BSES 1975 - 2000

CELEBRATING 100 YEARS
1900-2000
BSES
Advancing Sugar

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The first 75 years (1900 to 1975) are covered in '75 Years of Scientific Progress'.

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BACKGROUND

The Bureau of Sugar Experiment Stations (BSES) is the principal research, development and extension (R,D&E) organisation servicing the agricultural and milling sections of the Queensland sugar industry and providing research, development and extension to the agricultural section of the New South Wales sugar industry.

Created in 1900 by the *Sugar Experiment Stations Act*, it was, until 1951, a sub-department under the Queensland Ministry of Agriculture and Stock (now the Queensland Department of Primary Industries) jointly administered by Government and the Sugar Experiment Stations Advisory Board. In the same year, following an amendment to the Act, the name of the Board was changed to the Sugar Experiment Stations Board.

In 1997, an amendment to the Act recommended by the Sugar Industry Review Working Party (1996) redefined BSES as a body corporate. Public Service control was largely removed and more responsibility was transferred to the Board of Directors. At the time of this publication, BSES operated under the *Sugar Industry Act 1999* and sourced its funds from a range of areas, including State and Federal Government grants, voluntary grower and miller service fees, and commercial contracts.

The year 2000 marks BSES' Centenary and 100 years of service to the Australian sugar industry. This booklet has been produced to acknowledge and commemorate the achievements by BSES and its staff since the publication of '75 Years of Scientific Progress' in 1975.

FOREWARD BY CHAIRPERSON MR TOM FENWICK

BSES has achieved 100 years of service as the Australian sugar industry's premier R,D&E organisation. This booklet celebrates BSES's Centenary and covers the organisation's highlights from 1975 to 2000.

Industry support for BSES has remained strong in the face of economic uncertainties and a drop in the world sugar price. In return for continued industry support, BSES staff have achieved excellent results and helped the Australian canegrowing industry to maximise the output and quality of its product.

The sugar industry has been confronted with many challenges since 1975. Extremes in weather, disease threats, increased canegrub damage and higher environmental accountability are just a few of the issues that have had to be dealt with. The Australian sugar industry's commitment to R,D&E has helped to overcome such challenges and achieve continued success. Ongoing support for BSES will ensure that Australian raw sugar remains a preferred product on the domestic and international markets.

PREFACE BY CEO DR COLIN RYAN

BSES is known for the positive role it has played and continues to play in the Australian sugar industry. A strong R,D&E base has provided industry with the ability to solve many complex problems and to regularly review and update its growing, harvesting and milling techniques and machinery.

Changes to BSES's structure since 1975 and a broadening of the organisation's knowledge base have helped BSES keep pace with changing industry needs and continue to provide the best service possible to its clients. In the past 25 years, BSES has proven that it is adaptable to change, capable of handling a wide range of issues, and keen to collaborate with other research bodies to help solve important industry issues.

BSES was funded principally by the Queensland industry until 1987, but is now funded from a wider range of sources. This has resulted in an increased R,D&E portfolio.

While structure and funding arrangements have changed over time, the organisation's purpose, to advance the international competitiveness of the Australian sugar industry, remains the same. BSES is, and will continue to be, committed to increasing the Australian sugar industry's competitive strengths.

A CHANGING INDUSTRY

In 2000, the Australian sugar industry is different to the infant industry of the early-1900s. At the beginning of the 1900s, cane was planted by hand, growers had access to a few cane varieties, the crop was hand harvested, and recovery of sugar at the mills was relatively poor.

Today, canegrowing is highly mechanised and is more a business than a way of life. R,D&E is improving the performance of machinery, and plant breeding is producing a stream of improved varieties tailored to meet the needs of particular areas. There is now a systems approach in many aspects of canegrowing, such as integrated management of pests, green cane harvesting and cane transport. Development of new technology in the mill has put our industry at the forefront in raw sugar processing.

These achievements have been brought about by R,D&E activity, with BSES staff being prominent.

BSES ADMINISTRATION

The structure of BSES and the way in which it is administered has altered significantly since 1975 to meet the changing needs of the Australian sugar industry.

Organisational structure

Traditionally, BSES work was organised according to discipline (ie entomology, pathology). Today, a more strategic approach is taken and staff from different areas of specialisation work together on high-priority issues.

The catalyst for this change was a review of the sugar industry in 1985 by the Sugar Industry Working Party which recommended major changes to BSES's structure. In 1989, BSES undertook a large-scale restructuring of its divisions. Operations were streamlined by task rather than by discipline, Groups were established for Cane Breeding and Improvement, Agronomy and Crop Protection, and Extension and Agricultural Engineering. And, an Agri-Milling Unit was formed.

The new Group structure resulted in a small management team based in Brisbane. Group Managers became focused on creating a teamwork environment and applied strategic management techniques to their work to meet the organisation's changing needs.

On a local level, a small-scale restructure of BSES Sugar Experiment Stations was undertaken in 1976. Administrative Officers were replaced with Station Executive Committees. An Officer-in-Charge was also appointed at each of the Stations to head an Executive Committee. This resulted in greater sharing of responsibilities and more efficient management of the Stations. More recently, Officers-in-Charge of each Station have been appointed to represent the Chief Executive Officer.

BSES Board

A Board of Directors oversees BSES policy and administration matters. The Board is made up of a Chairperson, the Chief Executive Officer and six Directors from a cross-section of backgrounds including commercial, research, development and extension, cane production and milling. Membership is on a part-time basis and representatives are selected every three years. The range of experience brought to the Board ensures a good coverage of issues in policy decision making.

Funding

In June 1999, annual income was approximately $19.8 million. The two main sources of income were an industry levy (29%) and Sugar Research and Development Corporation (SRDC) grants (32.4%). The remaining funds were sourced from a number of areas including State Government grants, commercial contracts, joint research contracts, and the sale of cane from the organisation's Sugar Experiment Stations.

While BSES income has increased significantly since 1975, direct industry funding has declined sharply in real terms. This drop has been replaced by the increase in project work sourced through SRDC, commercial contracts and consultancies. The decline in direct industry funds now means that there is greater partnership funding with agencies such as SRDC and Cooperative Research Centres. Consequently, this has reduced flexibility and BSES's ability to respond to emerging issues.

In 2000, compulsory levies were abolished and replaced by a voluntary service fee.

Cane Protection and Productivity Boards

Cane Protection and Productivity Boards (CPPBs) have played and will continue to play an important role in BSES's history.

For many years, CPPBs were funded by compulsory levies. More recently they have become voluntary organisations. Following the changes, the three Boards in Bundaberg formed a joint venture with BSES. This arrangement resulted in significant savings for the Boards and BSES.

A close working relationship was also established between BSES and the Plane Creek CPPB. As a result, BSES provides a Productivity Officer and Research Assistant to work on CPPB issues in that region. CPPB staff work out of offices owned by BSES in Mackay and the Herbert, and closer relations are being established in other areas.

When a new mill was established on the Atherton Tableland, it was decided not to form a CPPB. BSES was contracted to provide clean seed to the suppliers of the new mill, and a distributor was contracted to grow and deliver the cane.

SRDC funding

The establishment of the Sugar Research Council (now SRDC) in 1987, has impacted significantly on BSES structure and staffing.

In 1987, BSES employed 129 permanent and 11 contract staff. In July 2000, there were 125 permanent and 189 contract staff (including Cane Analysis and Audit staff, see pg: 6) at BSES. SRDC project funding has meant a large increase in contract staff and a significant expansion in BSES research capacity. BSES has ensured that its core work, such as plant breeding, is maintained.

Consulting services

Consulting has become an important component of BSES funding.

BSES's first consulting agreement was signed in 1978 with the Western Australia Department of Agriculture to investigate agricultural requirements for the successful production of sugarcane in the Ord River region.

BSES's consulting agreement with the Ramu sugar industry, Papua New Guinea, was signed in 1981. The agreement, which continues today, provides for staff to visit Ramu biannually to advise on plant pathology, entomology, plant breeding and quarantine. Information is also exchanged between BSES and the Ramu industry on exotic pests and diseases that could spread to the Australian industry.

In the 1980s, a short-term agreement with the Malaysian sugar industry was established to advise on plant breeding and assist in the design of disease trials.

More recently, a long-term commercial contract was signed between BSES and the New South Wales canegrowing industry to provide a range of research, development and extension services.

Cane Analysis and Audit Service

The Queensland sugar industry has had a cane testing service for a very long time. The objective of the service has been to ensure that correct procedures are used for analysis of cane samples. The Queensland Sugar Cane Prices Board ran the service until 1991 when it was taken over by the Queensland Sugar Corporation. In 2000, the cane testing service was taken over by BSES and renamed the Cane Analysis and Audit Service. This has added about 90 seasonal staff to the BSES team.

Infrastructure

The number of BSES offices increased between 1975 and 2000 to meet the expanding needs of regional areas. The Sarina Extension Centre and Tully Sugar Experiment Station were officially opened in 1976. The David North Plant Research Centre (DNPRC) was purchased from CSR Limited in 1979 for new Head Office premises and an expanded research site. Head Office was relocated from Gregory Terrace to DNPRC in 1980, and all research other than disease testing was moved to DNPRC from the Pathology Farm at Eight Mile Plains.

In the 1980s, BSES acquired land for Innisfail and the new Centre was officially opened in 1985. In the same year, the Babinda Extension Centre was closed down and services were based at Meringa. In January 1999, an extension officer was located to Babinda.

For many years, an extension team operating out of the local CANEGROWERS' office in Ingham serviced the Herbert industry. In the late 1980s, it became apparent that the district would benefit from an Experiment Station. Land was acquired in the early 1990s for this purpose and the Herbert Sugar Experiment Station was built in 1995.

In 1997, BSES opened an Extension Centre in Tolga. BSES expansion into the Atherton Tableland was due to significant industry growth in the area and an increase in demand for BSES services.

The Eight Mile Plains Pathology Farm was closed down in early 2000 due to urban encroachment and rising costs. In the same year, a new Sugar Experiment Station was opened at Woodford, about 100 km north of Brisbane. The opening of Woodford marked the beginning of BSES's centenary celebrations.

In addition to Head Office and the David North Plant Research Centre in Brisbane, BSES has seven Sugar Experiment Stations which are located in Meringa, Tully, Ingham (Herbert), Brandon (Burdekin), Mackay (Central), Bundaberg (Southern) and Woodford.

BSES also has ten Extension Centres, based at Tolga, Innisfail, Proserpine, Sarina, Childers, Maryborough, Nambour, Rocky Point, Condong and Harwood.

New Technology

The past 25 years have seen rapidly increasing computerisation within BSES, and a resulting increase in throughput and efficiencies in all areas.

