SRDC Grower Group Innovation Project
Final Report

SRDC project number:	Grower Group Innovation Project GGP032
Project title:	The operation of the Two-in-One harvesting attachment in a controlled traffic system.
Group name:	Castellani Harvesting group
Contact person:	Elio Castellani MS 102 Ingham Qld 4850
Due date for report:	1st May 2009
Funding Statement:	This project was conducted by the Castellani Harvesting Group in association with the Sugar Research and Development Corporation (SRDC). SRDC invests funds for sugar R&D derived from the sugar industry and the Australian Government.

Australian Government
Sugar Research and Development Corporation

The Castellani Harvesting Group is not a partner, joint venturer, employee or agent of SRDC and has no authority to legally bind SRDC, in any publication of substantive details or results of this Project.

Executive Summary:
(An overview of the aim, conduct, key results and learnings from the project. Maximum 500 words)

The project has developed an automatic base cutter system to assist harvester operators utilising the Two in One harvesting attachment.

The trial results have proven that the Two in One system offers:

- The potential to reduce operator fatigue.
- Reduce in-field compaction and operate under a 1.85 controlled traffic system.
- Significant costs reductions associated with reduced maintenance and fuel cost.
- Units operate at lower operational speeds and significant increases in field operational efficiencies; compared to single row harvesters.

The sugarcane industry is one of the only remaining mechanised industries that harvests it crop as a single row. Most other industries have moved to wide swath harvesting to improve harvesting efficiencies and reduce costs. The Two in One concept is the first step towards wide swath harvesting in the Australian sugar cane industry. The Two on One is the only commercially available cane harvesting system available to the sugar industry globally, at this point in time.

Background:
(Why did you need to do this project?)
The Two in One harvester attachment was designed to be fitted to harvesters to maximise throughput in low yielding crops. It was soon adapted by harvester operators to harvest larger crops of cane in the Herbert region.

The Two in One works on the principle that it cuts the second row of cane and presents it to the harvester just as the first row in front of the harvester is taken into the harvester. Nine units were sold and fitted to harvesters in Australia and a number of units were exported overseas.

Harvester operators in the Australian sugar industry manually control all operations of the harvester, including base cutter height. Harvesting two rows at once makes it difficult to correctly judge the correct base cutter height. As a result, the base cutter level can be set too deep, and collect dirt along with the cane, as well as remove cane stools.

The Two in One controlled traffic harvesting system reduces the number of passes required in the paddock to harvest the crop, reducing compaction. Compaction negatively impacts the ratooning ability of a sugar cane crop.

Tools like an automatic base cutter height sensoring equipment could assist the harvester driver, especially with harvesters fitted with a Two in One attachment.

The Two in One unit owned and operated by Elio Castallani is a permanent fixture to the harvester since its installation 6 years ago. The unit has been used to harvest crops in excess up to 150 tcph, under varying conditions.

Currently, two, Two in One units operate in the Herbert region.

Aims:
(Include the Aim and the expected benefits that were listed in Section 2 of your original Application)

- To address the issue of base cutter height control in a controlled traffic two in one harvesting system.

- Harvesting two rows at once makes it difficult to judge correct base cutter height. Base cutters can be set too low, removing dirt along with cane. Floating base cutter system will address this issue.
- Technology addresses issues in the Regional Futures KPI, by promoting two in one harvesting units and floating base cutters in a controlled traffic system.
- Floating base cutter system will reduce soil removal and nutrient loss from the paddock .

Skills required of group members will be developed through technology demonstration and analysis of data collected from field measurements, as well as communication / mentoring with the growers and harvester operators.

Methodology:
(How was the project conducted?)

Prior to the commencement of the project a literature review concerning automatic base cutter systems, especially controlling a double row harvesting system was undertaken.

It was reported that there had been many attempts to develop automatic base cutter systems (Searcy and Coble, 1985; Wright and Simoneaux, 1998; Page and Wood, 2000; Neves et al., 2001; Manechini et al., 2005), but the difficulty to measure effectively the base cut height in the varying surface of a cane row, concluded that many of those systems remained as prototypes and/or only work under specific crop conditions.

