# REALISED VALUE OF RD&E IN THE AUSTRALIAN SUGAR INDUSTRY: ECONOMIC BENEFITS OF THE CHANGING FARMING SYSTEM

By

BL SCHROEDER[1], T CAMERON[2], AI LINEDALE[1], PG ALLSOPP[3]

[1]*BSES Limited, Bundaberg*
[2]*Queensland Department of Primary Industries and Fisheries, Bundaberg*
[3]*BSES Limited, Indooroopilly*
bschroeder@bses.org.au

**KEYWORDS: Sugar Cane, Farming Systems, Economic Assessment, RD&E.**

## Abstract

RESEARCH, development and extension (RD&E) are generally accepted as activities that add value to primary industries through productivity gains and/or decreased input costs. Although RD&E relating to farming systems activities has been ongoing for many years, it has been difficult to quantify the realised value of this effort as both productivity and profitability need to be considered. The Farm Economic Analysis Tool (FEAT) was used to evaluate the economics of changes to the sugarcane farming system for a 'hypothetical farm' in the Bundaberg district over three periods during the past 50 years: 1960 to 1970 (traditional farming system), 1980 to 1990 (past farming system), 2000 onward (improved farming system). This 'farm' was used to evaluate the different 'farming systems' that were generally practiced in the area during the three periods. As described in the FEAT analysis, the farming system has changed markedly over the past 40 to 50 years. Better sugarcane varieties coupled with the improved farming system is enabling viable and sustainable sugarcane farming businesses, which would not have been the case if the traditional approach was still being used. We suggest that RD&E has contributed significantly to this change. This has driven the overall sustainability and viability of sugarcane growing enterprises, and consequently that of the entire value chain.

## Introduction

Systematic, sustained and targeted research, development and extension (RD&E) are generally accepted as activities that add value to primary industries through the development and implementation of strategies that enable productivity and profitability gains on-farm (Rural R&D Corporations, 2008). BSES Limited and its partners and associates have traditionally undertaken such activities for, and on behalf of, the Australian sugar industry. This is highlighted in the BSES Strategic Plan (2008–2013) that identified nine high priority actions.

The development of improved conventional varieties and enhancing their adoption is one of the most important priority actions within the BSES RD&E plan. Several studies have quantified the benefit gained by industry from plant breeding activities. One of these suggested that the average productivity increases from newer varieties in the Queensland sugar industry (1975 onward) was 190 kg sugar/ha/year (Cox *et al.*, 2005). When best linear unbiased predictors (BLUPS) were used, it was found that this original average estimate of sugar gain had masked the rate of change over the years. The increase in sugar yield in Queensland has risen from 119 kg sugar/ha/year for cultivars released between 1960 and 1989 to 231 kg sugar/ha/year for cultivars released between 1975 and 2004 (Cox and Stringer, 2007). However, not all of these increases have been realised in practice because of ongoing degradation of the physical and biological environment.

The development of farming systems that improve the sustainability and supply security of the industry is another key priority action identified within the BSES Strategic Plan. This aims to give growers tools to realise, as much as possible, the genetic gain provided by plant breeders. In combination with the delivery of R&D-based tailored solutions that aim to improve the sustainability of industry, it forms the backbone of much of the agronomy, entomology, engineering and extension activities undertaken by BSES Limited and our associates. The benefits from some components of the farming system have been evaluated. An example is the estimated economic potential derived from calculating the partial net returns to growers and the industry when the modified nutrient inputs (as recommended by the SIX EASY STEPS program) were compared to traditional grower nutrient input strategies (Schroeder *et al.*, 2009). However, the overall benefit to the industry of a composite of the ‘farming systems’ RD&E activities has not been evaluated.

The difficulty in evaluating a composite of such activities is that there is no one simple measure, unlike plant breeding where increases in cane and/or sugar yield can be quantified relatively easily. Farming systems RD&E impacts on both productivity and profitability, the latter through lower input costs that are not as visible as yield increases. Recently, the Queensland Department of Primary Industries and Fisheries FutureCane officers developed the Farm Economic Analysis Tool (FEAT) to assist with decision making on-farm (Cameron, 2005). This tool was designed specifically for cane farmers to compare the profitability of different farming systems (Loeskow *et al.*, 2006; Poggio *et al.*, 2007; Carr *et al.*, 2008). It can be used to make accurate comparisons because it uses detailed costings of inputs (fertilisers, chemicals, etc.) and machinery use (tractor size and speed, fuel consumption, implement width and speed, etc.). It can also be used to compare historical farming systems to current practices to give a reasonably accurate estimate of the economic result of the changes. This is done by applying current input prices to both current and historical situations. Used in combination with the assumption that the RD&E has contributed to these changes to some extent, it allows for the value of the continuing ‘farming systems’ RD&E to be quantified. Here, we present an economic analysis of the changing sugarcane farming system that occurred over the past 50 years using a hypothetical farm. The FEAT analysis compares the economics of the different farming systems that have been in use during the past 50-year period.