The first computer was purchased for Bundaberg Sugar Experiment Station in 1977 for the Mill Technology Division. In 1978, another computer was purchased for Head Office, Brisbane, primarily for analysis of plant breeding and other trial results, development of plant breeding databases and

some administrative work, such as accounting. Desktop computers were purchased in 1986 for Meringa, Mackay, Brisbane and Bundaberg. Since then, computers have become readily available to staff.

Throughout the 1980s and 1990s, computers provided benefits in all areas of BSES research and extension. For example, storage and retrieval of plant breeding data for use in the cross-pollination program became more efficient. In 1975, it took about six breeders to compile a list of crosses using data stored on cards on manually prepared registers. Today, the same task requires one to two people and is completed in a fraction of the time.

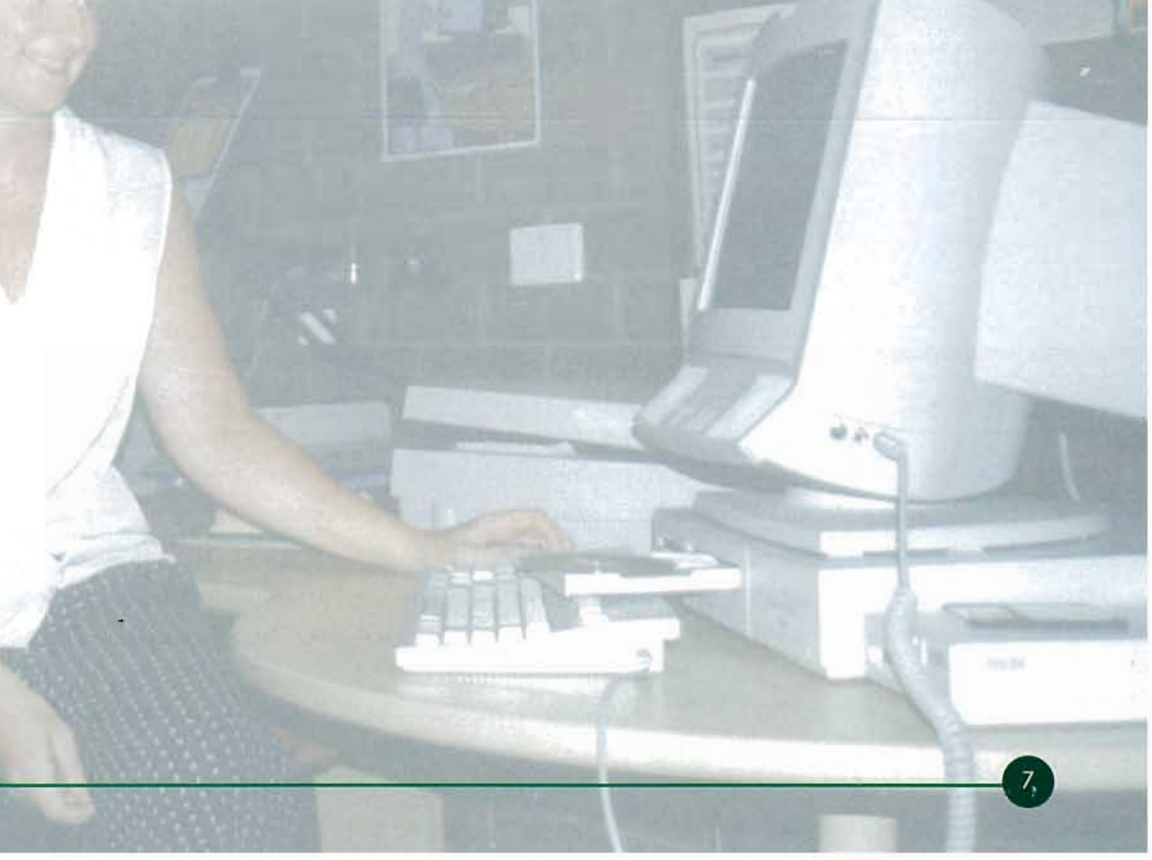
The processing capacity of computers has made it possible for BSES to handle vast quantities of data from large trials. Before 1975 and the advent of mechanical harvesting and mobile weighing bins, an average plant breeding trial would involve 15 experimental varieties; in the 1990s an average trial involves 100 experimental varieties.

In recent years, many advances have been made in the application of computer technology. BSES Head Office computers were networked in 1995 and networking of computers at the Stations was undertaken over the following two years. Staff located at Head Office and the Stations now have improved access to a range of locally produced data, including research and project management data bases, financial information and records management. Other network services, such as printers, e-mail and faxing have been centralised at each of the locations.

In 1997, BSES established its own website. The site takes advantage of the latest computer technology to deliver communication to BSES's customers, including growers, harvester contractors and millers. It also promotes the work carried out by BSES among its peers in Australia and internationally.

As an offshoot of the website, BSES developed an Intranet site for staff. Staff are able to tap into the site to access operational documents, software, newsletters, library and calendar information. The Intranet, along with e-mail, has greatly improved integration of work between Stations.

Towards the future, BSES will establish BSES Direct, an extension to the BSES website. BSES Direct will provide a new means of delivering information and services to BSES customers.



RESEARCH DEVELOPMENT AND EXTENSION

BSES research, development and extension is focused on industry R,D&E priorities. The organisation is committed to fostering innovation and creativity, and as such funds both high-risk and core projects. BSES ensures professionalism throughout all of its work, and maintains a science watch to keep abreast of changes and remain a leader in cutting edge research and development.

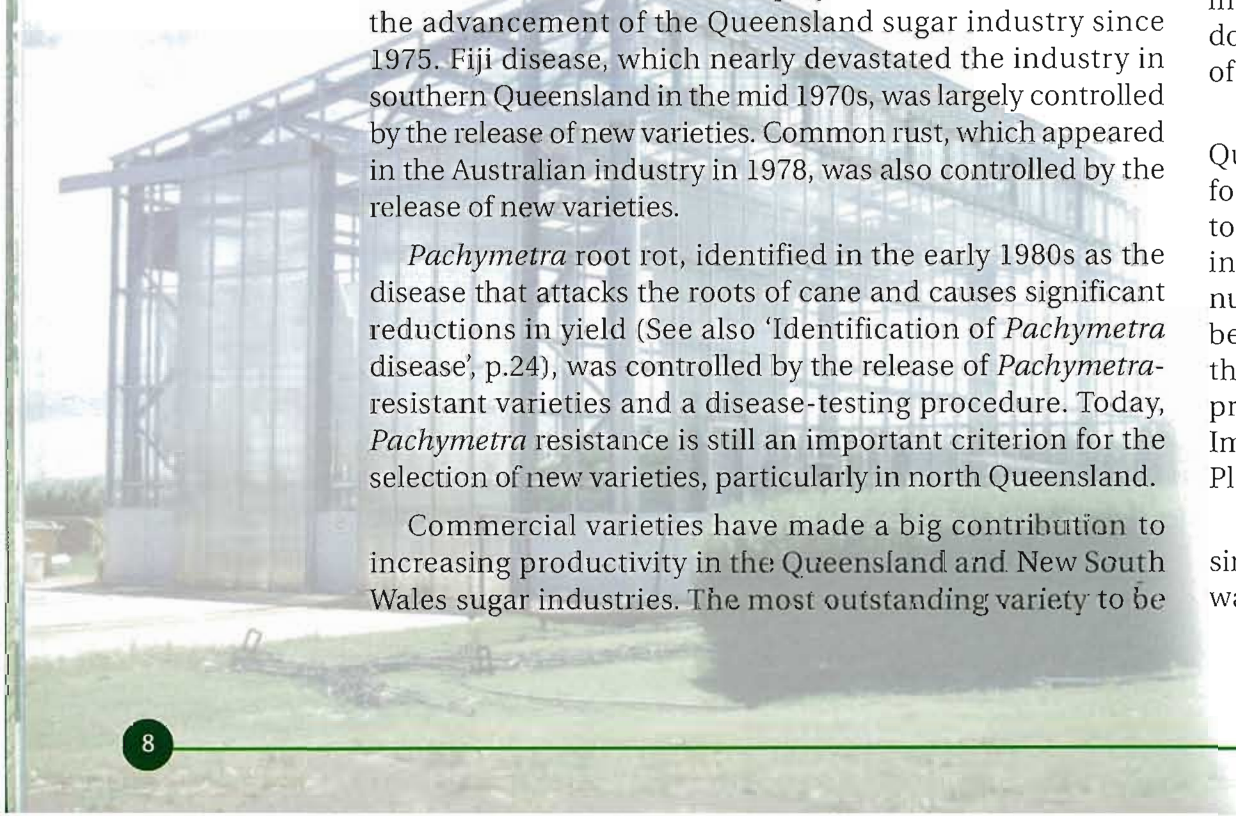
Cane Varieties

Release of commercial varieties

Commercial varieties have played a considerable role in the advancement of the Queensland sugar industry since 1975. Fiji disease, which nearly devastated the industry in southern Queensland in the mid 1970s, was largely controlled by the release of new varieties. Common rust, which appeared in the Australian industry in 1978, was also controlled by the release of new varieties.

Pachymetra root rot, identified in the early 1980s as the disease that attacks the roots of cane and causes significant reductions in yield (See also 'Identification of *Pachymetra* disease', p.24), was controlled by the release of *Pachymetra*-resistant varieties and a disease-testing procedure. Today, *Pachymetra* resistance is still an important criterion for the selection of new varieties, particularly in north Queensland.

Commercial varieties have made a big contribution to increasing productivity in the Queensland and New South Wales sugar industries. The most outstanding variety to be released in the last 25 years, Q124, has increased yield and sugar content in northern and central canegrowing districts, particularly in the Herbert and Mackay regions. In southern Queensland, new varieties have lifted ccs by over a unit and increased cane yield.



In January 2000, what is believed to be a new strain of orange rust *(Puccinia kuehnii)* was found on Q124. Orange rust is a disease that has been noted in Australia for over 100 years, but it has never caused any economic losses. However, in the current outbreak, it has caused losses of 30 to 40% in the cane yield of Q124, and there have also been serious reductions in ccs. The disease has been particularly serious in the Central and Herbert district regions where Q124 is the dominant variety. This disease will see the rapid replacement of Q124 with resistant varieties.

A decline in ccs has been a major problem in far north Queensland since 1975. Research has shown a difference of four units of ccs between sound cane in the field compared to cane delivered to the mill. Increased suckering and lodging in cane, along with increases in extraneous matter, the number of tops in the cane supply, and pest damage appear to be the major factors involved. Several of these are related to the increased power of modern harvesters. Suckering problems are associated with green cane trash blanketing. Improving ccs will be one of the greatest challenges for BSES Plant Breeding over the next 10 years.

