BSES Limited

FINAL REPORT SRDC PROJECT BSS329

UNDERSTANDING WATER QUALITY IN SUGARCANE FARMING SYSTEMS

by

TONI ANDERSON and PETER ALLSOPP

SD12003

Contact:
Peter Allsopp
Manager
BSES Limited
PO Box 86
Indooroopilly QLD 4068
Telephone: 07 3331 3333
Email: pallsopp@bses.com.au

Australian Government
Sugar Research and Development Corporation

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SUMMARY

The ‘new’ sugarcane farming system (reduced tillage, controlled traffic, legume break) has many advantages over the traditional farming system. However, the impact on water quality is not known. This project aimed to address the issue of water-use efficiency and water quality in that farming system by initially comparing it with a traditional farming system (full tillage, non-matched wheel and row spacing etc.) through effects on soil physical properties and their effect on water movement and quality.

Specifically, the objectives were:

- Evaluate the effect of the ‘new’ sugarcane farming system on soil physical properties and the influence on water quality.
- Determine the N loss mechanisms for different nitrogen management systems in the ‘new’ sugarcane farming system and their impact on water quality.

The first year saw an attempt to establish a soybean crop on the Burdekin trial site. That season had way-above-average rainfall and the Steering Committee felt that the results generated would not generally represent a more normal pattern of water application and water and nutrient movement. Due to these limitations, the project was varied to remove the crop after the harvest in 2011, return all plots to soybean and then follow a similar cane planting and monitoring schedule as originally proposed. This set the project back one year.

Following the Welsman review, staff resignations and reprioritisation of BSES objectives and assessment of staff capabilities and capacities saw BSES withdraw from the project.

However, the trial site forms the ideal basis for and will be used in another project on N mineralisation partially funded under Caring for Our Country, so the input will not be lost.

1.0 BACKGROUND

The Australian sugar industry has come under increasing pressure to reduce its environmental impacts. The pressure is not only coming from environmental groups but also the state and federal governments. The five-year federal government target includes a 25% reduction in the discharge of dissolved nutrients and chemicals from agricultural lands to the Great Barrier Reef lagoon. Similarly, the former Queensland government introduced a 4-year target of reducing the levels of pesticides and fertilisers found in Reef waters by 50%.

The ‘new’ sugarcane farming system (reduced tillage, controlled traffic, legume break) has many advantages over the traditional farming system. However, the impact on water quality is not known. This project aimed to address the issue of water-use efficiency and water quality in that farming system by initially comparing it with a traditional farming system (full tillage, non-matched wheel and row spacing etc.) through effects on soil physical properties and their effect on water movement and quality. Measurements of nutrient and pesticide levels in the water and their movements in the farming system configurations were an integral part of the project. In particular, under the new farming system the largest single input of nitrogen (N) is through growing a legume crop compared with fertiliser N under the traditional farming system. Nitrogen management from both legume residue and fertiliser N were to be closely monitored in order to establish the most suitable practice for N management in terms of water quality without impinging on productivity.

2.0 OBJECTIVES

The project aimed to refine and improve the best management practice recommendations provided within the Australian sugar industry. In doing this, the industry will be better placed to justify changes to meet the water-quality targets set by the state and federal governments.

Specifically, the objectives were to:

- Evaluate the effect of the ‘new’ sugarcane farming system on soil physical properties and the influence on water quality.
- Determine the N loss mechanisms for different N management systems in the ‘new’ sugarcane farming system and their impact on water quality.

These objectives were not met:

- The first year saw an attempt to establish a soybean crop on the Burdekin trial site. That season had way-above-average rainfall and the Steering Committee felt that the results generated would not generally represent a more normal pattern of water application and water and nutrient movement. Due to these limitations, the project was varied to remove the crop after the harvest in 2011, return all plots to soybean and then follow a similar cane planting and monitoring schedule as originally proposed. This set the project back one year.
- Following the Welsman review, staff resignations and reprioritisation of BSES objectives and assessment of staff capabilities and capacities saw BSES withdraw from the project.

However, the trial site forms the ideal basis for and will be used to enhance another project on N mineralisation partially funded under the Australian Government’s Caring for Our Country Program, so the input will not be lost.

