Controlled traffic experiences and results in a diversified vegetable industry

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Abstract
By isolating traffic impacts from crop growth areas, controlled traffic farming (CTF) provides a number of farming system benefits including improved energy efficiency, soil health, crop yield, timeliness and economics. The gradually increasing adoption of CTF in the Australian grain and cane industries has been largely based on a limited equipment suite and flat to mildly sloping topography. The Tasmanian vegetable industry faces a very different scenario, with a wide diversity of machinery, and topography ranging from flat to steeply undulating.

Research into controlled traffic in the vegetable industry has shown improvements in soil physical conditions can be achieved in a short time. Experience with the evaluation and demonstration of controlled traffic on commercial farms has highlighted tracking stability on slopes as a key factor for successful adoption in undulating topography.

Very few machines used in the vegetable industry are designed to be compatible with a common track or working width, a requirement of fully integrated controlled traffic. While some implements can be modified reasonably readily to suit controlled traffic, many others (e.g. single row potato harvesters) provide few options for change. Seasonal CTF is a system in which all tillage and crop management operations are conducted on accurately mapped tracks, but random harvest traffic is accepted because of incompatibility of track and working widths of harvest equipment. Seasonal CTF represents a reasonable starting place for adoption in the vegetable industry until more compatible machinery is available.

Key Words
Controlled traffic, vegetables, soil structure, tillage

Introduction

Controlled traffic farming (CTF) keeps all paddock traffic on the same wheel tracks, thereby separating compacted traffic zones from soil used for growing crops, and providing a wide range of benefits for crop production. Benefits observed in research and commercial practice in the grain and sugar industries include reduced soil erosion, more efficient energy, water and fertiliser use, improved soil structure, organic matter and timeliness, and increased productivity (Bowman 2008; Cotching 2009; McPhee et al. 1995; Stewart et al. 1997; Tullberg et al. 2007; Vermeulen et al. 2007).

Use of CTF in the Australian grain and sugar industries has increased in recent years as the benefits have become more widely recognized. The uptake of controlled traffic in some sectors of the intensive vegetable industry is almost non-existent for a number of reasons, including diversity and incompatibility of current equipment, and often diversity in ownership arrangements (e.g. private, contractor and company-based machines) requiring industry-wide involvement for effective change. This is particularly the case for the Tasmanian vegetable industry, which encompasses both the processing and fresh sectors, and relies on major firms to act as consolidators of product for processing or fresh export, most of which are also engaged in the contracting of services such as harvest. Pyrethrum and poppies are often included in the rotation and are grown in a similar manner to broadacre grain crops.

Research in vegetables in Tasmania has provided evidence of improved soil conditions through the use of controlled traffic, while on-farm demonstrations have identified a number of factors to be addressed for practical adoption of the technique. Constraints to be resolved for successful adoption of CTF in vegetable production include tracking stability on compacted wheel tracks and cross-slopes, and implement working and track width compatibility.

Methods

A number of trial sites have been established as part of a major effort to research and develop controlled traffic for the Tasmanian vegetable industry. These include a 2 ha experimental site near Devonport, with soils and topography representative of the prime vegetable production areas in Tasmania. This site has been used for soil and crop monitoring, and the trialling of alternative approaches to mechanisation. The site has two replicated treatments – controlled traffic based on a 2 m wheel track, and conventional practices (Conv) using random traffic. Both treatments are cultivated as required, although the type, number and intensity of tillage operations varies with the treatment and seedbed requirements. The crop rotation on this site has been chosen based on our capacity to carry out all mechanical operations on 2 m centre wheel tracks in order to maintain the integrity of the controlled traffic system.

Other sites have been established on commercial farms, and have included two vegetable production sites with similar soil type and topography, one site growing pyrethrum, and one site in the northern midlands featuring flatter topography and poorly drained soils. The commercial farm sites have generally been managed using seasonal controlled traffic (SCTF), as the crop rotations do not necessarily permit all operations (particularly harvest) to occur on precisely the same wheel tracks. The sites have tended to be un-replicated, but nevertheless provide comparative data that has proven to be valuable for demonstration and extension purposes. These sites have been useful in identifying issues that need to be resolved at the farm level for more effective adoption of controlled traffic in the vegetable industry.

Measurements at all sites have been broadly similar, and include soil bulk density and related derived parameters, soil resistance (measured by cone penetrometer), and regular soil moisture measurement during the growing season. Bulk density cores are taken at depths 0 – 50, 125 – 175 and 275 – 325 mm and provide data on bulk density, porosity, gravimetric and volumetric water content, water filled pore space and the ratio of soil:water:air in the sample. Soil resistance data are collected at 100 mm intervals across transects that include at least two wheel tracks and the intervening area, to a depth of 600 mm. Bulk density cores have been taken in close proximity to the soil resistance transects, usually at one location in the centre of a bed.

