SUGARCANE RESEARCH IN BARBADOS AND ITS COSTS AND BENEFITS

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Abstract

An overview of the organisation of sugarcane agronomic research in Barbados is given in the context of its constraints and opportunities.

The research programme has been made substantially more cost effective by the reorganisation of the variety testing component. This paper describes how the work is conducted. Using certain assumptions, an estimate is made of the dollar value of the benefits obtained. Current net annual expenditure amounts to about Bds$320 000, while the benefits to the sugar industry by the application of the research findings can be expected to exceed a million dollars annually. The main reasons for the relatively low cost are appropriate mechanisation and the contracting out of certain labour intensive aspects of the programme, such as raising seedlings and transplants.

Note: All prices are in Barbados dollars.
Bds$1,00 = US$0,50

Introduction

The Barbados sugar industry is very small by world standards. Its agronomic research programme is correspondingly small, but nevertheless consumes about 0,5% of the industry's total revenue in recent years. Unproductive research is a luxury that the Barbados sugar industry could ill afford, and the benefits of its research projects have to be constantly evaluated.

Sugarcane has been grown in Barbados since 1637, largely under rain-fed conditions, and rapidly became the main crop on the island. Sugar production reached a peak of just over 208 000 tons in 1967. Since then, production has declined and in recent years has not exceeded 70 000 tons. The area harvested contracted from 22 200 ha in 1964 to about 8 000 ha between 1993 and 1997. Cane yields also declined. Yields in the 1950s and 1960s were between 75 and 85 t/ha, but fell by 20-25% between 1967 and 1975. Current yields are between 50 and 62 t/ha.

Although the Barbados sugar industry has declined under the weight of economic and social pressures, it has a long and distinguished record of cane growing and research. This is probably best illustrated by the fact that the discovery that cane could be grown from seed took place here. Crossing and breeding of sugarcane began in the 1880s, and Barbados became the site of one of the two oldest breeding centres in the world. The West Indies Central Sugarcane Breeding Station (CBS) has been in continuous operation ever since. New varieties are constantly being evaluated and introduced, and most of the agronomic research budget is currently spent on this aspect.

The question arises whether the Barbados sugar industry could not simply use the research results from larger, richer industries. This is possible for its factory division where conditions are very similar to those pertaining elsewhere, but it cannot be done in agronomic research. The combination of soil types, climatic conditions and topography is probably unique. This is reflected, for example, in the fact that imported varieties rarely do well in the variety evaluation programme. No important variety has reached commercial status since the breeding programme began. The same is true for other similarly sized industries in the region, such as Guyana, Trinidad, Jamaica, Belize, and even St. Kitts, which produces only some 20 000 tons of sugar.

Current research organisation

Up to 1992, sugarcane agronomic research and the evaluation of new varieties were independent programmes. The former was controlled by the industry, and the latter by government. Agronomic research was wholly, and variety testing partially, funded by a 1,2% levy on the ex-factory proceeds of the industry. The combined annual expenditure of the two research programmes was well over $1 million.

In 1992, the industry took responsibility for the cane variety testing station and moved it from a site near the ministry of agriculture to 12 ha of land adjacent to the cane breeding station. At the same time, the two programmes were merged to form the Agronomy Research and Variety Testing Unit (ARVTU) with an annual net expenditure currently running to about $320 000.

Supervision of Barbados sugar industry research and development and project approval were entrusted in 1982 to a research and development committee consisting of representatives of government, the sugar industry, the sugar workers union, and the technical heads of research and development organisations.

The functions of the committee that controls the Research and Development Fund generated by the levy were laid down in the Sugar Industry Act of 1982:

1. To assess the work programmes and results of organisations having research and development functions in the growing, harvesting, handling and processing of sugarcane or its components, taking into account the specific conditions, constraints and needs of the sugar industry.

2. To consider the financial requirements for research and development.
3. To consider applications for financial support from institutions outside the sugar industry, engaged in research and development activities in the areas described in (1).
4. To initiate or support applications to national or international agencies for funding research and development projects in the areas described in (1).
5. To establish and maintain a sugar industry scholarship fund.

Sugarcane agronomic research is also done by some of the suppliers of materials, especially herbicides. Some of this work is done in cooperation with ARVTU. There are also cooperative links between ARVTU and the University of the West Indies and a regional research establishment.

