Why Controlled Traffic Farming?

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INTRODUCTION

The object of this paper is to summarise what we know about the science and practice of controlled traffic farming, and draw attention some of the things we don't know. The basics are straightforward. We know that wheel traffic can cause major soil damage. We know that driving on compaction-damaged soil is more efficient. Perhaps the most surprising aspect of CTF is that it has taken us so long to practice what we have always known: "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 first world farmers has occurred only in Australia, and then only since the mid-1990s. Controlling field traffic is, however only the first step in a much more profound system impact, which goes well beyond dealing with soil compaction. Controlling traffic is the key to 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 science tells us something about the magnitude of the soil damage inflicted by random traffic. It can tell us about the improvements we can achieve by controlling traffic. Unfortunately it can't tell us much about the system benefits, such as improved timeliness. Controlled traffic farmers tell us that CTF pays a large dividend in productivity and efficiency. It almost certainly pays a significant community dividend in terms of reduced pollution. I believe it is also the key to improving our greenhouse performance.

Controlled traffic systems of one sort and another are believed to be in place on more than 2Mha in Australia now. It would be great to get more information on just what this means, in terms of systems and outcomes, so we can do a better job of telling people what they can expect.

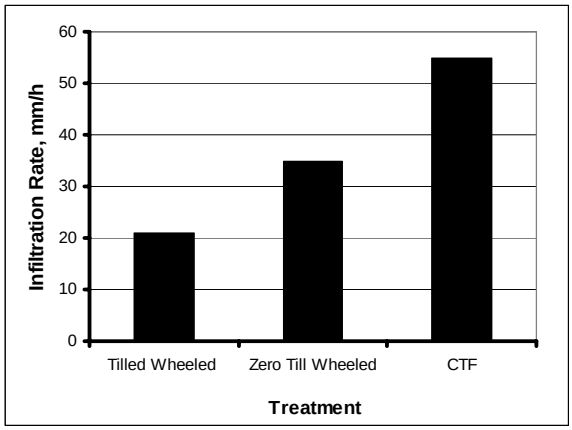
KNOWN SCIENCE

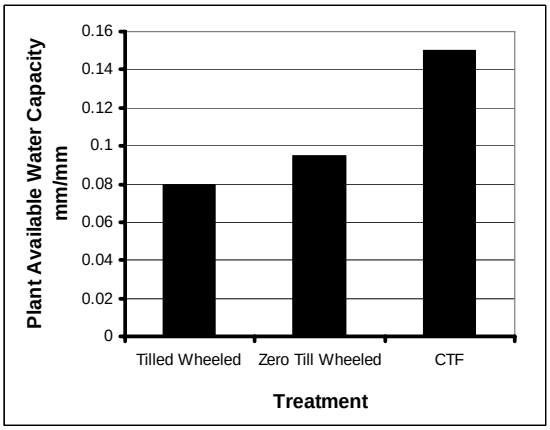
Soil in optimum condition for plant growth is relatively weak and permeable. When a wheel or track rolls over that soil, it must compress or compact it until the soil is strong enough to carry the load. The processes of transmitting surface loads down the profile is not straightforward, but it is generally accepted that tyre pressure is the most important factor affecting 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 this damage. Repair is usually 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.

Moisture

One of the major effects of wheel traffic 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) Infiltration rate during 80 mm/hour rainfall event **b) Plant available water capacity (0 - 30 cm after two years CTF.)**

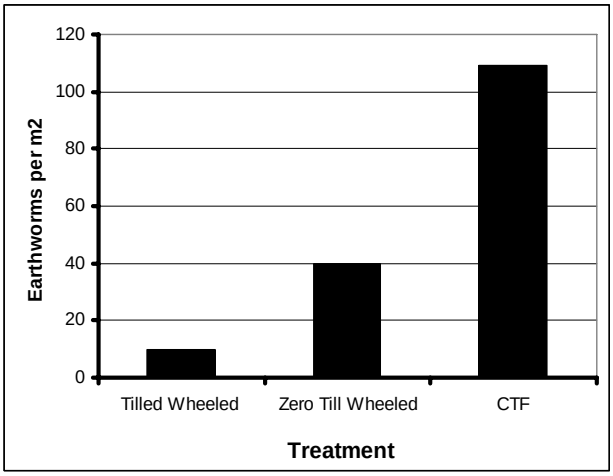
Figure 1.The impact of tillage and wheeling on infiltration rate and plant available water.

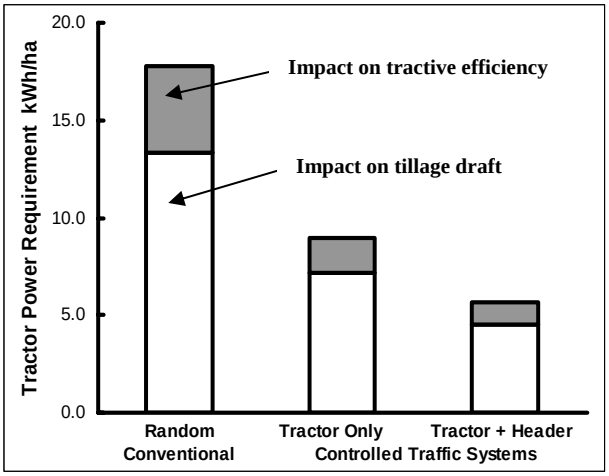
The impact of tillage and wheeling (1pass/year by 2t tractor wheel) on infiltration rate and plant available water is illustrated in figure 1, where conventionally farm soil (tilled and wheeled) is compared with zero tillage and random traffic and also with CTF (neither tilled nor wheeled). This data 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 is capable of storing less moisture in plant-available form.

