

## **CSC21 S Final Report**

### **Monitoring cane at the mill to improve nitrogen management on the farm - a pilot study.**



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**Supported by ;  
Sugar Research and Development Corporation**

**A collaborative research activity between CSIRO Tropical Agriculture, CSR  
Technical Field Department and BSES.**

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In addition, Mr Ron Kerkwyk and Louise Phillips at the Herbert Cane Pest and Productivity Board have supported various aspects of the study. Special thanks goes to the CSR Sugar Mills staff at Macknade Mill for their patience and assistance in the sample collection throughout the project. Jason Bull, Les Chapman of BSES and Mike Hughes of NSW Ag have also contributed through the provision of experimental crops for sampling in this project.

## 1. Non-technical Summary

*Improved N fertiliser management requires growers to have specific information of the N status of their current crops on a block by block basis. This project explored the prospects for monitoring N composition in cane supply at the mill, as a means of assessing the adequacy of N management on the farm.*

*The research showed that sugarcane contains considerable quantities of nitrogen in its stems and much of this nitrogen is expressed in the juice at the mill. Particular attention was paid to the N in juice present as amino acids (henceforth referred to as amino-N). This N form was shown to be very responsive to the N supply conditions under which the cane was grown. Factors such as high N fertiliser rates led to high levels of amino-N which could be detected in the juice at harvest time. Under conditions when cane or sugar yields were reduced due to inadequate N supply, then amino-N concentrations dropped to very low levels. Other factors, such as moisture stress that reduced cane growth, had a corresponding effect on juice amino-N concentrations, while varieties appeared to have only a small effect on these relationships. This information based on experimental plots was used to develop indicative diagnostic relationships between amino-N concentrations in cane juice at harvest and the adequacy of N supply (eg deficient, adequate, excess).*

*The project examined variation in amino-N in cane supply at the Macknade Mill during the 1996 crushing season. This variation was related to factors such as crop class, variety, time of harvest, CCS, and farm supplying the cane. Extensive variation in amino-N concentrations was found in cane supplied to Macknade Mill over this season. There was a large crop class effect detected, with plant crops on average registering 50% higher*

*amino-N concentrations in their juice than later ratoons. There was no significant variety effect detected. A major factor determining amino-N level was the farm from which the cane was sourced. Some farms always supplied cane with high levels of amino-N in the cane, indicating excess N supply. Others consistently supplied cane with low to adequate levels of amino-N. Overall approximately 45% of the cane supply to Macknade Mill during the 1996 crushing season was estimated to have been grown under conditions of excess N supply. Excessive N fertilisation rates is thought to be the most probable explanation, but this suggestion is being explored in follow up research.*

*The project also explored some options for rapid and cost effective analysis of amino-N concentrations in cane juice, that might be suited to installation into the juice stream of mills. Near-infrared Spectrometry (NIR) was shown to have considerable promise and this technique is being further evaluated in follow-up research.*

## **2. Background to the research**

The sugar industry spends approximately \$80m annually on nitrogen fertilisers. These fertilisers provide good returns to the industry and growers are naturally uneasy about risking inadequate nitrogen supply. While N fertilisers are an essential part of cane production, evidence has accumulated in recent years that nitrogen fertiliser rates sometimes exceed crop requirements. This evidence comes from surveys of grower practices in a number of regions (Johnson 1997) and from a significant number of trials that show no loss of yield, at least in the short term, when N rates are substantially reduced below normal practice (Keating et al. 1993, Catchpoole and Keating 1995, Muchow et al. 1996, M. Hughes and R.C. Muchow, pers. comm., R Beattie and G Shannon, pers. comm.) While there may be a direct cost to growers in terms of money wasted on unnecessary N fertiliser, we consider the indirect costs to the industry to be far more substantial.

These potentially include:

- increased lodging, leading to increased extraneous matter (EM) or dirt in cane supply.
- reduced CCS through higher water content and / or EM levels, lowering returns to growers and raising millers' costs.
- high levels of nitrogen compounds in juices affecting raw sugar quality and increasing the costs of sugar recovery in the milling and refining process.
- negative effects on the environment through excess N from fertilisers being lost to surface and ground waters via leaching or to the atmosphere via volatilisation or denitrification.

In the absence of information that is specific to a farm or block, growers are naturally reticent to reduce N rates for fear of encountering an N limitation to cane yield. The tendency is to err on the side of caution and apply higher N rates than may be necessary in any particular year or block (Keating et al. 1994, 1997). While there is a role for

education and extension of generalised information on N management, substantial change is unlikely until growers have a means of assessing their N fertility management specifically at the block level. The work reported in this paper was driven by the presumption that growers will be more willing to go down the pathway of better matching their N fertilisation rates to their crop's needs if they have some tangible measure or "test" of the adequacy or otherwise of their current N management

### **3. Objectives of the research project**

A two year pilot project is proposed to explore the technical and operational feasibility of cane analysis for nitrogen at the mill, as a means of improving N management on the farm.

Technical feasibility includes the assessment of;

- Relationships between N level and composition (total, amino acid, asparagine) in millable cane ( whole cane or extracted juice) and N supply during the prior season.
- Effects of other production variables such as weather, variety, harvest time and geographical location on these relationships.
- Appropriate sampling strategies for assessing the N status of cane supplied to mills.
- The options for rapid and cost effective analyses in the milling stream.

The objective in all cases being to assess the degree to which N deficits or N excess could be identified from analysis of cane supplied to mills.

Operational feasibility includes an assessment of;

- The economic and social constraints at both the miller and grower levels that may constrain the implementation of system that was identified as technically feasible.

