CONCEPTS AND VALUE OF THE NITROGEN GUIDELINES CONTAINED IN THE AUSTRALIAN SUGAR INDUSTRY'S 'SIX EASY STEPS' NUTRIENT MANAGEMENT PROGRAM

By

B.L. SCHROEDER[1], A.P. HURNEY[2], A.W. WOOD[3],
P.W. MOODY[4] and P.G. ALLSOPP[5]
BSES Limited, [1]Bundaberg, [2]Tully, [5]Indooroopilly
[3]CSR Sugar, Macknade
[4]Queensland DERM, Indooroopilly
bschroeder@bses.org.au

KEYWORDS: Sugarcane, Nitrogen Management Guidelines, Validation, Value.

Abstract

THE AUSTRALIAN sugar industry currently faces unprecedented scrutiny of its use of nutrients due to initiatives to protect the Great Barrier Reef from excess nutrients and sediment from agricultural activities along the Queensland coast. However, this quest needs to be viewed in conjunction with the need for a sustainable sugarcane industry. A comprehensive program for nutrient management (the SIX EASY STEPS program) has been developed recently for the Australian sugar industry. It replaces the previous general guidelines that did not differentiate between regions or soil types and lacked precision. The new system supports profitable and sustainable sugarcane production, enhances environmental awareness, and is consistent with best practice. The paper summarises the alternative N management strategies that occur within the Australian sugar industry. It describes best-practice nutrient management and the concepts that underpin the SIX EASY STEPS program, and explains the principles of the N management guidelines used within the SIX EASY STEPS program and link this to N use efficiency. It also assesses the value of the SIX EASY STEPS N management guidelines. Trial results presented indicate that the SIX EASY STEPS N guidelines are robust and much more in line with the concept of sustainability than any of the other strategies considered. Calculation of the target N-use efficiency factors across the full range of SIX EASY STEPS N guidelines, especially when all possible sources of N within the soil/plant environment are included, strengthens the SIX EASY STEPS as an appropriate and fully comprehensive nutrient management package. This is confirmed by the results of the economic analyses of data from both small plot experiments and commercially-based replicated strip trials conducted on-farm.

Introduction

The Australian sugar industry currently faces unprecedented scrutiny of its use of nutrients due to recent Australian and Queensland Government initiatives to protect the Great Barrier Reef from 'excesses' of nitrogen, phosphorus and sediment that may be derived from agricultural activities along the Queensland coast (Calcino *et al.*, 2010). However, this government/political imperative (Anon., 2008), which appears to be driven by environmentalists and lobbyists, should be viewed in conjunction with the need for a sustainable sugarcane industry that forms the economic backbone of many of the regional centres of tropical coastal Queensland.

Sustainable nutrient management that aims at profitable cane production in combination with environmental responsibility (Schroeder *et al.*, 2006) will enable both the above-mentioned

objectives to be met without disadvantaging either sector. A comprehensive approach to nutrient management, the SIX EASY STEPS program, was recently developed within the Australian sugar industry for this purpose (Schroeder *et al.*, 2008). It replaced the previous general guidelines that did not differentiate between regions or soil types and lacked precision.

Although the government-led nutrient reduction strategy focuses on N and P outflow into the Great Barrier Reef Lagoon, this paper will only cover aspects of N management because of its prominence at present. However, it is important to note that the P and other nutrient guidelines (contained within the SIX EASY STEPS program) are also based on principles of best-practice nutrient management (Schroeder *et al*., 2006). In this regard, the SIX EASY STEPS program advocates the concept of 'balanced nutrition' that aims to have all essential plant nutrients present in sugarcane-producing soils at optimum levels.

Here we:

- summarise the alternative N management strategies that occur within the Australian sugar industry;
- describe our understanding of best-practice nutrient management and the concepts that underpin the SIX EASY STEPS program;
- explain the principles of the N management guidelines used within the SIX EASY STEPS program and link this to N use efficiency;
- report on specific studies that have been undertaken to assess the value of the SIX EASY STEPS N management guidelines.

Alternative N management strategies

Several strategies for determining N application rates occur within the industry (Schroeder *et al*., 2009a). They include the following, each with their own objectives and criteria (Table 1):

- Traditional (previous industry guidelines).
- Grower-developed (strategies developed by growers to minimise risk of production losses on-farm).
- SIX EASY STEPS (current BSES guidelines aimed at sustainable sugarcane production).
- N-replacement (currently under investigation by researchers working within the CSIRO).

Table 1—Different N management strategies used within the Australian sugar industry (Schroeder *et al.*, 2009a).

N strategy	Objectives	N input criteria	Reference
Traditional	Maximising productivity and linking N application rates to sugar price	Averaged industry regional production functions	Chapman (1994), Schroeder *et al.* (1998)
Grower-developed	Minimising risk of yield losses	In excess of 'traditional' rate or personal preferences	Johnson (1995), Wegener (1990)
SIX EASY STEPS	Sustaining sugarcane production; profitability in combination with environmental responsibility	District yield potentials and soil specific N mineralisation index	Schroeder *et al.* (2005), Wood *et al.* (2003)
N Replacement	Minimising N application rates. Focus on the environment and N-use efficiency	N input based on yield and N off-take of previous crop	Thorburn *et al.* (2007, 2008)

The current imperative for sustainable N management has highlighted the need for the selection of the most appropriate N input strategies on-farm. Importantly, growers need to apply N at appropriate rates, which lead to neither under- nor over-fertilisation and provide the best economic returns.

