CTF: The Fundamentals

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INTRODUCTION

The starting point for controlled traffic farming is blindingly obvious. 'Plants grow better in soft soil, but wheels work better on roads'. Research in the USA and Europe demonstrated the problems of random field traffic over 50 years ago, but large-scale adoption of controlled traffic by 1st world farmers has occurred only in Australia, and then only since the mid-1990s. Controlled traffic systems of one sort and another are believed to be in place on about 2Mha in Australia now.

Controlled traffic research was originally stimulated by the problems of soil compaction. Keeping all heavy wheels on permanent traffic lanes is essential, but it is only the first step in a much more profound system change, which goes well beyond dealing with soil compaction. Controlling traffic provides the improvements in efficiency, timeliness and soil structure necessary to reduce the waste of inputs and natural resource degradation inherent in conventional farming.

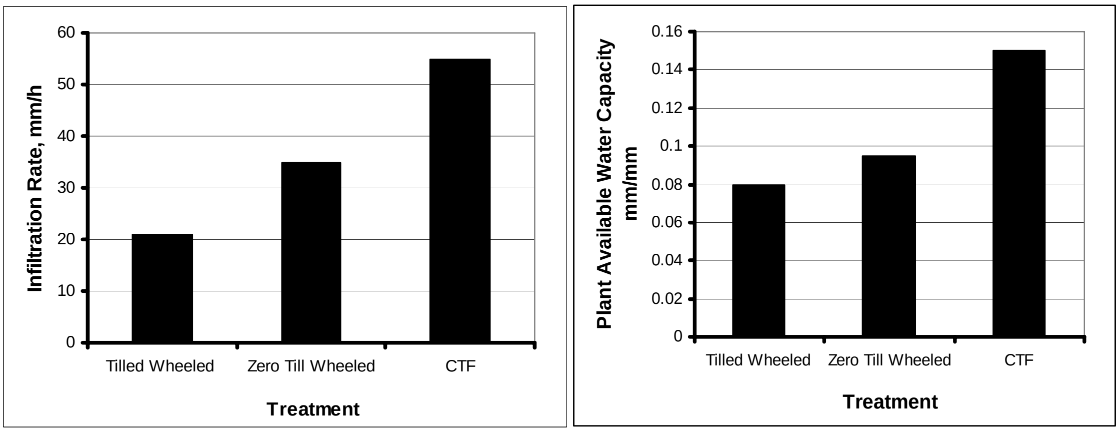
Controlled traffic farming-- CTF -- is a system to achieve greater productivity and sustainability from crop production in soil uncompromised by wheel traffic. Improvements in soil structure, field efficiency, or fuel use might still be an important motivator for adoption, but the outcome can be a truly revolutionary change in farming systems, providing major benefits to the economics of farming and to the broader environment.

The object of this paper is to summarise what we know to be important in terms of the science and practice of controlled traffic farming, and suggest future directions. It is important to note that most of the hard evidence to date is largely concerned with what we know already: uncontrolled wheel traffic causes major soil damage. What we know about practice generally coincides with that science, but all farms and farming systems are different. This conference is an opportunity to learn more about the technology, benefits and issues of CTF in different farming systems.

THE SCIENCE

Soil in optimum condition for plant growth is relatively weak and permeable. When a wheel or track rolls over that soil, it must compress or compact it until the soil is strong enough to carry this load. The processes of transmitting surface loads to lower layers of the soil are not straightforward, but it is generally accepted that tyre pressure is the most important factor in surface soil damage, but total axle load is a more important influence on subsurface damage, and the depth to which damage penetrates.

In most soils, natural processes of wetting, drying and biological activity will eventually repair that damage. This repair can be rapid at the surface, but it is much slower further down the profile. At a depth of 20cm, for instance the time the scale of repair is in years, even on 'self-ameliorating' soils. These natural processes, or tillage, can hide the surface damage quite quickly, but the subsurface damage persists. One of the major effects of this damage is on soil moisture. Tillage reduces infiltration of rainfall by destroying the surface's residue protection. Wheel traffic reduces infiltration by reducing the rate at which water can move down into the profile. Both these mechanisms increase runoff and soil erosion, particularly in high-intensity rainfall events, while reducing the total water getting into the soil. Wheeled soil has a larger proportion of small pores and holds on to moisture more tightly than non-wheeled soil, so a smaller proportion of this moisture is available to plant roots.



