Controlled Traffic: Progress and Potential

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Introduction:

Concepts such as zone tillage and raised bed production have been applied to specific agricultural and horticultural systems since the middle ages, and gantry farming was first proposed in the 19th century. Controlled traffic was first investigated seriously in the 1960's, as a response to soil compaction problems, suggesting that random traffic had not previously been recognized as a significant problem in field crop production. That it was first applied in furrow- irrigated row cropping says something about the situation in which the problem is most obvious, and the conditions where controlled traffic is most easily applied.

Restriction of all heavy wheel traffic to permanent wheeltracks largely eliminates the dissipation of tractive energy in unnecessary soil deformation. This was the original motivation for controlled traffic research and adoption in Queensland, and this single step will substantially reduce energy requirement, soil degradation and the cost of crop production operations. Subsequent large-scale field application has demonstrated a range of other benefits, of equal significance to those originally envisaged. It is difficult to overstate the contribution of innovative farmers, and their advisers, to this process.

An improved level of precision in field operations is necessary in controlled traffic. Improved precision also provides significant opportunities for better crop management, some of which have already been realized by far-sighted farmers. The rapid improvement in field guidance systems occurring now will, however, provide the basis for even more significant innovations in cropping systems.

This paper provides an overview of the current situation in terms of the benefits originally expected from controlled traffic and the by-product 'system' benefits now being achieved. Some of these by-products turned out to be of great practical importance. The paper also considers the potential for future development of precision controlled traffic farming.

Australia already leads the world in on-farm applications of controlled traffic systems. The interaction of research, development and on-farm application has provided a farming system that is demonstrably more viable and sustainable. All the evidence suggests that the potential for further improvement is just as great, provided we accept the challenge to do things differently, on-farm and in research, and in maintaining communication between the two.

Original Objectives – Energy, Cost and Compaction Benefits

Energy. Most of the energy wasted in traffic and traction must be dissipated in soil deformation under tyres, and this effect is relatively easy to measure. Random traffic operation of equipment such as planters and chisel ploughs entails an energy input to the soil in the range of 20 – 50MJ/ha, most easily understood as an average tractor drawbar power requirement of 7.5 kW/m (3HP/ft)of implement width. In practice this means 10 kW/m(4HP/ft) power delivered to the axles, so approximately 2.5

kW/m(1HP/ft) is dissipated in soil deformation under the tyres. This is 75% tractive efficiency, where 25% of power has been wasted.

This level of efficiency looks reasonable, until you realize that the implement requires extra power to re-loosen wheeled soil. Our measurements demonstrate that wheeling by tractor or implement tyres roughly doubles the tillage power requirement for the wheeled area. In this situation, when tractor and implement tyres wheel 30% of implement width, implement power requirement increases in the same proportion.

Our 25% power wasted in traction is now compounded by the fact that the traction process has increased tillage power requirement by perhaps 30%, in the process of re- loosening soil within the tilled zone. The net effect of poor tractive efficiency is that total power requirements are almost doubled. More detail is given later in these proceedings, by Tullberg and Victor-Gordon.

Cost. Reducing the energy requirement of operations by 50% also reduces operating costs, and the tractor size required for a given operation, by the same proportion. Just as important, the improved trafficability of permanent wheeltracks allows operations to start or re-start one or two days earlier after rain. Farmers are sensibly cautious about reducing the margin of safety offered by a larger tractor, but many long-term controlled traffic farmers can demonstrate the economic benefits of reduced tractor size.

Soil compaction. It is interesting to note that we normally recognize 'soil compaction' as a phenomenon in soil beneath the tilled layer. We see it there only because tillage has destroyed most of the evidence of surface damage, although increased cloddiness is sometimes visible behind tractor wheels. The most intensive energy input to the creation and breakup of compaction must have clearly occurred within this tilled layer, even though we sometimes find it difficult to identify. Perhaps it is the absence of this damage, along with the reduction in tillage frequency and/or intensity which accounts for the references to improved soil structure under controlled traffic.