Research and development activities

Research and development funds have in the past been used to finance the following activities:

- Variety testing and dissemination
- Agronomic research
- Sugar technology research
- Agricultural mechanisation research
- Scholarships in agricultural subjects
- Financial support of the local sugar technologists' association.

Since 1992 priorities have been redefined, and the funds are now earmarked for:

- Variety testing and agronomic research and extension
- Scholarships
- Support of the local agricultural technologists' association.

The programme has produced the following results:

- Introduction of new varieties
- An annual Variety Update with additional information on national cane yields
- A Growers' Manual which presents results of research and growing recommendations
- A Weed Control Manual
- A study of the reasons for the recent yield decline
- A method of reduced tillage
- Development of a quality based cane payment system
- Development and production of (sometimes adapted) equipment for tillage, fertiliser application, planting, harvesting, and transport
- Development and field testing of a prototype whole stalk harvester
- The organisation of an Annual Technical Conference.

Variety selection is the most expensive component of the ARVTU programme. Relocation of the new variety testing station allowed the development of new management strategies and adjustment of the technical procedures of the programme so that the costs of research were reduced drastically. Outlined below are the various ways in which ARVTU was made more cost effective.

General organisation

Reduction in labour and staff

The former government-run variety testing station in 1989 employed 25 field workers as well as three tractor drivers, one truck chauffeur, two supervisors, one carpenter and one watchman. Technical staff consisted of a Chief Technical Officer, a station manager, a variety officer, a clerical officer and an agricultural assistant. At that time the agronomy research unit of the sugar industry employed two agronomists.

At present, ARVTU employs six field workers, one of whom is part-time, one casual worker, one field assistant, a tractor driver/loader operator, and three agronomists.

Electronic weighing of cane

An electronic loadcell, built locally into a 360° cane loader, has been a major factor making it possible to run the unit with a relatively small labour force. This loader is specially constructed to accurately weigh all bundles of cane from the small trial plots, even on slopes. Special labour or equipment to weigh and load the cane is not needed, and four cutters, with occasional help, can handle the entire crop of about 1 500 tons from the field station and outside trials in 14 weeks (about 5 tons per person per day on average).

Contracts with CBS

ARVTU has contracted to CBS the raising of its annual seedling population from seed as well as the vegetative propagation of plants from single-bud planting material. Raising of seedlings is a labour intensive activity requiring considerable capital inputs and skilled labour. CBS has a fairly large labour force with experience in raising seedlings, and raises them for ARVTU at $1,00 per seedling. This includes germinating the seeds, transplanting into pots, irrigation and fertiliser application.

Stage 2 plants are raised from one-eye cuttings, which are cut with the help of two locally built special bench saws. After raising them in pots, they are supplied by CBS to ARVTU at $0,50 per plant.

Management of the field station

The small workforce is complemented by mechanisation wherever possible. Fertiliser and compost are applied mechanically. Weed control is carried out partially by tractor with mechanical implements or herbicides, and supplemented with hand work. A local prototype shielded sprayer can work in open fields and in cane up to 80 cm tall. After that, hand weeding, spot spraying with knapsack sprayers or a small all-terrain vehicle (ATV) with mounted sprayer are used. The ATV drives between the cane rows, and can spray weeds in reasonably erect fully grown cane.

All primary tillage is carried out with the unit's two tractors, one of which doubles as a cane loader during crop harvesting. The main mechanical operations are:

- trash spreading with a modified flail mower/straw chopper
- primary cultivation: strip- or full tillage
- furrowing
- plant hole preparation for seedlings
- transporting of seedlings into the field
- mechanical weeding with tines or duckfeet, 'offbarring' and moulding up with disc units
- irrigation with tractor-mounted tank
- fertilizer application on the station and on farms where trials are carried out
- compost application
- spraying both on the station and outside farm trials
- cartroad construction and repair
- cartroad maintenance with flail mower
- cane transport
- general transport and rock picking.

The cane loader with a special bucket attachment can also be used for loading compost, cleaning drains, digging up planting material of vetiver grass (*Vetiveria zizanioides*), and landscaping.

No mechanical work has to be contracted out.

