NEW FARMING SYSTEMS FOR SUGARCANE PRODUCTION

By

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Abstract

Mechanisation of the Australian industry has contributed to its high efficiency but has also led to farming practices that optimise neither crop production nor the use of machinery. The current system contributes significantly to increasing soil compaction, declining soil health, poor weed control plus crop loss and stool damage during the harvest/haulout operation. It is time to redress these deficiencies by developing new farming systems. Recent research has shown that narrow row spacings significantly increase yields and can therefore provide the economic engine to drive the adoption of best practices in improved farming systems. A sequence of systems based on dual, triple and quadruple row spacings is proposed. These systems overcome the constraints of light and water interception, soil compaction and soil health, weed control, and water use efficiency, and avoid crop loss and stool damage during harvest. The two closer row spacings cannot be managed with current machinery; they require modifications to existing equipment or new multi-row equipment designed to suit the system. Consequently, evaluation and implementation of the new systems will involve the establishment of model farms by large growers and/or progressive plantings by cooperatives or groups of smaller growers to rationalise the cost and use of narrow row equipment.

Introduction

Mechanisation has contributed to the high efficiency of the Australian sugar industry but a focus on efficiency and economic returns has overlooked some long-term implications for sustainability and viability. The warning signs have been evident but have been ignored, particularly at a time of weak sugar prices.

An assessment of mechanised operations and their appropriateness for sustainable production is overdue. Magarey et al. (1999) reviewed the opportunities for improving productivity and sustainability based on recent research into yield decline and high density planting. This paper considers current farming practices and the need to develop improved farming systems incorporating current best practices.

Limitations of current farming systems

The current sugarcane farming system in Australia is a compromise arising from progressive mechanisation. The steady increase in equipment size, weight and complexity means the system has evolved to accommodate the machinery rather than to optimise production. Agronomic principles have been eroded and current systems suffer from practices that impact adversely on sustainable productivity.

Resource interception

Mechanisation has resulted in a gradual increase in row spacing, giving an unhappy compromise between a row spacing suited to animal power and one matching the track width of modern equipment. The resultant spacing (about 1.5 m) provides a poor plant geometry or architecture that does not intercept all the available light, utilise all the available water or access all the available nutrients (Bull and Bull, 2000). Harvester and haulout traffic runs close to or over the row, damaging stools and eroding ratoon yields.

Soil compaction

The mismatch between row spacing and equipment track widths results in soil compaction close to the crop row with 64% to 90% of the area trafficked by the tyres/tracks (Norris et al., 2000). Consequently, cane is grown in an uncompacted strip only 0.15 m to 0.5 m wide.

Soil strength measurements show that in-field traffic has established a traffic pan at a depth of about 0.3 m in many fields (Braunack and Hurney, 2000). Ploughing operations often do not disrupt this pan and the root zone may be only 0.15 m wide and 0.3 m deep. Restriction of the roots limits crop growth, increases water stress and leads to stool tipping that causes the loss of stools during harvesting. Irrigation and fertiliser applications can reduce these effects, but the capacity to exploit the light and water falling on up to 90% of the field is seriously diminished.

Soil health

The concept of ‘yield decline’, a loss in productive capacity caused by deteriorating soil health under sugarcane monoculture, is being addressed by the Australian industry. Crop yields commonly decline by about 30% with ongoing sugarcane production. Early trials (Bell, 1935; Magarey and Croft, 1995) reported that fumigation of ‘old cane land’ could return yields to those achieved from virgin land. Garside et al. (1999) showed that breaking sugarcane monoculture by fallow or rotation crops increases subsequent cane yields by about 30% and this was linked with an increase in beneficial bacteria in the rhizosphere (Pankhurst et al., 2000).

KEYWORDS: High Density Planting, Narrow Rows, Soil Compaction, Soil Health, Yield Decline.
Poor soil health can be masked by high inputs of water and nitrogen (Garside et al., 2000) but this does not provide a lasting solution. Improved farming practices are required for the long-term alleviation of this problem.

**Planting efficiency**

Billet planters have increased the area that can be planted by a limited labour force but the standard of crop establishment has declined significantly. For example, planting material is frequently cut from lodged crops using a chopper harvester and over 60% of billets may be damage. Growers recognise this damage and plant up to three times the required amount of cane. This practice increases the cost of planting, causes an irregular delivery of billets, limits ratooning potential (Robotham and Chappell, 1998).

Weeds remain a major problem for the industry but are often not given the attention required. Collins (pers. comm.) reports that incorrect timing of weed control can reduce cane yield by up to 50%. Weed control requires timely access to fields because delays can cause significant yield losses across the whole field.