Best-practice nutrient management and the SIX EASY STEPS program

Best-practice nutrient management

Although best-practice agriculture is generally considered to be a continuous improvement process, the large number of associated terms and standards often leads to a confused understanding of the overall concept. In describing best practice management, Williams and Walcott (1998) suggested that best-practice management encompasses an underlying process, appropriate changes that may (or may not) have to be sought externally, and an agreed framework for successful implementation.

In recognising these components, a contemporary definition of 'best management practice' (BMP) states that it is 'an economically viable management practice that has been determined to be the most cost effective and practical means of preventing or reducing pollution and thus environmental harm' (Smith, 2008). We suggest that best-practice nutrient management is linked directly to the concept of 'risk'. It should be thought of as an overall combination of input strategies and processes that enables minimising the risk of losses in productivity (loss of yield), profitability (loss of income), nutrients (leaching, run-off and/or gaseous losses), and soil resources (erosion and fertility losses). Despite the apparent focus on losses, this definition also covers over-application of nutrients, or nutrients that are applied when not needed, because they could ultimately contribute to losses of nutrients and profitability.

SIX EASY STEPS program

The SIX EASY STEPS program is an integrated nutrient management package that enables the adoption of best-practice nutrient management on-farm (Schroeder *et al.*, 2006). The overall objective of the program is to provide guidelines that lead to sustainable, site/soil specific and balanced nutrient management across the industry. The SIX EASY STEPS consist of:

- Knowing and understanding our soils.
- Understanding and managing nutrient processes and losses.
- Soil testing regularly.
- Adopting soil-specific nutrient management guidelines.
- Checking on the adequacy of nutrient inputs (e.g. leaf analyses).
- Keeping good records to help interpret trends in production and modify nutrient inputs when and where necessary.

The program is being delivered to industry through grower-orientated short-courses called 'Accelerating the adoption of best-practice nutrient management' (Schroeder *et al*., 2007b). These courses provide growers (and their advisors) with comprehensive details of the SIX EASY STEPS process and information on how to develop nutrient management plans for each block of cane on their farms. The training program is supported by other SIX EASY STEPS initiatives such as:

- Soil reference booklets that provide information on soil-specific nutrient management guidelines for sugarcane production within districts (Wood *et al*., 2003; Schroeder *et al.*, 2007a).
- Replicated on-farm strip trials for growers to compare their current fertiliser programs with best-practice inputs for their soils (Salter *et al.*, 2008, Schroeder *et al*., 2009b).
- NutriCalc, a user-friendly nutrient requirement calculator based on soil test values.

- A Soil Constraints and Management Package (SCAMP) that utilises soil data to identify soil constraints to long-term productivity and profitability (Moody *et al.*, 2008).
- Development of 'SafeGauge for Nutrients' that aims to assess the risk of off-site losses (leaching or run-off) following fertiliser applications (Moody *et al*., 2008).
- Research trials that investigate aspects of nutrient management not fully understood and the nutrient requirements of new farming systems (Wood *et al*., 2008).

Results and improvements from these activities are fed directly into the nutrient management short-course.

Principles of the N management guidelines used within the SIX EASY STEPS program

The N guidelines in the SIX EASY STEPS program are based on a combination of district yield potential and a soil N mineralisation index. The district yield potential is determined from the best possible yield averaged over all soil types within a district and is defined as the estimated highest average annual district yield (t cane/ha) multiplied by a factor of 1.2 (Schroeder *et al*., 2007a). This concept recognises differences in the ability of districts and regions to produce cane. The district yield potential for several districts (Wet Tropics, Herbert, Plane Creek, Bundaberg/Isis and Maryborough) is 120 t cane/ha (estimated highest average annual yield of 100 t cane /ha multiplied by 1.2). The district yield potential for the Proserpine and Mackay regions is set at 130 t cane/ha, and two values have been set for the Burdekin region depending on perceived longer-term yields: 150 t cane/ha and 180 t cane/ha.

The district yield potential is used to establish the base N application rate according to an estimate previously developed by Keating *et al*. (1997). They found that 1.4 kg N/t cane was required up to a cane yield of 100 t/ha and 1 kg N/t/ha thereafter. This is used to set a base-line N application rate of 160 kg N/ha for the Wet Tropics, Herbert, Plane Creek, Bundaberg/Isis and Maryborough districts, 170 kg N/ha for the Proserpine and Mackay districts, and 190 kg N/ha and 220 kg N/ha for the Burdekin region (Table 2).

Table 2—N requirement for plant and ratoon crops .