Industry confidence in BSES varieties has grown steadily since 1975. In that year, 56% of the cane supply in Queensland was sourced from BSES varieties. In 2000, this figure was 98%.

The impact of technology on plant breeding

The 1970s marked an industry-wide shift from hand cutting to mechanical harvesting of cane. BSES employed the industry's last cane cutter, who retired from cutting cane in 1975. In that year, BSES moved from hand harvesting all of its trials to mechanical harvesting.

Mechanical harvesting enabled BSES plant breeders to conduct much larger trials. Mobile weighing bins, developed by BSES in the late 1970s, further boosted the efficiency of plant breeding trials. In previous years, trial cane was assessed visually and then weighed manually close to final selection stages. The mobile trucks proved far more accurate and efficient than the manual system and resulted in a reduction in the number of stages of selection. However, it is still important to make visual observations on varieties to assess characters such as suckering and lodging.

Laboratory facilities, developed around the same time, were capable of dealing with larger trial samples. Previously, laboratories would have struggled to handle 200 samples per day, but by the 1980s, most BSES laboratories had the capacity to analyse up to 800 cane samples per day, using fewer staff. The benefits meant an overall increase in the number of varieties released from the plant breeding program at a lower cost to industry.

Improved selection techniques

The use of family selection (varieties chosen using a statistically-based method of measuring performance among canes that are related genetically) in plant breeding has resulted in a 15% improvement in the performance of selected varieties since 1975. Prior to family selection, seedlings were chosen visually in the field. As technology advanced, bigger plots of cane organised in families could be weighed, so that strong parents could be selected for future crosses. Approximately 250 families are currently assessed, and the best-performing individuals within selected families are chosen for evaluation in larger plots.

Due to a better understanding of the strengths of individual varieties and improved breeding technology, BSES is now able to breed for specific traits (ie high sugar, resistance to disease) and can select varieties to meet the needs of growers in individual districts.

A high-early sugar program was commenced by BSES in 1987. High-early sugar is considered a very desirable selection trait. Three varieties with high-early sugar have been released commercially and more will be released in future years.

An improved awareness of the interaction between the cane plant and its surrounding environment has also increased the accuracy of variety selection. Trends in trial data have shown that factors such as soil, water and temperature will greatly influence the suitability of a specific variety to an individual area. Substations (areas separate to Sugar Experiment Stations where varieties are grown for BSES plant breeding trials) on major soil types in all canegrowing districts have been developed. Twenty-four substations are in operation today.

Control of flowering

Sugarcane plants do not flower readily in the Australian environment. In an average year, fewer than 40% of parent varieties in BSES's variety collection will flower. In 1992, only 16% of parent varieties flowered, resulting in very limited potential that year for crosses. In 1986, BSES built a photoperiod house (a controlled-climate facility used to initiate flowering) at its Meringa Station. The house was programmed to control temperature and light to help induce flowering in the parent collection. Mixed results were achieved for several years. However, by the early 1990s, results from a research program identified conditions conducive to flowering. **Today, BSES is able to obtain flowers from about 80% of varieties in its parent collection.**

Due to the success of the photoperiod house, an additional facility has been constructed at the BSES's Meringa Station. The facility will be used specifically to make crosses for high sugar content for far north Queensland. A similar facility was also built at the Bundaberg Station in 1996. The facility was built to aid the process of using southern and central varieties in the cross-pollination program (See also Increased capacity for quarantine, p.18).

Development of Australian Plant Genetic Resource Centre

BSES has become one of seven key players in the new Australian Plant Genetic Resource Centres. The Centres were initiated by the Commonwealth Government in 1990 to promote the preservation of germplasm from major crops for future crop breeding. BSES established, and now manages, the sugar industry's variety garden at BSES's Meringa Sugar Experiment Station. The garden is small (150 m x 50 m), and includes mostly noble canes representing a selection of important basic germplasm.

Plant breeders rights

In 1994, the Federal Government introduced the Plant Breeder's Rights (PBR) Act 1994 to replace the previous Plant Varieties Rights Act (1987). One significant change in the new act was the provision for a plant breeder to claim royalties on the harvested product from a variety. As a result, there is now a mechanism for a sugarcane breeder to obtain royalties on sugarcane varieties.

In 1995, BSES started applying for PBR on new commercial varieties (Q varieties). BSES now has rights on all Q varieties released since Q163, with the exception of Q164. As the compulsory BSES levy ended in 2000, BSES made the decision to commence using PBR to obtain royalties from protected varieties to ensure funding for the development of future varieties. It is only intended to collect royalties from growers who do not agree to pay the voluntary BSES service fee.

Technology transfer

Change in extension methodology

New challenges, ie increasing community and environmental issues, more competitive international markets and rapid changes in technology, have resulted in a more strategic approach to extension. **Since 1975, BSES extension has steadily moved away from a largely advisory role, to more participatory (growers, harvesters and millers are involved along with BSES staff), project-based extension** whereby extension staff work with various groups on projects. Results are then extended to the rest of the industry. BSES extension embraced this approach and contributed to advances in green cane/minimum tillage farming, water use efficiency, reducing cane loss, adoption of integrated pest management techniques and farm planning on new farms.

Communication and basic information on farm practices and project results have remained a high priority for BSES extension since 1975. The traditional avenues of communication, such as field days, information meetings and shed meetings, still play an important role. Additionally, new and exciting avenues of communication are available. Industry is kept informed through the mass media, information technology (eg CD-ROMS, the Internet) and farm management programs. In the future, it is predicted that industry will use e-mail and the Internet more frequently.

Benchmarking skills

The project 'Extension of Benchmarking Skills' (jointly funded by SRDC, BSES and Resource Consulting Services) was established in 1993 to develop the tools to rank growers in terms of a list of performance criteria (eg average cane yield, profitability). Many growers use this information to plot business performance and identify potential areas of improvement in farm management.

A computer package for benchmarking has been commercialised for the canegrowing industry. BSES's objective at the time the project was started was to eventually expand the package to include elements to aid in sustainable farming, long-term planning, and investment decisions. The project Extension of Benchmarking Skills marked a shift in approaching farming as a way of life and towards managing farming as a business.

Development of farm management courses for growers

BSES's involvement in farm management dates back to the late-1960s, when the organisation ran a 'Managerial Service' in conjunction with the Queensland Canegrowers Council (now CANEGROWERS) to provide farm business advice. During the time the service was in operation, hundreds of growers sought assistance to improve their farm management skills.

In the 1980s, two BSES extension officers developed a book-based farm record keeping system for keeping financial and farm activity records. The system was used through to the early 1990s, when personal computers became affordable.

The next phase of BSES's farm management work came in 1993 when training courses on Quicken® were developed. Quicken® is a computer-based cashbook designed for small businesses. The program proved to be popular among canegrowers, and courses were well attended. Surveys were conducted following the courses to gauge the impact of the training and assess growers' future farm management needs. Most indicated an interest in a productivity-recording program. BSES approached software development company, Saltbush and CANEGROWERS to assist in the production of a package, and CANEMAN was produced in 1996. CANEMAN, a productivity recording program which records all farm inputs (ie irrigation, fertiliser, cultivation) and outputs (ie tonnes of cane, CCS), was well received by industry and has helped many growers to improve their farm management skills.

Crop management

Adoption of green cane trash blanketing

Some early studies into green-cane trash-blanketing (GCTB) were carried out by BSES prior to the introduction of mechanical harvesting. Relatively little was done until the 1970s. In 1976, a BSES extension officer, based in Innisfail, instigated preliminary trials on the effects of burnt cane trash retention and minimum tillage on soil health and erosion. Several years later, BSES trash retention trials were established on a grower's farm in north Queensland.

Between 1980 and 1984, BSES extension officers and research staff were actively involved in GCTB trials on growers' farms. Throughout the 1980s, other researchers from CSR Sugar, the Queensland Department of Primary Industries and CSIRO undertook research on the relative benefits and pitfalls of GCTB. **By 1989, 78% of growers in far north Queensland (Herbert to Mossman) were using GCTB on their farms.**

Nitrogen loss from GCTB crops became a concern in the mid-1980s. The practice of retaining trash from green-cane harvesting meant that growers applied nutrients to the crop in a different manner. Instead of burying urea under the soil, it was broadcast over the top of the soil. Research by BSES, CSIRO and CSR scientists investigated the implications of these changes. Subsequent work by BSES extension officers resulted in improved fertiliser recommendations and placement techniques for GCTB crops.

While growers in far north Queensland readily adopted GCTB, BSES research has shown that for the southern districts and New South Wales, cool, wet weather impacts on the efficiency of GCTB and reduced productivity may be experienced. Adoption in the Burdekin district was constrained by harvesting difficulties and concerns about furrow irrigation. There were initial concerns about the GCTB system from Mackay south. GCTB is now widely and successfully practised in most of Queensland. It is still not practised in the Burdekin district, but adoption is around 35% in southern Queensland.

In recent years, BSES has monitored GCTB adoption throughout Queensland and compared it to burnt cane harvesting. GCTB has increased in many areas because it:

- reduces costs for erosion and weed control;
- reduces soil erosion;
- improves conservation of soil nutrients;
- provides lifestyle benefits, eg not having to burn the cane; and
- puts an end to deterioration of burnt cane in wet periods.

Approximately 70% of the Queensland crop is now harvested green. Community pressure to stop burning, combined with the many benefits that GCTB provides, makes it the preferred method in most districts. In areas where green-cane harvesting remains uneconomical, research is being conducted to determine if changes to farming practices or machinery may improve GCTB efficiency.

In line with the general shift to GCTB, harvester manufacturers have developed more powerful harvesters capable of cutting through the denser plant material. The downside of these improvements is that more trash and dirt is retained, and cane loss is increased. In recent years, BSES has instigated research into reducing cane lost during harvesting (see 'Reducing cane loss', p.16).

High density planting

BSES and CSR scientists investigated the concept of dual rows, a form of high density planting, in the early 1970s. The availability of suitable machinery and low use of chemicals to control weeds in dual rows limited uptake of the technology.

High density planting involves planting a crop at closer spacings than traditional practices so that yield is optimised. In the cane industry, the traditional row spacing is 1.5 m. Under close-row planting, cane is planted in rows 0.5 m apart. The reduced gaps between the cane rows allow light, water and nutrient uptake to be maximised, and this results in improved cane yield.

Two BSES scientists at Bundaberg investigated the concept again in the early 1990s. The scientists found a great deal of research from around the world on high density planting, but no application of the technique in the field. Trials with cane rows 0.5 m apart were established at BSES Bundaberg, and farm machinery was developed over the following years to plant and harvest cane under this system. Yield increases of over 50 tonnes of cane per hectare were common under carefully managed trials.