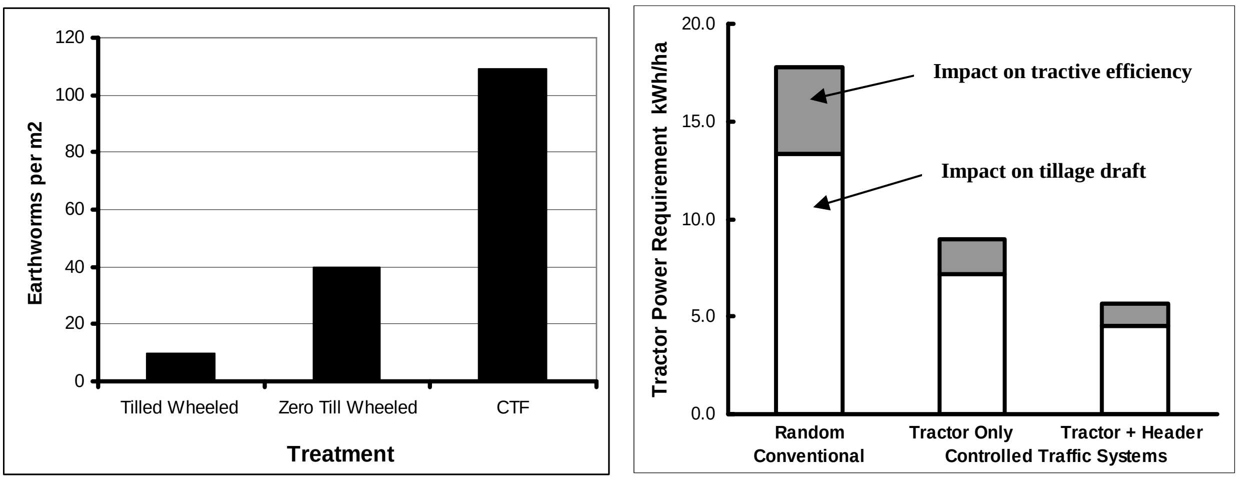
a) Iinfiltration rate during 80 mm/hour rainfall event

b) Plant available water capacity (0 - 30 cm after two years CTF.)

Figure 1. The impact of tillage and wheeling on infiltration rate and plant available water capacity.

The impact of tillage and wheeling (1pass/year by 2t tractor wheel) on infiltration rate and plant available water is illustrated in Figure 1, where conventionally farm soil (tilled and wheeled) is compared with zero tillage and random traffic and also with CTF (neither tilled nor wheeled). This data comes from Queensland's black vertisols, but broadly similar outcomes have been found in totally different soils in Victoria, in Western Australia, and other parts of the world. For all practical purposes, wheeled soil absorbs less rainfall and produces more runoff. It is more likely to get waterlogged, but capable of storing less moisture in plant-available form.

Most soil organisms do not enjoyed being dug up or squashed. Biological activity of all sorts -- from earthworms down to bacteria and fungi -- is much more plentiful in soil which has not been tilled or wheeled. The effect of one annual 2t tractor wheeling on earthworm numbers (mean, monthly samplings of top 15cm over two years) is illustrated in Figure 2a.



a) Impact of tillage and wheeling on earthworm numbers

b) Traffic effects on tillage/planting energy requirements.

Figure 2. Wheel traffic effects on soil biological activity, and power requirements of field operations.

More energy (or power) is needed to till wheeled soil, and traction is more efficient on permanent traffic lanes. These effects are illustrated in Figure 2b which compares the total tillage power requirement of random conventional traffic with that of controlled traffic systems, with just the tractor, and then both tractor and grain harvester ‘in the system’ (ie on the permanent traffic lanes). Impacts of tractive efficiency change (permanent lanes) and decreased tillage draft are shown separately.

THE PRACTICE

In uncontrolled ‘random’ traffic systems heavy wheels drive over at least 50% of paddock area per crop, causing damage at 30cm depth and below, so root zone damage is almost universal in cropped soils. People can often accurately claim they see no clear evidence of damage from heavy wheels—because the whole paddock is already damaged! Soil damage occurs instantly, on the first wheel pass. Second and subsequent wheel passes over the same soil do little further damage. On dry soil the surface damage is less severe, but the extreme wheel loads of larger grain harvesters can penetrate a long way down the profile.

