Controlled Traffic Farming at Tichborne

Bruce Watson

Presently, I am a Director in our family grain growing business, Kebby & Watson, which is based at Parkes, NSW. Our business is a 3,500 ha winter graingrowing operation including cereals, oilseeds and pulses, producing approximately 10,000-15,000 tonnes of grain per annum (when it rains). My areas of responsibility include finance, marketing, risk management and agronomy. Our business is utilising the latest in agronomic techniques including Controlled Traffic Farming, Zero Tillage, 2cm autosteer and full stubble retention. We retain a significant portion of grain on farm using silo bag technology and also utilise yield mapping and biomass imagery to assist in nutrition and management decisions. We have also recently introduced 6 capacitance probes to measure soil moisture and infiltration under our continuous cropping regime.

Kebby & Watson was awarded the 2008 Lachlan Slopes Conservation Farmer of the Year award and Bruce is also the Chairman of the Australian Controlled Traffic Farming Association (ACTFA)

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CTF Farmer, My Experiences, Grains

Peter Walsh

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My name is Peter Walsh. I farm 2000 ha in the wimmera area of Victoria. I have been using different forms of guidance and controlled traffic since 2001. This has taken several different forms and today I would like to talk about the pitfalls and successes I have had along the journey.

The initial driving force behind my quest for guidance was my father; at the time he was in his late 70s and was the main driver for the seeder. After 60 years of farming and operating machinery his back (as is the case with many farmers) had seen better years and he had difficulty in turning around to see if he was on line with the last pass. Consequently he would, on many occasions, just overlap a row or two. It was easier to make up marker arms rather than convince him of the necessity of driving accurately.

At the time the seeder was 9.4 mt and I bought a sprayer that was 28.5. After making a pair of full width marker arms that left a line in the centre of the next pass we were ready to put it into action. The first year it worked very well with Dad finding it very easy to follow the mark and when the crop came up I had nice straight lines to guide the sprayer. So here I was nice straight seeding lines and good guidance for in crop spraying, I thought I was controlled traffic farming. Little did I realize at the time how far I actually had to go.

Over the next couple of years we refined the system and to all intents and purposes it worked very well. The harvester did not match but that didn't seem to be a problem. We started to see some results of lining up our major passes and some reduction in wheel damage.

After taking on more land in 04, I increased the seeder to 14.6 mt and extended the sprayer to 29.5 and was spraying on every second pass. I also installed 2 cm RTK in the seeding tractor, a JD 8400. Whilst this gave me better efficiency and the ability to cover more area, it created more problems than it solved. I had dual wheels on the tractor, wheels everywhere on the bar and spraying every second pass was not as efficient as every third pass. Add to this that I now had a much larger (and heavier) harvester with a 10.7 mt front; we had some severe wheel tracking problems and the harvester wheels were completely random. I felt I had completely undone three years of good work.

At the start of 06 I could see I had to change my system otherwise I could never hope to achieve the results I knew were there to be had. Even though we had now taken on even more country I made the change to 10 .7 mt. Everything now matched - tractor and seeder on 10.7 with the tractor on singles and at 3 mt centers, SP sprayer on 3 mt with a pass width of 32 mt, and at long last harvester at 10.7. We are now set at what I believe is the correct combination for our operation. The 10.7 flex front for our harvester works very well and now lines up with everything else. We have RTK guidance on all equipment and the system is finally delivering the benefits that I could see eight years ago.

We still have many things to do to refine our system - like narrow wheels on the harvester and a catcher for the chaser bin - but now we can finally concentrate on the small things to finish off the transformation.

What I want to really emphasise today is that this is a full system and to implement only part of it such as the seeder and sprayer will ultimately be disappointing. Only when you put ALL of your wheel traffic in the same place will the full benefits of reduced compaction become apparent. With the wealth of information and data that is now available it is much easier to implement a CTF system on your farm. I urge you to do it and to do it right from the start thereby achieving your goals much quicker.

Good luck!

Back to Basics - CTF in Central West NSW

Peter Yelland

Central West Agronomist, Yelland Hawken Ag Solutions, Parkes NSW

BACKGROUND

I have had extensive experience in providing agronomy services to the growers in the central west over the past 7 years. This presentation is based on personal experiences and is directed at dry land grain growing.

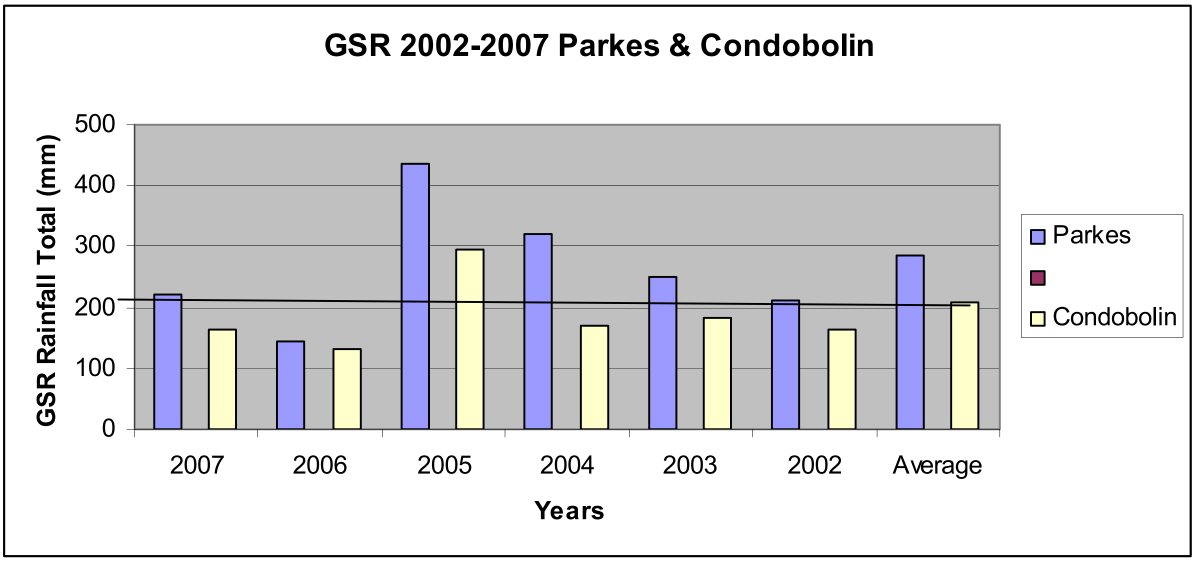
INTRODUCTION

Central West NSW is a traditional mixed farming area with wool production being the predominant up until the last ten years. Like many areas throughout Australia the Central West has moved towards grain production and is seeking more efficient methods of grain growing as costs increase and rainfall appears to have decreased. The central west grain growing region is cereal based with wheat being the dominant cereal grain grown for the high protein noodle market. Barley is also grown and has increased in recent seasons because of its reliability and relatively low cost of production, however its primary benefit is the stubble and its ability to produce large stubble providing essential ground cover. In the past 20 years break crop shave been introduced with canola being the most successful and more recently pulse crops are being used for varying reasons.

The area is divided by the Newell Highway of which differs greatly 100 kms East and West of this point. The average annual rainfall varies from 928mm in Orange to the East and 400 mm in Condobolin in the West.

The soils in the central west are predominantly red brown earths (Red Chromosols) and to lesser degree heavy clay Vertisols, which include some sodic soils. Both of these soils are fragile and in particular the red brown earths as they are not self repairing clays like some northern regions of NSW. Therefore they are more likely to be affected by compaction from both stock and machinery and possibly take a longer time to recover.

The soils are typically low in organic matter and low in most major nutrients not including Potassium, Calcium yet on a whole are reasonably adequate in trace elements.



Graph 1 – Comparison of Growing Season Rainfall in Condobolin and Parkes from 2002-2007 (Source- BOM website)

TILLAGE MANAGEMENT

The Central West like many areas in Australia has observed a rapid change in tillage management in the past ten years from full cultivation to minimum or no tillage. From a twelve month fallows to a continual cropping regime.

For many traditional farmers the compromise of a mixed farm was far too great. They have moved into a full cropping regime, or even in mixed farms have isolated cropping areas from stock, with the benefits very hard to quantify - factors such as:

- Yield increase/mm of rainfall
- Improved soil structure- moisture infiltration
- More efficient weed management
- Reduction in fuel usage
- Greater production/Ha under moisture deficient conditions
- Retaining stubble for moisture conservation

STUBBLE IS EVERYTHING

As in many areas in the dryland cropping areas of Australia ground cover is the lifeblood of our system and every effort should be made to preserve this. With drought conditions beginning in the Spring of 2001 and continuing through and including now it has never been more evident the value of stubble cover in reliable and marginal cropping areas. The challenge appears to be having the ability to start the process off and maintaining it in the initial years. In 2006 (<100mm GSR) the difference of harvesting a crop and not at all was generally directly related to stubble/ground cover.

The challenge is also highlighted under a break crop scenario such as canola or lupins, where their crop residues are so low the following crop yields can be compromised through a lack of stored soil moisture and exposed soil.

Barley stubble to date (generally) has been the most efficient stubble because of its volume and ability to break down quickly due to the favourable carbon to nitrogen ratio. Planting a break crop into a barley stubble is the preferred option of many growers (in a no till, and CTF system) because of the stubble loading effectively providing cover until the following wheat crop.

In the past five years the use of guidance technology has increased dramatically and could well be in the range of 30-40% of growers using some form of guidance. Whilst many growers are do not practice Controlled traffic there is a large percentage who have matched their machinery with the ability of changing into a CTF system. The adoption of Controlled traffic may be as low as 5-10% of growers and growers become increasingly aware of technology advances practices such as controlled traffic will only increase. At this current stage the lack of independent data regarding the benefits of controlled traffic farming in the Central West is evident.

Farm sizes in the Central West on a whole would be smaller than many areas with the average cropping size being an estimated 600 Ha, with the cost of recovery of moving into a CTF system is relatively unknown in the region, we can support the concept with some good theory and provide data from other regions and soils yet don't appear to be able to support that with local data.

Change is something we do not deny in agriculture, yet the facts remain that the average age of the Australian farmer in 2001 was 58 and if you can speak to the average 58 year old and ask him to mark the AB line, check to see how many satellites are available and nudge the machine 5cm to the left, throw the data card into the control box and enter the variable rates into the computer, you could probably understand it if he looks at you a little puzzled. Another fact is that 1% of Australian farmers produce 25% of our food and fibre, which in summary means it is not a matter of how many people adopt new technology for production purposes, it is a matter of the people who adopt the technology maybe on a larger production scale than the average producer.

Many growers in the Central West and possibly in Australia would not have any idea of what CTF agriculture is, simply because they do not understand and in the local area, the lack of data or hard black and white evidence is not readily available. There are many reasons why growers in the Central West of NSW are not using Controlled Traffic Technology and they include:

- Lack of knowledge- Very little independent data and local contacts for information on the benefits of CTF.
- Cashflow- Years of drought have left people with little surplus to purchase new equipment.
- Soil Type- Soil types on the slopes in particular can vary several times in the one paddock.
- Information- Supporting data is also hard to source. For example the Impact of stock on soil structure could it be a myth? Or is it more of an issue than we really think, or how compaction affects our yield or moisture holding capability.
- Terrain- Sloping paddocks, trees and contour banks and water courses make it difficult to establish long 'runs' for machinery.
- Economic benefit relative to area- With many growers farming a small area the cost of recovery from moving to a CTF system is seen as being too great. It is very rare to find a grower farming less than 800 Ha on controlled traffic.
- Visual Issues- Like many issues if we cannot see a yield difference visually form problems such as compaction it may be considered a problem that can be dealt with in the future.

ADVANTAGES OF CONTROLLED TRAFFIC

With many people adopting at least a guidance system it is more evident that the transition into CTF will evolve quite rapidly as the advantages are too numerous to deny. Many people joked about driving a tractor from the office 10 years ago but the reality is with CTF you could be very soon. As many of my clients moved into Auto-Steer for the 2008 sowing season, I have never seen so many people so fresh at the end of a day's work. Most of the time during sowing they will ask you what the news is, now they can tell you before smoko because they have just read all of the morning papers whilst driving the tractor.

One of the biggest issues facing agriculture today is the lack of skilled labour and adding to that is the cost of that labour if you can find it. Believe it or not but technology like CTF will help many growers use unskilled labour to operate machinery, as their concentration levels are not centred on many different functions and fatigue may not become as a bigger factor as previously experienced.

As the world demands more food it seems we as an industry need to produce more food for less, under reduced moisture conditions and less land coupled with soaring input costs, the need for efficiency has never been more evident.

CTF has already shown benefits for grain growers in varying forms such as:

- Reduced overlap - lowering input costs/Ha.
- Nitrogen application - allowing for timely application of both liquid and granular products.
- Fungicide application – with increasing disease pressure and variety breakdown, late fungicide applications are becoming an annual event and the crop damage is minimised with fixed tram lines is greatly reduced making the fungicide disease strategy proactive rather than reactive.
- Herbicide application - resistant weed management allowing late herbicide applications for escape weeds or late germinating weeds, or crop topping or desiccation without compromising crop safety or yield.
- Precise seed and fertilizer placement - inter row sowing is becoming a debate within itself. Hopefully using the relevant technology to inter row sow or sow next to the previous year's fertilizer band in the case of a failed crop. Seeding is possibly the most important operation of the year and precise seed placement can mean many dollars/Ha in profit if germination is uniform and timely.

- Creating own sowing window - a term that is used currently, however can be accurate given adequate stubble cover and moisture retention. Timely sowing could possibly be the best investment growers make in a growing season. Sowing into moisture at the correct time can be very beneficial in terms of profit/Ha.
- Less compaction - compaction is one of the big drivers of CTF throughout the world. Locally the header would have to be the most responsible for creating compaction issues at harvest time. Visually it is not uncommon to see header tracks two years after a wet harvest under a non CTF farming system.
- Reduction in driver fatigue - a common comment is growers are not as tired after a day's work through simply not steering their tractor. By not steering their tractor, the operator can also be concentrating on the tool bar and monitoring any issues associated with seeding depth and machine blockages etc.

CONTROLLED TRAFFIC IN THE FUTURE

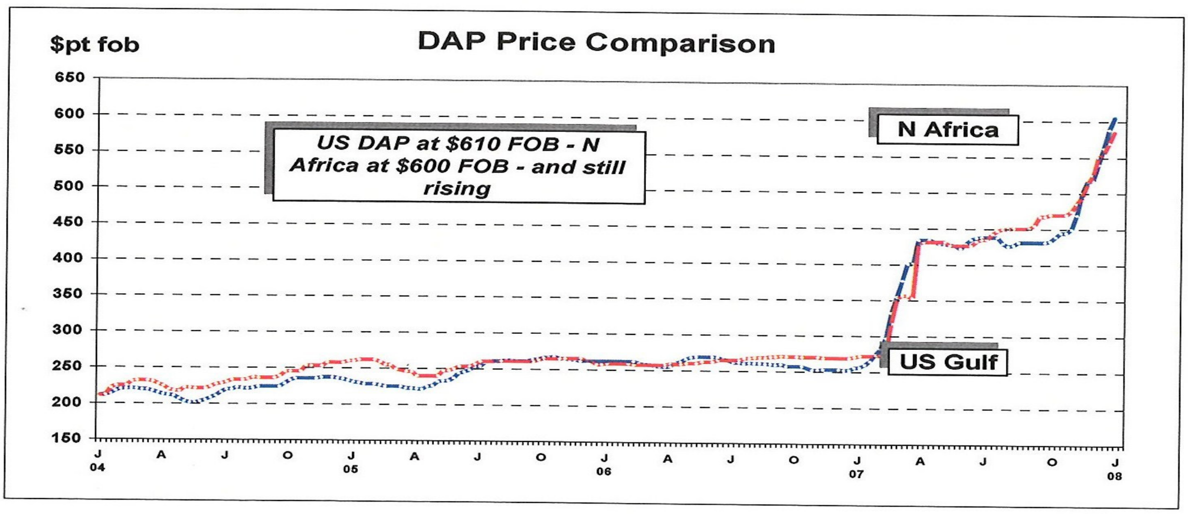
Because guidance based technology has decreased in cost in recent years, the adoption of controlled traffic will undoubtedly increase into the future. With apparent cost savings to be made, along with the many other benefits of CTF, there are many different scenarios as to why the practice will benefit not only from a soil compaction issue.

As previously mentioned, many people have their machinery ready to adopt CTF technology and with the majority using 1 m Auto steer, the jump will not be that great.

As technology advances and more local data becomes available, it will be more evident the value of CTF technology. The need to produce more yield/ha on potentially less rainfall requires a higher management skill coupled with the strategic use of inputs whilst avoiding crop and soil damage from machinery traffic.

With the cost of inputs rising so rapidly the return relative to investment has changed significantly, this places pressure on grower cash flow and a more strategic input use will be required with emphasis on applying inputs on an as needed, and a just in time basis. For example a 100kg/Ha of urea can cost anything up to $100/Ha as opposed to less than $50/Ha only a matter of 5 years ago.

If nutrient prices continue to hold their upward trend, many growers will be forced into seeking alternatives to current practices or refining their current application program through the use of yield and grain quality data and also variable rate sowing and application techniques.



Graph 2 – DAP Price Comparison from 2004-2008 (Source Market News April 2008)

The functions for which CTF could be used in the future in the Central West of NSW

Nutrient application - strategic macro and micro nutrient application during the growing season as yield, moisture, and nutrient measurement command a higher level of input - Paddock Monitoring and Imaging - using NDV1 crop imaging to determine crop growth, stress points and areas of high yield or low yield potential to be used for variable rate nitrogen application.

Variable rate application - utilising costly inputs (fertilizer) more efficiently, obviously allocating money to areas that are consistently high profit areas and reducing inputs on areas that are consistently low performing.

Disease anagement - to help protect yield quality and promote uniform grain size the use of fungicides late in the season are becoming a standard practice in medium to high rainfall zones.

Weed resistance management - late application of herbicides for either desiccation or strategic weed management.

Weed seeking technology - the obvious savings of using weed seeking technology with Glyphosate at $10/litre and also promoting other more expensive chemistry for summer weed control will reduce the reliance and possibly overuse of Glyphosate into the future.

CONCLUSION

With the cost of inputs rising so rapidly in recent years coupled with the variability in climatic conditions, growers are needing to focus on maximising their investment with a profitable return. CTF technology allows the decision making process to be more simplified and precise, whilst minimising the effect on soil structure.

The number of growers to adopt the technology may be minimal in the Central West currently, however it will certainly change where practical for the individual.

The benefits are obvious - it's a matter of making the cost benefit attractive enough to the smaller grower.

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Starting with the Harvester: What are the Benefits and Costs?

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ABSTRACT

This paper examines the costs and economic returns of matching harvest machinery into the CTF system. The common misconception amongst the Australian grain growing community is that it costs too much to modify tractors and other machinery to fit the harvester. This paper demonstrates that Australian and international on-farm research over the past 10 years has found that harvest traffic reduced yields by between 23% and 75%, and costs farmers between $123/ha and $300/ha. Costs of conversions are typically less than $30,000, making the return on investment high.

INTRODUCTION

The effects of compaction on soil properties, fuel use, and grain yield have been researched for many years and results widely agreed on. The soil, crop and economic impact of soil compaction from the grain harvester component of the system are not as widely researched. The harvester is a machine in grain a production system that has the narrowest operating width and the widest tyres; thereby having the largest percentage of compacted area. It is also typically the heaviest machine operating in the paddock, with new machines reaching 20 tonnes plus 7 to 9 tonnes of grain when full.

The harvest operation in sloping landscapes (with contour banks), and without autosteer systems, often leads to huge inefficiencies, which means that harvest traffic can sometimes cover considerable percentages of paddocks (Photograph 1).

Photograph 1: Harvest inefficiencies in sloping landscapes and without autosteer.

This topic has led to considerable debate in the grain growing community about the impacts of the grain harvester compaction on yield and therefore economic return.Yield Many grain producers in Australia believe that harvest mainly occurs during dry periods, therefore there is little or no impact. However, our leading Controlled Traffic (CTF) farmers have a strong message to 'start with the harvester'. This means that all other load bearing machinery wheels be matched to suit the harvester wheel spacing; as it is the most difficult to change.

It is also well known that the most significant soil damage occurs when wheels traverse moist ground, equal to or greater than the plastic limit (Radford, B et al). Whilst this is true, in many harvest scenarios the ground is as least slightly moist. A wet harvest will not only cause significant soil damage and crop yield reduction, it also has substantial effect on the ability to plant the next crop, especially in a no-till farming systems.

So what are the reasons why leading growers are recommending matching the header into the system from the start? What are the costs to achieve this goal, and what are the likely returns?

YIELD AND ECONOMIC IMPACTS FROM HARVEST TRAFFIC

There have been many studies determining the impact of wheel traffic on soils and crop production. Much fewer studies exist on the impact of harvest traffic on yield and economic return, especially in no-till systems (Botta, et al 2008). Below are results from several research trials on the topic.

Research trial A

Jensen and Neale (2001) conducted on-farm research trials on corn (maize), grain sorghum and wheat over a three year period on the black cracking clay soils of Queensland's Darling Downs Region. The cooperating farmer had a unique CTF system whereby the impact of the harvest traffic (harvester, chaser bin) could be differentiated from all other operational traffic (sprayer, planter, and tractor). A small plot harvester was used to gather complete grain yield from each row of crop across the harvester/planter width.

Whilst results indicated that a four fold difference (Figure 1) in grain sorghum yield can occur within a planter width (in this case 9 metres), the average reduction in sorghum grain yield was 50% in those rows adjacent to the highest intensity of harvest machinery (2.40t/ha to 3.59t/ha P=0.07). Taking into account each row's yield, the average reduction in yield across the paddock the paddock was 0.9t/ha. At current grain sorghum prices of $250/tonne, this equates to $225/ha loss.

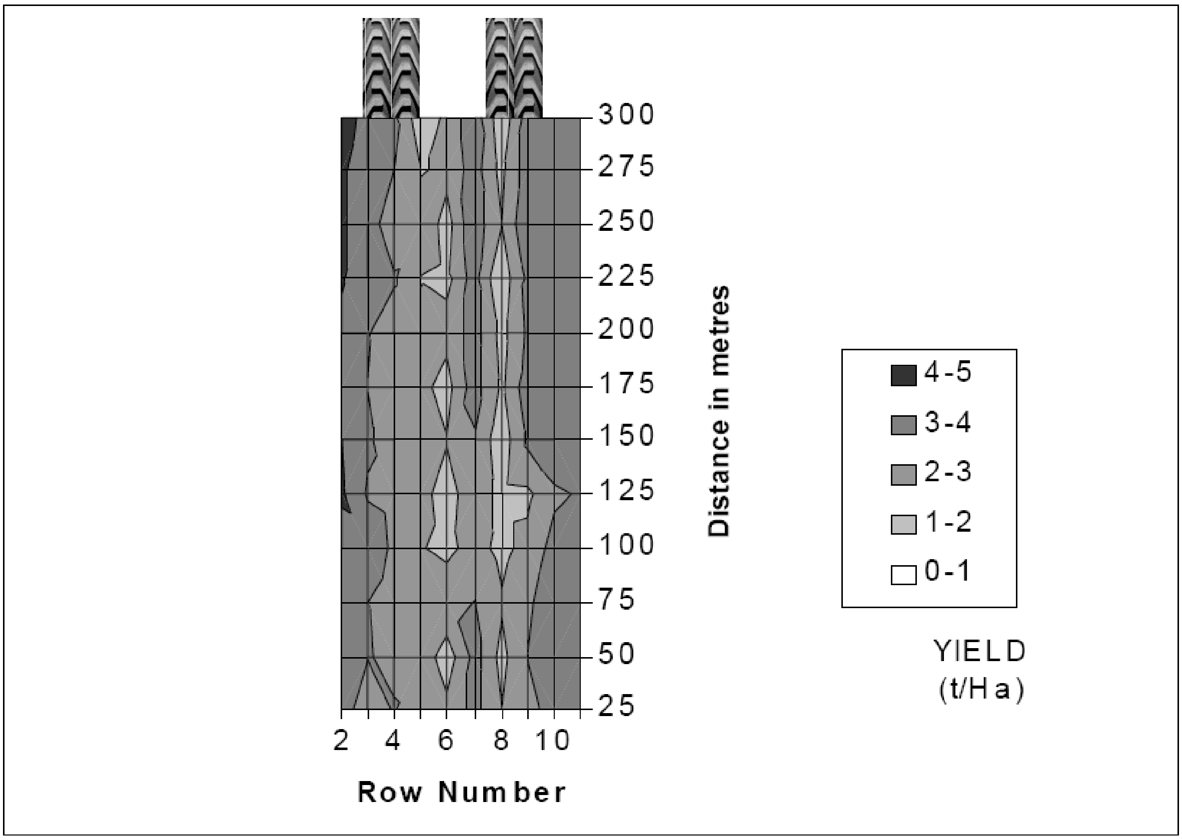


Figure 1: Actual sorghum grain yield map (plot 9m x 300m) showing four fold difference in yield and the position of the harvest traffic

Yield of wheat was reduced from a maximum of 3.5t/ha to a minimum 2t/ha (75% yield reduction) on a smaller plot trial (Figure 2). This 1.5t/ha yield loss, assuming it affected only half of the wheat rows, would equate to an average paddock loss of 0.75t/ha. At current wheat price of $400/t, then financial loss would be in the order of $300/ha.

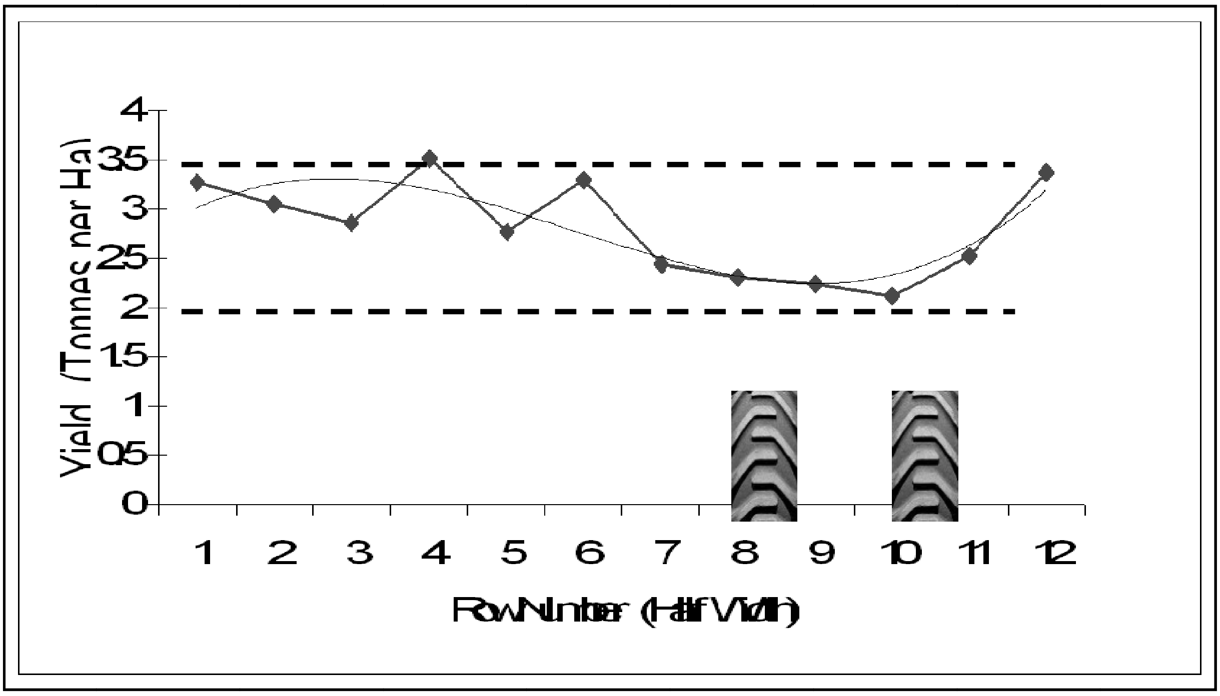


Figure 2: Wheat grain yield (one half of planting width) showing position of harvest wheel tracks

Corn (maize) yield for each row across the planter was also determined using the plot harvester. Results are indicated in Figure 3. It can be clearly seen that corn yield was directly related to number of established plants. Compaction resulted in lower plants established, therefore yield. Yield has been reduced by approximately 50% in the heaviest wheeled areas (4.4t/ha vs. 6.9t/ha). Taking into account average row yields, overall paddock yield has been reduced by 0.41t/ha, which at current corn prices of around $300/t, then this equates to $123/ha.

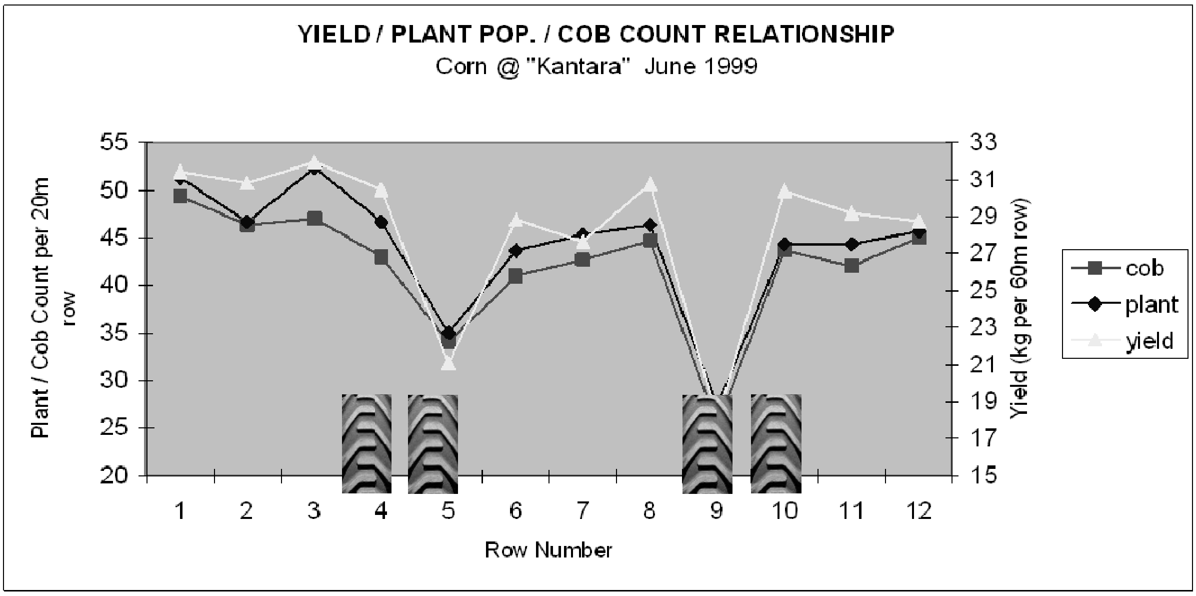
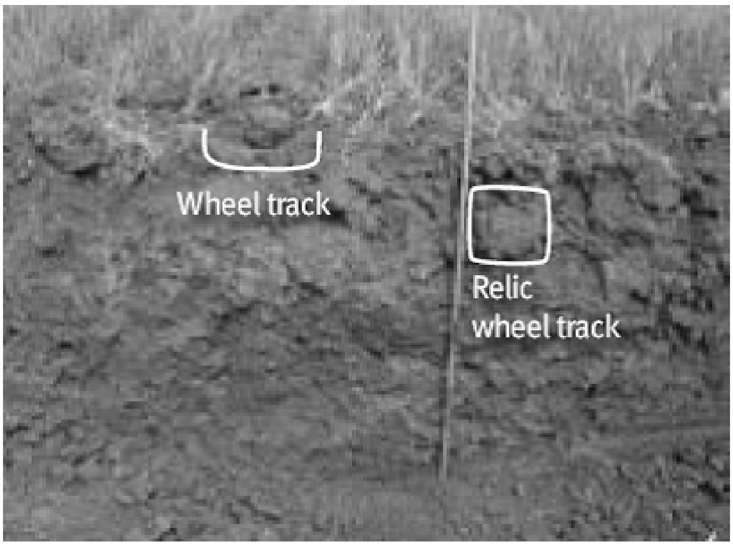


Figure 3: Corn yield and associated cob and plant counts; and the position of harvest wheel tracks.

In sorghum and corn, the harvest traffic never actually drove over the top of the crop rows. In wheat, some harvest traffic wheel drove over the crop rows as the row spacing in Queensland is 0.375m and tyre widths are nominally around 0.8m on a grain harvester, so this was inevitable.

Research trial B

Braunack (2008) conducted on-farm research in Central Queensland to determine the effect of a wet harvest on crop biomass and subsequent grain yield. He found that there was a 16% reduction in biomass and a 24% reduction in crop yield associated with previous harvest traffic. A suggested loss of $120/ha had occurred, however this was based on a wheat price of $300/t. Wheat in today's price is around $400/t, so losses could be in the order of $160/ha this season. Photograph 2 shows the remnants of previous wheel tracks in a soil pit in the paddock.



Photograph 2: Remnants of old wheel tracks in trial paddock are causing significant financial losses (Photo courtesy of QDPI&F)

Research trial C

Research in Argentina by Botta, et al (2007) was conducted on a large plot experiment using farmers' equipment to ascertain damage cause by harvest traffic in no-till farming situations. Whilst many soil measurements were conducted by the research team, it was interesting to note that work rate, fuel consumption and yields were also examined. After three years of research, results were surprisingly consistent. Yields improved in soybean crops by matching harvest traffic was up to 30% and returns were improved by US$134/ha based on soybean price of US$170/t.

Research trial D

Radford experimented with applied harvest compaction over a long term trial at Biloela in Central Queensland. Axle loads of 10t on wet soil reduced seedling emergence, soil water storage, crop Water Use Efficiency (WUE) and grain yield of sorghum, maize and wheat. Average yield reductions of 5 crops were in the order of 23% (0.79t/ha). Assuming and average price of $250/t for these crops, average annual loss of income is around $200/ha.

COSTS AND RETURNS OF A CTF SYSTEM THAT INCLUDES THE GRAIN HARVESTER

The common misconception amongst grain growers in Australia is that converting to a fully matched CTF 'costs too much'. It is fair to say that CTF Solutions deals with more farmers converting to CTF than any other company or organisation in Australia. CTF Solutions has helped over 300 farmers convert to CTF systems; with an estimated 90% of these being able to use and modify their current machinery suite. Obviously many farmers come to our company for advice when upgrading equipment, as to ensure they purchase the right gear for CTF. In this case, we look at marginal capital – i.e. how much of the new purchase price is directly related to CTF. Most people see a CTF grower with a new tractor and immediately assume that you need a new tractor for CTF.

