Nuffield Farming Scholarships Trust

A John Oldacre Foundation Award

Arable farming - where next?

James S. Peck N.Sch

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Contents

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UK

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Disclaimer

This publication has been prepared in good faith on the basis of information available at the date of publication without any independent verification. The views expressed are my own and not necessarily those of either The Nuffield Farming Scholarships Trust nor my sponsor, The John Oldacre Foundation.

1. Introduction

When I applied for a Nuffield Scholarship, I was a 33 year old Cambridgeshire arable farmer. I had been educated at Lackham Agricultural College Wiltshire, followed by Writtle College, Essex, completing five years of arable-specific courses. After travelling and working abroad I came back to the family farm (at that time 1,200 acres) in 1999 to work alongside my father and a team of four.

At this time, with wheat prices dropping down to £65 a tonne and oilseed rape at £135, it quickly became apparent that running costs of £180 an acre were no longer sustainable. We spent the next three years rationalising. We adopted an Eco Till system and came away from a full plough system to second wheat ploughing only. Due to retirements and restructuring, we reduced to a work force of one and embraced a direct drilled OSR (Oilseed Rape) approach and one pass cultivation regime on the wheats.

In 2003 my father decided that he no longer wanted to continue farming in the present manner. This gave me the opportunity to start PX Farms Limited as a contract farming company and to contract farm my father's land. Today, my company looks after 5,200 acres under contract and we consistently carry out custom works over additional acreage. We have a haulage business with nine bulk grain lorries (eight in a long term contract with a grain merchant) and store 26,500 tonnes of wheat with the help of 14 permanent and an additional six temporary harvest staff.

By 2009 the business had been rationalised to achieve running costs of £82 an acre while increasing yields and profitability. We had also diversified from standard farming into haulage, storage and converting redundant buildings into offices. We had protected the future development of the business by structuring the family trust and dealing with succession issues.

I had hit a brick wall in regard to plans for the future; conventional objectives had now been met. My fear was that I could stagnate, spend my time roaring around the countryside hunting and shooting and only develop to the extent afforded by reading the Farmers Weekly and seeing what the local machinery agents had to offer.

What I was missing was the inspiration, motivation and direction for where and how to develop the business next and a platform for my enthusiasm to drive forward the UK agricultural industry as a whole.

My turning point

This came when I was made aware of the Nuffield Farming Scholarship awards through an earlier Scholar. It seemed a wonderful idea although when I read the criteria that had to be met as a Nuffield Scholar, I was deeply concerned as to whether I could manage to be away from my business for the length of time required. As a person, I was not sure whether I was strong enough to relinquish control of my business sufficiently to be able to travel without the day-to-day ties, worries and joys. However I remembered being told many years ago, when I first considered starting my own business, that you need to take yourself out of your comfort zone or your character will not grow. With this in mind, I completed the application form.

Despite the toughest of interviews, to my delight and amazement I was awarded a Scholarship and thus began one of the greatest experiences and achievements of my life.

My study subject

I had picked a broad title because I was unsure what the next step in arable farming would be, or where to concentrate my efforts. The Nuffield Scholarship gave me a wonderful opportunity to travel the world to see the developments and changes in world agriculture. The Nuffield network allowed me to visit leading farms and universities and also opened doors to people whom I would not ordinarily be able to get close to. From the very start of my Scholarship - meeting the other UK Scholars and attending the Nuffield Contemporary Scholars' Conference in Washington DC - offers of help and information were available. At every point on my journey people went out of their way to show me their own operations and introduce me to neighbours and colleagues who might have systems or opinions that were relevant to my report.

Since embarking on my Scholarship the industry has changed dramatically and knowledge transfer has evolved at great speed. I found I could discover a new ground breaking invention on the other side of the world, and within 2 months it was on the web and published in the *Farmers Weekly*. With hindsight I feel the timing of my study tour was perfect – arable farming is entering a new decade and now both my business and I personally are positioned to be there in the forefront.

My personal focus had previously been on having the biggest tractors and equipment – I just loved machinery.

But now, with the perspective given by my Scholarship, I am focussing on assets. And the greatest asset any farmer has is his soil. I am passionate about soil. My study tour has majored on how best to protect and enhance this fundamental asset.

2. Background to my study tour : "Arable farming: where next?"

2a. Dilemmas facing the British arable farmer in autumn 2011

The outstanding feature of UK arable farming today is the volatility of prices and these unpredictable rises and falls are going to continue.

To put this in perspective, if the wheat market fluctuates by £12 a tonne on a given day, the difference in the sale price achieved on 10,000 tonnes is equivalent to the price of a new Land Rover.

In the past two years I have seen phosphate TSP go from £700 a tonne, reduce to £190 then rise back again to £440. Similarly, nitrogen has risen from 48 pence to 102 pence a kg.

Machinery increases over the past five years are reflected in the price for the same model of tractor going from £48,000 to £82,000; an increase of 71%.

Single farm payment has been reduced in real terms by a fluctuating euro:sterling exchange rate plus reductions due to the EU modulation policy.

Fuel costs are rising, and there is even the threat of red diesel becoming taxed as road fuel. All these will cause dramatic change to the countryside as we know it today.

