

**BUREAU OF SUGAR EXPERIMENT STATIONS
QUEENSLAND, AUSTRALIA**

**SRDC PROJECT - FINAL REPORT
BSS218 - DUPLICATION OF PHOTOPERIODIC
INITIATION FACILITY AT BSES MERINGA**

by

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NON-TECHNICAL SUMMARY

Partnership-funded research by SRDC and BSES has resulted in excellent flowering being obtainable in populations of parental sugarcanes that flowered reluctantly, or never, under natural conditions at BSES Meringa. This improved flowering was obtained using plant management and initiation techniques developed in this research, using the BSES photoperiod facility (PF) commissioned in 1986. The objective of this project, an infrastructure proposal, was simple in that duplication of the existing PF was proposed. A project manager was engaged to facilitate the project. Essentially, the existing PF was duplicated. Changes to the design were made to minimise costs, and improve functionality. The concrete slab was simplified and the front portal frame design modified to allow installation of three normally-rolled roller doors. A new generation control system, based on direct digital controllers was installed. A prolonged and intense monsoonal season, coupled with delays in the delivery of key components and unforeseen time required for commissioning of the control system, resulted in a delayed start to the initiation regime on 9 October 1999. Once in-house expertise had been acquired to allow complete checking of the controller functions, and misinterpreted operational specifications corrected, the PF operated fully as expected. As a consequence of these factors the implementation of the first initiation regime was less than satisfactory. The level of initiation achieved fell well below that possible. Ten clones produced 97 panicles, with the number per clone ranging from 1 to 68, the latter being produced by the clone Mandalay, a *S. spontaneum* clone originating from Myanmar. The duplicated PF is a state-of-the-art facility that is now fully operational after debugging during the first, delayed operational run. The facility is committed to the CP2002 funded project BSS219 for five years.

1.0 RESEARCH PROJECT BACKGROUND

One facet of research addressing the declining CCS level in northern Queensland is to make combinations among parental clones chosen specifically for high CCS. The availability of only one PF at BSES Meringa severely limits the number of clones that can be initiated and used in directed crossing to address the objectives of specific subprograms. This is because the current facility, built with whole-of-industry money, is required to produce desired combinations among shy-flowering clones for all programs that BSES conducts. As a trial exercise, a subset of high-CCS clones was selected as a putative group for initiation in a new PF. Their newness and their being untried as parents characterised the clones. Their parentages suggested they would be shy flowering. Combinations among these clones would provide excellent progeny for specific initiation of a specific subprogram to address the problem of declining CCS in the wet tropics. However, exploitation of this population in the current PF would only occur in a cursory manner because of the prior commitment discussed above.

Provision of an additional PF, based on the current BSES Meringa facility, would allow a directed and focused contribution of crop improvement to the resolution of the declining CCS situation in the wet tropics. Although the current facility has been used for an extended period of intense research, the facility in reality is of minimalist design. There are three chambers in which the beginning and end of the light period can be precisely controlled, and dark-period temperature can be regulated within a narrow range. The facility that the project aimed to construct, duplicated the current facility with one exception. One chamber would be provided with additional air-conditioning capacity so that its dark-period temperature could be reduced to 15°C to ensure male infertility. This will allow specific use of clones as female parents. Other changes made to the design were to correct deficiencies, or reduce costs through simplification. A problem with the original PF was the installation of a reverse-rolled door in the middle chamber, an aesthetic consideration imposed by the designing engineer. A change to the design of the portal frame carrying the doors ensured all three doors would be similarly oriented and normally rolled. The design of the cement floor slab was simplified considerably, allowing significant cost reductions. Spatial separation between the building and the nearest train in the external parking position was increased to remove any possibility of shading of the plants. The spacing between the end trolleys of adjacently parked, but offset, trains in the external parking position also was increased, again to remove possible interactions. The previous PF's deficiencies were addressed and cost saving achieved through altered design specifications.

Partnership-funded research between BSES and SRDC in Project BSS58 resulted in excellent flowering being obtained in populations of parental sugarcane clones that flowered reluctantly, or never, under natural conditions at BSES Meringa. This improved flowering was obtained using plant management and initiation techniques developed in research using the BSES Meringa PF commissioned in 1986. The flowering problem existing at Meringa, and background research into this have been reported (Berding, N. 1995. Improving flowering of sugarcane for breeding: progress and prospects. Proc. Aust. Soc. Sugar Cane Technol. 17:162-171).