Di Bella, 2007 reported that in Brazil at present John Deere/ CAMECO, Case, Techagro and CTC have commercial automatic base cutter systems in operation throughout the industry. These systems appear to be well accepted and adopted throughout out the Brazilian sugar industry.

There were no reports found which addressed the issue of automatic base cutter height control systems fitted to double row harvesters and Two in One units.

For this project it was decided to engage Techagro to install the automatic base cutter system to the Two in One harvesting unit.

On the 25th August 2007it was decided to install sensors and an onboard computer to measure variations in the hydraulic pressures within the harvester and to assist in the development of mathematical algorithms to operate the on board computer on the harvester fitted with the Two in One attachment.

It was decided to study the variations of the base cut disc pressure, both in the main system, as well in the second system of the Two in One, with the main objective to appreciate the relative variations of one system in relation to the other.

Pressure transducers were connected in both systems. Both sensors used were GEMS 0-5 v output and 0-3000 psi measurement range. Sensors were connected in the hydrometer of both base cut systems.

The output of the sensors were connected to an AGM 200- an On Board Computer (figure 1), and recorded in a Compact Flash card during 3 weeks.

Figure 1 shows the on-board computer installed in the harvester.

Figure 2 shows the variation in base cut disc pressures in normal quality soils and it is plant cane or young ratoons.

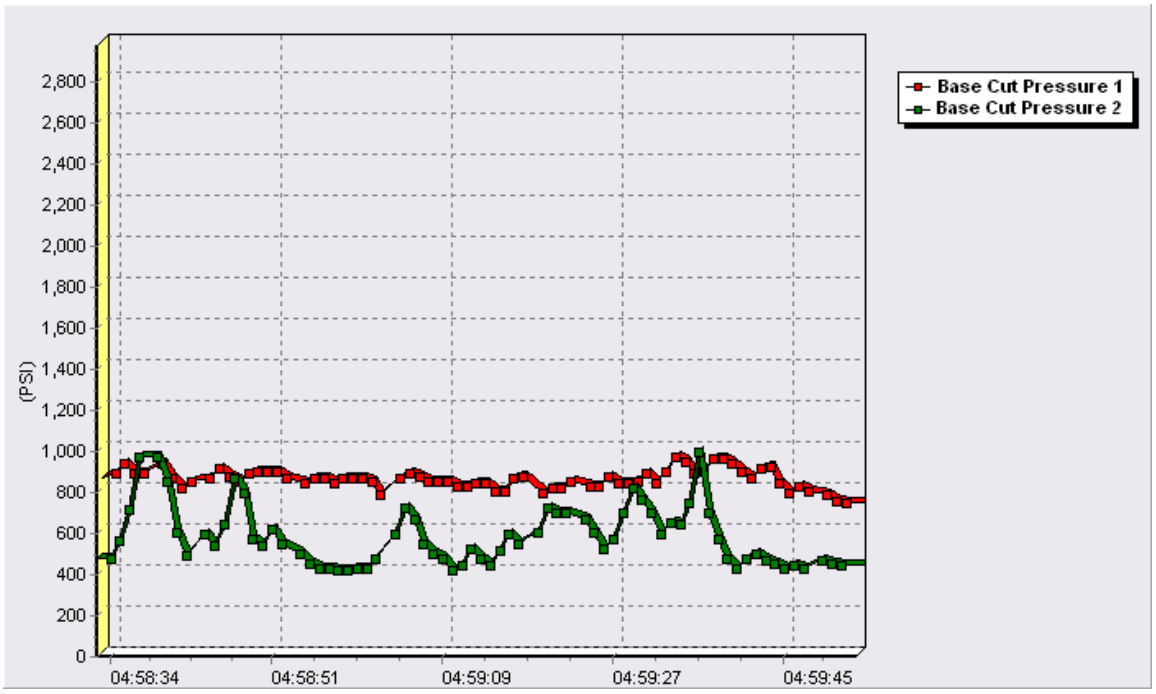


Figure 2. Variation in base cut disc pressures – normal cane/soil conditions

In this case secondary base cut system show lower average pressures, due to the cane that is cut by the secondary system goes to the primary one and put an additional pressure on the system. The pressures of the main system are more stable than the Two in One system.