As one example, running a Challenger that uses 1,200 litres of fuel a day on a standard shift and 2,000 litres on a 24-hour operation at a current cost of £804 and £1,340 respectively could potentially rise to £1,320 and £2,200. This equates to an increase of £17.20 a hectare per operation just in fuel costs. In an effort to address this increase in the cost per hectare, we must review our system of operation, dependence on fuel use per hectare and capital cost per hectare, looking closely at any options available to improve efficiency and operation.

2b. Environmental issues

Environmental payments, once an important element of farm income, have not kept up with rising prices. I calculate that current environmental payments will only provide an income equivalent to wheat at £100 per tonne.

As an illustration, take one of our managed farms which extends to 160 hectares. With 16 hectares of environmental area attracting payment of £30 per hectare this would produce a total of £4,800. On the other hand, if we grow wheat on the 16 hectares, based on a price of £190 a tonne as at 24th May 2011, this would provide a net income of £9,884 (after costs) from the 16 hectares.

This £5,084 net difference clearly illustrates that environmental rates, to be attractive, need to be based on £60 per hectare with the present options, plus being RPI-linked. There is only one structure for the whole of the country – but the country is very different from east to west and north to south. At present, arable farmers who want to do their bit to help the environment are subsidising the environmental schemes.

Therefore, it appears that the Campaign for the Farmed Environment and Defra's threat of compulsory set-aside are a deterrent for farmers and landowners to keep land in environmental schemes and out of production. However, there are other methods available which could benefit all environmental organisations and deliver real benefits – not just a half-hearted attempt - to the countryside and overall environment. These are discussed in Chapter 9.

2c. Where I travelled

During my Nuffield study tour (which lasted a total of 21weeks) I travelled in:

- UK)
- Canada)
- Australia) in all of which I saw best practice
- New Zealand)
- Argentina)
- U.S.A.)

and also

- several European countries)
- China) which added to my general perspective and maturity
- India)

2d. What my objectives were

- To discover the next big trend(s) in UK arable farming (although, given that today's markets are global, this trend was almost certainly going to be an international one).
- To bring back the techniques, skills and research needed to optimise this trend
- To return home and prove these findings by putting them into practice

Ultimately, in the best Nuffield tradition, to share my knowledge with my fellow farmers

3. Findings from my study tour

- In the 70s and 80s the great advances in arable production stemmed from seed breeding and nitrogen.
- Then came an era of ever-increasing tractor and equipment size which, in its turn, helped to cut the costs of production via reduced labour and increased speed of operation.
- Over the last decade No Till has become an established technique and the plough, increasingly, a relic of the past.
- At the same time many countries of the world have been able to benefit from GM seed breeding but there is still no sign of this becoming acceptable in the UK.

Against this background I have found some amazing practices being developed by forward-thinking arable farmers across the globe and these are detailed in the following chapters.

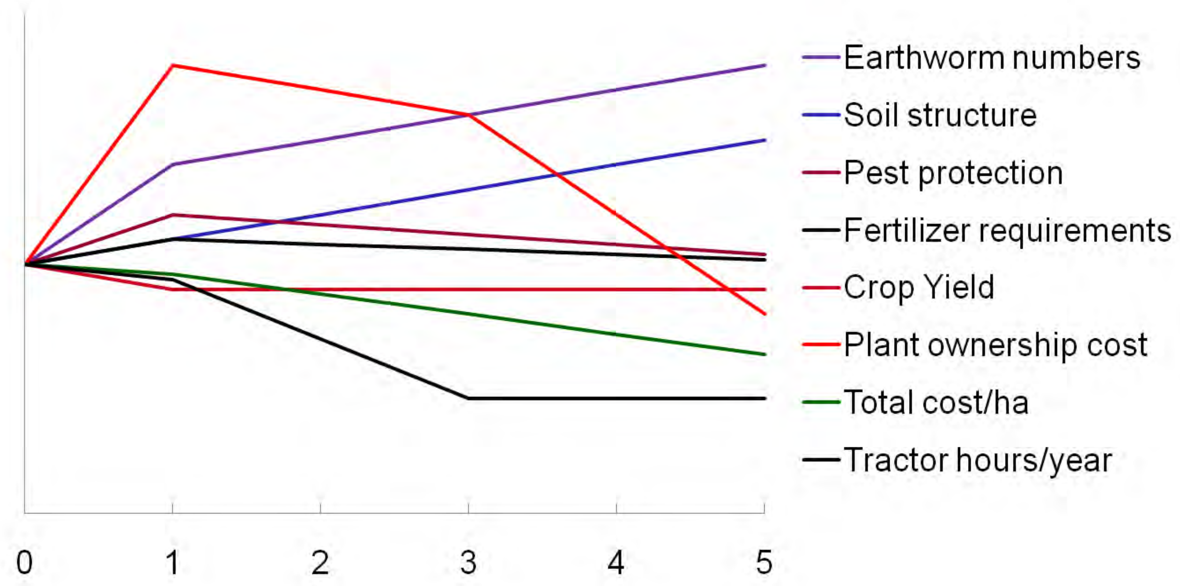
I would emphasise that I have been trialling these new practices on my own farm so I am not only describing what I saw on my travels, but also speaking from personal experience.

