

# FINAL REPORT

# PROJECT NSC005

## IMPLEMENTING AN INTEGRATED SUGAR SYSTEM IN NSW



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**Project Title:** Implementing an integrated sugar system in NSW

**SRDC project number:** NSC 005

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## **1. Executive Summary**

The New South Wales Sugar Milling Co-operative's (NSWSMC) move to whole cane harvesting for cogeneration will increase in-field haulout traffic by 30% with the potential for yield decline due to increased soil compaction. Trials were established in all three milling areas of NSW in 2003 comparing various controlled traffic (1.8 m) row spacing/ planting configurations with the conventional 1.5 m configuration. Results obtained for both one and two-year crops are reported. The trial results have indicated the potential for small yield increases and demonstrated that adoption of controlled traffic cropping systems will not result in loss of productivity. These results have given growers confidence that they can adopt a controlled traffic farming system without productivity losses. Although there were generally no major yield differences between the three controlled traffic systems evaluated, it is considered that the dual row configuration is the best option for NSW given the slower canopy closure in the other 1.8 m configurations. In addition, it is possible to zero till dual rows with double disc planting technology but this option is not possible for a wide row configuration. However the construction of the wide throat strip tillage machinery has enabled a reduced tillage option for wide throat plantings.

Further trials were established in 2004 comparing fallow plant with replant to determine the effect of a legume break on the yield of the following cane crop. These trials also included tillage treatments to observe effect on zero-tilling cane through soybean stubble. These trials were established with a stalk planter, with results showing no yield penalty through zero-tilling cane. In 2005 trials were established comparing conventional tillage with zero-tillage using a disc-opener billet planter, similarly results showed no yield penalty from zero-tilling cane through soybean stubble. An economic analysis indicated that by adopting a controlled traffic, reduced tillage, legume fallow system, on a 72ha farm, a grower will improve gross margins by \$12,857 when compared to a conventional system. Variable costs such as fertiliser and fuel are greatly reduced in such a system.

Harvester operator visibility when cutting large two-year old crops green is severely limited due to the increased bulk of cane material so GPS guidance systems ( $\pm 2$  cm) were evaluated in these trials. As a result of these trials the NSW industry has established an RTK GPS base station network, with coverage of all three mill areas. The entire harvesting fleet in Broadwater and Condong have been set up with GPS guidance in readiness for whole-of-crop harvesting, with a number of units being set up on growers' tractors. A total of 60 GPS units are now operating on the NSWSMC base station network.

A large scale extension program was undertaken throughout the life of the project with numerous field days, shed meeting, farm walks being conducted to increase the awareness among growers of the benefits of adopting the new farming system. As a result adoption of controlled traffic farming has increased dramatically since trial work began in NSW 2003. This has been a result of a broad scale extension program advocating the results of the farming systems work along with innovative growers making a successful transition to controlled traffic farming.

## **2. Background**

The NSW Sugar Milling Co-operative Limited (NSWSMC) with joint venture partner Delta Electricity is developing two 30 megawatt (MW), biomass powered power plants at sugar mill sites Condong and Broadwater in northern NSW. The plants will operate 12 months of the year and will be fuelled by cane based fuels, bagasse (the fibrous material left after crushing of the cane stalk for sugar extraction) and cane trash (the leafy material of the green top and the leaf attached to the stalk). Production of electrical energy will result in a net reduction in greenhouse gas production and will reduce and ultimately eliminate in-field pre-harvest cane burning in the region. The two co-generation projects will supply green renewable electricity to 60,000 households.

The move to co-generation and whole of crop harvesting will result in an increased frequency of haul-out traffic resulting in increased crop damage. In addition, the majority of cane in the NSW sugar industry is grown on low lying alluvial flood plains. Harvesting under wet conditions in NSW leads to dramatic yield decline from plant to ratoon crops and is an unsustainable system in large part due to the mis-match of machinery track widths with current row spacings. This necessitates a change in the farming system to incorporate controlled traffic, wider row spacing and permanent cropping beds, with the aid of GPS guidance.

With the current low world sugar prices and the increasing costs of farm inputs like fertilizer and fuel, growers need to farm smarter to remain viable in both the short and long term.

A number of close-row trials (four rows in a 2.1 m bed, high density planting) were established in NSW in 1999 and 2000 and data obtained for plant and ratoon crops (Ensbey, 2000). In reviewing the results of these trials at a 2002 workshop, the NSW industry elected not to adopt high density planting but considered that row spacing trials and evaluation of GPS were a high priority.

In response to the workshop this Sugar Research and Development Corporation (SRDC) funded project (NSC005) commenced in July 2003 with aims of assessing and demonstrating the viability of controlled traffic systems for the NSW industry and implementing a sustainable farming system compatible with the NSWSMC co-generation project. A project steering committee was formed. The role of this group was to evaluate and oversee the implementation of the project and to evaluate project methodology. Two sub-committees were formed from the members in the steering group. The first sub-committee was formed to investigate what equipment would be used to plant the trials. The second sub-committee was formed to investigate GPS guidance equipment that could be used in the project. The steering committee consisted of Agricultural staff from the NSWSMC and the BSES, growers and members of the Sugar Yield Decline Joint Venture.

This final report details the results of field trials comparing 1.5 m single rows with various planting configurations at 1.8 m row spacings (controlled traffic). Results from implementing a combination of zero-tillage planting, controlled traffic and legume fallowing are outlined in the report. The adoption of more sustainable farming systems incorporating the use of GPS by growers in NSW is discussed, with machinery modifications that have been developed to suit the new system outlined.

This project aims to increase the profitability and long term sustainability of the NSW sugar industry which is moving towards utilising the whole cane crop for electricity generation and sugar. This move will require marked changes to the farming system, harvesting, transport and mill operations.

### **3. Objectives**

This project aimed to increase the profitability and long-term sustainability of the NSW sugar industry, which is moving towards utilising the whole-of-cane crop for electricity generation and sugar. This move has required marked changes to the farming system, harvesting, transport and mill operations.

**Objective 1: Assess and demonstrate the viability of alternative cropping systems for the NSW sugar industry that incorporate the principles of controlled traffic/ permanent bed systems bringing about a reduction in crop damage during wet weather harvesting and under the more trafficked field conditions that will occur with whole-of-crop harvesting.**

#### **Achievement**

*An extensive trial program has shown that a controlled traffic farming system has the potential to provide productivity gains and significant benefits in reducing crop damage and soil compaction. Farmers have gained confidence that they can adopt a controlled traffic farming system without productivity losses.*

**Objective 2: Implement a sustainable farming system compatible with the New South Wales Sugar Milling Co-operative (NSWSMC) cogeneration project to maximise sugar and energy production.**

#### **Achievement**

*Thirty percent of farmers in NSW have adopted a proven farming system based on controlled traffic principles. The aim is to achieve fifty per cent of the NSW area planted being managed on a farming systems basis by 2010. Farmers that adopt the new farming system will gain the benefits of reduced compaction under the whole of crop harvesting regime.*

**Objective 3: Identify and extend best management practice for cropping, harvesting and transport systems in the NSW industry compatible with sugar and energy production.**

#### **Achievement**

*A concerted extension effort throughout the project has raised awareness and adoption of the best management practices developed as a part of this project. Results and farmer-developed ideas and practices have been shared with a wide section of the Australian sugar industry.*

## **4. Methodology**

### **4.1 ROW SPACING TRIALS ESTABLISHMENT IN 2003**

Five sites were selected across the three mill areas, Harwood, Broadwater and Condong in NSW. Sites were selected to cover a range of environmental conditions including rainfall, frosting and soil types. Each site was fallowed to soybeans that were harvested for grain in May 2003. The trials were planted in September 2003 and compared conventional 1.5 m single rows with dual rows (2 rows 500 mm apart), wide rows (450 mm wide drill), and single rows planted on 1.8 m row spacing (controlled traffic). The same billet planter was used to plant all trial sites and the wheel centres on the tractor and planter were adjusted to match the respective row spacings. At one site (North, Condong) an additional treatment of dual rows was zero-till planted through soybean stubble into beds using a whole stalk planter with double-disc openers. The bed height in the zero-till treatment was 10cm with all other treatments flat planted. There were two replicate strips of each treatment at each site with either five or six rows in each strip. Before planting, all trials were GPS scribed (+/- 2 cm) using a Trimble GPS system.

A range of knock down and pre emergent herbicides were used across the different sites providing good weed control. All sites were fertilised at planting with DAP (18% N, 20% P, 2% S) and subsequently side dressed with urea (46% N) at rates based on individual soil test results.

The Condong site was harvested as a one-year crop as the majority of the cane in the area is harvested at one year old. In the Broadwater and Harwood mill areas crops are harvested as both one and two-year crops, and trial sites were established to obtain one and two-year data (Table 1). Varieties were chosen for their suitability to local environment and soil type.

**Table 1.** Cane age at harvest and variety at each site.

<b>Site</b>	<b>Crop age (years)</b>	<b>Variety</b>
North (Condong)	1	BN81-1394
Clarke (Broadwater)	1	BN81-1394
Clarke (Broadwater)	2	BN81-1394
Hirst (Harwood)	1	Q-136
Mill Farm (Harwood)	2	Arris

After crop establishment, three permanent 10 metre lengths of row were marked out in each plot for shoot and stalk counts. Shoot numbers were recorded at monthly intervals until crop lodging prevented stalk counts from being carried out.