Crop	Soil organic carbon (%)						
	0–0.4	0.4–0.8	0.8–1.2	1.2–1.6	1.6–2.0	2.0–2.4	> 2.4
Wet Tropics, Herbert, Plane Creek, Bundaberg/Isis, Maryborough (district yield potential = 120 t cane/ha)							
Replant cane and ratoon after replant	160	150	140	130	120	110	100
Plant cane after a grass/bare fallow	140	130	120	110	100	90	80
Proserpine and Mackay (district yield potential = 130 t cane/ha)							
Replant cane and ratoon after replant	170	160	150	140	130	120	110
Plant cane after a grass/bare fallow	150	140	130	120	110	100	90
Burdekin (district yield potential = 150 t cane/ha)							
Replant cane and ratoon after replant	190	180	170	160	150		
Plant cane after a grass/bare fallow	150	140	130	120	110		
Burdekin (district yield potential = 180 t cane/ha)							
Replant cane and ratoon after replant	220	210	200	190	180		
Plant cane after a grass/bare fallow	180	170	160	150	140		

With the SIX EASY STEPS approach, inputs are then adjusted according to an N mineralisation index, which classes N inputs (Table 2) according to soil organic carbon (%) values (Schroeder *et al.*, 2005). This produces a range of N application rates for replant (plant cane established shortly after harvest of the final ratoon in the previous crop cycle) and ratoon cane that correspond to these N mineralisation classes within each of the districts (Table 2). As plant cane requires less fertiliser N than replant and ratoon cane, a range of N application rates has also been established for plant cane that follows a bare or grass fallow (Table 2).

When the SIX EASY STEPS N guidelines are considered in terms of N-use efficiency, it has been important to define two terms:

- N-fertiliser utilisation index (kg N/t cane produced) = N applied (kg N/ha) / yield (t cane/ha)
- Fertiliser N-use efficiency factor (t cane/kg N) = yield (t cane/ha) / N applied (kg N/ha)

Management strategies aim to improve N-use efficiency by ensuring that the 'N fertiliser utilisation index' is as low as possible, and the 'fertiliser N-use efficiency' is as high as possible, without affecting productivity and profitability. The values shown in Table 2 (recommended application rates and district yield potential values) can be used to determine the SIX EASY STEPS target N fertiliser utilisation index (N application rate/district yield potential) and target fertiliser N-use efficiency (district potential yield/N application rate) values that apply to replant / ratoon cane and plant cane in each of the districts (Table 3).

Table 3 – Target fertiliser N use efficiency and N fertiliser utilisation index values calculated for the N management guidelines in the SIX EASY STEPS program.

	Soil organic carbon (%)						
	0 – 0.4	0.4 – 0.8	0.8 – 1.2	1.2 – 1.6	1.6 – 2.0	2.0 – 2.4	> 2.4
Wet Tropics, Herbert, Plane Creek, Bundaberg/Isis, Maryborough (district yield potential = 120 t cane/ha)							
Recommended N: replant / ratoon cane (kg N/ha)	160	150	140	130	120	110	100
Target N fertiliser utilisation index (kg N / t cane)	1.33	1.25	1.17	1.08	1.00	0.92	0.83
Target fertiliser N use efficiency (t cane/kg N)	0.75	0.80	0.86	0.92	1.00	1.09	1.20
Recommended N: plant cane after a grass/bare fallow	140	130	120	110	100	90	80
Target N fertiliser utilisation index (kg N / t cane)	1.17	1.08	1.00	0.92	0.83	0.75	0.67
Target fertiliser N use efficiency (t cane/kg N)	0.86	0.92	1.00	1.09	1.20	1.33	1.50
Proserpine and Mackay (district yield potential = 130 t cane/ha)							
Recommended N: replant / ratoon cane (kg N/ha)	170	160	150	140	130	120	110
Target N fertiliser utilisation index (kg N / t cane)	1.31	1.23	1.15	1.08	1.00	0.92	0.85
Target fertiliser N use efficiency (t cane/kg N)	0.76	0.81	0.87	0.93	1.00	1.08	1.18
Recommended N: plant cane after a grass/bare fallow	150	140	130	120	110	100	90
Target N fertiliser utilisation index (kg N / t cane)	1.15	1.08	1.00	0.92	0.85	0.77	0.69
Target fertiliser N use efficiency (t cane/kg N)	0.87	0.93	1.00	1.08	1.18	1.30	1.44
Burdekin (district yield potential = 150 t cane/ha)							
Recommended N: replant / ratoon cane (kg N/ha)	190	180	170	160	150		
Target N fertiliser utilisation index (kg N / t cane)	1.27	1.20	1.13	1.07	1.00		
Target fertiliser N use efficiency (t cane/kg N)	0.79	0.83	0.88	0.94	1.00		
Recommended N: plant cane after a grass/bare fallow	150	140	130	120	110		
Target N fertiliser utilisation index (kg N / t cane)	1.00	0.93	0.87	0.80	0.73		
Target fertiliser N use efficiency (t cane/kg N)	1.00	1.07	1.15	1.25	1.36		
Burdekin (district yield potential = 180 t cane/ha)							
Recommended N: replant / ratoon cane (kg N/ha)	220	210	200	190	180		
Target N fertiliser utilisation index (kg N / t cane)	1.22	1.17	1.11	1.06	1.00		
Target fertiliser N use efficiency (t cane/kg N)	0.82	0.86	0.90	0.95	1.00		
Recommended N: plant cane after a grass/bare fallow	180	170	160	150	140		
Target N fertiliser utilisation index (kg N / t cane)	0.83	0.78	0.72	0.67	0.61		
Target fertiliser N use efficiency (t cane/kg N)	1.20	1.29	1.38	1.50	1.64		