- The number one development that I saw – in terms of its potential for British farmers – was **Controlled Traffic Farming (CTF)** and this is described in the following chapter.
- Secondly my existing belief in **No Till** was thoroughly endorsed and I saw further enhancements of the system – see Chapter 5 on page 28.
- The fundamental requirement for developments in both these areas is that fields need to be **GPS-mapped,** and this is discussed in Chapter 6, **Precision Agriculture,** on page 42. Further details are also given in the Appendix at the very end of this report.
- The physical operation that encounters difficulty under Min Till regimes is **Drilling,** and Chapter 7 on page 52 addresses this.
- **Weed control** is the issue most often mentioned as being the drawback with Min Till. Chapter 8, **Weed management**, on page 56 is devoted to such problems.
- Finally **environmental issues** are debated in Chapter 9, see page64.

The above techniques themselves are so intertwined and interdependent that inevitably the subject matter in the chapters overlaps on occasion. But I have divided it up as best I can for the sake of reference and clarity.

4. Controlled Traffic Farming (CTF)

CTF is a system that allows only one set of tramlines to be used by all vehicles accessing the croppable land. Running in the same wheeling as other vehicles shows a 30% reduction in fuel. Less fuel translates to less engine power being utilised which in turn means lower capital expenditure. Dependency on HP and fuel drops by 50%. The graph below vividly illustrates the benefits and savings achieved when using CTF. The horizontal axis refers to years.



Graph illustrates the change in inputs and outputs over 5 years when utilising Control Traffic Farming. Graph supplied by Dick Goodwin

It is not the number of passes, or scale of operation, that will increase or decrease compaction; it is simply *where* you drive.

The spacings of wheels or tracks is a challenge for the machinery companies to address. Machinery manufacturers need to join forces with the Controlled Traffic Farming movement to make the transition possible. Controlling machinery and tractor width can make a great difference. Whereas the traditional approach causes 140% (due to several uses of the same tracks) of the field to be compacted, the CTF approach can achieve an ideal 18% compaction.

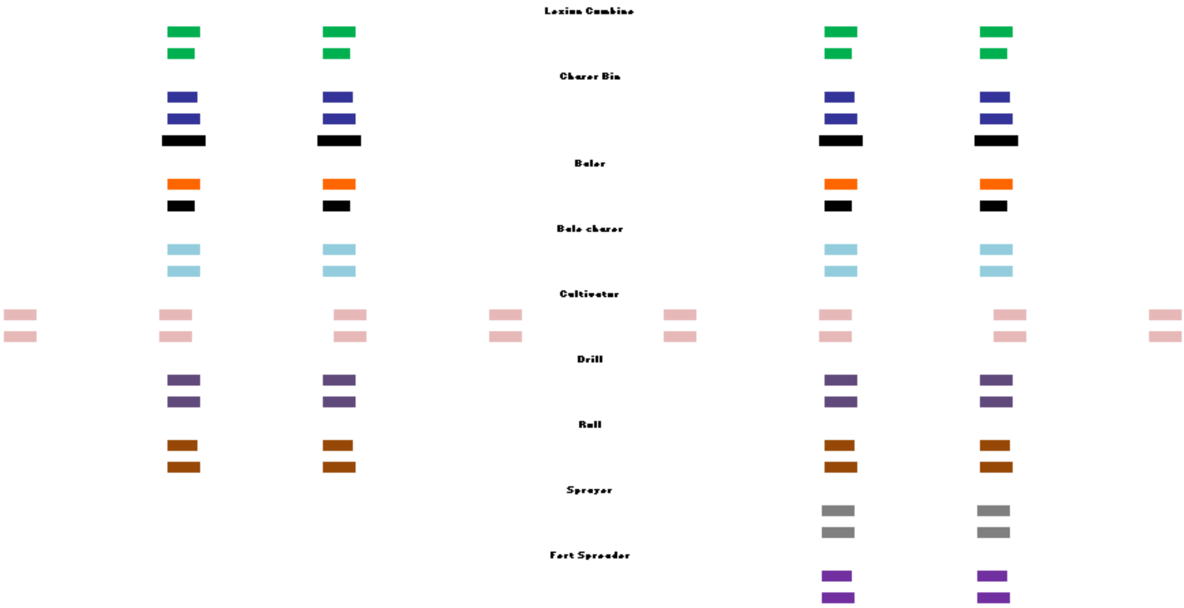
The sizes that manufacturers need to concentrate on are 3 metres, 4.5 metres, 6 metres, 9 metres and 12m. For example, the maximum Western European machinery size due to folding and road constraints will be 12 metres. A 12 metre drill, 36 metre sprayer and 12 metre combine provide an ideal template. This is the physical measurement across the widest part of each piece of equipment when in use. For example, the sprayer will cover 36 metres but can be folded during transportation.

All other machinery would need to fit into the 36 metre pattern. Operating at 6 metres will result in 25% of the field being tracked and 13% of the field uncropped.

The picture above shows sheep in Australia using the CTF tramlines to walk up and down. This demonstrates that animals naturally choose the compacted lines which are easier to travel on, whilst leaving the rest of the area undisturbed because the aerated soil requires more effort.

