Addressing the Challenges of CTF for the Vegetable Industry

John McPhee[1] and Peter Aird[2], [1]Tasmanian Institute of Agricultural Research, Devonport, Tasmania, [2]Serve-Ag Pty. Ltd., Devonport, Tasmania

INTRODUCTION

The Australian vegetable industry is a $1.66 billion business (farm gate, 2003/04), with value adding bringing the total to $2.36 billion. The industry is very diverse, with enterprises of every conceivable scale in every state growing a wide range of products. Nationally, the fresh market sector accounts for about 75% of the industry value. The Tasmanian situation is the reverse, being 75% processing based. The Tasmanian vegetable industry is worth $160 million (farm gate) and $360 m packed and processed. Potatoes represent about 50% of the industry value and are the dominant crop (75%) of the processing sector. The Tasmanian industry is contract based in both the processing and fresh sectors. Vegetables grown include potatoes, onions, carrots, brassicas, peas, beans, pumpkins and leafy vegetables. Many farms also grow pyrethrum, opium poppies, cereals, pastures for hay and silage and run livestock.

THE PRODUCTION ENVIRONMENT

Vegetable production occurs across the State, with the main areas in the north-west and north-east hinterland, and in the midlands and north-east coastal belt. There are distinct differences in soil type, topography and farm size between production areas (Table 1).

Table 1. Comparison of the main vegetable cropping regions in Tasmania

North-west/north-east	**Midlands and north-east coast**
Ferrosols (red clay loam on basalt)	Clay loams, sandy and duplex soils
Well drained soils	Well to poorly drained soils
Undulating to steep (10 – 20% common)	Flat to gently undulating
Water run erosion issues	Wind erosion issues
Small holdings (typically 100 – 150 ha)	Larger enterprises (typically about 200 ha)
Expensive land	Cheaper land
Big gun irrigation, pivots and linear increasing	Predominantly pivot irrigation, some big gun
About 75% of vegetable production	About 25% of vegetable production
Greater diversity of crops with some livestock	Smaller range of crops, livestock more likely

Use of leased ground is increasing, particularly for potato production. Contractors are used heavily for harvest, with peas, beans, poppies, pyrethrum, cereals, carrots and onions almost exclusively contract harvested. About 80% of potatoes are contract harvested. Although some crops are planted, grown and harvested year round, most production is based on summer irrigation. Planting intensifies from Sep – Feb, with harvest concentrated in the Jan – Jul period. Harvest often extends into winter, with high soil moisture leading to trafficability and compaction issues. Even in summer, many crops are harvested fresh (eg peas, beans) so pre-harvest irrigation to maintain crop quality results in high soil moisture and similar machine traffic issues.

THE MACHINERY ENVIRONMENT

Achieving equipment track width commonality will be a major challenge in the vegetable industry. The most common tractor track widths used in Tasmania for in-crop work are 1625 mm and 1730 mm (matching 32″ and 34″ potato rows), although some growers have experimented with track widths from 1800 – 2100 mm. Most vegetable crops are grown in rows or beds based on one of those track widths. Larger tractors used for primary tillage and harvest may be on 1830 mm centres. Most tractors in the vegetable industry are 70 – 140 kW, and can attain track centres of 1500 – 2200 mm within manufacturers' standard configurations. For in-crop work, tyre tread widths are 330 – 380 mm, while for primary tillage and harvest work the range is 460 – 600 mm. Equipment used for other crops in the rotation may have other track centre widths and tyre tread widths. As in most cropping industries, the trend in recent years has been to increase work rates with the use of larger, heavier machines, particularly tractors and harvesters. Table 2 shows crops grown on a typical Tasmanian vegetable farm, and relevant equipment track and tread widths.