Yield data were collected by mechanically harvesting and weighing each row of the plot. Only data from the middle three (five row strips) or four (six row strips) rows were used for analysis. CCS sampling was carried out prior to harvest by whole stalk sampling and small mill analysis. Commercial CCS was also obtained for each replicate strip.

Each trial was cut green with the same harvester fitted with GPS (+/- 2 cm) to evaluate whole of crop harvesting.

## 4.2 FALLOW TILLAGE TRIALS ESTABLISHED IN 2004

Four trials were planted in the three mill areas in September, October and November. Trial sites were established at Kevin Twohill's on the Tweed, Jim Sneesby's (Photo 1) and Jim Walsh's in Broadwater and on the Mill Farm in Harwood. These trials compared Plough Out/Replant (PO/RP) systems with fallow plant systems. Different pre-plant tillage systems and planting systems were used. All trials are well established except for the Condong trial which was planted in November and the cane was slow to get away. Planting at all sites was delayed due to the dry conditions. The Harwood mill farm site and Walsh's site at Broadwater were watered. Planting in Condong was delayed further by wet conditions.

One year old trials were set up at Kevin Twohill's in the Condong mill area, Jim Sneesby's in the Broadwater mill area and on the mill farm at Harwood. All treatments in these trials are dual rows on 1.8m spacings. A two year old site was planted at Jim Walsh's in Broadwater. This trial was harvested as plant two year old in 2006.

The three pre-plant tillage techniques included in this trial are zero tillage, zonal tillage and conventional tillage. The zero-tillage treatment involved the use of disc-opener planter that direct drilled sets through soybean stubble. This technique has many advantages including a reduction in land preparation costs, soil moisture conservation and improved soil structure and numbers of beneficial soil micro-organisms. Zonal tillage involves only working the area where cane is to be planted, with the benefits of a reduction in land preparation costs. These treatments are compared with the standard conventional cultivation methods.

The BSES double-disc opener dual row stick planter was used at each site for the zero-till planting treatments. There was an excellent strike at each trial site where we have direct drilled cane into the soybean stubble. A limited amount of choke ups were experienced. The reason this planter has caused so much trouble in the past is because of trash build up around the disc. This creates a resistance for the ground driven disc and choke ups are the result. When we were planting with this planter we spun the disc so they were free from trash after every row. I think this has to be considered in the construction of a precision disc-opener billet planter.



Photo 1. Plough Out/Replant (left) versus fallow plant (right) at Jim Sneesby's trial site at Broadwater.

### **4.3 TILLAGE TRIALS ESTABLISHED IN 2005**

In Spring 2005 trial sites were established in Broadwater and Harwood mill areas comparing zero-till planted cane with cane planted into conventionally tilled ground. These trials aimed to compare the economics of both systems, assess productivity and to demonstrate the robustness of a zero-tillage farming system. In Broadwater a trial site was established at Tom Walsh's and in Harwood a site was established at Alan Munro's property (Photo 2).



Photo 2: Shows the two tillage treatments, conventional till (left) and zero-till (right) at Munro's trial site (Woodford Island, Harwood mill area).

This trial work was the first time cane had been zero-tilled using disc-opener type billet planters in NSW, and as expected there were a number of teething problems. Issues that were faced when planting in 2005 included, soil break-out in heavy soils when using discs, billet blockages in the chute of the planter, getting an even feed with trashy cane and steering the planter in a straight line. However, subsequent measurements (eg millable stalk counts) indicated good establishment at the trial sites. Some of these issues were addressed when members of the steering committee visited growers in QLD whilst at the 2006 GIVE day held in the Burdekin.

## **5. Results**

### **5.1 2003 ESTABLISHED TRIALS**

#### **SHOOT DENSITY**

The effect of row spacing and planting arrangement on shoot density at two sites is shown in Figure 1. At both sites 1.8 m dual rows generally had the highest shoot/stalk density with 1.5 m single rows having the second highest density for both varieties. For a given site, all treatments tended to reach a peak shoot density at the same time.

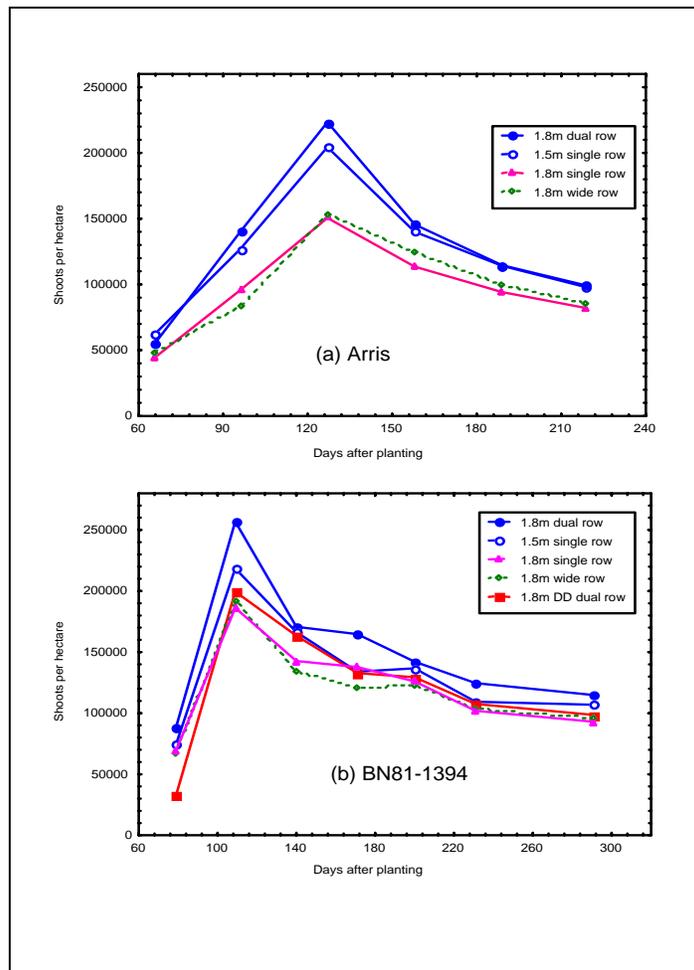


Figure 1. Effect of row spacing and planting configuration on shoot density at various times after planting for (a) Arris (Mill farm, Harwood) and (b) BN81-1394 (North, Condong) varieties.

The relative levels of 'crowd out' between dual rows and conventional single rows was not markedly different (Figure 1) and this contrasts with the large 'crowd out' effects previously recorded for close row spacings (HDP) in NSW (Ensbe, 2000).

## YIELD AND CCS

As found previously for other row spacing trials in NSW (Ensbeys, 2000), there was no significant effect of row spacing or planting configuration on CCS at any of the trial sites in this study (data not shown).

Table 2. Effect of row spacing and planting configuration on cane yield (t/ha) at each site.

Crop class	Site	Row spacing/planting configuration					LSD (P<0.05)
		1.8 m dual row	1.8 m single	1.8 m wide	1.8 m dual row zero till	1.5 m single	
Plant 1 year old	North (Cnd)	129.4	119.1	124.5	125.2	120.6	NS
	Clarke (Bwt)	85.3	78.5	80.4	-	79.2	NS
	Hirst (Hwd)	91.6	88.9	90.6	-	85.4	NS
	Combined sites	102.1	95.8	98.2	-	95.1	4.5
Plant 2 years old	Clarke (Bwt)	154.8	142.8	154.1	-	146.0	8.7
	Mill farm (Hwd)	221.7	220.5	203.9	-	204.4	NS
1 <sup>st</sup> ratoon 1 year old	North (Cnd)	123.9	119.0	122.8	120.9	103.6	NS
	Hirst (Hwd)	114.3	103.9	109.3	-	101.8	NS
	Combined sites	119.1	111.4	116.1	-	102.7	14.5
1 <sup>st</sup> ratoon 2 year old	Clarke's ( Bwt)	159.4	148.4	161.7	-	151.8	NS
	Mill Farm (Cnd)	112.5	108.8	109.8	-	109.9	NS
2 <sup>nd</sup> ratoon 1 year old	North (Cnd)	113.0	114.7	115.9	114.0	96.7	NS
	Hirst (Hwd)	58.2	58.9	54.8	-	54.0	NS
3 <sup>rd</sup> ratoon 1 year old	Hirst (Hwd)	80.3	78.3	83.9	-	81.5	NS

Although there were no significant ( $P<0.05$ ) treatment effects at individual sites for one- year-old plant cane, the dual row treatment resulted in the highest yield at each site (Table 2) with yields around 7% higher than the conventional planting arrangement of 1.5 m single rows. At two of these year-old plant cane sites the 1.8 m single rows had the lowest yield. An analysis of combined data across the three year-old plant cane sites indicated significant ( $P<0.001$ ) treatment and site effects but no significant site by treatment interaction. For the combined dataset the dual row plant cane yielded significantly higher than either of the single row treatments (Table 2). In general, these yield trends were continued in the 1<sup>st</sup> and 2<sup>nd</sup> ratoon crops. That the trend for higher yield from dual row 1.8 m treatments has been maintained into 2<sup>nd</sup> ratoon crops has given the NSW industry encouragement and is in contrast to the results from earlier HDP trials in which the yields from 2<sup>nd</sup> ratoon close-row treatments declined markedly. The yields for each trial are represented graphically in Figures 2 and 3.