The reality is that modifications to 3m fully matched CTF systems are almost always between $5,000 and $30,000, depending on the available equipment. The main exception to this is in situations where the client has purchased a header with an offset front. In this case, centred fronts would need to be purchased and are normally around $80,000 to $90,000 brand new.

Assuming grain yield losses from harvest traffic are in the order of $200/ha, then an area of only 150 hectares is required to pay back the $30,000 investment in following year. Typically, the average farm size CTF Solutions deals with is normally between 1000-3000 hectares, the economics of matching the harvester in the system is a 'no-brainer'. If a new header front is required, then an area of 600ha will pay back a $120,000 investment in one season.

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CTF – What's the Big Deal?

Rob McCreath

Farmer, 'Prestbury', Southbrook, Qld.

TAKE HOME MESSAGE: INNOVATE OR EVAPORATE

I started farming as a dairy farmer in the south west of Scotland.600 acres (240 ha).45" (1100mm) rainfall.160 dairy cows, 50 beef cows, half the farm under crop – much of it used to feed the cattle. Main crops were wheat, barley, and canola. Due to the wet climate, most grain was dried, or treated off the header with preservatives such as propionic acid and caustic soda. We used tramlines for accuracy, and to minimise crop damage. It was not unusual to drive through a crop 7 or 8 times to apply fertiliser, herbicide, fungicide, insecticide, and growth regulator.

We moved to Australia in 1994.We have 1030 ha, of which 350 ha is in crop We had no idea what equipment we would need, so bought the existing machinery on the farm. The planter was a 6.2 m wide cultivator with mounted airseeder and tynes on 7" (175mm) spacing.We took off half the tynes, and replaced the wide sweep points with narrow ones to improve stubble flow. This machine allowed us to zero-till winter crop successfully, but was not much good for summer. We therefore bought a 2nd hand 3PL summer crop planter with parallelogram planting units.8 rows x 30" (750mm), with wider rows behind tractor wheels = 6.2m . Sprayer – 18.6m (3 times planter width).Header – random traffic.

Our farm has some flat ground, but most is sloping – up to7% in some parts, with lots of contour banks.

We have had a Qld Govt Dept Natural Resources/CFI trial on the farm for the past 10 years. It compares crop planted up and down the slope with crop planted across the slope. The trial has shown little difference in water runoff or erosion. In my experience, some paddocks can be badly affected by erosion if planted across the slope.

We have planted crops up and down the slope for approx 10 years. It has worked well in most paddocks; the main problems have been mechanical, particularly the inability to harvest over some of our bigger steeper contour banks. For a time, we planted up and down the slope, and harvested across, but that was very rough on the harvester crossing the wheel tracks.

In 2003 we replaced our 2 planters with one Excel machine. It was 6.4m wide, and allowed us to plant summer and winter crops. It had a mounted twin bin airseeder, with a gas tank towed behind. This allowed us to apply seed, starter fertiliser, and nitrogen in one pass. The header was still unmatched(contractor).

In 2006 we took the plunge and converted to a 3m/9m system. We bought a 2nd hand John Deere 8400 tractor on 3m wheel spacing, and extended the planter to 9m, in order to match a 30' header. We took the airseeder bin off the planter, and put it on a cart, alongside the gas tank. We also bought a 2nd hand Spra-Coupe on the same 3m wheel spacing.

We took part in a project funded by Condamine Alliance, and carried out by CTF Solutions, designed to improve farm efficiency. As a result of this, we completely changed our farm layout. We removed a lot of fences to allow longer runs and removed some contour banks. We put the steepest country into pasture, and reclaimed some flatter area for cropping. We have stopped grazing cattle on crop stubble, and have stopped baling stubble. If we need straw for our cattle, we buy it from our neighbours.

Next step – autosteer, for accuracy and efficiency. It has been difficult to justify the expense We are looking at setting up network of base stations with other growers.

First Steps in CTF for Vegetables in Tasmania

John McKenna

'Echobank', Gawler, Tasmania

INTRODUCTION

We farm 160 ha of land, growing vegetable crops such as potatoes, onions, peas and cauliflowers, as well as poppies and cereals. We also graze sheep and cattle on both the cropping land and steep grass country.

- Number of farms 3
- Area cropped 120 ha
- Area leased 20-40 ha
- Livestock 130 beef (Fresian and Hereford) and Merino wethers
- Years farming 24

WHY AM I INTERESTED IN CONTROLLED TRAFFIC FARMING?

Our current production methods for vegetables have big inputs and are hard on soil. Most harvest operations are done by contractors. Harvest schedules are often determined by factory intake schedules, so sometimes we have to harvest when we really shouldn't in terms of the soil conditions. Intensive tillage is an accepted part of life in the vegetable industry.

The current system has many limitations – high fuel and time use, with many tractor passes, soil compaction and declining soil quality. Rising fuel costs are just one of the reasons to look at other ways to do the job.

GETTING STARTED

Discussions about soil management and the potential of CTF have been going on for a few years. The current work started through involvement in a National Land Care Program Project that assists with adoption of sustainable practices on-farm. A 8 ha paddock was chosen to trial CTF in an onion crop in the 2007-08 season. The paddock was divided into areas of conventional practice and CTF based on 1.6 m track width, which is the current standard in the industry.

The paddock was sown to pasture in March 2006, and cut for silage early October 2006 and late December 2006, and then sprayed off for onions in March 2007. Two tractors were fitted out for GPS guidance. Initial cultivation was done with a 3.2 m wide Agroplow in August 2007. In the CTF area, the tynes that would normally follow directly behind the tractor wheels were moved sideways so the wheel tracks were left intact. The second tillage operation was with a power harrow – 3.5 m wide in CTF and 2.9 m wide in the conventional area. Once again, the tynes following directly behind the tractor wheels were removed so the wheel tracks were left intact. A lot of dirt was thrown over the wheel tracks in this operation, so they weren't really visible after tillage, but the compacted trac was left intact. Onions were sown in August.

DURING THE SEASON

Irrigation monitoring indicated that the CTF area retained moisture better, but we weren't able to alter the irrigation applications between the conventional and CTF areas. There was also some evidence that the onion roots in the CTF were finer and more numerous.

HARVEST

A few different types of harvesters are used in the onion industry, but none of them are suited to CTF work in their current setup. A centre-pull direct loading Top Air harvester was leased by the project, with wheel tracks set to 1.6 m. Onions were loaded directly to a box trailer, which is not a commercial arrangement, but all we could do at this stage in an effort to maintain the CTF wheel tracks.

AFTER HARVEST

It is obvious that filtration in the CTF area is much higher than in the conventional area. Run-off during heavy rainfall has been observed in the conventional area, but not in the CTF area. Because there was wheel compaction on parts of the bed, it was necessary to rip the beds again with the Agrow plow tynes moved away from wheel tracks. Fuel savings for this operation were about 20% compared to the conventional area. It was also a faster operation. The tilth of the soil was much better in the CTF area.

SOME TEETHING PROBLEMS

There have been some reliability problems with the GPS guidance system. Mostly works well, but at critical times has gone off track. It is an intermittent problem that is taking a lot of sorting out.

Removing the tynes from the rotary harrow gave a deep friable seedbed tilth, maybe too soft for onions. We think this led to some depth control issues compared to a more conventional seed bed, and may have led to early irrigation issues, but it was difficult to maintain adequate moisture in the seed zone.

The tractor used for lifting and turning windrows was not GPS equipped, and windrows were shifted sideways. The harvester elevator and box trailer were not a good match, and with the windrows shifted from their original line, we ended up with more wheel compaction than we had wanted.

LESSONS LEARNED

- CTF is all possible, with the right equipment. This is one of the key issues in the vegetable industry, because there are so many different pieces of equipment used (particularly harvesters) and they are not designed with any thought given to common wheel track widths or working widths.
- Always use guidance – never let a tractor in the paddock that is not guided and working off the same A-B lines.
- Get guidance issues sorted early and properly.
- Different seedbed conditions due to CTF may require adjustments to planter setting and irrigation management.

WHAT NEXT?

The paddock is currently sown to grass as a green manure crop. We plan to grow potatoes in the coming summer. This is presenting us with some challenges with planting machinery to set up to avoid taking too much soil out of the wheel track. Harvest is also a challenge, as we need to get different equipment than that used for onion harvest.

CTF Sugarcane – Implementing Innovation

Gerry Deguara

Mackay, Qld 4740

Today I would like to share with you our journey to a controlled traffic system in sugarcane. Myself and Barbara and two sons Sam and Joe farm 300 ha at North Eton, approximately 36 kms west of Mackay. In partnership with my brother Tom we also farm another block at Oakdale, approximately 55 Kms west of Mackay, where we cultivate 300 ha, with the balance of the 1950 ha grazing cattle. Probably the main driver for the change was the wet harvest we experienced in 1998 where machinery with 10 tonne axle loads at 1.9 m spacings were driving on 1.5 m rows, damaging cane stools and compacting 70 – 80 % of the entire field. Our initial preference was for a 3 m system harvesting 2 rows at a time, as David Cox does. The problem was there was no commercial harvester available. A decision was made to go to a 2 m system with 2 rows of cane on a bed at 800 mm spacing. It was important that all tyres and tracks were no more than 500 mm wide to achieve with guidance on 25 % of the field compacted.

People say that I am too obsessed with this level of accuracy; but I firmly believe that, in sugar cane, zero till will not be achieved without it. Initially beds were formed with marker arms, but with the help of State Development, an RTK 2 cm guidance system was purchased and the dream of having permanent beds was becoming a reality.

When we joined John Hughes and Tony Crowley's Independent Ag Resources Group, monoculture was shown once again to cause massive soil health problems. A decision was made to stop the practice of plough out and replant and use the fallow period to grow legumes. Initially soybeans only were grown, planted in December and harvested in May. An 11 ha trial was undertaken in 2005, direct drilling chickpeas into soybean stubble. After a four month growing period, these were harvested and cane was direct drilled in early October. Remarkably, the crop still produced 108 t/ha and three years down the track it still looks healthier than the soybean-only fallow. This year we have 26 ha of chickpeas in flower now which will become our normal practice.

Reducing input costs, although difficult, is necessary to stay viable. The move to a legume fallow system has reduced chemical nitrogen requirements by 40% over a 5 year period. The higher density rows have eliminated the need for a grass spraying program in the rations, with residual chemicals only used in plant cane. Shielded sprayers are used in legumes and cane where necessary. The move to harvesting 2 m rows as opposed to 1.5 m rows has reduced harvesting costs significantly, with 30% less travelling and turning required; which, on a 100,000 tonne harvesting group, means a saving of 1800 kms of travelling for a 20 T harvester, which is significant.

Traditionally, legume crops have been ploughed back into the soil, but after purchasing a header, modifications were made to set the wheels at 2 m centres and for the last 4 years all crops have been harvested and sold. The initial crops were treated as bonus income but now they form part of our long term income. The next step is to grow a more diverse range of crops including fibre crops, peanuts and anything else that will let us achieve our long term goal of a 2 year fallow without losing income.

Zero till planting is practised in all our cropping, including cane. There are some challenging issues with the cane, but the benefits easily outweigh any shortcomings. I think the biggest challenge is establishing an even legume crop in a green cane trash blanket. Much good work is being done and hopefully improved planting technology will be available by the time our GPS guided beds become fallow in 2 years.

Harvesting has probably been the biggest challenge, but to me is the most interesting. After our first planting on the 2 m beds, I was approached by Chris Sarich from the BSES to join the 'Back on Track' group. As I had already committed to modifying a harvester, Mackay Sugar made funding available in return for harvesting trials on 5 farms. Although successful, the level of modification was too high and a second machine was modified. State Development provided some funding for the modification and a system to make RTK guidance operate on a tracked harvester. This harvester worked well but when our group size went to 100,000 tonnes, a new John Deere harvester was purchased and modified. The modification involved removing the whole front end of the harvester, including the base cutter box, which actually cuts the cane at ground level. EHS manufacturing fabricated a new box. After the whole front was widened, a new track dead axle was fitted and the machine was ready to go. This machine is performing to the stage where the modifications are gaining the attention of major harvester manufacturers. The hauls out wheels have all been set at 2 m centres. SRDC funding has been made available to make the trailer wheels steer independently of the tractor to minimise the damage on the ends. This has reduced the compaction on the ends by 75 %. Next year we hope to have 2 units similar to a maxihaul reverse filling with GPS to eliminate the need for turning at every end.

As mentioned, 1 year from now our GPS guided beds will become fallow. Achieving uniform strike in our legumes is essential as, without them, our system is missing its main part. Hopefully, planting technology will allow this to happen. After visiting many zero till grain growers, one thing we all share is a change in attitude as to how we view a job well done in the field. From once admiring a clean well cultivated field, I personally take pride in establishing a crop in the stubble of the last crop and hopefully the crop before that. If the income from the fallow period can be maximised, a 2 year fallow will be adopted. The application of mill mud has been under scrutiny for some time due to the high application rates. Over the past three months we have constructed an applicator to apply mill mud at the rate of between 10 – 50 T/Ha. The mud is a by-product of the milling process and is high in phosphorus. The applicator is also being used for composted cow manure at 5 T/Ha. Hopefully many other products will be used in the machine. 50 % funding has been made available for this applicator through the sustainable landscapes program. All N and K are applied as LOS dunder, a by-product of the distillery at Sarina. Our applicator has been modified to use variable rate technology.

A strategy of applying fertilizers and soil conditioners only on beds will reduce nutrient runoff. Our target over a 2 year fallow and a 4 year cane cycle is to reduce our chemical nitrogen usage by 50%; chemical phosphorous usage by 80% and residual chemicals by 60% - which I feel is achievable.

Zero till has been promoted as best management practice, but cannot work independently. Only when a precise controlled traffic system and soil health program are fully implemented can zero till be considered a successful option.

Our family hopes to continue growing cane, complementary crops, run cattle, and contract harvest sugar cane in the long term. Our system has only been possible since 2 cm GPS guidance has become affordable.

CTF Farmer, My Experiences, Grains

Ian Carter

Farmer, Liverpool Plains, NSW

Soils in a Carbon Accounting System

Jeff Baldock

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ABSTRACT

Soil organic carbon consists of a mixture of different materials exhibiting various stages of decomposition, and decomposing at different rates. Recent work has identified four biologically significant types of organic carbon in soils: plant residues, particulate organic carbon, humus carbon and recalcitrant organic carbon (dominated by charcoal). Although measures of total organic carbon are of use, identification of the allocation of carbon to the various fractions provides and improved capability to predict the response of soil carbon levels to current and alternative management practices. Quantifying the amount of soil carbon contained in each fraction is difficult and expensive, but a mid-infrared spectroscopic technique when combined with a statistical analysis appears to offer a rapid and cost-effective alternative. Various options exist to change soil carbon contents but the basic requirement is to enhance the return of plant residues to the soil. Under rainfall limited conditions carbon return will be maximised for any production system if the amount of carbon fixed by photosynthesis per mm of rain is maximised. In designing a system to achieve this goal, it is important to consider both the amount and distribution of rain. Practices that work in regions that experience significant amounts of summer rain may not be applicable to other regions where summer rain is more limited. The potential of adding biochar as a means of enhancing soil productivity and sequestering carbon is also being examined. It is important to define the properties of the biochar in order to ensure that the biochar can achieve the desired outcomes. Because soil organic matter content changes slowly, computer based models are used to examine potential long-term influences of management practices. The RothC carbon model has been calibrated to allow the dynamics of total organic carbon and the POC, HUM and ROC fractions under Australian conditions to be predicted. The influence of changes in wheat production on the amount of carbon stored in the soil was estimated.

Key words: Soil organic carbon, management practices, residues, pasture

FORMS OF ORGANIC CARBON IN SOIL

Soil organic matter contributes positively to a number of chemical, physical and biological soil properties (e.g. cation exchange capacity, structural stability and nutrient availability and storage). Carbon is the major element present in soil organic matter accounting for approximately 58% on a mass basis. However, other elements such as oxygen, hydrogen, nitrogen, phosphorous and sulphur also contribute. Methods of analysis have focused on the measurement of soil organic carbon content with a factor of 1.72 being used to convert soil organic carbon content into soil organic matter content.

The organic carbon present in a soil exists as a complex and heterogeneous mixture of organic materials varying in physical size, chemical composition, degree of interaction with soil minerals and extent of decomposition. Each of these different types of organic carbon will make different contributions to the soil properties. For example, the decomposition of cereal residues will tend to temporarily tie up nutrients; while decomposition of the more decomposed soil carbon fractions will result in a release of plant available nutrients.

Until recently, most studies have focused on determining the total amount of organic carbon presdsnt in a soil and have not attempted to quantify the allocation of carbon to the various different forms present. Although total organic carbon provides an important baseline measurement for assessing the influence of land use on the direction of any induced carbon change, it does not tell us anything about the type of organic carbon present. For example, is the organic carbon dominated by pieces of plant residue, nutrient rich materials or the more recalcitrant charcoal? It is now apparent that detgermining the composition of soil organic carbon can provide a more detailed assessment of the implications of management practices on both the dynamics and functioning of soil carbon.

We now recognise four different types of soil organic matter:

- Plant residues – shoot and root residues >2 mm residing on and in soil
- Particulate organic carbon (POC) – individual pieces of plant debris that are smaller than 2 mm but larger than 0.053 mm.
- Humus (HUM) – decomposed materials less than 0.053 mm that are dominated by molecules stuck to soil minerals
- Recalcitrant organic carbon (ROC) – dominated by pieces of charcoal

The amount of carbon found in each of these fractions is defined using the fractionation scheme given in Figure 1. The surface plant residues, buried plant residues and particulate organic carbon all consist of pieces of plant residue differing in size and extent of decomposition. The Humus fraction t consists predominantly of molecules attached to the surfaces of mineral particles but may also have small (<53µm diameter) particles. The recalcitrant fraction is typically dominated by small pieces of charcoal with average ages >500 years. Large contents of charcoal occur in regions that were historically grasslands and burned regularly and in local depressions. In a recent GRDC project, the allocation of soil carbon to the various fractions was measured. The amounts of each type of carbon was found to vary across locations (Figure 2a) and to be influenced by management practices at individual locations (Figure 2b).

The fractionation scheme presented in Figure 1 requires the use of specialised equipment, is very labour intensive, time consuming and therefore is expensive to complete. A more rapid and cost effective alternative based on the use of mid-infrared (MIR) spectroscopy is currently being examined and developed. With the MIR technology, estimates of the amount of total carbon, particulate organic carbon and charcoal carbon can be obtained rapidly (3-5 minutes) and the content of humus can be calculated as the difference between the total carbon and the sum of particulate and recalcitrant carbon. Although the values obtained using MIR spectroscopy are only predictions, an acceptable level of correspondence between measured and predicted values (Figure 3) provides confidence in the values obtained. Currently the amount of Humus carbon is calculated by subtracting the amounts of particulate and recalcitrant from the total carbon. With further work and continued analysis of Australian soils, this technology may be able to provide a rapid and routine means of quantifying both the total organic carbon as well as the allocation to biologically meaningful fractions.

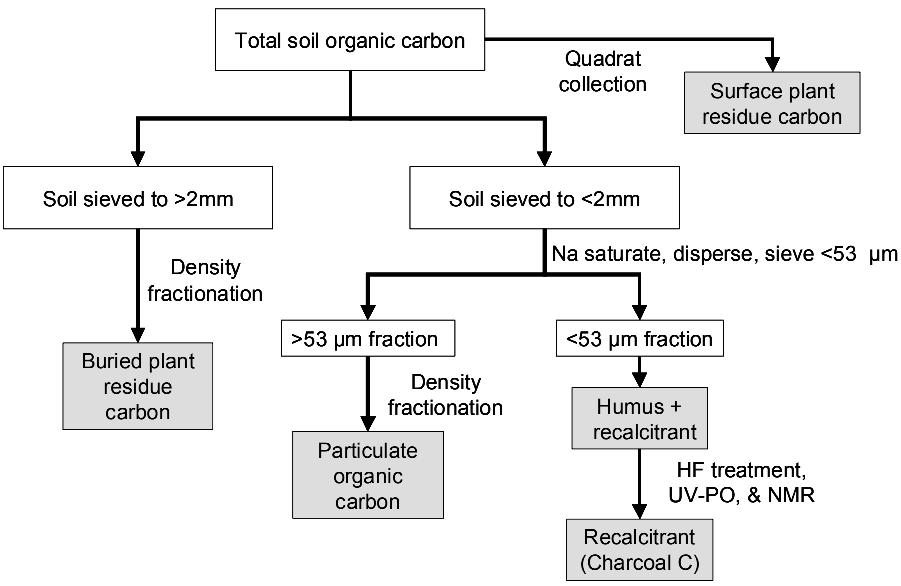


Figure 1. Fractionation scheme used to divide soil organic carbon up into biologically meaningful fractions. The resultant fractions are shaded grey and the Humus fraction is calculated as the difference between the (Humus+recalcitrant fraction) minus the (Recalcitrant fraction).

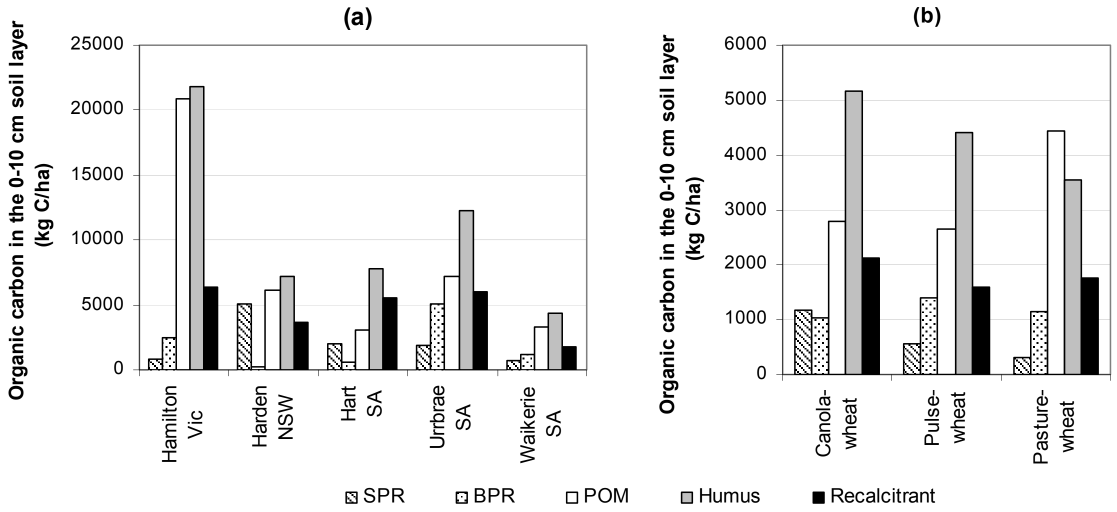


Figure 2. Amounts of each type of soil organic carbon found in the 0-10 cm soil layer at several locations within southern Australia (a) and within different crop rotations at a single location (b). (SPR: plant residues on the soil surface, BPR: plant residues buried in the soil, POM: particulate organic material)

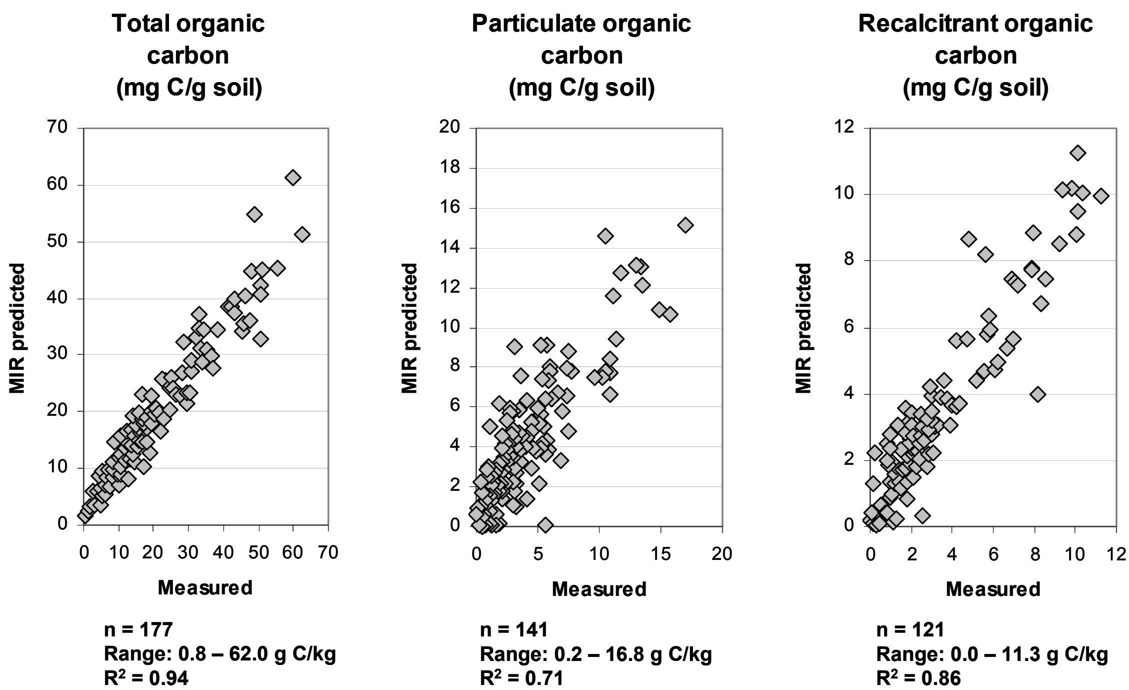


Figure 3. Correspondence between measured and MIR spectroscopy predicted values of total carbon, particulate carbon and recalcitrant (charcoal) carbon for surface layers of Australian soils.

HOW CAN SOIL ORGANIC CARBON CONTENT BE CHANGED?

A simple version of the soil carbon cycle is presented in Figure **4**. Carbon enters the soil as either plant residues or potentially as charcoal (or charcoal like materials) after fires. The plant residues are decomposed by soil organisms and progress through the various fractions discussed above and in doing so the majority of this carbon ultimately makes its way back to CO_2 via respiration. Charcoal carbon is much more stable in soils than plant residues and can persist for >1000 years. As a result much interest exists in regards to using biochar as a means of sequestering carbon (see below).

The amount of organic carbon in a soil results from the balance between inputs (plant residues) and losses (mineralisation of organic carbon to CO_2 during decomposition). To increase soil carbon, a requirement exists to increase the amount of plant residue returned to the soil, decrease the amount of carbon lost via decomposition or both. This can be achieved by enhancing plant growth or reducing stubble removal through gazing, baling or removal. Under the water-limited conditions of most Australian agricultural regions, without irrigation, inputs of plant residues are restricted by climate, principally the amount of rainfall received an how effectively that rain can be used to produce plant biomass. To maximise plant residue returns under any agricultural system (pasture, cropping or other) the goal is to maximise the amount of carbon captured by photosynthesis per mm of rainfall received.

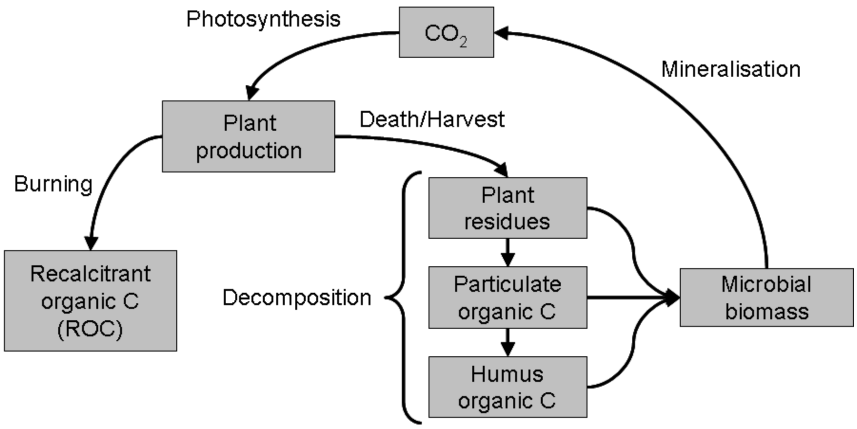
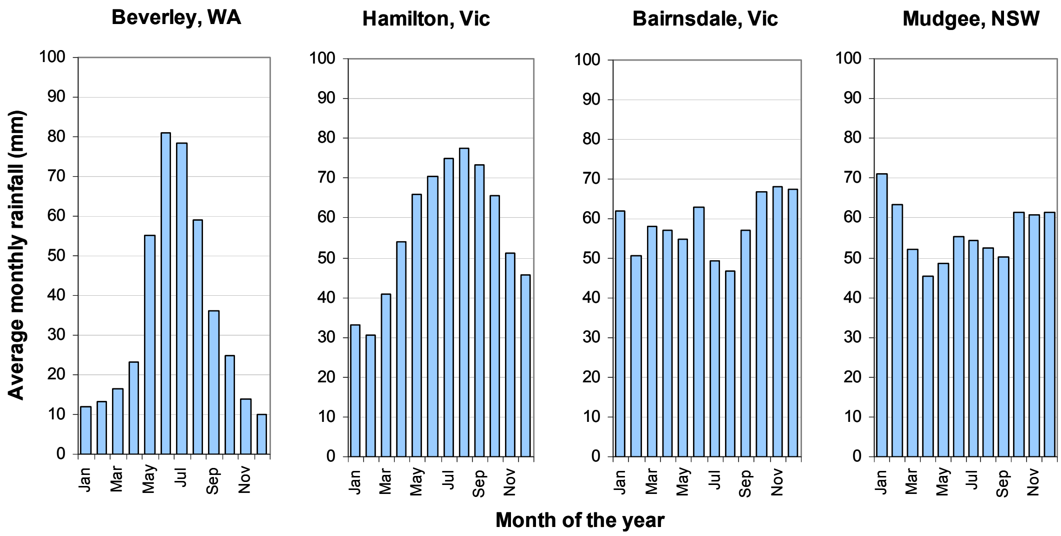


Figure 4. The soil organic carbon cycle. The combined total of plant residues, particulate organic C, humus C, microbial biomass and recalcitrant organic C make up the total soil organic C present.

The distribution of rainfall varies across Australian agricultural regions with winter rains dominating in the west and shifting towards a more even distribution in the east (Figure 5). The implication of this is that in the west, annual winter crops and pastures will be present and active during the part of the year when the majority of rain falls. Only 13% of the annual rain falls outside of the winter growing season and is not available to produce plant biomass. However, in the east, almost 40% of the annual rain falls in the summer months when evaporation demands are high. Although some of this rain may be stored in deeper soil layers and made available to subsequent crops or pastures, the majority of it (>75%) would be lost through evaporation and not be available to capture carbon and produce plant biomass. As a result the introduction of perennial vegetation to maintain actively growing plants over the summer period would offer the potential to increase the amount of plant biomass produced per mm of rain received and increase the return of carbon to the soil. It should be noted however, that it is not just the distribution of rain alone that is important, but also the amount of rain needs to be sufficient to allow the plants to survive and capture carbon throughout as much of the summer period as possible in order to optimise the capture and return of carbon to the soil.

What becomes apparent after considering this issue is that the design of crop and pasture systems to enhance the capture of carbon and return of residues to soil needs to be tailored to the environmental and soil conditions of any given site. It is entirely likely that a system designed to optimise carbon return to a soil located near Bairnsdale, Vic. may not be viable or may not work as efficiently at Beveley, WA. Caution must be exercised in translating the results of particular management practices obtained at one location to another or inappropriately suggesting that similar results could be obtained across the Australia's agricultural regions.

In Figure 6, the influence of altering management practices on the increase or decrease in the inputs of organic residues can be seen. If the change in management practice imposed at 20 years does not change the amount or nature of residues returned to the soil, soil organic carbon content will remain constant (solid black line of Figure 6). If the amount of residue returned increases, soil organic carbon contents will increase to a new higher value with the extent of the increase being related to the increase in the amount of residues returned (dotted and dashed black lines of Figure 6). Conversely, if residue returns decrease, soil organic carbon levels will also decrease (dotted and dashed grey lines of Figure 6).



	Beverly, WA	Hamilton, Vic	Bairnsdale, Vic	Mudgee, NSW
Total annual rain (mm)	**411**	**650**	**639**	**606**
Winter rain (Apr-Oct) (mm)	**358**	**482**	**394**	**368**
Summer rain (Nov-Mar) (mm)	**54**	**168**	**244**	**238**
% summer rain	**13**	**26**	**38**	**39**

Figure 5. Average monthly rainfall distribution, average annual, winter and summer quantities of rain received and the percentage of annual rain that falls in the summer for several locations across southern Australia over the period of 1900 – 2007.

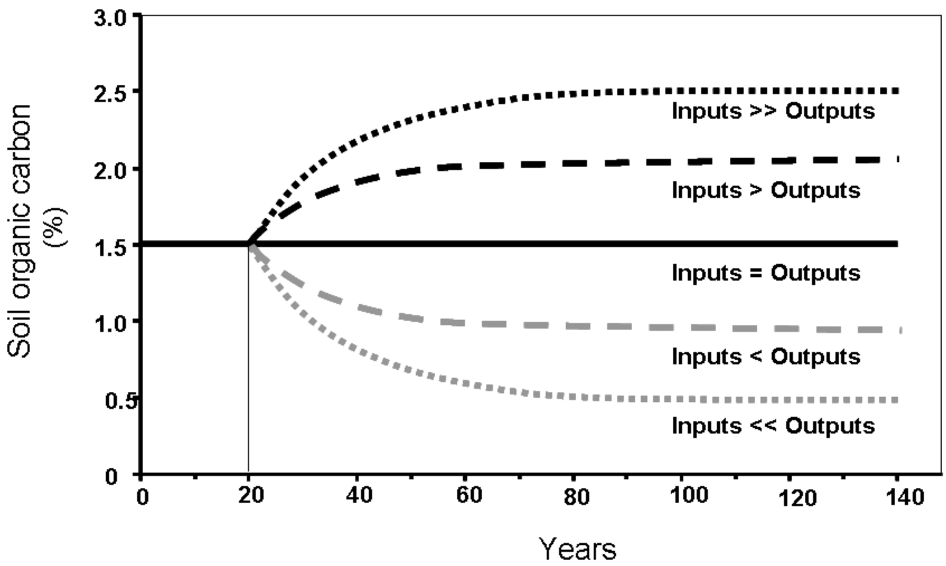


Figure 6. Influence of the relationship between inputs and losses on soil organic carbon content.

An alternative way of increasing soil carbon content and sequestering carbon in soils is through the production and application of biochar. The potential for creating and using biochar is being looked at favourably because it provides a means of producing carbon-neutral bio-energy, it offers a means of sequestering carbon in soils because of its apparent stability and several studies have shown that biochar application can increase soil fertility. Several important issues need to be considered with respect to the application of biochar to soils. Not all biochars are the same. The properties of biochars are dependent upon the nature of the materials used to create them and the extent of heating that they have been subjected to. Thus obtaining a plant growth response with one biochar does not mean that it would be obtained with all biochars. Biochars can carry nutrients (particularly P) and provide a liming potential (particularly for chars with high ash contents) but these characteristics will vary with the source materials used. For example, biochar created from wood would not be expected to have as high a nutrient content or liming potential as biochar created from legume crop residues or municipal green waste. It is important to define why particular biochars induce responses and characterise the properties of available biochars to ensure that intended responses are obtained.