HDP trials were expanded in the following years and the BSES agricultural engineering team developed appropriate machinery. **BSES has shown that high density planting is likely to be a viable system for several regions, and can potentially boost productivity and profitability in the Australian sugar industry.**

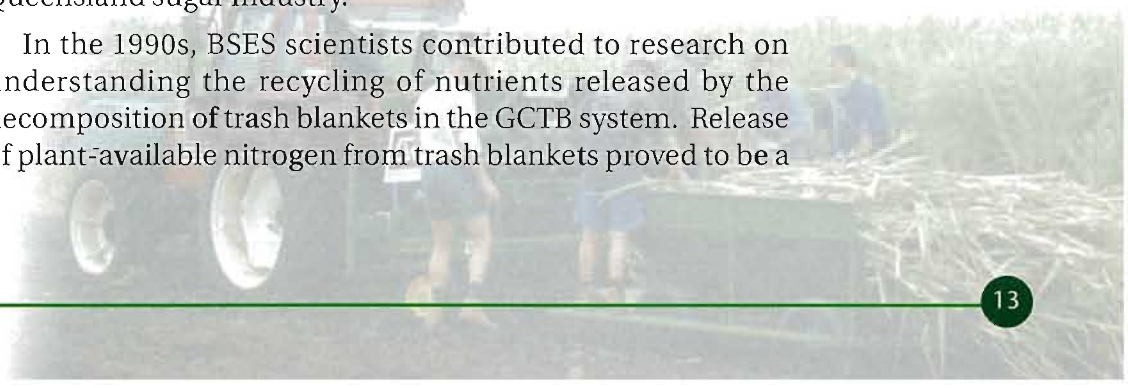
Improving crop nutrition

BSES research during the late 1970s identified calcium and magnesium deficiencies in north Queensland canegrowing districts. This research determined the remedial measures required to correct these deficiencies. By 1980, critical marginal and optimum soil values for calcium and magnesium were identified. This enabled growers to compare their soil analyses with these values and assess whether they needed to apply calcium or magnesium and how much needed to be applied.

The average response to lime and magnesium applications in north Queensland on deficient soils has been an increase of about 25 tonnes of cane per hectare, or a 35% yield increase. It has become common practice throughout Queensland to test for calcium and magnesium deficiencies in the soil and fertilise according to BSES recommendations. Research in the 1990s has further refined liming recommendations for improved lime use efficiency and prompted more balanced crop nutrition.

Similar research was also carried out by BSES on zinc deficiencies in the 1980s. Soil tests to identify where zinc deficiencies existed were developed and trials were conducted to determine optimum zinc applications. Good yield responses were achieved on zinc deficient soils using BSES recommendations, which are now followed throughout the Queensland sugar industry.

In the 1990s, BSES scientists contributed to research on understanding the recycling of nutrients released by the decomposition of trash blankets in the GCTB system. Release of plant-available nitrogen from trash blankets proved to be a



slow process, which may take 10 to 15 years before the system is stable enough to release significant nitrogen for crop growth. This finding parallels commercial experience, where growers are reducing fertiliser nitrogen applications according to BSES recommendations.

In the future, BSES research will seek to identify nutritional disorders and help industry further refine nutrient applications to ensure maximum crop growth with minimal impact on the environment.

Understanding the impact of soil compaction

BSES soil compaction research has highlighted how soil degradation through compaction reduces crop yield and industry profits. In recent years it has been estimated that soil compaction costs the industry somewhere between $54 million and $110 million each year.

Studies on transportation and soil compaction began in Tully in the 1970s, soon after the adoption of mechanical harvesting. Research into the impact of the commonly used roll-on/roll-off harvesting equipment, compared to high-flotation equipment, was prompted by concerns that compaction problems were worsened by wet harvesting conditions. Research showed that flotation equipment enabled harvesting under wetter soil conditions with less field damage than conventional equipment. However, the equipment had little or no impact on yield when cane was harvested in dry conditions.

Further soil compaction studies were undertaken in the 1990s to determine its connection with yield decline. Studies investigated the impact of in-field traffic on compaction under ideal harvesting conditions. The work showed that soil in the row was degraded by traffic travelling over the row. A Swedish compaction model was modified to indicate the cost of losses due to in-field traffic. Today, the model is used as a guide for controlled traffic, ie modifying row spacing for ideal positioning of haulout equipment to improve soil conditions and to reduce compaction. Traffic positioned away from the row, near the row, or down the inter-row has been shown to have less of an impact on soil quality and can potentially lift yields by 10 to 20%, compared with traffic over the row.

Improving water use efficiency

Irrigation efficiency, the shortage of irrigation water, and the environmental consequences of over-irrigation are important issues in most Queensland canegrowing districts and are high-priority research, development and extension areas for BSES.

Prior to 1975, production of irrigated cane was confined largely to the Burdekin district and parts of the Bundaberg region. Between 1966 and 1976, BSES carried out a series of irrigation experiments throughout Queensland. The experiments highlighted the increased efficiencies that could be gained from irrigation.

Drought conditions in many areas in the 1970s and 1980s led to demands for more water storage facilities, interest in on-farm storage, and requests for information on how to best use limited water. By the early 1980s, many growers had adopted irrigation on their farms, but there were still some who thought it was uneconomic to fully irrigate. Subsequent **BSES studies of the economics of irrigation and improved irrigation efficiency underpinned change, and now 60% of the Queensland crop is produced with irrigation.**

A BSES researcher established a water use efficiency benchmark of 12.2 tonnes of cane per megalitre of crop water use in 1994. The benchmark was modified to a cane water index and now forms the basis of the Queensland-wide assessment of water use efficiency in the sugar industry.

In recent years, BSES irrigation research has focused on distribution efficiency of irrigation systems, irrigation scheduling and water storage. Staff have applied a computer model, SIRMOD (developed as part of a joint BSES/SRDC/CSR research project), to help growers understand the interactions between factors affecting furrow irrigation efficiency.

Industry has been supportive of BSES efforts to improve water use efficiency. Work has been carried out in a participative fashion and has helped industry solve water-use problems. There is now capacity to optimise yields where there is sufficient irrigation water and make better use of the limited resource in other areas. From an environmental point of view, studies have been conducted to determine nutrient movement and many growers have installed tail-water return systems to contain run-off. This minimises movement of nutrients and chemicals off-farm and allows reuse of run-off for irrigation.

Harvesting

Reducing cane loss

Harvesting practices throughout the Queensland sugarcane industry have changed dramatically since 1975. Today, 70% of Queensland harvests green, compared to 3% in 1985. To keep pace, the power and capacity of harvesters have increased to cut larger amounts of cane. While there have been many agronomic and economic benefits from the shift to green cane, increased cane loss and dirt levels have been measured where green cane is harvested.

BSES conducted cane loss investigations during the 1980s, and estimated millions of dollars in losses caused by

inappropriate crop presentation and excess uptake of extraneous matter and dirt during harvesting. Significant financial losses were highlighted in all districts where cane was harvested green rather than burnt. A BSES survey of all canegrowing districts in 1991 showed that cane loss was very costly, and that high intake of dirt during harvesting was reducing the quality of cane and returns to industry. Collectively, reduced income due to these factors was valued at $80 million per annum.

Following the 1991 cane loss surveys, with funding from SRDC, BSES mounted the extension project 'Reducing Harvesting Losses'. Growing and harvesting practices throughout Queensland were studied for three years, and recommendations were developed on crop presentation and adjustments to core harvester operating standards to reduce losses. Dirt levels and their impact on harvesting losses were also addressed.

A cane loss monitor was developed in the early 1990s by BSES for installation in harvesters. This innovation helped harvester operators keep check on extractor losses, and today the monitor is installed in many new harvesters. The project also resulted in SRDC funding research into dirt levels in harvested cane.

In 2000, cane loss and dirt in cane remained significant industry issues. Harvesting machinery and techniques are constantly changing. Machine design changes have resulted in increases in cutting capacity and throughput, so that requirements to limit cane loss and dirt can change rapidly. Cane loss is an industry issue, which requires ongoing efforts to ensure losses are minimised.

BSES's role in harvester development

BSES's first agricultural engineer was employed in 1975. Early agricultural engineering research addressed the impact of harvesters on cane loss and dirt in cane (see also 'Reducing cane loss', p.15-16). BSES staff designed a portable harvesting facility for use in cane loss trials to obtain accurate measurements of billet losses, extraneous matter and varietal responses to harvesting. Their contributions were instrumental in raising awareness of harvester operating techniques to reduce losses, and resulted in some machine modifications. One such modification is the installation of the cane loss monitor, which helps operators adjust harvester speed to suit individual crops.

Research into billet quality was also undertaken during the 1980s. The BSES agricultural engineering team showed that drum choppers had less of an impact on billet quality than swinging knives. Drum choppers are now used in most canegrowing districts in preference to swinging knives.

More recently, research into primary extractors has resulted in design and performance improvements, particularly with the primary cleaner. This has increased harvesting rates, without increasing dirt and extraneous matter.

Research into improving harvester feeding capacity to handle bigger crops of green cane (two-year crops) at commercial rates, without increasing cane loss or extraneous matter, is also showing promise

Milling

Improving fugal efficiency

BSES has played a significant role in the design and development of continuous centrifugals and in ensuring their efficient operation in the Australian sugar industry. BSES research in this area started in the late 1960s and continued through to the 1990s.

Continuous centrifugals were first used in the Australian sugar industry in 1963 to process low-grade massecuite for molasses at a mill in Mackay. These machines offered a higher throughput and a lower power demand per tonne of massecuite processed than was possible with the batch machines. However, the speed at which the crystals left the centrifugal basket led to considerable crystal breakage on impact with the wall of the machine. This meant that the machines were unsuitable for use in the processing of high-grade massecuite to produce raw sugar. The crystal breakage and loss of crystal through the screen at the low-grade continuous centrifugals also led to processing losses and difficulties in subsequent processing of the crystal in the mill.

In the mid 1980s, BSES engineers successfully designed a deflector baffle for continuous centrifugals. The deflector is a curved surface of metal made up of a series of interconnected, conical sections inserted between the top of the spinning basket and the fugal wall. The impact of the crystals on the deflector plates gradually reduces the speed of the crystals before they collide with the wall of the machine. This has led to reduced crystal breakage with continuous centrifugals and made them an alternative to batch machines in the processing of high-grade massecuites. The construction of the deflector baffles is illustrated in Figure 1.