36 metre sprayer *folded for road travel*

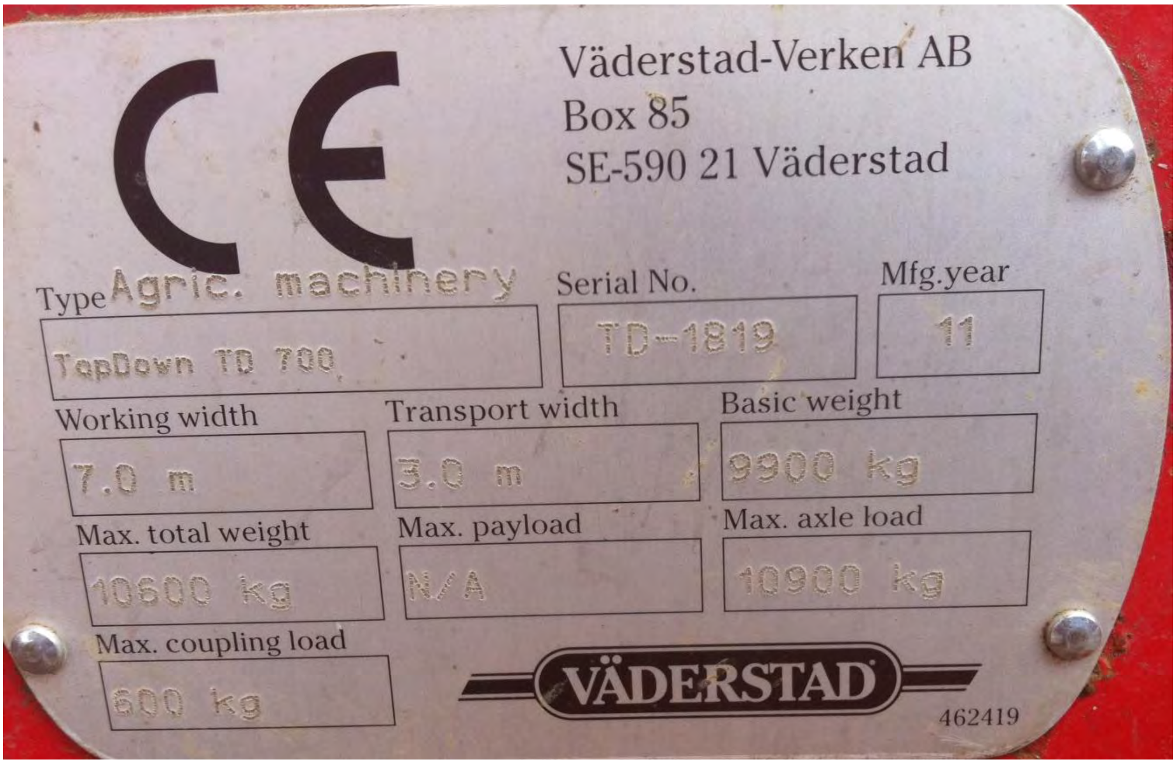
The diagram below shows a 6 metre system which we could not incorporate today due to lack of horsepower and available 12 metre cultivators, so we are having to run 6 metre spacings with the Vaderstad Topdown.



At this point I have to issue a warning based on my personal experience; machinery that is advertised as for example 7 metres working width might only operate at 6.75 metres. Costly mistakes can be made if every piece of equipment in a system is not physically – and accurately - measured. An additional 0.2m is needed to account for any GPS error.

Manufacturers need to change their ways and advertise the actual operating width of machinery. At the design phase they need to be mindful of how effectively their equipment will work in Controlled Traffic Farming systems.

In my own business we have had to change a '6 metre' Vaderstad Topdown – which cultivates at 5.75 metres – for a '7 metre' Vaderstad Topdown machine that works at 6.75 metres, then remove two tines to achieve a 5.9 metre working width. The combine header advertised as 12 metre actually works at 11.88 metres. To resolve this our CTF system had to be set at 11.66 metres across all machines, but the sprayer is 35 metres so we will have to take off two nozzles to compensate, or the last two nozzles will need to be changed to a 0.3 metre distance apart as opposed to the standard 0.5 metres to achieve an 11.86 system. If the entire sprayer was set up at 0.3 metres nozzle spacing this would allow greater efficiencies on auto nozzle shut off when overlapping.



Vaderstad Topdown erroneously showing working width as 7.0m

A 12 metre system, regardless of whether it is using cultivations or zero till, would result in a 13% tracked area with 13% uncropped.

The diagram below is my ideal, where I have used either a 12 metre cultivator or a direct drill pass which results in wheelings only occurring at 12 metre intervals.

This means 12% less of the field width is tracked as opposed to a system based on a 6 metre cultivator.

The drill will plant seeds across the entire field area, but cannot remove all compaction from tramlines used by the tractor and other machinery on pre and post passes. As the sprayer works at 36 metres and the other operations run at 12 metres there will be, after drilling, visible 'fuzzy tramlines' every 12 metres. These are due to the compaction of areas which carry some traffic throughout the year. The crop in these fuzzy areas will grow, but it will be stunted due to the seedbed being compacted. These slight dips in crop height can be clearly seen when looking across a cropped field. Even though the crop is less successful in these areas, it is important to seed them to provide competition for weeds that may try to establish.

Showing fuzzy tramlines

In the future when combine harvester headers are produced at exactly 12.2 metres, we can return to a true 36 metre system.