A second consideration in the potential use of biochars is where the source material has originated. If crop residues are burnt in place or removed, burnt and returned to the soil, the biological properties of the soil will deteriorate. The occurs because the substrate that normally provides energy and nutrients to soil organisms (plant residues) has essentially been converted into a material that may no longer be able to meet these requirements. Additionally, if residues are removed from one place, used to create biochar and then applicated to a different location, the build up (or sequestration) of carbon at the application location will occur at the expense of a decrease in carbon at the source location.

HOW MUCH ORGANIC MATTER IS IT POSSIBLE TO RETAIN IN SOIL?

Because of the limitation placed on plant dry matter production and decomposition rates by climate and soil properties, there are specific levels of SOM that can be reached for any system in a particular geographic region and soil type. This is described in Figure 7, where three soil organic carbon (SOC) levels are shown: $SOC_{potential}$, $SOC_{attainable}$ and SOC_{actual}. $SOC_{potential}$ is the SOC level that could be achieved if there were no limitations on the system except soil type. Soil type has an influence because surfaces of clays and other minerals will influence how much organic C can be protected against decomposition. For a soil to actually attain $SOC_{potential}$, inputs of carbon from plant production must be sufficiently large to both fill the protective capacity of a soil and offset losses due to decomposition.

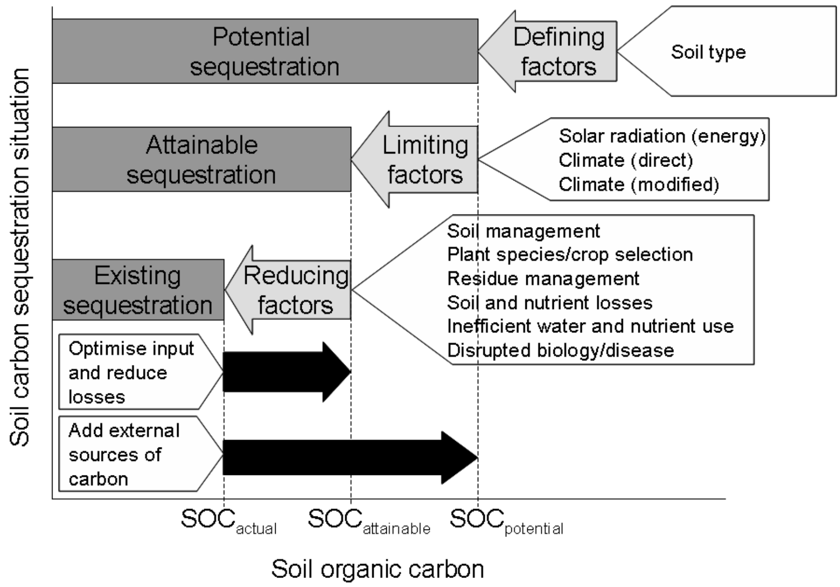


Figure 7. The influence of several factors on the level of SOC that can be reached in a given soil.

The potential amount of crop/pasture material that can be produced at a given location is defined by factors such as the amount of solar radiation, temperature range and availability of water. Under most conditions these factors, referred to as limiting factors, are out of the control of the farmer, with the possible exception of water where irrigation is an option. The amount of crop/pasture production possible after taking these limiting factors into account may be either greater or less than the amount required to allow the $SOC_{potential}$ to be attained. Where crop/pasture productivity is greater than the value required to achieve $SOC_{potential}$ (e.g. under irrigation or where mechanisms of protection are absent or of minor importance) then the attainable soil organic carbon content ($SOC_{attainable}$) will be greater than $SOC_{potential}$. However, under the dry-land agricultural conditions prevalent over most of

Australia, the availability of water sets an upper limit on plant productivity below that required to attain the $SOC_{potential}$. As a result, the $SOC_{potential}$ cannot be attained, and a lower value defined as $SOC_{attainable}$ results.

The value of $SOC_{attainable}$ is the realistically best-case scenario for any production system. To achieve $SOC_{attainable}$, no constraints to productivity (e.g. low nutrient availability, weed growth, disease, subsoil constraints, etc.) must be present. Such situations virtually never exist, and these constraints typically result in lower crop/pasture productivities than required to attain $SOC_{attainable}$. This second set of factors is referred to as reducing factors, which may well be under the control of farmers. Decreased productivity, induced by the reducing factors, leads to lower returns of organic carbon to soil and lower actual organic carbon contents (SOC_{actual}). Optimising agricultural management will allow SOC contents to move from SOC_{actual} values towards $SOC_{attainable}$. Where all constraints to productivity can be removed, $SOC_{attainable}$ may actually be achieved. Under conditions where $SOC_{attainable} < SOC_{potential}$, the only way to move SOC content beyond $SOC_{attainable}$ towards $SOC_{potential}$ is through the addition of an external source of organic matter to the soil, since the level of crop/pasture production required is beyond that which is possible under the ambient environmental conditions.

PREDICTING THE AMOUNT OF ORGANIC CARBON THAT CAN BE PRESENT IN A SOIL

Soil organic carbon content changes very slowly. When this fact is considered, along with the annual variability in rainfall normally experienced at any given location, measurements of soil organic carbon over several decades may be required to accurately define the effects of particular management treatments on soil organic carbon contents. Using data from long term cropping, crop/pasture rotations and continuous pasture trials from around Australia, the RothC soil carbon model (Figure 8) has been calibrated to Australian conditions. By running this model for long time-frames using soil and crop/pasture production data, estimates of the potential soil organic carbon content that will eventually be reached (SOC_{actual}) can be derived.

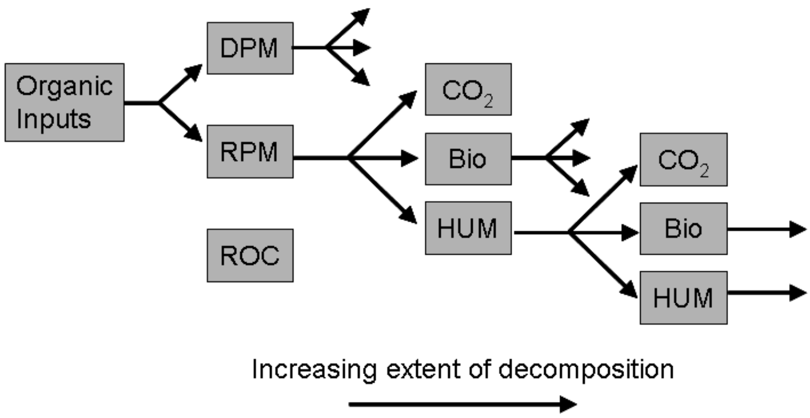


Figure 8. RothC soil carbon model

By using this model, along with the long term average climatic data for Dubbo, NSW, estimates of the long term effect of different levels wheat productivity on soil organic carbon content can be predicted (Figure 7). To complete these calculations the following assumptions were made:

1) crops had access to the rain that fell between April and October (winter crop)
2) wheat grain yield could be predicted using a French-Schultz approach with a slope of 20 kg grain/mm rain and an intercept of 90 mm rain
3) the starting amount of carbon in the soil was defined by that obtained when grain production attained water use efficiencies of (a) 50% and (b) 100%
4) the harvest index of the wheat crop was 0.37, the root:shoot ratio was 0.43 and the carbon content of shoots and roots was 45%
5) all stubbles were retained (no burning or grazing)
6) the soil had a clay content of 15%

The results of these simulations indicate that lifting grain yields by enhancing water use efficiency (WUE) can result in an enhanced soil organic carbon content. However, the increase in soil organic carbon is slow. In Figure 7a were the initial SOC content was set to that obtained for a WUE of 0.5, lifting the WUE to 1.0 (100% water use efficiency) over 25 years gives and additional 18.4 t soil carbon/ha (an average of 0.74 t C/ha/year). This should be considered the best possible case as it requires 100% water use efficiency year after year for the 25 years. In Figure 7b, where the soil organic carbon content was initially set to that predicted for a WUE =1, it would be much more difficult to lift soil carbon content.

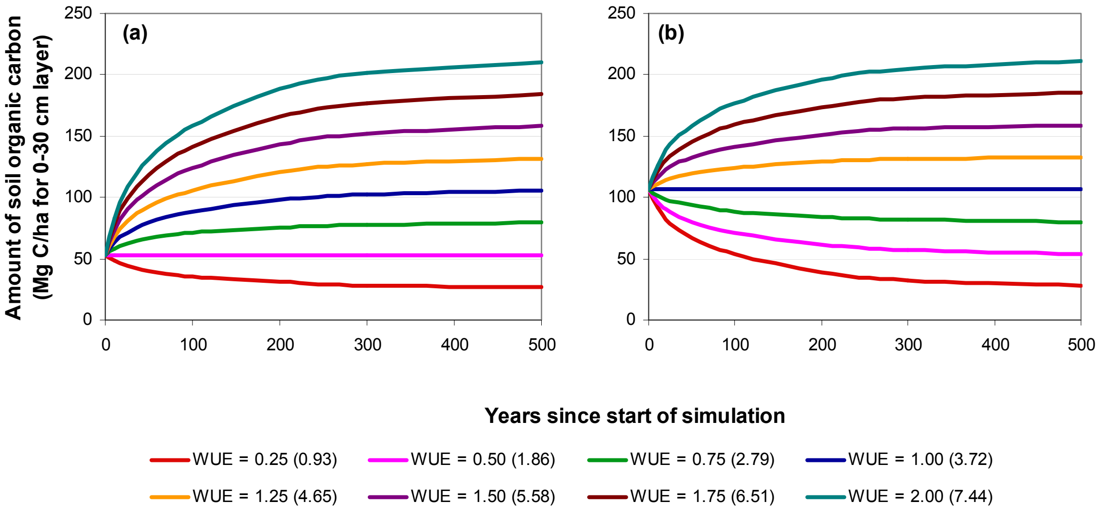


Figure 7. Predicted changes in the amount of organic carbon stored in a soil under different levels of wheat production at Dubbo, NSW using the RothC soil carbon cycling model. A WUE (water use efficiency) value of 1 means that all the crop used all growing season rainfall efficiently to product wheat grain. The corresponding wheat grain yields (t/ha) for each WUE are given in parentheses. (a) uses a starting soil organic carbon equivalent to that obtained with a WUE of 0.5 and (b) uses a starting soil organic carbon equivalent to that obtained with a WUE of 1.0.

It is also important to consider the nature of the organic carbon that is added to the soil. The most responsive fraction of soil organic matter is the particulate organic carbon fraction. During the first 5-10 years after altering a management strategy, almost all of the change (increase or decrease) in soil organic carbon content is related to the change in the particulate organic carbon fraction. The implication of this is that if one is building soil organic carbon, the carbon associated with the initial increase is the most labile form present in the soil and is highly vulnerable to decomposition. What maintains this labile carbon is the constant high input of residues. If this was to stop or be significantly reduced for a period of a few years, the soil organic carbon levels would drop rapidly, back to their values prior to initiating the change in management.

SUMMARY

Organic matter is an important soil component that potentially makes may positive contributions to soil health and potential productivity. Although measures of total soil organic carbon (or organic matter) are useful, measurement of the different forms of organic carbon present is required to correctly understand the dynamic nature of soil organic C and the implications of management practices. The quantity of organic carbon and its various fractions present in a soil is defined by the balance between inputs and losses. Increasing inputs via pasture and crop stubble management practices, will lead to increased soil organic carbon contents. Potential options to consider include enhancing the perennial component of pastures and ensuring that plants maintain a significant soil cover through out the year to minimise direct evaporation of rain from the soil surface. Using a carbon cycling model calibrated to Australian conditions soil carbon contents under different levels of wheat production at Dubbo were predicted. This exercise indicated that significant increases in WUE would be required to shift soil organic carbon contents appreciably and even then the increases would be slow and vulnerable to change as the labile fractions build up first.

Inter Row Sowing - Part of a CTF System

David Gooden

'Pallendina', Lockhart, NSW

ABSTRACT

Inter row sowing is part of our CT system where each crop is sown using +/- 2cm GPS auto steer between the previous year's stubble. Stubble has been fully retained for 5 years with the aim of leaving it standing following harvesting, when residue is spread evenly and stubble cut to 300mm. The combination of reduced compaction, full stubble retention and minimum tillage has led to improved soil structure and overall soil health.

INTRODUCTION

I manage crop production on a 3700 ha family farming operation located at Lockhart in Southern NSW 70 km south west of WaggaWagga. I farm with my wife, 2 brothers and parents. Our farm consists of Red Brown earths of loamy clay to clay loams with a pH of 4.8-6.0($CaCl_2$) over a clay based sub-soil. We have a growing season rainfall between 200-300mm. We grow canola, wheat, barley, faba beans, green manure crops of vetch or peas and have grown triticale.

The move to inter row sowing was a direct relationship with Control Traffic farming which we started 6 years ago when GPS –Ag Auto farm was fitted to our tractors and spaced machinery to 3 m centres and machine working widths matched to a 2:1 ratio. We had never aimed to be seeding between rows in 2002 when we were refining our production system, but saw it as a possibility when I saw it accidentally done at Phil Kerr's and also in our own system previously. The introduction of RTK and +/- 2cm guidance systems was possibly the single most important investment we made, as it gave us the ability to begin the process, thus paying for the investment immediately.

THE PROCESS

We needed a system to drive our productivity and long term sustainability. It was also important to have repeatability for each operation with different operators and to manage input costs at the same time.

Utilising our resources, i.e. land and water, labour and finances more effectively was our initial goal. We aimed to work together as a family business, maximise machinery use to its full efficiency, improve soil health and nutrient cycling, and reduce inputs per hectare.

Achieved goals by:

1. block farming
2. improved paddock layout
3. matching wheels and implement width
4. having a simple robust plan and sticking to it
5. strong family goals and regular meetings
6. using good agronomy
7. doing things on time

Benefits that have followed:

The benefits of developing a farming system has lead to many improvements

1. timeliness of sowing (soil softer and sowing by the date with a lower risk of failure)
2. improved soil condition leading to better water holding capacity and germination
3. application and adoption was simple
4. improved grain quality, yield
5. enjoyment and fulfilment through reduced fatigue (no burning) and knowing we are improving land management and doing something about climate change (increasing soil carbon and microbial activity)
6. reduced labour input into operation and increased efficiency (doing more)

Our machinery:

- JCB 3220 with tasweld 3m axles
- 5000ltr 27m goldacres dual boom (offset nozzles)
- TJ 325 on 710/42R Singles
- 13.5m Janke Bar, 300mm tyne spacing, narrow points and press wheels
- 9000 ltr Simplicity AirCart
- All on 3 metre centres
- Sowing 5000ha (2000ha contract)
- Mark Points prior to sowing (once only)

Importance of good agronomy

Improved crop performance does not happen overnight. It comes from a continual build up in:-

- soil condition
- nutrient balance
- moisture retention (as well as the following…)
- crop management
- weed management
- sowing rate, sowing date
- seed/ fertiliser placement,
- soil compaction
- disease control

Inter row sowing requirements

The success of inter row sowing requires a plan, setting up your machines, getting the right RTK guidance system complete with hydraulic block, managing the residue and leaving the stubble standing, sowing in the same direction each year. Stubble is not disturbed, therefore seeding rates are getting lower, with better germination.

The future

A CTF system allows us to implement and investigate further precision techniques. Variable rate applications shielded spraying as well as inter row nutrition or double cropping has potential; however research needs to keep up with the high adoption of changing farm systems in order to assess the full benefits.

CONCLUSION

The quicker you start farming a CTF system the earlier the benefits, but remember every part in the system from agronomy, machinery, labour must be done to its potential and capacity to achieve its maximum benefit.

Using Precision Ag Technology to conduct Real World, Field Scale Trials to Unearth Yield Limitations

James Hassall

Farmer & IMAG Consulting, Precision Ag Specialist, 'Kiewa' Gilgandra NSW 2827,
E-mail: j.hassall@bigpond.com; Website: www.imag.net.au

Key Findings/Take Home Messages

Currently available Precision Ag Equipment gives farmers the opportunity to experiment with different crop treatments and monitor their overall and spatial influence. The aim is to determine those factors that are 'Yield Limiting', i.e. preventing the crop from reaching its true potential.

Introduction/Background

While traditional soil testing is useful for predicting reasonably stable soil traits such as pH, CEC and Phosphorus levels, it is far less reliable at accurately determining the levels and spatial variability of more dynamic nutrients such as Nitrogen. Recent experience with a range of Precision Ag sensors, which generate Yield, Protein and NDVI maps, has given me a greater appreciation for the spatial variability of soil nitrate and allowed me to experiment with different techniques for managing this variability.

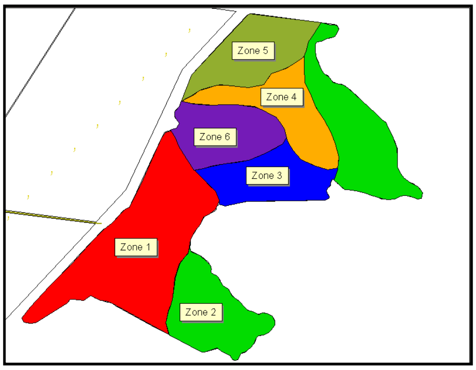
This forms part of my overall Precision Ag strategy of using different treatment strips, placed across an entire field, in conjunction with a range of Precision Ag tools to help determine which factors are limiting peak crop performance.

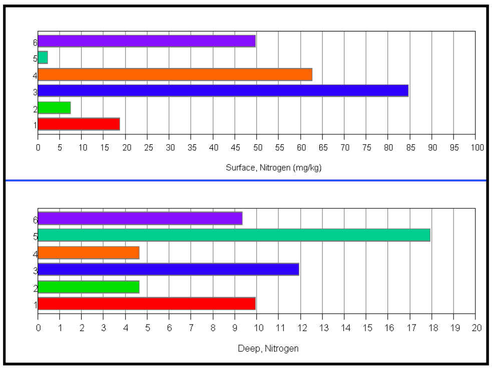
Presentation Content

My current cropping system, rotations, seed placement.

- 2000 ha of predominantly winter crop.
- Main crops include Wheat, Canola, Barley, Chickpeas, Triticale, Lupins
- Four year rotation: 1. Wheat, 2. Canola, 3. Barley or Wheat, 4. Pulse
- Canola and Pulse crop planted *between* previous years cereal stubble.
- Cereals planted *on top* of previous year's pulse or canola row.
- Autofarm RTK Autosteer, 1.8m Tramlines, 30ft AFM Direct Drill Seeder
- 30ft John Deere harvester with Yield Mapping and Zeltex Protein Mapping
- Ntech Greenseeker RT200, 6 NDVI sensors with VR capability.
- 2000 –Yield Mapping, 2004 – Protein Mapping, 2006 – NDVI Mapping.

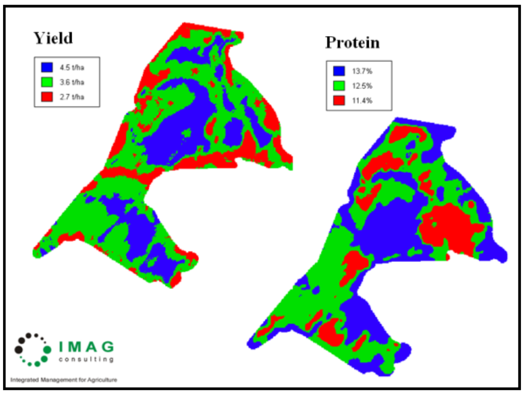
Soil Nitrate levels in different zones derived using crop yield and soil EM maps





Huge variability in soil nitrate levels across a field, how accurate can a soil test consisting of a few 'random' cores be?

Crop Yield and Protein Maps



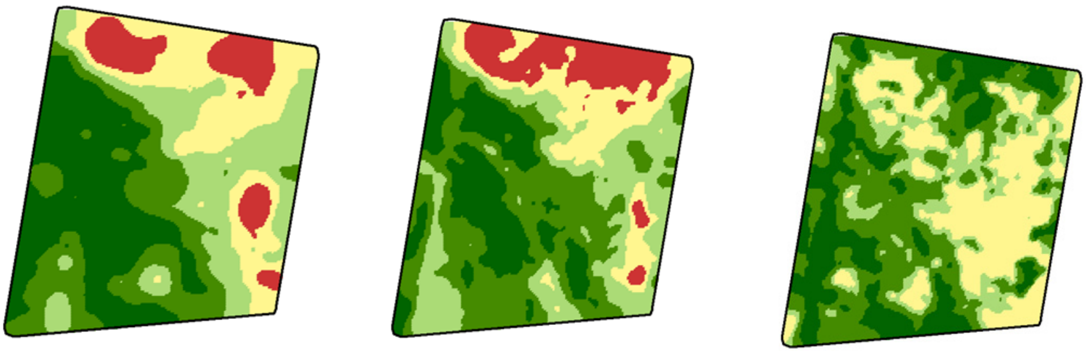
- The addition of a protein map can highlight different field dynamics.
- Areas of very low and very high protein can help explain what's influencing the yield map.

NDVI – In farmer speak, what is it, what is it really measuring?

- NDVI just a measure of chlorophyll.
- Influenced by the number of leaves and the chlorophyll in each leaf.
- Measures total chlorophyll, crop and weeds!

Nitrogen Rich Strips as a means of generating a Nitrogen Response Map

- Pre-drill strips across paddock with high rates of Urea. Nitrogen won't be the limiting factor to crop performance in these strips.
- Compare the NDVI readings from these strips with the rest of the paddock.



N Rich No Urea Nitrogen Response

Applied nitrogen persistence in different soil types

- If the applied nitrogen is not used by the current crop due to drought, frost etc. is there any left over for the next year's crop?
- Tends to persist for longer in heaver soils and will usually leach out of lighter soils if there is any significant rainfall over the summer fallow period.

A proposed strategy for better managing crop nitrogen inputs

- Look at applying nitrogen where it is likely to be most efficiently utilized.
- Initially put more on heavier soils at sowing as we know that:
  - Crop more likely to be bigger and hungrier there.
  - Less likely to lose the nitrogen if the crop doesn't utilize it all.
- Monitor crop development using NDVI sensors and N-Rich strips.
  - Assess whether the crop will respond to additional nitrogen in crop
  - Apply according to crop needs, soil moisture availability and seasonal outlook.
  - Actual rate doesn't necessarily need to be 'exact', more important to put it where it will be most efficiently utilized.

Farm trials as a means of better understanding true crop potential and the factors that may be currently preventing our crops from reaching it.

CONCLUSIONS

Current Precision Ag Technology gives farmers and agronomists the opportunity to monitor crop development and with the use of 'alternative treatment strips' gain a better understanding of the crop's limiting factors and variability across their particular property.

This presentation has focused primarily on Nitrogen, but the idea can be expanded to include a whole range of traditional, and not so traditional, crop management techniques. Every farm and field is unique, not only due to differences in soil type and climate, but also due to current and historical management practices. Farmers need to determine what is driving *their crop's* productivity in *their soil* as it stands today. Precision Ag Equipment provides farmers with the tools to easily and accurately do just that.

Contract Harvesting and Controlled Traffic Expenses and Costs

Peter Bradley

AGHA, Gladstone, Qld

My name is Peter Bradley; I run a contract grain harvesting business located in Central Queensland, which has been operating for over 10 years. I started in 1973 and sold out in 1983 to pursue other business endeavours, and recommenced in 1997 and have been developing the business gradually to the present day. I also hold the position of President of the Australian Grain Harvesters Association and have held this position for the last 3 years.

I have been asked to present to you today my views on Controlled Traffic Farming and what effect, if any, this had had on my business. My initial thoughts on CTF were that it would be time consuming and I had strong concerns over whether it would improve any of my contracting practices but still produce profitability.

At present in my business we run 3 John Deere 9660 STS bullet rotor combines, all of which are CTF ready. Two of the machines have Midwest centre mount 42ft fronts, and the third has the very 1st Midwest 12mt front. It is 40.9" on the knife. This particular front was developed over a 12 month period, after much discussion, pulling out of hair (and in my case the sudden and rapid increase in grey hair) and much trial and error.

The development group involved included me, Andrew Farquarson owner of FARMMS Agronomy at Clermont, QLD CTF members, and Martin and Craig Schultz from Midwest Manufacturing at Dalby QLD.

The front fitted very neatly between the 12 m rows typical of a summer crop configuration and is easily able to pick up all down cereal crops that are flat on the deck. The front cost us an additional $10'000 as all components had to specifically developed from cutting back from the 42ft components.

In order to make an informed decision we decided to use two very similar properties in Central Queensland so as to compare the effectiveness and profitability of CTF in our harvesting practices. The farms used in our trial included Rob and Deb Bauman "Bogandilla" at Dysart, who have been using CTF practices for approximately 14 years and Grant McClellan's property "Soldiers Plains" at Theodore. Importantly there is very little difference in the farms in terms of location, size and crop, and so we would be able to correctly compare data at the end of the harvest to come to a better decision in regard to CTF practices.

The table presented shows comparisons from each of our trials at these properties.

As you can see we were able to use 400 lt less fuel during the harvest at the CTF farm (a significant fact at this time with fuel prices so high) even though the crop and ground conditions at this farm were much wetter and yielded 2 tonne per hectare higher. Both crops were sprayed out 10 days prior to the commencement of the harvest yet the crop at the CTF farm produced a much greener crop. So the drop in the rate of fuel used was somewhat surprising to us. The time used to harvest the CTF farm was in total approximately 40 hours compared to 25 hours at the non CTF farm. The amount of time lost due to no chaser bin in the field at the CTF farm was around 12 hours which amounted in dollar terms to around $6080, at $500 per hour. This would suggest then that we would be required to make an additional $215 per hour or $25 per hectare at harvest to equal the return the profitability of having a chaser bin and unloading on the go.

Our CTF business will increase this next financial year by approximately 30%. Our figures show we will harvest around 60,000 acres (or 24,252 hectares) of cereal crop in 2008/2009, and 30,000 acres (or 12’100 hectares) of summer crop. This equates to around 1200 hours per header per year, which is a significant portion of our business each year. In doing so we have had to spend additional money to ensure we are CTF compliant including $40,000 on new fronts and $22,000 on auto steer and mapping. This additional expense adds up at $62,000 to be CTF ready.

Therefore we as the contractors need to charge at least $62.50 a hectare or at an hourly rate of at least $715 to make it profitable and to ensure that by being CTF ready we are not making a loss.

Thank you for your time, I do hope I have given you something to think about and if any of you have any questions or comments, I will make myself available to you.

Professional Contract Harvesting and CTF for the Australian Grains Industry – Where to from here?

Rod Gribble

R&C Gribble Precision Harvesting, Farm 549, Yenda, NSW 2681.

As a member and National Treasurer of the Australian Grain Harvesters Association (AGHA), I thank you for inviting us to participate in the Controlled Traffic Farming Conference.

AGHA has been around and representing the interests of professional contract harvesters since 1973. Our main objectives can be summarized in a few short statements:

- To bring a unity of standards to the industry
- To lobby governments and industry for the betterment of the industry
- And to work in cooperation with the grains industry for the benefit of all, whilst keeping at the forefront, that our industry must be profitable and financially sustainable, both in the short & long term.

Why are we all here? In a nutshell, to find commonality of standards for CTF.

Over the last 20 years, machines have got a lot bigger and a lot heavier. They have gone from a 12' cut and weighing 5 or 6 tonnes, to well over a 30' cut and near 30 tonnes loaded. We have gained some efficiencies, and it's a lot more comfortable, but it has come at huge capital cost and a cost to soil structure.

Machines are now a lot more expensive. The current model harvester, no matter what breed or colour, is at least four and a half times the price of an IH 1480 model of the middle 1980s. Are they 4 & ½ times more efficient than the largest capacity machine of the middle 1980s? Can we gain 4 & ½ times more return on investment?

Technology is forever changing and will continue to change but the cost benefit ratio is simply not there for contract harvesters. Machines cost in excess of $500,000 and with operational expenses approaching $500/hr. We simply cannot pay it off, make a living, and gain any sort of return on the investment. Like growers, contract harvesters must exceed a minimum of 20% over and above all operational expenses to be viable.

Technology, toys and modifications undoubtedly make life easier and increase efficiency, but are they profitable? A grower just recently said to me that: 'Australian farmers have been so successful at efficiency gains that we've made ourselves unviable'. If CTF is another new means of efficiency gains to increase profit for growers, all well and good. But that benefit must be extended to contract harvesters who provide a service so the benefit can be gained. Everyone should be well aware of the extremely difficult times and difficult environment, Australian growers and the service providers to those growers, have endured and are still enduring. Just because it has rained in some areas, the financial drought hasn't finished, as a myopic coastal dominated media would like to claim. Growers and contract harvesters must be profitable to remain viable.

There are substantial set-up expenses to owners for machines embarking on the CTF road and these costs have to be recouped. Machines need pricey 'modifications' for CTF:

- Axle extensions are $3-4,000.
- Extra heavy duty tyres and rims $3,500-$4,000/machine and with that we also need our tyre repair blokes' number punched into the phone – we'll be calling him. OFTEN.
- 'Centre mount' fronts – what width?
- Differential corrected auto steer - $18-$20,000.
- Unloading auger extensions – the list goes on.

Tyres already have problems with the weight and speed of operation of large modern machines, putting them on narrower tyres will only exacerbate the problem. Narrow tyres are very painful in wet/soft soil. Are tracks the answer? They may be in some circumstances, but for contractors they are way too expensive, we don't gain any return on the extra investment and we can't drive them on the road from property to property. So they are not really the answer for the modern professional contract harvesting business.

Pick-up bins and axles need modifications, at least $35,000 for a bin. Heavy-duty, narrow tyres and rims are essential. Again, one day it will rain again and narrow tyres are very painful in soft soil.

New ideas and technologies do create a lot of interest. We're definitely not saying that ideas and technology should be ignored. We are saying we require a reasonable return on investment when we incur additional expenditure.

Just over 10 years ago Precision Ag promised – or should I say - was sold, as the new panacea to the problems in agriculture. Vast quantities of promises and predictions were thrown about the agriculture market, as if they were confetti at a wedding. It created a lot of heat in the market. Multitudes of millions of dollars were spent in the pursuit of the rainbow.

What did we as contract harvesters gain out of this? Well we definitely got depleted bank accounts – that's for sure. We also gained massive amounts of data that no-one wanted to pay for. We have heaps of hardware that software won't 'talk' to. We also received an expensive education on spending thousands of dollars on machinery modifications and on the newest and latest technology phenomenon that did not pay any return on the investment.

So what do we all want out of Controlled Traffic Farming? For a start, we all need to make a profit out of it. We all must receive a viable return on the investment and that includes contract harvesters. Contract Harvesters must be profitable so we can provide a vital service to Australian growers.

And there must be an absolute uniformity of standards with Controlled Traffic Farming because contractors and growers alike cannot afford to chop and change at the drop of a hat nor metamorphose machinery and businesses at the whim of the latest trend. Professional contract harvesters, growers, research bodies and machinery manufacturers working together and understanding each other's requirements as to the broad implementation and adoption of CTF will be of substantial benefit to all.

Thank you for your interest and we look forward to contributing to the discussions and practicalities of Controlled Traffic Farming.

Sugar Cooperatives – Harvest, GPS, Bio-fuels

Mark North

Farmer, Murwillumbah, NSW

Warakirri Agricultural Trusts
Incorporating Warakirri Pty Ltd and Warakirri 2 Pty Ltd
People ~ Environment ~ Growth

Warakirri- A Corporate Agriculture Perspective

Peter McCann

Agricultural Development Specialist, Warakirri Agricultural Trusts

"A leading producer of agricultural commodities, developing the best people and assets, utilising progressive, efficient farming systems, in a safe sustainable manner for a rewarding investment."

Established in 1996, the Warakirri Agricultural Trusts are unit trusts formed to invest in rainfed cropping operations on a geographically diversified basis. Warakirri own and operate a number of properties in Victoria, southern NSW and southern Queensland. They are the agricultural investment of one of Australia's leading industry superannuation funds.

Eighty percent of the investment is in farming land, considered to be a secure and relatively low risk investment. Since inception, capital appreciation has met or exceeded the 3% capital gain target. The balance of the investment is used for the operational requirements of plant and equipment and working capital. The challenge for the trusts is achieving the 7% operating returns affected by the appreciating capital base as well as volatile incomes as a result of seasonal variation and commodity prices. There are a number of approaches applied to mitigate the risk of variable operating returns. Price risk is managed through marketing strategies and a range of crop types. The marketing philosophy is to preserve a margin/tonne above the cost of production, to achieve the returns on capital targets rather than maximise or enhance prices. A set of marketing guidelines determine the timing, price and amount of crop hedged at any particular stage in the cropping season. Seasonal Forecast models based on the Southern Oscillation Index (SOI) and Pacific Decadal Oscillation (PDO) are incorporated into planning strategies in addition to soil moisture measurements, and agronomic principles to develop annual crop plans.

Operating large properties has enabled Warakirri economies of scale by spreading the fixed costs of overheads, particularly the costs of machinery ownership. Operating budgets, capital budgets and cashflow budgets are developed to manage the diversity of enterprises and to help control costs. Due diligence studies, including longterm planning models and sensitivity analyses are used to assess potential land acquisitions. In addition the use of contract service providers and "joint venture" relationships have eliminated the requirement for expensive machinery for planting and harvest and the risk of maintaining lease payments or interest costs in years of under utilisation. Centralised buying of inputs & selling of grain enables a small but important cost saving and help to preserve profit margins and ensure secure and timely access to competitive markets.

Warakirri aims to achieve the targeted returns over the long term, without causing damage to the natural resource base and the communities within which it farms. The farming systems adopted by Warakirri help to minimise the impact of farming operations on and off farm. Careful consideration is given to the handling and storage of fertilisers, pesticides and fuel, machinery operation, biodiversity decline, soil acidity, salinity, fertility as well as the management of weed and insect resistance. Policies have also been implemented to address the potential impacts to neighbouring properties from chemical spray drift, nutrient run-off, deep drainage and rising water tables.

Ensuring a safe workplace for employees, service providers and visitors is essential for achieving Warakirri's social and ethical responsibilities and to protect against revenue loss from downtime or litigation. Farm accidents pose the largest risk to investor funds and as such a safety conscious culture has been instilled in all Warakirri employees and service providers with the aim for continuous improvement. Safety manuals complying with state and federal legislative requirements have been developed and implemented.

