at the intermediate level, and no changes were made to the rating. Pest damage ratings for eldana (the most serious pest) are done routinely in all trials, while other pest and disease ratings are done opportunistically.

The PRVT network has also been used as a validation of genetic gains achieved from the PB project. These trials are suited to assess the long-term gains achieved through breeding as they consist of all commercially available varieties for specific production conditions. Every trial can therefore be considered as a genetic gain trial by plotting average estimated recoverable crystal (ERC) yields against year of variety release. This was done for all trials harvested since 1976 in the coastal (combined with hinterland), midlands, and irrigated regions in Figure 15. The estimated rates of genetic gain from post-release trials were 0.34, 0.21, and 0.13 tons ERC/ha/year in the coastal (a), midlands (b) and irrigated (c) regions of the industry, respectively. A key difference between these estimates and those from plant breeding populations (Zhou, 2013), is that the PRVT are grower managed and may therefore be considered more representative of ‘commercial’ gains achieved. This is seen as a valuable resource/data source when justifying industry investment into variety improvement activities.
Figure 15. Average ERC yields (across trials and crops) of SASRI varieties in the coastal (a), midlands (b) and irrigated (c) regions of the industry as a function of year of release. The slope of the straight line represents the rate of genetic gain per year.

Return on industry investment

Table 1 shows the estimated operational and staff costs associated with establishing a conventional variety trial consisting of 100 plots on a grower co-operator farm located approximately 100 km from the SASRI research station at Mount Edgecombe, Durban. Costs are calculated over three crops (plant plus two ratoons). Highest costs are incurred in the first year of trial establishment and harvesting, due to greater travelling, subsistence, seedcane, and field consumable costs. The staff costs indicated, include time spent on trial planning, data gathering, processing, analysis and report writing; in addition to manual in-field operations. After three crops, the total operational cost alone is approximately R61 000. When staff costs are included, this value increases to approximately R270 000.

Table 2 shows the calculation of a return on investment associated with a specific variety trial (the same trial used to estimate costs in Table 1). In this calculation it was assumed that the benefits of the new variety (N58) over the commercial control (N12), would lead to a 10% adoption of N58 in the mill supply area (this is a conservative assumption given the adoption patterns observed in Figures 2, 3, 4, and 7). The yield benefit applied to the area planted (10 000 ha) with a prevailing RV price was used to calculate an estimated benefit to the industry. The benefit was compared to the costs estimated in Table 1 to determine a return on investment. The results showed that the return on investment for a typical variety trial where an RV yield benefit of 2.29 tons RV/ha is identified (as per this specific trial), can lead to returns on industry investment of 1:1387 (operational costs only) to 1:313 (operational and staff costs).
It is acknowledged that the return on investment will vary from one trial to the next, depending on the yield benefits identified and the costs of the trial itself. However, the large returns on investment shown here give confidence to the continued establishment of post-release variety trials to ensure adoption of new varieties. Even with a 0.5 tons RV/ha benefit, and an adoption area of 5% (5000 ha), the return on investment on a variety trial was calculated as 1:34. It must be emphasised that these returns on investment are conservative as the benefits were only applied to a single mill supply area. In practice, the variety benefits demonstrated in one mill area are often used to promote variety adoption in other areas as well. Therefore, overall industry benefits are likely to be much greater.

Table 1. Operational and staff costs associated with conducting a post-release variety trial consisting of 100 plots on a grower co-operator farm located 100 km from the SASRI Mount Edgecombe research station. Costs for three crops (plant and two ratoons) are shown.

<table>
<thead>
<tr>
<th>Operational costs</th>
<th>Plant crop</th>
<th>1st Ratoon</th>
<th>2nd Ratoon</th>
<th>Sum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Travel costs</td>
<td>12 070</td>
<td>4 260</td>
<td>4 260</td>
<td>20 590</td>
</tr>
<tr>
<td>Weighing machine cost</td>
<td>5 513.92</td>
<td>5 513.92</td>
<td>5 513.92</td>
<td>16 541.76</td>
</tr>
<tr>
<td>Subsistence</td>
<td>2 520</td>
<td>1 170</td>
<td>1 170</td>
<td>4 860</td>
</tr>
<tr>
<td>Seedcane</td>
<td>9 000</td>
<td>0</td>
<td>0</td>
<td>9 000</td>
</tr>
<tr>
<td>Field consumables</td>
<td>1 227.42</td>
<td>592.46</td>
<td>592.46</td>
<td>2 412.34</td>
</tr>
<tr>
<td>Soil sample</td>
<td>190</td>
<td>0</td>
<td>0</td>
<td>190</td>
</tr>
<tr>
<td>Sucrose samples</td>
<td>2 500</td>
<td>2 500</td>
<td>2 500</td>
<td>7 500</td>
</tr>
<tr>
<td><strong>Operational total</strong></td>
<td><strong>33 021.3</strong></td>
<td><strong>14 036.38</strong></td>
<td><strong>14 036.38</strong></td>
<td><strong>61 094.1</strong></td>
</tr>
<tr>
<td>Staff costs (manpower)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Researcher/technician/labour</td>
<td>116 878.08</td>
<td>46 277.6</td>
<td>46 277.6</td>
<td>209 433.28</td>
</tr>
<tr>
<td><strong>Total final cost (operational + manpower)</strong></td>
<td><strong>149 899.4</strong></td>
<td><strong>60 313.98</strong></td>
<td><strong>60 313.98</strong></td>
<td><strong>270 527.4</strong></td>
</tr>
</tbody>
</table>

Table 2. Calculation of the return on investment associated with a post-release variety trial. The actual RV yields of two varieties in a variety trial are compared. An adoption area of the new variety of 10% (10 000 ha) of a typical mill supply area was assumed to calculate the overall industry benefit.