Figure 3 show the variations in base cut disc pressures, when the harvester is cutting in hard soils and/or older ratoons.

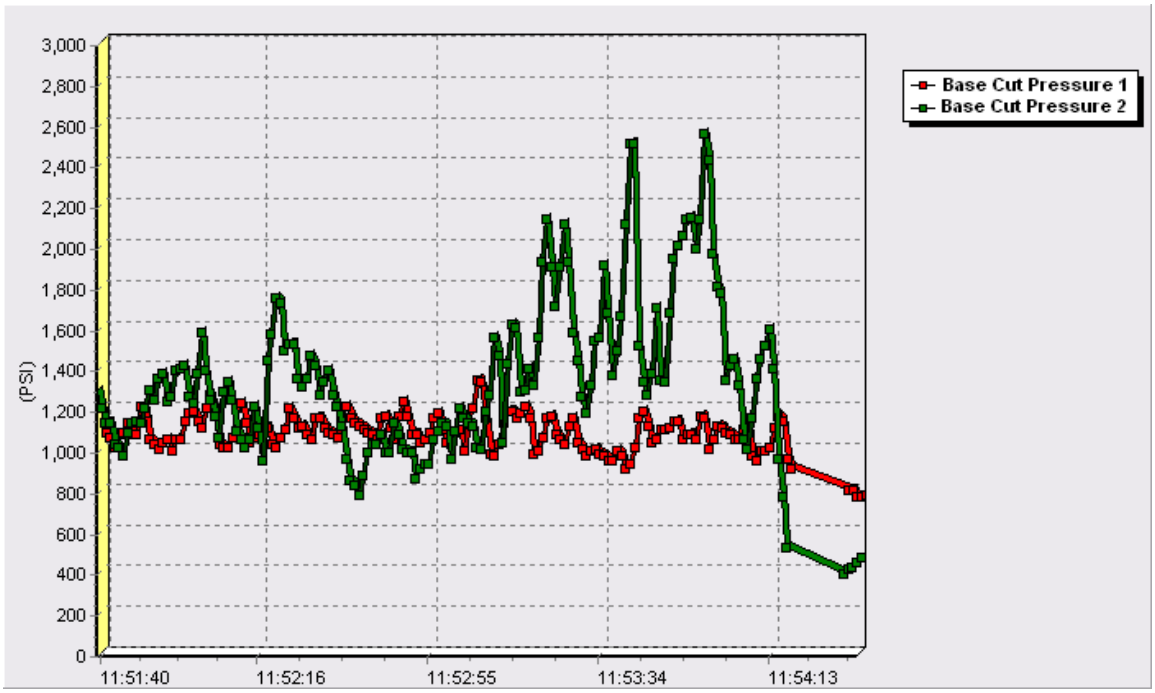


Figure 3. Variation in base cut disc pressures – hard cane/soil conditions

When the soil/plant conditions required more effort for the secondary base cut system, pressures increase over the primary base cut system, and show more instability with high pressure spikes.

Analysing the variations of both pressures in different soil/plant conditions, pressure settings allowed the algorithm for the dual base cut system control to be established.

For the primary system the range of base cut pressures form the minimal base cut pressure is 350-400 psi, while for the secondary system the range is 500-600 psi.

The hydraulic spiking issue needed to be resolved because it caused the automatic base cutter system to lift when underload causing cane pickup losses or ratooning failure associated will cutting the cane stool out. The hydraulic spiking also caused issues with hydraulic component failure.

In September 2007 installation of the automatic base cutter system to the harvester and development mathematical algorithms to operate the on board computer and automatic base cutter system were completed.

The present technical solution includes the development of a dual base cut height control system, which integrates a single on board computer, the automatic control both of the main base cut system and the Two in One attachment.

Figure 4. Hardware components in the harvester

The installed basic hardware consisted of a central processing unit AGM-200a, integrated by microcontroller system, with 8 digital inputs, 4 digital outputs, 4 analogical inputs, 1 analogical output, a GPS satellite positioning system and support for data storage by a Compact Flash (CF) digital card. It has a LCD digital screen and a membrane keyboard.