The information in Table 3 shows that the target N fertiliser utilisation index value ranges from 1.33 kg N/t cane (for replant / ratoon cane grown on soils with very low soil organic C in districts with a yield potential of 120 t cane/ha) to 0.61 kg N/t cane (for plant cane grown on soils with 1.6–2.0 % organic C in the higher yield potential (180 t cane/ha) areas of the Burdekin region.

As the SIX EASY STEPS program also recognises the N inputs from other sources (legume fallow crops, mill by-products, residual mineral N remaining after horticultural crops that are grown in rotation with sugarcane, irrigation water, etc), lower N fertiliser utilisation index values and higher fertilisation N-use efficiencies are used to take these into account. Examples of the calculated target values for the efficiency factors after legume fallow crops are shown in Table 4. Where the other sources of N supply enough N to meet the N requirement for sugarcane production, the N fertiliser utilisation index will be zero.

The SIX EASY STEPS program also recognises that, if a sub-district or farm consistently produces yields that are either higher or lower than the district yield potential, the baseline application rate should be adjusted upward or downward by 1 kg N per tonne of cane above the district yield potential. Such adjustments influence both target N-use efficiency factors.

Table 4—Target fertiliser N use efficiency and N fertiliser utilisation index values calculated for the N management guidelines for plant cane following legume fallow crops (Wet Tropics, Plane Creek, Bundaberg/Isis and Maryborough: district yield potential = 120 t cane/ha)

Crop	Soil organic carbon (%)						
	0–0.4	0.4–0.8	0.8–1.2	1.2–1.6	1.6–2.0	2.0–2.4	> 2.4
Plant (baseline N application rate)	140	130	120	110	100	90	80
Target N fertiliser utilisation index (kg N/t cane	1.17	1.08	1.00	0.92	0.83	0.75	0.67
Target fertiliser N-use efficiency (t cane/kg N)	0.86	0.92	1.00	1.09	1.20	1.33	1.50
Plant following a poor legume fallow	90	80	70	60	50	40	30
Target N fertiliser utilisation index (kg N/t cane	0.75	0.67	0.58	0.50	0.42	0.33	0.25
Target fertiliser N-use efficiency (t cane/kg N)	1.33	1.50	1.71	0.92	2.00	3.00	4.00
Plant following a good legume harvested for grain	70	60	50	40	30	20	10
Target N fertiliser utilisation index (kg N/t cane	0.58	0.50	0.42	0.33	0.25	0.17	0.08
Target fertiliser N-use efficiency (t cane/kg N)	1.71	2.00	2.40	3.00	4.00	6.00	12.00
Plant following a good legume (not harvested)	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Target N fertiliser utilisation index (kg N/t cane	0	0	0	0	0	0	0
Target fertiliser N-use efficiency (t cane/kg N)	–[1]						

[1] Division by zero

Assessing the value of the SIX EASY STEPS N management guidelines

A combination of small plot experiments and larger-scale on-farm replicated strip-trials has provided the means of assessing the value of the SIX EASY STEPS N management guidelines.

Small plot experiment

Data from a trial conducted in the Tully district of the Wet Tropics were recently used to assess the alternative N management strategies (Table 1) and what each of these means in terms of productivity, profitability and environmental implications (Schroeder *et al.*, 2009a). Cumulative response curves for both cane and sugar yields were produced by summing yields from successive crops within the crop cycle and plotting these yields against cumulative N rates (Schroeder *et al.*, 2009a). These curves were used to calculate industry partial net returns for each of the N management strategies. The N strategies that were evaluated were:

- Grower-developed (a possible grower application rate used in the Tully district).
- Traditional (previous industry guidelines as indicated by Calcino (1994)).

- SIX EASY STEPS (according to the guidelines shown in Table 2).
- N Replacement (1 kg N/t cane in the previous crop (Thorburn *et al*., 2007)).

The appropriate N inputs and yield data from the trial are shown in Table 5. While the grower-developed, traditional and SIX EASY STEPS approaches produced cumulative yields of 304, 305 and 303 t cane/ha, respectively, over the crop cycle (plant crop to third ratoon), the N Replacement strategy produced 277 t cane/ha over the same period. Based on sugar price (Aus$320/t sugar) and the cost of N (Aus$1.56/kg N) as applicable in June 2009, partial net returns for the N Replacement strategy were Aus$247/ha/year less than that of the SIX EASY STEPS. The grower-developed approach also resulted in Aus$36/ha/year loss in partial net return. The data (Table 5) indicated that yields did not normalise when low nitrogen inputs (such as those advocated by the N Replacement strategy) continued over the crop cycle.

