Controlled Traffic Farming

And the application of high accuracy GPS

Farmer Guidelines

Developed by LandWISE under SFF Project: "Controlling the Strip"

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Acknowledgements

LandWISE wishes to sincerely thank all those who assisted in the work that led to the publication of this guide.

Funding was received from the MAF Sustainable Farming Fund, Horticulture New Zealand Process, Foundation for Arable Research, Heinz Watties, McCain Foods (NZ) and Hawke's Bay Regional Council.

Trials were conducted on a number of farms and we received support from many people, including:

David Clark, Mark and Paul Apatu, Hugh Ritchie, John Bostock, Crop and Food, Mike Glazebrook, Willie Agnew, Hew Dalrymple, Neil White, John Austin, David Densley, Patrick Nicolle, John Roach, Jonathon Brownrigg, John Ahern, Ian Yule, John-Paul Praat, Andrew Curtis, Chris Butler, Mike Parker, Andy Luxmore, Terry Jacques, Matt Shan and Trimble Ag.

Overseas people helped build our knowledge too, including John Luna, Paul Blackwell, Don Yule, Scott Shearer, Jamie Grant, and Clay Mitchell.

Introduction

During the life of a crop many different machines will pass over the field. Under conventional cropping systems, it is common for each machine to have a different wheel track, and to work a different width. As a result, most of the paddock is driven on at some stage. The compacted soil causes poor plant growth, and is costly to restore.

Harvester, tractor and gondola all driving on different lines, compacting the soil

With conventional techniques, matching guess rows is imprecise and row spacings are variable. This results in overlapping with wasted inputs and gaps in which yield is lost and pests and weeds allowed.

Controlled traffic farming

Controlled traffic farming is an alternative approach that keeps all traffic to defined wheel tracks. Also known as Tramlining, Controlled Traffic Farming allocates separate areas for machinery and plants, so ideal conditions are maintained for both driving and growing.

The defined wheel tracks provide the best surface for machinery to operate on, and all soil compaction is kept to those tracks. The un-driven on soil will remain in optimal condition for plant growth, reducing or eliminating the need to cultivate.

Permanent wheel tracks or tramlines are retained year after year. Temporary tramlines are established for a given crop or more. They may include raised bed systems or harvest lanes for trucks.

Onion beds are a form of Controlled Traffic by default

Controlling Traffic can bring big changes in soil quality, reducing cultivation requirements and costs while potentially lifting yields. The benefits accrued will depend on the level of system adoption.

Controlled traffic farming is not using GPS. But GPS makes controlled traffic easier, and offers many more revolutionary opportunities.

Advantages

Perhaps the first benefit of controlling traffic is that it reduces or eliminates overlap. Many studies suggest this alone reduces the cost of inputs such as seed, fertiliser and agrochemicals by up to 10%.

Controlled traffic also avoids misses, so all the field is used effectively, with consequential increases in output.

Un-driven on soil remains in top condition after harvest

Keeping traffic off the growing area helps keep soil in prime condition for crop growth. Fewer passes are required. In non-compacted growing areas, minimal cultivation, if any, is required to obtain a suitable seed bed.

Soil with improved structure has better internal drainage, and copes better with adverse weather conditions. Crops experience less stress, resulting in higher yields.