### **4. Introductory technical information**

Monitoring as a basis for N fertilisation in sugarcane is not new. In South Africa, soil organic matter status assessed using near-infrared (NIR) spectrometry has been in use for an extended period (Meyer 1989). To date in Australia, soil tests have not proven to be of any predictive value of crop N requirements (Chapman 1994). This lack of success with soil testing for N in Australia is considered to relate to the complexity of the N sources and transformations in the soil system. Limited attention has been given to the role of a readily mineralisable organic N fraction and carry over of mineral-N reserves at depth in the profile when soil tests have been examined (Vallis and Keating 1994; Catchpole and Keating 1995; Muchow et al. 1996).

Plant tissue testing, based on some index leaf tissue, has been extensively used to monitor the adequacy of N supply for maximum sugar yield (Clements 1953, Baver 1963, Wood 1968, Meyer and Wood 1984). While leaf nitrogen affects cane and sucrose accumulation, the time delay and expense with laboratory determinations appear to have been a disincentive to use in practical management of N fertilisation of sugarcane.

Results reported by Catchpoole and Keating (1995) illustrate in part why we have chosen to look toward cane stalks as an indicator of N supply. These authors show how the concentration of N in stalks increased much more than that in green leaves, dead leaves, and cabbage when the supply of N to the plant was increased. For example, during the 1992/93 season in a ratoon crop in Bundaberg, the concentration of N in millable stalks at harvest rose by 56% and 78% for N rates of 160 ( $N_{160}$ ) and 320 kg N ha<sup>-1</sup> respectively, relative to a treatment with zero N fertiliser added ( $N_{zero}$ ). The equivalent changes in green leaf N% were only 6 and 12 % respectively. The response of stalk N% to external N supply was equally large during the 1993/94 season (eg. 83% increase for  $N_{160}$  relative to  $N_{zero}$ ) compared with only a 19% increase in green leaf N%. Muchow and Robertson (1994) also demonstrate that sugarcane is a luxury consumer of nitrogen and that the bulk of this luxury uptake ends up in the stalks.

The other attractive feature of an N monitoring method based on cane stalks at harvest time is that of “universal sampling”. The magnitude of the task in sampling leaves or soils from cane blocks is substantial. A test based on cane stalks at harvest time has the attraction that cane from every cane block is delivered to the mill for processing.

While we recognised the potential for a monitoring method based on some aspect of cane supply to mills, a number of questions remained before the feasibility of such a test could be considered. These included :

- Where is the N in cane stalks and what form is it in ?
- What factors affect N composition of cane stalks ?
- Is there any variation at the mill scale in N composition of cane supply ?
- Are there options for rapid and cost effective analysis of N composition ?

These questions were the subject of the pilot study that is reported in this paper.

## 5. Research methodology

The analyses undertaken utilised two sources of cane. In one set of studies, clean cane sampled from a diverse range of experiments throughout the industry was used. In the second study, the cane supply delivered to Macknade Mill in the Herbert River district during the 1996 season was the focus of study.

### *Factors affecting N composition of cane*

Whole cane stalks were sampled from the trials and treatments listed in Table 1. Juice was extracted from these stalks using procedures outlined by Muchow et al (1993). These juice samples were filtered through 0.8 micron millipore filters and sampled stored at -70°C. Total N content of the whole stalk and the fibre cake remaining after juice extraction was measured by mass spectrometry. The amino acid composition of juice was measured using HPLC.

Table 1. Details of trials sampled for studies of N composition

Number	Location	No of samples	Treatments
1	Grafton	12	4 N rates, irrigated and rainfed, 2 varieties
2	Yandina	9	3 N rates
3	Blibli	12	Lime, GMAG, MUDASH applications
4	Bundaberg	24	2 N rates, irrigated and rainfed, 3 varieties
5	Mackay	24	6 varieties
6	Ingham	8	2 N rates, 2 varieties
7	Ingham	12	2 N rates, Plant and ratoon crops

*Variation in N composition in cane supply to a mill*

First expressed juice was collected from every rake of cane processed at Macknade Mill over a 24 h period on five occasions during the 1996 crushing seasons (Table 2). The cultivar Q124 made up 60% of the cane supply while plant crops accounted for 18% of the juice samples collected. Note that plant crops dominated cane supply for the September sampling.

Table 2. Details of sampling program in study of N composition of cane supply to Macknade Mill in 1996.

Date	No of rakes	No. of bins	Weight (tonnes)	Average CCS	% plant crops	% Q124
10/07/96	108	2062	7592	11.4	0%	51%
7/08/96	138	2606	9889	12.9	16%	63%
18/09/96	117	2424	9410	14.5	52%	75%
16/10/96	130	2549	10893	13.4	9%	68%
13/11/96	131	2455	9169	12.7	12%	42%
TOTAL	624	12096	46953	13.0	18%	60%

*Options for rapid and cost effective analysis*

Amino-acid analysis via HPLC was used as the “reference” method in these studies. These analyses are, however, time consuming and expensive. Two other methods were also trialed in the search for more rapid and cost effective analysis options.

The “Ninhydrin” method relies of a colour reaction between the ninhydrin reagent (Moore and Stein 1954) and the amino acids present in cane juice. This is actually the same colour reaction used in the HPLC method, but in this case without the benefit of the isolation and reaction of individual amino-acids. As different amino acids react differently with ninhydrin, some precision is lost. However, for samples where the

relative abundance of different amino acids is not changing greatly, this may not be a major problem.

The “NIS” (Near Infrared Spectrometry) method relies on the propensity for amino-acids in the cane juice to differentially absorb near-infrared radiation (Clarke et al 1992). Spectral absorption patterns are recorded for samples of known amino-acid composition and predictive relationships developed through empirical calibration procedures. The NIS analysis was undertaken with a NIRSystems Model 6500 spectrophotometer fitted with a 0.5 mm quartz cuvette for juice presentation. Methods used for NIS analysis of juice samples were similar to those described by Botherington and Berding (1995).