Results

Results from various field sites are presented, along with some observations on experiences gained during the processes of implementing and managing controlled traffic in vegetable production.

Porosity

Porosity data at 150 mm depth, which is the approximate depth of final seedbed tillage, are presented for two sites, one being the main research site and the other being a replicated on-farm site which is managed under seasonal controlled traffic. Data for other depths reflect similar trends, although the magnitude of differences varies. Porosity is derived from bulk density samples. Although soil samples have been taken more frequently, only those from mid-growing season times are reported here. Porosity under controlled traffic is consistently higher than under conventional management, with the exception of Jan 2012 (Figure 1).

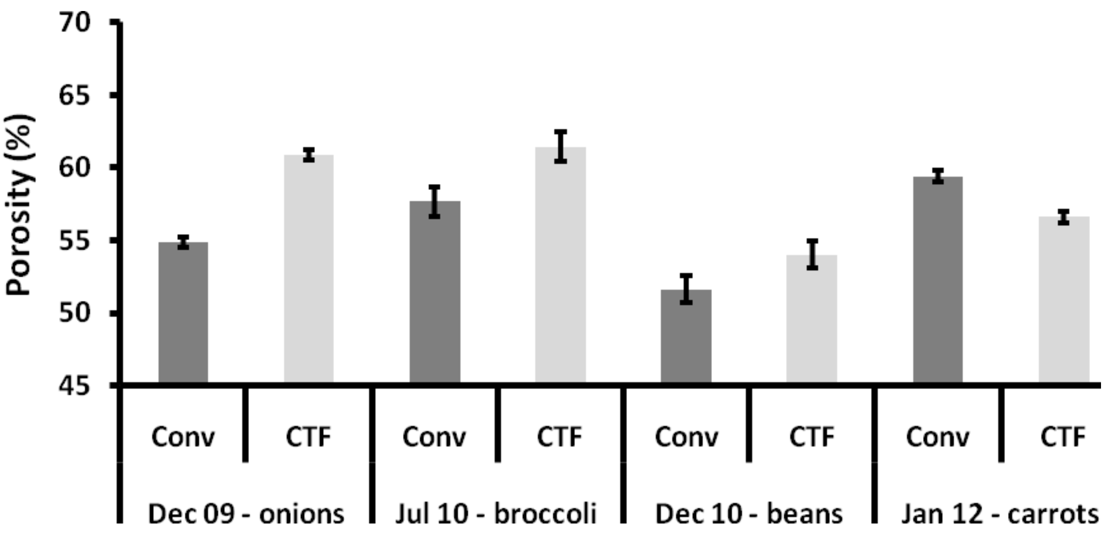

Figure 1. Soil porosity at 150 mm depth at the main research site from areas managed with conventional tillage and controlled traffic. Error bars indicate S.E. of means. All differences between treatments are significant (p<0.05) with the exception of the data for Jul 10.

The second site for which porosity is reported is on a commercial farm with replicated areas managed for 18 months under seasonal controlled traffic. Figure 2 shows higher porosity under controlled traffic in the third cropping season.

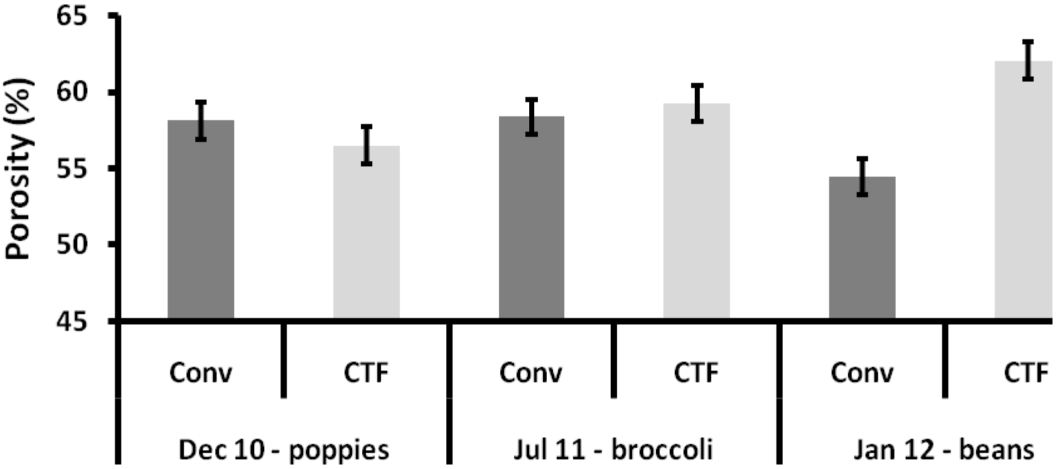

Figure 2. Soil porosity at 150 mm depth on a commercial farm site with areas managed with conventional tillage and seasonal controlled traffic. Error bars indicate S.E. of means. The differences between treatments for Jan 12 are significant ($p<0.05$).