Table 2. Crops and equipment characteristics typical of the Tasmanian vegetable industry

Dimensions (mm)	**Potatoes, carrots, onions, brassicas**	**Peas, beans**	**Cereals, pyrethrum, poppies**
Tractor track width for in-crop work	1625 or 1730	Generally 1625, 1730 or 1830	Generally 1625, 1730 or 1830
Row crop tractor tyre tread width	330 – 360	na	na
Tractor track width for out of crop work	Generally 1625, 1730 or 1830	Generally 1625, 1730 or 1830	Generally 1625, 1730 or 1830
Non-row crop tractor tyre tread width	460 – 600 530 common	460 – 600 530 common	460 – 600 530 common
Harvester track width	2200 – 2640	2200 – 2600	3000 – 4000
Harvester tyre tread width	300 – 750	400 – 750	700 – 800

BENEFITS OF CTF TO THE VEGETABLE INDUSTRY

The benefits of controlled traffic are well known from the grain industry and include improvements in soil structure and biological activity, infiltration, water holding capacity, yield and operational efficiencies through lower fuel use, lower power requirements, spatial accuracy and timeliness. Additional advantages that could be important for the vegetable industry include:

- potential to achieve more uniform maturity in many vegetable crops, with consequent improvements in harvest and processing efficiencies and product quality
- reduction in clod load to make harvest of root, bulb and tuber crops easier and cheaper
- opportunities for new spatial configurations for many crops, with the possibility of increased plant populations and yields
- elimination of heavy tillage operations and adoption of direct drilling to allow retention of crop residue and cover crops for controlling erosion and weeds
- direct drilling and guidance to allow permanent or semi-permanent drip irrigation systems, with consequent benefits for water use efficiency and foliar disease management
- improved opportunities for mechanical weed control through better guidance, which may become important with the development of herbicide tolerance in weeds, or for organic production

SOME OF THE CHALLENGES IN THE VEGETABLE INDUSTRY

Given the inter-dependence of many operators in the industry, it is not surprising there is debate about the best track width to use for CTF. Many options are discussed, but for the sake of simplicity, the options of 2 m, 2.5 m and 3 m will be covered here. Most potato, carrot and onion harvesters have track widths of 2.2 – 2.4 m, although there are exceptions. Most potato harvesters are bunker equipped single row machines, and track configurations are not symmetrical, with an out-rigger wheel required for stability. While it is possible to side-shift the digging front further than one row from the tractor, tracking and stability on sloping land are major issues. Some USA potato harvesters offer the option of tracking directly behind the tractor with wheels that can straddle the bed, but it means a major change to harvest operations, with the addition of an extra tractor and chaser bin to the system.

Top pull carrot harvesters are another issue. They harvest only one or two rows at a time at row spacings that may be narrower than potatoes. Tricycle-style self-propelled carrot and potato harvesters compound the problem, as these leave tyre tracks over 65% of the width of the machine on a single pass. The entire paddock is subject to multiple wheel passes at harvest.

In short, there is no commonality between tractor and harvester track widths, regardless of the crop.

A consideration in most vegetable growing areas, and particularly in Tasmania, is the width of tractor and machinery combinations for road travel. Vehicles exceeding 3.5 m total width on highways, and 3.2 m on minor roads, require at least one escort vehicle. A significant amount of travel occurs on minor roads. The road transport issue indicates a track width of 3 m maximum, but preferably less.

Soil erosion and drainage

Almost all vegetable cropping in Tasmania occurs on undulating land, particularly in the north-west and north-east. Slopes of 10 – 20% are common, with isolated parts of paddocks up to 35%. Erosion from rainfall or irrigation run-off is evident in current row and bed cropping situations, such as onions, carrots and potatoes. Compacted traffic lanes in a CTF system are seen as an erosion risk. Whether or not this is a justified concern, there are a number of measures that can be used to reduce the risk:

- *Farm layout* – a CTF layout would consider soil erosion risk as one of the primary issues. Key objectives are to ensure drainage down the slope and deal with concentrations of flow through appropriate drainage structures.
- *Run-on and run-off* – overland flow across paddocks could be reduced by construction of appropriate drains to prevent water flowing on to a paddock, and controlling it as it flows off.
- *Infiltration* – with a wide track CTF system, and retention of crop residue, a greater portion of the paddock will have improved infiltration conditions. The wheel track area will result in much less total run-off than current farming systems. It may even be possible to direct run-off from the wheel tracks into the cropping zone, which will have a much greater capacity for infiltration.
- *Irrigation* – the use of drip tape would immediately eliminate irrigation run-off in the wheel tracks, and alternative sprinkler packs on liner move irrigators could be used to reduce the problem. Pivot, solid set and travelling irrigators present issues with no clear resolution at this stage.
- *Straw barriers* – the use of straw barriers in furrows has been shown to reduce the speed of run-off flow and to retain soil on the paddock. Use of a recently developed “straw machine” would assist with erosion control in conjunction with the other methods outlined above.