## 6. Results

### *Where is the N in cane stalks and in what form is it ?*

Total N concentration of the cane stalks sampled from the trials listed in Table 1 ranged from 0.1 to 0.6 % N on a dry weight basis. The proportion of this N found in the juice ranged from 30% at low total N concentrations to 60 - 70% at moderate and high total stalk N concentrations (Figure 1). The dominance of juice N at high stalk N and the relative loss of N from juice at lower stalk N, reveals good prospects for a monitoring system based on juice, which has major sampling advantages over whole stalks.

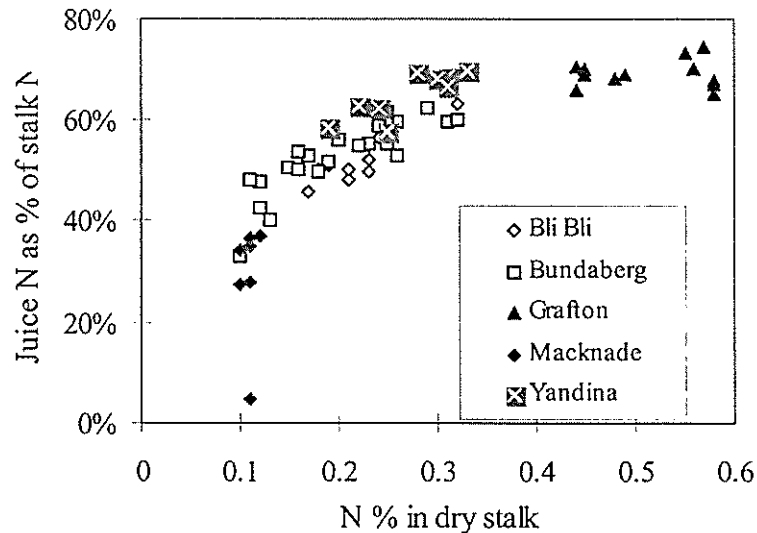


Figure 1. Percentage of total N in cane stalks found in expressed juice. (Note : data for Mackay excluded on account of use of a non-standard juice extraction method).

Juice N consists of “fixed” N, defined as insoluble in methanol, predominantly protein, and “free” N, predominantly amino acids. Only trace amounts of nitrate and ammonium were found in juice. Amino-N concentrations in juice rose with increasing total stem N concentration, but the relationship was not tight, indicating amino-N may lead to some different interpretation than does total stem N (Figure 2). The proportion of juice N present as amino acids was also variable, ranging from 20 - 90 %.

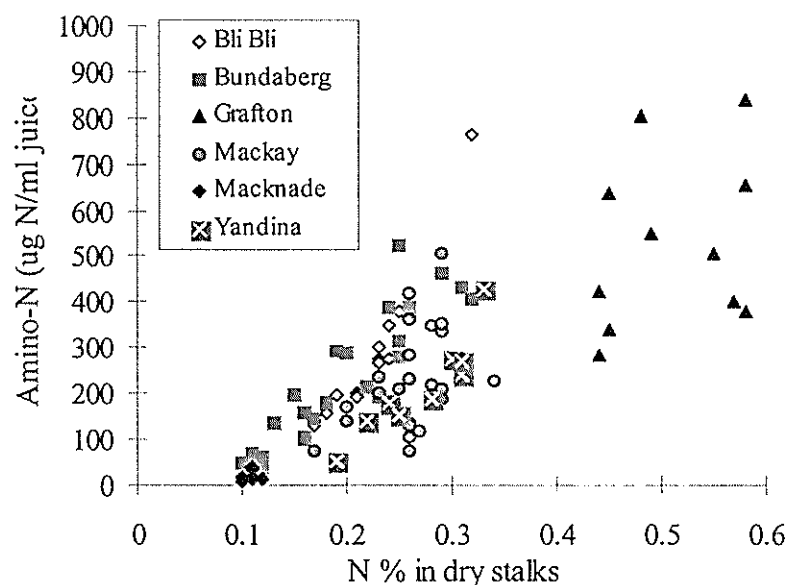


Figure 2. Amino-N concentrations in juice in relation to total N in whole stalks.

A total of 19 amino acids were detected in juice, but one, asparagine, accounted for 60 to 80% of all amino acids found, except at very low juice N levels ( $< 100 \text{ ug amino N ml}^{-1}$  juice). Other prominent species were aspartic acid and glutamine.

#### *Factors affecting N composition of cane*

Nitrogen supply was the major factor identified as determining amino-N concentration of sugarcane juice (Figure 3a,b, 4). Water stress also had an impact (Figure 3b), but this was thought to be via a shift in the balance between N supply and N demand. Water limited crops produced less biomass at the same N supply, hence raising amino-N levels in cane stalks. Varietal effects were small in comparison to these water and nitrogen effects.

Trial number 7, with a very wide range of N supply conditions derived from a combination of N rate and crop class conditions, provides an opportunity to examine a preliminary sugar yield - amino N diagnostic curve (Figure 4). Note that sugar yield reductions due to N limitation were associated with amino-N concentrations less than  $50 - 100 \text{ ug N ml}^{-1}$  juice. Also note the very large increase in amino-N without any significant change in sugar yield, indicative of luxury N accumulation in the presence of excess N supply.