In recent years, BSES, the University of Queensland and engineering firm, NQEA (Australia) Pty Ltd, have collaborated in the design of a continuous centrifugal specifically for high-grade massecuite. The work has built upon the technology from low-grade centrifugal research. Researchers involved were awarded the President's Medal for their paper at the 1990 Conference of the Australian Society of Sugar Cane Technologists. BSES has since maintained its involvement in the evaluation of these high-grade continuous machines and in the development of modifications to further improve raw sugar quality.

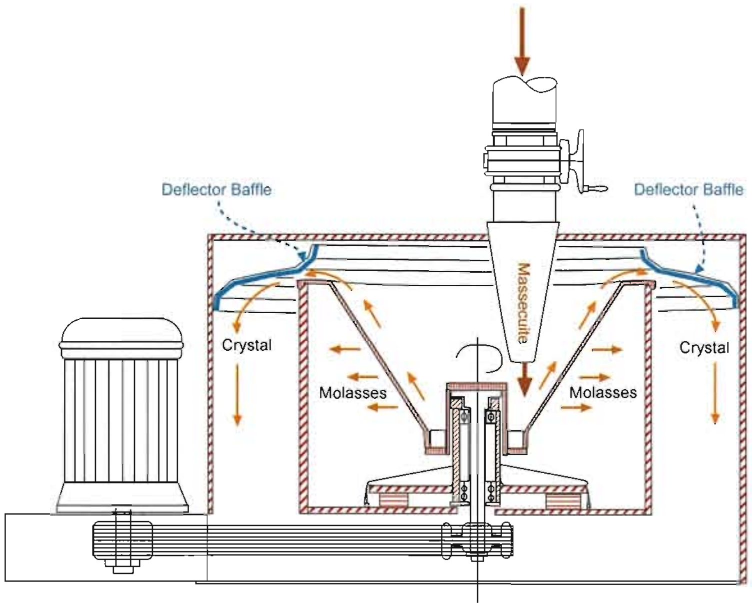


Figure 1 - Schematic diagram of a deflector baffle inside a K1000 centrifugal

Cane diseases

Advances in disease diagnostics

For most of the sugar industry's history, diseases have been tested by visual inspection. In recent years, sophisticated tests with high levels of sensitivity have been developed by BSES. These tests are based on two techniques, either enzyme-linked immunosorbent assay (ELISA), a serological test that detects protein, or polymerase chain reaction (PCR), a molecular test which detects DNA or RNA.

The development in 1991 of the ELISA test to detect ratoon stunting disease (RSD) was a great advance in RSD control. ELISA has allowed ten times more samples to be tested for RSD in a day than could be tested using phase-contrast microscopy, which has contributed to a reduction in the incidence of RSD (see 'Management of ratoon stunting disease', p.19).

PCR tests detect pathogen DNA (for bacteria, fungi, some viruses) or RNA (for most viruses) within the sugarcane plant with a high degree of sensitivity. These tests have been used by BSES quarantine in recent years to ensure imported foreign varieties, and varieties, which are moved across quarantine boundaries, are disease free. PCR tests for sugarcane mosaic virus, Fiji disease virus and sugarcane bacilliform virus have been developed at BSES and used to screen quarantine cane. Tests for other pathogens, such as leaf scald and phytoplasmas, have been developed overseas and are also used in quarantine.

Increased capacity for quarantine

BSES quarantine helps to protect the Australian canegrowing industry from the introduction of exotic pests and diseases through varieties imported for plant breeding. It also enables varieties to be moved safely between districts within Queensland and northern New South Wales for increased plant breeding options.

Prior to moving its Head Office to the David North Plant Research Centre in 1980 (see 'Organisational structure', p.4), BSES quarantine consisted of one small glasshouse at the top of its office building in Gregory Terrace, Brisbane. The DNPRC had eight large glasshouses with the capacity to store hundreds of varieties.

Since the move to DNPRC, BSES has expanded its quarantine services to meet the increasing needs of the Australian canegrowing industry. In 1994, services were expanded and a new quarantine glasshouse, with six compartments segmenting canes from different locations and different collections, was completed with financial assistance from SRDC. This boosted the organisation's quarantine capacity and made more space available for isolating genetically modified canes.

In 2000, BSES's glasshouses contained up to 800 varieties for its core quarantine programs. Programs cover the exchange of varieties between BSES Stations and the importation of new varieties. Varieties are also exported to a number of countries that exchange varieties with Australia.

Since 1975, BSES quarantine services have increased the number of varieties available to the Queensland and New South Wales breeding programs and minimised the risk of disease or pest outbreaks. In the future, BSES will continue to work towards high quality standards and the development of quality management agreements with countries involved in BSES's variety exchange programs.

Control of Fiji disease

In 1975, the Bundaberg cane industry faced devastation from the outbreak of Fiji disease. Virtually the only variety grown in the district, NCo310, was highly susceptible to the disease. The industry was in a state of crisis, with early efforts to control the disease through the use of disease-free planting material unsuccessful. Fiji disease is spread by a leafhopper. The sheer numbers of the pest meant that it was impractical to control Fiji disease through the use of insecticides.

Resistant varieties were developed to solve the problem. An enormous effort was made to accelerate the selection process. Glasshouses were built at Bundaberg, and BSES monitored varieties for resistance to Fiji disease using a glasshouse rating technique. By 1977, two varieties, Q87 and CP44-101, proved to be fairly resistant to the disease and were released for commercial growth. This helped to reduce the impact of Fiji disease. By 1980, BSES had developed four varieties with a high level of resistance to Fiji disease: Q108, Q109, Q110 and Q111. From this time onwards, there was a rapid decline in Fiji disease in Bundaberg.

The Fiji disease outbreak in Bundaberg was an important lesson for the industry and BSES. The industry relied too heavily on one variety, and that variety, NCo310, proved to be highly susceptible to Fiji disease. BSES is committed to developing Fiji resistant varieties and providing a number of variety options for individual canegrowing districts.

Management of ratoon stunting disease

Ratoon stunting disease (RSD), first discovered in the Australian canegrowing industry in 1944, is recognised as the most important disease of sugarcane world-wide. Bacteria that attack the vascular system of the cane plant cause RSD, restricting the plant's ability to carry water and to grow. While RSD was prevalent in the Australian cane industry 50 years ago, in 2000 only 5% to 10% of fields were infected by RSD.

Until 1980, RSD was identified by visual inspection. At times, cane was sliced to find red markings (an indication of blockages) in the cane plant.

A phase-contrast microscope technique, developed by BSES in 1980, resulted in far wider and more thorough testing for RSD. The technique used a relatively inexpensive lighting device fitted to ordinary microscopes. Cane Protection and Productivity Board staff were trained to use the technique, which allowed them to greatly increase the accuracy of RSD diagnosis.

In 1991, BSES developed a serological test for RSD, known as ELISA. The test allowed ten times more samples to be tested for RSD in a day than was possible using phase-contrast microscopy and was far more accurate. More than 45,000 samples have been tested annually in the BSES Tully and Mackay laboratories since the introduction of ELISA. The New South Wales industry recently adopted the test and has since recorded large increases in productivity.

The provision of clean planting material also plays an important part in RSD control. In the early 1970s, growers took cane plants to mills, where they were hot-water treated to kill any RSD bacteria, and then established the planting material themselves. Cane Protection and Productivity Boards now take existing and new varieties to hot-water-treat, plant and establish the cane under tight controls, and then provide clean seed to growers.

Control of common rust

Common rust was found in north Queensland in late 1978, and then spread rapidly throughout the area and the rest of Queensland. North Queensland was particularly vulnerable due to its dependence on highly susceptible varieties such as Q90. Losses of around 20 to 30% were experienced in the district.

BSES and the industry were able to respond immediately to the disease due to its high visibility (rust results in deep red stripes down the cane leaf). Rust was controlled by the development of resistant varieties. The first resistant variety to be released in north Queensland, Q113, resulted in a dramatic drop in the incidence of the disease. Other resistant varieties were soon released, and today resistance to rust is an important selection criterion.

Control of orange rust

Orange rust is a disease that infects the leaves of the sugarcane plant, producing small orange-brown lesions and moderate to significant crop losses. In 2000, the Queensland canegrowing industry experienced an orange rust epidemic for the first time in its history, with extremely high levels of the disease in the Central district, Herbert River, Burdekin district, Wet Tropics region and Atherton Tableland.

In March 2000, BSES established a task force to help manage the impact of orange rust. Task force members included BSES staff, staff from Cane Protection and Productivity Boards and other industry representatives. The task force developed a strategy to control the disease and to help minimise losses in the future. At the time this history was compiled, BSES was working on the development of varieties resistant to orange rust.

Outbreak of smut in Western Australia

In 1998, an outbreak of sugarcane smut disease occurred in the Australian sugarcane industry in the Ord River Irrigation Area, Western Australia. This was the first time that the disease smut had been found in Australia, and there are now only two sugarcane growing countries that do not have the disease – Fiji and Papua New Guinea. Obviously, the threat of smut reaching the east coast of Australia has increased.

To minimise the threat to the sugar industry in eastern Australia, BSES signed an agreement with the Indonesian Sugar Research Institute to test Australian varieties for their resistance to the disease. Beginning in 1999, some 250 varieties each year will be tested over a 12-month period for their resistance to smut. Unfortunately, most Australian varieties are proving to be susceptible to the disease, so BSES has undertaken a breeding program concentrating on known resistant varieties.

Cane pests

Integrated pest management

A large number of insect and vertebrate pests attack sugarcane in Australia. Since the 1940s, the first course of action against pests has been the use of synthetic pesticides. At first, this included the long-lasting organochlorines, such as benzene hexachloride (BHC), heptachlor and dieldrin, but concerns about residues of these materials in cattle, the potential for development of resistance and links with outbreaks of other pests, such as cicadas, saw these insecticides withdrawn from the market in the late 1980s.

Less-persistent insecticides are now used by the industry, with the major one, chlorpyrifos, produced in a controlled-release formulation, suSCon® Blue.

Canegrowers realise that there is a need to reduce reliance on a few synthetic pesticides, and the industry is attempting to broaden control options and integrate them into useable management strategies. This is the essence of Integrated Pest Management **(IPM) - a system where all suitable techniques and methods are used in as compatible a way as possible to maintain pest populations** below the level causing economic loss.

BSES has been at the forefront of this change, developing IPM systems through a three-pronged approach:

• The first is to make the most efficient use of the insecticides already employed in the industry - applying them only when needed and ensuring that they work to their full potential.

• The second is to develop substitute controls – eg the biological insecticide Biocane™ Granules based on the fungus Metarhizium, the synthetic insecticide Rugby® and pheromone traps for weevil borers.