Table 5—Tully trial: N inputs and cumulative cane yields for four N management strategies (Schroeder *et al*., 2009a).

	Grower-developed			Traditional			SIX EASY STEPS			N Replacement		
	N applied per Crop	Cumulative values		N applied per crop	Cumulative values		N applied per crop	Cumulative values		[1]N applied per crop	Cumulative values	
		N applied	Cane yield		N applied	Cane yield		N applied	Cane yield		N applied	Cane yield
	(kg/ha)		(t/ha)	(kg N/ha)		(t/ha)	(kg N/ha)		(t/ha)	(kg N/ha)		(t/ha)
Plant	150	150	84	120	120	82	120	120	82	[2]117	117	81
P+R1	180	330	151	160	280	150	140	260	148	81	198	143
P+R1+R2	180	510	236	160	440	229	140	400	225	62	260	204
P+R1+R2+R3	180	690	304	160	600	305	140	540	303	61	321	277

[1] 1 kg N/t cane in previous crop (Thorburn *et al.*, 2007)

[2] Cane yield of 117 t/ha for the last ratoon of the previous crop cycle

The yield and N input data were used to calculate the N-use efficiency factors for each of these N management strategies (Table 6).

Table 6—Mean N application rates, yield data, calculated N fertiliser utilisation indices (kg N/t cane) and fertiliser N-use efficiency values (t cane/kg N) for the small plot trial conducted in the Tully district (Grower-developed approach versus Traditional approach versus SIX EASY STEPS versus N Replacement

N strategy	Crop	N applied	Cane yield	N fertiliser utilisation index	Fertiliser N-use efficiency
		(kg/ha)	(t/ha)	(kg N/t cane)	(t cane/kg N)
Grower developed	Plant	150	84	1.79	0.56
	P+R1	330	151	2.19	0.46
	P+R1+R2	510	236	2.16	0.46
	P+R1+R2+R3	690	304	2.27	0.44
Traditional	Plant	120	82	1.46	0.68
	P+R1	280	150	1.87	0.63
	P+R1+R2	440	229	1.92	0.52
	P+R1+R2+R3	600	305	1.97	0.51
SIX EASY STEPS	Plant	120	82	1.46	0.68
	P+R1	260	148	1.76	0.57
	P+R1+R2	400	225	1.78	0.56
	P+R1+R2+R3	540	303	1.78	0.56
N Replacement	Plant	117	81	1.44	0.69
	P+R1	198	143	1.38	0.72
	P+R1+R2	260	204	1.27	0.79
	P+R1+R2+R3	321	277	1.16	0.86

The calculated N utilisation index values for the SIX EASY STEPS approach and the N Replacement strategy over the crop cycle (1.78 kg N/t cane and 1.16 kg N/t cane, respectively) were lower than that of the grower-developed and traditional approaches (2.27 kg N/t cane and 1.97 kg N/t cane, respectively). The grower-developed strategy would be considered wasteful of N inputs as well as being environmentally unacceptable. In this case the actual N-use efficiency was much lower than that of both the SIX EASY STEPS and the N Replacement strategies.

Although the N Replacement concept appears to be more efficient, the decease in productivity (cane and sugar per hectare) resulted in losses in profitability compared to the SIX EASY STEPS approach. These results indicate that improvement in N fertiliser-use efficiency cannot be seen in isolation from productivity and profitability on farm. The SIX EASY STEPS approach that considers both these aspects is balanced and therefore more appropriate than systems aimed at either maximum production or being overly environmentally focused.

Replicated demonstration strip trials

Four participative replicated demonstration strip trials that were recently established in first ratoon cane crops in the Tully district to compare the productivity and profitability associated with three of the N input strategies identified in Table 1 (Grower-developed versus SIX EASY STEPS versus N Replacement). The N input strategies that were tested included the growers' usual application rates, the SIX EASY STEPS guidelines (Table 2) and the N Replacement strategy (1 kg N/t cane produced in the previous crop).

An economic assessment of each N input approach was undertaken using the 'pooled' data from the four trials by:

- Determining the partial net return per hectare to the grower, where:

Grower partial net return = (gross income calculated from the Tully cane payment formula) – (cane yield x estimated harvesting costs plus levies) – (fertiliser cost) …… (1)

- Calculating the industry (grower and miller) partial net return per hectare, where:

Industry partial net return = (sugar yield x price of sugar) – (fertiliser cost x application rate (kg/ha) – (cane yield x estimated harvesting costs plus levies).…….. (2)

The results of the statistical analysis and economic assessment of the pooled yield data from the four strip trials are shown in Table 7. Yields associated with the 'grower' and SIX EASY STEPS N inputs were not significantly different, but the N Replacement strategy resulted in yields (t cane/ha and t sugar/ha) significantly lower than those obtained from both of these approaches (across the four trial sites).

Table 7—Influence of different fertiliser strategies on cane yield, CCS, sugar yield and partial net returns using pooled data from the Tully SIX EASY STEPS calibration strip trials (first ratoon crop harvested 2008).