**Water use efficiency**

About one third of the Australian sugar industry is irrigated. Scheduling and application method is dictated more by cost and convenience than a consideration of delivery losses, drainage losses or crop growth requirements. The objective has been to refill the soil profile in a single application (e.g. 40 to 60 mm of water) and then repeat the application within 10–14 days before the profile is depleted. Consequently, crop growth goes through periods of waterlogging, reasonable water availability, and water stress before the next irrigation. The increasing cost of water and regulation of water storage facilities means that the industry has to develop more efficient irrigation systems. Many of the practices to address these issues are known but adoption has been slow because they do not fit the existing system. A starting point for designing a new farming system was provided by studies of narrow row spacing which showed a near linear increase in cane yield as row spacing decreased from 1.5 m to 0.5 m (Bull and Bull, 1996, 2000). The 0.5 m rows provide a near square arrangement of plants that optimises light and water interception and increases cane yields by up to 60 t/ha. Yield gains of this magnitude can provide the 'economic engine' for new farming systems based on more efficient row spacings.

A row spacing of 0.5 m is difficult to manage with current machinery and grower preconceptions. The problems in developing new equipment, financing the transition from old to new machinery and convincing growers to make the necessary change in farming operations are considerable. One approach is to consider a range of row spacing options to facilitate progressive adoption of the principles involved and ultimately lead to a system based on 0.5 m rows. Accordingly we have considered dual, triple and quad (close or narrow) rows (Figure 1).

**Harvesting and haulout**

Mechanisation has improved the efficiency of harvesting but has led to appreciable crop loss and soil compaction due to the mismatch between row spacing and machinery track widths. A new farming system has to resolve this mismatch and minimise stool damage and soil degradation.

### Possible new farming systems

We have taken the view that a new sugarcane farming system must provide better row spacing, limit soil compaction, recover soil health, promote a deeper root zone and be compatible with high efficiency irrigation systems. Many of the practices to address these issues are known but adoption has been slow because they do not fit the existing system. A starting point for designing a new farming system was provided by studies of narrow row spacing which showed a near linear increase in cane yield as row spacing decreased from 1.5 m to 0.5 m (Bull and Bull, 1996, 2000). The 0.5 m rows provide a near square arrangement of plants that optimises light and water interception and increases cane yields by up to 60 t/ha. Yield gains of this magnitude can provide the 'economic engine' for new farming systems based on more efficient row spacings.

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### Key measurements and estimates of the area of compacted soil across the field are summarised for each system in Table 1.

**Dual-row system**

Dual rows are planted 0.5 m apart in mounds at 1.8 m centres and increase planting density per hectare by about 67%. Adoption can be rapid because dual rows match current harvester track widths and require only minor modifications to equipment. Dual rows increase yield by approximately 20 t/ha but require complete establishment of each row for full realisation.

The dual-row system allows the introduction of several improved practices. Controlled traffic lanes are established between the row pairs leaving a clearance of 0.28 to 0.34 m between the outside of the

<table>
<thead>
<tr>
<th>System</th>
<th>Distance between row/bed centres</th>
<th>Distance between rows</th>
<th>Distance between outside rows</th>
<th>Tyre/track width +/- driver error</th>
<th>Compacted soil area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single rows</td>
<td>1.5</td>
<td>1.50</td>
<td>1.50</td>
<td>0.622 +/- 0.20</td>
<td>60-90</td>
</tr>
<tr>
<td>Dual rows</td>
<td>1.8</td>
<td>0.50</td>
<td>1.30</td>
<td>0.622 +/- 0.20</td>
<td>34-56</td>
</tr>
<tr>
<td>Triple rows</td>
<td>2.0</td>
<td>0.47</td>
<td>1.06</td>
<td>0.622 +/- 0.20</td>
<td>23-46</td>
</tr>
<tr>
<td>Triple rows*</td>
<td>2.0</td>
<td>0.47</td>
<td>1.06</td>
<td>0.378 +/- 0.05</td>
<td>19-24</td>
</tr>
<tr>
<td>Quad rows*</td>
<td>2.1</td>
<td>0.47</td>
<td>0.69</td>
<td>0.378 +/- 0.05</td>
<td>18-23</td>
</tr>
</tbody>
</table>

* narrow profile tyres and tracks using an effective guidance system.
Soil compaction zones from traffic

Fig. 1—Configurations of conventional and improved row spacing options.

track and the cane. This limits traffic near the stool and reduces the compacted area to 34 to 56% of the field and enhances field accessibility under wet conditions. Traffic lanes remain in place for many crop cycles, obviating the need to rip the whole field to overcome soil compaction during seedbed preparation. The dual row mounds are minimum tillage zones, thereby enhancing soil structure and health. Dual rows reduce the length of travel by 17% and, if the crop is trickle irrigated, only a single tape is placed between the duals, saving 17% in tape cost. Once controlled traffic lanes are established, weed control procedures are restricted to the mound area, further reducing costs.