Many Tasmanian vegetable paddocks have complex slope profiles, so strategic drainage, perhaps with grassed waterways, may be required to ensure traffic lanes remain firm and trafficable when wet.

Farm and operational logistics

Tasmanian vegetable farms tend to grow a very diverse range of crops. Paddocks often have irregular shapes, with many being dissected by drainage lines or having boundaries dictated by dams, creeks or other features. Slope may be an issue for maintaining accuracy of traffic, particularly in wet conditions. GPS will assist directional tracking, but it is still important to maintain traction on the wheel track to keep the equipment on track. The cost of GPS units would also be an issue for many operators on relatively small farms.

Headlands are usually planted across the slope and harvested first to allow room to turn harvesters at the end of the row and for parking trucks. Such an arrangement is inconsistent with the objectives of controlled traffic. Headlands could be grassed, but land is valuable and up to 5% of a paddock area could be devoted to permanent headlands under such a strategy. An alternative would be to crop the headlands anyway, and accept they will not be managed under a controlled traffic system.

THE CURRENT SITUATION

Technical challenges to the introduction of controlled traffic in the vegetable industry are considerable, but all within the bounds of possibility if there is the will to change and the benefits are worth pursuing. The processing vegetable industry is under significant economic pressure due to rising input costs and cheap imports of processed product. There has been a change in the profile of CTF in the last year. A number of growers have joined the conversation, recognising the potential benefits of CTF, but issues of machine configuration and compatibility dominate the discussion. In the grains industry, an independent grower may make a personal decision to convert to CTF and be faced with modifications to maybe five machines. In the vegetable industry, a grower deciding to change track width may need to consider modifying at least six owned machines, and the consequences of that change for up to eight contract harvesters for different crops.

WHAT TRACK WIDTH?

Although there is currently some discussion around appropriate track widths for the vegetable industry, there is no one width that stands out as being obvious. Table 3 outlines track width options and the implications for availability of machinery to suit.

Table 3. Some track width options to consider for a CTF system in vegetables.

Track width centres (mm)	**2000**	**2500**	**3000**
Approx. bed width (mm) [A]	1500	2000	2500
% area wheel tracks [B]	25	20	17
% reduction in number of passes [C]	19	35	46
Equipment availability or opportunity for modification [D]			
Tractor	RA	A	A
Precision seeders	M	M	M
Potato planters	A	A	A
Potato harvester	?	A	A
Onion harvester	A	?	A
Carrot harvester	?	?	?
Bean harvester	NA	M	M
Pea harvester	NA	M	M
Grain/py harvester	NA	NA	RA
Poppy harvester	A	?	A

[A] – calculation of bed width is not exact. The maximum width of a bed is the track width less the section width of the tyre. In reality, it is less than this on account of bed shape (ie raised or flat), the accuracy of steering/guidance and the contact width of the tyre. Bed widths have been calculated as track width minus tyre section width (400 mm in this case) minus 100 mm to allow for other factors, then rounded down to the nearest 100 mm. This leads to wheel tracks around 500 mm. This width could be reduced with narrower section tyres, but is consistent with measurements of current non-CTF bed systems.

[B] – the area of wheel tracks is actually the area that is not the bed. The percentage of wheel track area would be smaller if only the tyre section width was considered in the calculation, but in line with the comment under [A] (above), allowance is made for other factors. Once again, this could be reduced with narrower section tyres.

[C] – as tractor track width increases, so does the working width of implements. It is assumed that the tractor is working the same number of bed widths on each pass, so actual working changes with each option. An example would be a potato planter, which in the 1625 mm system would be planting two rows each pass, giving a working width of 1625 mm. For any other track width, it is assumed that a single pass would plant the width of the bed, but the land area covered is the track width. The % reduction in number of passes is referenced to the current 1625 mm system.

[D] – equipment availability, or opportunity for modification, represents the ease with which equipment can be sourced for each track width option. There are a wide range of machines and designs available from different manufacturers, and a comprehensive survey of all options if far from complete. The code in the table is as follows: RA – readily available from local suppliers; A – available, but needs to be imported, or made to order based on a standard machine; NA – not yet known to be available or existing models cannot be modified to suit; M – should be able to be modified; ? – availability, or suitability for modification, unknown at this stage.