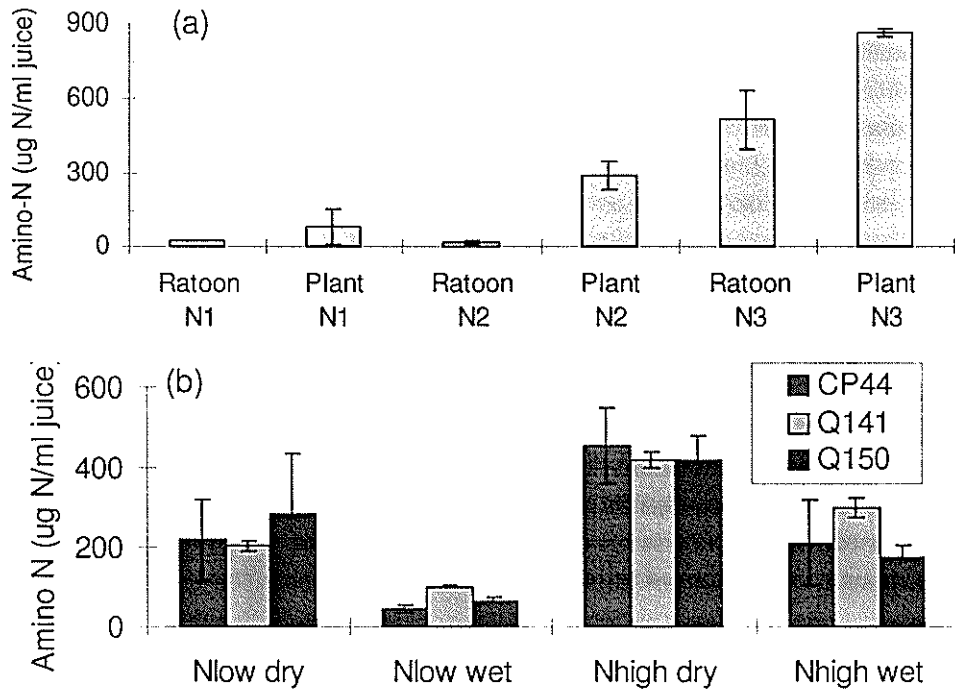


Figure 3. Factors affecting amino-N concentration in cane juice. (a) Trial 7 - N fertiliser and crop class at Macknade 1993/94 (N rates for plant crops in 1993 were 56, 107 and 268 kg N ha<sup>-1</sup> for N1, N2, N3 respectively; N rates for plant and ratoon crops in 1994 (the year of sampling) were 0, 55, 774 kg N ha<sup>-1</sup> respectively). (b) Trial 4 - Water and N levels for three varieties in Bundaberg 1994/95 (dry = rainfed, wet = irrigated until 279 days after planting; Nlow = 20 kg N ha<sup>-1</sup>, Nhigh = 220 kg N ha<sup>-1</sup>: see Bull et al. (1996) for further details).

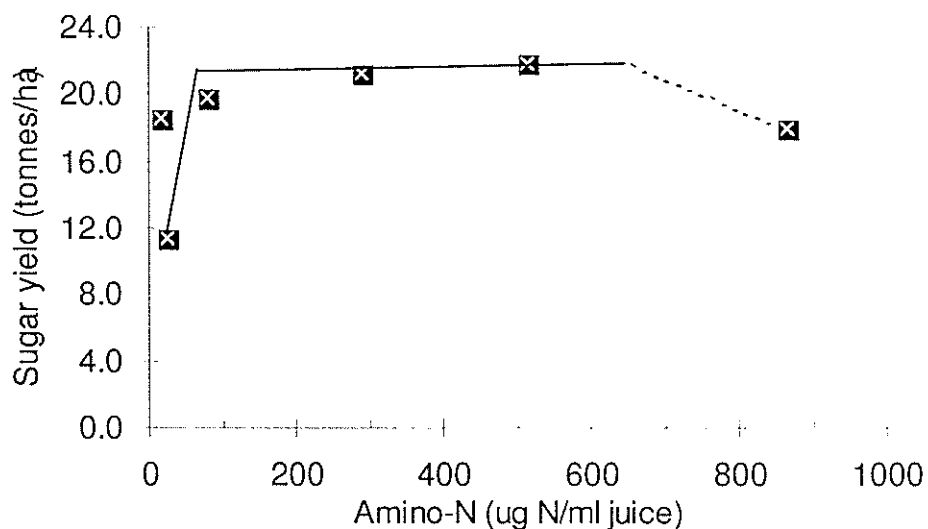


Figure 4. Sugar yield in relation to amino-N in cane juice observed for Q117 grown over the 1993/94 season at Ingham (see Muchow et al., 1996 for trial details). Lines indicate an idealised diagnostic response.

### *Variation in N composition in cane supply to a mill*

Amino-N concentration of juice sampled at Macknade Mill (Figure 5) ranged from 73 to 542 ug N ml<sup>-1</sup> juice with a mean of 206 ug N ml<sup>-1</sup>. Matching juice amino-N concentrations with consignment information indicates little in the way of detectable variety effects (data not shown), but a significant effect of crop class. Amino-N concentrations were 40 - 50% higher in plant crops. The higher amino-N in plant cane may reflect the greater relative “over-fertilisation” of plant crops that is well recognised in the Herbert district. This crop class effect probably also explains the higher concentrations recorded in the September sampling which was dominated by plant crops (Table 2).

Care is needed in direct comparisons of amino-N analyses on mill and laboratory sourced juice samples. Tests revealed that amino-N determined on juice collected direct from No. 1 mill (x) was approximately 20% lower than amino-N on the same shredded cane processed via a Carver Press (y). This difference was predictable ( $y = 0.75x + 20.5$ ,  $r^2 = 0.94$ ) and was presumably due to differences in extraction efficiency.

While a definitive statement on diagnostic values for amino-N concentration is not yet possible, our interpretation of the data gathered from experimental situations with known N status (Figure 4) suggests that values in excess of 200 ug amino-N ml<sup>-1</sup> juice are excessive. Conversely, values less than 80 ug amino-N ml<sup>-1</sup> are indicative of a potentially N limiting situation. On this basis, approximately 45% of cane supply at Macknade Mill in the 1996 season contained more N than necessary for maximum sugar yield. Only one rake of cane had amino-N concentration low enough to suspect an N limitation to yield.