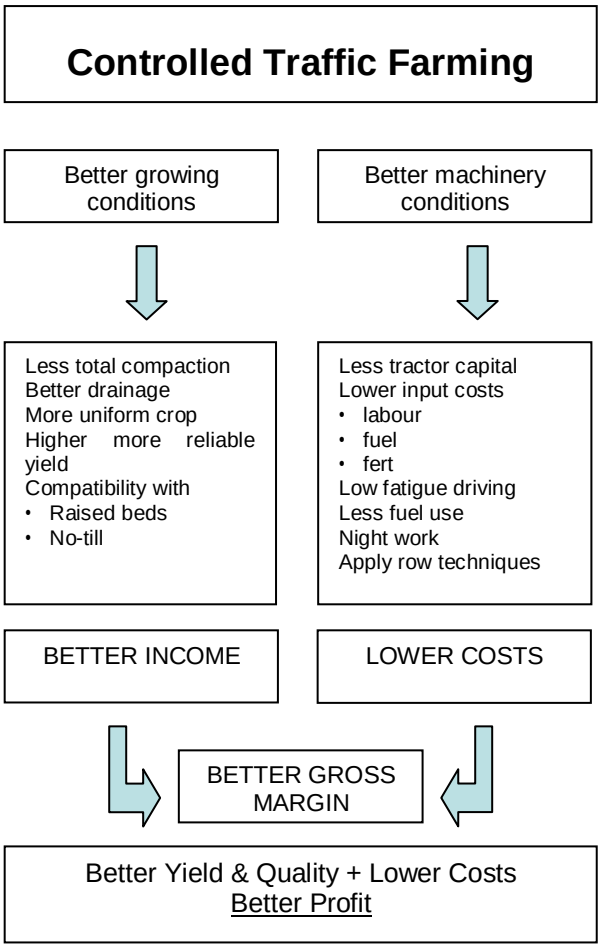
Consolidated tramlines have lower rolling resistance and wheel slip than cultivated soil. Firm ground is able to support higher axle loads, so tramlines also allow safe machinery access in wetter conditions.

Under normal conditions, narrower tyres can be used to carry the same loads.

Consolidated wheel tracks and un-compacted growing soil increases traction and reduces cultivation draft. Less draft horsepower, less time and less fuel are required. All lead to better gross margins.

Firm tramlines reduce rolling resistance and carry weight better

Accurate tramlining enables the use of other techniques, such as band spraying and mechanical weeding. Band spraying allows more expensive agrochemicals to be directed to specific areas, with cheaper products used in inter-rows. Highly accurate mechanical weeding reduces the hand labour needed for crops such as squash.



The advantages of Controlled Traffic Farming

Costs

The main direct costs associated with controlled traffic farming are making machinery fit the tramlines and investment in guidance systems.

Machinery working widths and wheel track widths should be the same and some method of establishing and keeping to the tramline is required.

The speed with which changes are made limits the rate at which the new system can be fully implemented. Machinery replacement policy must recognize this, with a plan to guide purchase decisions that eventuate in a controlled traffic farming system.

Relative soil compaction

Most compaction (80%) occurs the first time a vehicle passes over the soil. After the second pass, little more compaction occurs.

A simple exercise illustrates the difference between conventional and controlled traffic farming approaches. Consider a crop requiring a single cultivation pass, planting, single spray and harvest.

In a conventional system (Diagram A), an 8 row cultivator, 8 row planter, 20 row sprayer and 6 row harvester were used. These compacted 70% or more of the soil with no chaser bin being used. Around 50% was compacted before or during crop growth.

A controlled traffic solution (Diagram B) would match cultivation, planter and harvester widths at 6 rows, and put tractors on 3m wheel centres to match the harvester. The sprayer would cover 18 rows, but could travel on alternate pairs of tramlines.

Under this scenario, compaction is reduced to only 25% of the ground. Shifting the system to eight rows will reduce compaction to 19%. Also as tramlines are well consolidated, tractors could run on narrower tyres, further reducing the area compacted.