All other passes will have to be divided by 35 metres. I intend to set the field up at 2.91 metres. The hedge cutter will be set at 2.91 metres. The first headland pass will be 2.91 metres so the hedge cutter will steer itself around the outside of the field. To remove any compaction from this repetitive passing, it will be easy to set up a subsoiler to run in the wheelings. Since keeping hedges cut is done for environmental reasons on a three year rotation, the need to remove wheeling is only necessary every third year.

Tractors all come in different widths and tyre sizes. After measuring wheels and tracks and spacings it is surprising how many different widths exist on my farm. There appeared to be no UK standard even with machines made by the same manufacturer. The American manufactured machines have greater flexibility to alter wheel widths by using a bar sliding axle adjustment on the rear but

European-based machinery is fixed, only allowing a small movement in rim dishes to change tyre width.

In Australia, people who are adopting CTF have gone for 3 metre track spacing and have requested this as the standard from manufacturers. John Deere has responded by producing a front hub spacer which takes the front axle out wider to fit the 3 metres and the company provides a warranty on the vehicle when this adaption is used. To get other makes out to 3 metres a company called Trazweld in Queensland will extend a current axle as an after-market customisation. However, that falls outside the original manufacturer's warranty.

This is unworkable in the UK because a 3 metre centre axle with 710 tyres is 3.71 metres wide and therefore will not fit our roads.

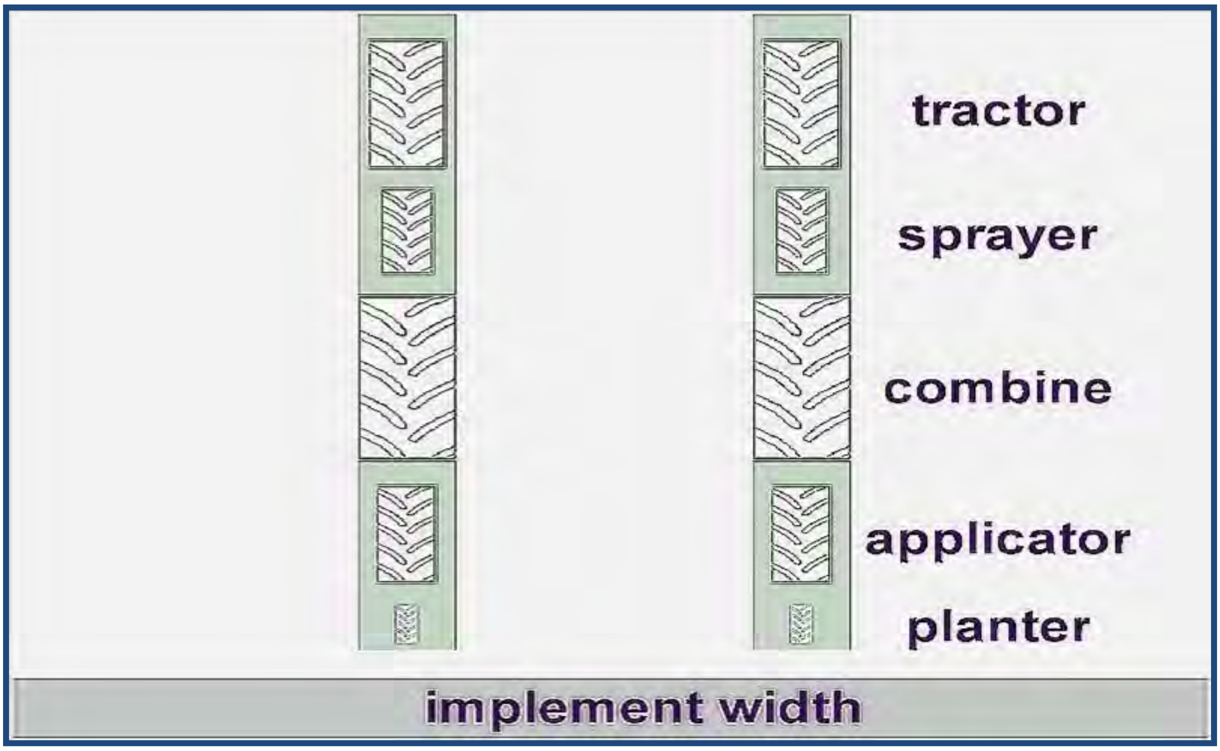
3 metre centre to centre track width

The picture on the next page shows a wheeled tractor similarly adapted.

