RESEARCHING AND IMPLEMENTING FARMING SYSTEMS IN THE NSW SUGAR INDUSTRY

By

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Abstract

The New South Wales Sugar Milling Cooperative’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 mill areas of NSW 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. 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 (± 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. Adoption of controlled traffic farming has been increasing annually 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.

Introduction

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 cogeneration projects will supply green renewable electricity to 60,000 households.

The move to cogeneration 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 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.

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 this workshop, a 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 cogeneration project.

This paper reports the results of field trials comparing 1.5 m single rows with various planting configurations at 1.8 m row spacings (controlled traffic). The adoption of more sustainable farming systems incorporating the use of GPS by growers in NSW is discussed.

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.

Materials and methods

Trial establishment

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 centers 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 wholestalk planter with double-disc
openers. The bed height in the zero-till treatment was 10 cm 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).

### Table 1

<table>
<thead>
<tr>
<th>Site</th>
<th>Crop age (years)</th>
<th>Variety</th>
</tr>
</thead>
<tbody>
<tr>
<td>North (Condong)</td>
<td>1</td>
<td>BN81-1394</td>
</tr>
<tr>
<td>Clarke (Broadwater)</td>
<td>1</td>
<td>BN81-1394</td>
</tr>
<tr>
<td>Clarke (Broadwater)</td>
<td>2</td>
<td>BN81-1394</td>
</tr>
<tr>
<td>Hirst (Harwood)</td>
<td>1</td>
<td>Q-136</td>
</tr>
<tr>
<td>Mill Farm (Harwood)</td>
<td>2</td>
<td>Arris</td>
</tr>
</tbody>
</table>

**Agronomic measurements**

After crop establishment, three permanent 10 m 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.

**Results and discussion**

**Field 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.

**Yield and CCS**

As found previously for other row spacing trials in NSW (Ensbey, 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). 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\textsuperscript{st} and 2\textsuperscript{nd} ratoon crops. That the trend for higher yield from dual row 1.8 m treatments has been maintained into 2\textsuperscript{nd} 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\textsuperscript{nd} ratoon close-row treatments declined markedly.

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 (Ensbey, 2000).

![Fig. 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.](image-url)
Table 2—Effect of row spacing and planting configuration on cane yield (t/ha) at each site.

<table>
<thead>
<tr>
<th>Crop class</th>
<th>Site</th>
<th>Row spacing/planting configuration</th>
<th>LSD (P&lt;0.05)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1.8 m dual row</td>
<td>1.8 m single</td>
</tr>
<tr>
<td>Plant</td>
<td>North (Cnd)</td>
<td>129.4</td>
<td>119.1</td>
</tr>
<tr>
<td>Plant</td>
<td>Clarke (Bwt)</td>
<td>85.3</td>
<td>78.5</td>
</tr>
<tr>
<td>Plant</td>
<td>Hirst (Hwd)</td>
<td>91.6</td>
<td>88.9</td>
</tr>
<tr>
<td>Plant</td>
<td>Combined sites</td>
<td>102.1</td>
<td>95.8</td>
</tr>
<tr>
<td>Plant 2 years old</td>
<td>Clarke (Bwt)</td>
<td>154.8</td>
<td>142.8</td>
</tr>
<tr>
<td>Plant 2 years old</td>
<td>Mill farm (Hwd)</td>
<td>221.7</td>
<td>220.5</td>
</tr>
<tr>
<td>Plant 1st ratoon 1 year old</td>
<td>North (Cnd)</td>
<td>123.9</td>
<td>119.0</td>
</tr>
<tr>
<td>Plant 1st ratoon 1 year old</td>
<td>Hirst (Hwd)</td>
<td>114.3</td>
<td>103.9</td>
</tr>
<tr>
<td>Plant 1st ratoon 1 year old</td>
<td>Combined sites</td>
<td>119.1</td>
<td>111.4</td>
</tr>
<tr>
<td>Plant 2nd ratoon 1 year old</td>
<td>North (Cnd)</td>
<td>113.0</td>
<td>114.7</td>
</tr>
<tr>
<td>Plant 2nd ratoon 1 year old</td>
<td>Hirst (Hwd)</td>
<td>58.2</td>
<td>58.9</td>
</tr>
</tbody>
</table>

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.

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 (data not shown) and highlights the potential for this cost saving approach (North et al., 2007).
Crop class

Relative yield of dual rows

North (Condong)  Hirst (Harwood)

Fig. 2—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 2. 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).

GPS

The NSW two-year-old crop system coupled with fertile floodplain soils results in high yields often in excess of 200 tonnes per hectare. Visibility for the harvest operator cutting these green crops is severely limited by the increased bulk of cane material, necessitating a guidance system. Whole crop harvesting will yield significant quantities of biomass for electricity generation but due to the lower bulk density of the whole-of-crop product, a consequence will be additional in-field haulage traffic. This has the potential to increase soil compaction and in turn reduce the viability of subsequent cane crops.

The implementation of GPS guidance with an accuracy of $\pm 2$ cm in the harvesting of green cane will make it easier for the operator to harvest high yielding green crops typical in NSW. Guidance will eliminate driver error in both the harvesting and in-field haulage operations and, as a result, reduce compaction levels. This will reduce soil degradation and compaction around the cane stool and also reduce runoff because of increased rainfall
infiltration. This is an opportune time to implement GPS guidance technology in the sugar industry as there is now an awareness of the benefits of implementing a controlled traffic farming system. Cane harvesting is a skilled job and requires concentration over a long day. Guidance will reduce the stress on these key operators, allowing better job satisfaction and social benefits for sugar industry families.

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 have 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 further ten units being set up on growers’ tractors. All of the growers using GPS have converted to controlled traffic cropping systems and recognise that GPS is an integral part of controlled traffic.

**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 3 details the current adoption rates in NSW.

Following the initial successes of these controlled traffic trials, a number of NSW growers formed a farming systems group in 2004. This group gained funding and has since purchased a zero-tillage billet planter and undertaken zero-tillage planting trials. In the past two years, growers from outside the group have used the planter to trial controlled traffic and/or zero-tillage planting which has contributed to increased adoption of these technologies. The NSWSMC has a target of 50% of the NSW mill area be converted to the new farming system by 2010.

<table>
<thead>
<tr>
<th>Year</th>
<th>Condong</th>
<th>Broadwater</th>
<th>Harwood</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003</td>
<td>15</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>2004</td>
<td>18</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>2005</td>
<td>20</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>2006</td>
<td>30</td>
<td>15</td>
<td>25</td>
</tr>
</tbody>
</table>

**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).

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.

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.

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.

Acknowledgements

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REFERENCES