Of particular relevance to the NSW industry are the results for two-year-old plant cane, with a significant ( $P<0.05$ ) yield response (Clarke site) and a trend for increased yield (Mill farm) from 1.8 m dual rows compared to conventional 1.5 m rows. Based on these results the NSW industry is confident that adoption of controlled traffic involving dual rows on 1.8 m spacing will not result in any productivity loss and the yield trends obtained (Table 2) suggest a potential for small productivity gains of around 6 to 16%.

Across all sites and crop classes the average yield of dual rows (1.8 m) was 10% higher than that of conventional 1.5 m single rows. Yields from either 1.8 m single rows or 1.8 m wide rows were not significantly different from conventional 1.5 m single rows at any of the sites (Table 2) and averaged (all sites) 6% and 7%, respectively, higher than 1.5 m single rows. Although 1.8 m single and wide rows had somewhat lower stalk densities than 1.5 m rows (Figure 1), the absence of significant yield differences is in agreement with the work of Garside et al. (2004, 2005) who found that sugarcane can produce similar yields over a range of stalk densities. Single or wide row planting at 1.8 m tends to result in slower canopy closure compared to dual rows in NSW presenting problems with weed control and increased susceptibility to frost damage.

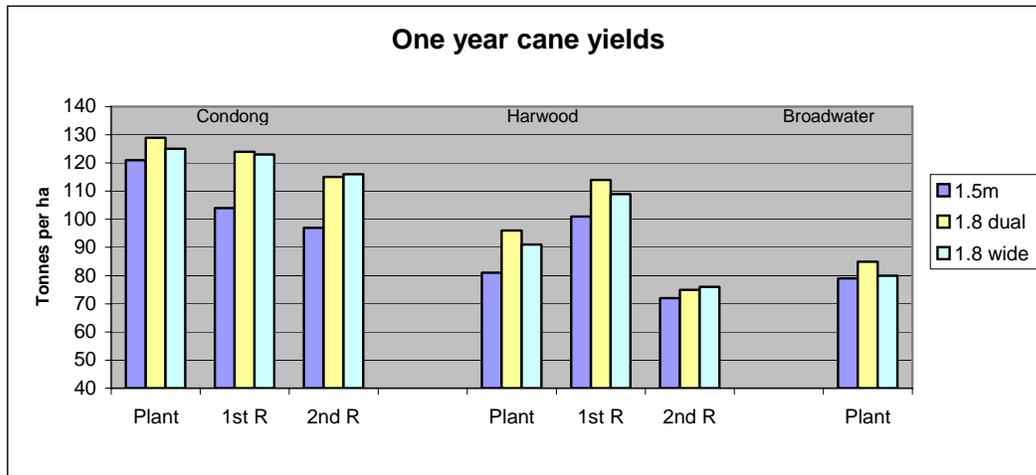


Figure 2: One year old cane data for Harwood, Broadwater and Condong.

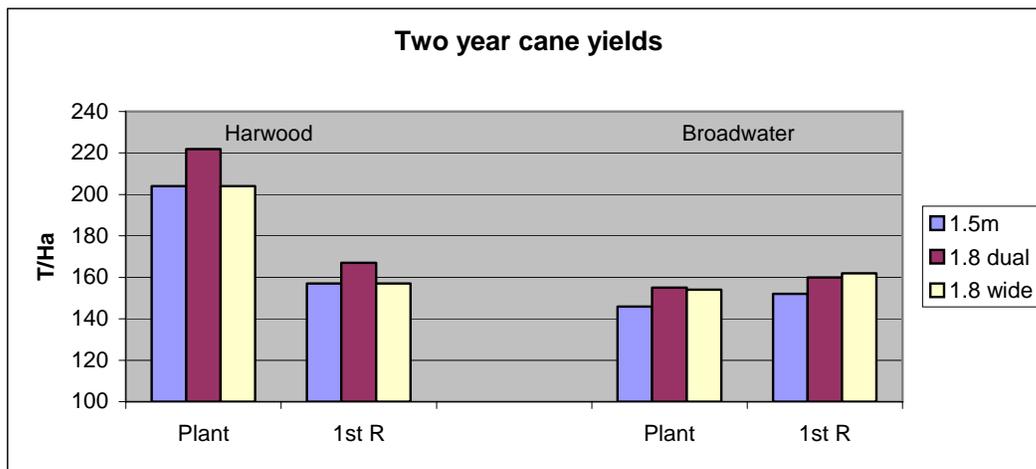


Figure 3: Two year old cane data for Harwood, Broadwater and Condong.

Cane yield from the zero till dual row planting at North's site was not significantly different from conventionally (billet) planted dual rows in the plant and ratoon crops. This result has been supported by subsequent trials evaluating zero till cane planting in NSW and highlights the potential for this cost saving approach (North et al., 2007).

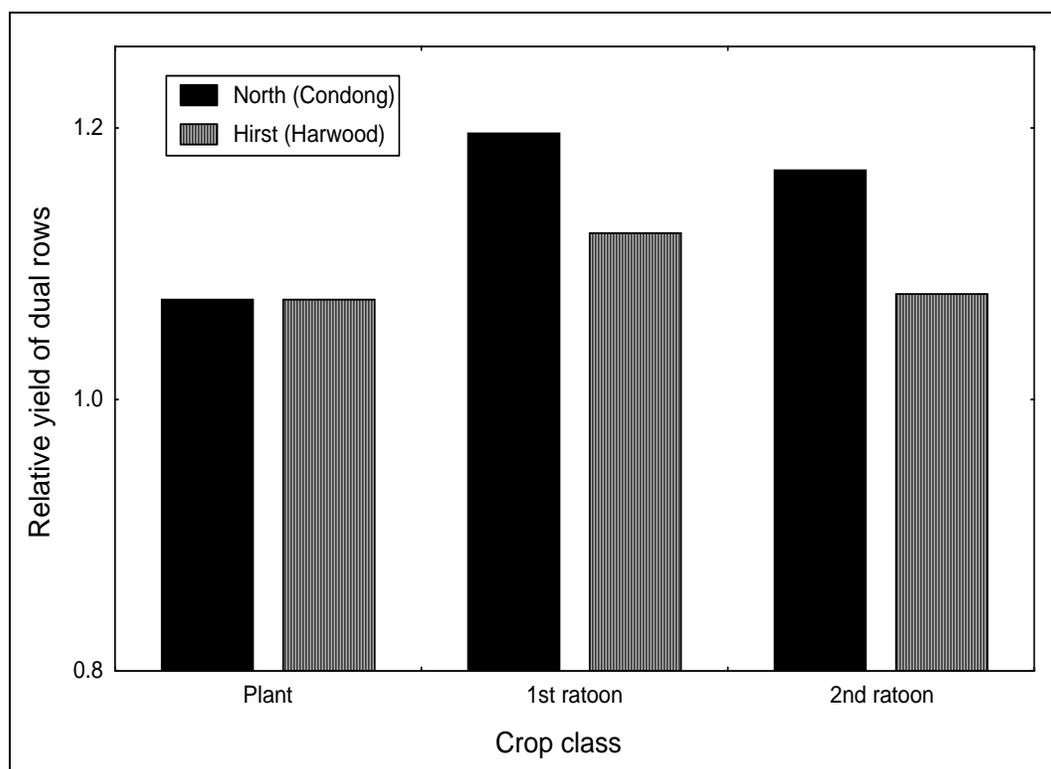


Figure 4. Relative yield of dual rows for each crop class at two sites.

All harvests for these trials occurred during times of relatively dry ground conditions and the controlled traffic systems have yet to be evaluated under wet harvesting. However, if compaction was having a larger impact on yield in the conventional (1.5 m) system then the relative performance of 1.8 m dual rows would be expected to increase in the ratoon crops. The relative yield of dual rows (yield of dual row treatment/yield of 1.5 m single row treatment) for each crop class at two sites is shown in Figure 4. At North's site there is a clear trend for an increase in the relative yield of dual rows in ratoon crops. There was also an increase in the relative yield of duals in the first ratoon crop at Hirst's site. The lack of any substantial difference in relative yield between the plant and second ratoon crops at the Hirst site is attributed to the heavy frost damage to the second ratoon crop (reflected in the lower second ratoon cane yield of all treatments).

## 5.2 2004 ESTABLISHED TRAILS FALLOW / TILLAGE TRIALS

These trials aim to put a dollar figure on the advantages of fallowing paddocks with a legume crop, the benefits of reduced tillage planting and comparing cane planted on mounds and on the flat.

Table 3. Effect of farming system on cane yield (t/ha) at each site.