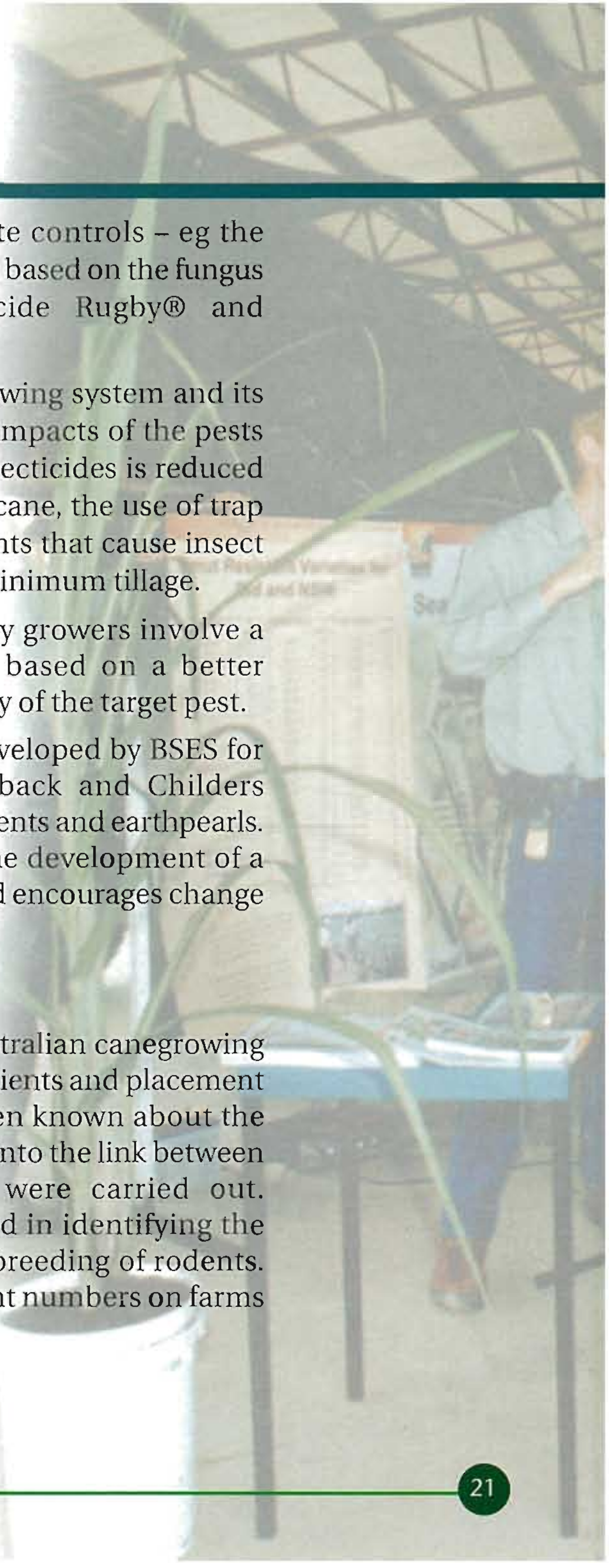
• The third is to redesign the canegrowing system and its management so that the numbers and impacts of the pests are reduced and the requirement for insecticides is reduced –ie the use of more tolerant varieties of cane, the use of trap crops, and promoting the growth of agents that cause insect diseases through trash blanketing and minimum tillage.

Practical IPM programs employed by growers involve a combination of these ideas, and are based on a better understanding of the biology and ecology of the target pest.

Management packages have been developed by BSES for the major pests of sugarcane - greyback and Childers canegrubs, soldier flies, weevil borers, rodents and earthpearls. Underpinning this research has been the development of a culture amongst growers that accepts and encourages change to pest management practices.

Management of rodents

Historically, rodent control in the Australian canegrowing industry has relied on baits. Active ingredients and placement strategies have varied, but little has been known about the biology of the pest. In 1975, early studies into the link between rodent biology and rodent control were carried out. Researchers were particularly interested in identifying the conditions that were conducive to the breeding of rodents. This work indicated a link between rodent numbers on farms and weed and grass levels.



Since 1980, rodent control has shifted from reliance on baits to reducing the ability of rodents to breed. In the early 1980s, BSES and the Queensland University of Technology undertook a joint project to research the diets and breeding habits of rodents. The work confirmed that rodent numbers could be significantly reduced if their main source of food, weeds and grasses, was controlled by reducing in-crop weeds, slashing grasses in headlands, and managing harbourage areas.

Concerted efforts were made by BSES and the Queensland Parks and Wildlife Service during the 1990s to help growers revegetate harbourage areas. Many growers were involved in three-year trials to monitor the impact of revegetation on rodent numbers. Growers were also presented with the option of commercial tree plantings in harbourage areas. Public concerns over secondary poisoning of owls helped confirm the importance of reducing the use of baits. Owls have now been recognised by a number of growers in the industry as effective in helping to keep rodent numbers down. Since 1997, around 130 artificial nesting boxes have been erected on farms from Mossman to Mackay to attract owls and increase owl numbers.

At the time this history was compiled, BSES was trying to secure funding to run courses for growers in central and north Queensland on harbourage management. Research was also underway to find alternative, environmentally acceptable rodenticides.

BSES has also undertaken an extensive amount of rodenticide work over the years. The goal has been to gain and maintain long-term registration of a suite of rodenticides that can be used within rodent IPM programs. The work has included screening (caged) trials with numerous compounds as well as determining field efficacy of the rodenticides and the potential for impact on non-target wildlife.

Control of canegrubs

Canegrubs are the number one pest of sugarcane in Australia. The pest has caused crop damage ever since sugarcane was first grown. The struggle to control canegrubs is ongoing. With the release of the organochlorine insecticide benzene hexachloride (BHC) in 1947, grub numbers were significantly reduced. BHC and another organochlorine, heptaclor, were the main forms of control used in 1975 and through to the late 1980s. However, the persistence of organochlorines in the environment made them unsafe for long-term use and eventually resulted in the Australian Federal Government making it illegal for organochlorines to be used in crops after 1987.

During the 1970s, BSES scientists assisted Incitec (now Crop Care Australasia) in the development of an alternative to BHC. BSES had foreseen the eventual demise of organochlorine use in Australia, as had been the case in many industries overseas. The alternative, suSCon® Blue, was a controlled-release organophosphate which had proven to be far less persistent than the organochlorines, but still highly effective in the control of canegrubs. First commercial use of suSCon® Blue was in 1984, then large-scale adoption of suSCon® Blue occurred from 1987 onwards.

For several years, suSCon® Blue proved to be successful in controlling canegrubs throughout Queensland. However, in the late 1980s and early 1990s there were incidences where it failed to work as expected. Research was conducted to determine whether application methods had something to do with the drop in effectiveness in some areas. Results showed that the product was more prone to rapid breakdown in highly alkaline soils, thus making it less effective. Other products are being researched for future use in controlled-release systems.

Throughout the 1990s, research into canegrub control broadened significantly. Research has been carried out on the biology of the pest, to understand naturally occurring diseases and how to encourage these diseases as a means of control. The soil fungus Metarhizium anisopliae has been shown to control greyback canegrubs effectively, and has been developed for use as a biological insecticide. The commercial product, Biocane™ Granules was made available for the planting season in 2000. It is hoped that more biological insecticides will be devised in the future.

Variety resistance trials are part of BSES's current canegrub research to determine whether or not certain varieties are resistant to canegrub damage. Some varieties have proven to be tolerant to the pest, but no resistant varieties have been identified. Research into transgenic cane with built-in canegrub resistance has been carried out since the mid 1990s, but no transgenic varieties were released in Australia in 2000.

Overlaying all of this work has been significant research into the ecology of the pest. This has provided substantial information on where canegrubs are at different times of the year, at what times of the year they breed, and diseases that attack the pest.

Control of soldier fly

BSES has had a long involvement in the development of better systems for soldier fly control, starting with the testing of BHC in the late 1950s and early 1960s, and carrying through to the development of IPM systems for control of the pest in the 1990s.

BHC was first used against soldier flies in the late 1950s following a rapid increase in damage caused by the pest. The insecticide provided little relief from the pest, and in the 1960s dieldrin was released for use against soldier flies. Initially, dieldrin gave fairly good control, but after several years of using the product, it became apparent that long-term use of the insecticide reduced its effectiveness and, at the same time, impacted on levels of the pest's natural predators.

During the late 1980s and 1990s, BSES research highlighted the benefits of an IPM strategy to control soldier flies. By developing an understanding of the feeding patterns of the pest, the effect of management practices on numbers and the importance of predators, BSES has been able to develop a basic management strategy (which will vary from district to district). This is based on reducing numbers in infested fields, reducing re-invasion, incorporating vigorous ratooning varieties and increasing the pest's natural predators.

Soil health

Identification of Pachymetra root rot

Root rot and corresponding reductions in the growth of plant cane became a recognised problem in the late 1970s, when significant reductions in yields were being experienced in north Queensland.

In 1981, BSES discovered that a fungus unique to Queensland canefields was linked to the root rot problem. Later (1984), a spore count assay for this fungus was developed, enabling researchers to measure root rot levels in different districts. Assays showed high levels of disease in many districts.

With assistance from a Professor of taxonomy in England, the fungus was described in 1989 as *Pachymetra chaunorhiza.* Since then, the disease it causes has been known as *Pachymetra* root rot.

BSES developed a resistance screening test in the mid-1980s so that the disease could be controlled through varietal resistance. Varieties highly susceptible to *Pachymetra* were identified and discarded from the breeding program in northern areas of Queensland. The inheritance of *Pachymetra* resistance was also examined, and the disease was shown to be moderately heritable (linked to the resistance of parent canes).

More recently, *Pachymetra* has been shown to be only one of a number of organisms causing poor growth, and research efforts have been focused on the more general soil problem known as yield decline.

The problem of yield decline

Research into yield decline followed on from the work on *Pachymetra* root rot in the 1980s and 1990s (see 'Identification of *Pachymetra* root rot', opposite)

A soil fumigation experiment in the late 1980s showed that potential cane yield was well above that being achieved in commercial crops. Soil biology was probably a key limiting factor. In 1989, glasshouse biocide trials showed that the broad-acting fungicides, mancozeb and benomyl, could greatly improve root health and plant growth in soils across Queensland.

The extent to which yield decline was restricting yields, and the promising results achieved by BSES, resulted in the Yield Decline Joint Venture in 1993. The venture was established by BSES, CSIRO and SRDC. In 1995, the Queensland Departments of Primary Industries and Natural Resources joined forces with the sugar industry to examine yield decline causes and controls.