In this facility, time of commencement of initiation, commencing day length, rate of light-period reduction, and dark-period temperature all can be optimised. The condition of

plants used in this facility also can be optimised for initiation in terms of nutrient management and age. Results from Experiment 10 within Project BSS58, which applied techniques developed from this research, demonstrated the results possible (Berding, N and P H Moore. 1996. Towards optimised induction of flowering in sugarcane. pp. 44-46. In J R Wilson, D M Hogarth, J A Campbell, and A L Garside (eds). Sugarcane: Research towards efficient and sustainable production. CSIRO Div. Trop. Crops and Pastures, Brisbane).

One variable, which cannot be controlled, is the ambient temperature plants experience during the light period when external to the PF. This external exposure under ambient conditions is necessary for the plant to photosynthesise to maintain growth. Strong circumstantial evidence supports the hypothesis that light-period temperatures $>32^{\circ}\text{C}$, during the critical initiation window, are detrimental to initiation in sugarcane. However, despite the conduct of Project BSS158 in the CSIRO phytotron in Canberra, this hypothesis has not been tested. In practical terms, only one initiation session per year currently is possible if optimum results are desired.

2.0 OBJECTIVE AND STATEMENT OF ITS ACHIEVEMENT

Objective

To build a PF to allow artificial initiation of flowering in selected populations of high-sucrose sugarcane clones, to produce progeny from planned combinations specifically to improve CCS in the far northern industry.

Achievement

The facility has been completed and is fully operational, being used for the first, normally timed, initiation sequence commencing 1 April 2000.

3.0 METHODOLOGY AND JUSTIFICATION

As this is an infrastructure project, no statement of methodology, or any justification of this, appears warranted, and so is not provided.

4.0 RESULTS

The construction of the photoperiod facility (PF) was severely delayed, not only because of very wet conditions experienced during the year, but also because of delayed delivery of key components such as the winches. There were also technical problems implementing the control system, which relies on direct digital controllers (DDCs). Initially, three DDCs were installed, but insufficient memory capacity existed to allow operation with a full almanac. This was resolved with installation of an additional DDC to maintain common, but invariant, control functions and operations across all chambers. These are distributed to the other, controlling DDCs. This allowed release of sufficient

memory so each chamber can operate with an independent almanac. This allows for future flexibility if each of the three chambers was to operate under independent regimes.

Without belittling the input of the contractors involved in installation of the electrical and control systems, the task of installing and bringing into operation a multi-DDC system, with precision requirements, was beyond their experience. Bonlec Controls supplied the DDCs, and due to their customer philosophy eventually brought all their expertise into play to correct this. Initially, even simple and explicit instructions for the control program were not executed correctly. For example, the control system effects lights on (sunrise) of a morning, the time depending on the day length required for the particular treatment day. Exiting instructions have the trolleys moved from the room 30 min after almanac sunrise, if the external ambient temperature is greater than 21°C. The program that operated the PF for some time had the trolleys exit the PF 30 min after lights on, ie sunrise and NOT almanac sunrise, with no reference to the almanac sunrise. Consequently, trolleys were exiting into ambient darkness. Only when sufficient in-house expertise in the programming of the DDCs was acquired was this error detected and corrected. Consequently, the initiation regime the plants received was far from optimum. While such errors are regrettable and embarrassing, they are perhaps unavoidable in a system of this complexity in a situation where operation was implemented as soon as the contractors allowed access, and no time for familiarisation and training in DDC programming was possible.

Initiation commenced on 9 October and was concluded on 3 March. Although this was much later than desirable, because of possible negative effects of high summer temperatures, other factors contributed to the bad result obtained. Of the 63 clones present (Mandalay was a duplicate entry) in the PF (x 6 pots/clone = 384 pots), 10 clones produced a total of 97 panicles. The number of panicles per clone ranged from 1 to 68, the latter coming from Mandalay, a late flowering *Saccharum spontaneum* clone from Myanmar. Eight crosses were made, but only one survived to harvest because of cyclonic conditions experienced, which resulted in stalk breakage from movement of the lanterns. Many panicles were lost to predation from finches. This has been experienced before with summer initiations. As the lateness of the initiation was not anticipated, measures to counter this were unavailable, as summer initiations generally have proved ineffective.

A second initiation was commenced on 1 April 2000. The material used in this initiation consisted of 128 selected high-sucrose clones. The primary criterion used was high CCS, and consequently some of the clones constituted rather new breeding material as they were drawn from recent populations.

Minor problems have been experienced in the operation of the PF since the commencement of the initiation, but these have been resolved without major disruption to the initiation regime.

- A transient voltage was detected in the circuits operating the photoelectric door sensors. This was thought a possible explanation for problems that had been experienced with Chamber 3, and persistent error messages being generated by this. This problem was solved by installation of isolating relays on all door sensor circuits.