## Procedure and details of information used within the FEAT analysis

A hypothetical Bundaberg farm was used in the economic evaluation. The characteristics of the ‘farm’ are summarised in Table 1.

**Table I—**Summary of the hypothetical farm used in the FEAT analysis.

| Characteristic | Description |
|---|---|
| Location | South east of Bundaberg |
| Mill area | Cane delivered to a hypothetical mill (Millaquin/Qunaba) |
| Size | 75 ha of arable land |
| Soil types | A combination of red volcanic, yellow clay loam and grey sandy loam soils (Schroeder *et al.*, 2008) |
| Type of enterprise | Owner/grower; sugarcane / fallow crops |

We identified three discrete periods between 1960 and the present in which general on-farm management strategies were different: 1960–1970 (traditional farming system), 1980–1990 (past farming system), 2000–present (improved farming system). The characteristics of the farming systems used within each period, together with appropriate data and information, were sourced from BSES and industry records, and from associations with the industry over the past 50 years. The general characteristics of these different farming systems are shown in Table 2.

**Table 2—**General characteristics of the farming systems used during three discrete periods between 1960 and 2008.

| Period | | Characteristic of the farming system |
|---|---|---|
| Farming system | Years | |
| Traditional | 1960–1970 | ▪ Sugarcane grown as a plant crop and two ratoons with a fallow period between crop cycles. Cane was burnt prior to harvest.<br>▪ 25% of the farm fallowed each year. On the hypothetical farm, this was 18.75 ha.<br>▪ Fallow usually consisted of poorly managed cowpea or velvet bean crops that were used solely as cover crops.<br>▪ Tractor fleet of three 67-kW and one 50-kW tractors. |
| Past | 1980–1990 | ▪ Sugarcane grown as a plant crop and three ratoons with limited area left as bare fallows. Cane was burnt prior to harvest.<br>▪ Plough-out replant strategy: Plant crop was established soon after the harvest of the last ratoon of the previous crop cycle.<br>▪ Aimed to have continuous sugarcane production on-farm with as little (< 8%) bare fallow as possible. On the hypothetical farm, this was 6 ha.<br>▪ Tractor fleet consisted of fewer but larger tractors than those used previously. Hypothetical farm: one 82-kW and one 67-kW tractor. |
| Improved | 2000–present | ▪ Sugarcane grown as a plant crop and four ratoons with break crops grown between sugarcane crop cycles. Green-cane trash retention in general use.<br>▪ Break crops were grown on 28% of the farm. They included legume fallows (grown for grain) or small crops (land often leased). On the hypothetical farm, this covered 20 ha. The break crops were a source of income and enabled improvements in soil health.<br>▪ Tractor fleet was further rationalised in terms of numbers, but the power increased relative to earlier periods. The hypothetical farm had access to one 93-kW tractor. |

More specific details relating to the plant-crop production are given in Table 3, and details of ratoon management are given in Table 4.

Present input values were applied to the current and historical farming practices and the same commodity price was used in each case. This approach enabled the level of profitability to be determined with changed and unchanged farming practices.