3.0 METHODS, RESULTS AND IMPLICATIONS

3.1 Trial design

Proposed treatments were:

- Treatment 1 – sugarcane on 1.52 m following harvested soybeans (1.52 H)
- Treatment 2 – sugarcane on 1.83 m following harvested soybeans (1.83 H)
- Treatment 3 – sugarcane on 1.83 m following mulched soybeans (1.83 M)

The site was mapped with an EM-38 ground conductivity meter and sampled for soil compaction to assist in interpretation of subsequent data.

3.2 Initial soybean break crop

Soybeans were planted 14 December 2009 and soybean biomass and cane trash samples were taken 8-9 April 2010 (Tables 1-2) and biomass and cane trash dried and weighed in preparation for nitrogen assessment.

Soil cores to a depth of 1.5 m soil were collected on 16 April 2010. Soil samples were divided into 0-10, 10-20, 20-40, 40-60, 60-90, 90-120, 120-150 mm increments and were frozen to stabilise the N components.

Table 1 - Soybean biomass (mid-pod fill) and yield results

Treatment	Number of plants (per ha)	Dry weight (t/ha)	Nitrogen (%)	Nitrogen content (kg/ha)	Carbon (%)	Carbon content (t/ha)	Soybean seed yield (kg/ha)
1.52 H	177 934	8.4	3.1	260	45.1	3.9	2418
1.83 M	219 926	8.3	2.6	216	44.8	3.7	-
1.83 H	202 441	7.3	2.5	183	44.9	3.3	1796

Table 2 - Trash biomass (mid-pod fill)

Treatment	Dry weight (t/ha)	Nitrogen (%)	Nitrogen content (kg/ha)	Carbon (%)	Carbon content (t/ha)
1.52 H	11.3	0.88	99	36.6	4.1
1.83 M	9.1	0.91	83	33.5	3.0
1.83 H	11.0	0.94	103	35.3	3.9

Points to note were:

- The concentration of N in the soybeans (2.7%) was somewhat lower than would normally be expected (3-3.5 %). There was no obvious reason for the soybeans' lower N values.
- There was a significant row-spacing x location effect for N concentration - with the 1.52 m spacing the top end of the 1.52 spacing plots had a higher concentration than the bottom end (3.48% vs 2.68%). There was no difference between the top and bottom end for the 1.83 m spacing plots.
- These row-spacing effects on N concentration carried through to N content, with more N contributed with the 1.52 m spacing (251 kg N /ha vs an average of 198 kg N/ha for the 1.83 m spacing).
- There were some significant row spacing x row number effects for C content, although the Steering Committee felt that this was not significant to the experiment.
- The concentrations of N and C in the original sugarcane trash were not significantly different among treatments although there were some near-significant effects. For example, the % C in the trash was higher in the bottom location as opposed to the top location (38% C vs 32% C) and a similar trend existed for N (0.95% N vs 0.87% N). However, these effects did not show through in N or C contents with the trash. This was encouraging from the point of having no significant trash differences to start with, so any differences that developed should be attributable to the soybean and how the residue was managed.
- Carbon:nitrogen (C:N) ratios were 17:1 for the soybean and 39:1 for the trash. Generally, it is expected that N mineralization commences when the C:N ratio is 20 or less. Thus, the incorporation (mixing of trash and soybean) with the 1.52 m spacing was likely to result in rapid mineralization, whereas retaining the trash and soybean residue on the surface (1.83 m spacing) was likely to favour initial immobilization and a delay in mineralization until later in the growing period.
- The soybean yield was lower than expected (Table 1) - the crop finished quickly before pod-filling was complete. This was possibly due to a lack of water. Problems during the harvest resulted in various amounts of soybeans being left in the field.
- There was no significance in the difference amongst the yields in the four plots.

3.3 First sugarcane plant crop

Cane was planted into the experiment in mid-2010. Cane growth was monitored by collecting biomass sample from beds 2 and 7 in each plot.

At the mid-September biomass sampling, there were no significant differences amongst treatments or row number means (Table 3). There were, however, significant differences between locations in the paddock. This was likely due to a soil type change.