		Planting Configuration						Replant
		Fallow Plant						
		Beds		Flat				
		Zonal-Tillage	Zero-Tillage	Zonal Tillage	Zero-Tillage	Conv-Tillage		
Crop Class	Site							
Plant 1 Year Old	Twohill (Condong)	117	125	108	111	111	123	
	Sneesby (B'water)	147	149	151	150	161	143	
	Mill Farm (Harwood)	119	128	113	117	123	101	
Plant 2 Year Old	Walsh (B'water)	140	141	138	142	141	129	
1st Ratoon 1 Year Old	Twohill (Condong)	121	133	117	119	119	126	
	Mill Farm (Harwood)	86	108	87	94	89	78	

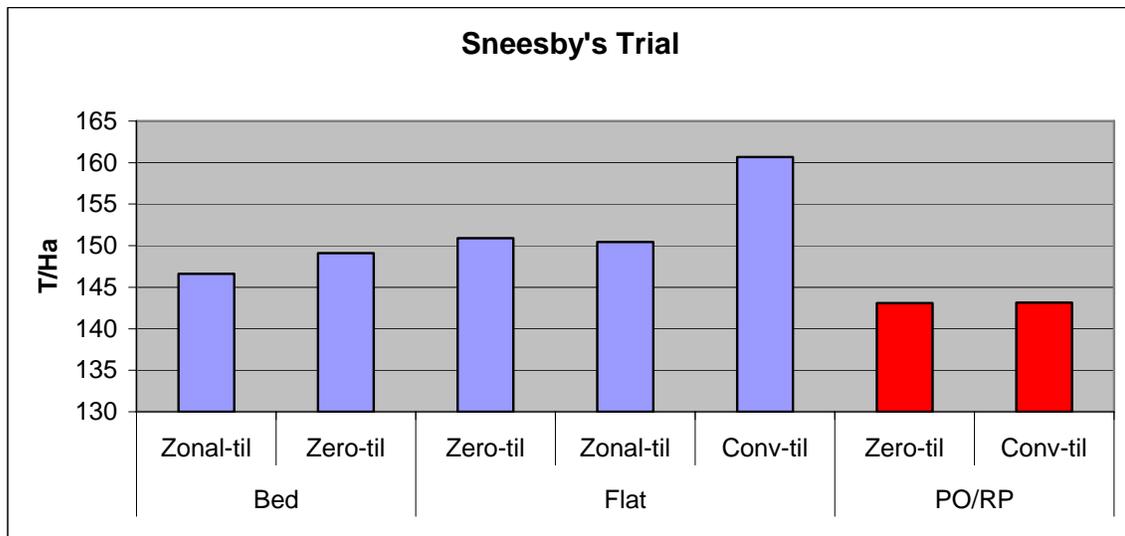


Figure 5: Yield results gained from Sneesby's tillage trial in Broadwater. Variety BN81-1394

At Sneesby's site (Table 3 & Figure 5) all soybean fallow treatments out yielded the plough out replant (PO/RP) section of the trial. Overall the conventional tillage fallow treatment performed the best with a yield advantage of 13% over the PO/RP treatments. The flat planted zero and zonal tillage treatments performed slightly better than the same treatments planted on beds. This is possibly due to the drier than normal start to the growing season in 2005.

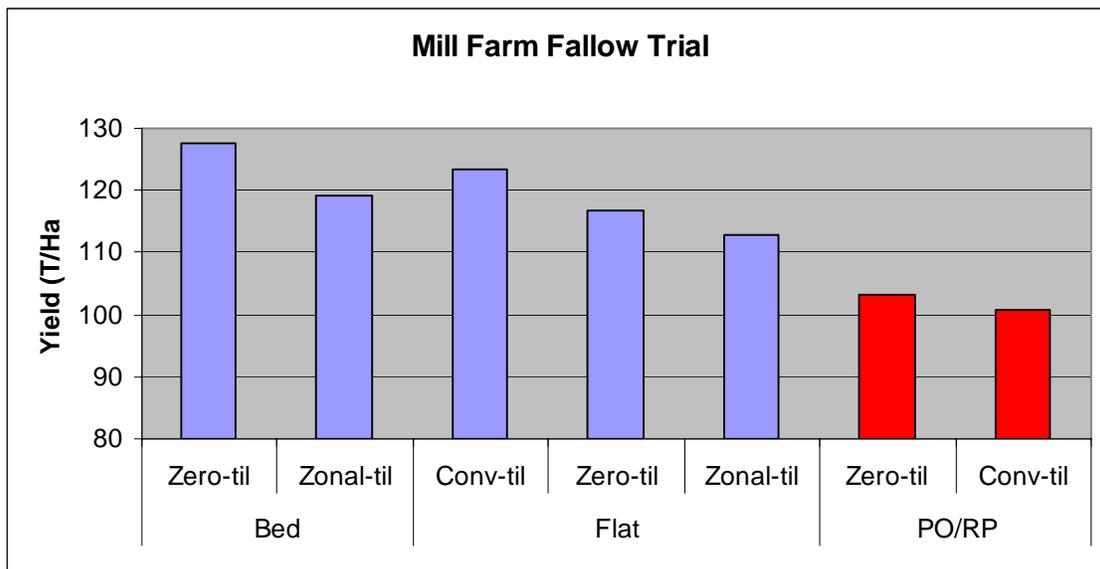


Figure 6: Tillage trial yield results from the Harwood mill farm. Variety Concord

Like Sneesby's trial, all the fallow treatments at the Harwood mill farm site (Figure 6) out yielded the PO/RP treatments. The zero tillage system grown on beds was the highest yielder in this trial and had a 26% yield advantage over the conventional tillage replant system. The flat planted zero tillage treatment also performed well having a 16% increase in yield over the conventional system. Similarly the 1<sup>st</sup> ratoon 1 year old harvest data shows that all fallow treatments out yielded the replant section by an average of 19%. This aligns with work carried by the SYDJV who showed that yield increases from fallowing carried over into ratoon crops.

This site has shown a high yield response to fallowing indicating that soybean fallowing can improve soil health, by reducing the number of undesirable nematodes, increasing the number of beneficial soil organisms and providing the soil with nitrogen. A reduced rate of nitrogen was applied onto the fallow treatments at each site to compensate for the soybeans contribution.

This is a very promising result for the zero-tillage treatments as there is a considerable amount of savings to be made by adopting such a system and if yields gains can be made it makes for a very attractive system.

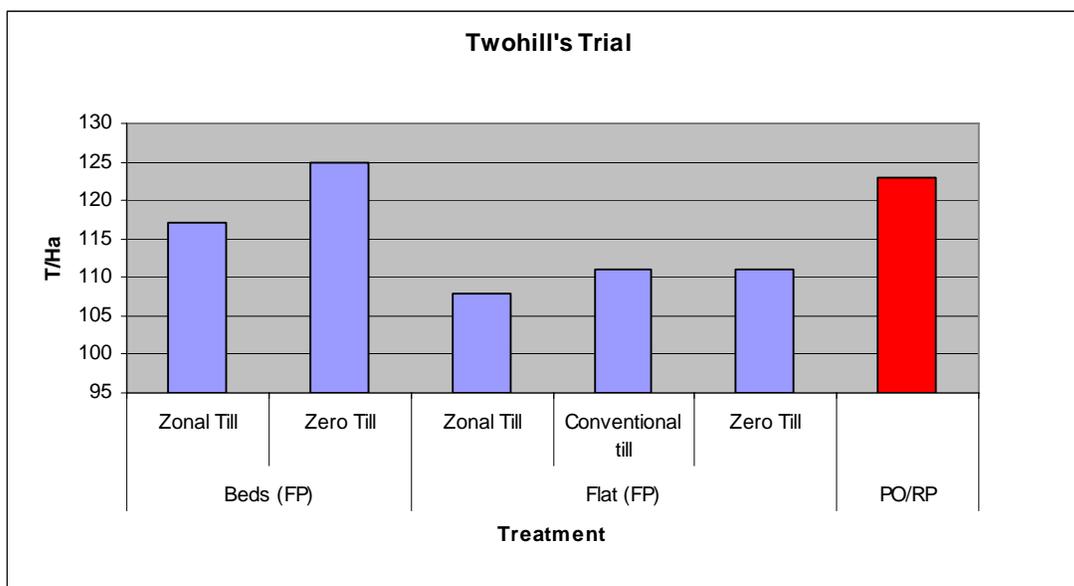


Figure 7: Yield results from Twohill's tillage trial in Condong. Variety Q-193

Considering the very late plant (November 2004) the tillage trial at Twohill's has yielded surprisingly well (Figure 7). The zero tillage treatment on mounds performed the best at this site yielding 125t/ha. The PO/RP section yielded high at 123t/ha. Unfortunately this trial was not replicated and the PO/RP treatment was located on the edge of the paddock where yields have been traditionally higher. This may explain this unusual result.

The high yields associated with the replant section of Twohill's trial are in contrast to Sneesby's site and the Harwood mill farm site where all fallow treatments yield higher than the replant sections. The cane that was planted onto the beds has out-yielded the cane that was planted into a flat profile. In both the bed and the flat sections of the trial the zero-tillage sections have performed well. There was no effect on CCS across the trial. Similar trends were experienced in the year old 1<sup>st</sup> ratoon crop

All of the zero till treatments planted in these trials was planted with the BSES double-disc opener stalk planter. To add value to these trials and test the viability of zero tillage planter in commercial reality a number of replicated trials were developed in 2005 using a disc-opener billet planter. The results of these trials are outlined in the following section.