**Table 3—**Characteristics of the general farming systems used during three discrete periods between 1960 and 2008: Plant cane.

| Information / data used within the FEAT analyses | Farming strategies used within the discrete periods on the 'hypothetical farm' | | | | | |
|---|---|---|---|---|---|---|
| | Traditional (1960–1970) | | Past (1980–1990) | | Improved (2000–present) | |
| | Implement or activity | Amount[1] | Implement or activity | Amount | Implement or activity | Amount |
| Land preparation | 3-furrow disc plough | 2.5 | 3-furrow disc plough | 1.5 | Square plough | 1 |
| | Disc harrow | 3 | Disc harrow | 1 | Disc harrow | 2 |
| | Ripper | 1 | Ripper | 2 | Ripper | 1 |
| | Rotary hoe | 2.5 | Rotary hoe | 3 | Rotary hoe | 0.5 |
| | Mark out | 1 | Mark out | 1 | Mark out | 1 |
| Planting | Harvest cane plants | 5 t/ha | Harvest cane plants | 8 t/ha | Harvest cane plants | 8 t/ha |
| | Sugarcane setts | 5 t/ha | Sugarcane setts | 8 t/ha | Sugarcane setts | 8 t/ha |
| | Whole stick planter | 1 | Billet planter | 1 | Billet planter | 1 |
| | Casual labour | 13 h/ha | Contract planting | | Contract planting | |
| Fertiliser application | N (kg/ha) | 115 | N (kg/ha) | 150 | N (kg/ha) | 100 |
| | P (kg/ha) | 20 | P (kg/ha) | 40 | P (kg/ha) | 25 |
| | K (kg/ha) | 60 | K (kg/ha) | 110 | K (kg/ha) | 80 |
| | Fertiliser box | 1 | Fertiliser box | 1 | Fertiliser box | 1 |
| Weed control[3] | | | | | 2,4-D amine | 1 |
| | Paraquat | 1 | Paraquat | 1 | Paraquat | 2 |
| | Diuron | 1 | Diuron | 1 | Diuron | 1 |
| | Cotton King | 3 | Cotton King | 2 | | |
| | | | Multiweeder | 3 | Multiweeder | 1 |
| | Tyne cultivator | 4 | Tyne cultivator | 1 | Tyne cultivator | 1 |
| | Sprayer | 1 | Sprayer | 1 | Sprayer | 2 |
| Insect control[4] | Aldrin | 0.3[2] | Chlorpyrifos | 0.2[2] | Imidacloprid | 0.3[2] |
| | Organochlorine | 0.2[2] | | | | |
| Disease control | Fungicide | 1[2] | Fungicide included in contract planting | | | |
| Irrigation | Water (Part B[5]) ML/ha | 0.5 | Water (Part B) ML/ha | 2 | Water (Part B) ML/ha | 2.8 |

[1] Amount is the number of operations or quantities if units are specified.
[2] Proportion of plant cane treated.
[3, 4] Chemicals indicated illustrate the type of approach rather than the specific formulation.
[5] Part B is the variable cost for the amount of water used.

**Table 4—**Characteristics of the general farming systems used during three discrete periods between 1960 and 2008: Ratoon cane.

| Information / data used within the FEAT analyses | Farming strategies used within the discrete periods on the 'hypothetical farm' | | | | | |
|---|---|---|---|---|---|---|
| | Traditional (1960–1970) | | Past (1980–1990) | | Improved (2000–present) | |
| | Implement or activity | Amount[1] | Implement or activity | Amount | Implement or activity | Amount |
| Cultivation | Ripper | 1 | Cultivation activities replaced by chemical weed control | | | |
| | Rotary hoe | 1 | | | | |
| | Tyne cultivator | 2 | | | | |
| Fertiliser application | N (kg/ha) | 120 | N (kg/ha) | 170 | N (kg/ha) | 140 |
| | P (kg/ha) | 10 | P (kg/ha) | 10 | P (kg/ha) | 10 |
| | K (kg/ha) | 70 | K (kg/ha) | 90 | K (kg/ha) | 100 |
| | Fertiliser box | 1 | Fertiliser box | 1 | Fertiliser box | 1 |
| Weed control[3] | Paraquat | 0.5 | Paraquat | 1 | Paraquat | 1.33 |
| | Diuron | 0.5 | Diuron | 1 | Diuron | 1 |
| | Rake tops | 1 | Multiweeder | 2 | | |
| | | | Tyne cultivator | 1 | | |
| | Sprayer | 1 | Sprayer | 1 | Sprayer | 1.33 |
| Insect control[4] | Minor amounts of insecticide applied | | | | Chlorpyrifos | 0.05 |
| | | | | | Imidacloprid | 0.05 |
| | | | | | Applicator | 0.05 |
| Disease control | Fungicide | 1[2] | Fungicide included in contract planting | | | |
| Irrigation | Water (Part B[5]) ML/ha | 0.5 | Water (Part B) ML/ha | 2 | Water (Part B) ML/ha | 2.8 |

[1] Amount is the number of operations or quantities if units are specified.
[2] Proportion of ratoon cane treated.
[3, 4] Chemicals indicated illustrate the type of approach rather than the specific formulation.
[5] Part B is the variable cost for the amount of water used.