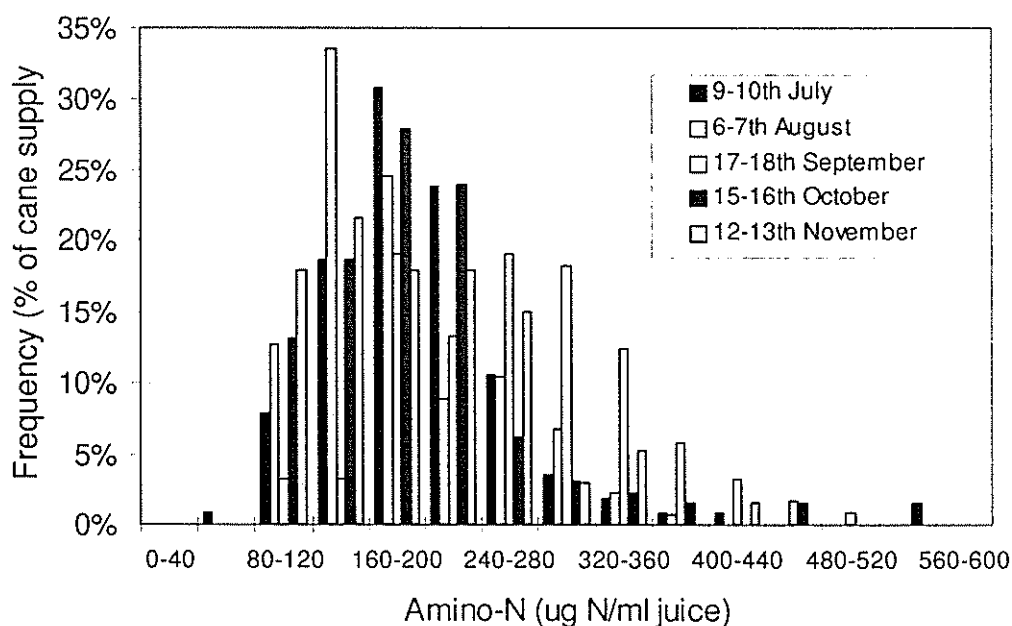


Figure 5. Variability in amino-N concentration measured in juice of cane supplied to Macknade Mill on five occasions in the 1996 season.

*Options for rapid and cost effective analysis*

Good correlations existed between amino-N analysis via HPLC and ninhydrin reactive N (Figure 6). While the latter method does not directly measure total amino-N, it correlates sufficiently well with HPLC-derived estimates of total amino-N to be useful in handling the large number of samples involved in sampling at the mill scale (eg. Figure 5).

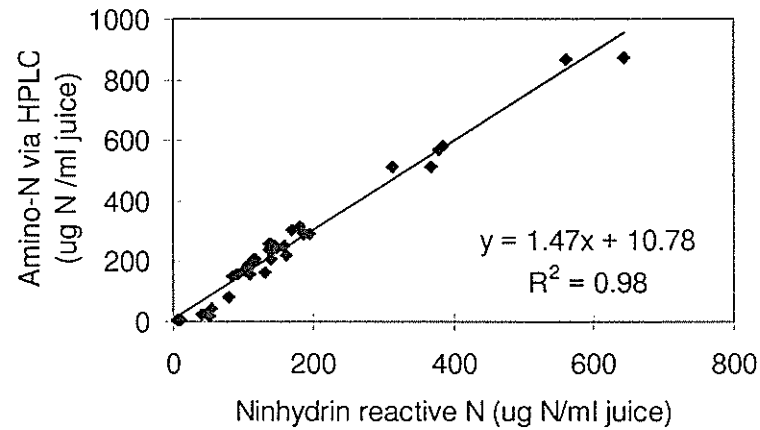


Figure 6. Relationship between amino-N measured by HPLC and “ninhydrin-reactive N” measured via colorimetry for sugarcane juice from both experimental trials (Ingham) and the 1996 Macknade Mill cane supply.

Implementation of amino-N analysis in a mill situation will require some form of “on-line” monitoring of the juice stream. Near-infrared spectrometry (NIR) has been shown to have many promising applications in a sugar mill situation (Brotherton and Berding 1995). Preliminary tests indicate it is possible to develop acceptable calibrations that enable amino-N to be estimated by NIR (Figure 7). More extensive testing of this method is now needed.

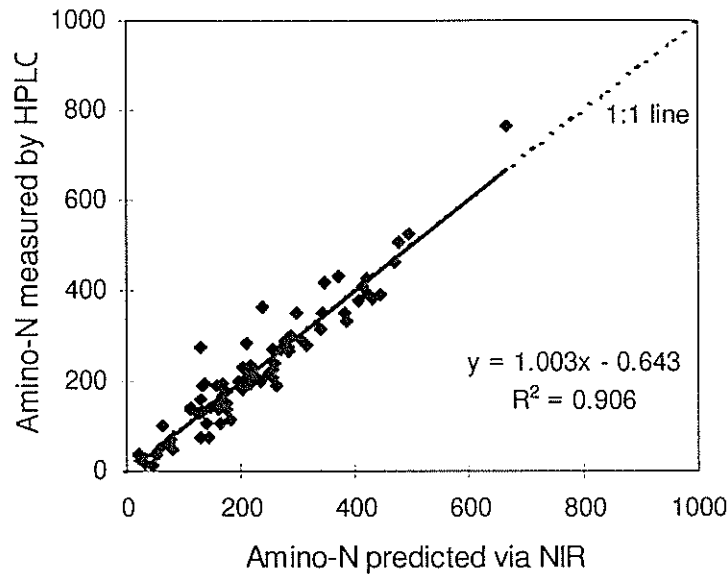


Figure 7. Relationship between amino-N measured via HPLC and amino-N predicted with NIR for sugarcane juice from the trials listed in Table 1 (all units in ug N/ml juice; excludes the Grafton trial)

## 8. Recommendations

### *Remaining questions*

The work described in this paper will continue with additional support provided by SRDC. The new activities will focus on the value of the additional information to growers making decisions on adjustment of their N fertiliser rates. Cane supplied by participating growers will be monitored at the mill, and where indicated, adjustments made to subsequent N fertiliser management. Impact of these adjustments in terms of yield, CCS and juice amino-N levels will be monitored over subsequent years. In addition, the new work will extend the studies to other mill districts (initially Bundaberg), and will further evaluate the real-time analysis options for amino-N in the mill juice stream.

