Controlled Traffic Farming (CTF) Reduces Soil Emissions, Saves Nitrogen, and Reduces other Environmental Impacts of Mechanised Cropping.

C.A. Bluett1, *J.N.Tullberg1,2, D.L.Antille1,2, C. Scheer3

1 Australian Controlled Traffic Farming Association, HRZ Consulting, Buninyong 3357, Vic.
2 University of Southern Queensland, National Centre for Engineering in Agriculture, Toowoomba 4350, Qld.
3 Queensland University of Technology, Inst. for Future Environments, Brisbane 4000, Qld.

* Corresponding author: jtullb@bigpond.net.au

Introduction

Controlled traffic farming (CTF) is a cropping system with all load-bearing wheels of field equipment restricted to permanent traffic lanes. This leaves most field area untrafficked, to be managed for optimal crop production. The permanent traffic lanes can be laid out for optimal drainage and logistics and managed for optimum trafficability and field access. The ideas behind CTF can be traced to the 19th century, but despite substantial R&D effort in many countries from the 1960s onwards, large-scale commercial application has occurred very slowly. This has changed since the 1990s in Australia, with a steadily increasing proportion of grain (now ≈28%) being produced in CTF systems.

Important factors in this increase have been:-

- Research and on-farm demonstration of CTF, showing its benefits.
- A series of CTF conferences organised by ACTFA and its predecessors.
- Large-scale adoption of no-till, for which CTF is a natural companion.
- The development of RTK autosteer to provide the necessary precise guidance.

Farmer adoption has been driven largely by recognition of the on-farm productivity and economic benefits, but valuable promotion assistance has come from “environmental” organisations (e.g. “Landcare”) concerned with off-farm effects at catchment scale, and with coastal eutrophication. Encouragement of CTF adoption for environmental reasons might increase further now the significant emission reductions from CTF have been demonstrated.

Emission impacts of CTF

Emissions were monitored using standard replicated chamber procedures (14 times/crop) at 6 sites over 3 years in rainfed grain crops in Queensland, Victoria and Western Australia. Sites included light and heavy soils, and growing season rainfalls ranging from 96 to 522mm. This work demonstrated that nitrous oxide (N₂O) emissions from random-trafficked soil were consistently greater (more than twice, on average) than those of neighbouring non-trafficked soil, and that non-trafficked soil absorbed ≈1.5 g ha⁻¹ d⁻¹ more methane (Tullberg et al. 2018).

The best Australian CTF systems reduce permanent traffic lanes to <10% of field area (commonly 12-15%), but non-CTF systems traffic ≈50% of field area. CTF should therefore reduce soil emissions by 30-55%, and emissions might be further reduced by avoiding N input to traffic lanes. More work is required, but a first estimate suggests that CTF should reduce annual soil emissions from Australian grain by 90 –150 kg ha⁻¹ CO₂-e. This represents 20 - 30% of emissions of these low-input dryland cropping systems. The emission effects of CTF are likely to be greater in wetter environments with higher N fertiliser inputs.

These reductions in global warming potential take no account of the life-cycle emission effects of CTF systems, such as increased yields from more available water and reduced denitrification loss, reduced N fertiliser input, and the 25-35% reduction in fuel use.
Mechanisms.
The largest soil pores are the major pathway for water and air movement, but they are also the least able to resist mechanical loads, and hence the first to be damaged when soil bulk density is increased by traffic compaction. Reduced pore volume and water transmission ensure that the upper profile of compacted soil becomes waterlogged more rapidly during rainfall events, and remains waterlogged for longer afterwards. Compacted soil thus provides the semi-anaerobic conditions conducive to denitrification and emissions when nitrate is available.

Other Environmental Impacts
Loss of transmission pores obviously reduces infiltration rates. Multi-year CTF trials in Australia and China have demonstrated large reductions in run-off and off-site movement of soil, nutrients and agricultural chemicals. Compaction also reduces yield by inhibiting the ability of roots to fully explore the soil profile, an effect confirmed in many yield comparisons between conventional and CTF production.

Less obviously, wheel traffic compaction damages smaller storage pores, reducing available water capacity (McHugh et al. 2009). Compaction has also been shown to have large negative effects on soil biota, especially beneficial organisms. Whether a direct physical effect or a consequence of restricted aeration, the disease-suppressive capacity of CTF soil has been noted as a reason for use of permanent beds in horticultural and sugarcane production.

Conclusion.
Soil compaction is a serious issue in most agricultural systems, occurring almost instantly under heavy load but ameliorating only slowly without deep tillage. The outcome is almost universal soil compaction in non-CTF systems, often extending well below normal tillage depths. This paper has summarised some of the negative environmental effects of compaction, but the economic and environmental costs of creating compaction are also important.

Compacting agricultural soil requires substantial energy. This can be observed as motion resistance to equipment movement, and it represents the largest single component of the mechanical energy (i.e. fuel) cost of no-till cropping. It is this energy that is dissipated in reducing the porosity, connectivity, available water capacity, health and productivity of trafficked soil. Travelling only on the permanent lanes of CTF substantially overcomes this problem, and also provides more timely access to fields.

Both research and on-farm practice have confirmed that CTF will normally increase crop yields and reduce costs, while overcoming some of agriculture’s most significant environmental issues. Many Australian farmers can also confirm that it makes farming easier, providing system benefits in timeliness, weed management and crop uniformity. When CTF adoption costs are small – with planning – it is surprising that it is so rarely mentioned in the context of the soil-related production and environmental problems faced by farmers.

References