Benchmarking performance of the trusts is at the heart of Environmental Management with the aim for continuous improvement. It provides the means to question what we do in search of a better way. There are three key benchmarks that are used by Warakirri to monitor the progress of the trusts towards achieving its objective to be among the top 20% of agricultural producers in the broadacre grains industry.

Dollar water use efficiency ($WUE) is the key productivity measure. By measuring gross crop receipts per hectare for every 100 mm of annual rainfall received, it enables the comparison of all operations regardless of rainfall. Typically $WUE is linked to land value where more productive land, measured as higher gross crop receipts, generally commands a higher value.

The seasonal volatility of income, linked to season and commodity prices, means that ratios of income to costs, historically used as benchmarks, will also be volatile. As a result it is very difficult to discern what affect management plays. By measuring the ratio of total costs required ($/ha) for each unit of water use efficiency, the effect of rainfall induced seasonal variation is removed and a more stable benchmark is provided. It can then be determined that increased $WUE has not occurred as a result of simply increasing costs. Warakirri aims to improve its water use efficiency benchmark using minimum tillage and stubble retention to reduce run-off and evaporation, improving soil infiltration, and maximising rainfall use through summer weed control and dry planting of crops. This benchmark is about ensuring there is a balance between the pursuit of higher $WUE and the costs incurred in doing so.

Over the last 5 years the trend has been for the Warakirri Agricultural Trusts to increase their reliance on contract service providers to perform the main tasks of planting and harvesting crops. This has enabled Warakirri to minimise the need for capital expenditure on large items of machinery required for these services. In order to enable comparison between operations that own and operate their own machinery using family labour and those that rely on contract service providers, a machinery benchmark, TPML (Total Power, Machinery & Labour) is used. This benchmark includes, wages, contractor costs, depreciation, the opportunity cost of capital, fuel and machinery repairs and maintenance. Typically TPML is linked to land value as the higher value land typically requires more machinery services to achieve the higher targeted water use efficiency.

Farming's importance to Australia's economy, and as an earner of export income, is generally not reflected in superannuation fund portfolios, yet best practice farmers, despite the vagaries of season, make excellent returns over the long term. This suggests that agriculture should be represented within the diversified portfolios of superannuation funds. The Warakirri Agricultural Trusts are attempting to counteract the perception that agriculture is a high risk and poorly managed industry. This is achieved by combining the best elements of the traditional family farm with increased emphasis on effective planning, management and financial controls typically found in successful business outside of agriculture. The aim is to attract quality managers and assistant managers by committing to their further professional development, providing opportunities and a career in professional farming for younger people with limited access to capital.

Cereal Farming Systems in Kenya

Jonti Barclay and Bryn Llewellyn

KENYA

History

- Brief history of Kenya over the last 100 years

Geographic

- Brief description of Kenya's Geography

Population

- Current population

Political

- Politics since Independence

GENERAL FARMING

- Brief overview of current Kenyan farming systems

MADRUGADA LTD. AND OL DONYO LTD

- Short look at Jonti's farm, Madrugada Ltd; and Bryn's farm, Ol Donyo Ltd.

FARMING RESTRAINTS

Marketing

- Marketing problems

Security

- Security issues

Labour

- Increased mechanization due to Labour demands

Dumping

- Problems associated with the dumping of 'Aid' wheat/flour

Politics

- Overhanging threat of current policies

Banks

- High Bank rates

Research

- No research assistance

State Monopolies

- Demands arising from crops with only a single market

Weather Forecasts

- Lack of any reliable forecasting

Fertilisers

- Poor quality of products

Land Prices

- High purchase and rental prices

FARMING ADVANTAGES

Local Demand

- Import 60% of our wheat

Labour

- Quality, quantity and wage levels of employees

FARMING CHALLENGES

- How to get into Zero till linked in with Controlled Traffic Farming

Matching New Pulse Varieties to New Systems

Jason Brand[1], Larn McMurray[2] and Michael Materne[1]

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[2]Lentil Breeder, South Australian Research and Development Institute (SARDI), PO Box 822, Clare, South Australia, 5453.

INTRODUCTION

Pulses are now an integral part of sustainable cropping systems in south-eastern Australia, delivering significant rotational, economic and environmental benefits to growers. Frequent cereal cropping in many areas results in declining soil fertility, build up of grass weeds and increasing levels of soil borne diseases leading to low cereal yields. To increase the frequency of pulses in rotation it is important that we continue to improve the profitability, reliability and sustainability of pulses in modern farming systems through targeted research and development.

Modern farming systems offer many new opportunities and challenges for pulse breeding and agronomy. Conservation practices including no-till cultivation with press wheels, controlled traffic, wider row spacing's and stubble retention have been widely adopted by farmers in south-eastern Australia. However, current pulse varieties have been developed from breeding and agronomic research under traditional cultivation practices including, stubble burning or removal, narrow row spacings and harrows for soil levelling. It is suggested that these varieties will not have the complete package of traits best suited to modern systems.

Pulse breeding and agronomy programs are now identifying and incorporating new genes/traits into varieties that can have significant beneficial impacts on the farming system. In this paper we discuss the importance of pulses in modern farming systems and some key components of the modern no-till system that potentially impacts variety development. We also present some preliminary data and current research from the pulse agronomic research program in south-eastern Australia which is addressing these issues.

PULSE BENEFITS TO THE CROPPING SYSTEM

The benefits of pulse cropping systems have been well documented in Australia over many years (Armstrong 1998, Angus 2002). Panagiotopoulos (2002) stated that pulse crops benefited following cereal and oilseed crops by an order of over $300 million in the 2001 cropping season, equivalent to almost 30% of the total value of the Australian pulse crop that year. The key benefits of pulses in sustainable farming systems can be summarised as follows:

Economic -
Pulses can provide significant returns to farmers and in many of the key production regions growers rotate the cereal phase around high value pulse crops. In these regions, an average 2.0 t/ha lentil crop can result in profits exceeding $1200/ha. A wheat crop would need to yield greater than 4.0 t/ha to equal these returns. In addition, many growers have found significant value in grazing pulse stubbles. Sheep and cattle show a higher growth rate when grazed on pulse stubble than when fed on crops such as barley stubble.

Higher cereal yields (Table 1) through -

A. 'Disease break' – pulses, when grown in rotation, are effective in controlling major cereal root diseases such as cereal cyst nematode and take-all. They can also provide improved control of root lesion nematode if a resistant species or variety is grown.

B. 'Improved weed control' – this particularly applies to the problem grass weeds (e.g. annual ryegrass, wild oats and brome). Grass specific herbicides (Group A) can be applied in-crop. In addition, wickwiping (lentils and potentially chickpeas) and crop-topping (desiccation) (peas, beans, lentils) can be used to kill grass weeds that are resistant to the Group A herbicides. In some cropping regions wheat is now seen as the weak link in resistant ryegrass control due to its relative low level of crop competitiveness and the absence of effective chemical controls.

C. 'Spread management windows' – pulses, due to their divergent growth and development, allow sowing, spraying and harvest windows to be widened, allowing for more efficient and timely use of farm machinery. For example pea can be sown later and chickpeas harvested later than cereal crops.

D. 'Improved nutrition' – as pulses fix their own nitrogen (N), no N inputs are required. In many cases the pulse will also contribute significant N to following cereal crop. Some studies have also shown this improved nutrition in the cereal can increase grain protein content by 0.5-1.8%.

Table 1. Yield of wheat grown after pulse crops from a survey of published Australian experiments[1]

Previous crop	Yield as a % of wheat after wheat	No. of comparisons
Wheat	100	
Lupin	146	75
Fieldpea	142	52
Chickpea	153	4

1. Angus, J. (2002). Opportunity cropping. GRDC Crop research Update, Birchip, 2002.

MATCHING VARIETIES TO MODERN FARMING SYSTEMS

It is well known that genotypes perform differently in different environments. *'Genotype'* refers to the genes or traits that make up the variety's characteristics (e.g. tolerance to disease or abiotic constraints, flowering, growth habit etc). *'Environments'* refer to where the crop is grown and vary across regions but also within regions based on factors such as soil type or yearly variations in factors like rainfall, temperature and disease, rainfall or farmer management practices. To match varieties to modern farming systems, understanding the interaction between genotype and management (GxM) is essential. *'Management'* refers to all the components of the farming system that we can control that may alter the performance of a variety (e.g. herbicide/fungicide application, sowing time, plant density, row spacing, stubble management etc.). The way genotypes respond to different management practices can also vary across years.

In modern pulse agronomy research we investigate both the *impact of farming systems (M) on genetics (G) and the impact of genetics (G) on farming systems (M).*

1. Impact of farming systems (M) on genetics (G)

Breeding is a long term process and often old agronomy has been used to select varieties that will be grown in contrasting new systems. For example, no-till cultivation and stubble retention practices are being widely adopted in south-eastern Australia. Traditional varieties have come from breeding trials where stubble has been burnt and may not have the complete package of traits best suited to these systems. New farming systems offer challenges but more importantly new opportunities for breeding. Genes or traits that confer an advantage in new farming systems can be identified and incorporated into varieties that further enhance the profitability of the overall farming system.

2. Impact of genetics (G) on farming systems (M)

Genes (or traits) introduced by crop breeders can have significant impacts on the overall profitability and sustainability of the farming system. We need to understand and maximise these potential benefits by using the most appropriate agronomic management practices. Through Pulse Breeding Australia (PBA) several new novel agronomic traits are available or under development that will improve yield and adaptation. By exploring the impact of these new varieties in various farming systems breeders can be supplied with information on the value of new traits and how important they are among many breeding objectives. For example, several weed management traits are available, including herbicide tolerance (e.g. group B tolerant lentils), early maturing lentils, chickpeas or field peas for crop-topping and reduced height and evenness of canopy chickpeas for wickwiping.

COMPONENTS OF THE MODERN NO-TILL FARMING SYSTEM THAT MAY IMPACT VARIETY DEVELOPMENT

Modern no-till farming systems have several key components that differ from conventional systems and may affect the type of variety that produces maximum yield and profitability. These include:

a. 'Row spacing' tends to be wider, often to aid with stubble management.
b. 'Standing stubble', particularly with interrow sowing; can also aid with lodging resistance.
c. 'Sowing dates' used are often earlier.
d. 'Plant densities' differ and are often reduced per unit area due to fewer rows but potentially greater number of plants per row.
e. 'Herbicide usage' and 'weed management' practices are altered to allow for 'one pass' cropping. In many cases herbicides are all applied pre-sowing.

Potential traits that may be valuable in no till systems are listed in Table 2 below.

Table 2. Aspects of the no till systems and potential traits that may provide yield improvements or improve management in no till systems. These traits are hypothetical and their benefit in the actual system is currently being investigated.

System feature	Potential traits
Wide rows	Early vigour, lodging resistance, increased canopy width and biomass
Standing stubble	Increase height, early vigour
Sowing time earlier	Disease resistance, herbicide tolerance, flowering and maturity later
Herbicide usage and problem weed control	Early maturity chickpeas (crop-topping), reduced height chickpeas (wickwiping), improved herbicide tolerance including tolerance to group B chemicals (in crop use of imazadoline and sulfonurea residues).

2007 RESEARCH TRIALS

In 2007, a preliminary trial was sown to investigate the adaptability of a range of lentil varieties to inter-row sowing in wider row spacings and conventional cropping systems. This trial is a comparison of two systems and not just row spacing as sowing methods and chemicals were not identical, i.e. in the wider row spacings plots were sown with narrow lucerne points, press wheels and herbicides were applied pre-sowing. The narrow row spacing's plots were sown with narrow lucerne points, harrows and herbicides were applied post-sowing, pre-emergent.

Methods

Site details
Site location: Dimboola, approximately 30 km north west of Horsham.
Soil Type: Black cracking clay and red rise.
Cropping History: 2007 – Lentils; 2006 – Barley; 2005 – Chickpeas; 2004 – Barley; 2003 – Fenugreek.
Tillage practise on farm: No-till, inter-row sowing, 30 cm row spacing.

Varieties
Varieties and lines were chosen to represent the range of growth habits, plant heights and flowering/maturity times available in the PBA lentil breeding program (Table 3). Growth habits vary

from prostrate to erect, tall to short, bushy to ‘stick like’, multi branching to few branches. Pod location in the canopy also varies.

Treatments
1. Inter-row, 30 cm row spacing, standing stubble (approximately 10-15cm high)
2. Inter-row, 30 cm row spacing, slashed stubble
3. 19 cm row spacing, slashed stubble

Agronomic management details
Plot size: 8 m x 1.5 m
Fertilizer: Grain legume super + 2% Zn (0:15:7) at 60 kg/ha.
Replicates: 4
Herbicides: Pre-sowing (2 weeks prior): glyphosate 450 @ 1500 mL/ha + carfentrazone-ethyl 240 @ 65 ml/ha. Pre sowing (on day of sowing): simazine 900 @ 1000 g/ha. Post emergent: diflufenican 500 @ 50 g/ha + flumetsulam 800 @ 20 g/ha + wetter.
Insecticides and Fungicides: Applied as required unless indicated in treatments.
Target plant density: 120 plants/m^2

Results

Climate

The season was characterised by an excellent early break in late April/early May (generally greater than 75 mm rainfall), followed by a relatively dry winter and spring. Maximum temperatures were generally slightly above average and minimum temperatures below average. Several maximum temperatures were recorded above 25^{o}C in September and October, with the hottest day being 36.1^{o}C on October 21. There were few significant frosts recorded during the flowering and podding periods of the lentils (September 25, October 2 and 8 at -0.2 ^{o}C). Rainfall was well below average for the growing season, but close to average annually, due to high summer rainfall (Table 4). Overall climatic conditions in 2007 were more similar to those experienced in northern cropping regions of Australia where crops are grown on stored moisture rather than in-crop rainfall.

Table 4. Monthly rainfall, growing season rainfall (GSR) and total rainfall (mm) at Dimboola in 2007 compared with long term averages

Month	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	GSR (M-O)	Total
2007	64.4	23.2	8.8	89.8	65.4	5.4	33.4	6.2	10.6	6.2	41.6	23	127.2	378
Average (Horsham)	23.2	24.8	23	31.7	46.6	50	46.8	49	46.2	44	33.7	27	281.9	446.1

1. Underlined figures sourced from Bureau of Meterology (Horsham for Dimboola site)

Plant growth and grain yield

- Plant establishment – Most varieties established between 85 and 90 plants/m^2, Nipper was slightly higher at 100 plants/m^2 and CIPAL415 and Northfield significantly lower at 65 plants/m^2. There was no effect of system on emergence.
- Flowering – Row space had no impact on flowering date. Flowering dates of varieties were as follows: CIPAL411 (22 Sept), Boomer (23 Sept), CIPAL607 (24 Sept), Nugget and Aldinga (26 Sept), Nipper and CIPAL415 (28 Sept), and Northfield (30 Sept).
- Height – Generally crop height (top of canopy) and height of the lowest pod were greater in the 30 cm row spacing’s compared with 19.5 cm spacing’s (Table 5). In particular, height to lowest pod was increased by at least 20% in most varieties. The only variety to show no significant response to row spacing was CIPAL411. Boomer was the tallest variety followed by Nugget and CIPAL411. The increased height could have been because wider rows had a greater number of

plants per metre of crop row, thus increasing interplant competition for light and increasing height, or may have been due to the effects of stubble on growth. This will be tested in further experiments where row densities between systems are kept the same.

- Biomass – No major differences in biomass were noted between the row spacing treatments. CIPAL411 generally produced the most biomass, followed by Boomer and Nugget (data not shown). Northfield and Aldinga produced the least biomass.
- Grain Yield – Grain yields averaged approximately 25% higher in the plots sown at 30 cm row spacing's (standing) compared with 19.5 cm row spacing's (Table 6). Across the varieties, improvements in yield ranged between 15% (Northfield) and 50% (Aldinga). Harvestability was also much easier in the 30 cm row spacing's, as plants tended to be more erect and did not lodge.

Table 5. Total crop height (to top of canopy) and height of lowest pod at harvest for lentil varieties grown in 19.5 cm and 30 cm row spacing's at Dimboola in 2007

Stubble	**Aldinga**	**Boomer**	**CIPAL411**	**CIPAL415**	**CIPAL607**	**Nipper**	**Northfield**	**Nugget**	***Mean***
				Crop height (cm)					
Slashed 19.5 cm	17.5	20.3	21.3	15.5	18.0	18.3	16.8	20.0	*18.4*
Slashed 30 cm	18.5	22.5	21.8	16.8	19.0	19.3	17.3	21.5	*19.6*
Standing 30 cm	19.0	22.5	21.0	17.5	18.5	19.0	17.0	21.3	*19.5*
Mean	*18.3*	*21.8*	*21.3*	*16.6*	*18.5*	*18.8*	*17.0*	*20.9*	
lsd (P=0.05)$_{(RSxVar)}$ - ns	**lsd (P=0.05)$_{(RS)}$** – 0.8		**lsd(P=0.05)$_{(Var)}$** – 1.1						
				Height to lowest pod (cm)					
Slashed 19.5 cm	6.3	9.0	10.0	4.8	7.0	8.8	6.3	8.5	*7.6*
Slashed 30 cm	8.8	11.3	10.8	6.8	9.3	9.8	7.8	10.5	*9.3*
Standing 30 cm	9.5	11.8	9.8	6.5	8.0	9.5	8.3	10.8	*9.3*
Mean	*8.2*	*10.7*	*10.2*	*6.0*	*8.1*	*9.3*	*7.4*	*9.9*	
lsd (P=0.05)$_{(RSxVar)}$ – 1.4	**lsd (P=0.05)$_{(RS)}$** – 0.8		**lsd(P=0.05)$_{(Var)}$** – 0.8						

Table 6. Grain yield (t/ha) of lentil varieties grown in 19.5 cm and 30 cm row spacing's at Dimboola in 2007

Stubble	**Aldinga**	**Boomer**	**CIPAL411**	**CIPAL415**	**CIPAL607**	**Nipper**	**Northfield**	**Nugget**	***Mean***
Slashed 19.5 cm	0.47	0.65	0.74	0.46	0.46	0.48	0.29	0.57	0.51
Slashed 30 cm	0.71	0.77	0.67	0.56	0.63	0.60	0.38	0.65	0.62
Standing 30 cm	0.71	0.78	0.92	0.61	0.56	0.67	0.32	0.70	0.66
Mean	0.63	0.73	0.78	0.54	0.55	0.59	0.33	0.64	
lsd(P=0.05)$_{(RSxVar)}$ – ns	**lsd(P=0.05)$_{(RS)}$** – 0.1		**lsd (P=0.05)$_{(Var)}$** – 0.1						

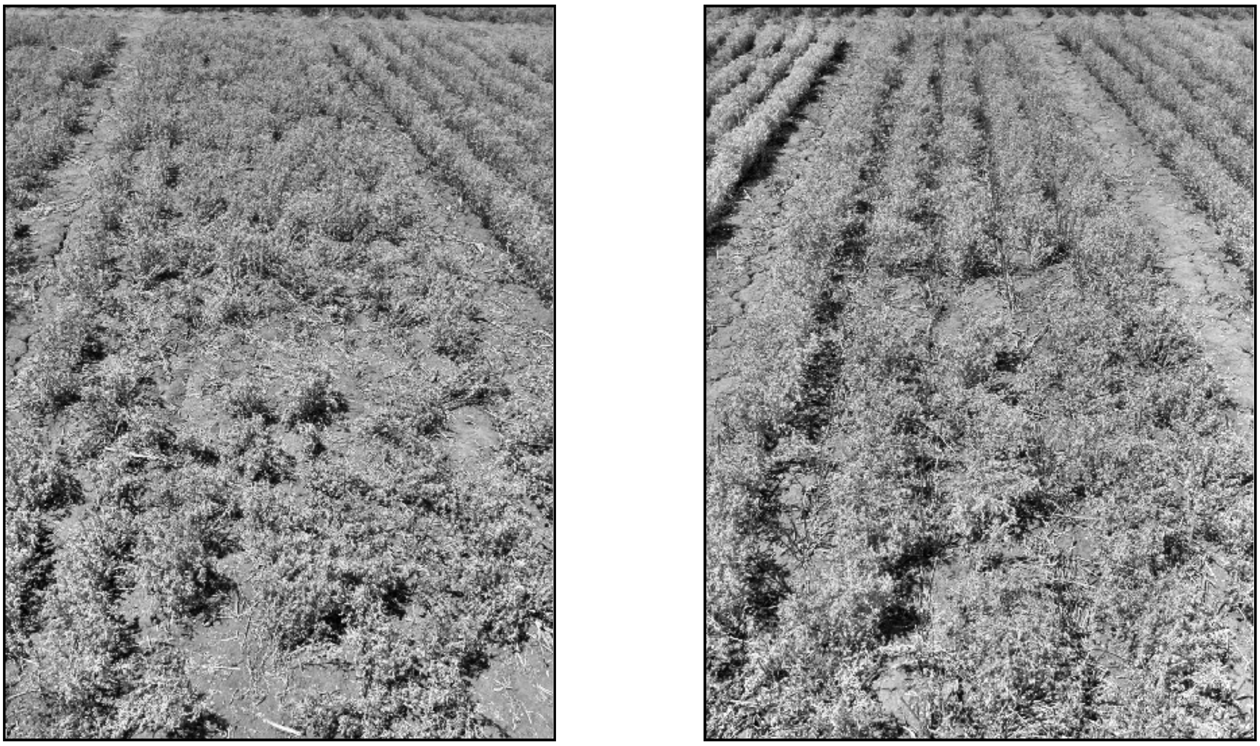

Figure 1. Improved harvestability in wider rows.
Aldinga in row space trial at Dimboola at harvest (bottom). Left – 30 cm row spacing, inter row into standing stubble; Right – 20 cm row spacing in slashed stubble.

2008 RESEARCH TRIALS

In 2008, trials have expanded to encompass a wider range crops, treatments, varieties and locations. Both lentils and chickpeas are being sown, with a wider range of varieties and breeding lines investigated. More specifically, selections were made in 2007 from breeding trials of lines with additional traits to the varieties sown in 2007 that may show response to wider, inter-row sowing into standing stubble. Two sites have been sown, one in the Wimmera (Horsham) and another in the southern Mallee (Curyo, 20 km NW of Birchip). Treatments that have been added are summarised below:

Row Spacing
1. Inter-row, 30 cm row spacing, standing stubble (approximately 15 cm height)
2. 19 cm row spacing, slashed stubble
3. Inter-row, 30 cm row spacing, slashed stubble (Horsham only)
4. Inter-row, 60 cm row spacing, standing stubble (approximately 15 cm height; Chickpeas only)

Sowing dates
Mid/late May and Late June

Plant Density
Four varieties have been sown at additional densities, 30% above and below the target plant density.

Full details of these trials will be available in presentation at conference (available on website).

CONCLUSION

- Grain yields averaged approximately 25% higher in plots sown on 30 cm the row spacing system (standing stubble) compared with the 19.5 cm row spacing system. Varieties responded differently to changes in row spacing with yield improvements ranging from 15% (Northfield) - 50% (Aldinga). (Table 6)
- It was notable that in terms of grain yield the variety most susceptible to lodging, Aldinga, showed the greatest response to wider row sowing. The vigorous, taller new varieties such as Boomer appear to be well suited to wide rows and standing stubble, which provides a trellis to improve harvestability.
- Research is continuing and expanding to encompass a wider range of breeding lines and to the other pulses crops

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Panagiotopoulos (2002). More to Pulses than Money.

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Table 3. Disease and agronomic characteristics of lentil varieties and advanced breeding lines used in trials

		Ascochyta Blight									
Name	Seed Type	Foliage (c)	Seed (d)	Botrytis Grey Mould (e)	Vigour #	Lodging Resistance#	Pod Drop #	Shattering #	Flowering Time #	Maturity	Comments
Aldinga	Red	MR	MS	MS	Mod	S	MR	MR	Mid	Mid	tall
Northfield	Red	R	R	S	Poor/Mod	MS	MR	MS	Mid/Late	Mid	short
Nugget	Red	MR/R	MS/MR	MR*	Mod	MS/MR	MR	MS	Mid	Mid/Late	
Nipper	Red	R	R	R	Poor/Mod	MR	MR	MR	Mid/Late	Mid	short/erect
Boomer	Green	MR/R	MS	MR	Good	MS	S	MS	Mid	Late	tall/bulky
CIPAL411	Red	MR	MR	S	Mod	MR	MR	MR	Mid	Early/Mid	erect/high pods
CIPAL415	Red	MR	MR	MS	Mod	MS	MR	MR	Mid/Late	Mid	prostrate/many branches
CIPAL501	Red	MR	MR	MR	Mod	MS	MS	MR	Mid	Mid/Late	
CIPAL607	Red	R	R	R	Poor/Mod	MS	MR	MR	Mid/Late	Mid/Late	
CIPAL611	Red	R	R	MR	Mod	MR	MR	MR	Mid/Late	Mid	
CIPAL801	Red	R	R		Mod	R	MR	MR	Mid	Mid	
CIPAL802	Red	R	R		Mod	R	MR	MR	Mid	Mid	
CIPAL803	Red	R	R		Mod	MR	MR	MR	Mid	Mid	
99-088L*02H051	Red										

R = resistant, MR = moderately resistant, MS = moderately susceptible, S = susceptible; # Ratings relative to Nugget

Optimising Cropping Technology

Clay Mitchell

Farmer, Iowa, USA

Crop Sensors and High Yielding Cereal Crops – A Tool for Better Nitrogen Management?

Nick Poole

Foundation for Arable Research (FAR), New Zealand

The following summary is an updated version of a conference paper first presented in Australia in February 2008. The results presented are from a GRDC funded project (SFS 00015) on disease and canopy management in cereals taking place in southern Australia and an agribusiness extension project on canopy management which took place in NSW. These are joint projects linking the Australian farmer groups (lead group Southern Farming Systems) with the New Zealand levy organisation FAR and in northern NSW Agvance Agriculture and the Eastern Farming Systems group.

This work has led to an investment in crop sensor research in New Zealand to assess whether the management of larger, higher yielding crop canopies can be improved with the use of the same technology.

KEY SUMMARY POINTS

Crop sensors, measuring the reflectance from the cereal crop canopy, may offer a better opportunity of matching crop needs to nitrogen input, when combined with GPS technology.

- Early Australian trials in wheat have shown good correlations between crop structure scores, such as tillers, and crop reflectance readings NDVI (normalised difference vegetative index) when assessed at early stem elongation (GS30-31).
- At the same growth stage, initial work, comparing the reflectance of nitrogen rich strips (plots receiving nitrogen at planting) with zero N control plots, has revealed that these reference points could be a guide to the likelihood of a nitrogen response.
- Trial work has also demonstrated that crop sensors (GreenSeeker® in these trials) could have use as a research tool to quantify differences in green leaf retention during flowering and grain fill.
- In work in NSW the correlations between NDVI readings at flowering and final yield have been better than dry matter readings taken at the same time. This result appears to be linked to the ability to differentiate biomass that is actively photosynthesising as opposed to total biomass.
- There are number of issues that need to be clarified if NDVI readings are to be used commercially as a basis for nitrogen application, for example the documented lack of correlation to canopy size above a Green Area Index (GAI) of three, means that in high yielding crops (Australian HRZ or New Zealand) NDVI may not be a reliable guide for nitrogen application later in stem elongation.
- Another issue is the possible need for different NDVI algorithms for different varieties and the ground truthing to ensure that variations in canopy biomass are linked to nitrogen, as opposed to other agronomic factors.
- Despite these drawbacks initial FAR work carried out in New Zealand, illustrated that NDVI measurements taken with the GreenSeeker® at late booting (GS45-49) (when canopies were frequently in excess of GAI four), gave very good correlations to final yield taken three months later at harvest.
- The use of crop sensor derived information, such as NDVI, combined with GPS could be a powerful tool for applying variable rate inputs on the "visual" basis of crop need.

CTF/No Till Farming 2008 – What Have we Learned and Where to from Here?

Robert Ruwoldt

Victoria No Till Farmers Association

This is a CTF conference but I would like to say there is more to the crop production process than just CTF. The way we practise farming today has to be a systems approach; if we leave some parts out we will not get the best out of our farming, or even worse, the system will fail and we will go back to our bad old ways.

Everyone looks at change and some people try some change but too many leave out some of the most important parts to make the system complete. There seem to be too many people out there that challenge the very farmers that are leading the way and these farmers are the ones that have the experiences and have learnt the hard way (the school of hard knocks). Some farmers' consultants and agronomists seem hell bent on stopping the adoption of new farming systems. Why is this so? There seems to be so much confusion out there at the moment and everyone seems to want to put their own slant on the system to add more confusion.

It has taken many years to get where we are today and at times it has been hard work and mentally very challenging to work all the necessary interconnecting aspects out but now the system just flows and it all seems just too easy. Sometimes I look back at the things we did along the way and I have to laugh at myself and the stupid things we did and the procrastinating over such little issues, e.g. row spacings, press wheels, what seeding point. If only I could have gone straight to our current system, but my ignorance and the people around me saying that it will not work, would not let us.

One of the main things to come out of all this change is motivation of farmers. Agriculture is now at a very exiting stage for us all. Where it goes from here we will have to wait and see, but I am sure there will be more change and advancements along the way.

The system has to be complete. We have to get our soils into better condition and to do this we need to :

A Stop bashing the shit out of our soils (No-Till/Zero-Till)

This is the most important part of the system; we need to keep improving the soil by letting the soil work for us. I see it on our farm, the longer we go on doing No-Till/Zero-Till the better the soil becomes and the higher the yields of our crops become.

Disc seeders are much better at placing seed in the soil with minimal soil disturbance. To achieve this we have to plant our crops on wider row spacing's (less soil bashing). The ability to seed between the last years residue is just too important and beneficial to the environment that our new crop is growing in, the protection from mother nature's elements is invaluable.

People say we need narrow rows to get ground cover to stop weeds growing, well what is last year's residue doing? Just the same thing if kept standing.

It is sometimes difficult to convince farmers to increase their row spacings, agronomists, neighbours and many so-called experts say you cannot do it but these people have seldom followed through on long term No-Till/Zero-Till practices, so how do they know?

B We have to stop driving all over our paddocks

If we continue to drive wherever we think we need to with our big fat tractors we are compacting the whole field and the improvement in the soil just stops right there. The hard pan caused by wheel tracks was called a seed bed. This must be eliminated for soil and plant health to improve.

Auto steer, well we don't use this technology to just drive straight or do we? Auto steer is a fantastic tool to make CTF work even better, with CTF and wider row spacing's we can successfully inter row seed every crop every year. If we control our traffic the soil that doesn't get driven on just seems to get better and better as time goes by.

The better the soil becomes the more we see compaction as a major issue but we only see it now because we have stopped driving on it and the soils are un-compacting as time goes by. Compaction just costs us money where ever we look, crop yield, more fuel, extra HP required to do the same job etc.

C Weed control

Well we all know about weed control don't we or do we?
Using the system that we currently use greatly improves the weed control program, we still have weeds but to a much lesser amount with a lot more options to control them.

Wider row spacing's allow for better penetration of herbicides, we get the chemical to the target with a lot less loss.

The ability to band spray herbicides and fungicides reducing cost on our pockets as well as the environment in the process.

The ability to include a shroud sprayer in the weed control process is just another tool and is only possible with wider row spacing's.

The main benefit of all this change?

- Growing more grain with less input and less water!
- Our fertilizer rates have decreased by half and at the same time growing more grain.
- Our water use efficiencies have doubled and there is good reason for that to happen.

I hope the improvements keep coming without much more change as I need a rest. I am sure the soil will just keep getting better the more residue we put back in and the yields will keep going up hence repeating the cycle.

We can only reap the rewards if we work with our soil rather than trying to subdue it with road building practices.

So stop bashing and compacting your soils and enjoy the ride!

Future Directions for GPS Technology

Brendan Williams

GPS-Ag Director, Bendigo, Vic

The pace of change is ever increasing as increased sales volumes world-wide drive further investment in the development of GPS technology. The key new areas that are looming are ISO compatibility, CAN bus, wireless, multi-functional displays and implement steering. What impact will this have on the farm? As far as what is happening at home the biggest change is farmers are rapidly implementing variable rate technology and in the process are finding out the pitfalls of current equipment, suppliers of the technology and the delivery of prescription maps. Clearly inter-row sowing continues rapid adoption through the eastern states and as a flow on so has controlled traffic. There is increased interest in better control of implements.

FACTORY FIT OR AFTER-MARKET SUPPLIERS

Autosteer

Purchasing Autosteer from the manufacturer will generally mean a seamless installation, but how well equipped is the dealer to support the product? How portable is it to other makes and models of equipment – one of the key benefits of the aftermarket technology is that it can be transferred and transferred in a manner that does not compromise accuracy in the other makes and models. Will the tractor manufacturer be able to support the product when connected to another brand of airseeder? Will the tractor manufacturer support the implementation of variable rate and the production of prescription maps. The technology is new and inviting at the time of purchase but if you keep the tractor for 10 years you are tied to the technology for the same time. At the current pace of change in 10 years the technology will be superseded many times over.

Variable rate

Purchasing variable rate from the manufacturer is often seen as the easiest option but how well equipped are these dealers and companies at support the technology. Often locally manufactured seeders are primarily concerned with supporting the hardware. This is definitely a worrying sign, as whoever sells the gear should support the gear. The loser will be the farmer, suffering from lack of support. What manufacturer will support the farmer in the provision of prescription maps? Who will supply prescription maps and ensure that they work for a range of controllers that a farmer may have?

MULTI-FUNCTION OR MULTIPLE DISPLAYS

Multi-function displays on the surface seem to be the preferred solution - they definitely reduce cab clutter but having more functions in one display means they are generally more complicated to use. So if keeping things simple is important then multiple displays might be a better option. Any malfunction or breakdown will bring the total system to a stop. Whereas separate displays may mean you can keep going, given the importance of timely seeding this is a very significant benefit.

ISO COMPATIBILITY

An increasing number of tractor manufacturers are offering ISO compatible displays in the cab. This means you can plug you implement into the tractors display. This saves cab clutter by using an existing display but you get a multi-function capability which is more complicated to use. Generally due to limitations in the ISO specifications these applications are less information rich than other non-ISO displays. So if information richness is important then ISO compatibility at this stage may not be the best option. You also have issues of who services what components – is it the implement or tractor problem?

CAN BUS (CONTROLLER AREA NETWORK)

Most manufacturers are using CAN bus technologies to reduce wiring but it is generally have more electronic components. The main benefit of CAN bus is that you don't need a massive cable connecting the implement to the display (especially important with airseeders), another benefit is the systems capacity to self-diagnose problems. The display will tell the operator by way of error code what the problem is. The downside of all this is that if the self diagnosis doesn't work then they are more difficult to diagnose.