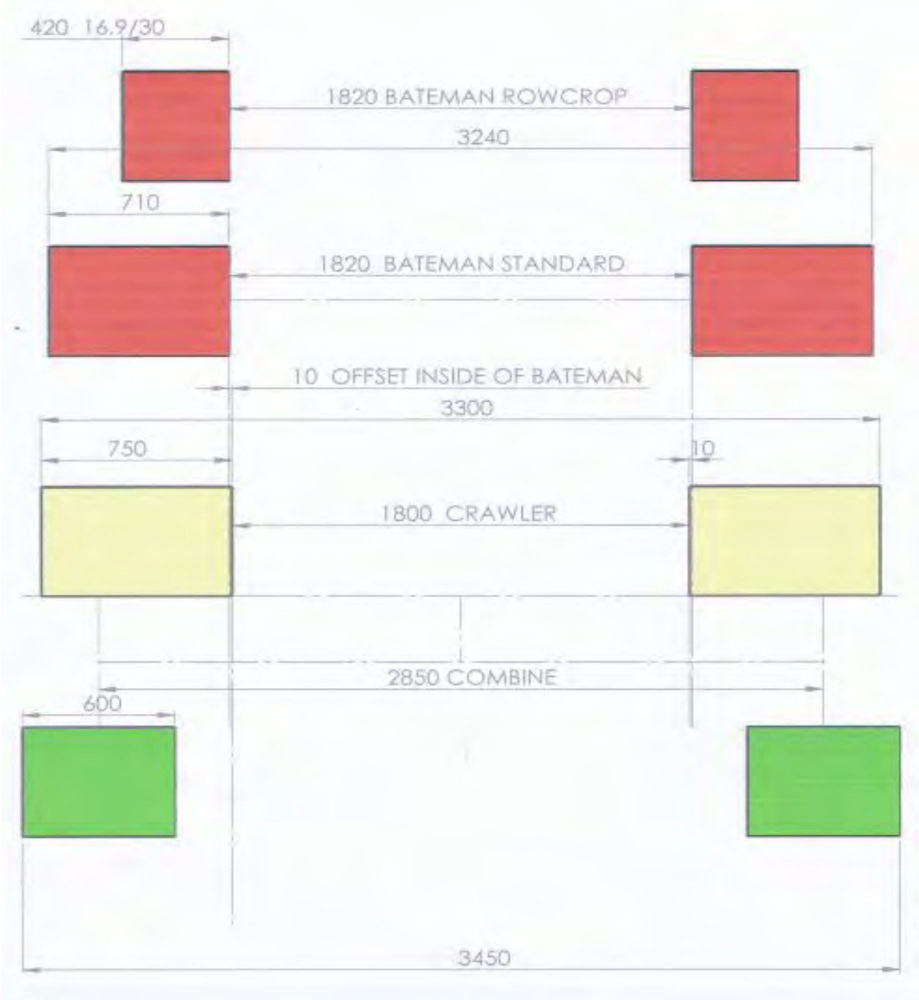
Wheeled tractor adaptation. Front axle 3 metre centre

Machinery necessarily comes with many different tyre and track sizes depending on the operation, time of season, soil conditions and application. When trying to find a centre track width that would suit both roads and machinery, it struck me the centre track is not relevant in the UK, but the inside width between the two tracks is actually the important measurement. 1.8 metres works well. The outside width will change depending on machine. Trailed implements like drills and chaser bins need to follow in the same track.

The diagram on the next page demonstrates the ideal.



With the machinery we currently have available it will run as shown below.



We have recently purchased a Horsch chaser bin that has a hydraulic axle that pushes out for field use and pulls in for road use.

The Bateman, John Deere, Challenger and Agrifac sprayers in the UK also have hydraulic axles able to be used at either road width or field width at the click of a switch. I hope more implements in the future come with hydraulic axles so they can be set at the correct width for controlled traffic operations.

Hydraulic axle for road and wheel width

Being able to alter track widths and tractor wheel widths on the move would transform the difficulties of Controlled Traffic Farming and West European road widths.

Once the machinery is set on required widths and track widths, it is vital that all equipment is driven in exactly the same tramlines. Historically this would be done either by eye by the human operator, or using marker pegs at the edge of the field. To maintain the accuracy required for CTF the use of a RTK (real time Kinematic) repeater is vital. (I discuss Precision Agriculture in Chapter 6).

In the USA, I saw a basic low-tech solution which does not remove wheelings from one year to the next so that they know where to drive each year without needing a GPS system. This of course is a low capital approach. It would work in the UK on a No Till or Min Till approach. GPS would be needed to set the field up in the first instance. Tines would be hydraulically lifted out of operation when travelling down tramlines. With diesel usage reduced from running on compacted ground and no crop grown in the lines, why would you remove them each year?

GPS providers need to provide control panel functionality which can be customised as required. In the example described above, it would be set to automatically lift hydraulic rams with tines out of work so that the tramlines are maintained.

Chaser bin with hydraulic rear axle so that it can be re-aligned

So Controlled Traffic Farming controls the placement of traffic in a field. With track spacing and machinery running on a 12 metre system there is only 18% of the field trafficked.

However harvesting at 12 metres causes a problem as the auger does not reach over to the established wheeling. Therefore, the chaser bin or trailer has to pull onto fresh, uncompacted ground compacting a greater percentage.

Oztek in Australia have developed a hydraulic belt to stretch out to catch the grain from the auger rather like a baseball glove.

Trevor Postlewaite in Australia has also developed an auger based system.

The chaser bin is compacting fresh ground due to auger not being long enough.
Past combine wheeling can be seen to the right of the John Deere.

Oztek chaser bin in Australia fitted with a rubber belt.

Auger extension fitted to a chaser bin.

To make this work efficiently, the combine and chaser bin speeds need to be synchronised together to avoid grain being spilt. If sensors were fitted either side of the belt it could turn the combine auger off automatically if the thresholds on either side were breached.

Combine manufactures are working on a new auger system to combat these problems. Meanwhile, farmers are still designing and constructing their own solutions. An Australian farmer, as I discovered on You Tube, has built his own auger to fit an 18 metre header.