Pressure sensors that record the pressure at the base cut discs were installed both in the primary base cut system on the harvester, as well as the secondary base cut system and the Two in One device. Refer to figure 5.

Figure 5. Sensors installed on the Two in One unit.

Embedded firmware for the Dual BCS was developed to perform the simultaneous control of the two base cut systems. A simple menu driven software allows for setting up separately the operation parameters for each base cut system (primary or secondary). Minimal and range of base cut pressures are initially set up. Up to three settings can be saved for different field conditions, shifting from one to another with a single button touch.

When the system is operating in automatic mode, the operator can assess the results of the base cut system and adjust it on the go, according to the desired result. To shift from manual to automatic mode, is a single button touch, or pull up or down on the joystick is required.

In September 2007 Techagro Pacific personnel provided introductory operator training to Elio Castallani.

On the 23rd October 2007 “fine tuning” of the automatic base cutter height system was conducted and field testing of the unit in 1.64 and 1.85m row configurations was assessed. Refer to figures 6 and 7.

Figure 6. Assessment of the ground job while in automatic function.

Figure 7. The Two in One unit harvesting 1.64m rows

On the 24th and 25th October 2007 a field trial was conducted to assess the performance of the system. Refer to figure 8.

A field was established in 2006 consisting of 3 replicates and 4 treatments. The trial was planted using GPS to ensure row consistency.

Figure 8. Harvesting of a 1.85m treatment in the trial.

The treatments are as follows:

(1) Two in One base cutter system operated manually on a 1.64m row spacing
(2) Two in One base cutter system operated automatically on a 1.64m row spacing
(3) Two in One base cutter system operated manually on a 1.85m (controlled traffic) row spacing
(4) Two in One base cutter system operated automatically on a 1.85m (controlled traffic) row spacing

The following assessments were undertaken or monitored over the period of the project:

- Visually assess for cane pickup losses
- Soil in cane supply levels
- Compaction
- Fuel usage
- Yield differences between treatments
- Benchmarking compared to other harvesters operating within the region.

After the conclusion of the 2007 trials the following issues required further investigation and development:

- Controlling constant base cutter pressures on the Two in One unit. After discussion with hydraulic experts and Techagro staff it is anticipated that the installation of reduction boxes (Figure 9) and a new hydraulic pump (Figure 10) on the Two in One will stabilise base cutter pressures on the Two in One. Refer to figure 3. During this reporting period this issue

was addressed and the modifications have been successful (refer to Figure 9 and 10 for a photograph of the parts installed).

Figure 9- Reduction boxes fitted.

Figure 10- New hydraulic pump fitted.

- Changes to the hydraulic lift mechanisms in relation to the operating plan of the base cutter on the Two in One will be required to reduce the speed of rising and lowering of the unit. This issue was addressed during the reporting period and has proven to be beneficial. (Figure 11 compares new and old hydraulic ram).

Figure 11. Comparing the new and old hydraulic lifting rams.

- Further development is required to perfect the design of the land wheel on the Two in One, because of the changes in topography found within the field. These changes will allow the automatic base cutter system more effectively if these changes are made. This issue was

addressed during the reporting period and has proven to be beneficial. Refer to Figures 12 and 13 for photographs of the new designed land wheels.

Figure 12- Land wheel.

Figure 13- Land wheel.

- Modification of the kicker disc blade holders was undertaken to improve cane flow across the front of the harvester. This modification has proven to be beneficial. Refer to Figure 14-16 for photographs.

Figure 14.

Figure 15.

Figure 16.

- A camera has been installed on the harvester to assist the operator monitor operations (project funding was not used to purchase this item). Refer to figures 17 and 18.

Figure 17-External camera fitted.

Figure 18- Camera screen in the cabin.

It was decided not to purchase auto steer for the harvester at present due to the fact that very few blocks within the harvesting group is planted using GPS and that funds be used to address issues encountered in the 2007 season (this variation was approved by SRDC).

The system was evaluated again in September, 2008 when the 1st ratoon trial was harvested.

Results and Outputs:
(What results were produced by the Project? The results should include data collected, articles or reports written, events held and anything else you see as relevant to the industry. Relevant files including photographs should be provided on a CD.)