Diagram A: Conventional Trafficking

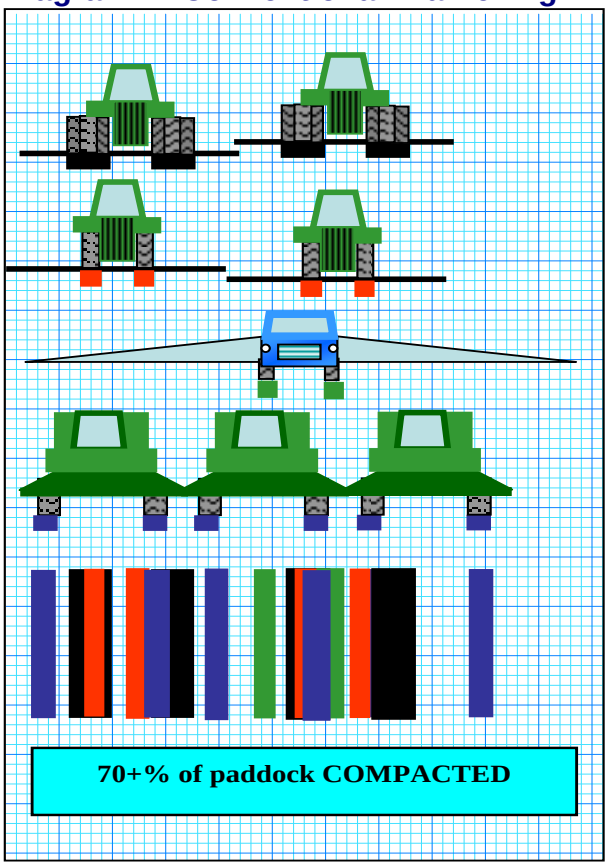
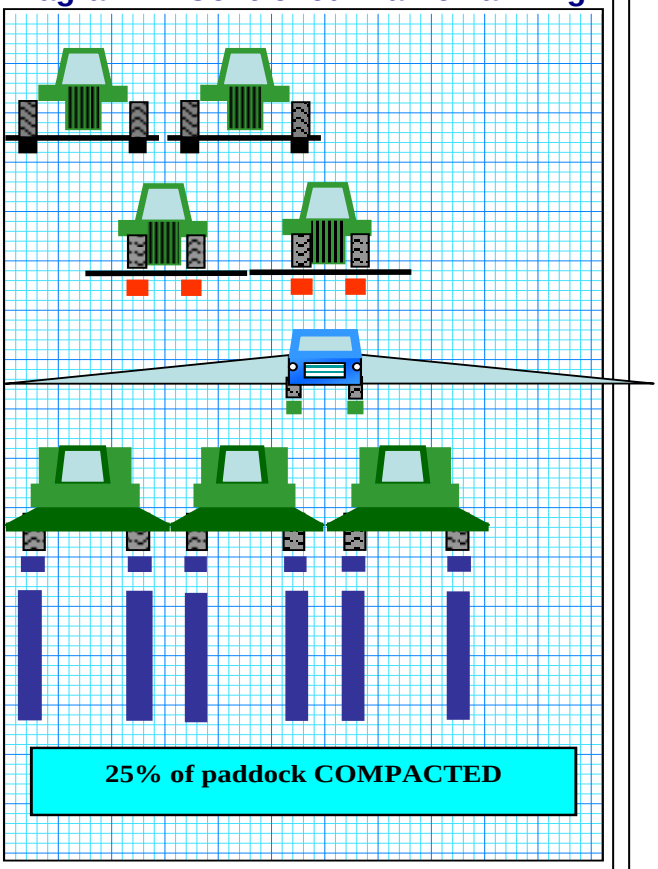


Diagram B: Controlled Traffic Farming



Machinery matching

Machinery matching is a critical element of the controlled traffic system. Only when each machine has the same bout width, or works to multiples of the same bout width, is tramlining possible. And only when wheel tracks are the same can the same lines be used.

Conventional cropping typically has a wide variety of machinery working widths. Plant row spacing varies between crops and the number of rows per pass varies between operations.

Tractor and equipment wheel track widths vary considerably, even in a single tractor machine combination. So converting to controlled traffic usually means significant changes are required.

In most arable and process cropping systems, the harvesting machinery sets the wheel track widths in a controlled traffic system. This is because the harvesters are usually most limited when modification is required.
NOTE: It is essential that checks are made to ensure manufacturer warrantees are not invalidated, and that any such modifications are safe. This can entail design or assessment by a qualified mechanical engineer.

Harvester wheel track is not easily reduced

Combine harvesters, whether for cereals or maize, typically have a 3m wheel track. This is the same as a standard outer wheel track on a tractor fitted with dual wheels.
Rather than reduce the width of the harvester, common practice increases the width of the tractor.

The simplest modification is to remove the inner wheels, and retain the outer ones with the track width that matches the harvester.