BASE STATION NETWORKS

Governments around the world seem to want to get involved in the supply of RTK GPS corrections. Why is this? Because they can! Do they work – yes. Is it a good idea? Probably not because it is impractical to deliver these services to tractors, everyone seems to think if they can deliver the service to the office then the job is sorted! These systems deliver RTK corrections via internet. Delivery of gps corrections is not new its all been done before and the only successful solutions are run by AMSA (marine beacon), Omnistar and John Deere (Starfire). Currently at best these offer 10cm accuracy and they cost at least $1,000pa. Will the government run a better service than this???

The problem is they offer RTK corrections via the internet. How reliable is the internet on farms and what does it cost?

Via telephone line

This uses a dedicated office PC to accept the information and needs a means of re-transmission to the tractors in the field. A repeater mounted on a tower close to the house is required to get the signal from the office to the field and a repeater would cost about $3,000. Often this is not practical because the house/office is not ideally located as a re-transmission site, not central to the farm or on the highest point. How reliable is the internet connection – need 100% 24/7???

Via stationary satellite dish

Same issues as above we need to re-transmit the data to the field. Possibly slightly more reliable connection than landline - but at a cost.

Via mobile phone

This is probably the most convenient solution because it does not require re-transmission of the data to the tractor but its success depends on having reliable mobile coverage over the entire farm. If that fits your farm then this may be a viable alternative but you need to be aware of the data costs of this service.

WIRELESS

Wireless functionality offers many exciting functions that provide benefits to both users and business' providing technical support. It is now possible for technicians in an office to examine and change setting on a system operating in the paddock. Like many technologies there is always someone willing to oversell its capabilities, it won't solve all the issues but it will reduce the cost of servicing this equipment and it will provide better support to farmers. However nothing replaces technically competent manpower in the field.

UPGRADE EXISTING SEEDER OR PURCHASE A NEW SEEDER

Practically any airseeder or combine can be converted to variable rate. A 2-3 product system will cost somewhere around $10,000-$20,000 depending on the drive mechanism. Retro-fitting will mean you get specialist support. Buying it with a new seeder means you are reliant on support from the manufacturer. Unless there is a definite need for improved seeder hardware then retrofitting the seeder is probably the best option.

STEERING WINDROWERS

These have been demanding vehicles to steer especially at high speed and in undulating terrain. There are a number of new options that promise improved performance.

STEERING THE IMPLEMENT

Inter-row sowing seems to be the most demanding application with respect to accuracy. Steering the implement is the latest technology that provides improved performance.

Equipment tracking often limits does not track sufficiently well to be able to inter-row sow but these fears are unfounded provided some basic guidelines for setting up the machinery are followed. In most situations implement drift is manageable. For example there are customers inter-row sowing with 50ft Flexicoils on 9 inch tyne spacing albeit on relatively flat terrain, 60ft DBS systems on 12 inch spacing operating over Mallee sandhills and even 120ft Multi-planters in Qld. In the case of the 120ft wide Multi-planter is operating in very extreme conditions operating over steep contour banks and is using an AFTracker system that steers both the tractor and the implement simultaneously. Given the breadth of experience we now have it’s a safe bet to say that inter-row sowing on 12inch tyne spacing is very achievable with most equipment and in most terrain types.

For more information please feel free to call GPS-Ag Pty Ltd 1800211884

Getting the Most from Guidance

Breil Jackson

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Getting the most from guidance is as simple as using it for every possible application on the farm. The requirement for higher efficiency, cost savings and greater production are enormous right across the whole spectrum of farming activities. I believe every broadacre cropping farmer should be using some sort of satellite guidance system on their farm. It is a useful tool for saving money in this time of extortionately high input costs, for the increased production benefits, for the ease of setting up a tram tracking system, for the improvements that come with offsetting crop rows, and the ease with which offsetting can be achieved.

There is, however, a more fundamental reason why every cropping farmer should be using satellite guidance, especially when spraying. That reason is, when a computer drives your tractor to spray your paddock with high accuracy guidance, you can guarantee to cover every square inch of the paddock. That gives you the potential to kill every single weed, every time you spray. Given that the rate is right and the equipment is set up properly, if you kill every single weed every time you spray, you never let those weeds seed, your chances of getting weed resistance in a no-till situation are drastically reduced. Guidance also makes it simple to spray at night and still get perfect coverage, when summer weeds are easier to kill. Weed resistance can be influenced by numerous factors, but it is essentially a numbers game – if you have high populations of weeds partly due to previous populations seeding because they slipped around the end of the spray boom when the foam dropped in the crop and you couldn't see it, you are never going to be free of the burden of weeds. Don't be one of the farmers to see weed resistance because you are trying to kill high numbers of weeds with relatively weak (in-crop) chemicals. Help keep the weed numbers low, keep the chemical strong – don't allow weed resistance. What is it worth to you not to get weed resistance? In the long term, for many broadacre cropping farmers – many thousands of dollars. For this reason alone, a high accuracy guidance system is cheap. View it as an insurance policy.

Of course, there is the huge cost saving from only putting out the correct amount of chemical, seed and fertiliser on your land. Every paddock has a constant area - there is no sense or point, economically, environmentally, or for any other reason, in spraying 10% more, or sowing 10% more, than you are going to harvest. The paddock area is fixed – spray and fertilise only what's there. Guidance makes this possible.

Tram tracking offers many benefits. High accuracy, repeatable guidance makes a move to tram tracking extremely simple, in terms of putting the tracks in the paddock and keeping them in the same place. Keeping the tracks in the same place means less compaction and greater air content in the soil - a softer soil allows faster infiltration and greater capacity for holding water. Essentially, if you don't compact your soil, you increase the size of the bucket. Some research has indicated up to 50% increase in some soils. What is it worth to have up to 50% more moisture in your soil when things get hot in September? In the long term the value of that in any given season could be hundreds of thousands of dollars.

With the high cost of machinery these days and trash handling ability being paramount in a no-till system, high accuracy guidance means that you don't need a machine that can handle trash, you just need a machine that can avoid it. By running tynes and disks away from where last year's trash rows are, you don't have to handle the trash, you don't disturb it, you just plant between it. Anyone that has ever watched a machine that blocks up will know that as soon as you run into the residue rows, machines block quickly. If you can keep the residue away from a tyne, particularly, the blockages don't occur.

There is also evidence that offsetting rows leads to less crop diseases when you are planting the same family of crop, such as cereal on cereal, if you can keep the new crop row away from last years root zone. You can also achieve better establishment by keeping canola, for example, out of a thick row of stubble.

High accuracy guidance allows you to perform tasks such as shielded spraying, which can offer advantages in killing certain types of weeds, and there are cost savings depending on what you are trying to kill in what situation.

You can use guidance in a wide row cropping system to leave a large part of the paddock permanently undisturbed between the rows. This is only possible with repeatable high accuracy guidance. The undisturbed soil becomes a moisture bank which acts like a sponge, soaking up the water and releasing it to the ensuing crop.

Putting a header on tram tracks with high accuracy guidance means that this very expensive machine is running at full capacity all the time. You take a full cut, you don't have to steer, all you have to do is control the speed of the machine and keep the capacity up. A header running on tram tracks has more horsepower available to drive the rotor because it is not being wasted compacting your paddock. It is hard to imagine a more efficient harvesting situation.

Satellite guidance also maximises the human resource, allowing an operator to focus on the task at hand rather than on driving straight. Concentration levels are higher for longer. You need less labour and those you have do a better job.

There are many other uses for guidance around the farm, including putting in fencelines that are perfectly compatible with your cropping rows, which means less corners and low efficiency or wasted areas. I put in tank drains, roaded catchments, and roads, all using the guidance, so that they are fully compatible with my cropping paddocks. This increases efficiency. When I am laying out paddocks, the whole farm layout is based on achieving efficiency with tram tracks. The longest, straightest runs mean highest efficiency. You should not be doing any farm re-designing without using your guidance system to get everything compatible. This is the best way to achieve the most from your land resource, your applied inputs, your time, and to maximise total farm production.

Based on all these factors, I believe that a high accuracy repeatable guidance system is as important as the tractor in a modern farming system. No serious broadacre cropping farmer can reasonably argue a case for not adopting guidance technology.

European Network GPS and future directions

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INTRODUCTION

Farmers are now a significant user group for the GPS (Global Positioning Systems) industry in Australia, Europe and in other parts of the world. The agricultural GPS market is separated from surveying based GPS markets, such as mining, construction and local government. The companies working in the agricultural area have chosen to cut the price on GPS receivers to farmers to encourage uptake. Farmers may think the systems are expensive but GPS receivers and base stations sold to the surveying industries cost 50 – 100 % more for technically similar equipment. This has caused a much bigger uptake by farmers using intelligent farming practices like CTF.

Supplying GPS to farmer at a lower price has also some drawbacks. If the receivers and base stations where completely identical, surveyors would spoil their market by buying the agricultural GPS receivers. The technical difference between the two markets is mainly lack of communication standards in agriculture. Most agricultural suppliers have implemented their own communication protocol. For example, Trimble in agriculture use the CMR-w protocol which is a variant of the open and published CMR+ protocol used in the surveying industry. For Trimble this ensures that surveyors cannot buy the agricultural base stations. The more expensive but technically identical base stations using CMR+ can be used by agriculture so to share across agriculture and surveying, the surveying base stations have to be used. Some agricultural suppliers also protect their systems by use of different radio types.

Major investments have been made by some companies in setting up base stations across agricultural areas. The company then has a competitive position, for supplying corrections to new users in the area.

For ease of reading, we have used the term GPS to describe all GNSS (Global Navigation Satellite Systems). GPS is the tradename of a GNSS run by the American army.

DIFFICULTIES FOR THE FARMING INDUSTRY

A farmer investing in his first auto steering system wants a reliable system where high accuracy can be achieved on his entire property. The most inexpensive solution is usually to set up an agricultural base station with approximately 10 km range at a high point. Most farms can be covered by a single base.

Difficulties most often arise when farmers wish to work together. Contractors, e.g. harvest teams, have major difficulties as their steering system may not be compatible with the local base stations. If they use the same brand as the customer there is a good chance but no guarantee, as the radios may be of different types.

No absolute accuracy

Most users believe they have an accurate positioning system where they can document with cm accuracy the work done on their farm. This is not the case for most agricultural users because most agricultural base stations are not surveyed in to the true position. The position is most often created by the base station itself by averaging the positions gathered over some hours. This can cause deviations of several meters compared to true cadastral positions. It also means that all recorded positions are linked to the specific base station. If a position is typed into a steering system, that uses another base station, e.g. at a neighbour's farm, the tractor may end up several meters from the tracks laid out. A minor deviation in heading may occur as well. This problem can be solved if base stations are surveyed in to their true position. To keep the cost down this is seldom done, and the farmer is not informed about difficulties that may occur in the long term.

An intermediate solution when setting up more base stations is to use corrections from the first base station to position the other stations. This means that a user can shift between these base stations and still stay on track. But the positions recorded are not true cadastral positions. So at least the first base station should be surveyed in. If more base stations are set up individually and already in operation, they can not easily be converted into a local network. Preferably all base stations should be corrected to their true positions and all track records re-calculated or recorded again. Otherwise machines will not run precisely in the tracks in future.

10 cm systems do not guarantee 10 cm accuracy

In Australia most new users buy RTK systems with a claimed accuracy of 2 cm. Several users upgrade from the lower accuracy 10 cm systems that use satellite corrections from either the John Deere SF 2 service or HP and XP signals from Omnistar.

For many CTF farmers 10 cm accuracy may be adequate. The problem is that these satellite services do not offer absolute precision. The 10 cm measure is defined by John Deere as the accuracy that can be achieved within a 15 minute period – also named "track to track accuracy". Nothing is guaranteed about the absolute accuracy. From operation to operation the positions can shift more than 1 meter. This is a serious problem for CTF users. If tracks are visible, as they will often be in NoTill cropping systems, errors can be corrected by the shift track function that moves the tracks recorded in the steering computer. This is a messy solution.

Another difficulty is an initialisation time of up to 45 minutes before maximal accuracy is reached. Short term loss of satellite signal can cause loss of accuracy as well. Shading from trees can cause sudden shifts in track positions in the order of 30 cm or more.

RTK - NETWORKS IN EUROPE AND AUSTRALIA

High precision RTK positioning is adopted by agriculture independent of other surveying users. In most European countries, it has been cheaper to set up agricultural base stations instead of paying fees for RTK services that are already in operation. But, the increasing numbers of agricultural users should encourage network owners to get their share of this new market.

Suppliers of auto steering systems compete on setting up base stations. Once base stations are established in an area, it is easier to sell more steering systems. Typically, these local networks use non-standardised correction signals to avoid competitors using the networks. The biggest agricultural networks in Australia are established with AutoFarm or Trimble base stations. Local networks are run by farmer groups, and sugar mills own some networks on the east coast. Often networks are set up and run by the importer e.g. GPS-Ag or by local distributors who may be machinery dealers or dealers of electronic equipment. Machinery dealers typically offer RTK service for free the first year followed by a modest yearly fee.

The competitive rush to set up base stations is starting now in Europe. The highest proportion of farmers adopting auto steering is in the Netherlands and in Denmark. The RTK situation for agriculture in those two countries is however very different. In Holland, base stations have been supported financially by both the Dutch farmer organisation and the government, who see high precision steering and CTF as significant value to the important horticultural industry. It was a requirement that the networks established use open standard for communication, to enable all suppliers to benefit. Opposed to this, the Danish government has chosen to support a few farmers, who demonstrate new precision technologies, but setting up base stations has been left to commercial competitions. Case IH has just announced a plan to establish coverage of all significant agricultural areas in Denmark within the next few years. This will be done by Case to gain market share. Other Trimble based systems are expected to gain from the network as well. The competitors will probably not just wait to loose market shares. They may join their forces and establish an alternative, perhaps a network that uses open standards for communication.

CORS networks. Ten years ago surveyors used mobile base stations when they made RTK measurements. The base station was placed on a known position to achieve absolute true positions. Now, in most European countries CORS (Continuously Operating Reference Stations) networks are established. Surveyors and other RTK users can subscribe for correction signals from these networks. CORS Networks combine correction information from several base stations and extend the distance between stations, up to 50-75 km. There is no longer need for a base station every 10 km. Corrections to users are sent from a computer server that combines information from several base stations. Fewer base stations are required but continuous data communication is required both from the base stations to the central computer and from the computer to the rover GPS receiver e.g. on a tractor. Trimble, Leica and Topcon have developed software for CORS networks. These systems use open communication standards.

Many countries in Europe are covered by two competing networks, supplied with server software from Trimble and from Leica. Setting up CORS networks in Europe is easy compared to Australia as areas are smaller and broad-band internet is accessible in most areas. The Danish GPS-net network covers Denmark well with 25 base stations. Australia is 180 times bigger than Denmark, but the population is only four times bigger. To cover Victoria alone, a CORS network will require close to 100 base stations. More State agencies are working to establish CORS networks. VicPOS in Victoria is the most progressed and RTK accuracy can be achieved in the Melbourne and nearby areas. A program to extend RTK across the State has just been announced.

Tractors with Trimble auto steering have been linked to CORS networks in Denmark, the Netherlands and Switzerland. Corrections are received through the internet (GPRS) by use of mobile phone technology. Data volume using the compressed CMR+ standard is around 0.5 mB/hour. Operating cost depends on the price set by the network owner. The first experiences shows accuracy similar to use of local base stations. No accuracy tests have been made yet. In the Netherlands the fee is set to 1,000 Euro/yr which is equivalent to the cost of StarFire 2 from John Deere. Several other auto steering suppliers are testing use of CORS network signals for their systems.

RECOMMODATIONS

CORS Networks

For European conditions use of CORS networks can become a good alternative as CORS networks are in operation already. With CORS networks, farmers are not restricted to the range of single base stations. The fee to use the signals needs to be negotiated with the national network owners. Use of mobile phones (GPRS or 3G) is generally cheap in Europe.

In Australia only minor rural areas are covered by CORS networks. There is State Government interest in extending CORS networks to cover cropping areas. Next-G technology may be a good way to transmit corrections, if data transmission is reliable and cheap. Clearly, a mobile phone connection on the rover is required. The recently released Leica rover has a mobile phone built in. CORS network corrections could be sent over the internet to a farm computer and re-broadcast over the farm by radio link. This would have to compete in price with a farm base station.

Use open communication standards and true positions and CORS Networks

Open communication standards and protocols are recommended for all RTK applications in cropping areas. These should also be surveyed for true position. This will allow access by all agricultural users as well as other industries such as surveying, construction and mining. Regional CORS networks have major advantages.

Farmer groups or others involved in setting up networks of base stations should use open data protocols and standardised radio communication. The investment may be higher but the opportunities with the network are a lot bigger as well. Competition will force down the price on these systems as well. A major problem can be that dealers of the auto steering may not be aware of the open and standardised option, as they have been trained to sell the company solutions only. Most auto steering systems can use standardised correction signals. If the auto steering dealer will not supply a standardised network, other suppliers will.

The official public standard for RTK corrections is called RTCM. It exists in several different versions. As an alternative Trimble has published the CMR standard that is also free for everybody to use. CMR+ is the recommended version for agricultural applications.

Back up GPS data

Computers do break. Most often they do not, but when they do it causes a lot of hazards. This is true for auto steering systems as well. With no back up of your A-B lines it is impossible to go back exactly in the tracks. The A-B lines and curved tracks can in most steering systems be exported. Do it - and keep it as backup.

If your base station is hit by lightning or for some other reason needs replacement, then a new base station can easily be installed, if you have recorded the position of your present base station. Keep this information in a safe place.

ACKNOWLEDGEMENTS

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Economic and Environmental Analysis of Converting to Controlled Traffic Farming

Based on a report prepared for the Clifton Allora Top Crop (CATC) Group

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BACKGROUND

The CATC Group is comprised of 16 separate farming businesses on the Eastern Darling Downs of Queensland that range in size from 260 ha to 1600 ha. The majority of these properties have been continuously farmed for in excess of 100 years, which has resulted in a gradual decline in soil fertility and structure. The CATC group is made up of a number of innovative farmers who are early adopters of technology and who all share a common goal to become more economically and environmentally sustainable.

All of the CATC group members are following a similar path in the transition from conventional cultivation farming to Controlled Traffic Farming (CTF); however they are all at slightly different stages in that process.

The area farmed by CATC group members is approximately 6,500 ha and of this area 4,132 ha has been fully converted to CTF.

Historical Practices

As a general summary of the group members, the traditional farming practices were:
- ⇨ Cultivating the soil 4 – 6 times during the fallow period.
- ⇨ A full disturbance planting.
- ⇨ In crop sprays of 1-2 applications.
- ⇨ Harvest plus a chaser bin.
- ⇨ No uniformity in wheel base widths and no uniformity to wheel tracks.
- ⇨ Burn stubble soon after harvest.
- ⇨ Up to a third of the land in long fallow.

Current Practices

The transition that is occurring amongst the group is based on the following set of assumptions:
- ⇨ No cultivations during the fallow period.
- ⇨ 2- 4 fallow sprayings.
- ⇨ Retain maximum stubble during fallow.
- ⇨ Direct drill planting with minimal soil disturbance.
- ⇨ All workings on tram tracks where possible. Most members have or are converting their tractors to a uniform wheel spacing (3 metres seemed to be the most common width).
- ⇨ The width of the planter and harvester are generally configured to be the same and the spray rig is often double or triple that width, this allows the majority of the traffic in the paddock to be confined to the allocated wheel tracks.
- ⇨ Because of the increased moisture (higher infiltration and greater storage) in the soil profile there is generally a higher cropping frequency than with the old system.

Future Practices

The next fundamental step is to implement high precision guidance to maximise the benefits of the CTF system. With higher precision guidance there is a raft of additional management options and benefits to farmers including; selective band spraying, more crop rotation options, higher water use efficiency and higher cropping frequency.

ENVIRONMENTAL BENEFITS

The change in farming systems by the CATC group members will undoubtedly have a number of environmental outcomes most of which will be beneficial to the Condamine Catchment. However attempting to quantify these benefits is more of a challenge.

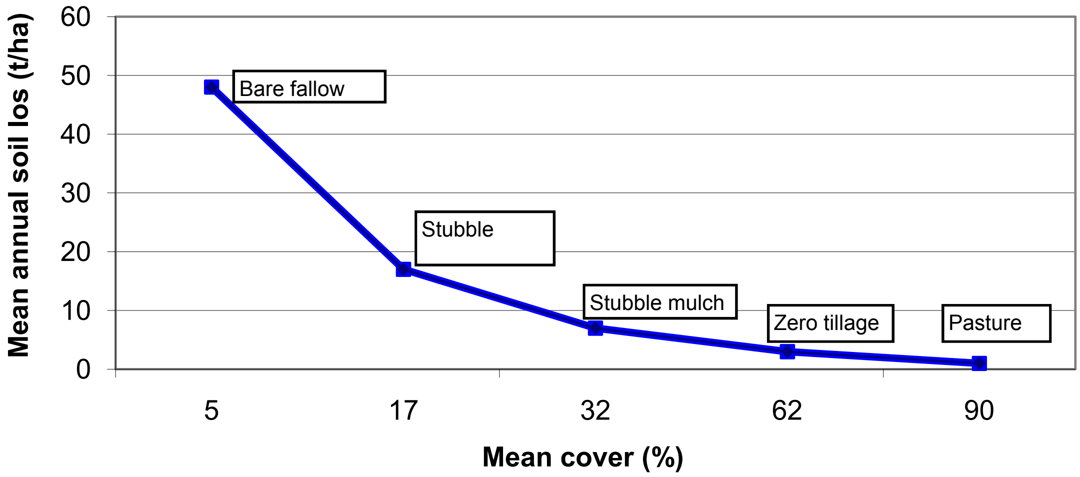
Reduced Soil Loss/Erosion

One of the most noticeable affects of the move to CTF/No-Till is the reduction in erosion and subsequent soil loss from the properties. Between 20 and 30% soil cover reduces soil loss movement by 80-90% (Freebairn 2004) as graphically represented in Figure 1.

Reducing soil loss has several benefits:

- Cleaner water (i.e. less sediment) in the river systems,
- Less chemical and fertiliser residues in the river systems, and
- Less loss of top soil from the farmers property resulting in better productivity.

Table 1: Annual Average Soil Loss



.Figure redrawn from (Freebairn & Wockner 1991)

Therefore to quantify the reduction in soil loss as a result of the CATC group members implementing a change from conventional farming to conservation farming I will use the following assumptions:

The average starting point for the CATC group with regard to soil loss (refer to Figure 1) is somewhere between bare fallow (48 t/ha) and stubble incorporated (17 t/ha). For this report I will adopt a starting soil loss figure of 33 t/ha.

Because the majority of the CATC group members are early adopters I will assume that the soil loss as a result of implementing conservation practices is at the zero tillage point on the figure 1, which is 3 t/ha.

Therefore the total reduction in soil loss as a result of implementing conservation farming practices is 195,000 ton per annum (based on 6,500 ha with an annual soil loss saving of 30 t/ha).

Reduced Fuel Usage

One of the big savings in CTF is the reduced number of cultivation workings because weeds in the fallow stage are sprayed rather than cultivated. The main environmental benefits of this are related to a substantial reduction in the use of diesel fuel and repairs to machinery.

The average historical practices of the group were 4 full tillage cultivations plus 1 planting with full disturbance. The current practices as a result of implementing changes are 4 fallow sprays and 1 minimal disturbance planting.

The following assumptions used in this exercise are sourced from (Harris 2005):

- Fuel usage per kilowatt (KW) of tractor power per hour is equal to 0.25 litres.
- The average tractor size used by the group is 188 KW.
- The average speed for cultivating is 4.5 hectares per hour.
- The average fuel usage for cultivations is 10.4 litres per hectare.
- The average speed for spraying is 20 hectares per hour.
- The average fuel usage for spraying is 2.3 litres per hectare.

Table 2 – Estimated fuel usage under different farming systems

Details	Conventional	Zero Till - CTF	Saving
Number of workings *	5	1	**4**
Number of fallow sprays	0	4	**-4**
Fuel usage per ha	52	20	**32**
Total fuel used by group (l)	338,000	130,000	**208,000**

* The number of workings includes one planting activity.

This analysis finds that there is an average reduction of 208,000 litres of diesel fuel used per year by the CATC group members. (I have not made any allowance for the improved fuel efficiency by driving on the compacted tram tracks).

Reduction in Fertiliser and Chemical Pollutants Entering the Waterways

As discussed earlier, the Zero Tillage and CTF systems are designed to reduce soil and water runoff from the paddock. Therefore there will be less fertiliser nutrients and chemical pollutants leaving the paddock and entering the river catchment.

The Zero Tillage and CTF systems are estimated to have a 30% higher fertiliser requirement than the conventional system because we have allowed for a 20% higher cropping frequency and a 10% improvement in crop yield. However the total amount of fertiliser residue leaving the property and entering the catchment will be less because of the substantial reduction in soil sediment loss as calculated earlier in the report.

This process would be very similar for calculating the potential residue loss from any chemical applications. The reduction in soil loss with conservation farming is the predominate factor in determining the potential reduction in fertiliser or chemical residue leaving the property.

To estimate the amount of Nitrogen (N) residue that could be susceptible to run off from the property we have to consider how much N is applied, how much is likely to be used by the plant and how much is remaining in the soil. One of the accepted method for calculating the N requirement for a crop (as reported by DPI and CSIRO) is to estimate the target yield and protein of the crop and then times these by 1.75 for wheat and 1.60 for sorghum and barley. Because only about 50% of the available soil N ends up in the harvested grain you would times the N requirement by 2.

Table 3: Example of N Requirements for a Conventional and CTF System

Details	Conventional	Conservation
Yield (t/ha)	2.5	2.75
Protein (%)	12.5%	12.5%
N Removed in grain (kg/ha) *	55	60
N Needed (kg/ha)	110	120
N Available for loss (kg/ha)	55	60

* N removed in grain = yield * protein * 1.75

After the crop is harvested 50% of the N applied is still within the top profile of the soil and potentially susceptible to loss from soil and water run-off. If we assumed that under the conventional farming system that up to 33% of the unused N left the property in eroded top soil, there would have been a total loss of N into the catchment from the CATC group members of 119 ton (i.e. 55 kg/ha * 1/3 * 6500 ha).

However, under the conservation system the soil loss is reduced by up to 14 times of the conventional farming system (i.e. from 42 t/ha with conventional to 3 t/ha with conservation). Therefore the potential amount of N being lost from the properties and entering the catchment under the conservation system for the CATC group members is estimated to be 9 ton (i.e. 60 kg/ha * 1/3 * 6500 ha)/14.

Therefore the estimated environmental benefit relating to reduced N residue entering the catchment from the CATC group members is 110 ton of N per annum.

Carbon Emissions

Peter Grace from the Institute for Sustainable Resources (ISR) a Department of QUT has developed a greenhouse gas calculator for the cotton industry (http://www.isr.qut.edu.au/tools/index.jsp). This model should work equally for any cropping activity in the given region.

The model indicates that for every 1,000 litres of fuel used that there is 2.7 ton of carbon dioxide (CO^2) emitted and for every 1 ton of nitrogen fertiliser used there 2.4 ton of CO^2 emitted. Therefore if the CATC group are saving 208,000 litres of fuel per annum they are saving approximately 562 ton of CO^2 or 152 ton of carbon (i.e. the carbon component of CO^2 is approximately 27%) emissions per annum.

In the analysis we have ascertained that there has been a potential reduction in N loss from the properties of 110 ton which equates to a saving of 264 ton of CO^2 emissions or 71 ton of carbon.

Summary of Environmental Benefits

The environmental benefits of changing farming practices from a conventional tillage system to a conservation system are many. The most difficult challenge is in quantifying the benefits and then trying to place a value on them.

Table 4: A summary of the Environmental Benefits of Converting from Conventional to Conservation Farming

Indicator	Conventional		Conservation		Benefit	
	Per Ha	Group	Per Ha	Group	Per Ha	Group
Soil Loss (tons)	33	273000	3	195000	30	195000
Fuel Usage (litres)	52	338000	20	130000	32	208000
Nutrient Loss (kg)	18.30	119000	1.3	9000	17	110000
Fuel - CO^2 Loss (t)	0.23	913	0.1	351	0.12	562
N - CO^2 Loss (t)	0.044	286	0.003	22	0.040	264

THE ECONOMIC BENEFITS OF CONVERTING TO CTF

The costs to convert to a CTF system will vary from farm to farm depending on what combination of tractors and equipment farmers currently own and what level of compatibility they wish to achieve across their machines.

Quantifying the direct benefits of converting to a CTF system is not easy to pinpoint, but there are numerous anecdotal reports, as listed below.

Reduced Overlap and Reduced Input Costs

The main benefit with reduced overlap is coming with the transition from zero tillage to CTF rather than from conventional cultivation to zero tillage. Accurate positioning of each operation under CTF, has been shown to reduce the area and consequently the inputs required, by the order of 15-30% (Chapman and Powell 1998).

Table 5: Effect of a 15% Reduction in Overlap with CTF

Details	**Zero Till**	**CTF (15% saving)**	**Savings Per Ha**	**Savings CATC Group**
Seed ($/ha)	34	30	4	$16,528
Fertiliser ($/ha) *	124	108	16	$66,112
Chemical ($/ha) **	89	77	12	$49,584
Total	**247**	**215**	**32**	**$132,224**

The CATC group $ savings relate to 4,132 ha of land being converted to CTF.
* Fertiliser based on applying 120 kg/ha of urea @ $900/ton.
** Chemical based on applying 5 l/ha roundup @ $12.5/l & $15/ha for an in-crop spray.

The CATC group should receive an annual reduction in crop input costs for converting to the CTF system of around $32/ha or $132,224 per annum (based on 4,132 ha).

The seed and fertiliser costs for conventional farming system would have been the same as for zero till in the above table ($158/ha) and the chemical cost would have been $15/ha for one in-crop spray.

Reduced Compaction and Increased Ground Cover Leads to Increased Yield

The combination of less traffic in the cropping zone promotes better soil structure and increased stubble cover from zero tillage ultimately allow more moisture to enter and be retained in the soil. These combined practices can lead to crop yields increasing by an estimated 10 - 30%.

A 10% improvement in crop yield would produce an additional 1,033 ton of grain per annum for the CATC group, which at a price of $200/ton equates to $206,600.

Greater Cropping Frequency

Because there is more moisture retained in the profile there is greater potential for opportunity cropping, this could increase the annual cropped area by 10 - 40%.

Based on evidence from CATC group members and from various research we will adopt a 20% increase in cropping frequency from 80% with a conventional system to 100% with a CTF system. A 20% increase in cropping frequency equates to a potential increase in gross income for the CATC group of $478,006 (i.e. an extra 827 ha * $578ha).

Less Yield Variability Leads to Higher Grain Prices

In drier years the yields from the CTF system are historically higher than with conventional farming as are the grain prices. This can allow the option to be more proactive with grain marketing and the opportunity to capitalise on higher grain prices during drier year, which could result in 5- 20% higher grain prices on average.

To be conservative we have worked on a 5% improvement in grain prices. A 5% improvement in grain prices (i.e. $200/t + 5% = $210) equates to a potential increase in gross income for the CATC group of $113,630 (i.e. 11,363 ton * $10/t).

Less Fuel and Oil Usage

As discussed in the environmental analysis the estimated fuel usage for the conventional farming system was 52 litres/ha and 20 litres/ha for the CTF system. If we value the fuel at $1.60 per litre there is an annual saving of $51/ha or $210,732.

Fewer Repairs and Maintenance

The repairs and maintenance figures normally reduce quite markedly with CTF systems because there are fewer tractor hours and less horsepower required than with a conventional farming system.

For this analysis I will adopt the repairs and maintenance figures calculated by (Harris 2005).

Conventional –

4 cultivations @ $3.05/ha	= $12.22 (an average of a chisel plough and a cultivator)
1 planting @ $3.54/ha	= $3.54
1 spray @ $0.72/ha	= $0.72
Total	**= $16.48**

CTF -

4 fallow sprays @ $0.72/ha	= $2.88
1 planting @ $3.81/ha	= $3.81
1 spray @ $0.72/ha	= $0.72
Total	**= $7.41**

Therefore there is potentially a reduction in the repairs and maintenance expense of $37,477 across the group (i.e. based on a $9.07/ha saving over 4,132 ha).

Less Labour Required

With the conventional farming system they cultivated the ground 4 times plus had a planting. The speed of operations as established in the earlier section was 4.5 ha per hour which means that it would take 918 hours to complete the group area of 4,132 ha. Because there were 5 working in total there was a labour requirement of 4,590 hours and if we valued that at $20/hr the total labour costs were $91,800.

With the CTF system there were 4 fallow sprays at a rate of 20 ha per hour for a total time of 826 hours plus one planting of 918 hours equals a total labour requirement of 1,744 hours valued at $20/hr = $34,880. Therefore the annual saving in labour across the CATC group is potentially $56,920.

Selective Spraying

The CTF system provides the opportunity for more accuracy with regard to operations such as selective spraying, shielded spraying and band spraying. Having these options can reduce the area of the paddock that needs to be sprayed by as much as 50%. Often the herbicides used for band spraying are more selective which means they are generally also the most expensive chemicals.

Even though this is a recognised benefit with CTF I have not attached any dollar benefits to it in this analysis.

Greater Cropping Options

Another benefit with having a CTF system is that there are a number of double cropping and rotational cropping options that would not have been available with a conventional farming system. These options are available because the operator has greater control over the accuracy of seed and chemical placement. This does provide a distinct benefit to the grower but once again I have not attempted to attach any dollar benefit in this analysis.

Capital Costs to Convert to CTF

The costs to convert to a CTF system from a conventional system will vary from farm to farm depending on what combination of tractors and equipment farmers currently own and what level of compatibility they wish to achieve across their machines.

I have selected the main modifications and equipment upgrades that members of the group have undertaken and then apportioned a costing to represent an average across the group. I have then tried to rationalise how much of this upgrade was specifically for CTF

Table 6: A Summary of the Average Cost of the CATC Group Members to Convert to a CTF System

Item	Cost	CTF %	CTF Capital
Upgrade tractor	$200,000	20%	$40,000
Upgrade planter	$50,000	100%	$50,000
Widen wheel base's to 3 metres	$22,000	100%	$22,000
Upgrade spray rig	$50,000	50%	$25,000
Total	**$170,000**	**44%**	**$137,000**

Based on the assumptions in the table above the CATC group members have spent an average of $137,000 in capital expenditure towards converting to a CTF system.

SUMMARY OF THE ECONOMIC BENEFITS

In Table 4 I have summarised the economic outcomes in the form of a gross margin comparison between a conventional farming system and a CTF system for the CATC group members.