Natural soil repair processes of wetting, drying and biological activity work from the surface down through the profile. At depths of 20 -- 30 cm, this occurs on a timescale of years. Growers report improvements in their soil after one year's controlled traffic, but improvements at depth continue for at least five years -- with positive yield effects resulting from increased plant available moisture.

Under the right conditions, deep tillage has sometimes been shown to have positive effects, but the cost is rarely justified by the results. Beneficial outcomes have been reported only where it has been used to deal with clearly identified problems, and carried out under the right soil moisture conditions. Tilled soil is always weaker, so a wheeled tilled soil is often in worse condition than it was before tillage. The most important step is to keep wheels off -- so nature and crop roots can do the work for you.

Controlled traffic and zero tillage are a perfect match. Eliminating the surface ruts and soil damage caused by harvesters and tractors gets rid of one of the major reasons for tillage, and a major frustration for zero till farmers. Hard, permanent traffic lanes make spraying faster and easier, and timeliness of operation is improved. This is largely a matter of bringing forward the window of opportunity for field operations after a rainfall event.

This window usually opens when paddocks become ‘trafficable’ after rain. Compacted permanent traffic lanes of CTF paddocks are usually trafficable for planting and spraying at least two days before random traffic paddocks. This increase in timeliness of operations can provide significant direct yield benefits, and many indirect benefits, such as improved herbicide weed control. Equally, it can allow a smaller CTF tractor and planter to complete the job ahead of a larger tractors operating in random traffic systems.

Controlled traffic farming uses less power to achieve greater production with healthier soil which provides more plant available moisture. Without wheel compaction, soil disturbance is required only where there is an identified need, and even then it will require a lot less energy than current tillage.

CTF also allows a new approach to runoff management. Runoff is substantially reduced on account of the greater infiltration capacity of non-wheeled soil. A properly designed layout of permanent traffic lanes (even without raised beds) can ensure that runoff remains distributed across the whole paddock, rather than concentrating into erosive flows. This is achieved by providing positive drainage, which -- combined with an undamaged soil profile -- is also effective in preventing waterlogging. For the high-rainfall situation, raised beds provide a positive insurance policy against waterlogging.

THE FUTURE

We know a lot about the problems caused by wheel traffic, and some of the direct benefits which occur when these problems are eliminated. We still don’t know enough about the broader system effects, simply because nearly all of our knowledge -- whether derived from research or practice -- is based on the issues of cropping damaged soil.

We are learning more about the immediate challenges of controlled traffic, and the solutions. Australian farmers and their suppliers have been the major innovators in developing and adopting accurate guidance systems, moving to a common track width, and achieving modular working widths. These are the immediate requirements of lining up all heavy wheels on permanent laneways.

We are also learning more about the immediate benefits: more rapid access to paddocks after rain, more efficient, timely operations with less power, less unnecessary soil disturbance, more moisture, more planting opportunities and better crops. We are starting to see more possibilities of using yield maps and satellite images to improve systems that are no longer compromised and confused by random traffic effects.

We are starting to learn more about the integration of these opportunities, benefits and challenges but the whole topic has still to register properly on the institutional research radar. We are still too busy investigating the old problems of soil compaction etc to notice the new opportunities of better access to undamaged soil with precisely positioned tools. These opportunities will occur in plant breeding, fertiliser management and weed control.

Machinery is still a major limitation. Equipment would be lighter, and farming would easier and cheaper, for instance, if:

- Depth control was independent of load-bearing wheels, without parallelograms on everything.
- More accurate implement guidance could be achieved with drawbar equipment.
- An integrated, multi-bin 'commodity cart' approach was used for all field materials handling.

Some innovative companies are looking at some of these issues, but it is a slow process.

Controlled traffic farming is the integration of all the challenges and benefits of permanent traffic lanes and uncompromised soil, to achieve a more productive, profitable and sustainable agriculture. The objective is to optimise cropping systems in the absence of the constraints of random wheel traffic. This is a matter of taking advantage of the opportunities of improved timeliness and greater precision. For instance, interrow planting immediately after harvest when soil moisture is available; capitalising on the ability to access growing crops without causing crop damage; using greater precision to better target the application of fertiliser and herbicide.

The research institutions might eventually address some components of this challenge, but the system issues will have to be sorted out by farmers, individually and in groups, working with input from scientists and consultants. The Australian Controlled Traffic Farming Association should be an important catalyst for on-farm research of these issues.