Assessment of soil compaction effects is difficult, and quantitative measurements often demonstrate smaller traffic effects than those provided by more qualitative, visual assessment (McHugh, these proceedings). Some part of this difficulty might be related to the fact that non-compacted (ie non-wheeled) soil is simply not available on most farms and research stations.

A variety of indices can be used to illustrate soil response to wheel traffic, but the most convincing data is that related to rainfall infiltration and crop performance. Evidence from a number of sites and experimental approaches indicates that wheel traffic can be expected to provide a substantial increase in runoff under most conditions. In recent work at Gatton, controlled traffic reduced runoff by 30% on average, and this effect was greater when the soil surface was protected by crop residue. Crop yield response to controlled traffic has reliably reflected the increase in soil water resulting from reduced runoff from non-wheeled plots. These trials have given no indication that the soil condition achieved in the absence of traffic and tillage is not optimal. Detailed results are provided later in these proceedings by Li, Ziebarth and Tullberg.

Indirect, System Benefits

The most important indirect benefit of controlled traffic is its comprehensive compatibility with zero till and other less intrusive crop production systems. Increased tractor tillage energy efficiency might be valuable, but it is of much greater significance that random traffic itself has often created the surface compaction (wheel ruts) or sub-surface compaction (hard layers) that generate the demand for tillage. The need for comparisons has ensured that our research has continued to compare controlled traffic effects in both conventional and zero tillage, but the majority of farmers adopting controlled traffic have also taken the opportunity to reduce tillage.

Controlled field traffic depends on permanent wheeltracks, or traffic lanes, which clearly require accurate installation. Installation guidance systems have included sophisticated GPS guidance systems, large conventional marker arms, and lengths of wire stretched between vehicles. Regardless of the system, accuracy is usually significantly improved by controlled traffic. In all cases overlap and 'misses' are reduced, and field efficiency increased, providing significant direct reductions in operating cost and consumables.

Readily visible, permanent wheeltracks are also a major advantage when spraying, improving guidance and allowing spray applications to occur at night, when conditions are often more favourable. Controlled traffic improves the reliability and timeliness of chemical application.

Because the tracks are usually at a different height to the non-wheeled field surface, they also have a major influence on overland flow of runoff water. Wheeltracks can be used as a disposal pathway for surface water to take it rapidly to contour channels on sloping land subject to high-intensity rainfall, or -in "raised beds" systems -- as a drainage system to of avoid waterlogging. These topics are dealt with from totally different perspectives in these proceedings by Cannon and Hamilton respectively. The common factor across this work is the improvement in soil condition that occurs when traffic is controlled and tillage reduced.

Crop Management Innovations

Controlled traffic farming demands and fosters better field guidance systems for tractors and implements. The price of these systems -- whether GPS or Vision type – appears high at present, but we can be sure that this technology will rapidly get cheaper over the next few years. When repeatable and reliable field guidance for tractors and implements is accurate to within a few centimeters, we have an exciting new set of crop/soil management opportunities. These opportunities are particularly important when combined with the ability to access crops without damage from permanent wheeltracks during their growth and maturation.

An immediate benefit is the ability to apply rowcrop techniques to more closely spaced crops. This has already been carried out by growers who have inter-planted the summer crop between the stubble rows from the winter crop, or used small-scale surface profile changes (furrows) to concentration limited rainfall to achieve a 'planting rain' effect in the planting row only. It not difficult to envisage the use of interrow weeding equipment- mechanical or shielded spray- to deal with difficult weeds, or slow the development of resistance. Split application of fertilizer appears to have great potential for increasing crop yield in wet years, and the ability to drill it into moist soil would be a great advantage over aerial distribution, as well as cheaper. This topic is considered later in these proceedings by George and Lewis.

The level of precision will obviously determine what can or cannot be achieved within a given row spacing. There appears to be considerable potential to use systems such as twin-row planting to provide a greater margin for error – and, perhaps, a planter which delivers greater residue tolerance by using half the number of ground-tools. The ability to produce small windrows of residue, and move them precisely in relation to the planter, could also be an important part of this scenario.