The economics of the hypothetical farm were analysed with FEAT for each of the three periods. We applied current (2008) prices and costs of production to the inputs and activities within each period so that we could assess the present level of profitability for the improved farming system and for previous farming practices. In particular, the following assumptions were made: sugar price was $330/tonne, and fuel (diesel) price was $1/litre net of rebate and GST.

This enabled the different systems to be evaluated against each other. Our assumption was that the area of the farm remained constant over the full period, but inputs, activities and labour varied according to the changing circumstances within the three discrete periods. Although the variety mix has changed dramatically over time, our model uses the district realised yields for each period and does not consider which specific varieties were grown.

The economic data are presented as totals for the hypothetical farm, the plant cane, ratoon cane, fallow (either relatively poorly managed cowpea for the 1960s or bare fallow for the 1980s) and legume crop (2000–present).

## Results and discussion

In general, the farming system changed dramatically over time:

- The 'traditional' system was characterised by many in-field operations and tillage practices, labour-intensive planting operations, relatively low nutrient inputs, weed control that was reliant on extensive cultivation practices, and little irrigation. The crop cycle consisted of a plant crop and few ratoons (usually two) with 25% fallowed land.
- The 'past' system consisted of changed land preparation operations (that nonetheless still consisted of many in-field operations, especially the use of the rotary hoe), a move to contract planting, increased nutrient inputs as a grower strategy to minimise risk of production losses (unsubstantiated by RD&E), a combination of cultivation and chemical sprays to control weeds, and increased irrigation usage. The period was characterised by an apparent desire to create a sugarcane monoculture on farms, with little break cropping. The crop cycle generally included an extra ratoon crop.
- The 'improved' system has fewer and less aggressive in-field operations, a move towards wider-row spacings, general adoption of green-cane trash retention with the associated decrease in need for cultivation activities for weed control, rationalised nutrient inputs, more efficient use of irrigation water, and, importantly, the inclusion of well-managed and harvested legume crops within an extended 'fallow' area on-farm. The crop cycle generally consists of a plant crop and four ratoons.

Our FEAT analyses indicate that the three farming systems delivered markedly different levels of profitability on-farm, based on current prices and costs (Table 5). Notwithstanding the marked influence of water availability and management in the Bundaberg district, the large differences in profitability, particularly between the traditional approach and the current 'improved' system, are mainly due to reductions in fixed and variable costs, rather than increases in productivity.

Mean sugar yields were similar for the three periods (11, 12 and 11 t/ha, respectively). Inputs and operations have become more efficient. This is particularly apparent in the reduction in the number of land preparation activities and their associated costs (1960s: $507/ha/year versus 1980s: $519/ha/year versus 2000s: $253/ha/year). Another significant contributory factor is the change in nutrient applications. Average amounts of N, P and K applied to both plant and ratoon cane increased after the 1960s, but have subsequently been rationalised (Tables 3–4). In plant cane, this resulted in nutrient costs increasing from $628/ha/year (traditional system) to $964/ha/year (past system), and then decreasing to $649/ha/year (improved system). Decreases in hired labour, tractor usage (despite the trend towards more powerful machines) and the grower's own time inputs have also contributed markedly to the larger profit from the improved farming system.

Our comparison of farming systems also noted that fixed costs have dropped markedly due to decreases in hired labour and depreciation. The latter relates directly to lower amounts invested in plant and machinery within the improved farming system. In the 1960s, the hypothetical farm included $226 000 invested in on-farm equipment. This has decreased to $112 000 for the improved farming system.

Another important change relates to the fallow land on the hypothetical farm within the specified period. During the 1960s, the relatively poorly managed legume crops were essentially unproductive, although they would have presumably contributed to the maintenance of soil health and the pools of available nutrients. The ploughout/replant system of the 1980s enabled increased sugarcane production (an increase from 4256 t of cane to 6031 t of cane for the hypothetical farm). However, the benefits of having break crops were negated. The move towards well-managed legume crops within the improved system is contributing to sustainable sugarcane production, particularly in terms of soil health.