Table 7 - A Summary the Economic Impacts of CTF on the CATC Group

Details	**Conventional**		**CTF**		**Change**
	$/ha	**Group**	**$/ha**	**Group**	**%**
Area (ha)	1	3305	1	4132	**+ 20%**
Average Yield (t/ha)	2.5	2.5	2.75	2.75	**+ 10%**
Total Tons (t)	2.5	8262	2.75	11,363	
Average Price ($/t)	$200	$200	$210	$210	**+ 5%**
Income	**$500**	**$1,652,500**	**$578**	**$2,386,230**	**+ 44%**
Seed/Fertiliser/Chemical	$173	$571,765	$215	$888,380	+ 55%
Fuel & Oil	$83	$274,976	$32	$132,224	- 52%
Repairs & Maintenance	$16	$52,880	$7	$28,924	- 45%
Labour	$22	$73,400	$8	$33,056	- 67%
Contract Harvest	$40	$132,200	$40	$165,280	+ 25%
Production Costs	**$334**	**$1,105,221**	**$302**	**$1,247,864**	**+ 12%**
Crop Gross Margin	**$166**	**$547,279**	**$276**	**$1,138,366**	**+ 108%**
CTF Annual Allowance *		$0	$53	$220,000	
Total Gross Margin	**$166**	**$547,279**	**$223**	**$918,366**	**+ 68%**

* The CTF capital costs relate to 16 group members spending an average of $137,000 per group member in their conversion to a CTF farming system for a total cost of $2,200,000. We have included an annual replacement allowance of 10% or $220,000.

Findings from the Economic Analysis

- The collective benefits of increased cropping frequency, increased yield and improved grain prices have the potential to improve the gross income of the group by 44% or $733,730.

- The cost of chemicals was understandably dearer under the CTF system and this was largely offset by the higher fuel and repair costs under the conventional system.

- The total production costs ended up being about 12% higher for the CTF system even though the production costs on a per hectare basis were $302 for CTF and $378 for conventional. The main reason for this is that the 20% saving in costs was offset by a 20% increase in the cropped area.

- An annual allowance of $220,000 for the costs to change to a CTF system has been included in the analysis.

- The total potential economic gain from converting to a CTF system for the CATC group is $371,087. On an individual group member basis the economic gain is $23,193 (based on 16 group members), which represents a 17% Return On Capital invested (i.e. $137,000 invested per group member). Therefore the payback period on the $137,000 investment is approximately 5.9 years (assuming all of the stated benefits are available from day one).

- The combined benefits of the CTF system have the potential to nearly double the profit level for the group members businesses.

Precision Agriculture – A Point in Time

Randall Wilksch

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INTRODUCTION

This is a family farming business located at Yeelanna on Lower Eyre Peninsula, South Australia. The business comprises my parents, Max and Julie, myself, and my wife Julie, and youngest brother Jordan and wife Kylie. I am the eldest of three boys, with Jordy being the youngest. Our other brother Leighton works for Landmark as a Research Agronomist at Paskeville on Yorke Peninsula.

In 2008 we are cropping 3000ha with no livestock. In conjunction with the CBA we own just over 1600ha, lease remaining 1400ha of that. Crops we grow are Wheat, Malt Barley, Feed Barley, Canola, Faba Beans and Lupins. Rotation is highly variable and often based on weed control.

- Our Annual Rainfall is 433mm which in the last two years has only averaged 355mm
- Growing Season Rainfall 346mm which in the last two years has only averaged 195mm
- Because of this our 10 year rolling average for wheat yields has rolled down to 2.95T/Ha.
- Our biggest issues are herbicide resistant ryegrass and snails / slugs.

Similar to much of southern Australia we have highly variable soil types. We range from sandy buckshot gravel pH 5.5 to highly alkaline clay soils of pH 8.5, often within 50 metres or so. The property we lease is predominantly sand over clay with limestone reefs running through. Max has always had a real interest in soil and has been measuring and testing soil since the early 1980s. Because of this we have been "site specific" farming for years, especially during the pulse phase of the rotation, growing beans or lupins in odd shaped pieces in paddocks following soil types.

PRECISION AGRICULTURE

In the late 1990s we moved into the Case IH family of Harvesters and our local dealer set up our harvester to Yield Map as part of a trial site we were involved with. This gave us the ability to make lovely coloured maps of stuff we didn't understand or couldn't use with our computer but was fun to look at. The first paddock we successfully mapped was 170A, a sandy gravel (prone to waterlogging) flat rising to a clay loam (over limestone marl) hill. Max had been soil testing this paddock since the 1984 and trying to work out why the higher producing, "better" clay soils had lower inherent phosphorous levels than the poorer gravel soils. During 2005 that it became blatantly obvious to me that if you consistently apply a blanket rate of DAP but extract more grain from some soil types *of course* the amount in the soil will change! Figure 1.

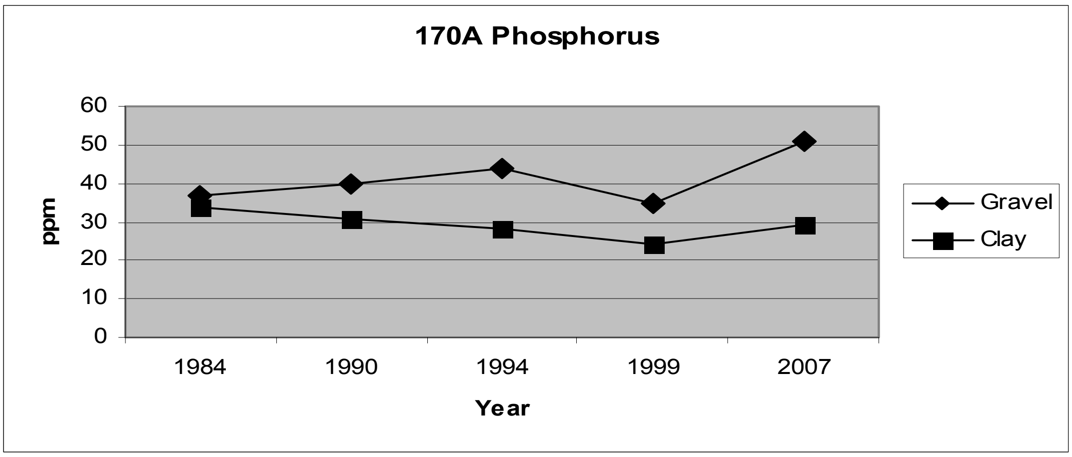


Figure 1. Historical Soil Phosphorous (Cowell P) across two distinct soil types.

We have been messing around with both small plot and paddock trials sites for years and marking out ideas with the standard chemical drum on a dropper positioning system. Trials were always weighed out with a weigh crate and we have manual records on everything in the office. When we changed over the airseeder we bought one that was "VRT equipped" even though we didn't know why or how to use it!

We were determined not to jump on the GPS guidance bandwagon for the sake of straight line vanity and it wasn't until the work done on at Maitland on Yorke Peninsula on interrow sowing that we could see some real benefits. We were already sowing up and back, and drive fairly straight, so the absolutely outrageous claims of "saving 10 to 15%" on overlap held no sway with me. No we are not overlapping 5 or 6 tynes on our 54foot airseeder, at least not before 2am anyway. So after debating with many people the pro's and con's of autosteer (and then discovering only one company could steer Cat Tractors) we made a move to a gpsAg A5 RTK.

We are now in our third year of 2cm auto steer and are very happy with our ability to interrow sow which is exceeding our expectations in our hills by successfully interrowing about 85 to 90% of the time.

We have been involved with SPAA and Allan Mayfield for some time and through this relationship have done some trial work with the *Yarra N Sensor*. In Figure 2 it can be seen mounted on the roof of the tractor. The N Sensor uses infrared light to measure "greenness" of the crop and we have in the past coupled it to our Bogballe spreader and spread urea variably. We have set it so where the crop is rich and lush green it applies less urea and where it is poorer and yellow it applies more urea. The same total volume of urea is spread in the paddock, just used more effectively.
For the last two years my brother Leet has made available to us Landmarks *NTech GreenSeeker* enabling us to compare the biomass maps from different machines in the same paddock.

Figure 2. Yarra N Sensor on roof coupled to Bogballe VRT spreader
and NTech GreenSeeker on front weights of tractor

I personally feel that either of these methods is going to be better for measuring biomass and variable rating urea than a satellite image. Mostly because you can get the image on the day you want it. The problem is that the cost of the technology is still a little difficult to justify.
So where are we at?

The next step was to take these two biomass maps and add them to five years of yield maps combine them. Actually this bit was quite beyond me so I emailed it to Sam Trengove, (Allan Mayfield Consulting) and he combined them into a zone map, of above average, average and below average yielding zones across the paddock. With ever increasing prices of phosphorous it has become more important to maximise the efficiency of fertilizer. For our region, district practice has long been 100kg DAP, and 100kg Urea to grow a 3.5tonne/hectare crop of wheat on a cereal or canola stubble (64 units N, 20units P). Within our own paddock given the historical data of variable phosphorous readings across soil types (Figure 1) we decided to vary the phosphorous from zero to 20 units of P across both clay and gravel soils in a replicated trial to establish economic use of P for the paddock.

Late May we sowed a trial varying the rate of DAP, whilst balancing Urea to maintain a standard rate of nitrogen across the trial. Although the whole lot was mapped by the airseeder we still used the tried and true standard chemical-drum-on-a-dropper positioning system. Leaf nutrient analysis taken 10th June showed that phosphorous (P) levels were deficient in all areas of the paddock with the zero P treatment. During early August Leet and I mapped the paddock with the *GreenSeeker* whilst spraying to give a biomass map of the whole paddock including the trial. This did not show up any obvious treatment effects, probably as at this stage there was adequate soil nutrition for plant growth. Unfortunately for us August, September and October received no significant rainfall.

Next step was to successfully yield map the paddock again with the harvester. The unfortunate conclusion that we reached from this trial is that given rainfall there was adequate phosphorous nutrition for this crop to reach it's potential. Rainfall, not phosphorous was the limiting factor!
This trial has been repeated this year in the same location with variable rate DAP and has been sown to Faba Beans so we'll see if we can make Phosphorous, not rainfall the limiting factor.

Even though the 2007 trial did not show economic results, other soil tests taken across the property show that we have been accumulating phosphorous in our soil and we now believe we can better manage this resource. The next step is to purchase a more comprehensive controller for the airseeder and apply all seeding phosphorous as replacement plus 2 units from the previous year's yield map.

CONTROLLED TRAFFIC

This next bit I've put in to provoke a few questions and provide so controversy! I got very keen in 2005 after the wet spring to move strongly into CTF. I was sure after I mapped our wheel tracks across the paddocks that we were certainly doing some serious damage and restricting yield. We could see the ruts in paddocks caused by an annual average of 4 passes of the 6000L boomspray and MFWD tractor. We run a RTK autosteer so each pass is precisely down the same wheel tracks, so surely we have large amounts of compaction causing yield loss? I borrowed a penetrometer from PIRSA and set out to do some paddock transects. Jordy and I measured every row (305mm spacings), beginning at paddock edge and going out three boomspray passes, for ten separate paddocks; although I have shown only 137 rows here. (Figure 3). All measurements were taken at soil moisture field capacity and all these paddocks have had at least 4 passes in this year with a 6000L boomspray and this was all that showed up.

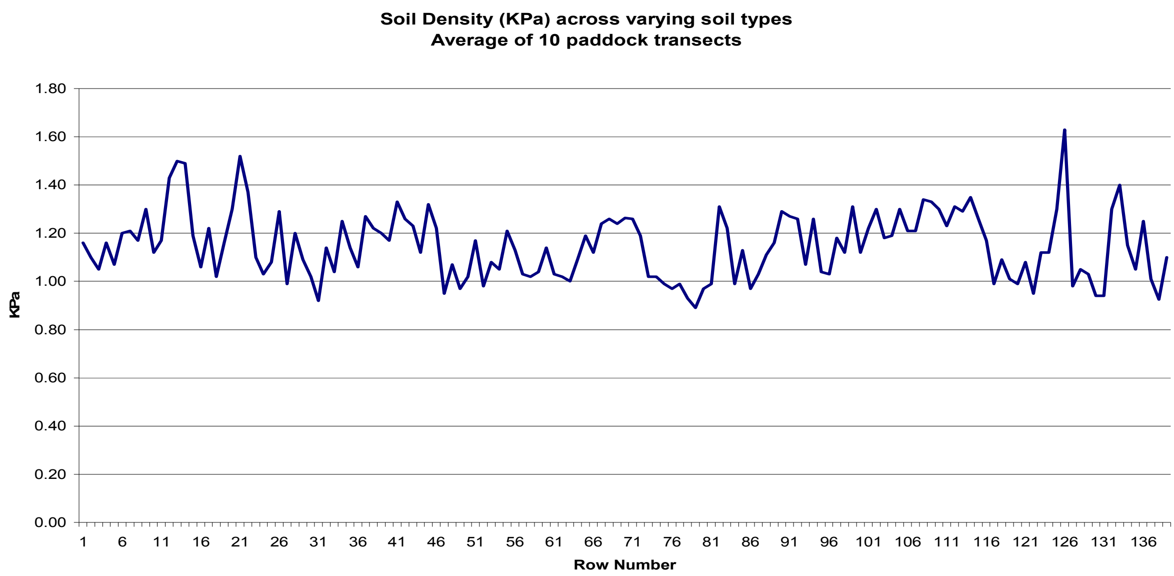


Figure 3. Soil compaction to 500mm depth measured at field capacity.

The two peaks at rows 13 and 21 and repeated at 125and 133 are the boomspray passes. Even though we could see the ruts, and the plants sown in them are smaller from being run over, we concluded in our soil type there is no significant compaction measured. We are part of another project run by Minnipa Agricultural Centre looking at compaction and early data seems to be suggesting in our soil types there are bigger yield restraints than compaction. We also leased a property in 2007 that due to the sheet limestone we used a 10m wide by 1.5m diameter round ribbed stone roller to roll 750 of 860 hectares immediately post seeding! When you are trying to smash rock into sand with a roller, compaction isn't in your thinking!

We also don't wish to downsize machinery to match wheel tracks up due to timeliness of seeding issues. It is probably cheaper to increase area and lease more land than spend money on changing machinery?

We also will always sow the trafficked rows as annual ryegrass control in unsown rows is more difficult to deal with.

Therefore, while we use a RTK autosteer and match machinery as close as possible without expensive modifications we are still unsure about some of the proclaimed benefits of purist CTF and the suitability to our system, but it is somewhere we aspire to get to over time.

CONCLUSIONS?

When we started down the yield mapping path there were certainly some neighbours who insisted on telling me that this stuff is irrelevant to farming, and we will never use it. At the time I responded that perhaps we wouldn't but maybe eventually my kids or grandkids could. And now within seven years and being pushed by high fertiliser prices we are really trying to get the best economic return for our fertiliser dollar.

We are working through a number of issues including; is it better to focus on utilising our better soils to their potential - thereby over time creating greater differences across the paddock or should we be focusing on trying to improve our poorer soils to even the paddock up over time?
We also have had to learn that when the technology throws a wobbly it is important that we don't also. We are only in each paddock once with harvester so you only get one chance annually to yield map it. If you are too impatient to work with the technology at harvest then you can't fix this in your January holidays. If the autosteer goes off line during seeding and you manually drive the remainder of the paddock you won't interrow sow this bit next year.

What is most important is to work out what suits your system and always remember you do what you want to do in this business. However, if I could leave you with a take home message, (apparently that is what you do at these meetings!) it would be get your yield mapper working and take lots of photos of everything.

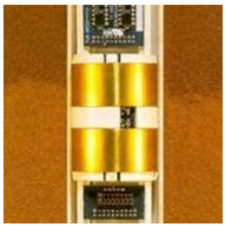
I'd also particularly like to acknowledge the SPAA (Southern Precision Agriculture Association) as a tremendous resource and facilitator of Precision Agriculture. See: www.spaa.com.au

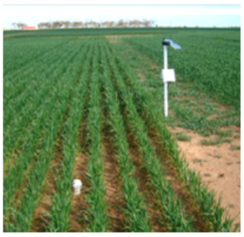
Using Soil Moisture Sensors to Make Better Decisions

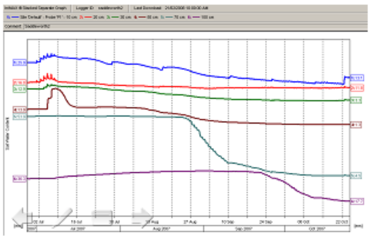
Brian Thomson

Porosity Ag Services, Mudgee, NSW

POROSITY AGRICULTURAL SERVICES







Summary

- Soil moisture is the MAJOR driver of yield in ALL crops
- Soil moisture sensors give you a volumetric soil moisture percentage, not just a subjective "wet" or "dry"
- By using soil moisture monitoring sensors, the data generated will give you better understanding of:
  - infiltration rate
  - water holding capacity
  - PAW (plant available water)
- Better understanding enables best management decisions:
  - sowing
  - fertilising
  - fallow practices
  - many other decisions (spraying / cut for hay)
- Maximising production = Increased profit $$$
- Improving efficiency of inputs = Cost savings $$$

For more information call Brian Thomson - 0418 849161

Crop Management with Active Sensors

Jim Wilson

Soilessentials Ltd.

BACKGROUND

Active crop sensors like the CropCircle, Yara ALS and Greenseeker use a light source to illuminate the crop and measure the reflectance in several specific wavelengths. This crop reflectance can be calibrated to the crop characteristics of interest – e.g. Green Area Index.

Until recently Precision Agriculture (P.A.) has mainly consisted of relating historical data to current crop and soil management. This works well to measure and manage characteristics which only change slowly over time such as:

- EMI / Soil Conductivity which shows the accumulated soil erosion and deposition over millennia
- Soil Fertility (pH, P, K, etc) is the accumulated sum of of fertiliser and lime applications and crop and leaching losses over decades.
- Yield Maps are the sum of everything that happened to that crop in the *previous* growing season.

This approach allows us to manage soil fertility, seed rates and sometimes N rates. However this historical approach has a significant problem when we are trying to manage the crop currently growing in the field.

THE PROBLEM

Different weather patterns cause crops to grow and respond differently to inputs on different soil types and aspects. In a dry years heavier areas with greater water holding capacity might be best while in wet years lighter free draining areas will thrive. The management of the crop has to change to take into account the current weather patterns and the response of the crop to those patterns. Active sensors are the ideal tool to do this.

THE ROLE OF ACTIVE SENSORS

The crop is the perfect sensor and active sensors allow a snapshot of the crop to be taken every time the crop is sprayed or fertilised. As active sensors have an inbuilt light source they are not limited by time of day or ambient light conditions. The scan can either be used in real time to variably apply N or growth regulators or it can be mapped back at the farm office and an application map created. Either technique allows growers the ability to respond to crop variability introduced by current weather patterns. It also allows growers to compare crops across fields and get an objective relative quality and amount of crop variability for each field which aids decision making when assigning fertiliser rates and job priority.

Crops do not grow evenly across the field and another very useful product of Active sensor scans is a “change” map where a previous map is subtracted from the current map. This is easy to do with active sensors but much more difficult with satellite images due to atmospheric correction problems. A change map shows problem areas where the crop is not growing strongly and also can be a help when producing N application maps – If an area has already had some nitrogen and has not responded to it is unlikely to respond if more N is applied. When trying to increase nitrogen use efficiency the easiest way is often not to apply more to areas that are unlikely to respond to it.

MANAGEMENT STRATEGIES

Variable rate application with active sensors is usually limited to nitrogen and agrochemicals simply because those are the main inputs applied to the growing crop. The nitrogen application strategy can change based on different agronomic models, timings and crops but the system should allow agronomists and growers flexibility to choose the best strategy for their crop.

SUMMARY

Active crop sensors allow crop scouting and real time management of nitrogen and agrochemicals and therefore can contribute to an improvement in the current growing crop's margin per ha.

Sugar GPS Coordination Applications and Future Directions

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ABSTRACT

During recent years there have been several changes both technologically and operationally in the way Mackay Sugar has undertaken harvest and transport management. From the introduction of remote sensing technologies in 2001 through to the continued development of GPS technologies, Mackay Sugar has been at the forefront of innovations and applications.

This paper discusses why these technologies have been introduced and will outline what further changes are intended to allow the development of an integrated farming, harvest and transport management system.

Some of the developments discussed in this paper include the introduction of GPS tracking devices onto harvesters, the development of a harvester yield monitor, the construction of a GPS base station network, development of Near Infrared Spectroscopy (NIR) technology and the development of GIS software to integrate the different spatial datasets.

INTRODUCTION

The Mackay Sugar Co-operative owns and operates 4 raw sugar mills located throughout the Pioneer River Valley in the Mackay district of Queensland. The co-operative has approximately 900 grower shareholders growing sugar cane on approximately 88,000 hectares of land. The annual crop size (depending on conditions) can be 5 to 7 million tonnes of sugar cane and is harvested and processed annually between June and December. The crop would normally yield between 800,000 and 1,000,000 tonnes of raw sugar.

- Cane supply staff have the important task of keeping sugar cane supplied to the mill at an appropriate rate (up to 50,000 t/day). This task is complex owing to a number of factors, including:
- Sugar cane deteriorates quickly after harvesting, and it is preferable to process within 24 hours of harvest to maximise sugar production. This means that the control of the volume of cane being harvested on a daily basis is essential.
- Existing Cane Supply and Processing Contract requirements means that the proportion of cane being harvested is equal amongst the harvesting groups (a harvesting group is typically a group of growers using the same cane harvester to harvest the cane crops)
- A number of factors such as weather conditions, soil type/condition, disease, access to irrigation will change farm estimates during the harvest season and it is therefore necessary to perform a re-estimation of the remaining crop for all farms on a regular basis throughout the harvesting season.

To meet the challenges that have been raised above, Mackay Sugar regularly re-estimates the cane crop remaining on each farm during the harvest season. In its simplest form, the re-estimation process is the calculation of a ratio comparing the actual yield for an area of harvested cane against the original estimate for that same area and applying the calculated ratio to the remaining crop estimates for each farm. This in turn is used to calculate what percentage of the daily cane loading is required for each of the harvesting groups.

The two necessary inputs for re-estimation are, area harvested (to a point in time) and the tonnes of cane harvested from that area. The tonnes harvested for each farm is determined by the weight of the sugar cane delivered across the weighbridge at the sugar mill to which it is delivered.

In 2001 Mackay Sugar introduced remote sensing technology to tackle two major applications (Markley *et al,* 2003). The first application developed was a crop estimation program and the second application was to develop a program that used remote sensing to determine area of harvested cane land at different times throughout the harvesting season. Unfortunately, obtaining regular cloud free imagery (especially following the demise of the image quality of the Landsat 7 satellite) has proved to be difficult at times and whilst remote sensing applications are still widely used by Mackay Sugar, a more reliable method of determining area harvested on a regular basis needed to be developed.
The introduction of GPS tracking devices onto harvesters was the first in a series of steps that Mackay Sugar has taken in what could commonly be described as a 'precision ag' route. This has included development of a harvester yield monitor, the construction of a GPS base station network, development of NIR technology to measure different sugar cane constituents that include nutrient components, the liaison with other GPS technology datasets such as Soil Electrical Conductivity (EC) mapping data and the development of GIS software to integrate the rapidly expanding spatial datasets.

GPS ON HARVESTERS

Currently, Mackay Sugar has 164 harvesting groups harvesting 1480 cane farms with group sizes ranging from less than 5000 tonnes per harvester to in excess of 125,000 tonnes. In order to offer a more reliable estimate update, especially for the larger harvesting groups, Mackay Sugar introduced GPS tracking technology onto harvesters in 2005. One of the influencing factors for the introduction of GPS technologies onto harvesters was the relatively inexpensive cost coupled with an acceptable spatial accuracy for the applications proposed of the GPS receiver (between 2 and 3 metres).

Originally there were GPS units fitted to 43 harvesters in the Mackay Sugar area but this has since expanded to 51 harvesters that represents approximately 45% of the total sugar cane crop being harvested in the Mackay Sugar region. Mackay Sugar also fitted the same GPS tracking devices to its entire cane haulage locomotive fleet and track maintenance vehicles (another 64).

The original tracking units installed was a dats 3022 device manufactured by MT Data. The 3022 remote tracking unit consisted of a Trimble Lassen iq GPS receiver, a processing unit and a CDMA 1x modem used to transmit data from the remote vehicle to the Mackay Sugar data network. The first year of operations encountered numerous problems, mostly concerning the performance of the Telstra CDMA-1x network along with a few software bugs in the tracking device. Following considerable debate, Telstra proceeded to upgrade their CDMA network in the Mackay area at the start of 2006 and along with changes to the device software, an almost 100% reliability factor was obtained in the 2006 and 2007 cane harvest seasons for the data collected by the devices and the transmission of that data via the CDMA-1x network.

Unfortunately, the decision by Telstra to close the CDMA network in early 2008 has meant a complete re-development and re-installation of all tracking devices on harvesters and locomotive fleet. The units (dats 3026) were once again manufactured by MT Data and incorporates a ublox GPS receiver module, an on board processor and a Siemens NextG modem. Whilst the initial development and installation has progressed relatively smoothly, there are some concerns that NextG coverage in the Mackay area may be below that experienced with the CDMA network.

The primary reason for the installation of the GPS units was to track harvester location and to then convert those GPS positions into harvesting tracks and then finally into harvested area (Figure 1) (Crossley and Dines, 2004). The area is then used (in conjunction with the tonnage of cane supplied) to calculate a re-estimation of cane remaining on farms which is in turn used to re-calculate daily loading requirements.

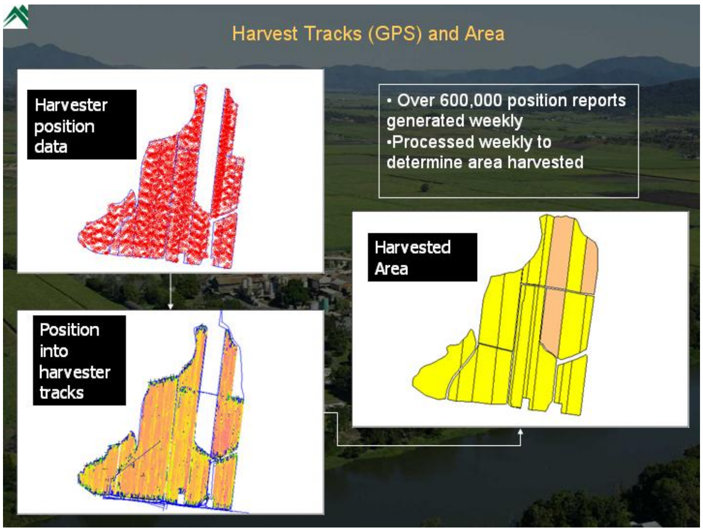


Figure 9

Knowing the position of the harvester is essential to create area maps, but knowing more about the characteristics of the harvester when position reports are generated would provide valuable information for assessment purposes. To achieve this there are digital inputs from the elevator switch and the ignition switch on the harvester into the tracking device. Another important feature is the ability to individually program when and how a position report is generated.

The configuration of the devices is performed at a central location with the configuration details transmitted to each device on start-up. The configuration of each device is individually programmed and is tailored to suit the differing circumstances of operations. A typical configuration program would be to generate a position report as follows:

- When a harvester has traveled *X* metres OR
- If the time between reports has exceeded *Y* seconds OR
- If the Elevator switch has changed state (on to off or visa versa) OR
- If the Ignition has changed state (off to on or visa versa) OR
- If the harvester has changed direction by greater than *Z* degrees

N.B. - Factors X, Y and Z are programmable.

From the interpretation of when and why a position report is generated, harvester efficiency reports (Figures 2 and 3) are compiled and distributed to harvester operators. These reports detail the time that harvesters remain in differing states (harvesting, turning or waiting) within each paddock for all farms harvested. When the tonnes of cane harvested from each paddock are added to the report, harvester throughput (pour rates) is calculated.

The examples shown in Figures 2 and 3 are from farms within two different harvesting groups and highlight the significant variation that can occur between harvesters. This report is the first step in highlighting to all parties the variability of the harvesting operation and is used as a catalyst to drive farm and harvesting improvements.

Harvesting Efficiency Report

9998 JOE		Start	End	Run	Harvest	Harvest	Turning	Turning	Waiting	Waiting	Consignment		Pour Rates t/hr		Av
Block	Pdk	Date	Date	Time	Time	%	Time	%	Time	%	Tns	Bins	Harv	Elev	Speed
1	2	8/11/2007	23/11/2007	3.5	2.36	67%	0.65	19%	0.49	14%	253.89	45	72	107	5.75
2	1	28/07/2007	24/10/2007	3.75	2.44	65%	0.8	21%	0.51	14%	157.12	27	41	64	6.04
3	1	2/09/2007	2/09/2007	1.92	0.72	38%	0.87	45%	0.34	17%	74.95	12	38	104	5.2
4	1	28/07/2007	30/08/2007	1.37	0.56	41%	0.57	42%	0.24	18%	110.82	20	80	197	5.31
5	1	28/07/2007	26/09/2007	2.04	1.15	56%	0.37	18%	0.52	25%	46.31	8	22	40	6.72
6	1	30/08/2007	2/09/2007	3.36	1.69	50%	1	30%	0.67	20%	202.36	34	60	119	6.67
7	1	27/09/2007	27/09/2007	1.39	0.69	50%	0.5	36%	0.2	14%	68.63	12	49	98	6.27
8	1	27/09/2007	27/09/2007	2.76	1.86	67%	0.46	17%	0.44	16%	187.77	31	67	100	6.29
9	1	25/10/2007	23/11/2007	5.15	3.34	65%	1.05	20%	0.76	15%	250.41	46	48	74	6.06
	Whole of Farm			**25.24**	**14.81**	**59%**	**6.27**	**25%**	**4.17**	**17%**	**1352**	**235**	**53**	**91**	**6.03**

Figure 10

9998 GERRY		Start	End	Run	Harvest	Harvest	Turning	Turning	Waiting	Waiting	Consignment		Pour Rates t/hr		Av
Block	Pdk	Date	Date	Time	Time	%	Time	%	Time	%	Tns	Bins	Harv	Elev	Speed
1	1	4/08/2007	3/09/2007	18.12	14.38	79%	2.36	13%	1.39	8%	1946.5	319	107	135	7.23
2	1	2/09/2007	3/09/2007	7.61	5.08	67%	1.63	21%	0.89	12%	766.93	125	100	150	6.27
3	1	3/08/2007	4/08/2007	9.97	8.17	82%	1.38	14%	0.41	4%	961	155	96	117	6.08
4	2	4/08/2007	4/08/2007	2.96	2.38	80%	0.39	13%	0.2	6%	279.75	46	94	117	6.14
4	3	4/08/2007	2/11/2007	11.29	8.95	79%	1.24	11%	1.1	10%	847.89	158	75	94	6.24
4	6	2/11/2007	2/11/2007	2.87	1.99	69%	0.52	18%	0.36	13%	300.76	51	104	151	7.96
4	7	2/11/2007	2/11/2007	1.55	1.12	72%	0.34	22%	0.09	6%	92.85	16	59	82	7.37
5	2	5/08/2007	5/08/2007	5.03	3.71	74%	0.81	16%	0.5	10%	432.25	65	85	116	7.09
6	1	5/08/2007	4/11/2007	14.8	10.77	73%	2.42	16%	1.61	11%	1372.9	230	92	127	5.57
7	1	30/11/2007	30/11/2007	4.58	3	66%	1.19	26%	0.4	9%	333.75	52	72	111	6.93
Whole Farm				**78.78**	**59.55**	**76%**	**12.28**	**16%**	**6.95**	**9%**	**7334.6**	**1217**	**93**	**123**	**6.69**

Figure 11

Harvester Yield monitor developments

Yield monitors on sugar cane harvesters in Australia have had a stop/start development following the work by Cox in 1996 (Cox *et al,* 1997). It has been suggested that failure to make significant progress in yield monitor development has been linked to the cost of GPS devices and the reliability of the monitoring equipment.

Mackay Sugar started the development of a potential cane harvester yield monitor in 2005 with the installation of pressure sensors onto the chopper motor of a 1999 Austoft 7700 harvester. The sensors were installed onto the bottom chopper motor and measure the pressure of the hydraulic oil entering the motor and the pressure of the oil leaving the motor which in turn is the inlet to the roller train. The analog values from these sensors are inputs into the dats 3026 GPS tracking device. The pressure values are captured and transmitted as part of the location reports that are generated by the dats 3026 device.

Early analysis indicated that pressure variations recorded via the sensors appeared to have a direct correlation to variations in yield (Figure 4).

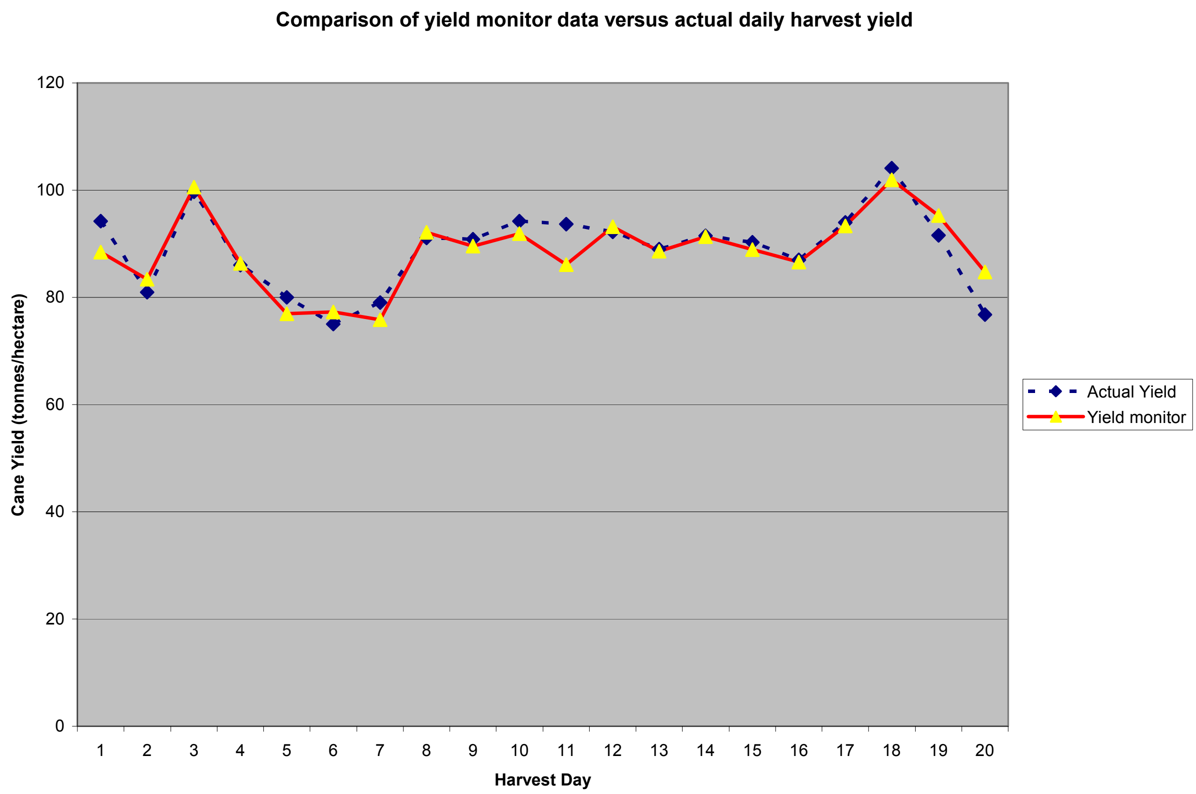


Figure 12

Progress has been made on the refinement of both the sensor positions and the algorithm development to convert pressure into yield with seven (7)harvesters now having yield monitor applications fitted.