Table 3 - Sugarcane biomass (t/ha) at mid-September sampling

Treatment	row	Location	
		Top (t/ha)	Bottom (t/ha)
1.52 H	2	1.86	1.52
	7	1.20	1.06
1.83 M	2	1.81	0.82
	7	1.95	0.96
1.83 H	2	1.58	1.06
	7	2.13	1.18

Close to harvest, there were no significant differences in plant population among treatments, with the overall plant population relatively low at 70,000 stalks per hectare. Sample stalk weights indicated a yield of around 122 t/ha, which correlates quite closely with the weigh truck figures of 106 t/ha. There was some billet loss observed, improving the match (Table 4). The low plant populations resulted in an increase in sucker numbers with around 21,000 suckers per hectare, however the suckers did not contribute much fresh weight around 7 t/ha (Table 4).

Overall there was no significant difference among treatments for cane yield, suckers, CCS or N content of the various plant components (Tables 4-5).

Table 4 - Sugarcane harvest field measurements

Row spacing	Soy management	Stalks (m^2)	Suckers (m^2)	Stalks (t/ha)	Cabbage (t/ha)	Green leaf (t/ha)	Suckers (t/ha)	Whole crop (t/ha)
1.52	harvested	7.3	2.3	121	5.2	5.4	4.5	136
1.83	mulched	7.1	2.0	115	4.7	5.0	6.9	131
1.83	harvested	6.5	2.2	102	4.6	4.3	9.2	120

Table 5 - Sugarcane harvest nitrogen content

				N content (kg/ha)		
Row spacing	Soy management	Stalks	Cabbage	Green leaf	Suckers	Whole crop
1.52	harvested	59	6	15	9	89
1.83	mulched	81	7	13	13	114
1.83	harvested	34	5	12	13	65

It was thought that the lack of response among the treatments was largely associated with seasonal conditions, in particular a very wet spring, although throughout the growing season there was high unseasonal rainfall, low radiation and low evapotranspiration (not supplied here)j. The over-riding influence of seasonal conditions probably masked any potential treatment (N) effects (Table 5).

The possibility of producing significant differences was also limited by inherent constraints imposed by the design of the previous experiment on the site. These constraints meant that there was only room for two replicates of three treatments, making it necessary for differences to be quite large to be significant.

In addition, during harvest there was indiscriminate compaction which could be attributed to a number of factors including non-GPS guidance on the harvester and/or haulout vehicle and a miss-match of row spacing with 1.52 m row spacing next to 1.83 m row spacing. The mixture of row spacings increased the difficulty of maintaining the wheel-tracks of harvester and haulout vehicle in the furrow.

This indiscriminate compaction greatly reduced the possibility of obtaining significant differences in terms of water and N movement into the ratoons. Further, it was apparent that the treatments that were imposed would produce their major effects in the plant crop. Thus the Steering Committee decided that the resources would be best used in another fallow period and plant crop where confounding could be minimised.

3.4 Variation to original plan

As N movement in the soil and water was the main focus of the project, the Steering Committee decided to include a wider range of N treatments at the expense of having two different row spacings. Thus, the Committee settled on 1.8 m rows and four N management treatments (Figure 1):

- Treatment 1 - Incorporated soybeans
- Treatment 2 - Incorporated soybeans + fertiliser
- Treatment 3 - Mulched soybeans
- Treatment 4 - Mulched soybeans + fertiliser

This design also removed the possibility of confounding by other factors and allowed the incorporation of three replications.

With the re-design of the experiment there would be no treatment differences introduced until the end of the soybean phase when the four N management treatments would be imposed. In this way, the fate of N in the soil and water will be measured without concerns with confounding factors such as row spacing, compaction, etc. Further, the removal of row spacing as a variable allowed for a wider range of N treatments to be included.

The team expected that there would be a difference in the water quality effect of incorporated and mulched soybean due to the rate at which the N would be released. It is expected that N mineralisation would occur more quickly when the residue is incorporated. This was demonstrated in the Wet Tropics by Garside and Berthelsen (2004). Under current industry guidelines, fertiliser can be applied in a plant crop after a legume crop (depending on the yield and N content of the legume crop). Incorporation, mulching and fertilising are all accepted practices within the industry and it is a combination of these that were proposed to provide a wider range of Ntreatments. These aim to identify the most suitable combination of legume management and fertiliser N from both a productivity and environmental perspective.