## 5.3 2005 ESTABLISHED TRIALS

### 1 YEAR OLD HARVEST DATA

In May 2006, nine months after planting, biomass sampling took place at the tillage trial that was established on Woodford Island in October 2005 (Figures 8 & 9). Sampling allowed an accurate weight of cane to be measured across both treatments and also gave the grower the option to stand over the block and cut it in 2007 as plant 2 year old. The variety in this trial is BN81-1394. Another trial was established at Walsh's in Broadwater and was also harvested as plant two year old in 2007.



Photo 3: The Hodge double-disc-opener planter in action at Harwood.

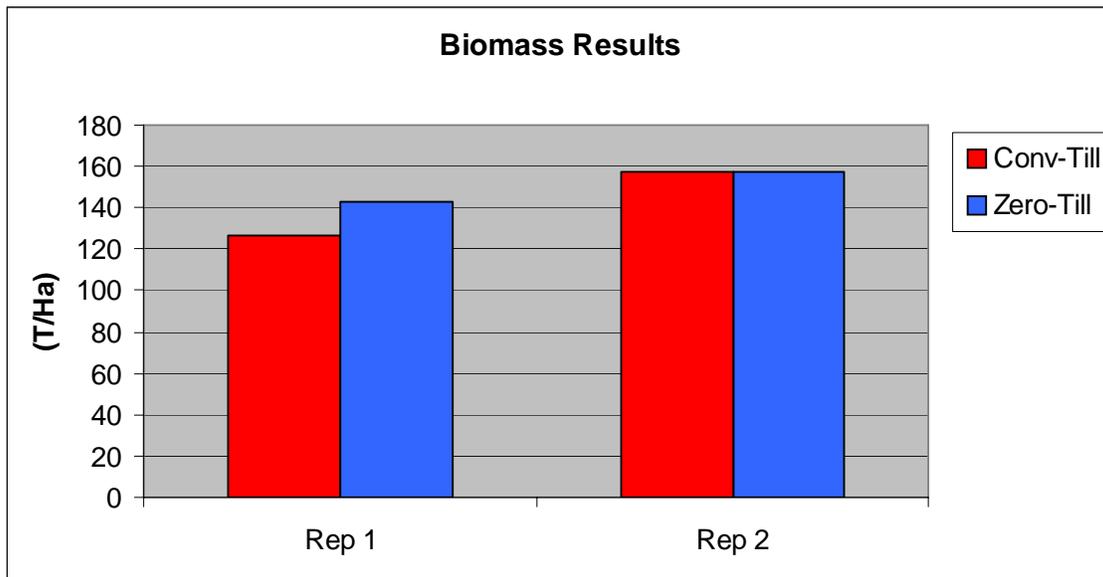


Figure 8: Individual replicate biomass for both the conventional and zero-tillage treatments.  
(R Munro and Sons, Farm 1277, Block 600)

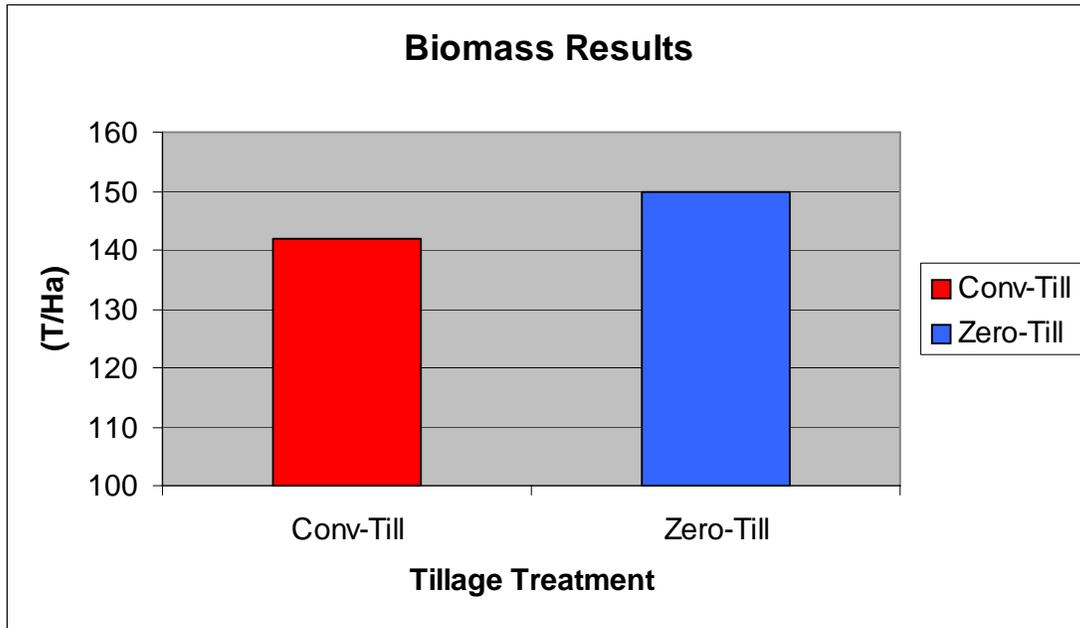


Figure 9: Shows mean treatment biomass for the conventional and zero-tillage treatments. (R Munro and Sons, Farm 1277, Block 600)

An analysis of variance was undertaken using Statistica version 5.0 to analyse the data from this trial. There was no significant difference observed ( $p < 0.05$ ) between the zero-tillage treatment and the conventional tillage treatment. In replicate 1 the zero-tillage treatment out-yielded the conventional till by 16 t/ha, with no difference in yield in replicate 2.

## 2 YEAR OLD HARVEST DATA

In August 2007, the Munro tillage trial was harvested on Woodford Island (Figure 10). In September 2007 the Walsh tillage trial (Figure 11) was harvested. As was the case in previous trials there was no significant differences in CCS (data not shown).