Usually the rear wheels are easy to set and require no significant engineering. Similarly, the front wheels on two wheel drive tractors can often be altered quite easily.

Remove inside duals to leave outer wheels on 3m track

Front axles can be easily widened on 2WD machines

The front wheels on four wheel drive tractors are however more complicated to extend, particularly if suspension is fitted. Proprietary solutions include extending front axles, or fitting ‘cotton reel’ spacers to push the front wheel track out to 3m.

With controlled traffic tractors on well formed wheel tracks, duals or extra wide tyres are not normally needed. There is opportunity to reduce tyre width, and the width of the compacted tramline, leaving more un-compacted soil for plant root development.

Axle extension to move front wheel centres out to 3m.

Cotton reel spacer extending front wheel track

While equipment suited to 3m controlled traffic operations is often larger, there are medium powered vehicles available. Most trailed equipment can be built or adapted as required.

Trailed sprayer built with 3m track

Guidance systems

There are various forms and levels of accuracy with guidance systems. They range from simple mechanical marker arms to complex satellite Global Positioning Systems.

Simple guidance such as marker arms can be used to establish a crop. The same wheel tracks can be followed for all other operations. This may be satisfactory for temporary tramlining, but does not unlock the full benefits of permanent controlled traffic.

Global positioning systems (GPS) can either guide the driver such as with light bars or use computerised systems to provide automatic steering on the machine.

GPS use signals from satellites to determine the exact location of a point on Earth. The accuracy varies, and for very precise location a form of 'signal correction' is required.

Simple GPS equipment will guide you to a few metres most of the time. This is insufficient for controlled traffic applications.

Differential GPS uses correction signals sent from satellites, and reduces error considerably. Most of the time, it will guide you to within 300mm of your target point.

At the high end, Real Time Kinematic (RTK) GPS using ground base stations and radio links allows tractors and equipment to be positioned to within one or two centimetres. This is more accurate than even a very good driver can maintain, so computer assisted automatic steering is used – freeing the operator for other tasks.

High accuracy GPS with automatic steering is the 'full adoption' solution. All operations can be repeated along exactly the same wheel tracks. GPS allows very precise tracking time and again even through full ground cover or in the dark.

Summary of Guidance options

Non-GPS

- Marker arms
- Tramlines
- Foam markers

GPS based

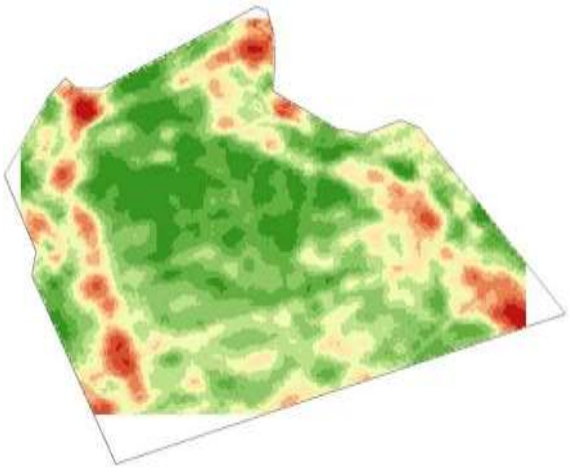
- Machine guidance: (Light bar)
  - Manual steering
  - Broad acre spraying, spreading
- Machine control: (Auto steer)
  - Automated steering
  - Row crops, permanent crop layout

Flow on benefits

Once the decision (and action) to adopt GPS controlled traffic farming is made, the door is opened to a whole range of new management options. These are based on the ability to pin-point, map and record operations anywhere at any time.

Yield Maps

Yield mapping is often one of the first GPS recordings to be adopted. Real time positioning and harvest measurement captures yield data with considerable detail. Presented graphically, this allows farmers to go back and look at why certain areas are performing better or worse.



Yield maps identify variation, allowing further investigation of causes (Massey CPA image)

Product application and traceability

GPS enables guidance and recording of chemical and fertiliser placement.

All machinery movements and applications can be automatically recorded and mapped

Recording applications not only satisfies customer and regulatory authority requirements, but can quickly highlight any missed areas or double ups.