## 9. Intellectual property

While the research conducted in this pilot project has considerable potential for commercial application, we do not envisage commercial considerations of intellectual property being a significant factor in its further development.. While there will be some benefits to growers in terms of reduced costs and some benefits to millers in terms of improved quality of cane supply, the sugar growing environment will be the major beneficiary of better N fertiliser management. Under these circumstances, it would seem the approach should be to minimise any intellectual property hurdles to application of the research.

If there were ever commercial returns to come from this work, the assignment of intellectual property to the various parties involved has been estimated in Table 3. These estimates are based on the respective investment of resources (cash or in-kind) in the work to date. This equity will evolve from this point in further phases of the project.

Table 3. Estimate of equity in project at 30/6/97 (basis of calculation detailed in Appendix 11.2)

Organisation	Equity %
SRDC	33.1
CSIRO Trop Ag	49.3
CSR	8.8
BSES	8.8

## 10. Technical summary

The following conclusions can be drawn from the “N at the Mill” pilot project.

- Approximately 60% of the N contained within cane stalks is found in the pressed juice; the proportion is less in cane that has been grown with limited N supply.
- The proportion of juice N present as amino acids ranges from 20 to over 90%, depending on the overall N supply.
- Amino acid N in cane juice responds strongly to N supply, particularly N excess.
- Factors that limit cane yield, such as water stress, will also raise amino acid N concentrations.
- Differences between varieties were small in comparison with the large effects of N supply and water supply.
- Amino acid N in the cane supply at Macknade during the 1996 crushing season varied by over a factor of eight. Approximately 45% of this cane supply had high amino-N concentrations indicative of excess N supply.
- Cane from plant crops on average exhibited amino-N levels 40-50% higher than did cane from ratoon crops.
- There was no clear variety or time of year effects in the amino-N data gathered, apart from the time of year effect associated with proportion of plant crops in the cane supply.
- Preliminary studies have shown that NIR holds promise as a rapid and cost effective means of amino-N analysis.

In summary, our understanding of the factors determining amino acid composition of sugarcane juice, the variation in juice composition found at the cane supply at the mill, and indications that analysis of cane juice can detect both sup-optimal and excess N supply, leads to the suggestion that a block specific diagnostic test, based on cane juice at the mill, is feasible. The value of such a test is the subject of on-going research.

## 11. Appendices

### Appendix 11.1 : Statement of achievement, impact and recommendations for follow-up.

It is my view, as project supervisor, that this project was successful in meeting the objectives as outlined in the original proposal. The project was reviewed in February 1997 and received a favourable review report.

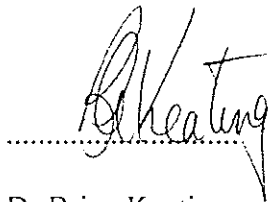
On the basis of this review report and a new proposal developed by the project team, SRDC has funded a follow on project - CTA29.

As a pilot project, impact to date has necessarily been limited. There is widespread knowledge and interest in the "N monitoring at the mill" concept, and the subject is almost invariably raised at any meeting of growers or researchers considering options to improve N management.

The objective of the follow-up project CTA29 are ;

To build on the promising results of csc21s ( "N at the Mill" pilot project) wherein N composition of cane juice at the mill reflects the N status of the farm block supplying the cane. We propose that the new project would;

1. Confirm for additional sites, seasons and varieties the relationships between amino-N content of sugarcane juice and the N status under which the cane was grown. In this context, N status is seen to embody both N supply from soil and fertiliser sources and N requirements by the crop.
2. Work in a case study mode with growers, extension staff and Productivity Boards to demonstrate how grower managed trials on-farm, can be combined with the monitoring of N in cane supplied to mills, to improve N fertiliser management back on the farm.
3. Develop promising leads in rapid and cost-effective analyses of N compounds in the mill juice stream to a "proof-of concept" stage.



Dr Brian Keating  
Principal Research Scientist  
12/2/98

## Appendix 11.2 : Total Funding support

ITEM	CSIRO/CSR/BSES CONTRIBUTION*	SRDC CONTRIBUTION
<b>SALARY + ONCOSTS (21%)</b>		
CSIRO		
B A Keating	78021	0
R C Muchow	22022	0
K Smith	64286	40179
M L Goode	47592	29745
Casual Labour	0	6000
<b>TOTAL CSIRO</b>	<b>211920</b>	<b>75923</b>
CSR	37752	0
BSES	37752	2400
<b>TOTAL SALARY</b>	<b>287424</b>	<b>78323</b>
TRAVEL		
CSIRO		
Experimental	0	10984
Project meetings/training	0	0
CSR		
	0	0
BSES		
	0	0
<b>TOTAL TRAVEL</b>	<b>0</b>	<b>10984</b>
OPERATING		
CSIRO	0	37690
CSR	0	10000
BSES	0	5100
<b>TOTAL OPERATING</b>	<b>0</b>	<b>52790</b>
CAPITAL	0	0
<b>TOTAL CAPITAL</b>	<b>0</b>	<b>0</b>
CSIRO TOTAL	211920	
CSR TOTAL	37752	
BSES TOTAL	37752	
<b>PROJECT TOTAL</b>	<b>287424</b>	<b>142097</b>
CSIRO Contribution	49.3%	
CSR Contribution	8.8%	
BSES Contribution	8.8%	
SRDC Contribution	33.1%	

\* Multipliers : 1.6 for SRDC supported salary; 2.6 for CSIRO/CSR/BSES supported salary

### **Appendix 11.3 : Communication of project findings to cane growers**

The attached article was published in the September issue of the magazine "Australian Canegrower".