One local corporate agricultural enterprise is currently considering a change to 2 m track centres. The primary motivation is to reduce the area of land used as wheel tracks in crops such as onions and carrots, and hence achieve an immediate productivity gain. While CTF is not the major impetus for this move, the company understands that they could move towards CTF in the future. They are also conscious of the implications for a large number of contracting growers if changes to track width are made that require specialist modifications to tractors and other equipment – eg. beyond 2 m centres.

CURRENT ACTIVITIES

One grower is currently operating under a very simple, small scale CTF system. The crops grown are leeks and bunching carrots for the fresh market, so the large harvest machinery associated with most

crops is absent from the system. The guidance system is a straight eye and the paddock layout could be improved. Nevertheless, the site has proved to be a valuable gathering place for others interested in CTF, as it graphically demonstrates the improvement in soil structure and timeliness that can be achieved with a CTF system. We have had a number of gatherings in that paddock as a means of encouraging discussion and ideas about the future of CTF in the vegetable industry.

WHERE TO NOW?

While it is clear that a move to a fully integrated CTF system requires significant change, it is equally clear is that it won't happen overnight. For that reason, it is necessary to consider interim steps towards a full CTF system.

The cheapest way to make a start is to change very little, and most of the important initial steps are not even related to machinery. The following list outlines the priority issues to be addressed for someone considering a move to CTF:

- Get a clear understanding that soil compaction is an issue in vegetable production, and is likely to be affecting crop yield, uniformity of maturity and quality, infiltration, water holding capacity and tillage costs through– this is about the mindset, not the technology.
- Visit other areas and industries using CTF to talk to growers about their experiences.
- Keep all trucks off the paddock at all times – this should be done now anyway.
- Purchase a GPS guidance system for normal paddock operations to improve efficiency.
- Use the GPS guidance system to collect data to generate an accurate topographical map of the farm.
- Design a farm layout for efficient CTF operation, taking into account field logistics, access, drainage and erosion issues, and using a "clean slate" approach to any infrastructure that can be moved – eg fences.
- Make the easier changes to farm layout in accordance with the farm plan.
- Consider how irrigation system planning fits into the farm plan – the options of pivot, linear, solid set, drip and traveller and how they fit with controlled traffic and run-off and erosion management.
- Stop cultivating the tractor wheel tracks – remove the tines and other tillage elements that follow the tractor tyres from whatever equipment is being used. This will reduce power requirements, and with GPS guidance, it will be possible to return to the same wheel tracks after each harvest, regardless of how compacted the paddock has become from other wheel traffic. This step will be easier for some tillage equipment than others.
- Modify tillage equipment for efficiency of working width, taking into account lowered draft requirements due to not cultivating the tractor wheel tracks.
- Modify planting equipment to work only between the wheel tracks.
- Try to establish a rotation that minimises traffic in the cropping zone from one season to the next. Selection of compatible crops in the rotation might include consideration of harvest machinery, opportunity to direct drill, the retention of drip irrigation, use of green manure crops and other factors. This requires rotation planning up to 24 months in advance.

All of these interim steps could be done without changing the track width of the system, and it may be possible to access some equipment to minimise traffic on the cropping zone. This approach provides the opportunity to learn about using and developing the CTF system without embarking on the expense of significant machine modifications, particularly in an industry where total compatibility of equipment depends on the agreements and actions of many players. Beyond these steps, progression to another track width requires modification of a range of machines, particularly harvesters.

THE REST OF THE JOURNEY

Change to a fully integrated CTF system in the vegetable will require a considerable degree of co-operation. Since most crops are grown under contract, the role of fresh vegetable packers, vegetable processors, extractives companies and contract operators will be critical. Each company provides a range of services to its growers, and so is in a position of influence in relation to future directions. Once the first moves are made, it is likely that CTF will exist as a compromise system for some time, while people become more attuned to the idea and have the opportunity to experience their own successes and failures.

The first steps forwards are going to be taken by those who can see the benefits of CTF in the long term, even if they can't fully see how to get there yet. This is a time when those growers who are making the move will need as much support as possible from a range of advisers, machinery suppliers and others. Fortunately, although the vegetable industry has its own set of complexities to deal with, the experiences of the grain industry mean that at least there are people in some areas of the machinery industry who know what CTF is about.