GPS base station network

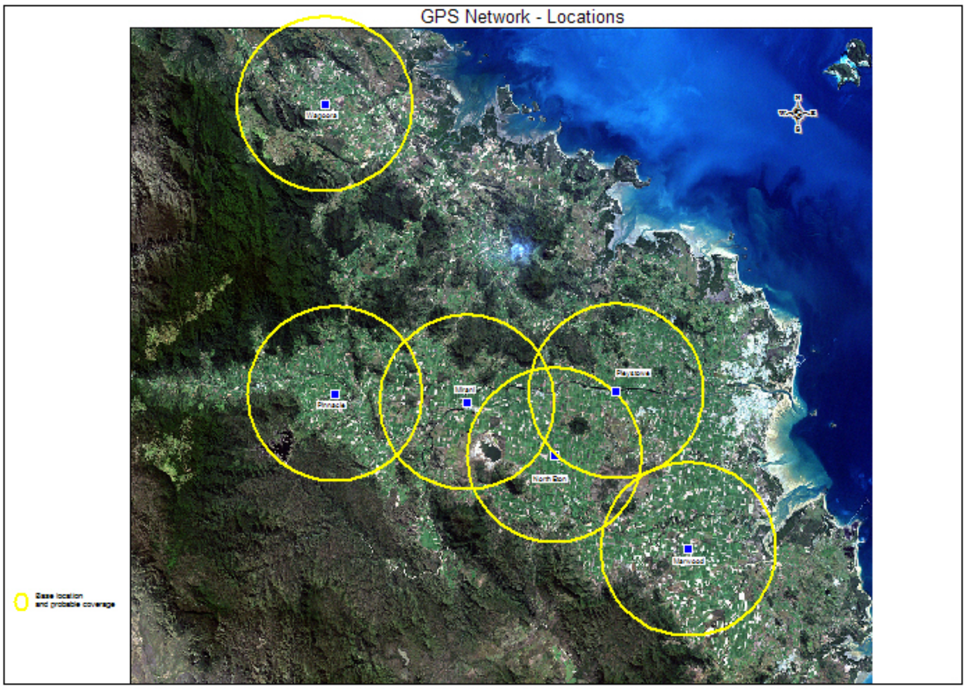
The number of growers migrating towards controlled traffic farming has been steadily increasing over the past few years. At the same time there appeared to be a proliferation of base stations within the region, many within a few kilometers of existing bases.

The Mackay Sugar Board of Directors recognized that these base stations were adding significant costs to growers wanting to adopt guidance technology. In early 2007 the Board of Mackay Sugar approved development of a series of Dual Frequency 2 cm RTK base stations throughout the Mackay Sugar cane growing region. The concept of a community network meant that the entry cost to individuals wishing to adopt the guidance technology would be decreased sufficiently to act as a driver for increased uptake.

The basic specifications for the supply of the base stations were as follows:

- Dual phase GPS receiver
  - Access to GPS and/or GLONASS with a capability of upgrade to Galileo
- GPS language – capable of transmitting CMR+
- Data transmission radios
  - 35 watt PacificCrest UHF
  - 900 MHz Spread Spectrum

Five of the six base stations were supplied by AgGuide and consisted of a Topcon GPS receiver and antenna plus and a radio component to match the original specifications. The bases were predominately located on masts attached to sheds within the region that gave the best value for coverage (See Map 1) and were completed by September 2007. To date the bases have operated satisfactorily with minimum downtime. The number of users has increased steadily over the last 12 months and it is now estimated that approximately 15% of the area is now utilizing controlled traffic practices.



Map 1

INTEGRATION OF NIR AND GPS TECHNOLOGIES

Sugar cane is harvested into a series of containers (bins) that are linked together to form what is known as a 'rake' of cane. A rake would normally consist of between 6 and 30 uniquely numbered bins that are consigned to the sugar mill with details of the farm and the paddock from which they were harvested manually noted by the harvesting operator onto a paper consignment note.

On arrival at the factory the individual bins are weighed to gather the net weight of the cane. Juice from the rake of cane is sampled and analysed to determine information needed for cane payment. Cane payment is then calculated by using a formula that combines the weight of the cane supplied together with the analysis information of the cane.

Mackay Sugar has recently installed (Cane Analysis System) CAS-NIR into its factories to automatically measure the components in the cane supply needed for cane payment. The CAS-NIR performs analysis of the cane supply at frequent intervals with the results of those analysis averaged to determine the result for the rake of cane. One of the advantages of the CAR-NIR with the frequent analysis is the potential to provide analysis information at a resolution of an individual bin.

A trial project has found that CAS-NIR measurements can also provide information on the nutritional status of cane, especially for key nutrients of N, P, K and S. Understanding relationships between NIR measurements and field data, including application rates, crop response to nutrients, soils information and the linking of this data to a geographic position has the potential to provide valuable information to fine-tune nutrient management.

Unfortunately, inaccuracies in the current manual consignment system account for 30-40% of cane being assigned to incorrect paddocks from where it had been harvested thereby making the link between analysis information and paddock position of the cane inside the bin almost impossible.
The development of electronic cane consignment will reduce inaccuracies in the manual system by associating the cane bin being filled to the position of the harvester at the time of filling.

The benefit of electronic consignment is the ability to provide in-field mapping of cane constituents through the interfacing of the analysis data of each bin from the CAS-NIR to the position of the harvester at the time the bin was filled via the GPS tracking system.

TURNING DATA INTO KNOWLEDGE

The sugar industry, like so many other agricultural industries has gathered a wealth of data regarding all facets of production, a process that seems to be gathering at an increasing pace. Unfortunately, providing applications to turn that data into useable knowledge have been slow in development. Turning data into knowledge is the aim of the AgDat project that has been established by a consortium of sugar industry participants.

The AgDat project has been envisaged to provide end to end data management, including capture, validation, reconciliation, sharing, security and publishing. The project builds on the extensive work undertaken in the sugar industry over the last decade whereby information technology has been utilised to enhance recording and reporting of on farm activities and extends this paradigm to further integrate work undertaken by other organisations.

AgDat is designed to provide a complete solution commencing with tools that enable and support ordinary users to capture complex spatial information, through the provision of web sites where this information can be collated and portrayed in conjunction with data from a number of sources.
The agricultural sector is being placed under increasing pressure to meet both regulatory requirements and community standards when it comes to the water quality runoff particularly in regards to the Great Barrier Reef catchment. The AgDat project will hopefully allow growers to meet those requirements in a timely, effective and cost efficient manner.

Whilst the initial AgDat development will be focussed on the Sugar Industry, the concept of AgDat is not sugar centric. Consideration of the needs of other agricultural sectors has been considered during the system design and functional specification stages and it is envisaged that the AgDat model will be configurable to suit the needs of these sectors.

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Conservation Farming/Controlled Traffic and Catchment Scale Implications

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The Lachlan Catchment Management Authority (LCMA) has a Land Management Target to improve soil health on 500,000 hectares of cropping land by 2016 by maintaining groundcover and minimising soil disturbance. To attain this target the LCMA provided incentive funding from 2004 to 2006 for the purchase or conversion of sowing machinery to adopt conservation farming practices. One major adoption impediment identified was the generally low level of knowledge of conservation farming and any formalised education available to learn conservation farming techniques. To address this and other issues identified in the program, the LCMA formed a conservation farming reference group consisting of farmers, agribusiness, cropping groups and government staff. One main action of the group was propose the production of a conservation farming training manual covering all aspects needed to adopt conservation farming. The manual was to be in the form of modules to address aspects such as: why adopt no tillage; soil health; handling crop residues; machinery selection; Controlled traffic farming, Precision Agriculture, agronomic and economic issues and monitoring change.

Within 12 months, the manual has been produced and 9 workshops have commenced in the Lachlan catchment with over 140 landholders registered. These workshops have been subsidised by the LCMA. Some of the main aspects to date are:

1. Despite a training requirement attached to incentives, catchment wide interest has come from farmers:
   - Who have currently or previously received incentive funding
   - Those who have adopted conservation farming from advice by other groups or to address individual farm environmental issues such as erosion or soil compaction
   - Those interested in adopting conservation farming for economic or environmental issues
   - Those that have developed an interest from completing such things as property planning.
2. Selecting a range of expert presenters with local credibility to deliver relevant modules has been well accepted. This has been enhanced by visiting local farmers advanced in conservation farming.
3. Being conscious of the mix of theory with practical aspects using local farmer experiences to maintain interest has been important.
4. Monitoring of individual change and catchment impact will be challenging due to the varied audience. This is despite having a number of monitoring tools built into the training package.
5. The workshops have been an invaluable tool for internal staff training and meeting local farmers
6. Conservation Farming is seen as a major farm management practice that will help farmers improve water use efficiency, adapt to climate change, improve soil health and reduce Greenhouse Gas emissions.

In conclusion a major aim of the workshops will be assisting farmers implement conservation farming as normal farming practice on a sustained basis.

CTF Directions

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INTRODUCTION

"Plants grow best in soft soil, wheels work best on roads" neatly encapsulates the major conflict at the centre of most mechanised agriculture, and the rationale for controlled traffic farming. Three important things happen when we drive heavy equipment wheels over soft soil:

- We use a lot more energy (i.e. tractor power) compacting soil under the wheels.
- More energy is required to ameliorate compacted soil to its previous condition.
- Important soil processes don't work as well until it has been fully ameliorated.

Productivity increases under CTF as natural amelioration extends through the soil profile, improving soil's capacity to store and supply water and nutrients to plant roots, and improving the volume of soil available for root exploration. Costs are reduced under CTF by avoiding the energy wasted in first compacting and then ameliorating soil.

Natural amelioration spreads downwards under the influence of plant roots and soil biota, in addition to wetting/drying effects. In shrink/swell soils it occurs very rapidly at the surface, but happens more slowly as it moves downwards through the profile. The surface 2 cm might recover in two weeks, but it might take two years to get to 20 cm. Amelioration to 100 cm may take 10 years. This is why some of the benefits of CTF are found immediately, but improvements continue for a number of years.

Without controlled traffic, we can't avoid driving over at least 50% of land area per crop. The damage is immediate, so it's not surprising that farmers often continue to till in well-watered areas where erosion is not seen as an issue. Tillage only does a partial repair job, and then only down to tillage depth, but it has been the basis of cropping systems for thousands of years. Over large areas of Australia, it has been replaced by minimum or zero tillage, random traffic systems, which are now being displaced by CTF -- controlled traffic, zero tillage.

The physical impact of CTF well known. Runoff is reduced and plant available water capacity increased, supporting better yields and/or greater cropping frequency. Less runoff, filtered through greater residue will reduce movement of soil, nutrients and agricultural chemicals, reducing erosion and improving water quality (For more detail see, for instance Tullberg et al. 2007).

This paper focuses on those effects relevant to climate change: fossil fuel energy incorporated in the fuel, herbicides and fertilisers, and on soil emissions and soil carbon. Environmental effects of CTF are compared here to the alternatives. For the purposes of this paper these are taken as:

- ***Stubble Mulch*** -- minimum tillage, random traffic systems aimed at maintaining at least 30% residue cover, assumed here to involve 3 tillage, and 1 herbicide operation per crop.
- ***Zero till*** -- random traffic, assumed here to involve 4 herbicide operations per crop, with some tillage required every third year on average (= 0.33 tillage operations per year).
- ***CTF*** -- controlled traffic, zero tillage, opportunity cropping (= increased cropping frequency, reducing herbicide operations to 3/crop).

Within the general headings noted above, there is great variability depending on geographical location and season. The outcome of any analysis obviously depends on the answers to questions such as "how many operations", "how much of what fertiliser, herbicide" etc. Many of these options have been incorporated in a simple Excel spreadsheet to allow rapid examination of different options. The assumptions used in the example presented here (Table 1) are intended to be reasonably typical of broadacre cropping in eastern Australia. It can be readily manipulated to illustrate other systems.

Table 1. Crop production operations in different systems.

System	Primary Till	Seedbed Till	Spraying	Planting	Harvesting
Stubble Mulch.	1	2	1	1	1
Zero Tillage	0.33	0	4	1	1
CTF	0	0	3	1	1

FUEL REQUIREMENTS OF FIELD OPERATIONS

Typical fuel requirements of farm machinery operations are quoted in various publications by Queensland DPI, and the values quoted in the stubble mulch column of table 1 are based on these. Fuel use in individual zero till operations operations is assumed to be similar, except for spraying, while fuel use in CTF operations is much smaller in operations such as seeding and spraying, where rolling resistance is a large component. Harvester fuel requirements are reduced by 30% for the same reason.

For all practical purposes, each litre of fuel burnt produces 2.75 kg of carbon dioxide (CO_2), so it is quite straightforward to calculate the carbon dioxide production per hectare of cropping.

Table 2. Fuel requirements of cropping operations in different systems, L/hectare

Operation	Chisel plough	Cultiv ator	Seeder	Sprayer	Header (4t crop)	System Fuel Use L/ha	CO_2 kg/ha
Stubble Mulch*	9.8	6.0	5.0	1.4	8.0	36.2	99.6
Zero Till	9.8	0	5.0	1.4	8.0	21.9	60.1
CTF	0	0	3.0	0.7	6.0	11.0	30.5

HERBICIDES

Reducing tillage certainly reduces on-farm fuel use. Unfortunately, the production of herbicides is an energy-intensive process, and often based on mineral oils. Accurate information is difficult to obtain, but the energy incorporated in some common herbicides has been tabulated by Zentner et al. (2004), and some of this data is set out in table 3. Glyphosate is the most commonly used herbicide, and also the most energy intensive, which might account for some of the recent price increase.

Table 3. Diesel fuel equivalents of herbicides (manufacturing component)

Commercial Product	Herbicide/s	Manufacturing Energy MJ/kg	Application rate (label) kg/ha	Energy/Spray MJ//ha	L/ha Diesel Equivalent
2,4-D Amine	2,4-D	98	0.500	49	1.2
Atrazine	Atrazine	190	0.500	95	2.4
SpraySeed	Diquat/Paraquat	430	0.250	108.1	2.7
Roundup CT	Glyphosate	511	0.450	229.95	5.8

*Petroleum feedstock, 1kg Diesel = 40MJ .

Herbicide selection obviously determines the total diesel fuel equivalent of any given cropping system. For the current estimates, it is assumed for each other herbicide application, 2 glyphosate applications occur, so a reasonable assumption of average herbicide manufacture is 4.6 L diesel /ha, or 12.7 kg CO_2 /ha, per spray operation. This could be reduced slightly to the extent that natural gas has replaced petroleum oil in this manufacturing process.

FERTILISERS

People are often surprised to find that the production of nitrogen fertiliser is usually the largest single energy input to agriculture (other than the sun!). It's another significant source of carbon dioxide, a major cost, and another major inefficiency. Only around half of the nitrogen applied is taken away in crops, and the unused N is an important source of pollution and greenhouse gases.

Inefficient use of nitrogen is often associated with waterlogging, which might be part of the background for the common observation that more nitrogen is required in (random traffic) zero tillage systems. There are also a number of claims of "greater yield with less fertiliser" in CTF. This has not been the subject of specific research, but most CTF trials have demonstrated greater yields (often 10 -- 15%), without any increase in fertiliser input.

Nitrogen efficiency and nitrogen requirement could be argued about for a long time. For the purposes of this paper is assumed that zero tillage requires roughly 10% more N, and CTF requires approximately 10% less N, which is the basis of the values quoted in table 4.

Nitrogen fertiliser production requires approximately 75 MJ of energy per kg of fertiliser, but the feedstock involved is almost always gas, which produces only 0.065 kg carbon dioxide per MJ energy. For most practical purposes, we can therefore assume that about 4.9 kg carbon dioxide is produced per kilogram of N fertiliser produced.

Assumed application rates and emissions relate to nitrogen fertiliser production are included in table 4, along with emissions related to herbicide production and diesel fuel. All these inputs are similar to the extent they are all energy-related. They are all also a direct consequence of management inputs, and will change if these inputs are changed.

Table 4. Energy-related CO_2 emissions, from inputs (nitrogen fertiliser, herbicide and diesel fuel).

System	N.Application Rate kg/ha	N. Production CO_2 kg/ha	Herbicide Prod'n CO_2 kg/ha	Diesel fuel CO_2 kg/ha	Total CO_2 kg/ha
Stubble Mulch.	45	205	12.7	99.6	362.3
Zero Tillage	50	245	50.8	60.1	405.9
CTF	40	196	38.1	30.5	304.6

SOIL EMISSIONS

All the above data is related to direct energy inputs, and CO_2 produced by combustion of fossil fuels. Carbon dioxide is the most important "greenhouse" gas, and cropping has other important effects on CO_2 absorption and emission (compared with the natural ecosystem it replaced). Absorption occurs rapidly by photosynthesis of growing crops to produce organic matter -- some small proportion of which will become soil organic matter, and be out of atmospheric circulation for some years. Agriculture also reduces soil organic matter (and carbon storage) by accelerating the cycling of soil organic matter back into atmospheric CO_2 , with tillage.

Other expertise is needed to make sense of this complex subject, but there would be general agreement with the proposition that in moisture-limited environments, other things being equal, growing more biomass, removing as little as possible, and causing less soil disturbance will all increase the rate of soil organic matter accumulation, or reduce its rate of loss from the soil. CTF meet these targets.

CTF maximises water use efficiency and minimises soil disturbance. Water use efficiency and biomass production could be further increased if we can develop precision CTF systems to allow relay cropping -- planting a double crop before harvesting the previous crop -- to soak up excess water prior to harvest. Cover crops which provide weed suppression could make good economic sense in this situation.

Nitrous oxide (N_2O) and methane (CH_4) are the other significant soil emissions from cropping agriculture. In both cases the quantities are small, but because nitrous oxide and methane have approximately 310 times and 23 times the greenhouse impact of carbon dioxide, they are both important. To make the data comparable, their impact is usually expressed in terms of their carbon dioxide equivalent, CO_2 E.

Nitrous oxide is a significant component of agriculture's greenhouse impact, produced largely by denitrification of soil nitrates. In cropping agriculture, these are derived largely from fertilisers, and their loss, whether by denitrification, leaching or runoff, represents the loss of an expensive input. Each of these mechanisms occurs when soil is close to saturation. Methane is seen mostly as an issue for rice growing and animal agriculture, but cropped systems often produce small amounts of methane. Relatively dry areas of natural vegetation usually absorb and oxidise small amounts of methane.

Research into nitrous oxide production from soils has shown large, apparently random, small-scale spatial variability. Random traffic and non-uniform fertiliser distribution could be part of this. Great variability also occurs with time, but this is associated with high levels of water-filled porosity. Soil compaction and continuity of soil porosity appear to have an important influence (Ball et al.2008).

Research into CTF impacts on nitrous oxide and methane production is rare, but recent work in Holland (Vermeulen et al. 2007) has compared emissions of these gases from random traffic and "seasonal" precision CTF (with annual mouldboard ploughing) in an organic vegetable production system. This work, carried out over three crops in two seasons demonstrated a large and statistically significant reduction in nitrous oxide emissions from seasonal CTF. Methane was absorbed by seasonal CTF, while random traffic produced small methane emissions. Consistent and significant improvements occurred in total and air-filled porosity, together with yield increases in seasonal CTF.

It is obviously not possible to talk with confidence about the implications for Australian CTF when these results were obtained in organic systems with annual soil disturbance, nitrogen input largely from manures and higher rainfall. At the same time, it might reasonably be suggested that improved porosity and pore continuity would be a major factor. On this basis, random traffic zero tillage might produce the greatest nitrous oxide and methane emissions and full zero till CTF the least. Relative emission rates might be the similar in the Australian situation, but a drier climate and generally smaller rates of fertiliser application might reduce the absolute values, but this is all highly speculative.

Mean values of emissions per 30 days would have been calculated from the Dutch results (each of which was an average of measurements made over at least 33 days). These are set out in table 5, which also provides their CO_2 equivalent values. Although the methane values appear relatively insignificant, this source of emissions or absorption might be active for a much longer period than those of nitrous oxide, which will occur largely during periods when soil nitrate levels are high.

Table 5. Seasonal CTF effects on nitrous oxide and methane emissions in organic farming (Holland)

System	Emissions - kg/ha in 30 days		CO_2 Equivalent - kg/ha in 30 days		Total
	Nitrous oxide	Methane	Nitrous oxide	Methane	CO_2 E kg/ha
Random Traffic	+2.04	+0.0225	632	+0.52	633
Seasonal CTF	+1.41	-0.146	437	-3.37	434

Increasing nitrogen efficiency makes obvious economic and environmental sense, but this is another topic best left to experts. It is clear nevertheless that nitrogen efficiency can be improved by avoiding the situation where excess nitrates are available in waterlogged soil. In practical terms, waterlogging can be minimised by using CTF to avoid soil compaction and provide effective drainage. The time period over which nitrates are available can be minimised by split fertiliser application, which is also facilitated by the permanent traffic lanes of CTF. Viability would be determined by a simple balance between costs and fertiliser-saving benefits of the additional operation.

TOTAL EMISSIONS

Emissions from all sources considered above are set out in Table 6 which includes the 30 day emissions measured under grossly different conditions in Holland. This might be the case if emissions in Australia occur at a smaller rate, but over a longer period. Zero tillage has also been assumed to produce 20% more emissions than stubble mulch, on the assumption that random traffic zero tillage is more prone to waterlogging and inefficient nitrogen use. These assumptions are highly speculative

The major point of the comparison is to indicate the possible relative importance of emissions from different sources. Soil emissions largely related to use of nitrogen fertiliser, together with the manufacture of that fertiliser, are clearly the dominant effects. CTF offers some possibility of improving nitrogen efficiency and reducing those emissions. This makes good sense in economic and environmental terms.

Table 6. Cropping System Effects on Emissions

System	Diesel fuel CO_2 kg/ha	Herbicide Prod'n CO_2 kg/ha	N. Production CO_2 kg/ha	Total CO_2 kg/ha	Soil Emissions* CO_2E kg/ha
Stubble Mulch.	99.6	12.7	205	362.3	633
Zero Tillage	60.1	50.8	245	405.9	760
CTF	30.5	38.1	196	304.6	434

*N.B. These values are highly speculative

CONCLUSIONS

1. Emissions from on-farm fuel use in CTF systems are approximately half those of random traffic zero tillage, and one third of those from stubble mulch systems.
2. Emissions related to herbicide and fertiliser manufacture appear to be 30 -- 40% greater from random traffic zero tillage than from CTF or stubble mulch systems.
3. Available evidence on soil emissions suggests that these should be very substantially smaller from CTF systems, but further research is needed.

To the extent that CTF allows cropping systems to more closely mimic the processes of natural vegetation that contributed to the greenhouse gas levels established prior to significant human influence, this is unsurprising.

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Controlled Traffic Farming in Europe – Constraints and Opportunities

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INTRODUCTION

The aim of this paper is to highlight the contrasts between European and Australian conditions that have an impact on the design and uptake of controlled traffic farming systems. Necessarily, it is a broad brush approach because of the immense diversity of traditions, cultures and climates that prevail across the European continent.

Climate is a big factor in these contrasts as well as the relative position of the continents involved. Europe stretches from around 40–60 degrees north, whereas Australia sits between 12 and 43 degrees south. In equivalent terms the southern part of Europe starts at the north end of Tasmania and runs from there a further 20 degrees south. This means that our winters are colder and often wetter with soils slow to dry out and warm up in the spring.

BACKGROUND

European crops and farming systems

We have many crops in common with Australia, but with some notable differences such as limited amounts of cotton and no sugar cane. Primarily the cereal crops are similar, ranging from rye to maize and rice while oilseeds include canola, sunflower, soybeans and linseed, with peas (both dry and vining) and beans as the main pulses, plus onions, carrots, sugar beet and potatoes.

Traditionally, the mouldboard plough has been and continues to be used extensively, not only on lighter soils, but also on heavy clays. Legislation to stop straw burning in the early 1990s effectively curtailed significant moves towards minimum and no tillage. Elevated crop prices in 2007 also resulted in a significant re-investment in ploughs although the recent increase in fuel prices might mean that these are used less extensively than planned.

Crop yields can be relatively high compared with many parts of Australia, largely because of the more favourable rainfall conditions. Wheat for example can top 12 t/ha from 200-300 plants/m^2 sown in rows just 12.5 cm apart. Dealing with the associated straw, most of which is now chopped and spread, can be a challenge! To the casual observer, it might seem that the use of CTF is widespread (Fig. 1), but these are simply tramlines for chemical applications. Having first been introduced in the 1970s during crop sowing, it is now common practice but rarely sustained from one crop to the next.
Haulage of grain off fields is largely confined to modest-sized trailers that service the harvester and travel directly to the farmstead; chasers are relatively uncommon, but where they are used, grain is unloaded directly to trucks at the field entrance.

Many farms also have livestock enterprises where cash crops alternate with grass and maize grown for forage.

Farming infrastructure

Average farm size in the EU 15 was 19 ha in 2005, but some countries tend to have larger farms such as the UK and Denmark, with an average of 57 ha and the Czech Republic with an average of 84 ha. Universally however, field or paddock sizes are relatively small compared with Australia, as indicated in Fig 2, which is a snapshot of fields west of Paris.

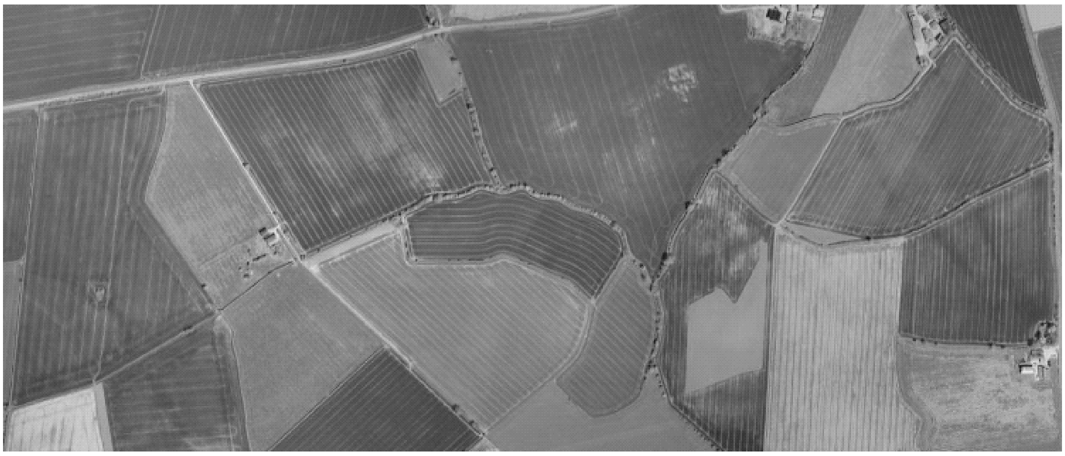

Figure 1. Temporary tramlines for chemical applications have been common across Europe since the 1970s. (Google Earth)

Figure 2. Typical shape and size of fields across Europe. The field pinpointed is around 14 ha and is at the larger end of average. (Google Earth)

Crucially, the area taken up by headlands is significant in these smaller fields and will therefore have an impact on the efficiency of any CTF system.

Farms are also commonly fragmented with blocks of fields separated by significant distances, often along narrow roads barely capable of accommodating one vehicle, let alone wide enough to allow passing (Fig. 3). It is also the case that across much of Europe, population density, even in rural areas, is significantly higher than in many of the farming areas of Australia. This together with narrow roads and strict legislation make wide equipment a considerable embarrassment. Germany for example requires a special dispensation for any vehicle measuring more than 2.55 m wide when used on the public road.

Fig. 3.Narrow roads constrain movement of wide vehicles

Another inevitable consequence of smaller farms is smaller machinery, both in terms of width and power. However, this is not to say that there aren't a significant number of properties with several thousands of hectares.

DRIVING FORCES FOR AND AGAINST CTF IN EUROPE

Interest in CTF in Europe has been slow and has yet to reach critical mass. There are a number of reasons for this, but motivation for conversion is increasing and is reflected by a growing awareness and interest in CTF. Table 1 sets out some of the drivers for and against conversion to CTF, a number of which have been discussed in the preceding sections.

Table 1. Drivers for and against CTF adoption in Europe

Aspect	For CTF	Against CTF
Subsidies		✓
High crop yields	✓	✓
Crop price	✓	✓
High input costs	✓	
Tradition of mouldboard ploughing		✓
Small farms		✓
Small fields/paddocks	✓	✓
Livestock enterprises		✓
Relatively little contracting	✓	
Road legislation/population density		✓
Conservation of water	✓	
Drinking water quality	✓	
Soil erosion	✓	
Greenhouse gas emissions	✓	
Good field drainage	✓	

Subsidies in general seem to stifle innovation and cushion growers against commercial realities. For a period up until last year, some farmers were not experiencing profit above subsidy, but equally there were those growing exactly the same crops with very similar farming enterprises making a good profit. High crop yields and prices have both a positive and negative effect on CTF uptake. Research has shown that CTF increases yields on the non-trafficked area by 10-20% nearly 100% of the time, but with narrow gauge systems, the tracked area can be 30-40%, so even though these intermediate tracks are sown, the loss in yield might be significant. The truth is that we actually don't know yet whether yields in cropped tracks drop below conventional random traffic or not.

High input costs are a massive driver for CTF adoption because it is precision farming at its most efficient. All practitioners of CTF will know that it drives down input costs across practically all operations on the farm, particularly in terms of tillage, fuel and machinery investment. Unlike Australia however, the improved efficiency of tramline systems for chemical applications and "to and fro" working is unlikely to have a large impact, because it has already been practised for many years.

Mouldboard ploughing tends to preclude anyone wishing to adopt CTF, but there are still advantages where high value crops are grown and CTF is adopted "within season", known as seasonal CTF or SCTF. Organic farmers in the Netherlands and many other growers across Europe use this technique, but often refer to it as "bed farming" rather than SCTF.

As will be seen from the next section, satellite guidance is a highly effective enabling technology for CTF, but because CTF needs the highest grade of guidance, smaller farms presently find it difficult to justify on its economics. Smaller farms tend to have narrower equipment with a greater diversity of width and they often bale straw, which in most instances makes CTF even more difficult.

The reason that road legislation and infrastructure constrains CTF is that it is generally impractical to match all equipment to the track width of harvesters, most of which are close to 3 m. The last four aspects in the table above relate to the health of soils and this has recently become of major importance across Europe, largely because soils are becoming degraded, a great part of which is associated with excessive compaction.

SATELLITE GUIDANCE – AN ENABLING TECHNOLOGY

As stated by one of my CTF Europe colleagues recently, satellite guidance no longer has to be pushed into the market; it is now being pulled by customers. I envisage this pull increasing dramatically over the next few years for a number of reasons. Firstly, the cost of fuel and chemicals has approximately doubled over the past 12 months and wastage through overlapping is no longer acceptable. Secondly, the cost of guidance systems is not only declining but they are increasing in capability and becoming more reliable and more accurate. Skilled labour is also increasingly difficult to secure and it will not be long before most of the in-field driving tasks will be managed by guidance systems.

Reliable delivery of guidance to individual farms is still a big factor in Europe, constrained partly by topography but also by features such as woodlands that are closely integrated into the farming landscape. Some countries, such as Denmark and the Netherlands do already have GPRS delivery of an RTK correction signal, but in the UK, it seems more likely that local RTK networks will prove popular. Delivery via the internet seems another possibility and no doubt this and other developments will move ahead rapidly.

PRACTICAL IMPLEMENTATION OF CTF

As we have seen, matching all wheel track widths to those of grain harvesters is largely impractical in Europe and we have therefore had to come up with viable alternatives. Influencing these alternatives are grain trailers that generally have a track width of just 1.8 m, although 2 m is now becoming more common. In practice we are seeing two principal systems for CTF adoption in grain production, namely OutTrac and TwinTrac. OutTrac, as the name implies, has the harvester travelling "outwith" the narrower track of all the other vehicles, as indicated in Fig 4.

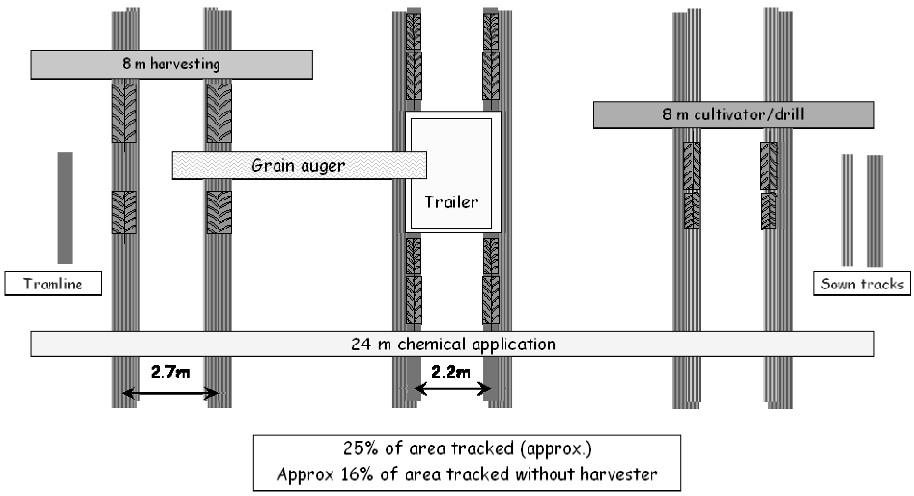

Figure 4. An OutTrac CTF system that uses two track widths centred on each other but with a common implement width

TwinTrac is a clever idea suggested by a UK farmer that caters for two track widths but doesn't enlarge on the tracked area. Fig 5 shows the basis of the system but where this is being used, implement widths tend to be non-integer sizes and the great advantage of the system is that it can accommodate a wide range of options. Other systems and combinations have been identified and so far no two farms have adopted exactly the same system.