Automatic Recording brings the advantages of traceability without anyone having to physically do anything (much).

Real-time mapping shows work done and helps avoid misses or overlaps

Variable rate technology

In some cases, such as when different yield-potential areas are identified, GPS allows variable rate technology to accurately adjust inputs on the go. Most activity is related to adjusting plant populations or fertiliser additions to optimise rates in different 'management zones'.

Remote sensing

An increasing array of tools is allowing a range of factors to be cheaply monitored. Among these are soil sensors that allow detailed soil zone maps and crop bulk maps to be prepared. These may be combined with yield maps to increase understanding of identified variability at paddock scale.

EM38 Soil scanner mapping soil variability

On farm trials

The highly accurate recording of position and a range of measurable factors increases opportunities for on farm trials. These are easily combined with geographic information systems (GIS) for analysis.

Making Controlled Traffic Farming a Success

Many farmers are making the move to controlled traffic in New Zealand. The energy efficiency and soil quality gains are compelling once farmers understand them.

Some changed their working width and/or wheel centre widths several times in the conversion process. In hindsight they all say, "Decide on the best width for you and go there in one step." They also recommend the highest level of GPS accuracy.

Other lessons learnt along the way include:

- Repair any soil compaction first. If it the soil needs ripping, do it at the beginning. Soil takes a long time to recover on its own. If possible remove tines where tramlines will run.
- Setup the Tramlines in perfect soil conditions, preferably not on soil that is wet or has just been deep ripped or ploughed.
- Use cultivation and planting equipment that you are familiar with - try not to change too much at once.
- Use them or lose them – wheel tracks tend to lose strength over time, especially if not driven on.
- Have a strategic plan – if not changing all of the machinery or farm at once have a goal and a plan of how to get there. E.g. purchase new machinery to fit the new system, even if the system is yet to be fully implemented.
- The reduced draught allows farmers to reverse tyres, reducing tyre wear and damage done to tramlines.
- If the wheel ways get very wet, they will carry far less load and will easily become rutted. If very wet conditions are encountered and it is vital to carry out an operation, the tyre inflation pressures should be lowered to the minimum recommended for the load being carried. Also minimise the load being carried.
- Repair any damaged tramlines. To prevent water ponding in rutted wheel tracks soil needs to be pulled in and compacted when dry.

Prongs pull soil into wheel tracks after rutting has occurred

Rutted wheel tracks

Goal	Technique	Modifications	Guidance
Limit Soil Damage at harvest to reduce cultivation costs	Harvest lanes restrict soil damage to specific zones. Match chaser bin and harvester wheel tracks, drive adjacent tracks	Educate drivers, keep all trucks to specific lane ways Extend axles; extend augers or elevators.	None
Save 3-10% on input costs	Reduce overlap & under lap		Marker arms or d-GPS
Plant accurately after strip tilling Mechanically weed	Use precision techniques to work in straight lines	Install autosteer	RTK
Reduce costs and increase yields	Full Controlled Traffic Farming	Match wheel centres and working widths. Install autosteer.	RTK

Case Study: Opou Station

David Clark farms Opou Station, a 400 ha cropping farm in Manutuke, Gisborne. The main crop is maize, although squash was grown in rotation in recent years.

The medium to heavy clay soils are prone to compaction and soil damage, especially when wet. Wet soils are common in spring when planting is due.

Heavy clay sols are susceptible to deformation and compaction when wet

David has been trying to 'take the load off the soil' for more than a decade. Having tried wider and wider tyres, and a range of alternative cultivation tools, he has now settled on Controlled Traffic Farming. This, together with strip-till and increasingly no-till, is the basis of his cropping operation.

At Opou Station, tramlining keeps soil compaction restricted to only about 16% of the cropped area. This area is for machinery, the remaining 84% is for plants. The result after only a few seasons is visible soil change and a major reduction in the amount of cultivation required.

Conventional traffic compacted soil (on left) compared to that in the controlled traffic area (on right)

Machinery catalogue

Prior to conversion, two main tractors and a lot of the farm's cropping machinery was due for replacement. This was an opportunity to convert everything at once, rather than spread over several years or more. But it still required considerable research and planning.