**Table 5—**Summary of economic data for the different farming systems used on the 75 ha 'hypothetical farm' using current (2008) prices and costs of production applied to the inputs and activities within three discrete periods.

| Parameter | Units | Farming systems used | | |
|---|---|---|---|---|
| | | Traditional (1960–1970) | Past (1980–1990) | Improved (2000–present) |
| Profit: farm | $/yr | –71 000 | –37 000 | 33 000 |
| Cane production: farm | t/yr | 4 256 | 6 031 | 4 389 |
| Sugarcane production area | ha | 56 | 69 | 55 |
| Estimated cane yield: farm | t/ha/yr | 76 | 87 | 80 |
| Sugar production: farm | t/yr | 606 | 820 | 610 |
| Estimated sugar yield: farm | t/ha/yr | 11 | 12 | 11 |
| Gross margin: farm | $/ha/yr | 501 | 562 | 656 |
| Total variable costs: farm | $/ha/yr | 1 799 | 1 929 | 1 689 |
| Variable costs: plant cane[3] | $/ha/yr | 2 536 | 3 059 | 2 539 |
| Land preparation | $/ha/yr | 507 | 519 | 253 |
| Planting | $/ha/yr | 489 | 578 | 585 |
| Fertiliser applications | $/ha/yr | 628 | 964 | 649 |
| Pest and disease control | $/ha/yr | 308 | 183 | 196 |
| Variable costs: ratoon cane[3] | $/ha/yr | 1 289 | 1 551 | 1 467 |
| Cultivation | $/ha/yr | 153 | 0 | 0 |
| Fertiliser applications | $/ha/yr | 593 | 754 | 694 |
| Pest and disease control | $/ha/yr | 50 | 105 | 72 |
| Irrigation: farm | ML/ha/yr | 0.5 | 2.0 | 2.8 |
| Variable irrigation costs: farm | $/ha/yr | 38 | 152 | 213 |
| Fixed costs: farm | $/yr | 99 520 | 75 880 | 38 247 |
| Depreciation: farm | $/yr | 17 340 | 11 890 | 8 575 |
| Hired labour: farm | $/yr | 58 608 | 31 258 | 0 |
| Plant and machinery: farm | $ | 225 931 | 154 912 | 111 720 |
| Irrigation fixed cost: farm | $/yr | 1040 | 10 201[1] | 7 141 |
| Tractor usage | h/yr | 1239 | 487 | 276 |
| Workers, including grower | person-years | 2.5 | 1.8 | 1.0[2] |
| Gross margin: bare or poor fallow | $/ha/yr | –283 | –323 | –73 |
| Gross margin: legume crop | $/ha/yr | n/a | n/a | 1550 |

[1] Paid full fixed cost but used 50% of allocation [2]0.66 as grower and 0.33 as contractor to others [3] Including harvesting cost

The fact that average yields have not increased is probably indicative of the negative environment (E) and genotype × environment (G × E) effects arising from the degrading physical and biological environment. However, if the past farming systems (Table 2) had continued as the typical method of farming, these effects would have caused a decline in yields due to the loss of productive capacity of soils within a long-term monoculture system (Garside and Bell, 2006).

Decreases in sugarcane production on the hypothetical farm are more than compensated by the income from the production of grain from the legumes and the lower N usage in the subsequent plant crop. This could equally be said for land leased for small-crop production.

The profitability/sustainability of the hypothetical farm indicates that, if the hypothetical farm had continued to be managed according to the traditional farming system, the grower would currently be losing $71 000 per year. Our model suggests that the improved farming system is delivering a profit of $33 000 per year, $104 000 better than would have been achieved if the traditional approach was still being used.

## Conclusions

Our study shows distinct differences between the profitability of the traditional, past and improved sugarcane farming systems. Although water availability and management are acknowledged as extremely important drivers of productivity in the Bundaberg district, and notwithstanding the contribution from the variety breeding program, the profitability improvements on the hypothetical farm were largely due to the adoption of improved farming practices. The FEAT analyses show that, if on-farm management had continued according to the traditional farming system, the grower would have suffered substantial economic losses each year. Obviously, this would make their business unsustainable.