Field trial results.

Cane pickup losses

There was no noticeable difference between the automatic and manual treatments for cane pickup losses where the cane was correctly filled in. Refer to figures 20 - 21.

Difficulties were experienced in poorly filled rows; this issue is no different when operating manually. Refer to figures 19-21.

Figure 19. Harvesting of 1.85m rows in automatic function on the Two in One.

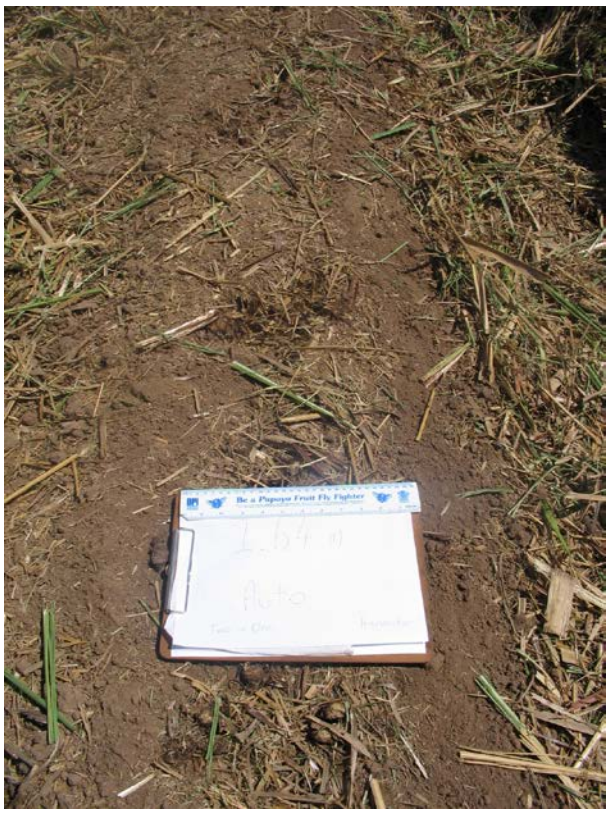


Figure 20. Ground job in a 1.64m row in automatic function.

Figure 21. Ground job in poorly filled in cane.

Crop yield, CCS and monetary return.

The 2007 results are as follows:

TREATMENT		TCPH	CCS	$/HA
1.64m Auto On		111.6	16	2319.95
1.64m Auto On		105.9	15.6	2104
1.64m Auto On		95.4	16.1	2003.62
1.64m Manual		104.6	16.1	2197.95
1.64m Manual		104.6	16.1	2197.95
Average 1.64m		**104.42**	**15.98**	**2164.694**
1.85m Auto On		106	16.5	2322.16
1.85m Auto On		104	15.4	2019.57
1.85m Auto On		116.2	15.8	2361.43
1.85m Manual		106	16.2	2250.59
1.85m Manual		111.8	16.1	2348
Average 1.85m		**108.8**	**16**	**2260.35**

The 2008 results are as follows:

TREATMENT		TCPH	CCS	$/HA
1.64m Auto On		106.0	16.2	2705
1.64m Auto On		104.6	16.9	2867
1.64m Auto On				
1.64m Manual		101.2	16.5	2663
1.64m Manual		106.4	16.8	2888
Average 1.64m		104.55	16.6	2781
1.85m Auto On		105.1	16.55	2782
1.85m Auto On		106.3	16.8	2885
1.85m Auto On				
1.85m Manual		106.5	16.8	2889
1.85m Manual		102.0	16.3	2644
Average 1.85m		104.97	16.6	2800

Figure 22 highlights the yield, CCS and monetary returns from the trial.

The additional benefits of a wider row spacing in relation to harvesting efficiencies are apparent from previous research undertaken by BSES and are applicable to this situation.