It is only a small step to envisage the division of the non-trafficed, permanent beds for several seasons into zones or strips which grow only grasses, and zones which only grow broadleaves, after band-spraying soil applied herbicides. Defined band, or zone application, would certainly reduce the constraint on cropping options following the use of soil-applied herbicides.

Precision controlled traffic will be the basis for zonal management of permanent beds. Zonal management might appear far-fetched, but it will clearly become feasible within the next few years as precise guidance gets cheaper. We need to consider all the possibilities which will improve productivity and sustainability. This could usefully include systems such as relay cropping (Massaso and George, these proceedings) and intercropping (Lewis, these proceedings). Both these approaches should help to increase double-cropping opportunities, maintain residue cover, and maximize the productive use of soil moisture.

Challenges

There are, of course still many practical challenges to be overcome to ensure that the on-farm benefits of controlled traffic become readily available to larger numbers of growers, and the environmental benefits available to the community at large. Growers have already demonstrated that they can deal with the first major challenge – that of thinking differently about the way they go about their farming. It would, nevertheless be considerably easier to look at the future if some of the machinery limitations could be overcome.

The major problem is still the incompatibility of the standard tractor with the grain harvester. While there might be little structural damage when harvester wheels run on dry soil, wet harvests are not uncommon in many areas. The weight of the harvester ensures that – even with the most generous tyre equipment – it makes a nasty mess of a soft permanent bed. Its effects also go a long way down through the profile, which is a problem if there is moisture further down. It looks like we can now get rubber-track crawlers, and the rear axle of many standard FWA tractors to 3m. How long will it be before a standard, warranted front axle is available?

A further point to be addressed is the one of tyre size/pressure/trafficability of permanent wheeltracks. Those of us working in black soil know that the permanent track can usually carry heavy loads without damage, but what happens under marginal moisture conditions, and on weaker soils? What happens on black soil when we put a 15t header axle on tyres not much bigger than the 18.4 section? Its no good if the header can't operate at all when it gets of the permanent wheeltracks. Perhaps the answer is the use of a smaller diameter dual tyre outside the high-pressure narrow tyre. Perhaps the answer is rubber tracks. Perhaps the answer is to use swath or windrow systems – as suggested by Wayne Chapman (these proceedings). Alternatively, we might find that a larger header front has to be articulated on its own ground wheels anyway. With these on the permanent wheeltracks, the front axle of the header might become much lighter.

The task of the planter becomes easier in some respects in controlled traffic farming. It's easier to get seed down to moisture in softer soil. It can, however become more difficult to cut through residue with a disk. If CTF results in greater yields and more frequent cropping, we might have to look more closely at residue management, or the way we deal with the residue at planting. I still believe that depth control – for planting and/or precision tillage – is a problem which will need to be properly addressed as we separate the load-carrying and depth control functions of implement wheels. Why control position to an accuracy of about 5cm if you can't control depth?

Conclusion

Great progress has been made since the first controlled traffic conference at Yepoon in 1995. No one now regards it as a topic for purely 'academic' attention. Farmers have demonstrated it works. There are still plenty of practical problems. I have mentioned some here, but we hope that one outcome of this conference is that most such problems can be identified and addressed by those best equipped to do so.

It is also important that we continue to look ahead at some of the challenges which will emerge when we try to achieve the full potential of precision controlled traffic farming. Some of these still appear to be academic, but if progress continues at its current rate, I think I can safely predict that some of them will be urgent practical problems before the next controlled traffic conference.

The last few years have demonstrated that success has been based on good two-way communication between farmers, extension people and researchers. From my own perspective, an additional input has been the regular observation of a totally different approach to mechanised cropping in China, which provides a totally different perspective on our approach to sustainable crop production. Our major for this conference is to provide the opportunity for starting new and productive lines of communication for all contributors.

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