- Since commissioning of the PF, a high failure rate had been experienced in the photoflood bulbs used to provide the incandescent contribution to the day length extension. A change of supplier for these bulbs did not resolve this problem. Installation of peak-voltage relays, limiting the maximum voltage allowable on a circuit, resolved this problem.
- Problems have been encountered with the software, and the occurrence of sticking 'latches', or toggles between 'on' and 'off' positions that are triggered in control circuits, when alarms are activated. The software currently does not automatically reset such latches on all occasions, and manual resetting is required for full function to be regained. The supplier of the DDCs and the controlling software, Bonlec Controls, has been advised of these problems, but to date no solution has been provided.
- Because of poor installation, water entered the ambient temperature sensor modules, causing their failure.
- On three occasions, loose termination of wiring on the sub-boards caused circuit failure. The most serious of these was loss of air-conditioning/heating for one night, and night temperatures were not maintained to specifications.
- A more serious problem occurred with the cable drive in Chamber 3. This is the longest cable reach of the three, and initially the error messages generated could not be resolved in terms of operational malfunction. The cable eventually broke, and only then did the reason become apparent. The external turn-around pulley had seized, and may not even have been rotating from the time of installation. The cable literally sawed through the pulley. The contractor had not installed the six pulleys in question with sealed roller bearings, as are present in the existing PF, and in fact used bronze bushes that may or may not require frequent lubrication, a fact that has yet to be determined. As well, lubrication of these bushes was not possible. As a corrective measure, all pulleys were removed and grease nipples fitted to allow maintenance.

The research assistant responsible for operating the PF, Ms Fiona Joseph, has acquired full expertise in operating the controlling software, and all operations and changes can now be executed in-house with little reference to the supplying contractor.

5.0 DISCUSSION

Analysis of outcomes compared to objectives

There can be no doubt that the project has fully achieved its objective. A second, fully functional PF is operational at BSES Meringa. This essentially mimics the design of the existing PF but incorporates functional and design improvements, including a state-of-the-art DDC-based control system. A normally timed initiation operation commenced on 1 April 2000 and has produced satisfactory results to date.

6.0 ASSESSMENT

Impact

The availability of a second PF provides a powerful tool that will facilitate one facet of the attack on the declining CCS levels in the wet tropics. This will come through the ability to make desired combinations among clones in sub-populations chosen specifically for their high CCS. The PF has been dedicated to this program for five years. Progenies generated from combinations made among parents initiated in this PF will fuel Project BSS219.

Cost and potential benefit

Potential return of research investment in flowering initiation in sugarcane is significant. An increase of a mere 0.5% in productivity in the northern region through an improved CCS level would result in an improvement in gross return of about AUD\$1,600,000. In fact, this would be an underestimate of improved profitability given the increase was achieved through CCS improvement. Such an increase is possible from use of combinations among high-CCS parental clones that can only be brought to flower through use of the PF. Obviously, the payback period for capital invested in the PF, and associated research and operating costs, is short.

Future research needs

There are aspects of the initiation process in sugarcane that require further research, and addressing these may well be facilitated by the PF built by this project. However, these fall outside the ambit of this project, and discussion of them in this context is not considered appropriate.

7.0 DESCRIPTION OF PROJECT TECHNOLOGY

This infrastructure project has resulted in the construction of a state-of-the-art PF facility, no doubt the most sophisticated operating in any sugarcane R&D site in the world. While not radically different from the facility it duplicated, there are improvements over the previous design. The design was simplified and made more functional. Importantly, the three trains, each of four trolleys, each carrying 32 x 33 L pots, are located more favourably relative to each other, and to the building, when in the external parking area.

All functions of this facility are controlled from two sophisticated electrical sub-boards that house a suite of four DDCs, which operate all functions in the PF as well as monitor ambient and chamber temperature, and circuit and equipment operations. A remote computer housed in one of the Meringa office buildings logs all these. The controllers can be accessed from this computer or interrogated remotely from a portable computer connected by modem for diagnostic and adjustment purposes.

Full details of the PFs specifications are held at BSES Meringa and are available on request.