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</thead>
<tbody>
<tr>
<td>Average RV yield (R/ha) of top performing variety (N58)</td>
<td>12.84</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Average RV yield (t/ha) of commercial control variety (N12)</td>
<td>10.55</td>
<td></td>
<td></td>
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<tr>
<td>Difference between top performer and commercial control (Tons RV/ha)</td>
<td>2.29</td>
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<td></td>
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<td>RV price (R/tRV)</td>
<td>3700</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Benefit of top performer over commercial control (R/ha)</td>
<td>8 473</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conservative adoption of 10% of mill supply area (ha)</td>
<td>10 000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Estimated industry benefit (Rands)</td>
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<td></td>
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<tr>
<td><strong>Total operational cost of a 3-year variety trial</strong></td>
<td>61 094.1</td>
<td></td>
<td></td>
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</tr>
<tr>
<td><strong>Total staff and operational cost of a 3-year variety trial</strong></td>
<td>270 527.4</td>
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<td></td>
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</tr>
<tr>
<td><strong>Estimated return on investment of R1 (operational costs only)</strong></td>
<td>1 387</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Estimated return on investment of R1 (operational and staff costs)</strong></td>
<td>313</td>
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<td></td>
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</tr>
</tbody>
</table>
Challenges, opportunities, and the future

The rate of variety release in the industry has improved markedly in recent times (Figure 16a), and this is a reflection of the outputs of the PB project. The exponential increase is due to the simultaneous release of multiple varieties per annum for different production regions; a key outcome of regional breeding. However, even at the regional level, the number of available varieties for commercial production is substantial. This is reflected by the increase in the average and maximum number of varieties tested per trial (Figure 16b). The requirement for trials consisting of large variety numbers is related to the relatively slow rates of variety adoption in the industry, whereby growers still require comparisons of latest varieties with very old commercial controls. This increase in demand for variety information has led to increases in the size of trial networks (Figure 17), which puts a strain on available resources. Additionally, larger trials are more difficult to manage by growers in terms of labour usage and weed control. Furthermore, larger trials are also associated with reductions in spatial homogeneity, thereby compromising accuracy of trial results. Addressing the issue of an expanding trial network necessitates re-aligning the rates of variety release with the rates of variety adoption in the industry. To this end, more emphasis must be placed on knowledge exchange activities to promote quicker adoption.

Figure 16. The number of released varieties in the sugar industry from 1945 to 2017 (a), and the average and maximum numbers of varieties per post-release trial since 1975.
High trial numbers with limited resources often results in limited data gathering and interpretation per trial. Additionally, environmental characterisation before and during the lifespan of trials are limited. For example, soil type characterisation is often poor, and done subjectively with grower and extension input. Seasonal effects are not regularly defined through crop model applications (e.g. calculations of drought indices). Better environmental characterisation of trials will add value to recommendations and assist with interpretations of GxE interactions (Ramburan et al., 2012b).

The lack of proper environmental characterisation also increases the risk of duplication of target conditions in trials. In some regions, PB selection trials and PRVT trials are conducted under very similar conditions. It is therefore essential that the two trial networks are properly aligned to complement each other, improve efficiencies, and eliminate redundancies. In this regard there are ongoing efforts to characterise target environments for different regions and rationalise trial numbers to test for these environments. The PB selection trials will, in future, include larger numbers of commercial control varieties, thereby doubling-up as PRVT trials. Additionally, PRVT will also include un-released, promising genotypes with potential in the respective regions.

All of the above structural changes require a closer collaboration between members of the PB team, the VEP, and extension specialists in the different regions. The value of PRVT in ensuring realisation of genetic gains in the industry are apparent from this review. Therefore, merging of resources within the two activities (PB and VEP projects) are necessary to ensure the sustainability of PRVT. In this regard, a new model of the stages in the PB project is proposed (Figure 18). This model will ensure that PRVT is incorporated within the PB project moving forward. This system will ensure that components of knowledge exchange, variety adoption, and variety agronomic management are incorporated into the PB project to deliver holistic value of genetic improvements to the industry.

![Figure 17. Number of post-release variety trials harvested per annum.](image-url)
Selection stages of the SASRI Plant Breeding Project and the proposed role of post-release variety testing on knowledge exchange and adoption. The core breeding program is indicated by the stages from seedlings to release.

Conclusions

There is evidence that PRVT is contributing positively to adoption of varieties in different regions of the industry. This is reflected in the association between the nature of data presented at grower contact events, the timing of grower contact events, and the concomitant increases in adoption of specific varieties. These associations are also backed by extension opinions of the value added by post-release trials. There is also evidence that such trials are complementing breeding activities by finding variety niches and specific adaptabilities that would not have been identified through routine breeding trials. The data generated from post-release trials are also a valuable resource to SASRI in general, as regular data mining exercises contribute to new knowledge of cane production and management. Estimates of progress due to breeding may also be estimated using data from PRVT.

There is a general feeling amongst growers and extension staff that post-release trials are now embedded in South African grower culture. This review has shown that there are significant returns on industry investment into PRVT trials. The results also suggest that PRVT should continue at SASRI, in one form or another, as it plays a pivotal role in ensuring commercial value of genetic improvements. In this regard, a decision has been taken to incorporate the operations of the VEP into the corre PB project to ensure sustainability, improve efficiencies, and enhance knowledge exchange activities.
REFERENCES