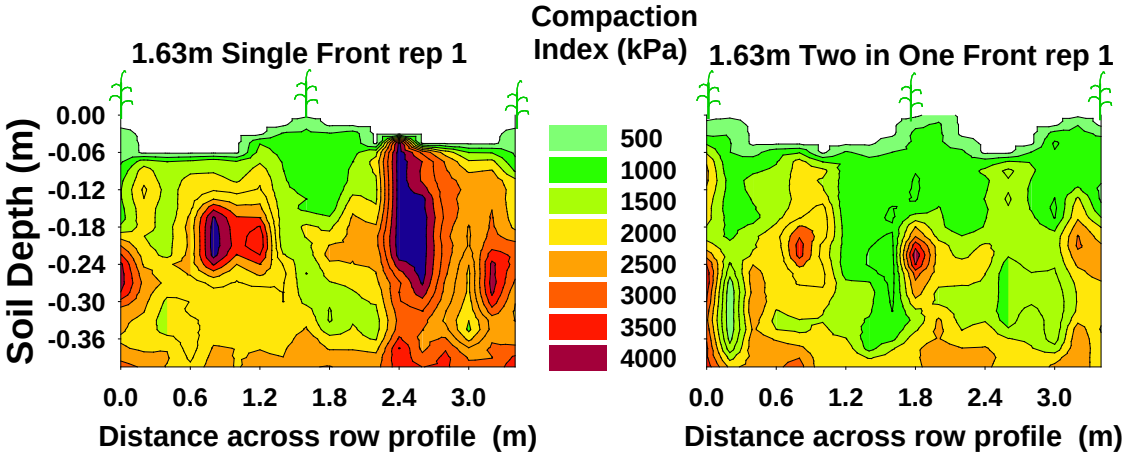
Fibre and ash assessments:
between treatments were measured to determine % soil in cane. The results are as follows:
% soil in cane: 1.00 manual and 1.09 automatic.

Compaction.
BSES staff conducted compaction assessments in the first ratoon crop. The studies highlighted some interesting trends when comparing all treatments. Refer to figure 23.

In the trial the following treatments were assessed:

1. The harvester used as a single row front, in a 1.63m row spacing.
2. The harvester used with the Two in One to harvest 2 rows, in a 1.63m row spacing.
3. The harvester used as a single row unit, in a 1.63m row spacing.
4. The harvester used with the Two in One to harvest 2 rows, in a 1.63m row spacing.

The data shows more compaction (red and blue) under the single front when compared to a two row front, in a 1.63m row spacing.



When comparing a single row front and a two row front on a 1.84m row spacing, higher compaction levels were experienced when cane was harvested on a single row.

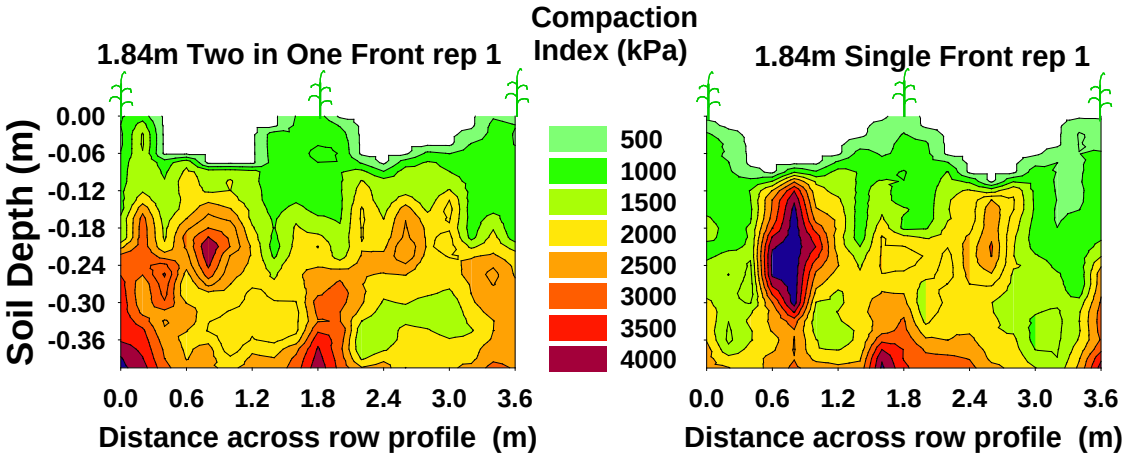


Figure 23. Compaction results from the various treatments

A single row on a 1.63m row spacing experienced the highest amount of compaction when compared to an treatment. This indicates that there significant opportunities offered by harvesting cane on a wider swath when considering compaction issues.