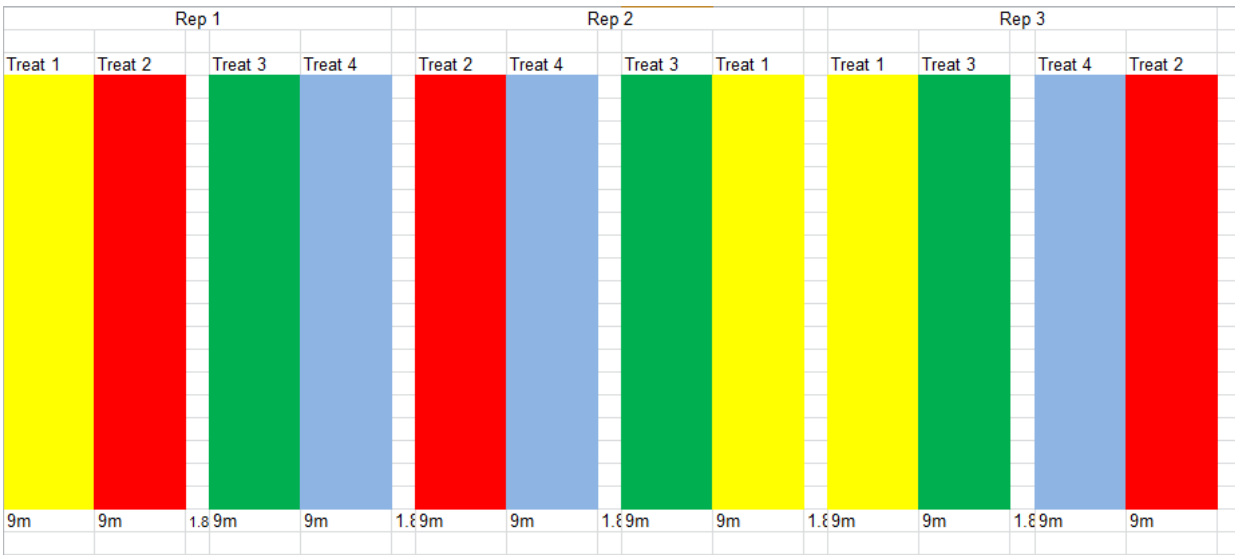

Figure 1 - 1.8 m row spacing option

The variations to the trial plan are detailed in Table 6.

Table 6 – Variation to original plan

Financial Year	Original plan	Proposed plan
09/10	Soybean crop planted Cane planted	Soybean crop planted Cane planted
10/11	Plant cane harvested	Plant cane harvested Ratoon destroyed
11/12	2nd ratoon monitored	Soybean crop planted Cane planted
12/13	2nd ratoon harvested	Plant cane crop harvested

3.5 Second soybean crop

Following the 2011 harvest of the plant crop of sugarcane, the crop was ploughed-out and replanted to soybeans. This crop was still to be harvested when the project was terminated.

Figure 2 – Second soybean crop

3.6 Water-sampling equipment and use

Flumes were obtained from Aquatech Consulting in New South Wales. Five flumes were ordered and received. These five flumes, plus one on hand, meant that there were six flumes available for the trial i.e. one flume per plot.

Soil-solution samplers with Teflon cups were obtained from Prenart Equipment ApS in Denmark. The decision to purchase Teflon cups was made on advice given by Dr Andrew Noble (ACIAR, but formerly with CSIRO). 19 were purchased.

Three portable water samplers (6712 ISCO) were purchased from John Morris Scientific. There are now six portable samplers available for the trial (one per plot).

In the first soybean crop, due to some equipment failure a full data set was not obtained for all irrigation events but water quality samples were taken from each of the irrigation events. The run-off water was analysed for total nitrogen (µg N/L), total filterable N (µg N/L), ammonia (µg N/L), NOX, Particulate N (µg N/L), DON (µg N/L) and Urea-N (µg N/L).

A run-off hydrograph for an irrigation event where all equipment was operating is shown in Figure 3.