Treatment	Mean N applied (kg/ha)	Mean cane yield (t/ha)	Mean CCS	Mean sugar yield (t/ha)	Grower partial net return (Aus$/ha)[2]	Industry[1] partial net return (Aus$/ha)[2]
Grower	149	90.7[a]	14.97	13.50[a]	2080	3464
6 Easy Steps	128	87.2[a]	14.86	12.89[a]	1996	3323
N Replacement	82	80.4[b]	14.79	11.85[b]	1879	3109
Probability	–	<0.0001	Ns	<0.0001	–	–
CV%	–	3.79	1.35	4.00	–	–

Means with the same superscript letter in each column are not significantly different

[1]Industry = total partial net return (grower plus miller),

[2]Assumptions: sugar price = Aus$320/tonne, cost of N = Aus$1.56/kg

The grower and industry net returns indicated a decrease in value: Grower > SIX EASY STEPS > N Replacement. However, as the yields associated with the 'grower' and SIX EASY STEPS strategies were not significantly different from each other, the net return values were also viewed as being not different. Hence the partial net return values associated with the SIX EASY STEPS approach (grower: Aus$1996 and industry: Aus$3323) and the N Replacement strategy (grower: Aus$1879 and industry: Aus$3109) form a valid comparison. The SIX EASY STEPS approach resulted in a mean grower partial net return of Aus$117/ha and a mean industry partial net return of Aus$214/ha higher than that of the N Replacement.

Discussion and conclusions

The SIX EASY STEPS program is consistent with the defined principles of best practice management. It aims to directly minimise losses of productivity, profitability, applied nutrients and inherent soil fertility.

This is achieved through the SIX EASY STEPS framework that enables growers to tailor their nutrient inputs for their specific circumstances (particular soils, climatic and production conditions, etc). Although this paper deals almost exclusively with N, it was recognised earlier that the SIX EASY STEPS program is aimed at overall nutrient management that encourages sustainable and 'balanced' inputs on-farm.

Trial results presented indicate that the SIX EASY STEPS N guidelines are robust and much more in line with the concept of sustainability than the other strategies considered. The fact that these guidelines are based on a combination of district yield potential and a soil mineralisation index enables N inputs to be both district and soil specific.

Despite the use of pre-determined yield potentials within the current SIX EASY STEPS N guidelines, the program has enough flexibility to allow deviations from these values. Already, it is recognised that adjustments can be made for sub-districts or farms that consistently produce yields (over more than 15 years) that are either higher or lower than the district yield potential.

Calculation of the target N-use efficiency factors across the full range of SIX EASY STEPS N guidelines, especially when all possible sources of N within the soil/plant environment were included, indicated that appropriate N efficiencies are being targeted.

This strengthens the SIX EASY STEPS system as an appropriate and fully comprehensive nutrient management package. This was confirmed by the results of the economic analyses performed on data from both small plot experiments and commercially-based replicated strip trials conducted on-farm. Importantly, the economic viability of the SIX EASY STEPS N guidelines was illustrated for both the grower and milling sectors.

In overall terms, it is vital that the most appropriate N inputs are used within the sugarcane production system in Australia. This not only has implications for the environment, especially the Great Barrier Reef, but also for the communities of regional Queensland that are dependent on a sustainable sugar industry. It is our opinion that the SIX EASY STEPS guidelines, especially those that relate to N management, are the only viable option at present.

Acknowledgements

The data and information presented here were obtained from projects funded partially and/or severally by BSES Limited, CSR Ltd, Queensland Department of the Environment and Resource Management (DERM), Queensland Primary Industries and Fisheries (QPIF), Sugar Research and Development Corporation (SRDC) and Terrain NRM. We acknowledge the input of our other collaborating colleagues including Dr Barry Salter, John Panitz and David Calcino, and Dr Joanne Stringer for assistance with the statistical analyses. We also acknowledge the co-operation and assistance of growers who participated in the series of demonstration strip trials.

REFERENCES

Anon. (2008). Scientific consensus statement on water quality in the Great Barrier Reef. Queensland Reef Water Quality Protection Plan Secretariat, Brisbane.

Calcino, D.V. (1994). Australian Sugarcane Nutritional Manual. BSES/SRDC, Indooroopilly, 60 p.

Calcino, D.V., Schroeder, B.L. and Hurney, A.P. (2009). Extension and adoption of the 'SIX EASY STEPS' nutrient management program in sugarcane production in north Queensland. Proc. Int. Soc. Sugar Cane Technol., 26: in press.

Chapman, L.S. (1994). Fertiliser N management in Australia. Proc. Aust. Soc. Sugar Cane Technol., 16: 83–92.

Johnson, A.K.L. (1995). Risk perceptions and nutrient management responses in the Australian sugar industry: preliminary results from the Herbert River District. Proc. Aust. Soc. Sugar Cane Technol., 17: 172–178.

Keating, B.A., Verburg, K., Huth, N.I. and Robertson, M.J. (1997). Nitrogen management in intensive agriculture: sugarcane in Australia. In: Keating, B.L. and Wilson, J.R. (eds). Intensive Sugarcane Production: Meeting the Challenge Beyond 2000, 221–242. CAB International, Wallingford, UK.