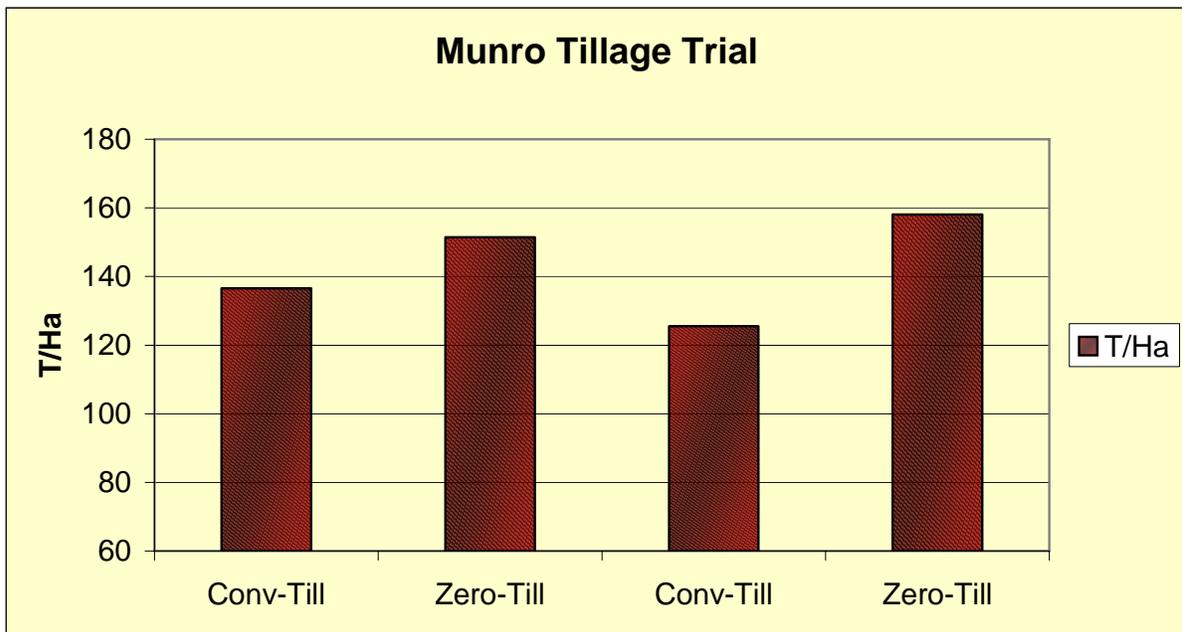


Figure 10: Yield results for the Munro tillage trial

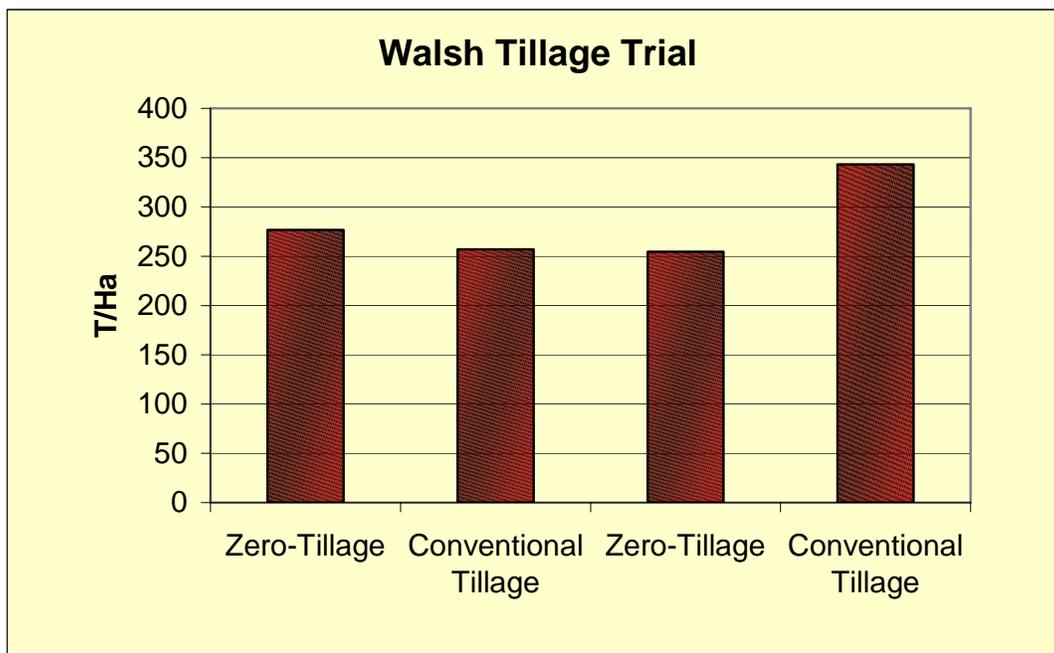


Figure 11: Yield results for the Walsh tillage trial.

Both trials were cut as two year old plant, being the first two year old direct drill billet planted trials being cut in NSW. Results were positive and aligned with 1 year old direct drill results from cane planted with both whole-stalk planters and billet planters. There were no significant difference in cane yield between the conventional tillage treatments and the direct drill treatments again illustrating the potential for cost savings by adopting such a system.

Table 4: Economic analysis showing gross margins for plough out replant and controlled traffic farming systems.

<b>COMPARING PLOUGHOUT/REPLANT TO CONTROLLED TRAFFIC ON A 72 HA FARM</b>		
	<b>Plough out replant 1.52 m rows</b>	<b>Controlled traffic + soy fallow 1.85 m rows</b>
Cane crops	Plant + 3 ratoons	Plant + 4 ratoons
Standover	50%	50%
Total tonnes cane (based on trial results, excludes trash)	5,862	5,152
Avg Pol	13.5	13.5
Tot cane income @ \$200/t pol	\$150,730	\$132,467
Soy income @ \$550/tonne (assume 1 crop in 5 lost)	Nil	\$18,450
<b>TOTAL INCOME</b>	<b>\$150,730</b>	<b>\$150,917</b>
Total variable costs*	\$88,579	\$75,909
Gross Margin per year	\$62,151	\$75,008

Cost calculations done using F.E.A.T.® QDPI

- Savings in variable costs come from smaller area planted each year, residual nitrogen from soy crop plus reduced tractor hours. Harvester savings have not been included.

## **6. GPS**

This project has provided the NSW industry with the opportunity to thoroughly evaluate GPS guidance systems for whole crop harvesting. Trials have been cut green using GPS to evaluate the system under whole crop harvesting. Both sub-metre visual guidance technology and +/- 2 cm RTK auto-steer technology has been trialed. The auto-steer technology has been most successful to date as it has less error and reduces driver fatigue. Visual guides (e.g. light bar) were evaluated but found to result in increased driver fatigue.

As a result of these trials the NSW industry has established an RTK GPS base station network, with coverage of all three mill areas. The entire harvesting fleet in Broadwater and Condong have been set up with GPS guidance in readiness for whole-of-crop harvesting, with a number of units being set up on growers tractors. A total of 60 GPS auto-steer units are working off the base station network that was set by the NSW SMC. All of the growers using GPS have converted to controlled traffic cropping systems and recognise that GPS is an integral part of controlled traffic.



Photo 4: Trials being harvested on auto-steer in Condong.

The implementation of GPS guidance with an accuracy of  $\pm 2\text{cm}$  in the harvesting of green cane potentially eliminates driver error in both the harvesting and in-field haulage operations, and as a result reduce compaction levels by up to 50%. The Sugar Yield Decline Joint Venture (SYDJV) identified the resulting compaction of the stool area as one of the factors limiting sugarcane production. This will reduce soil degradation, compaction around the cane stool and reduce runoff as a result of increased rainfall infiltration. Rainfall simulators have measured a 30% increase in rainfall infiltration rates in a controlled traffic farming system. This increase in infiltration will significantly reduce soil erosion loss on-farm sediment and an improvement in water quality.

GPS guidance combined with a controlled traffic cropping system is likely to deliver yield increases of around 15 to 20% over a crop cycle compared to the current system where around 95% of the field is trafficked. Research conducted by the Sugar Yield Decline Joint Venture (SYDJV) has quantified the impact of compaction on cane yield. "Soil compaction from harvesters and haulouts has been shown to reduce cane yield, both directly and through adverse effects on water infiltration and other soil hydraulic properties." (Garside 2002).

Trial work by the SYDJV has indicated yield increases of up to 20% where compaction has been reduced. A controlled traffic farming system, which includes the adoption of guidance, therefore has the potential to increase sugar yield across the NSW sugar industry, which will improve the overall profitability and sustainability of the NSW sugar industry and the surrounding environment. Conservatively, a 10% yield increase equates to a 250,000 tonne increase in cane production across the NSW industry. At a sugar price of \$30/t this equates to an extra \$7.5 million dollar of revenue for both growers and millers. These figures alone show the cost benefit of moving into a guidance system.



Photo 5: A harvester operator using GPS auto-steer.

The NSW sugar industry regularly experiences wet ground conditions during the harvest season and the current system results in considerable damage to cane stools from machinery on or near the cane row. This represents a considerable cost to growers who may have to replant blocks sooner than would be the case where little or no damage had occurred. GPS guidance on harvesting and haulout machinery would increase the length of the crop cycle (by not running over growing zones), resulting in reduced grower production costs and a more viable industry.

In order to collect the additional cane leaf biomass the industry has commenced whole-of-crop, green cane harvesting. This will create new challenges for harvester and in-field transport operators with the increased bulk of cane material making it difficult to manually operate machinery straight along cane rows due to reduced visibility.

This new system of crop harvesting will yield significant quantities of biomass for electricity generation but due the lower bulk density of the whole of crop product will result in additional in-field haulage traffic.



Photo 6: Base station set up on growers shed in the Condong Mill area.

Figures 12, 13 and 14 show base station locations and individual base station coverage for each mill area.

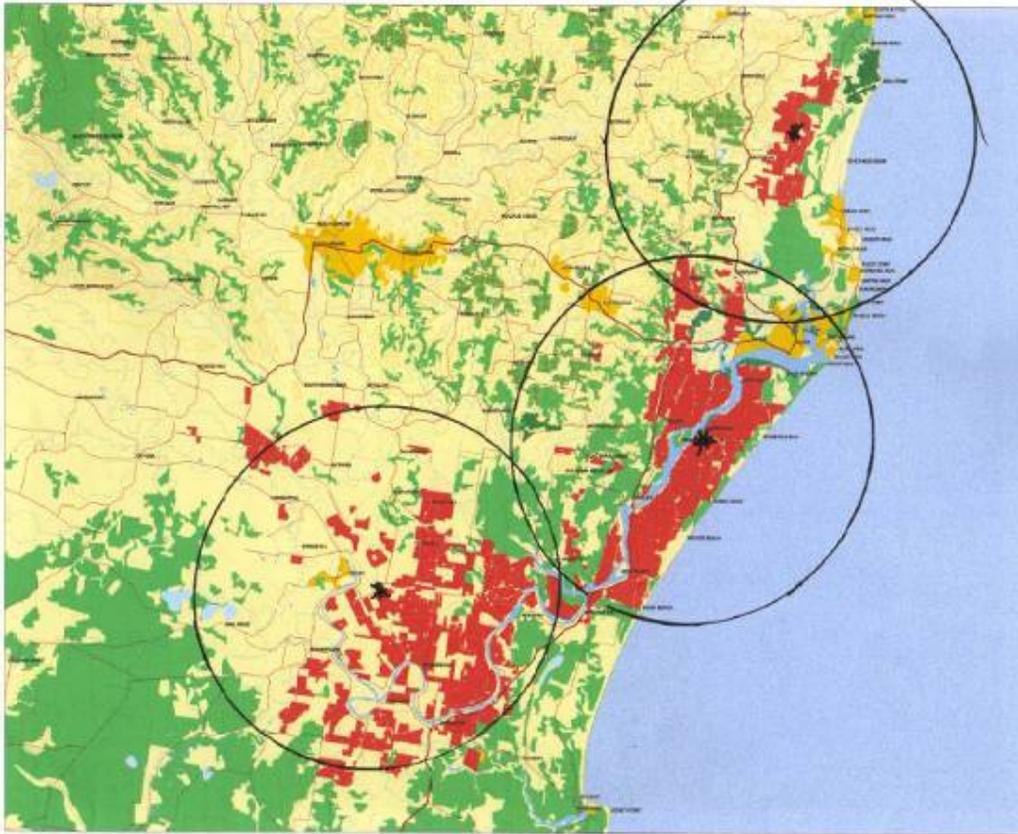


Figure 12: GPS coverage map for the Broadwater mill area.