Examples of the contribution by RD&E to the process of having strategies in place to curb the negative environmental effects or replace unacceptable practices include the development of:

- The 'new farming system' that encompasses breaking of the sugarcane monoculture through the use of fallow legume cropping, controlled in-field trafficking and the adoption of minimum tillage principles (Garside and Bell, 2006).
- The SIX EASY STEPS program aimed at facilitating sustainable nutrient management on-farm (Schroeder *et al.*, 2006).
- GrubPlan: an integrated approach for controlling greyback canegrubs (Samson *et al.*, 2007).

We suggest that without such on-going assessment, development, promotion and adoption of improved systems and practices, growers would not have access to technologies that have enabled their farming enterprises to remain viable. Better varieties coupled with the improved cropping system are enabling growers to continue to have viable and sustainable sugarcane farming businesses. This then helps to support mill profitability through a continuing cane supply and translates to further profitability down the value chain.

Our analyses also suggest that there is potential for growers to move toward further adoption of best-practice management on-farm to secure the full economic benefits of new sugarcane varieties. We encourage growers to further embrace the principles of best practice management (Calcino *et al.*, 2008; Hurney *et al.*, 2008; Schroeder *et al.*, 2008) that are now accepted as fundamental to further improvements in sugarcane productivity and profitability and to maintenance of the resource base. Overlying this is the complex interaction of fluctuating sugar prices and input costs. Growers' responses to these in terms of inputs applied are likely to have effects in years subsequent to these management decisions. We need further economic analysis to understand how these effects drive long-term farm profitability.

## REFERENCES

Calcino DV, Schroeder BL, Hurney AP, Allsopp PG (2008) SmartCane plant cane establishment and management. Technical Publication TE08010, BSES Limited, Indooroopilly, Australia, 33 pp.

Cameron T (2005) Farm Economic Analysis Tool (FEAT), a decision tool released by FutureCane. Department of Primary Industries and Fisheries, Brisbane, Australia.

Carr AP, Carr DR, Carr IE, Wood AW, Poggio M (2008) Implementing sustainable farming practices in the Herbert: The Oakleigh Farming Company experience. *Proceedings of the Australian Society of Sugar Cane Technologists* **30**, 25–33.

Cox MC, Stringer JK, Cervellin RJ (2005) Productivity increases from new varieties in the Queensland sugar industry. *Proceedings of the Australian Society of Sugar Cane Technologists* **27**, 124–132.

Cox MC, Stringer JK (2007) Benchmarking genetic gains from new cultivars in Queensland using productivity data. *Proceedings of the International Society of Sugar Cane Technologists* **26**, 624–631.

Garside AL, Bell MJ (2006) Sugar Yield Decline Joint Venture Phase 2 (July 1999–June 2006). Final Report, SRDC, Project JVD002.

Hurney AP, Schroeder BL, Calcino, DV, Allsopp PG (2008) SmartCane fallow and land management. Technical Publication TE08009, BSES Limited, Indooroopilly, Australia, 25 pp.

Loeskow N, Cameron T, Callow B (2006) Grower case study on economics of an improved farming system. *Proceedings of the Australian Society of Sugar Cane Technologists* **28**, 96–102.

Poggio M, Morris E, Reid N, Di Bella L (2007) Grower group case study on new farming practices in the Herbert. *Proceedings of the Australian Society of Sugar Cane Technologists* **29**, 64–70.

Rural R&D Corporations (2008) Measuring economic, environmental and social returns from Rural Research and Development Corporations' investment. Rural R&D Corporations, Canberra, Australia, 38 pp.

Samson PR, Chandler KJ, Sallam MN (2007) GrubPlan: Options for greyback canegrub management. Technical Publication MN07002, BSES Limited, Indooroopilly, Australia. 20 pp.

Schroeder BL, Calcino DV, Hurney AP, Smith RJ, Panitz JH, Cairns RA, Wrigley TJ, Allsopp PG (2008) SmartCane principles of best management practice. Technical Publication TE08006, BSES Limited, Indooroopilly, Australia, 21 pp.

Schroeder, BL, Wood AW, Moody PW, Panitz JH, Agnew JR, Sluggett RJ, Salter B (2006) Delivering nutrient management guidelines to growers in the central region of the Australian sugar industry. *Proceedings of the Australian Society of Sugar Cane Technologists* **28**, 142–154.

Schroeder BL, Wood AW, Park G, Stewart RL (2009) Validating the 'SIX EASY STEPS' nutrient management guidelines in the Johnstone Catchment. *Proceedings of the Australian Society of Sugar Cane Technologists* **31**, (see Index).