Benchmarking against other harvesters in the region

As part of this project HCPSL staff undertook an analysis of standard harvesters and the Two in One harvesters operating in the same productivity zones and on the same soil types over years. The average of all single row harvesters in the mill area is also included. Refer to figure 24.

Year	2 in 1 Yield (TCPH)	Single Row Yield (TCPH)	Yield Diff	Total All Harvesters Mill Yield Average
2003	81	70.9	10.1	71.1
2004	90	82.3	7.7	82.3
2005	98.4	84.6	13.8	97.3
2006	83.5	68.2	15.3	85
2007	84.5	75	9.5	75

Figure 24. Benchmarking results

The data indicates that the Two in One units are not performing worse than the single row units in relation to cane yield and have no noticeable negative impact on cane yield.

HCPSL data also indicates that the 2, Two in One harvester units operating in the Herbert are operating at the lowest harvester speeds in the region. This attributed to the increased throughput through the harvester. Refer to figure 25.

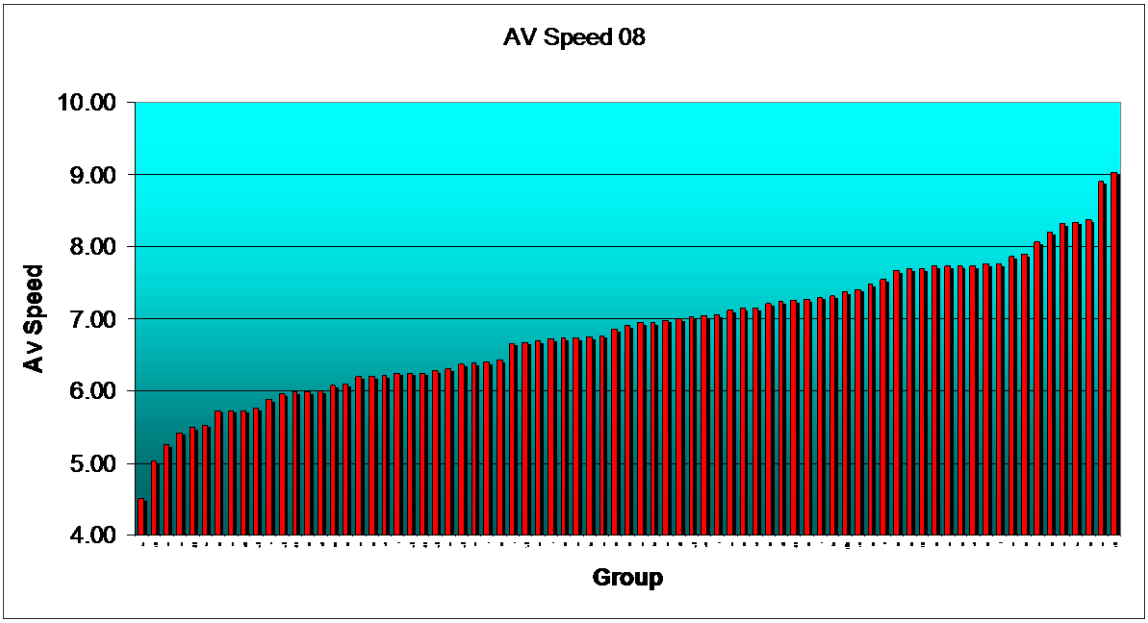


Figure 24. Average speed of harvesters in the Herbert in 2008.

Costs of harvesting between farms.
The table below highlights the average cost of harvesting in the 2007 season for all growers within the harvesting group.

- Farm A- 0.97
- Farm B- 0.81
- Farm C- 0.92
- Farm D- 1.01
- Farm E- 1.136
- Farm F- 1.4

Figures are in litres / ton

The figures indicated that there are significant differences in harvesting costs between farms.

Costs of harvesting when comparing methods.

The table below highlights the average cost of harvesting in the 2007 season for different row configurations for the harvesting group.