# Monitoring at the mill improves nitrogen management in the field

By Brian Keating, CSIRO Tropical Agriculture and Sugar CRC

Australian cane farmers spend a lot of money on nitrogen (N) fertilisers — something like \$80 million per year which represents about half their fertiliser costs. While this is a big investment in anyone's eyes, the returns to growers and the broader industry are also large — estimated at something like \$500 to \$1000 million worth of extra cane, produced in response to the N fertiliser input.

But the problem with N fertiliser management on cane has been that growers have not had a reliable or cost effective way of assessing whether they have got their practices right.

Faced with this uncertainty and a knowledge about how N deficiency will impact negatively on their bottom budget line, many growers naturally err on the high side of N application rates to be safe rather than sorry. But there are hidden costs of excess or inefficient N fertiliser use.

Excess nitrogen can move below the cane root zone in rainfall or irrigation water, promoting acidification of the soil and contaminating groundwaters, streams or coastal waterways.

## THE BREAKTHROUGH

After a number of years of detailed study on nitrogen inputs, losses and transformations in sugarcane systems, CSIRO researchers came to the conclusion that no substantial improvement in N use efficiency was possible until growers had a specific way of assessing the adequacy — or otherwise — of their own N management practices on their own cane blocks.

Soil and leaf testing have a place for many nutrients, but have proved somewhat problematical with respect to nitrogen in sugarcane systems.

The breakthrough came when the CSIRO team noticed that cane stems were

exhibiting greater variation in N content, in response to variation in N supply (for example, from different N fertiliser rates), than any other part of the plant. So when the research team applied more N fertiliser than was needed, they found higher than normal levels of N in the cane stems. Likewise, when a crop received no fertiliser N and had its growth reduced through N deficiency, we saw a reduction in N levels in the cane.

The large differences being found in N concentration in the cane, combined with the fact that every stalk of cane grown is 'sampled' at the mill, provided us with the breakthrough we were looking for.

We approached the Sugar Research and Development Corporation (SRDC) in 1995 for funding. SRDC had been looking for a breakthrough in nitrogen

research that was going to deliver a benefit to growers. They saw the potential benefits of our research and agreed to fund a two year pilot study.

**THE CHALLENGES**

While getting SRDC's backing was the first obstacle, many obstacles remained. Our CSIRO team was joined by partners

from CSR Technical Field Department and BSES. We began to systematically address a series of questions that had to be answered before we could be sure we had a viable monitoring technique.

**Where is the N in cane stems and what form is it in?**

The first issue that had to be explored was the relative levels and forms of N in different parts of the cane stem. Many

samples and analyses later, we had sorted out a typical N composition of cane stems.

Over half the cane stem N was found in the juice and approximately half this juice N was in the amino-N form, predominantly the amino acid asparagine.

It was clear that our work could move forward by focusing on juice, rather than whole stems, greatly reducing the sampling difficulties and moving us one step closer to a practical technique.

**What factors affect amino-N in cane juice?**

We sampled cane from experimental trials in Ingham, Mackay, Bundaberg, Nambour and NSW, and examined how amino-N levels in juice changed with factors such as location, irrigation inputs, variety, and of course, N fertiliser management. The conclusion was that amino-N levels in juice responded in a consistent way to all these factors, and could be interpreted in terms of the relative balance between N supply and N demand.

N supply is the N available to the crop, either as fertiliser or from a fertile soil with high levels of N mineralisation.

N demand in this context is the N required to meet the crop yield being achieved. The better the growth, for example, with additional irrigation in a dry region, the higher the N demand.

Data on amino N levels in juice from a trial in Bundaberg with managed water and nitrogen environments illustrate this concept (Figure 1). While there were variety effects, to date these have been found to be small in comparison to the large effects of N supply and N demand on amino-N levels in cane juice.

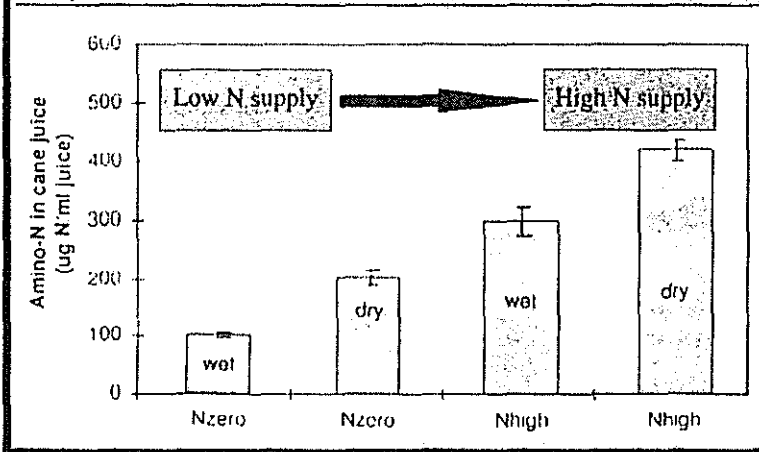
One of these studies enabled us to make a preliminary assessment of the sugar yield-juice amino-N relationship. These measurements have also highlighted the enhanced sensitivity of the juice amino-N technique. For instance, a two to three-fold increase in total N in cane stems in response to increased N supply, translated to a 50 to 100 fold increase in juice amino-N levels.