Breeding and variety selection

The breeding programme of CBS is now more focussed on improved quality without losing cane yield and vigour. Feedback of computer generated data from the different variety testing programmes in the region helps improve the choice of parents for each territory. This is expected to improve the quality of the crosses made. The challenge is to increase the chance of finding superior varieties in the material supplied by CBS and to make the selection procedure more cost effective. The number of seedlings was reduced from ca. 50 000 to ca. 20 000. To compensate for this reduction and still produce about the same number of improved commercial varieties, the following techniques are used:

A form of family selection has been introduced in which seedlings from each cross made by CBS are evaluated for their yield and quality potential, using a sample of seedlings from each family. The best families are then selected to make up the initial population of seedlings (Bellamy, 1995). This allows the planting of a smaller nursery which is made up of better quality seedlings from which the selection rate for advancement to the next stage is expected to be the same as from a larger seedling population. Barbados is in the forefront of this development in the Caribbean, and continues to exchange information with other countries.

Careful management of the seedlings before and after transplanting ensures that losses are reduced to a minimum. Efficient weed control aids assessment of the true potential of seedlings.

Changes to the variety testing programme. Variety evaluation and selection involves establishment of a series of trials over a period of about 13 years (Table 1).

Table 1. Selection stages of the current ARVTU procedure.

Stage	Description	Years
1	Family assessment and seedling nursery	1,0
2	Clonal rows	1,5
3	Unreplicated yield trial	1,5
4	First replicated yield trials	4,5
5	Second replicated yield (strip) trials	2,5
6	Farmer evaluation	2,5

A number of changes have been made to the design and establishment of these trials in an effort to reduce costs and increase efficiency. These are:

Stage 2

Raising of stage 2 plants in pots started in 1996 and involves the production of one-eye cuttings during harvest time, when stage 2 varieties are selected from the seedlings. These selections used to be planted during the crop, which meant diverting labour from harvesting operations, and watering of the planted field during this normally dry period. With the new system less planting material is needed to produce the same number of plants and it is easier, after harvest, to establish a full stand without gaps caused by germination failures. Extra cuttings are planted to ensure that the correct number of growing plants are available for transplanting into the field.

Stage 3

The selection procedure was altered so that stage 3 is no longer planted as large trials of 100-120 varieties on various plantations with three replications on each site, but only on the field station (also a bulking-up stage). This saves a large amount of labour (and planting material) and is made possible by the better and more representative growing conditions on the new station, so that it is more likely that the varieties show their true potential. At the former site, because of the rather unusual, non-representative growing conditions, it was necessary to establish the varieties off the station early to obtain information on their performance elsewhere.

Stage 4

This stage is now planted in 4-row plots (previously 6-row), which are easier to cut and pile, and to load mechanically.

Stage 5

Strip trials have proved to be a very effective method of collecting meaningful data. Stage 5 variety trials are now planted following this design, after an intermediate stage to allow the bulking-up of planting material necessary to plant the large strips with replicates. These trials are harvested with chopper harvesters by the farm on which they are grown, and yield data are collected by one ARVTU staff member. This also allows an assessment of suitability for mechanical harvesting and does not require any ARVTU labour.

Cultural practices

Strip tillage

Tillage on the station is in the form of strip tillage (de Boer, 1992) where each successive planting is in the interrow of the previous planting. Apart from reducing the cost of cultivation, this form of tillage makes it possible to cultivate the relatively small plots very accurately, which helps to improve overall production of cane.

Compost application

The aim is to apply compost every time a field is cultivated, at the rather high rate of about 10 t/ha, banded in the furrows, thereby building up soil tilth and fertility. There is then no need to apply triple superphosphate.

Fertiliser application

NK fertiliser (24-0-18) is applied to the seedlings and stage 2 (planted in June) at a rate of about 310 kg/ha, to cane planted in November/December at a rate of about 430 kg/ha, and to ratoons at about 560 kg/ha. Further savings are expected from the application of only sulphate of ammonia to seedlings and stage 2 when compost has been applied for a few years.

Rat control

Rat baiting is essential. Serious damage can be inflicted on certain varieties. A loss of 15 t/ha was measured in one field in 1994. The station now has two different designs of bait stations that are used alternately and shifted throughout the year around the fields. Placement depends on where cane is cut or where the bait is taken most readily. Two types of bait are used and alternated periodically.