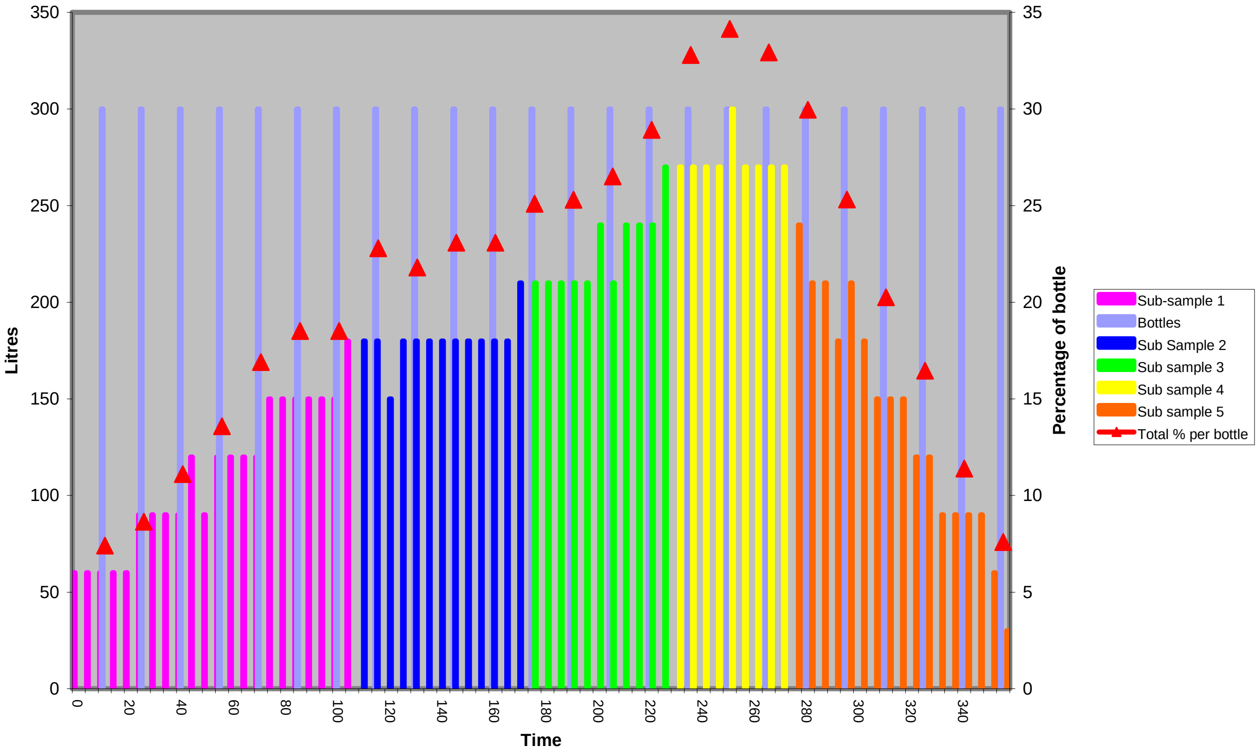

Figure 3 - Runoff hydrograph with auto sampler samples times and percentage of sample weighted for analysis

Figure 3 shows some of the information that was brought together to ensure that the best possible analyses could be done of the water samples that were collected. The bars of varying height that are coloured in pink, dark blue, green, yellow and orange are measurements that are taken from the run-off flume. These bars give an indication of the number of litres of water that have left the three monitored furrows per plot every 5 minutes.

With this information the total flow can be calculated and divided into five sub samples. This means that each sub sample is representative of the same volume of water leaving the paddock. These sub samples are represented in the pink, dark blue, green, yellow and orange bars.

The auto sampler takes a sample every 15 minutes this sampling interval is indicated by the long light blue bars. Along each of the long light blue bars is a red triangle, this indicates the percentage of each bottle that was sent for analysis within the sub sample.

Due to rain the crop was irrigated 3 times in plots 1, 4, 7 and 8, while plots 2, 3, 5 and 6 were irrigated twice. A good data set was obtained in the last irrigation that was monitored. However, due to the lack of data collected it could not be used for statistical analysis.

3.7 Information distribution

The project team established an online blog to assist in getting the trial information out to a wider audience. As activities occurred in the trial, the site was updated and emails were sent to all interested parties.

This blog assisted in maintaining links with researchers and extension. Three groups were targeted: Natural Resource Management Groups, Reef Rescue P2R paddock modelling and monitoring programs, and the Solute Masterclass participants. The blog was highlighted in a Burdekin newsletter to encourage growers to keep track of the project and give feedback.

An article was printed in the February 2010 Burdekin Sugar Notes Newsletter (Appendix A) explaining the main thrust of the project.

3.8 Project Steering Committee

The Steering Committee members were Drs Aaron Davis (ACTFR) and Alan Garside (Agritrop), and Rob Milla (DEEDI), Steve Attard (CSIRO) and Toni Anderson (BSES). As the group met often through the project, the 'older hands' provided excellent mentoring for the younger staff working on the project.