A 9 metre system already works without any auger attachments needed. Most machinery available in the European market would suit a 9 metre system and is available as standard. In Australia I saw two 9 metre systems that were working well.

However I have chosen to persevere with our cobbled-together 12 metre system as I believe machinery will change in the future to resolve all the current problems with a 12 metre system. Furthermore, persevering with a 12 metre system fits the objective of seeking a lower percentage of tracked area, less than a 9 metre system would require. In this regard a new combine header is coming out next year at 12.26m, which will enable me to run at 12m. I'm definitely a customer!!

To fit into our own CTF system, the field passes need to be mapped accurately. This means that the A and B lines need to be at 2.91 metres to fit into our 11.66 system. Field boundaries need to be mapped by RTK or GPS so that the location of the A and B lines can be accurate. These then need to be uploaded into each GPS controller so whatever the machine width, it calculates in multiples of 2.91 metres. This works with different widths of machines such as mower, rolls, cultivators, subsoilers and mole drainers. Using a low-width basis provides the most flexibility for multiple sizes of implements. For example, a 9 metre combine would drive on every 3rd bout but a 6 metre mole drainer would drive on every 2nd bout. This in particular would enable contractors to work on a farmer's land and still stay within their system. This demonstrates the infancy stage of CTF; building the self discipline of planning machine purchases to fit within the required sizes. As machine replacements take place, larger spacing on the field passes can be achieved, building towards the ideal of all farm machinery working on a true 12 metre system and only driving on 13% of the field.

Headland management is where I see the greatest challenge. Headlands account for 25% of a field. Headland turning needs to be treated the same as the field passes described above. Turning needs to be mapped and machinery designed to enable turning on the same radius each time. Trailed equipment needs to have rear steering axles to follow the tractor on headlands. The ability to steer implements is also important in the field on slopes or hard ground to keep the implement on the same track as the vehicle pulling it, *see picture below detailing headland farming management.*

The diagram below shows one of my fields at Scotland Farm where we have carried out all the cultivation and harvesting passes in one direction. This combine yield map shows the impact from headland turning where the yield has dropped dramatically as shown by the red areas. If you look at the top edge of the map you can see there is a much lower drop in yield, which is a direct result of less compaction as there was no turning on this headland. The lines across the field clearly show the straight line direction that was used. Since we are currently not using a true 12 metre system, not all the implements follow exactly the same line which is why the line areas are broader in places. When all machinery is following a true 12 metres the straight lines will be sharply defined. **I believe this map demonstrates the importance of controlling compaction by implementing Controlled Traffic Farming.**

To remove compaction from the headlands, the tined subsoiler seen in Geraldtown Australia runs between the rows of crop using GPS. *(See picture on next page).* This remedial work is carried out after the crop has been drilled to allow better root development. There will inevitably be areas that get most compacted and need to be made good, for example where the chaser bin loads lorries. These areas need to be marked on maps and identified as the only areas where traffic comes off the tramlines.

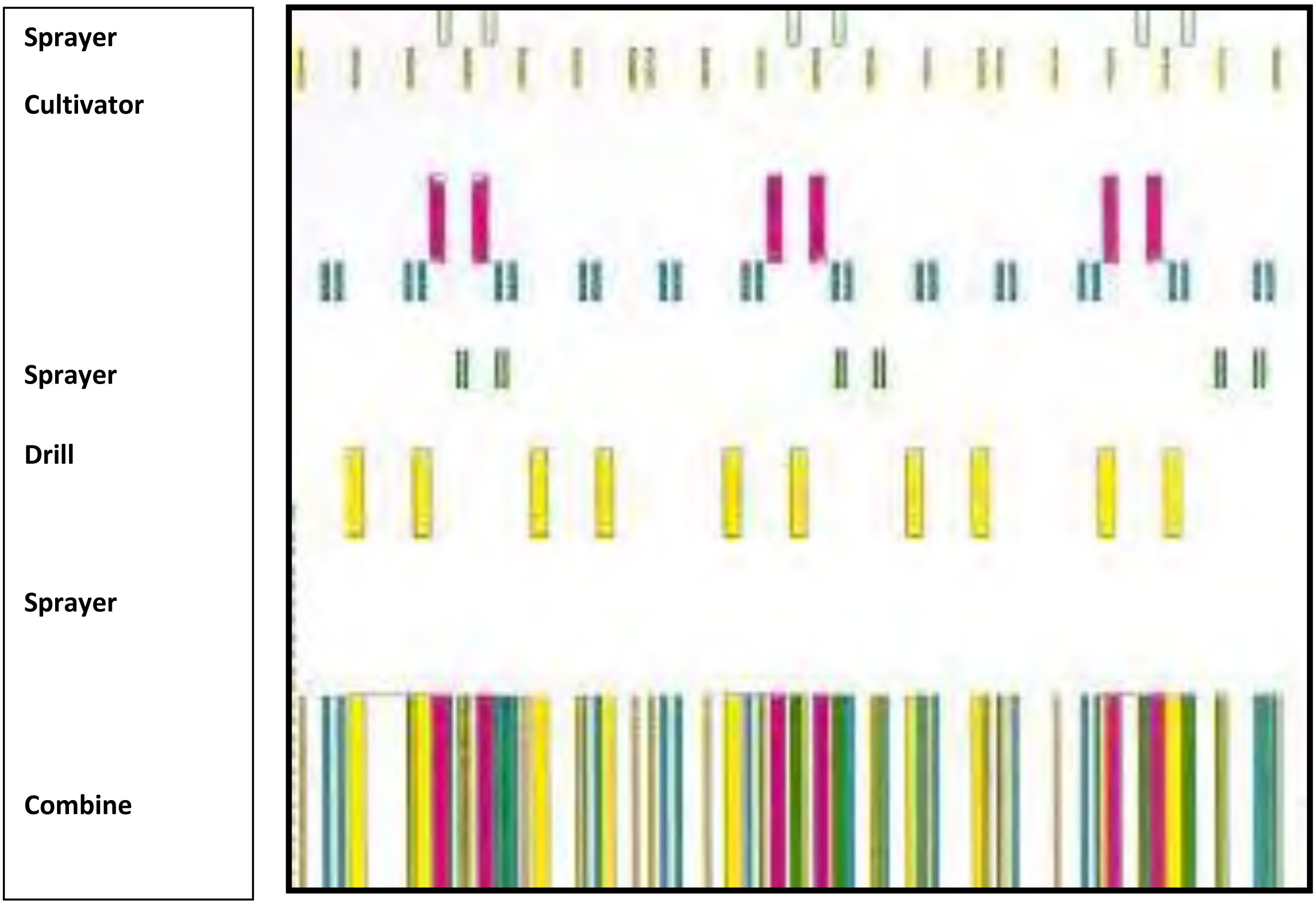
The diagram on next page supplied by Dick Godwin from Silsoe demonstrates the path taken from a pea harvester by a tractor and trailer. It was recorded from a GPS data log. It shows that no traffic