Dual rows are the first step towards a better farming system and can be managed with only minor changes to current machinery. Success requires attention to detail, accurate planting with high quality material, proper weed control between the rows and prevention of any traffic on the rows.

Triple-row system

Triple rows are planted 0.47 m apart on beds at 2.0 m centres, and increase planting density by about
125%. Yield gains are intermediate between the dual and four-row systems at around 35 t/ha but triple rows cannot be managed with conventional machinery. They require tractors with a track width of 2.0 m, a bedformer, a three-row planter (billet or wholestalk) and a wide-throat harvester to cut three rows at once. Modern harvesters and haulouts have a track width of 1.9 m that will match the traffic lanes for triple rows, leaving a clearance of 0.15 to 0.22 m between the outside of the track and the outside line of cane.

Triple rows are the next step towards quad rows. They accommodate growers wishing to advance beyond dual rows but uneasy with the precision, guidance and narrow track (low flotation) requirements of the four-row system. Triple rows incorporate controlled traffic and minimum tillage and can readily be managed to include a break crop to reduce pest and pathogen populations in the fallow period. The length of travel is reduced by about 25% but, if trickle irrigated, they will require two tapes for each bed, increasing tape costs by 50%. Triple rows are conceptually attractive to growers because they require slightly lower capital and operating costs than the four-row system but the potential yield gains are also smaller.

**Quad row system**

Quad rows are planted 0.47 m apart on beds at 2.1 m centres, and increase planting density by about 186%. They cannot be managed with conventional machinery and require equipment with a track width of 2.1 m and a footprint of about 300 mm. This narrow footprint is optional for dual and triple rows but is a requisite for quad rows. A bedformer, a four-row planter (billet or wholestalk) and a wide-throat harvester to cut four rows at once is also required. The clearance between the edge of the track and the outside line of cane is only 0.15 to 0.20 m, and it is essential to use a guidance system to accurately install the beds and guide planting, and harvesting operations.

Quad rows are dependent upon planting material with viability in excess of 90% to achieve the required level of establishment. Stalk numbers per stool are generally low (2 to 3) in plant and ratoon crops so stooling out across traffic lanes and interrows is not a problem. The quad-row system incorporates the principles of controlled traffic and minimum tillage and the progressive improvement of soil structure in the beds should enhance both horizontal and vertical root growth. The narrow traffic lanes are designed to limit the extent of soil compaction and should become well compacted over time. Beds can be managed to reduce pest and pathogen populations using a break crop between ploughout and replanting. The length of travel is reduced by about 29%, but trickle irrigation requires two tapes for each bed (between rows 1 and 2 and rows 3 and 4), increasing tape costs by 43%.

The quad-row system is the ultimate density for maximising yield potential and reduces unit production costs by about 25% (Bull and McLeod, 2000) but it requires investment in new machinery and adoption of precision agriculture. However, the investment costs can be recouped within the first crop cycle (plant and three ratoons) if growers take a cooperative or group approach to investment and implementation (Bull and McLeod, 2000).

**Summary**

The three farming systems outlined represent stages in the adoption of closer row spacings to increase production and profitability. Each system requires the use of controlled traffic, minimum tillage, rotation cropping, high quality planting material, precision planting, timely weed control, improved irrigation scheduling based on monitoring soil moisture and the matching of machinery track widths to row/bed spacing. The need for precision planting with high density has required the use of double disc openers (Robotham, 2000), and the need to improve billet quality for planting has led to the use of constant speed, rubber coated rollers in chopper harvesters (Robotham, 1999). These changes are now being adopted in more conventional planting practices.

**Implementation**

Introduction of a new farming system is constrained by perceptions of the risk of change, assessment of costs and benefits from change and a capacity to evaluate the new system and equipment. Until these issues are recognised and resolved progress is unlikely.

**Needs and risks**

The Australian industry involves over 7000 growers with age, experience, farm size and lifestyle all influencing perception of the need to adopt a new farming system. Companies and larger growers plus some of the younger or newer growers are more likely to critically assess the risks and benefits involved in adopting a new system. They are better positioned to make changes but they must be convinced it will be beneficial. Many of the smaller growers do not see a need to change, have limited resources to risk on change, cannot perceive how such major changes can be accomplished or do not wish to change a preferred life style. Some growers recognise that the present farming system is becoming more risky each year. They wish to introduce improvements in an incremental manner without a major exposure to risk, but are happy to sit back and wait for somebody else to test and refine the new system.

**Costs and benefits**

Growers are vitally concerned with the capital and operating costs involved in a new system and require a realistic assessment of the benefits that will accrue. Although gross margin analyses, based on trial data discounted for a lower performance, suggest that the new systems are highly profitable (Bull and McLeod, 2000), many growers expect that commercial results will be less attractive.
Again reliable assessment of costs and benefits is not possible until the new system is in place, but it is unlikely to be put in place until costs and benefits can be reliably assessed.