Moody, P.W., Blogg, D., Legrand, J., Schroeder, B.L. and Wood, A.W. (2008). 'SCAMP' and SafeGauge for Nutrients': Two new decision support tools for minimising off-site movement of nutrients. Proc. Aust. Soc. Sugar Cane Technol., 30: 276–284.

Salter, B., Schroeder, B.L., Wood, A.W., Panitz, J.H. and Park, G (2008). The use of replicated strip-trials for demonstrating the effectiveness of different nutrient management strategies for sugarcane. Proc. Aust. Soc. Sugar Cane Technol., 30: 361.

Schroeder, B.L., Hurney, A.P., Wood, A.W., Moody, P.W., Calcino, D.V. and Cameron, T. (2009a). Alternative nitrogen management strategies for sugarcane production in Australia: The essence of what they mean. Proc. Aust. Soc. Sugar Cane Technol., 31: 93–103.

Schroeder, B.L., Wood, A.W. and Kingston, G. (1998) Re-evaluation of the basis for fertiliser recommendations in the Australian sugar industry. Proc. Aust. Soc. Sugar Cane Technol., 20: 239–247.

Schroeder, B.L., Wood, A.W., Moody, P.W., Bell, M.J. and Garside, A.L. (2005) Nitrogen fertiliser guidelines in perspective. Proc. Aust. Soc. Sugar Cane Technol., 27: 291–304.

Schroeder, B.L., Wood, A.W., Moody, P.W., Panitz, J.H., Agnew, J.R. and Sluggett, R.J. (2006). Delivering nutrient management guidelines to growers in the Central region of the Australian sugar industry. Proc. Aust. Soc. Sugar Cane Technol., 28: 142–154.

Schroeder, B.L., Wood, A.W., Moody, P.W., Stewart, R.L., Panitz, J.H. and Benn, J. (2007a). Soil-specific nutrient management guidelines for sugarcane production in the Johnstone Catchment. BSES Limited Technical Publication TE07001, Indooroopilly, 60pp.

Schroeder, B.L., Wood, A.W. and Panitz, J.H. (2007b). Accelerating the adoption of best-practice nutrient management. BSES Limited, Brisbane, Australia.

Schroeder, B.L., Wood, A.W., Panitz, J.H., Salter, B. and Moody, P.W. (2008). The 'SIX EASY STEPS' as a delivery mechanism for best practice nutrient management in the Australian sugar industry. Soils 2008 Conference, Massey University, Palmerston North, New Zealand.

Schroeder, B.L., Wood, A.W., Park, G., Panitz, J.H. and Stewart, R.L. (2009b)**.** Validating the 'SIX EASY STEPS' nutrient management guidelines in the Johnstone catchment**.** Proc.

Aust. Soc Sugar Cane Technol., 31: 177–185.

Smith, R.J. (2008). Riparian and Wetland Areas on Cane Farms. SmartCane Best Management Practice Booklet, Wetland Care Australia. BSES Limited Tech. Publ. TE08006, 44pp.

Thorburn, P.J., Webster, A.J. and Biggs, J.S. (2008). Nitrogen balances in sugarcane farming systems as affected by nitrogen fertiliser applications. Proc. Aust. Soc. Sugar Cane Technol., 30: 357–358.

Thorburn, P.J., Webster, A.J., Biggs, I.M., Biggs, J.S., Park, S.E. and Spillman, M.F. (2007). Innovative management of nitrogen fertiliser for a sustainable sugar industry. Proc. Aust. Soc. Sugar Cane Technol., 29: 85–96.

Wegener, M.A. (1990). Analysis of risk in irrigated sugarcane at Mackay. Proc. Aust. Soc. Sugar Cane Technol., 12: 45–51.

Williams, R.T and Walcott, J.J. (1998). Sustainable agriculture – using best practice to manage the paradoxes facing land managers. Proc. 9th Aust. Agronomy Conf. http://www.regional.org.au/au/asa/198/7/114williams.

Wood, A.W., Schroeder, B.L., Hurney, A.P., Salter, B. and Panitz, J.H. (2008). Research aimed at enhancing nitrogen management guidelines for the SIX EASY STEPS program. Proc. Aust. Sugar Cane Technol., 30: 362–363.

Wood, A.W., Schroeder, B.L. and Stewart, R.L. (2003). Soil specific management guidelines for sugarcane production: Soil reference booklet for the Herbert district. CRC Sugar Technical Publication, CRC for Sustainable Sugar Cane Production, Townsville, 92 p.

PRINCIPES ET VALEUR DES DIRECTIVES CONTENUES DANS LE PROGRAMME DE L'INDUSTRIE SUCRIERE AUSTRALIENNE SUR LA GESTION DE LA FERTILISATION APPELE "SIX EASY STEPS"

Par

B.L. SCHROEDER[1], A.P. HURNEY[2], A.W. WOOD[3],
P.W. MOODY[4] et P.G. ALLSOPP[5]
BSES Limited, [1]Bundaberg, [2]Tully, [5]Indooroopilly
[3]CSR Sugar, Macknade
[4]Queensland DERM, Indooroopilly
bschroeder@bses.org.au

MOTS-CLÉS: Canne à Sucre, Directives de Gestion de l'Azote, Validation, Valeur.