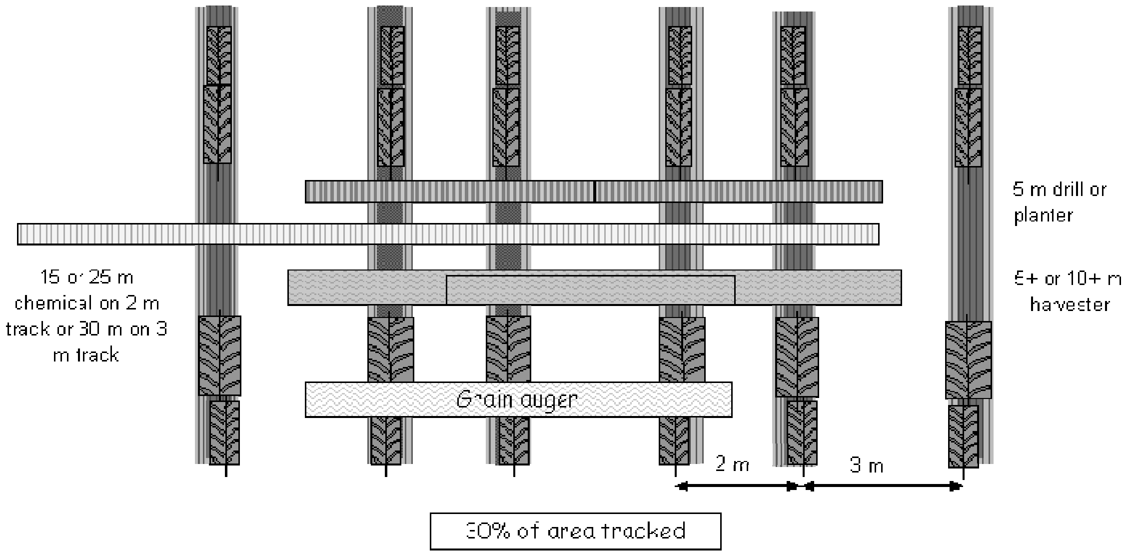

Figure 5. TwinTrac CTF system in which the narrower tracks straddle the outer tracks of adjacent passes of the harvester. Implement width is the addition of the two track widths

CTF is also being used for forage crops, particularly in Denmark. Here systems as wide as 14 m have been adopted to improve both the annual production of grass and longevity of the sward. Traditional management leads to a reduction in grass productivity year on year meaning that a new start is often needed by year four. Loads on these soils are high with slurry injection being a core activity, including during the growing season (Fig. 6).

Figure 6. 14 m wide slurry injection system working on a controlled traffic layout

As mentioned earlier, both Dutch and Danish growers have adopted SCTF systems for high value crops, but they recognise the shortcomings of these and are keenly working to integrate harvesting into the system.

Most CTF farmers have now accepted that they need RTK satellite guidance because of the greater accuracy and more importantly, the repeatable positioning that comes with it. There is a tendency to associate CTF with no-till and this is not altogether helpful because no-till has yet to become widely adopted. To some extent this revolves around the high residue levels but also because of an association between the negative impact of compaction and no-till systems. No-till land tends to experience a loss in yield over the first few years but this will almost certainly be absent if CTF is adopted simultaneously. The difference between three years of no-till on randomly trafficked clay soil compared with the same period under CTF was plainly illustrated in December 2007. Under very moist conditions on the trafficked treatment it was impossible to prise out soil with a fork inserted to around 30 cm depth, despite working around all four sides of the area. In stark contrast, soil in the CTF field alongside could easily be raised with just one insertion of the fork. This, as I'm sure you will all know, reflects the essence of CTF – healthy soils promoting healthy crops that return a healthy and sustainable farm profit.

THE FUTURE FOR CTF IN EUROPE

The uptake of CTF in Europe is I believe, likely to be somewhat slower than it has been in Australia, but I would like to be proved wrong! The reasons for this slower uptake are:

- Continuation of subsidies until at least 2013
- Farm sizes and road infrastructure constraining the flexibility of CTF systems
- Opportunity cropping based on water supply is uncommon in Europe
- A widespread tradition of mouldboard ploughing
- Language barriers and wide contrasts in traditions and farming systems
- Conservatism – not wanting to be the first to try out something new

Aspects that might alter this prediction include:

- Further significant improvements in guidance systems and reduction in costs
- Further increases in production costs, particularly fuel and fertilizers
- Incentives for growers to adopt more environmentally friendly production techniques.

As far as the positive impact of CTF is concerned, I have no doubt that it will be widespread, significant and sustainable. Agritechnica last November in Hanover reflected the continuing rise in enormity of machines with little regard for the soils upon which they work. Videos tended to represent soil as an inconvenience, as dirt that had to be beaten into submission rather than nurtured as our primary asset. Increasingly there is recognition that this cannot continue and some are seeing CTF as a solution that constrains us rather little compared with other less effective approaches to soil care.

KNOCK-ON BENEFITS FOR CTF IN AUSTRALIA

The most obvious benefit is the increasing demand for guidance systems that will generate more competitive pricing while improving capability and range of uses. The other main benefit is in the development of CTF systems for a wider range of crops, particularly those of a high value and bulky nature, such as potatoes, onions, carrots, celery and spinach. These are the real challenge for CTF and I believe European farmers as well as applied research activity in Tasmania will be leading the way. And dare I say it, based on grower interest, perhaps going down the route of gantry systems to create the ultimate in CTF efficiency and flexibility (Fig. 7)!

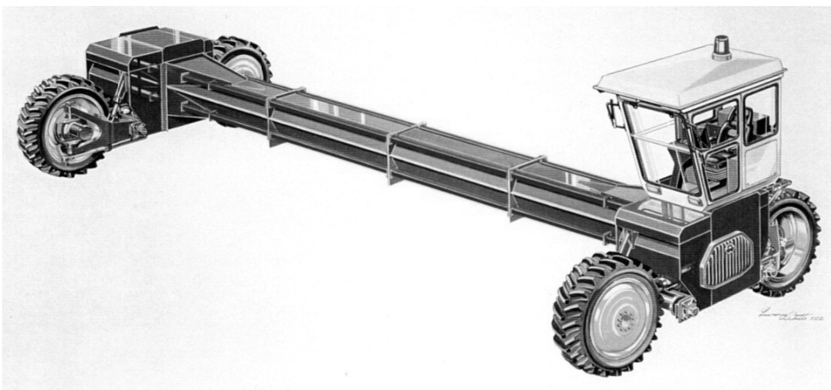

Figure 7. The gantry tractor is not new but could it have a major role to play in CTF?

POSTER PRESENTATIONS

A Jouney into Controlled Traffic Farming - Two Case Studies from Central Western NSW

Nathan Border

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Three case studies of farmers in the central west of NSW. These properties contrast varying climates north and south of the district. There is considerable difference in rainfall pattern and amounts and it is interesting to contrast the farmers systems and how they tackle the variable climatic constraints. Graeme has been working with no-till and no livestock for over 20 years. He began controlled traffic with lines scratched into the ground from a contractors ute and has now progressed to 2cm autosteer. There have been many lessons learnt, many challenges overcome and aspirations for further directions. I have followed the journey that Graeme has gone through, highlighting the positives of his system, and the things other farmers can learn from his experiences. Graeme has moved to a disc seeder this year that he has manufactured himself.

Stuart has been working with no-till and no livestock for around 10 years. He has been working with GPS technology for many years now, but this season he has matched machinery on a 3m track and has put down permanent lines. He is now operating on 2cm autosteer. Stuart has sown with a converted disc seeder this year and has also made use of the moisture seeking abilities of a tyned airseeder for earlier sowing opportunities. Like Graeme, he has learnt many lessons along the way, faced many challenges and has many aspirations for further directions.

Roger has been working with no-till and no livestock (on farming country) for almost 10 years now. His passion from agricultural college was to be on controlled traffic no-till farming within 10 years, and he has achieved that despite some of the driest years on record. Roger has a well planned farming system and is a very progressive and innovative farmer, utilising the resources available to him. Roger has a clear direction for next season and plans to move to disc seeding technology.

I have followed Stuart's, Roger’s and Graeme’s journey and highlighted the positives of their system, and the things other farmers can learn from their experiences. Stuart, Roger and Graeme are all very progressive farmers in this region and the contrasts of their locations give them different challenges and positives. They have all tried a variety of alternative crops and their yields are considerably higher than the district average because of their attention to detail and the way their system is working now. They are very interesting to talk with and have lots of good ideas about farming profitably, efficiently and sustainability in this harsh environment.

Healthy Soils for Dryland Cropping Regions of Northwestern and Southwestern Victoria

Tim Johnston

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We need healthy soils! - Healthy soils perform a range of services including water filtration, habitat provision and profitable and sustainable agriculture. The Healthy soils project in the grain growing regions of Victoria helps farmers manage their soil for productivity and for environmental protection. The project will improve farmer's capacity to manage soil health issues by providing soil management strategies and techniques. The objectives of the project are to; i/ improve access to soil information ii/ provide soil health assessment tools iii/ enhance soil health extension programs iv/ coordinate a Victorian program for soil health. The focus areas for the project are the dryland cropping regions of north western and south western Victoria. The project is being led by a team from the Victorian Dept of Primary Industries, together with collaborators including: Mallee Sustainable Farming (MSF) Birchip Cropping Group (BCG) Southern Farming Systems (SFS) Nutrient Management Systems (NMS). Funding is provided by: - Victorian Governments 'Our Environment, Our Future - Sustainability Action Statement' - Land & Water Australia - 'Healthy Soils For Sustainable Farms' program - Agriculture Development Division, Dept of Primary Industries.

Automated Short Furrow: A System for Precision Irrigation

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ABSTRACT

Farmers, worldwide, are facing increasing pressure to utilise resources, particularly water, more effectively. This paper is about a prototype irrigation system aimed at providing farmers with a relatively simple and low cost method to facilitate precision irrigation. The irrigation system, named 'automated short furrow' (ASF) uses substantially less energy than conventional systems requiring a pressure of only 70 kPa at the field edge. Water is applied sequentially to sets of relatively small and short furrows, typically approximately 30 m in length. By automating the sequencing of the short furrow sets, and controlling the flow of water into the furrows, operational and labour overheads are minimal and system performance is enhanced. With the relatively short furrows, the distribution uniformity of applied water is very high under a wide range of conditions, even when small amounts of water (<15 mm) are applied per application. Since only a very small proportion of the soil surface is wetted, there are relatively low evaporation losses from the wet soil surface. The configuration of the system piping and emitters is such that, although the irrigation furrows are short, relatively high machine operating efficiencies are possible and controlled trafficking is encouraged. In a field trial, the average cane yield obtained using the prototype irrigation system was 129 t/ha for a 12 month plant crop. In the same trial the average cane yield for cane irrigated using sub-surface drip irrigation was 123 t/ha for a nearly identical amount of water.

Keywords: irrigation, sugarcane, economics, energy conservation, water conservation, efficiency

INTRODUCTION

Farmers, worldwide, are facing increasing pressure to use water and energy more effectively whilst boosting and sustaining profits. Unfortunately, however, irrigation efficiencies are often misunderstood and quoted somewhat casually without losses being measured or defined accurately. All this contributes to a situation where there is much confusion and misconception regarding irrigation systems performance and options to become more precise (Clemmens, 2000). Many issues surrounding irrigation efficiency and performance could be addressed if greater emphasis was placed on the fates of applied water at the field, farm and watershed scales, especially in the development of improved irrigation systems and associated management strategies.

Thus, before describing the development and trial of a novel irrigation system, named 'automated short furrow' (ASF), a perspective of irrigation systems performance is provided in this paper. This includes an explanation of the water balance and how irrigation uniformity and other characteristics of irrigation systems can impact water management options and performance. The ASF system is aimed at providing farmers with a robust, relatively low cost but highly effective option to facilitate precision irrigation.

IRRIGATION PERFORMANCE FUNDAMENTALS

Any consideration of irrigation systems performance should consider the water balance, the uniformity of irrigation water applications and the management of the water applications.

The water balance

In Figure 1 the various fractions of water applied which are involved in defining irrigation performance at the field level are illustrated.

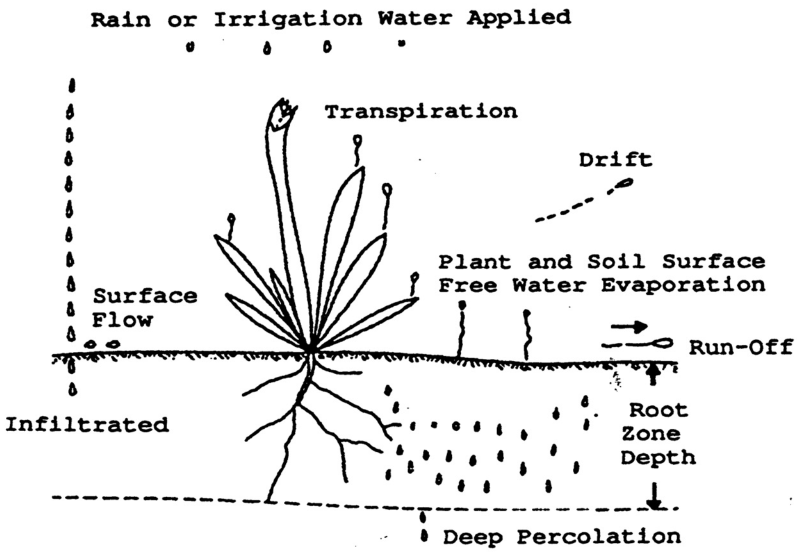

Figure 1 Various fates of water in the soil-plant-atmosphere system (ASCE, 1978)

The components of the water balance can be deemed, amongst other things, to be, 'beneficial', 'non-beneficial' and 'consumed' or 'non-consumed' (Burt *et al.*, 1997). The aim of improved and more precise irrigation is to reduce as far as possible, the non-beneficial components, especially the consumed, non-beneficial components such as evaporation from the soil surface. Runoff and excessive deep percolation losses (i.e. in excess of leaching requirements) from a field are non-beneficial but not consumed. They return to the system and are potentially available for other users downstream. However, this "return flow" water is often of much poorer quality than the original irrigation water and valuable nutrients and top-soil may be lost in runoff and deep percolation. Energy and finances used to apply irrigation water which is not used beneficially are also wasted.

Uniformity of irrigation water applications

Irrigation uniformity refers to the evenness of irrigation water applications. It can have significant effects on irrigation performance because even if the timing and average magnitude of water applications is well matched to crop water demand and soil water storage capacity, non-uniformity results in some areas receiving relatively higher water applications and other areas receiving relatively lower water applications. Excessive runoff and deep percolation losses are likely on the areas receiving the relatively higher water applications and reductions in crop yield can be expected on the areas receiving the relatively lower water applications. The traditional approach to dealing with low uniformities is to increase water applications. However, reductions in crop yields can also occur on the areas receiving excess water and thus the benefits of such an approach, especially on poorly drained fields are doubtful. Irrigation practitioners should rather aim at improving the uniformity of water applications.

Water management

Managers of irrigation systems, by the appropriateness of their actions and/or instructions often contribute the most to poor or good irrigation systems performance. Important performance characteristics of an irrigation system which impact on how easily or well a system is managed are the inherent flexibility of the irrigation system in terms of the amount of water which can be applied at each irrigation application, how frequently/flexibly the water can be applied, the associated labour requirements and the rate at which water is applied.

Thus, in addition to cost effectiveness and robustness, characteristics of an irrigation system capable of precision irrigation include:

- a great degree of operational flexibility,
- a water application method which results in reduced non-beneficial components of the water balance, such as evaporation from the soil surface, excessive runoff and/or deep percolation, and
- a high degree of uniformity in the spatial extent of water applications as non-uniformity can seldom be effectively corrected by simply adjusting water application amounts, as is often presumed.

Whilst many irrigation systems fulfil many of these ‘precision irrigation’ requirements, there are also numerous issues. For example, the cost and maintenance requirements of drip irrigation are often prohibitive; runoff losses and high evaporation losses from the soil surface under centre pivots can be problematic; uniformity and energy demands of ‘big guns’ often renders them ineffective; traditional ‘long’ furrow irrigation systems often have poor uniformity and matching the frequency and amount of water applied to crop water requirements can be problematic, especially on shallow soils. Thus, there is still great potential to improve irrigation systems and motivation to develop and assess novel systems such as automated short furrow irrigation.

AUTOMATED SHORT FURROW IRRIGATION

A novel system to implement precision irrigation was developed and installed in a trial at the University of KwaZulu-Natal Ukulinga research farm near Pietermaritzburg in South Africa. The engineering, economic, agronomic and practical performance characteristics of the irrigation system, named “automated short furrow” (ASF) were compared to sub-surface drip (SSD) irrigation by taking measurements and keeping records of sugarcane yields, water use, soil water energy levels, system overhead and operating costs and assessments of the uniformity of irrigation water applications. The two treatments used in the trial, namely ASF irrigation and SSD irrigation, were arranged in a randomised block design with four replications on a total trial area of 0.5 hectares. SSD was included as a treatment because it is often considered to be the benchmark in terms of irrigation system performance. In the plant crop, both treatments received nearly identical amounts of water. The irrigation scheduling tool, *SAsched* (Lecler, 2004) was used to schedule the irrigation water applications using weather data from a nearby automatic weather station.

Description of the ASF irrigation system

The novelty of the ASF system begins at the field edge. From the field edge water is conveyed in a sub-main pipe consisting of low class polyethylene or PVC piping. Polyethylene laterals join into the sub-main via a ‘boot and piston valve’. The laterals (running downhill) convey water to emitters typically made of 10 mm diameter lengths of polypipe, spaced at a distance to suit the row spacing of the crop and to permit controlled trafficking. The emitters convey water into short furrows. The furrows are approximately 30 m in length and are typically ‘U’ shaped, with a top width of approximately 0.15 m and a depth of 0.15 m. The ends of the furrows are blocked and coincide/intersect with the position of the next downstream lateral. The furrows should be land-planed so that they are relatively smooth. In the Ukulinga trial, sugarcane was planted on either side of the short furrows in a tramline arrangement, so that controlled-trafficking could take place, i.e. 0.6 m between cane plants and 1.8 m between furrows.

When an irrigation application is initiated the most upstream boot and piston valve allows water into the most upstream lateral and, via the emitters, into the first set of 24 short furrows. The boot and piston valve also prevents flow to the remaining downstream laterals. After approximately 40 minutes, the 'boot valve' automatically stops the flow to the first set of furrows and allows water to flow to the next downstream lateral and set of furrows. This sequence continues automatically until a whole field has been irrigated. Typically all the lateral and sub-main piping would be buried, so that only the emitters are visible and trafficking can take place in the field without disturbing the irrigation system and *vice versa*.

Evaluation of the ASF system

The main focus of the engineering evaluations was to evaluate the distribution uniformity of applied water for a specified depth of application, and investigate the factors affecting the uniformity of water applications. In addition, system flexibility and ease of management were assessed. The ability to control the depth and timing of irrigation water applications is important because, when the amount of water applied per irrigation application is not well matched to soil water holding characteristics, performance will be poor because of either:

- excessive crop stressing if the soil is depleted to a level coinciding with larger irrigation applications, or
- inefficient irrigation with excessive runoff and deep percolation losses and associated drainage problems, if large irrigation applications are applied at relatively low soil water depletion levels to avoid excessive drying of the soil and crop water stress.

Both of these are typical problems with conventional furrow irrigation, especially on soils with low water holding capacities.

Infield measurements of various surface irrigation performance parameters were undertaken based on procedures described in Koegelenberg and Breedt (2003). The data from the field measurements were then used together with a surface irrigation simulation programme, SIRMOD III, to assess the performance of the furrows in terms of low quarter distribution uniformities, DU_{lq} (Walker, 2004). The DU_{lq} for the six furrows evaluated in the trial ranged from 71% to 81% for water application depths of only 10 mm. These DU_{lq} values are considered to be very good even though the slopes at the trial site (1:40) were steeper than optimum, and many of the system parameters were not optimised because of constraints related to the prototype system. Many of these initial constraints have since been overcome as the developers have grown in knowledge of the system.

Theoretical simulations undertaken using SIRMOD III have since shown that DU_{lq} values above 85% can be obtained for a range of slopes and soil types, and that the DU_{lq} values are relatively insensitive to variations in slope, soil characteristics, and flow rates compared with typical (long) furrow irrigation. For most soils optimum furrow lengths are between 20 m and 40 m; however, for heavy clay soils, the furrow lengths can be considerably extended to>200 m, with a concurrent reduction in system cost. The application depth of 10 mm per irrigation water application means that even poor soils with low water holding capacities can be effectively irrigated without excessive losses or crop stress. Because only a small portion of the total field surface area is wetted, losses due to evaporation from the soil surface are relatively low, especially when compared with overhead sprinkler/centre pivot irrigation systems.

The ASF system was considered to be easy to manage, highly flexible from an operational perspective and had minimal maintenance requirements. A fertigation system was developed to apply nutrients. Apart from refinements to the boot and piston valve, no system problems or deterioration in components, for example clogging of emitters, has been observed. Although the furrows used in ASF are short, the configuration of the piping and emitters is such that the furrows and piping do not interfere with mechanised field operations and controlled trafficking is encouraged. High machine operating efficiencies, associated with long in-field travel paths, are attainable.

Substantially less energy is used for ASF compared to other irrigation systems. For example, ASF requires a pressure of only 70 kPa at the field edge compared to approximately 150 kPa for traditional drip irrigation (considered to be a relatively low pressure system) and 250 kPa for centre pivot systems. Reduced pressure and water losses are directly related to reduced energy requirements and operating costs. Preliminary analyses using the Irriecon V2 economic analysis tool (Armitage *et al.*, 2008) and data from, *inter alia*, the Ukulinga trial, indicate that there will be at least a 40% cost saving for ASF relative to SSD, for similar or better crop yields and equivalent water usage.

Sugarcane agriculturalists and irrigation practitioners have commented favourably on the potential for ASF during field days held at the Ukulinga trial site. Agriculturalists were particularly impressed with the simplicity of ASF, compared to SSD and the impressive cane yields.

In the Ukulinga trial plots, the average cane yield attained using ASF was 129t/ha for a 12 month plant crop. In the same trial, the average yield for cane irrigated using sub-surface drip irrigation (SSD) was 123 t/ha. Nearly identical amounts of water were applied to both the SSD and ASF plots. The soils at the trial site are shallow Westleigh and Mispah types, only about 0.6m deep. Typical cane yields for a 12 month irrigated crop in the same region are less than 90 t/ha, on much better soils.

CONCLUSIONS

ASF may offer the desired combination of low cost, high efficiency and easy management, needed for precision irrigation. Similarly to SSD, small amounts of water can be applied frequently with ASF, with a high degree of flexibility and with relatively high distribution uniformities. This facilitates effective irrigation under a wide range of soil, crop and climate conditions. However, dissimilarly to SSD, ASF is a relatively low cost and simple form of irrigation. The wider community would benefit from ASF facilitating efficient production utilising less water, especially where SSD is not viable for financial or other reasons. This is vitally important given limited water resources in most countries and the increasing competition for them, particularly in Australia and in South Africa.

A key aspect of the system is the boot and piston valve which allows the use of buried piping provides good flow control and renders the system relatively robust without requiring electronics, electric power and associated communication systems. Although the furrows are short, machinery run lengths can be long, resulting in high machinery field operating efficiencies. The layout of the system also encourages controlled trafficking and associated system benefits.

While ASF has many potential advantages, the system still needs to be evaluated under commercial farming conditions. The knowledge and systems required to implement a commercial scale system trial have been developed during this project.

ACKNOWLEDGEMENTS

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Raised Bed Cropping in Australia: Yield Stability through Short- and Long-term Soil Health in the Crop Root Zone

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BACKGROUND

The grains industry in Victoria is worth almost $200 million annually with significant yield increases from nearly 60,000ha of raised beds installed on soils prone to water logging. While continuous cropping on raised beds has proved to be significantly more productive under experimental conditions and therefore more popular amongst growers, the contribution to soil health and quality through other rotations has also been significant.

MATERIALS AND METHODS

A long-term farming systems trial was used to compare the productivity of three different systems. The site consisted of two Vertosol (Isbell, 1996) soils different in their shrink-swell characteristics. The self-mulching black Vertosol (BV) was known to be less susceptible to water logging than the grey sodic vertosol (GSV) and therefore known for its higher productivity. System productivity (crops and grazing included) was compared by converting all grain yield to dry sheep equivalent days (DSE days) (Walcott and Zuo, 2003). Soil structure was assessed twice during the trial at three and five years after commencement in 2002 and 2005 respectively. Crop yields and the difference in soil structure between raised beds and flat ground experienced by growing roots were analysed using the residual maximum likelihood procedure (REML) in Genstat 5.42 (GenStat Committee, 2000)

RESULTS

Measured differences (i.e. lower) in soil BD were apparently evident over the entire profile depth to 40cm while significantly lower soil BD was observed at the 15 cm depth in profile in the 2x2 system compared to other systems. In the comparison of soils, the soil BD difference in the black Vertosol was greater than that of the grey Vertosol and its occurrence at 35cm depth was remarkable as this was below the initial tillage depth of 20cm. The increase in soil macro-porosity as a consequence of the decrease in soil BD resulted in more water storage in the profile for plant use. The total profile water storage to 40cm depth can increase or decrease depending on the soil type and its management. Between 2002 and 2004, water storage at depth in the Black Vertosol soil actually improved but at the end of five years of the trial, the more hostile Grey Sodic Vertosol soil had developed a greater capacity to store soil water, showing a better response to raised beds.

DISCUSSION /FUTURE WORK

By nature of their design, permanent raised beds also encourage the concepts of reduced tillage and controlled traffic (CT) in broad acre farming. Bed farmers in the region have experienced an average yield increase of ~20% in wheat, barley and canola crops compared to cropping on flat paddocks despite sub-optimal rainfall experienced in recent times in the region. The impact of different farming systems particularly in the absence of indiscriminate compaction has led to significant differences in soil structure under beds, leading to an increase in plant available water capacity (PAWC) that appears to be contributing to yield stability under these circumstances. The beneficial soil structure outcomes from systems involving pastures did not produce the best yield results in the short-term in our experimental work. However, in the long-term they are likely to contribute more to sustainable soil health outcomes. Reduced compaction and increased aeration will favour soil biological activity when temperature and soil water are at an optimum. Initiatives such as the growing of deep rooted perennial forages (primer crops) on beds and the retention and management of crop residues will further enhance the build up soil organic carbon which will in turn enhance soil health and favour increased productivity.

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Testing the Economic Viability of Controlled Traffic Cropping

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ABSTRACT

A method for calculating the profitability of controlled traffic systems was demonstrated using an example from the Moree area in northern NSW. A partial budgeting approach was used to assess the economic viability of a controlled traffic system in terms of marginal return on capital and cashflow approach.

INTRODUCTION

There is a lack of information on the profitability of controlled traffic cropping systems in Australia (Wylie 2007). The methodology used does not have to be overly complicated (Malcolm 2004), but good information on the costs and benefits of the system are required to obtain a reasonably accurate estimate of potential profitability. This paper outlines a method for calculating the profitability of controlled traffic systems using an example from the Moree area in northern NSW.

METHODS

Initially, a partial budgeting approach was used to assess the economic viability of the system in terms of marginal return on capital (Patton 2001; Malcolm *et al.* 2005). Then a cashflow approach was taken to evaluate the impact of the enterprise change on cropping system profitability (Malcolm, Makeham et al. 2005).

A partial budget is a method of assessing the likely value of making a change (such as growing a new crop or altering machinery resources) by comparing it with the existing situation. In a partial budget, the extra costs and returns of the change are compared with those of the existing situation. The net returns or losses can then be expressed as a percentage return on extra (or marginal) capital. This measure provides an initial basis for comparison with other investment alternatives (Patton 2001).

If the return on extra capital percentage is high enough, then the technology change merits further investigation. This is usually done using a cash flow budget since it may take some years for the full returns to become evident. If the return on extra capital percentage is too low, the change would usually be rejected. A grower may reject the idea as they believe they can achieve a higher return on the capital by investing elsewhere. This could be an alternative investment on-farm, such as installing more grain storage.

The example used here uses data from a large farming operation to the south of Moree in northern NSW. The existing cropping system was no-till, but the old ‘round and round’ pattern of spraying and sowing had been kept. The existing five-year crop rotation (long fallow wheat- chickpeas-wheat-long fallow sorghum) was not altered when controlled traffic was introduced and the farm manager did not feel that yields overall had changed due to the introduction of controlled traffic. The 2-metre paddock tramlines were marked out by a contractor for $6.00/hectare and two new 24-metre width boomsprays were purchased. The existing planter was also kept with little alteration required to suit the controlled traffic system.

The farm manager noted that in the existing no-till system, the overlap in a paddock was up to 20%, in one instance, “We used enough chemical for 350 hectares to cover a 286 hectare paddock”. This was due to marker foam evaporating before the operator got back around again. Therefore, overlap assumptions were 20% for spraying operations and 5% overlap on sowing operations for the conventional no-till system, and 2% overlap for both spraying and sowing operations under controlled traffic.

Full gross margin budgets were constructed for each crop in the rotation and the Moree region long-term average yields were used in the calculations.

- Short fallow wheat 2.2 t/ha (AH12 grade)
- Long fallow wheat 2.7 t/ha (PH13 grade)
- Chickpeas 1.50 t/ha
- Sorghum 3.3 t/ha

Early 2008 prices were used for crop variable costs such as seed, fuel and oil, herbicides (Roundup CT $12.50/L) and fertilisers (Starter Z $1320/tonne, anhydrous ammonia $1140/tonne). A crop area of 2000 hectares was assumed. Labour savings were costed at $20 per hour.

Recent (2000-2008) average prices were used for wheat ($217/tonne PH13, $199/tonne AH12), chickpeas ($439/tonne) and sorghum ($211/tonne).

RESULTS

Table 1 shows the differences in gross margin returns, the differences are due solely to cost savings from reduced overlap.

Table 1: Gross returns

A. Existing rotation - no-till				
Area		**Crop/Fallow**	**GM/ha**	**GM/activity**
1,600	ha	Summer Fallow	-$64	-$ 101,851
800	ha	Winter Fallow	-$64	-$ 51,079
400	ha	Short Fallow Wheat	$ 162	$ 64,786
400	ha	Long Fallow Wheat	$ 257	$ 102,918
400	ha	Chickpeas	$ 294	$ 117,771
400	ha	Long fallow Sorghum	$ 399	$ 159,675
			Total crop gross margin	**$ 292,221**
		Estimated labour cost @ $20.00/hr	477 hrs	$ 9,542
B. Controlled traffic plus no-till				
Area		**Crop/Fallow**	**GM/ha**	**GM/activity**
1,600	ha	Summer Fallow	-$54	-$86,834
800	ha	Winter Fallow	-$54	-$43,417
400	ha	Short Fallow Wheat	$ 167	$66,878
400	ha	Long Fallow Wheat	$ 267	$106,678
400	ha	Chickpeas	$ 312	$124,920
400	ha	Long fallow Sorghum	$ 415	$165,982
			Total crop gross margin	**$334,207**
		Estimated labour cost @ $20.00/hr	447 hrs	$8,950
			B- A: Expected change in returns	**$42,579**

Table 2 summarises the capital outlay assumptions.

Table 2: Capital outlay

	Capital outflow	Capital inflow
Purchases 2 x 24m boomsprays Marking out @ $6/ha	 $ 100,000 $ 12,000	
Sales eg. sell old boomsprays		 $28,000
Expected extra capital cost	**$84,000**	

The return on marginal capital is 51% as shown below. This indicates a reasonably good return.

$$\text{Return on marginal capital} = \frac{\text{Change in returns}}{\text{Extra capital}} \times \frac{100}{1} = \frac{\$42{,}579}{\$84{,}000} = 51\%$$

A cash flow budget was set up which covered six years on a monthly basis. Interest costs were not included in the cash flow since different financing options can affect the amount of interest liability. However, in calculating the Net Present Value, a marginal tax rate of 10% was used to allow for tax deductibility of capital items as well as tax liability on extra income.

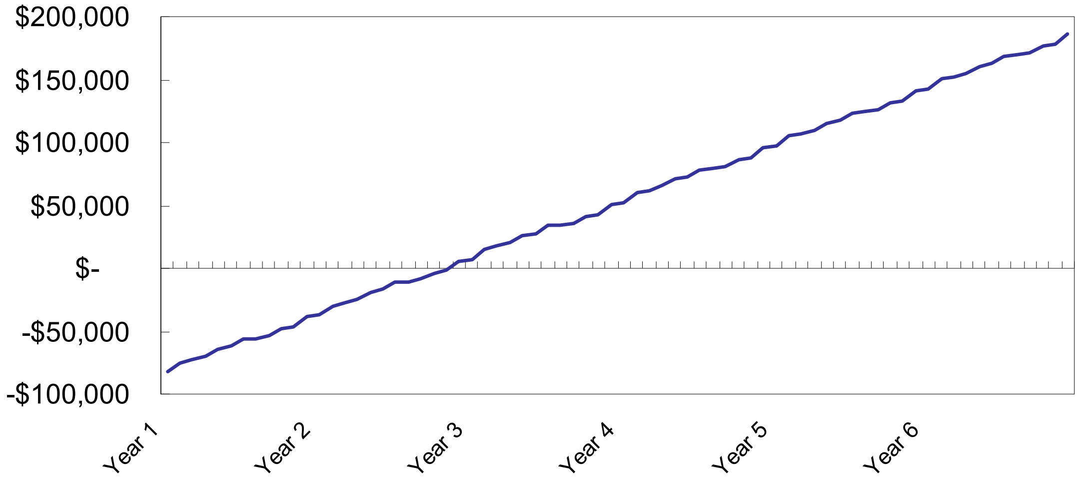

Figure 2: Cashflow difference between controlled traffic and conventional over 6 years

Other scenarios

In the late 1990s surveys by the Kondinin Group observed that typical overlaps in conventional no-till cropping systems were between 5 and 10%. Tullberg (2001) stated that “Farmers adopting controlled traffic often report reductions in the time and material input to operations of 10 - 20%.” Other literature has stated that yield improvements have been observed under controlled traffic conditions (Jones 2000; Li *et al.* 2007). As shown in Table 3, an improvement in yield due to improved soil conditions, whether that is due to improved root penetration and nutrient uptake or improved water storage capacity, can have a significant impact on returns.

Table 3: Alternative Assumptions

Scenario	Rate of Return
10% overlap conventional no-till	28%
5% yield improvement	104%
10% yield improvement	158%
10% overlap conventional no-till and 5% yield improvement	81%
10% overlap conventional no-till and 10% yield improvement	135%

CONCLUSION

The economic benefits from controlled traffic are reasonably easy to calculate with simple budgeting tools such as partial and cash flow budgets. In this example, an improvement in yields combined with cost savings from reduced equipment overlap was shown to have a significant positive impact in profitability.

However, detailed information on the cropping systems both before and after the change is required to calculate the potential profitability change with any accuracy. The magnitude of the change in profitability is likely to vary widely between farms with a number of key factors, such as the level of capital investment; cost savings gained, and yield improvements. Further research is required to quantify the benefits before any general messages could be proposed about the profitability of the system.

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