System and equipment evaluation

A complete change in a farming system presents challenges because of the magnitude and cost of commercial evaluation. The nuances of the new system must be solved and fully functional prototype equipment available for commercial evaluation of the new system. The geographical extent of the Australian industry means that a different farming system may be required for each region. We cannot establish commercial evaluation areas without suitable procedures and equipment to guarantee planting, management and harvesting of the new system. However, we cannot define the procedures or procure the equipment without commercially based evaluations to justify the investment.

Implementation options

Dual rows pose few problems for implementation and are being widely tested by the Australian and other industries under a range of conditions. Responses will vary from success to failure as growers learn the management skills required.

However, there are probably only two options for evaluating and adopting the triple and quad-row farming systems. Both require faith that research trials and demonstrations point the way to improved productivity and profitability and that the prototype research equipment provides a model for the new machinery required. A few large growers might establish pilot areas totally converted to the new system. Such an approach does not need to mesh with conventional operations and growers can develop management techniques to suit their own circumstances. Alternatively, interested smaller growers and contractors might group together in a cooperative to pool resources and progressively establish the new system on their own farms. Pooling of resources allows the purchase and/or modification of a set of shared equipment for planting, managing and harvesting expanding areas of the new system. Such cooperation and amalgamation has to be the route for improving farming systems and maintaining industry viability.

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NOUVEAUX SYSTEMES DE PRODUCTION POUR LA CANNE A SUCRE

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Résumé
La mécanisation des opérations culturales dans l’industrie sucrière australienne a contribué à sa haute efficience mais a aussi conduit à des pratiques qui n’optimisent ni la production agricole, ni l’utilisation des machines. Le système actuel contribue d’une manière significative à augmenter le degré de compaction et les pathogènes du sol, à un contrôle inefficace des mauvaises herbes ainsi qu’à des pertes de rendement et à des dégâts aux souches pendant la récolte et le transport. Il est temps de combler ces lacunes en développant de nouveaux systèmes de production. La recherche a récemment démontré qu’en réduisant l’écartement entre les rangs, le rendement augmente significativement et pourrait servir de moteur pour l’adoption de systèmes de production plus performants. Une séquence de systèmes basée sur des rangs doubles, triples et quadruples est proposée. Ils permettent de surmonter les contraintes liées à l’interception de la lumière et de l’eau, au compactage du sol, aux pathogènes, au contrôle des mauvaises herbes et à l’utilisation de l’eau et éviter ainsi les pertes de rendement et les dégâts aux souches pendant la récolte. Les rangs triples et quadruples ne peuvent accommoder les équipements conventionnels, il faut modifier ces derniers ou utiliser un équipement conçu spécifiquement pour les rangs multiples. L’évaluation et la mise en pratique des nouveaux systèmes impliqueront l’établissement de fermes modèles et/ou de plantations progressives par des coopératives ou groupes de petits exploitants afin de rationaliser le coût et l’utilisation des équipements pour les rangs serrés.

Mots clés: Plantation à haute densité, rangs étroits, compaction du sol, santé du sol, baisse de rendement.

NUEVOS SISTEMAS DE AGRÍCOLAS PARA LA PRODUCCIÓN DE CAÑA

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Resumen
La mecanización de la industria Australiana ha contribuido a su alta eficiencia, pero también ha conducido a la adopción de prácticas que no optimizan ni la producción ni el uso de la maquinaria. El sistema actual contribuye significativamente al incremento de la compactación, reducción de la salud del suelo, mal control de las malezas mas las pérdidas de producción y daños a las cepas durante la operación de transporte de la caña. Este es el momento, para compensar por estas deficiencias por medio de nuevos sistemas de producción. Investigaciones recientes han demostrado que la siembra usando espaciamientos reducidos entre surcos aumenta significativamente la producción y pueden constituir el motivo económico para promover la adopción de mejores prácticas agrícolas. Se propone una secuencia basada en el espaciamiento de dos, tres y cuatro surcos apareados. Estos sistemas compensan las restricciones de interceptación de luz y agua, compactación y salud del suelo, control de malezas y eficiencia en el uso del agua y reduce las pérdidas en producción y los daños durante la cosecha. Los dos espaciamientos más cercanos no pueden ser manejados con la maquinaria actual; requieren modificaciones al equipo existente o el desarrollo de nuevos equipos que se ajusten a este sistema de siembra. La evaluación y la implementación de los nuevos sistemas requieren del establecimiento de granjas modelos en las cooperativas o grupos de pequeños agricultores para racionalizar los costos de los nuevos equipos.