The Opou Controlled Traffic Farming system is set up around a 12 row (9m) working width. All machinery is on three meter wheel centres, the wheel spacing set by the maize harvester.

A 12 row maize harvester set the standard for the system

Cultivating, planting, fertilizing and harvesting are all done 12 rows at a time. A 12 row shrouded sprayer allows separate treatments to be applied within and between the rows. A 27m broadcast spray boom covers 36 rows (three normal runs) in each pass.

Controlled traffic effects have allowed larger implements to be pulled by similar sized tractors. And standardisation and work efficiency has allowed the number of tractors to be reduced from five to two.

The inside rear duals were removed and the front wheels were spaced out with cotton reels to three meters. Tractor tyres are narrow at 22 inches. This, in combination with highly accurate tracking, keeps compaction to defined areas maximising the amount of uncompacted soil available for plant growth.

Each tractor has been fitted with high accuracy RTK-GPS and auto-steer for guidance. A GPS base station is mounted on the shed roof.

Tractors have RTK-GPS and auto-steer

Field work

Paddock preparation begins after harvest with mulching of crop residues for retention on the soil surface.

The triple flail mulcher unit covers 9m at a pass

The current preferred practice is to strip-till the ground in autumn while the soil is at optimum moisture status – neither too dry nor too wet. It is then left fallow until spring, when the crop is often sown without any further cultivation.

Previously cultivation involved several passes with disc-rippers and soil finishers in spring. Prevalent rain often kept soils too wet and planting was constantly delayed. Now planting can be done in the best windows, and with improved internal drainage, those windows are getting bigger.

A buffalo cultivator is used for side dressing. The high accuracy GPS and auto-steer allows travel speeds of 8-10km/hr, cultivating to within 50mm of the plants.

At maize harvest, a jockey bin travels in the set of tramlines adjacent to the harvester. This has required the harvester auger to be extended, and some modification of the bin is needed to get loading in the centre.

The 12 row strip-till machine prepares strips in autumn with soil in optimum condition

Buffalo side dresser accurately follows plants rows

Jockey bin on 3m centres travels in adjacent tramlines

Unfortunately squash harvest remained problematic. Contract harvest equipment did not fit the 12 row system, and trucks and forklifts continued to cause significant compaction.

Squash harvesting does not fit tramlines

Squash is normally harvested when dry soil is most resistant to compaction damage. David found the clay soil 'springs back' if left for a couple of weeks.

Trucks and forklifts cause considerable compaction

The compaction was removed with as little depth as possible. The strip-till machine was often sufficient.

Where compaction is more severe, a pass with a disc-ripper and follow up with a soil finisher was undertaken, as leaving compaction had a clear impact on subsequent crop performance. Even so, such cultivation every couple of years was a far cry from conventional practice.

Results

The result after only a few seasons is a major reduction in the amount of cultivation required. Reduced rolling resistance further aids machinery efficiency. The effect was noticed by the fuel delivery driver, keen to know why their fuel sales had dropped.

LandWISE trials at Opou Station compared conventional, strip-till and no-till maize being produced under the Controlled Traffic Farming system. Part of the trial area was under no-till for five successive years. The main trial ran for three years.

There was very little difference in the yields obtained. In the first year there was a possible advantage to the cultivated area. By year three this had reversed, with an indication that no-till yields are slightly higher than strip-till yields, with conventionally cultivated yields least.

The time, fuel and cost savings are significantly in favour of the least possible cultivation. On a gross margin basis, no-till is the winner, followed by strip-till with conventional cultivations returns being lowest.

MORE INFO

www.controlledtrafficfarming.com
www.ctfsolutions.com.au
www.ctfeurope.eu
www.trimble.com/agriculture.shtml
www.mitchellfarm.com
www.precisionagriculture.com.au

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See the LandWISE website and seek out LandWISE Notes, fact sheets and guidelines for successfully implementing controlled traffic and a strip-till cropping system.

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