DES INITIATIVES ont été mises en place pour protéger le récif de la grande barrière des éléments minéraux et des sédiments produits en excès par les activités agricoles le long de la côte du Queensland. Du fait de ces initiatives, l'industrie sucrière australienne fait face actuellement à un examen minutieux et sans précédent de l'utilisation des engrais minéraux. Cependant, l'étude de cette utilisation ne doit pas être dissociée des besoins d'une industrie sucrière durable. Un programme global de gestion de gestion de la fertilisation, appelé "SIX EASY STEPS" a été

développé récemment par l'industrie sucrière australienne. Ce programme remplace les recommandations précédentes qui manquaient de précision et qui ne différenciaient pas les régions ou les types de sol. Le nouveau système fournit une production rentable et durable de canne à sucre, améliore la conscience environnementale, et est conforme à de meilleures pratiques. Le papier récapitule les stratégies alternatives de gestion de la fertilisation azotée que l'on rencontre dans l'industrie sucrière australienne. Ce papier décrit la gestion de la fertilisation associée à de meilleures pratiques et les concepts qui soutiennent le programme "SIX EASY STEPS". Il explique les principes des directives de gestion de l'azote et lie ces principes à l'efficacité d'utilisation de l'azote. Il évalue également la valeur des directives de ce programme. Les résultats des essais montrent que les directives du programme "SIX EASY STEPS" sont robustes et correspondent beaucoup plus au concept de durabilité que toutes les autres stratégies considérées. L'évaluation des facteurs d'efficacité de l'utilisation de l'azote ciblée, dans l'ensemble des directives de "SIX EASY STEPS", spécialement quand toutes les sources d'azote sont disponibles, renforce la démarche "SIX EASY STEPS" comme un système approprié et global de gestion de la fertilisation. Ceci est confirmé par les analyses économiques des résultats provenant à la fois d'essais en petites parcelles et d'essais en bandes répétées sur exploitations.

CONCEPTOS Y VALIDEZ DE LAS RECOMENDACIONES DE NITRÓGENO CONTENIDAS EN EL PROGRAMA "SEIS PASOS SENCILLOS" PARA EL MANEJO DE NUTRIENTES DE LA INDUSTRIA AZUCARERA AUSTRALIANA

Por

B.L. SCHROEDER[1], A.P. HURNEY[2], A.W. WOOD[3],
P.W. MOODY[4] y P.G. ALLSOPP[5]
BSES Limited, [1]Bundaberg, [2]Tully, [5]Indooroopilly
[3]CSR Sugar, Macknade
[4]Queensland DERM, Indooroopilly
bschroeder@bses.org.au

PALABRAS CLAVE: Caña de Azúcar, Recomendaciones para el Manejo de Nitrógeno, Validación, Validez.

Resumen

ACTUALMENTE la industria azucarera australiana enfrenta una vigilancia sin precedentes sobre su uso de nutrientes, debido a iniciativas para proteger la Gran Barrera de Coral del exceso de nutrientes y sedimentos provocados por las actividades agrícolas a lo largo de la costa de Queensland. Sin embargo, esta acción necesita verse en conjunto con la necesidad de una industria cañera sostenible. Recientemente se ha desarrollado un programa global para el manejo de nutrientes (el programa SEIS PASOS SENCILLOS) para la industria azucarera australiana. Éste reemplaza las recomendaciones generales previas que no diferenciaban entre regiones o tipos de suelo y carecían de precisión. El nuevo sistema fundamenta una producción cañera rentable y sostenible, aumenta la conciencia ambiental y es consistente con la aplicación de mejores prácticas. El artículo resume las estrategias alternativas para el manejo de nitrógeno dentro de la industria azucarera australiana. Describe las mejores prácticas para el manejo de nutrientes y los conceptos que fundamentan el programa SEIS PASOS SENCILLOS, explica los principios usados dentro del programa en cuanto a recomendaciones para el manejo de nitrógeno, y relaciona todo con la

eficiencia en el uso de nitrógeno. Además, se evalúa la validez de SEIS PASOS SENCILLOS para recomendaciones en el manejo de nitrógeno. Los resultados de los experimentos que se presentan indican que las recomendaciones de nitrógeno de SEIS PASOS SENCILLOS son robustas y mucho más en línea con el concepto de sostenibilidad que cualquiera de las otras estrategias consideradas. El cálculo de los factores clave en la eficiencia del uso de nitrógeno a lo largo de los SEIS PASOS SENCILLOS para recomendaciones de nitrógeno, especialmente al incluir todas las posibles fuentes de nitrógeno en el ambiente suelo/planta, refuerza al programa para que se considere como un paquete completo para el manejo de nutrientes. Esto se confirma con los resultados de análisis económicos de datos provenientes de experimentos en parcelas pequeñas y tratamientos en franjas con repeticiones, realizados en campos comerciales.