Phase One of the research (1993 to 1999) focused on the complex interactions between the cane plant and the soil, and considered chemical, physical and biological soil properties. Further studies reinforced the importance of soil health. Fields, where cane crops were grown for successive years without a break, had higher levels of root pathogens and nematodes, poor chemical and physical characteristics, such as soil compaction, lower levels of trace elements, and greater soil acidity.

The Joint Venture was seeking in 2000 to develop farming systems that would improve soil health and cane yields. Phase Two of the Yield Decline Joint Venture started in July 1999 and will run for six years.

New technologies

Development of near infra-red technology (NIR)

Near infra-red (NIR) spectroscopy technology, was refined by BSES scientists to perform comprehensive analyses of cane samples from large variety trials. **BSES and the Australian sugar industry are the first to have improved the original NIR system,** and are pioneers in analysis of high-moisture material.

In 1987, an NIR spectrophotometer was tested at BSES's Meringa Station to determine the feasibility of analysing sugarcane samples for soluble and insoluble quality components. The instrument showed the potential to determine these components from a sample of disintegrated cane, which led to further research to adapt available NIR technology to meet the sugar industry's needs.

In 1993, BSES entered a collaborative agreement with NIR Systems Australia. Further research confirmed the feasibility of using NIR for quality component analysis of sugarcane. In 1995, a new sample front-end presentation, known as the large cassette module, was designed and developed at BSES Meringa for use with the NIR Systems 6500 scanning monochromator. This allowed use of larger subsamples of disintegrated cane of 3 to 4 kg, and avoided the need to use multiple subsamples of 150 g for analysis.

The NIR system has recently been duplicated (with funds from SRDC) to measure the realised ccs potential of new varieties. New calibration techniques are also being researched to increase the system's speed and precision.

BSES researchers have been working in collaboration with Sugar North Limited on calibrations and operating software so that NIR can be used in the mill. To date, the work has made it possible to scan prepared cane on-line prior to crushing in the mill, applying innovative technology in a new way. Many constituents in the cane are analysed. While refinements are being made to the system, BSES has shown that NIR can improve process control in the mill, provide a meaningful measure of cane supply quality, and provide analysis suitable for cane payment. NIR is in use in five mills and is under trial in a number of other mills.

Biotechnology

Biotechnology, a relatively new field of research, has made significant inroads in the canegrowing industry since BSES commenced research in 1986. Biotechnology is the manipulation of cells and organisms for practical benefits. Support for funding for biotechnology projects has steadily increased due to its success, and the number of staff employed by BSES to work in this field has grown from two in 1986 to over 14 in 2000.

An initial step in developing a transformation system for sugarcane was to develop ways to culture the cane plant in the laboratory. Soon after biotechnology research commenced, BSES scientists and other collaborating researchers developed various sugarcane tissue culture systems that are now used regularly for the transformation of sugarcane.

Biotechnology-based tests have assisted in the development of highly sensitive and efficient techniques for checking for ratoon stunting disease, Fiji disease virus, sugarcane mosaic virus and sugarcane bacilliform virus. New techniques are revolutionising disease control in the industry, helping in the development of resistant varieties, and boosting quarantine efficiency.

Research by BSES and the University of Queensland culminated in the successful transformation of sugarcane cells by micro-projectile transformation in 1992. This was an industry milestone, enabling researchers to add beneficial genes to the cane plant and improve characteristics such as disease and pest resistance.

In the mid 1990s, BSES scientists, in collaboration with scientists from other research organisations, showed how to assess the occurrence of specific genes in cane cells using molecular markers. Scientists are now able to assess the molecular make-up of different varieties and determine whether or not desirable genes have been transferred when breeding for specific traits.

Novel resistance genes for major pests and diseases, such as canegrubs, Fiji disease and sugarcane mosaic virus are being investigated by BSES. When successfully completed, the work may lead to major breakthroughs in the management of pests and diseases and further reduce industry reliance on chemicals. While progress in this work in 2000 was promising, there had been no commercial release of genetically modified cane.

LOOKING AHEAD

Towards the future, BSES will remain focused on meeting the R,D&E needs of the Australian sugar industry. Work undertaken by BSES will achieve the best results for its clients whilst helping industry to achieve environmental sustainability and long-term productivity and profitability.

BSES will also keep up-to-date with new technologies and will continue to scan research developments outside the industry. It is vital the organisation stays abreast of change and is in a position to offer the most up-to-date R,D&E services possible.

Without the dedication of its staff, BSES would not be where it is today. BSES will ensure it recognises the significance of its staff and fosters an environment of creativity and innovation.

The future direction of the industry will be very much dependent on a cohesive, team approach by the various R,D&E organisations that serve it. BSES will continue to collaborate with these organisations to help the sugar industry identify its future opportunities and deliver outcomes that benefit industry as a whole.

STAFF

BSES Directors

Owen Sturgess Director 1972 to 1989

Mr Owen Sturgess joined BSES in 1956 as a pathologist, and was well known for his work on poor ratooning and chlorotic streak disease. He was promoted to Senior Pathologist within a few years, and in 1964 became Head of the Extension Group. During his time in this position, Mr Sturgess was instrumental in developing the BSES system of farm management accounting. In 1967, he was promoted to Assistant to the Director and later became Deputy Director. Mr Sturgess was appointed BSES Director in July 1972, replacing Mr Norman King.

As BSES Director from 1972 to 1989, Mr Sturgess played an important part in BSES's history. He oversaw the management of BSES during a time when the industry and BSES were experiencing a reasonable amount of change. Inflationary pressures during the 1970s and 1980s meant that the sugar industry had to address new methods of managing farm businesses to maintain its production and remain competitive. There were significant demands on growers to improve performance on the farm. Changes to BSES's funding base meant there were pressures to restructure BSES and downsize in some areas. The growth of new technology and introduction of computers in many areas of business also meant that BSES had to look at how to improve its services to industry.

During Mr Sturgess's leadership, there was a serious outbreak of Fiji disease in the Bundaberg region. The industry also had to find new controls for its major pest, the canegrub, following the phasing out of BHC. Under Mr Sturgess's leadership, BSES dealt with these issues admirably.

Aside from his contributions to BSES, Mr Sturgess was active in International Society of Sugarcane Technologists and was responsible for a major restructuring of that organisation. He also served as Editor of the Australian Society of Sugarcane Technologists.

Dr Colin Ryan Director 1990 to 1999, 2000 to date – Chief Executive Officer

Dr Colin Ryan joined BSES in 1974 as a Pathologist after completing postgraduate studies at the Waite Agricultural Research Institute in Adelaide. From 1974 to 1986, he worked as Pathologist at the BSES Eight Mile Plains Pathology Farm, the principal disease testing centre for the Queensland sugar industry. For most of this time, he was also Officer-in-Charge of the Pathology Farm. A promotion, in 1983, promoted Dr Ryan to Head of the Pathology Division. In 1986, he was moved to Head Office where he worked as Research Coordinator until 1988. In that year, he was promoted to Deputy Director. In 1990, Dr Ryan became BSES Director following the retirement of Mr Owen Sturgess.

Dr Ryan's passion for research, development and extension and the role it plays in the sugar industry, is reflected in his many achievements. Under Dr Ryan's leadership, BSES has embraced the latest technology where needed, become more flexible in its operations, and focused its R,D&E activities on strategic issues. This has ensured that BSES is on track to help industry meet the challenges of the 21st Century.

During Dr Ryan's time in office, BSES has secured several commercial contracts and significantly increased its level of funding from external sources. BSES's infrastructure and facilities have grown to ensure the organisation can service growers' needs throughout Queensland and northern New South Wales. During this time of growth, Dr Ryan has also made certain that he and the BSES management team are closely involved in local meetings and activities, and stay informed of industry needs and local issues.

Some highlights in BSES work during Dr Ryan's leadership include the development of the ELISA test and subsequent reduction in ratoon stunting disease, identification of Pachymetra root rot as a major cause of reduced yields, and adaptation of near infra-red spectroscopy to perform comprehensive analysis of cane samples. Others include the development of new techniques to improve water use efficiency, major advances in plant breeding, biotechnology, high density planting, and the smut campaign which minimised the risk of smut spreading from Western Australia to the east coast.

Most recently, following the introduction of the Sugar Industry Act 1999 and the move to service fees (see 'Funding', p.4-5), Dr Ryan's title has been changed to BSES Chief Executive Officer.

Staff who retired during 1975 - 2000
(after 25 or more years service)

GA (George) Christie 1933-1976. George joined BSES as a cadet and gained experience in a number of districts as well as training in soil testing. He spent several years in the RAF during WW11 and, soon after returning to BSES, established the BSES office in the Burdekin area. George was given the responsibility of establishing the Burdekin Sugar Experiment Station in 1950, and was the Senior Officer in the area until 1966. In 1966, he set up the first BSES office in Maryborough. Several years later (in 1969), he was transferred to Head Office as Chief Advisor in charge of the Extension Division.

CG (Graham Hughes) 1934-1977. Graham commenced work with BSES as a pathologist but also was in charge of plant breeding activities for some years. He served as Chief Pathologist for many years until his retirement. Graham is best known for his work on ratoon stunting disease. He was also co-author of Sugarcane Diseases of the World and the Manual of Cane Growing'.

DRL (Dave) Steindl 1935-1977. Dave served as a Pathologist at Head Office and later at Eight Mile Plains until his retirement. He was highly respected, and is also best known for his work on ratoon stunting disease for which he and Graham Hughes were awarded the Medal of the Institute of Agricultural Science.

CG (Colin) Story 1935-1982. Prior to WW11, Colin was a Junior Advisory Officer in a number of districts. After several years in the army, he returned to Mackay Sugar Experiment Station where he spent the remainder of his career. At his retirement, his long association with the region's extension, Experiment Station management and district administration resulted in him being the best known and respected BSES Officer in the district's history.

SO (Selwyn) Skinner 1936-1981. Selwyn was another Junior Advisory Officer who gained experience in several districts prior to spending several years in the army in WW11. Returning to duty at Bundaberg, he was transferred to Innisfail in 1949 where he served until 1969 in an advisory capacity as well as assisting in plant breeding and agronomy programs. He later was moved back to Bundaberg where he took over responsibility for management of the Station and was appointed Administration Officer for the district.

FC (Fred) Lindsay 1940-77. Fred was a Technical Officer in the Plant Breeding group, firstly at South Johnstone, and finally at Meringa. Fred was a respected mentor for aspiring plant breeders and technicians.

EA (Eddie) Pembroke 1940-57; 1960-87. Eddie joined the army after a brief period with the advisory staff of BSES. In the years after returning from active service, he was based at Meringa. After a short period in other employment, he returned and was stationed at Mackay where he was District Adviser for 17 years before retirement. During this period, he was responsible for training newly recruited staff to the Extension Division.