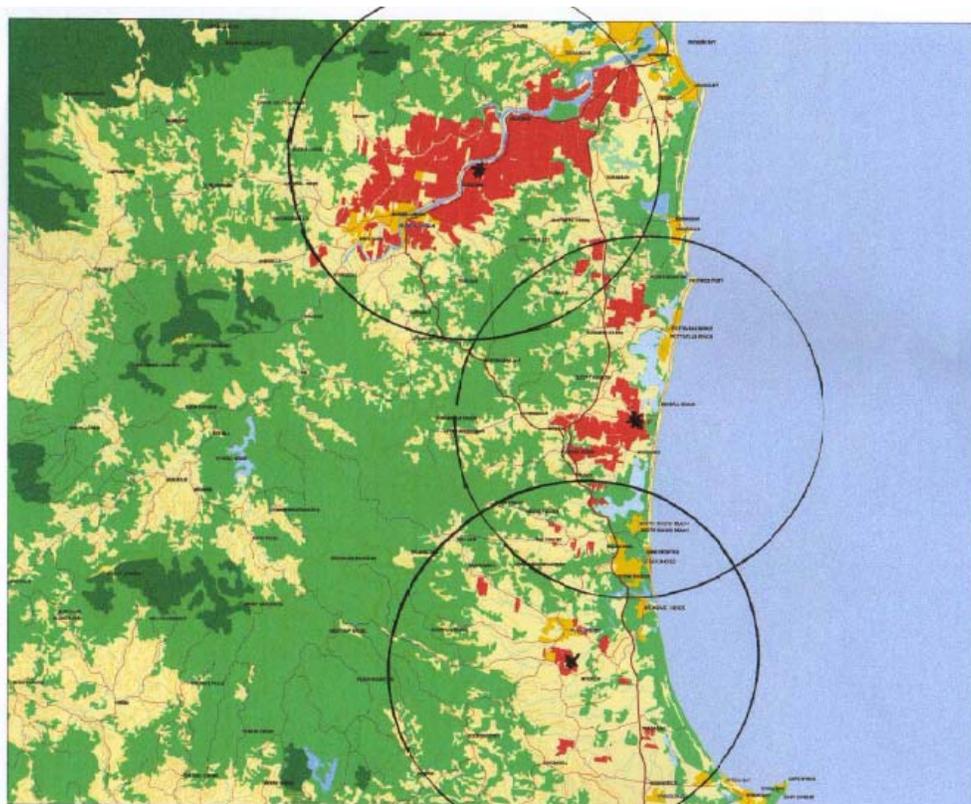


Figure 13: GPS coverage map for the Condong mill area.

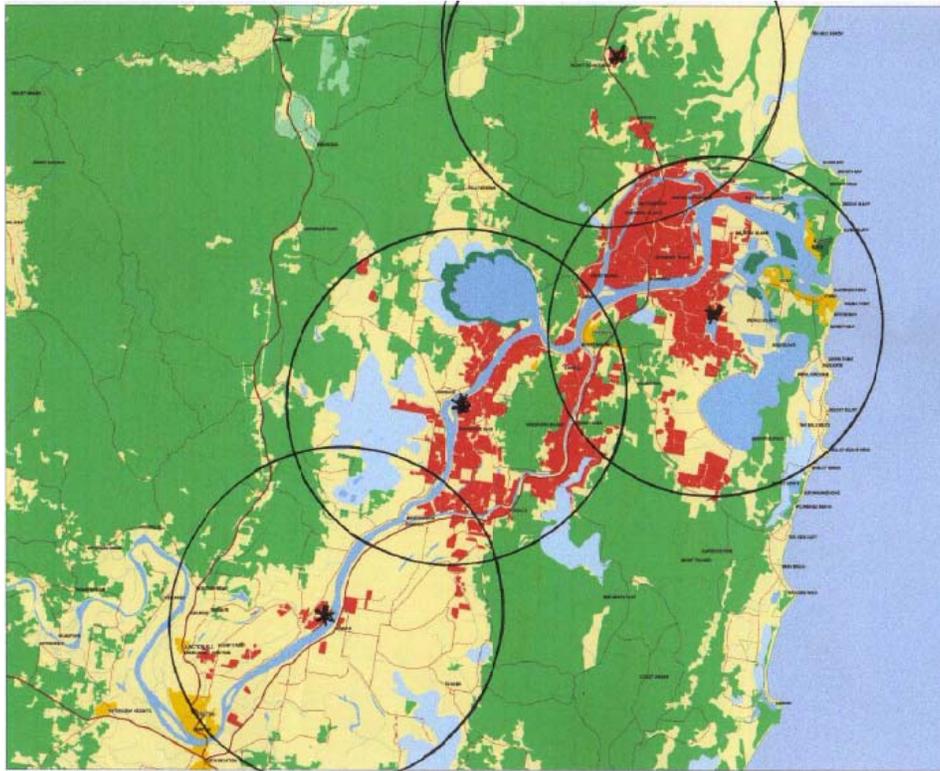


Figure 14: GPS coverage map for the Harwood mill area.

## **7. EXTENSION**

A large scale extension program was undertaken throughout the project with numerous field days, shed meetings and farm walks being conducted to increase the awareness among growers of the benefits of adopting the new farming system. As a result adoption of controlled traffic farming has increased dramatically since trial work began in NSW 2003. This has been a result of a broad scale extension program advocating the results of the farming systems work along with innovative growers making a successful transition to controlled traffic farming.

Two NSW field days were conducted in 2005 and 2006 showcasing the work carried in the NSW farming systems project. Around 200 people attended each day which included presentations by mill staff, BSES extension officers, NSW DPI, and members from the SYDJV.



Photo 7: Alan Garside talking to a group of growers at a field day about the benefits of soybean following.



Photo 8: Brian Robotham illustrating the benefits of a controlled traffic system with the use of the demonstration tarp.

Research findings from NSC005 were presented at the 2007 ASSCT conference held at Cairns by Nathan Ensbey and Mark North. This paper described the work conducted since 2003 on developing the new controlled traffic farming system and zero-tillage planting. This paper was awarded the President's Medal at the closing function of the conference.

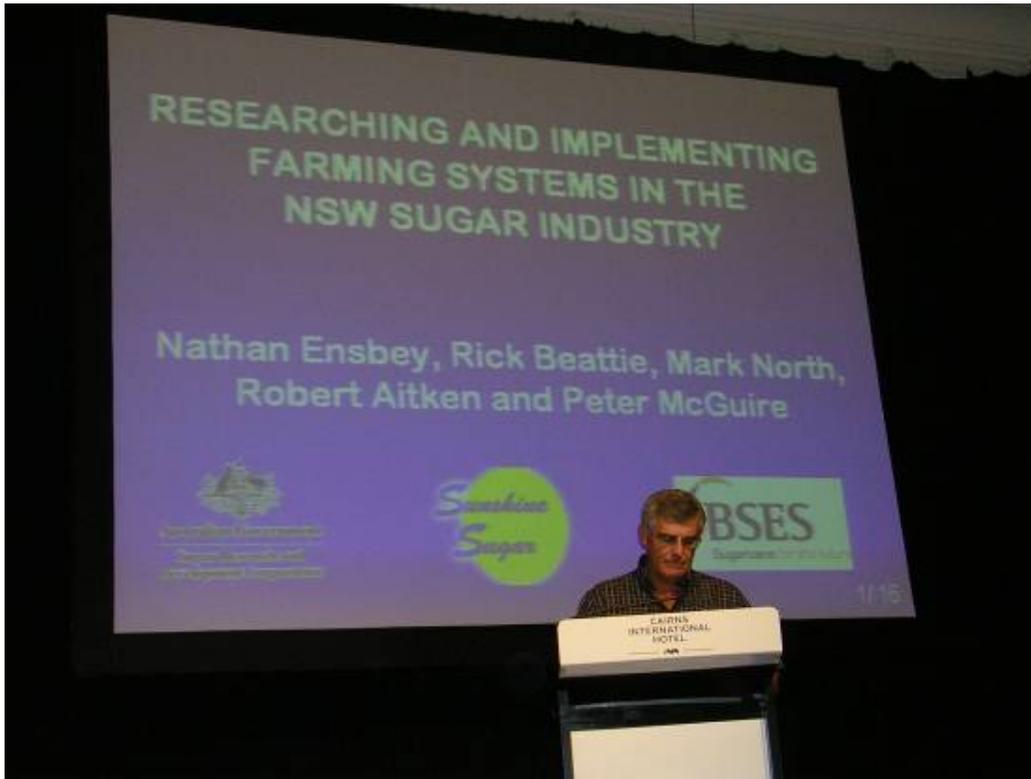


Photo 9: Mark North presenting the farming systems paper at the 2007 ASSCT in Cairns.