**Is there any variation at the mill scale in amino-N levels?**

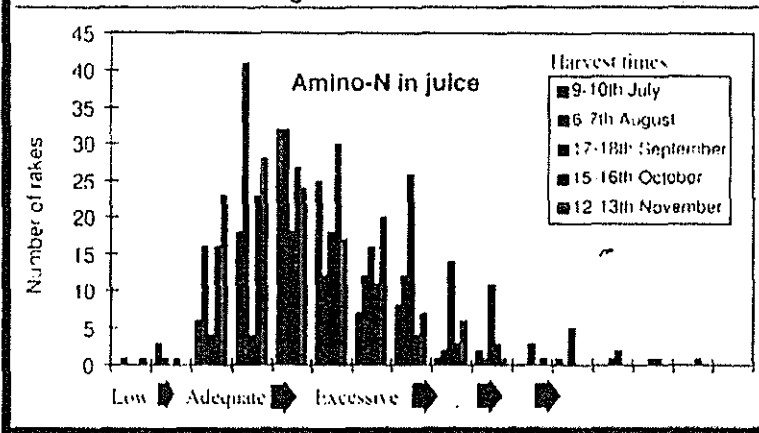
At this stage in the pilot project, we knew that amino-N in juice was a sensitive indicator of N supply to the cane crop and we had some indication of what was a low, adequate or excessive level of amino-N in juice.

But all studies up to this point had been based on hand-cut samples of cane taken from experimental plots. It was obvious

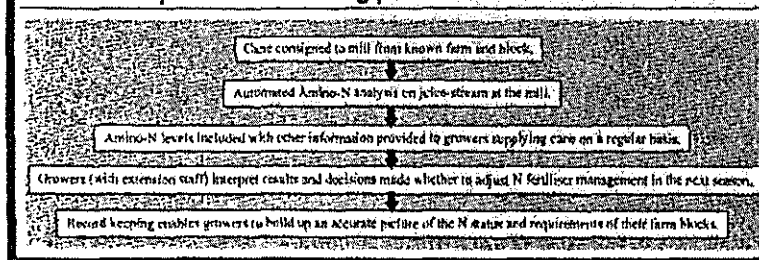
**FIGURE 1: Effects of water and N fertiliser treatments on amino-N in cane juice at harvest time**



**FIGURE 2: Variation in amino-N in cane supply to a north Qld sugar mill over the 1996 crushing season**



**FIGURE 3: Steps in the monitoring process**



that information on amino-N in the juice stream at the sugar mill was now essential for the feasibility study to progress.

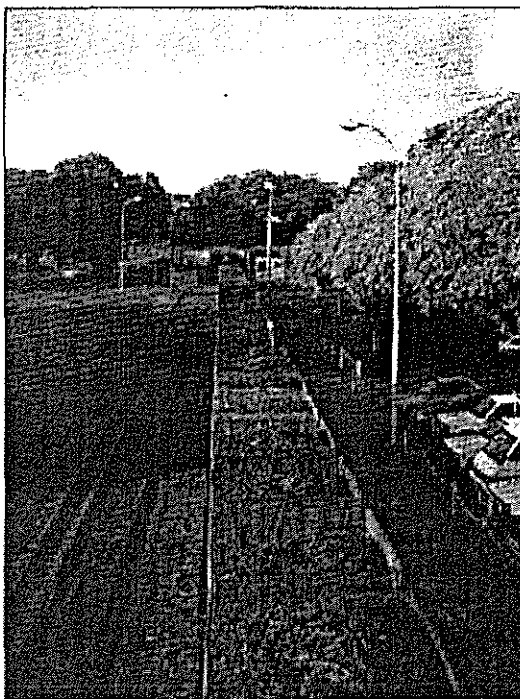
If no variation was found in amino-N levels, then there would be no value in the proposed monitoring technique.

We set ourselves up in the juice laboratory of a north Queensland sugar mill and on five occasions over the 1996 crushing season, sampled every rake of cane supplied to the mill over a 24 hour period. Over five 24-hour periods, juice from 625 rakes of cane was sampled, representing 12,098 bins or 46,953 tonnes of cane. These samples came from a total of 167 farms and equated to a representative sample of about 500 hectares of caneland.

Our results are summarised in Figure 2. The variation found in amino-N levels in the cane supply at this mill covered much the same range as did the earlier analyses from the experimental plots. Approximately half of the cane supply had amino-N levels in the juice that the research team believe are excessive.

A small number of consignments (less than five per cent) exhibited amino-N levels that were so low that inadequate N supply may be limiting sugar yield.

These data are now being combined



**Cane bins arriving at the mill.**

with other information — cane quality, cane yield, crop class, variety, soil types and management practices — in a search for the reasons for the extensive variation in amino-N discovered.

#### **Rapid and cost effective analysis**

We have been using a range of techniques to measure the level and composition of amino acids in cane juice. One technique — Near Infrared Spectrometry (NIR) — holds promise for cheap and timely analysis of amino-N in cane juice.

#### **REMAINING QUESTIONS**

Our work will continue with additional support provided by SRDC over the next few years. The new activities will focus on the value of the additional information obtained from the N analysis at the mill, to growers making decisions on adjustment of their N fertiliser rates.

Cane supplied by participating growers will be monitored at the mill, and where indicated, adjustments made to subsequent N fertiliser management. Impact of these adjustments in terms of yield, CCS and juice amino-N levels will be monitored over subsequent years. In addition, the new work will extend the studies to other mill districts, and further evaluate the real-time analysis options for amino-N in the mill juice stream.

**CSIRO Tropical Agriculture and the SRDC have co-funded this work. The research team was made up of Brian Keating (Ph: 07 3377 0373), Russ Muchow, Mayling Goode and Keith Smith of CSIRO Tropical Agriculture, Andrew Wood of CSR Technical Field Department and Graham Kingston and Nils Berding of BSES.**

Bundaberg Sugar has joined the current phase of the research effort. The team acknowledges the support of the staff of CSR Sugar Mills and the Herbert Cane Pest and Productivity Board in the conduct of the pilot study. ■