- Single row- 1.29
- Two in One (2 rows/ 1 row)- 1.06
- Two in One (2 rows/ 2 rows)- 0.83

Environmental Impact:
(Outline any new information on adverse or beneficial environmental impacts of conducting the Project and/or implementing its findings)

The adoption of a controlled traffic system has significant environmental and soil health benefits. The ability to harvest two rows of cane on a controlled traffic system compared to a single row harvester is that each interspace is traversed one less time by harvesting equipment.

Harvester fuel consumption is significantly lower with the Two in One units operating in the Herbert.

Intellectual Property and Confidentiality:
(If there is any protected Project Technology, eg information that has been kept confidential, such as equipment specifications, patentable knowledge please outline. Is there anything in this report that should be treated as confidential, and if so under what circumstances?)

Techagro will continue to maintain and own the intellectual property of its automatic base cutter system.

Corradini will continue to maintain and own the intellectual property of the Two in One system under patent.

Capacity Building:
(How has the Group's capacity to conduct R&D and implement better farming systems been enhance?)

Outcomes:
(What benefits have been achieved or are expected from the project, and what more has to happen to get the full benefit from the project? How do the expected benefits compare with those predicted at the start of the project, as outlined in the Application?)

The uptake of the Two in One has been gradual within the industry; with those committed to the concept and its use, utilising the unit to its full potential.

Many within the harvesting sector perceive the system as difficult to operate because of the higher operational skills required to operate the unit. It is agreed by most within the sector that automatic base cutter systems and auto-steer will remove some of the "fear factor" and assist in the operation of such a unit.

Many individuals with the harvesting sector and industry view wide swath harvesting as a medium to long term solution to addressing rising harvesting costs.

Due to this project both Two in One harvester units operating in the Herbert are now fitted and operational with Techagro automatic base cutter sensing equipment.

Environmental Impact:
(Outline any adverse or beneficial environmental impacts of conducting the Project and/or implementing its findings)
The adoption of a controlled traffic system has significant environmental and soil health benefits. The ability to harvest two rows of cane on a controlled traffic system compared to a single row harvester is that each interspace is traversed one less time by harvesting equipment.

Harvester fuel consumption is significantly lower with the Two in One units operating in the Herbert, therefore having a low carbon foot print.

Communication and Adoption of Outputs:
(Outline any communication activities that have been conducted and any that are planned. How has SRDC been acknowledged or involved? Have any lessons from the project been applied by members of the Group, or others?)
During the project the following activities were undertaken:

- The local industry harvesting seminar conducted in May, 2008 (50 attended).
- The local industry harvesting seminar conducted in May, 2009 (35 attended).
- A presentation was undertaken at the GIVE 09 in Ingham in March, 2009 (204 attended).
- Local cane productivity meetings conducted in May, 2008 (150 attended)

A second Two in One unit operated by Q&R Harvesting is now being commissioned with an automatic base cutter system. The research findings from this project have greatly assisted with the development of other Two in One unit.

Recommendations:
(What recommendations would you make as a result of the project, including suggestions for further research and development?)

Wider swath harvesting offers the industry opportunities to:

- Reduce or contain costs.
- Reduce in-field compaction.
- Further investigate opportunities to undertake wide swath harvesting by the installation of a second Two in One front on a harvester. Such a unit will have the potential to harvest a 4.5 to 5.5 m swath; increasing the area by 1/3- double the area over current systems operating in the industry.

Publications:
(List and attach copies (electronically if possible) of all articles, newsletters and other publications from the project.)

- GIVE 08 presentation provided to attendants.
- GIVE 09 presentation provided to participants attending.

References cited as apart of the project:

Di Bella, L.P., Sandell, G.R., Klok, J.A., Wood, A.W. and Powell, J. (2005) Opportunities for managing harvesting costs in the Herbert: an evaluation of the Corradini Two in One for costs and cane quality performance. Australian Soc. Sugar Cane Technol., 27: 243-251.

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TechAgro (2002). Automatización de la velocidad de traslación y de la altura de los discos de corte realizada a una cosechadora CASE III. Final Report. TechAgro/São Martinho Mill, Sao Paulo, p. 4.

Acknowledgements
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- CSR Sugar and Tully Sugar for analysis of cane for CCS, fibre and % soil.