Irrigation

When the new ARVTU field station was conceptualised, a permanent underground irrigation system was planned. However, since the unit did not have secure land tenure at that time, a temporary system was devised which involved a 7 570 litre overhead storage tank in the field and a 750 litre tank mounted on the tractor three-point linkage. From this tank, three rows of plants can be watered with hoses (gravity operated) by three workers walking behind the tractor or one row by the tractor driver alone. This system worked so well that it has become the standard method of operation, particularly with seedlings or one-eye transplants in plant holes. Virtually no water is wasted, overhead and maintenance costs are reduced to a minimum, and only one litre of water per plant per watering goes a long way to establish that plant even under the driest conditions. Watering twice a week may be necessary in the early stages, while after that once a week is usually enough until the plants are actively growing. One hectare or more can be watered in a day with three people and a tractor driver.

Because of the pre-germination of stage 2 plants, no cane needs to be established during the dry season as before, thus reducing the need for irrigation water.

Weed control

Weed control is done manually (by hoe), mechanically (duckfeet, discs, tines) and chemically with a locally built prototype unit fitted with low-drift, ground following nozzles and anti-drift skirt. This also allows killing unwanted cane with glyphosate in extremely close proximity to cane that is not to be killed. Interrow spraying, including a final application of a pre-emergence herbicide, is done with knapsack sprayers and with the small ATV with mounted sprayer.

Current research cost

Average annual expenditure at ARVTU is given in Table 2.

Table 2. Average actual annual expenditure of ARVTU, 1995-1997 (rounded to the nearest Bds$100).

GROSS EXPENDITURE	392 700
LESS INCOME:	
87.3 tons sugar @ $744 (average for 1995-97)	64 900
Sale of varieties overseas (estimated)	10 000
NET EXPENDITURE	317 800

The main cost elements were:

Salaries and wages: Bds$234 000

- Six (reduced to 5 in 1997) full-time field workers
- 1 part-time worker (maintenance of road edges, etc)
- 1 recorder/assistant to the agronomist
- 1 equipment operator/supervisor
- 3 agronomists.

Equipment operational cost: Bds$45 200

- Three 4WD vehicles, of which two are used as pick-ups for transport of workers, cane samples, cane plants, transplants and fertiliser.
- Two 4WD 60 kW tractors, one with a 360° cane loader.
- One 4WD ATV with mounted sprayer.
- Soil tillage and weeding equipment, fertiliser bander, boom sprayer, carrybox, tractor mounted watering tank, swipe for cartroad maintenance and trash spreading, firecart, two cane trailers, compost applicator.

Contracts: Bds$72 000

- 20 000 seedlings from CBS
- 1 500 stage 2 varieties as pre-germinated one-eye cuttings from CBS
- Moth borer control work (breeding of parasites, joint infestation survey)

- Security, firefighting, supply of irrigation water
- Construction, maintenance of buildings and equipment.

Office costs: Bds$25 900

- Land and buildings rental, utilities, telephone, stationery, photocopying and subscriptions.

Materials: Bds$11 700

- Fertilisers, herbicides, ratbait, tools, labels, tags, pegs and paint.

Benefits

While the expenditure on research is known, the benefits are less easily quantified. What follows are estimates, based on available information, on what can be reasonably expected. Where it is considered impossible to produce an estimate, this is indicated with (+). The total estimated annual benefit amounts to more than $1,2 million. Even if this is an overestimate, the cost of agronomic research in Barbados is clearly recovered by the benefits derived from its results.

New varieties introduced to farmers: Bds$1 117 500

Assuming 0,75 t sugar/ha extra on 2 000 ha = 1 500 t sugar @ $745 (field share of price received for sugar in 1996).

Note: The above figure represents the additional yield obtained in 1996 from the three main alternative varieties B74541, B77602 and B80689, compared with the yield of B62163 (8,75 tons cane extra, at 9,4 tcts (tons cane per ton sugar).

Reduction in fertiliser: Bds$105 000

125 kg/ha NK fertiliser (24-0-18) less on plant cane:
$75 on 1 000 ha = $75 000.

250 kg fertiliser less on forced back cane:
$150 on 200 ha = $30 000.