Soil structure score

A visual scorecard has been developed to assist in the assessment of soil structure (Cotching 2009). The assessment allocates a score of 1 to 10, with 1 being very "poor" structure and 10 "well" structured. Figure 3 shows the average soil structure score assessed at a number of locations on a commercial farm site with areas that had been managed with conventional, seasonal and fully controlled traffic. While there is inevitably some subjectivity in such assessments, it is clear the soil structure in the two main treatment areas differs by at least two units in the scores, and the seasonal controlled traffic data lies between the other scores.

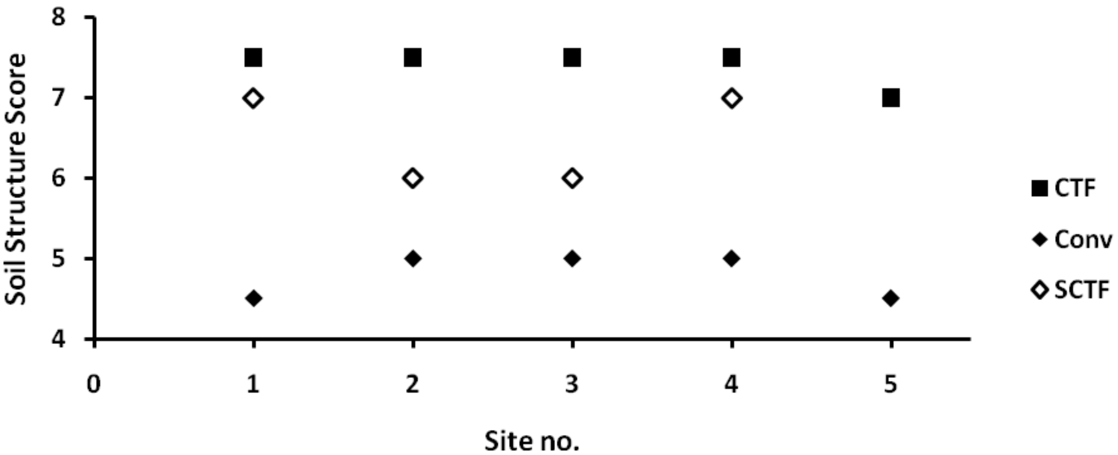

Figure 3. Visually assessed Soil Structure Score in accordance with the method of Cotching (2009). Each data point represents the average of two samples.

Tillage operations

The main research site is the only location where obvious differences in tillage requirements have been noted to date. Table 1 shows the number of tillage operations performed in the transition between each of the crops grown on the site. This shows a reduction in the number of tillage operations under controlled traffic of almost 40% over four cropping cycles, with reductions in individual seasons of one to two operations.

Table 1. Number of tillage operations to transition between crops managed under conventional and controlled traffic systems.

Crop transition	Conventional	CTF
potato – onion	4	2
onion – broccoli	3	1
broccoli – beans	4	3
beans – green manure – carrots	5	4

Discussion

Porosity

The increase in porosity under controlled traffic has implications for water holding capacity, drainage, aeration and root growth, all of which can be beneficial for plant growth. The increase in porosity in Jan 12 on the main research site (Figure 1) is thought to be due to some changes that were made to tillage operations between the two treatments. These changes were made on the premise that the controlled traffic area should manage with shallower tillage, but in hindsight, this may not have been the case. Improvement in porosity at the commercial farm site (Figure 2) indicate that soil condition benefits can be gained, even if the controlled traffic system is compromised by seasonal harvest traffic.

Soil structure score

Although the site from which these data were obtained was not replicated, and there is an inescapable degree of subjectivity in the assessments, there is clearly some soil structure benefit to be gained from the controlled traffic and, to a lesser extent, seasonal controlled traffic systems. At the time of sampling, the site had been under controlled traffic for 15 months. The seasonal controlled traffic area had the same history, but had been subjected to potato harvester traffic after 15 months of fully controlled traffic.

Tillage operations

Controlled traffic eliminates compaction removal as a reason for tillage in vegetable production. Therefore, tillage operations under controlled traffic are largely undertaken for residue management and seedbed preparation. This reduces both the number and energy intensity of tillage operations required, as shown in Table 2. The reductions observed in this work are in accordance with observations from other industries.

Conclusion

The changes in soil physical conditions that occur through the use of controlled traffic have impacts across many aspects of vegetable production. Although current tillage practices seek to remediate the impacts of traffic compaction, soil which is not subject to traffic in the first place provides a more robust growing environment under variable climatic conditions and requires significantly less effort for seedbed preparation. The initial findings show clear benefits from controlled traffic for soil management in intensive vegetable cropping. These benefits are likely to consolidate over a longer period of time under controlled traffic management.

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