Soil Health and Energy

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. There have been no exhaustive tests, but soil organic matter levels have generally increased in CTF. There is nothing surprising about the idea of soil health and organic matter levels changing in tandem, and this might be the reason for the improvement in plant available water capacity.

The good bit is that these improvements in soil condition come as a result of spending less money on fuel for the tractor. Zero tillage itself is a great step in this direction, but you still need to drive over the paddock several times. Controlled traffic provides more efficient traffic and traction, and the soil disturbance of planting will require less energy when you don't have to stir compacted soil.





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.

The reduction in energy (or power) for planting or tilling non-wheeled soil, and the improvement in tractive efficiency on permanent traffic lane are both 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 confined to permanent traffic lanes). Impacts of tractive efficiency change (permanent lanes) and decreased tillage draft are shown separately.

KNOWN 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 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 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. CTF 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 from increased plant available moisture.

Under the right conditions, deep tillage has occasionally been shown to have positive effects (in WA sands, particularly), but the cost is often not justified by the results. Beneficial outcomes have been reported only where deep tillage 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.

In our water-limited cropping environment, it is amazing that some of our major problems come from excess water. Controlled traffic farming facilitates better water use efficiency by providing more opportunities for using available water for cropping. If soil is moist and plant growth is possible, cover

crops are more valuable than weeds. Controlled traffic farming also provides a new approach to runoff management, getting rid of excess water rapidly and safely. A properly designed permanent traffic lane layout can ensure that runoff remains distributed across the whole paddock, rather than concentrating into erosive flows. Good layout ensures drainage which, combined with an undamaged soil profile, can prevent waterlogging in most conditions. Raised beds provide a positive insurance policy for the high-rainfall situation.

WHAT'S UNKNOWN

We still don't know enough about the broader system effects, simply because nearly all our agronomy -- whether derived from research or practice -- is based on the issues of cropping damaged soil. Traditional research is good at picking up the impact of changes in system components -- but it is not good at assessing the impact of system change. Whatever else they might have achieved, "farming systems" have not done much to quantify the effects of system change.

Grower surveys should tell us something about system impact but most do not distinguish between a grower operating a complete CTF system, and a grower who has simply purchased a guidance system. Both can make some claim to be controlling traffic, but only one is getting the full advantages. What are the system benefits, and what impact might they have?

Timeliness: Controlled traffic farming eliminates many of the time wasters. CTF growers, for instance, can get back on the paddock two days or more before growers in non-CTF zero till, and there is general acknowledgement that timeliness is extremely important. Unfortunately, we still have only the most approximate estimates of its impact. These estimates are usually between 0.5% and 2% yield loss for every day of delay in planting or harvesting, but there have been few attempts to measure the effects directly.

Harvesting and planting timeless effects can sometimes be cumulative. Rainfall at harvest time usually costs money in terms of crop downgrading, but for CTF growers the loss will be smaller -- because they will be harvesting again more rapidly after rain. In many Australian environments, moist soil at harvest time also represents a planting opportunity. Getting another crop established is always a better option than tilling out header ruts and then spraying weeds.

Zero tillage compatibility: Timeliness of spraying is probably even more important than timeliness of harvesting and planting -- but again we have no quantitative information. There is little doubt, however that timely spraying is an essential component of effective zero tillage cropping. Controlled traffic and zero tillage are a perfect match.

Precision: Controlled traffic farming means that inputs can be applied more precisely at the time they are needed, and the place they are needed. Permanent traffic lanes allow access to growing crops without causing crop damage, and 2 cm guidance allows precise positioning of inputs -- physical or chemical. We can achieve significant input economies when chemicals can be band-applied, and fertiliser precision drilled at the right time.

Environmental impact: Controlled traffic farming provides a major environmental dividend, because it facilitates the use of less energy, maintenance of more residue, and active crop production for a greater proportion of the year. We also know that a significant proportion of nitrogenous fertilisers are lost simply because they are placed in wet soil, long before now required by the crop. In controlled traffic farming, with precision guidance, fertiliser can be drilled in the interrow, or provided in liquid form when and

where it is needed. Another valuable outcome of this strategy is a simpler, more residue-friendly planter, uncomplicated by the need to apply fertiliser long before it is needed.

WHAT'S NEEDED

The full implications of CTF have still not registered on the institutional research radar. We are all still too busy and too comfortable investigating the old problems of soil compaction etc to notice the system opportunities of better access to undamaged soil with precisely positioned tools. Controlled traffic farming will provide new opportunities in plant breeding, fertiliser management and weed control.

There are also opportunities to produce machinery to exploit improvements in precision and control and allow cheaper, lighter equipment to provide:

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

CTF allows information to replace brute force, and precision to replace bulk steel.

Research institutions might eventually address some components of this challenge, but current indications are that these system issues will have to be sorted out by farmers, individually and in groups.

I believe this should be a major role for the Australian Controlled Traffic Farming Association.