## **8. ADOPTION**

The field trials discussed in this paper have been used as demonstration sites at grower field days and, together with the presentation of results in newsletters, sugar cane magazines, and agricultural journals, have raised awareness of cropping systems. This, together with innovative growers making a successful transition to controlled traffic, has resulted in increased adoption rates.

Single rows on 1.5 m row spacing are still the most widely used planting configuration across the three mill areas of NSW. It should be noted that a lot of growers are still in the transition phase of changing from 1.5 m rows to a controlled traffic system. Table 5 details the current adoption rates in NSW.

The NSW SMC has a target of 50% of the NSW mill area be converted to the new farming system by 2010.

Table 5. Adoption rates (%) of controlled traffic farming (CT) in the three mill areas of NSW during 2003-2006

Year	Adoption of CT (%)		
	Condong	Broadwater	Harwood
2003	15	4	3
2004	18	7	5
2005	20	10	8
2006	30	15	25
2007	32	16	26

## **9. Conclusions**

The impetus for the trials reported in this paper and subsequent adoption of controlled traffic by growers have arisen from the move to cogeneration and whole cane harvesting by the NSW sugar industry. The trial results have indicated the potential for small yield increases and demonstrated that adoption of controlled traffic cropping systems will not result in loss of productivity. Results obtained have allayed concerns about yield losses from increased row spacings (Ridge and Hurney, 1994).

To date, results gained from the NSW farming system project have aligned with ongoing research that has been carried out by the SYDJV. Several trials have been harvested comparing dual rows, wide rows, and single rows on 1.8m with single rows on 1.5m. Both one and two year plant cane results have indicated that by adopting a wider row spacing and planting either a wide or a dual row within it you will not be compromising yield. The dual row treatment has out performed all other treatments at the plant cane stage averaging 7% greater yield than the conventional 1.5m single row system.

Ratoon trial results have shown a trend for the control traffic treatments to increase their yield advantage over the 1.5m system. Yield increases of up to 15% were experienced at some sites in dual rows. This can be credited to a reduction in compaction associated with controlled traffic farming.

When moving to a 1.8m dual row farming system, it is essential that planting rates are increased to take into account the two rows. Planting rates of around 12.4 tonnes per hectare (5t/acre) are the norm for a typical dual row planter (depending on variety), which is an increase of between 2.5- 3.7 tonnes per ha (1-1.5t/acre) of cane when moving from a single row system.

Modifications are required to the planter to ensure an even feed of billets. Current planters are mass flow types and require more amounts of cane to be planted to gain an even strike. Future work is required to develop a precision feed billet planter to address this issue. Failing to increase planting rates will lead to patchy strikes and a reduction in yield and make the switch to a dual row, controlled traffic system less viable.



Photo 9. An example of a mass flow feed required to get an even strike in dual rows

Harvesting modifications are an important part of the conversion to a controlled traffic farming system. Elevator extensions on the harvester are essential and, by not extending it, haulout operators are forced to run over corresponding stools of cane leading to increased levels of compaction and defeating the purpose of the whole operation. Widening of crop dividers and the throat of the machine is important to ensure the wider stool of cane can be fed into the machine. These are relatively inexpensive operations that are essential part of converting to such a system.

Although there were generally no major yield differences between the three controlled traffic systems evaluated, it is considered that the dual row configuration is the best option for NSW given the slower canopy closure in the other 1.8 m configurations. A number of growers have since planted wide throat rows on 1.65m-1.7m row spacings and whilst not gaining the full advantage of a controlled traffic system, it has provided a reduced level of compaction with minimal machinery modifications. This option is becoming increasingly popular as some harvester operators believe it is easier to cut a wide throat on 1.65m-1.7m than a dual row on 1.8m.

Shoot density and yield data from the cooler NSW environment presented here confirms previous studies from Qld (Garside et al., 2002, 2004) showing high shoot densities during early crop growth are not necessarily reflected in large yield differences.

Trials that were planted in 2004 with the BSES wholestalk planter, illustrated that there was no yield decline by zero-tilling cane into soybean stubble when compared to planting into conventionally worked ground. Until recently, the availability of a zero-till billet planter has been limited, with all farming systems trial work being done with a disc-opener whole-stick planter.

Further trial work carried out using a zero-tillage billet planter illustrated that yields could be sustained on a commercial scale, zero-tilling through soybean stubble. Whilst doing these trials a few limitations of zero-tilling however were realised.

One of the major limitations of the zero-tillage system is maintaining the controlled traffic system from the soybean crop through to cane planting. Most of the soybean crops in NSW are harvested by contractors with headers set up on 2.8m axle widths. For a true controlled traffic system to be implemented headers need to be modified to either 1.8m (straddle one bed) or 3.6m (straddle two beds). Growers in NSW have successfully carried out these modifications to headers and are set up on either 1.8m or 3.6m row spacings.

Soil break-out is a universal issue when planting on heavy soils in NSW. Various options have been investigated including slowing the planter down to around 4km/hr, using side press wheels (photo 10), and more recently the use of strip tillage machinery to reduced soil hardening. An issue that was realised with the current zero-till system came about during a late planted block in the Harwood mill area was penetration through the soil with the discs. Weights were attached to the planting frame in 2006 following similar trouble with soil penetration in 2005. In the majority of cases this worked well, but in a late planted block even with the weights on the planter, the discs were having trouble penetrating the ground. In Queensland the majority of growers zero tilling through soybean stubble are slashing their beans off prematurely to preserve moisture and then planting through the stubble in autumn.



Photo 10. Press wheels mounted to the side of discs have reduced 'break-out

In NSW, growers harvest their bean crops in May/June, and don't plant until September/October. In some instances, (especially late plant) this extra time between harvesting soybeans and planting cane allows the soil to become increasingly difficult to penetrate due to it drying out. Spring is typically the driest time of year in northern NSW and the later paddocks are zero-tilled, the harder the ground is becoming, causing the penetration and covering issue.

As a result strip tillage machinery has been designed (photo 11). This equipment enables a simple low cost pass, cultivating only the area of the bed that is to be planted with cane, reducing the need for heavy weights for penetration. Some growers have even diverted back to narrow conventional type openers as the strip tillage machinery does away with the need to use disc type openers (photo12).



Photo 11. Strip Tillage Machinery



Photo 12. Conventional drill plough working in strip tilled bed.

During the course of these trials there has been a significant increase in the number of growers adopting controlled traffic in NSW and the use of GPS is now embedded in the NSW Sugar Milling Cooperative infrastructure and is seen as an integral part of whole crop harvesting.

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The authors would like to thank growers who have allowed trial work to be carried out on their properties and have given their continuous input into the NSW farming systems project. The effort of Rodgers Holdings Pty Ltd in harvesting these trials is gratefully acknowledged. We thank Alan Garside and Brian Robotham for their help and advice throughout the project. The work was carried out with funding provided by the Sugar Research and Development Corporation and their support is greatly appreciated.

## **OUTPUTS:**

- A robust farming system that has the potential to reduce input costs, improve soil health and on farm profitability.
- A network of growers who are committed to advancing the new farming system into the future.

## **INTELLECTUAL PROPERTY AND CONFIDENTIALITY:**

There is no intellectual property associated with the outcomes of this project. This project aimed to build on the research from the Sugar Yield Decline Joint Venture. The NSW sugar Industry has been active in sharing information on all aspects of new farming systems.

## **ENVIRONMENTAL AND SOCIAL IMPACTS:**

A reduction in cane fires in the NSW industry has obvious environmental advantages. A move to controlled traffic farming reduces the level of soil compaction, increases rainfall infiltration and results in a reduction in sedimentation and nutrient runoff.

### **EXPECTED OUTCOMES:**

This project has indicated the potential for yield increases and demonstrated that adoption of controlled traffic cropping systems will not result in loss of productivity. The project extension activities and visits to other areas has given growers confidence that they can adopt a controlled traffic farming system without productivity losses. Although there were generally no major yield differences between the three controlled traffic systems evaluated, it is considered that the dual row configuration is the best option for NSW given the slower canopy closure in the other 1.8 m configurations. In addition, the benefits of reduced tillage planting has been proven and demonstrated. This offers significant advantages to farmers with the current high input prices for diesel and fertiliser.

Adoption of the new farming system in NSW has been encouraging and this system will be further developed by farmers to suit their own situation.

### **FUTURE RESEARCH NEEDS:**

There is a need to develop a precision billet planter. Mass flow planters do not lend themselves to disc opener technology. High volumes of cane being forced into a small opening leads to billet stacking which results in poor sett to soil contact, which can lead to poor strikes.

### **RECOMMENDATIONS:**

Farming systems trial work will continue to be a priority in the NSW sugar industry. Recent economic hardships have reduced the adoption of new systems over the last 12 months. However the results gained from trial work and growers who have adopted the system indicate that it is a robust system and one, which will continue to be adopted into the future.

### **LIST OF PUBLICATIONS:**

Ensbey, N.J., Beattie, R.N., North, M.B., Aitken, R.L., and McGuire, P.J. (2007) Researching and Implementing Farming Systems in the NSW Sugar Industry. Proc. Aust. Soc. Sugar Cane Technol., 29: 71-78.