8.0 RECOMMENDATIONS

Given the sophistication of the PF built in this infrastructure package, and given the variable flowering handicapping many crop improvement programs servicing sugarcane industries around the world, one could conceive the technology contained in the PF and the knowledge possessed to initiate flowering, constituting a potentially valuable intellectual property package. If our industry's outlook permitted commercialisation of this knowledge, one could conceive provision of such a facility as a turnkey package at any location required. Alternatively, if additional PF capacity was constructed and operated on a commercial basis in Australia, clones or cultivars could be received for initiation and crossing, either in client-directed combinations, or in combinations made at the PF operator's discretion. This service obviously would be charged for on a success basis, ie no seed, no charge. This would be akin to operating a sugarcane version of an animal stud service. Obviously, location of an environment allowing two initiation sessions per year would be a decided advantage for a commercial PF operation.

However, commercial reality and a scientist's outlook may well be poles apart, but given the perceived market and the powerful tools developed in this and previous initiation projects, assessment of this potential appears warranted.

9.0 ACKNOWLEDGMENT

Ms Fiona J Joseph, the research assistant appointed for this project, deserves considerable credit for her assistance in seeing this project to a successful completion. Her dedication, persistence, and attention to detail, coupled with her excellent communication skills, helped her ascend a steep learning curve with great success. Her acquired expertise in harassing contractors to perform installations to specification and in an acceptable workmanlike manner is reflected in the high standard seen in the completed PF. Her mastery of the DDC control system is testimony to her intelligence and commitment.



Figure 1: General photograph of PF

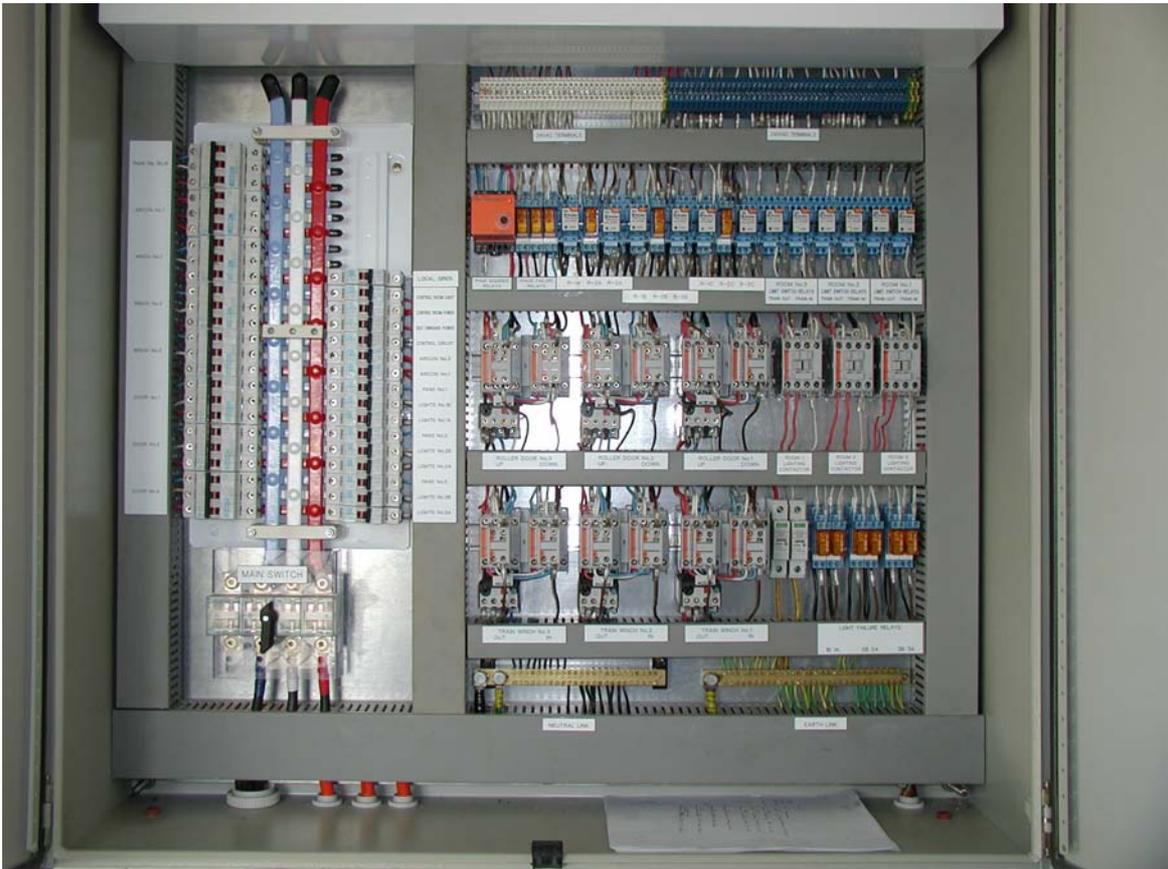


Figure 2: Main electrical distribution board



Figure 3: Direct digital controller board