3.9 Solute masterclass

On 13-14 April 2010 Steve Attard, Toni Anderson and Jayson Dowie attended the CRC-IF Solutes Masterclass in Melbourne. Toni Anderson and Jayson Dowie's attendance was funded through a SRDC Travel and Learning grant (BSS336), while Steve Attard was funded through this project.

The course allowed project team members to discuss some of the technical aspects of soil solution sampling. Some of the important points of discussion were:

- Confirmation that the soil solution samplers that have been purchased in the project are the most appropriate for the intended purpose.
- The procedures that are planned for the site are consistent with the procedures that other researchers are implementing. In particular, the multiple lines of evidence for both volume and quality so that one line of evidence can support another.
- Discussions about what the project intends on doing highlighted a number of potential challenges in relation to the depth that this project intends on placing the suction samplers
    - Difficulties may occur in extracting a sample from 1.5 m due to the level of suction that will need to be applied and which may cause equipment failure.
    - Ensuring appropriate levels of soil contact at that depth may be difficult and failure to do so will inhibit solution extraction.
    - Maintenance and upkeep of Teflon cups is close to impossible at a depth of 1.5 m if attached to flexible tubing, as extraction is unheard of.
    - Volume of solution extracted through a soil solution sampler is small and the project team needs to consider that the best method will be to deal with the low volumes that will be extracted (bulking samples and the most important tests required).

The Masterclass did highlight that there is very little expertise within Australia regarding the equipment that is being used in the way for which it is intended. The learnings from the Solutes Masterclass were discussed at a Steering Committee meeting.

4.0 OUTPUTS AND OUTCOMES

The project did not meet its designed outputs and outcomes as it was terminated early.

5.0 RECOMMENDATIONS

We consider that most growers would consider yield and profitability on which to judge the suitability of a farming system, rather than less obvious criteria such as any benefits to water quality. This influenced BSES' decision to terminate the project.

However, water quality remains a focus of government policies, albeit reduced in Queensland with the recent change of government. Understanding water-quality advantages/disadvantages of 'new' farming systems would still be of use in 'selling' the system to growers and the wider community.

Appendix A - Newsletter article

BSES Sugarcane for the future

Burdekin Sugar Notes

February 2010

Ryan Matthews	0427 726 937	Toni Anderson	0427 655 681 (Irrigation)
Jayson Dowie	0427 624 561	Dave Millard	0427 585 419 (QCANESelect™)
Marian Davis	0427 771 845	Cam Whiteing	0417 607 873 (Engineering)
Bill Webb	0418 185 242	Greg Shannon	0408 180 543 (Extension Leader)

Contents

Events Calendar

FPA workshops

Where: BSES Brandon
When:
March: 1, 16 and 29
April: 7, 15 and 26
May: 3 and 12

Contact: Dave 4783 8619
Bookings essential

Soybean Roving Field Tour

Where: Paul Hatch's 441 Mitchell Rd
When: March 5, 7.30 am
Contact:
Mike Hanks 4760 1560 or
Mark Whitten 4760 1585

Understanding water quality in sugarcane farming systems

SRDC has funded a research project led by BSES Limited looking at the water quality impacts of different destruction methods of a legume cover crop and controlled traffic minimum tillage vs. conventional.

The objectives of the project are:

1 - Evaluate the effect of the new sugarcane farming system on soil physical properties and the influence on water quality.

2 - Determine the N loss mechanisms for leguminous nitrogen in the new sugarcane farming system and their impact on water quality.

BSES is collaborating with CSIRO, DEEDI, Agritrop and ACTFR throughout the three-year term of this project. Each participating organisation provides different skills, experience and knowledge to ensure that this project is a success.

So far in the project:

- The previous sugarcane crop was harvested green and the ratooning crop was sprayed out with glyphosate.
- Soybeans were planted through the trash, directly into the undisturbed existing beds.

Stay tuned for further updates on our newest research project.

Left: Planting beans into trash December 2009.

Below: Toni in the bean crop February 2010.

BSES Limited - Burdekin
Postal Address - PO Box 117 / Ayr / QLD 4807
Street Address - Bruce Highway / Brandon / QLD 4808
Phone - 07 4782 5455
Fax - 07 4782 5487
bses.org.au