KC (Ken) Leverington 1944-1988. Ken started in BSES as a cadet. While working for BSES, he passed the senior examination and obtained a science degree. Initially he was involved in experiments to improve the accuracy of fertiliser recommendations based on soil and/or plant analysis. Later he was involved in irrigation, soil physical and salinity problems and green cane harvesting. Ken initiated BSES work on insecticide residues in soil and water, and was asked to participate in some of the initial work on raw sugar quality. He headed the Soils and Agronomy Division for a number of years, and eventually rose to the position of Deputy Director where he was responsible for overseeing the research programs of all

BSES Divisions. He was knowledgeable on a wide range of topics from chemistry to computing, and was respected for his keen, inquiring and analytical mind.

OWD (Ab) Myatt 1946-1977. After 10 years as an Extension Officer, Ab established the BSES Centre in the Herbert River district where he was held in high esteem by the local industry. The Herbert River Sugar Experiment Station was opened in 1995, and Ab was able to attend the opening. The Station conference room was named in his honour.

BT (Brian) Egan 1947-1994. Brian has the distinction of being the longest serving BSES officer. He joined BSES as a cadet, and was a Pathologist for most of his working life. He was particularly known for his work on chlorotic streak, Fiji disease, and deterioration of cane after harvest. He was the first Coordinator for Cane Pest and Disease Control Boards, and finished his working life as Executive Officer with responsibility for external grants. Brian was editor of ASSCT and was active in ISSCT.

SC (Stuart) Leddy 1947-85. Stuart was the BSES accountant for many years and sensibly retired before external grants made accounting a more stressful occupation.

JR (Jack) Burge 1948-68; 1975-91. Jack commenced work with BSES as a Chemist in the Soils Laboratory. After a period when he worked in the fertiliser industry, Jack rejoined BSES as Extension Coordinator, and served in that role until his retirement.

AD (Alan) Doolan 1949-76. Alan was a Mill Technologist who remained in Head Office when the Division transferred to Bundaberg. His main responsibilities, in addition to assisting in mill research during the crushing season, was to ensure that laboratory equipment used for the payment of cane at sugar mills met Australian Standards. This was carried out in the Head Office Metrology Laboratory.

CC (Colin) Horne 1950-80. Colin was Secretary to the Sugar Experiment Stations Board from its inception in 1951, and had an amazing memory of all facets of the operation of BSES.

AA (Archie) Matthews 1950-94. Archie was an Extension Officer who worked in many BSES centres, including Mackay, Proserpine, Innisfail and Nambour. Archie had an inquiring mind and was one of the first to be concerned by Poor Root Syndrome in north Queensland.

FM (Frances) Doolan 1950-94. Frances came from a cane farm in north Queensland, and started her career in BSES at Meringa as a Clerk-typiste. She moved to Brisbane and became BSES librarian, a position she held for many years with great distinction.

FM (Frank) Short 1951-77. Frank was a Laboratory Attendant in Head Office, and was noted for his enthusiasm for playing 500 at lunch time.

CA (Claude) Rehbein 1951-84. Claude was an Extension Officer who served in several centres including Meringa, Nambour and the Burdekin. He finished his career as Administration Officer at the Burdekin Station.

BE (Brian) Hitchcock 1951-86. Brian was an Entomologist who worked at Meringa and Mackay. He is best known for his work on soldier flies and margarodids, and for initiating the studies which led to the development of controlled-release insecticides. In addition, he was involved in research on canegrubs and rodents. Brian was also Chairman of the Station Executive Committee at Mackay.

CL (Clive) Toohey 1951-88. Clive was an Extension Officer who worked at Mackay, Nambour and Bundaberg. When stationed in Nambour, he had to service the area from Maryborough to Rocky Point. Clive was a noted Thespian and played major roles in theatrical productions.

JC (Jim) Skinner 1953-90. Jim was the first professional Plant Breeder employed by BSES, and was responsible for developing a scientifically-based plant breeding program. He is well known internationally for his work on pollen control in cross-pollination and for his work on selection methodology. A strong leader of the Plant Breeding Division, many of Queensland's top varieties were selected and developed under his guidance.

IT (Ian) **Freshwater 1953-93.** Ian was an Extension Officer who spent some time in Innisfail, but was best known for his work in the Burdekin district. Ian was also the leading BSES person in the consultancy team that worked in the Ord River Irrigation Area of Western Australia from 1977-1982.

JM (John) **Sedl 1953-95.** John was a Chemist who worked in the Soils Laboratory for many years. He also worked on raw sugar quality and played a major role in the administration of Head Office. Although John retired in 1995, BSES was still using his skills in the Chemistry Laboratory on a casual basis in 2000.

GM (George) **McCabe 1954-90.** George had the position of Leading Hand at the Burdekin Station.

JE (Joyce) **Murphy 1955-87.** Joyce started work with BSES as a Clerk-typiste. She became the Director's Secretary and, finally, she took on the task of running the Records Section, which she did with great distinction.

LS (Les) **Chapman 1955-97.** Les started with BSES as an Extension Officer in the Burdekin district, but transferred into the Agronomy Division at Mackay where he became well known for his work on nutrition of sugarcane soils. Les was also knowledgeable on most topics connected with the growing of sugarcane. In later years, Les played an important role on the Station Executive Committee at Mackay.

RK (Rob) **Hilhorst 1956-81.** Rob was a Plant Breeding Technician at Bundaberg and, for many years, was in charge of the selection program at Bundaberg. Rob graded varieties in Dutch and was responsible for many technicians and field hands learning to count in that language. In his final year, Rob was the Farm Manager at Bundaberg.

OW (Owen) **Sturgess 1956-89.** Refer page 27.

HR (Henry) **Schipke 1956-93.** Henry was Farm Foreman at the Mackay Station, and was the man behind the scenes for a number of Farm Managers. Henry was particularly expert with machinery.

PN (Phil) **Stewart 1960-86.** Phil was a Mill Technologist who worked mainly at Meringa. When the Mill Technology Division was reduced in size following the downturn in the sugar industry in the mid 1980s, Phil took redundancy and joined the Church as an Anglican priest.

CC (Col) **Corkill 1960-88.** Col was employed as a Technician in the Plant Breeding Division at Meringa. He was subsequently appointed as the first Farm Manager at Meringa and later transferred to Tully as Farm Manager.

D (Doug) **Garioch 1961-88.** Doug was also employed as a Technician in the Plant Breeding Division, based in Mackay. Doug was responsible for the selection program in central Queensland. He was the first Farm Manager at the Mackay Sugar Experiment Station and was subsequently transferred to Meringa as Farm Manager.

CD (Cliff) **Jones 1961-2000.** Cliff started in BSES as a Research Assistant to Owen Sturgess and subsequently moved into extension at Meringa. After a few years in Meringa, he moved to Childers in 1967 and remained there until retirement. Cliff was a gregarious, friendly and very popular extension officer who was involved in activities that greatly improved canegrowing in the Isis mill area. In particular, he was involved with relocation of farmers on erosion-prone land onto more suitable areas, and he was also involved with the introduction of large-scale irrigation into the area. Cliff was probably the best story teller in BSES.

LGW (Lionel) **Tilley 1964-98.** Lionel was an Extension Officer who was highly respected in all areas in which he worked – Mossman, Bundaberg, Ingham and Mackay. He had a particular interest in weed control. In his final years, he served as Officer-in-charge of the Mackay Sugar Experiment Station.

JH (Jim) McKay 1965-91. Jim was a Laboratory Attendant in the Mackay Soils Laboratory.

PG (Phil) Atherton 1965-96. Phil joined BSES after more than 10 years working in sugar mills and became highly respected by the sugar industry for his knowledge and advice on sugar milling. He was Chief Mill Technologist for many years and, in 1989, became the first Agri-Milling Leader under the new BSES structure. In his final years, Phil was seconded to the Queensland Sugar Corporation to oversee the cane testing service.

JA (Jim) Currie 1965-96. Jim started his career as an Extension Officer. Following a brief period of resignation, he rejoined BSES as Farm Manager at Meringa. He was subsequently transferred to Mackay as Farm Manager.

MJ (Max) Braithwaite 1966-91. Max joined BSES as a Technician in the Plant Breeding Division on the Burdekin Station, and was in charge of the selection program until a plant breeder was appointed. Max became the first Farm Manager on the Burdekin Station and was the advisor to the Group Manager on machinery for experiment stations.

LK (Len) Kirby 1966-92. Len was a distinguished Mill Technologist based at Bundaberg. He was well known for his creativity and innovation and was responsible for major research developments in high-grade fugal design.

DR (Ross) Ridge 1966-99. Ross was an Agronomist who had a wide range of skills. He commenced as a Soil Scientist at Head Office, was transferred to Tully when that station was established, and was finally transferred to Bundaberg. In Bundaberg, in addition to agronomy work, Ross was involved in agricultural engineering, and he was responsible for several improvements to cane harvesters.

CWA (Cecil) Chardon 1968-94. Cecil commenced work as an Extension Officer, but then became involved in farm business management. He developed an interest in computing and was employed as a programmer in the computing section of BSES. His particular interest was in database development.

BDA (Bryan) Stickley 1968-97. A chemist by profession, Bryan took over the study of pesticide residues and developed many of the methods used to identify minute amounts of a range of chemicals and their breakdown products in soil, water, plant materials and mill products. He has been responsible for the BSES environmental monitoring programs. Since his retirement, Bryan has continued to supervise pesticide work at BSES on a part-time basis.

PR (Peter) Downs 1969-99. Peter was an Extension Officer who served in Bundaberg, Mackay and Maryborough. Peter left BSES to take up a position with Maryborough Sugar Factory.

AG (Alan) Noble 1970-95. Alan joined BSES from CSR as a Mill Technologist, based in Bundaberg. He was involved in aspects of fugals, rotary screens, and cane fibre testing.

DG (David) LeBrocq 1971-98. David joined BSES as a Technician in the Agronomy Division at Meringa, but subsequently transferred to the Plant Breeding Division. David was an expert computer programmer and developed a data management package that is widely used in the sugar industry. He also made major improvements to a cross-pollination database system used by the plant breeders.

GJ (Graham) Leonard 1974-2000. Graham was a biochemist who worked principally on raw sugar quality issues. Graham commenced work at Sugar Research Institute and spent a year in Germany before joining BSES. He was acknowledged as the sugar industry expert on research into raw sugar quality matters, and he developed tests for major sugar quality parameters. These tests are still industry standards some 20 years after development. In retirement, Graham stills spends several days a week at BSES.

CELEBRATING 100 YEARS

1900-2000

BSES

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