Note: These savings depend on the extent to which farmers follow the recommendations. There are indications that more than half the farms are now applying less fertiliser.

No interrow tillage: Bds$30 000

Assuming 120 ha @ $250.

Strip tillage: Bds$25 000

Net saving in primary tillage cost no less than $125/ha (de Boer, 1992); assuming 200 ha strip tillage.

Less waste when applying herbicides

By instruction on the most effective methods of spraying, accurate calibration and proper maintenance of sprayers (+).

Extension and education, information

All have a positive influence not easily measured (+).

ARVTU insurance

Because of the continuous flow of genetically diverse varieties, ARVTU is a form of insurance policy for the sugar industry. It is possible for a variety to become affected by a disease, causing it to collapse quite quickly. If there is a range of other resistant or immune varieties available, these can be used to replace the susceptible variety and ensure the survival of the industry. This aspect of the variety programme is of immeasurable value at a relatively low cost, and alone would justify the ongoing operation of a variety testing programme (+).

Total identifiable estimated benefits
= Bds$1 277 500.

Conclusion

Applied agronomic research must eventually result in economic improvements. If this is not the case, the research should be terminated or redesigned. On the other hand, some research can, by providing reliable data, lead to further research projects being redesigned or shelved. For example, for five years, large numbers of leaf samples were collected from about 20 farms in strategic areas in Barbados. These samples were analysed for nutrients, and a data bank was built up. Annual cost of the project was ca. $60 000. After the first three years, it appeared that there was no relationship between the data collected and yield figures. No correlation could be established between nutrient levels in the leaves and resultant yields.

The project was continued for two more years on a smaller scale but then was suspended, pending in-depth analysis of the data obtained (Anderson *et al.*, 1995). It emerged that the currently used fertiliser recommendations are approximately correct, apart from a few isolated problem areas. It has been possible, however, to slightly adjust fertiliser recommendations with the help of this project. Fertiliser trials indicated a response to phosphate applications, and this was confirmed by the leaf analysis. Potash levels were lowered, based both on this leaf analysis work and on available soil analysis data. More work on this aspect does not appear to be necessary, and the value of the exercise lay mainly in avoiding additional research expenditure rather than increasing returns.

A similar situation occurred with respect to the effect of nematodes on yield. A two-year programme eventually resulted in the conclusion that nematodes are not primarily responsible for yield reductions, but that additional work on their interaction with soil-borne fungi might be useful (Cadet and de Boer, 1990). The expenditure on this project produced no direct returns, but the availability of hard facts about nematodes helps to direct possible further research.

Projects without direct benefit must be compensated by others that have measurable returns, such as the recommendations to apply less fertiliser in plant cane, not to till inter-rows, and the introduction of higher yielding varieties.

Apart from these actual benefits, it could also be argued that the most important value of a research unit, and especially of a variety selection programme, is the insurance it provides against pests and diseases. There have been cases of diseases threatening to destroy a sugar industry in the absence of alternative resistant varieties. The infant sugar industry in Papua New Guinea for instance, was seriously affected by the advent of Ramu Stunting Disease, a previously unknown disease, for which resistant varieties had to be found. Barbados has been able to avoid serious problems with smut because other varieties were readily available to replace susceptible varieties. In fact, B62163, the dominant variety at the time of the appearance of smut, was resistant. But other diseases could have affected the cane at any time, and the presence of a broad genetic base in the form of a number of alternative varieties guarded against this risk.

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REFERENCES

Anderson, DL, de Boer, HG and Portier, KM (1995). Identification of nutritional and environmental factors affecting sugarcane production in Barbados. *Commun Soil Sci Plant Anal* 26(17&18), 2887-2901.

Bellamy, SR (1995). Family selection in the Barbados sugarcane variety testing programme. Report prepared for the 1995 West Indies Central Sugarcane Breeding Workshop held in Barbados. 6 pp.

Cadet, P and de Boer, HG (1990). Behaviour of plant parasitic nematodes associated with sugarcane in Barbados. *Proc Barbados Sug Technol Ass Conf* 8: 41-19.

de Boer, HG (1992). Strip tillage: techniques, application and cost saving. *Proc Barbados Sug Technol Ass Conf* 10: 143-151.