Tined subsoiler seen in Geraldtown, West Australia

control is in place, and that very heavy and repeated usage of specific areas on the field is occurring. In a situation like this, if data records were analysed at the end of each operation, in particular after harvesting, the uptake of controlled traffic farming would be dramatically increased. This type of low tine disturbance subsoiler is not available in the UK. It may be better not to crop these corners, or do remedial works after harvest.

The path taken from a pea harvester by a tractor and trailer.

Visit a stubble field after harvest and walk over the field. Depending on the combine harvester's header width, there is a wheeling (an indent left by vehicle wheels) clearly visible every three metres. A tractor has a physical width of 2.8 metres from the outside rim of one tyre to the outside rim of the other. If it is fitted with tyres 700mm wide this leaves behind a total footprint of approx 1.4 metres. Then there is the corn carting trailer or chaser bin, and the combine. If you include the baler, bale chaser, the hedge cutter and sprayer, all using wheels set at slightly different distances apart, it is not long before the ground is compacted over as much as 86% of the total area. The diagram below shows how all the different wheels fall during one harvest season. This level of compaction, which is exacerbated by wet weather, is a major reason why zero tilling has not worked in the past. The soil is not friable and therefore a quality seedbed cannot be established.



When the weight of a vehicle squashes the ground, air is squeezed out causing soil to become moulded. That is not suitable for zero tilling and will cause rooting issues (roots growing horizontally because it is easier than the vertical path).

Ploughing or cultivating temporarily alleviates the issue by moving the top 6-8" of soil. Ploughing allows air to fill the soil, carbon to be released and nitrogen to be made available. However, this type of operation damages the soil structure by soil disturbance and destroys the natural balance of the soil. When disturbed, soil immediately bulks up by 25% and settles gradually through the year. When harvest comes, it is still partly bulked up and the land is friable and frothy, so when traffic drives on the soil it compresses harder.

Land which has been in zero till for over seven years responds differently. It can handle traffic better and the water holding capacity can be up to 2.5 times greater. In times of intense rainfall, zero till land will handle water more efficiently and water erosion of nutrient rich top soil is reduced. Some zero till land on first impression appears hard on top and incapable of growing a crop, but dig down and there is a wonderful soil structure and rooting profile.

If land is kept continuously growing a crop or has residue covering the soil, the sun cannot dry the land out, meaning the top will remain friable. The residue, however, must not make a mat sealing off the soil. This can be prevented by managing the residue, types of harvest operations used, and managing weed growth.

In New Zealand, I was part of a demonstration proving the difference between soil management from Controlled Traffic Farming and conventional farming. The test is to cut a sod of soil 200mm by 200mm by 200mm from each example plot and drop it from a metre height into a bucket with a wooden board in the centre. The larger pieces can be dropped three times in an effort to break them up.

See this demonstrated in the picture on the next page.

The second picture shows the results from (a) a conventionally tilled field and (b) from a CTF field. The soil on the plastic bag shown on the right with no compaction or lumps is from the CTF field and the contents of the bucket (left) from conventional farming. This clearly demonstrates that conventional farming is damaging the soil structure.

For description of these two photographs please see previous page

At Nebraska University in USA I was shown a trial where three types of farming have been conducted for 20 years on a research farm. Seedbeds are established by means of CTF, minimum till, or plough. This picture shows soil that has been taken from each site and water has been applied. Each cup is then turned upside down and the moulds with the best water holding capacity stay formed.

It is interesting to see the different effects on soil erosion from various farming practices. The picture shows that the Controlled Traffic Farming with zero till (*see photograph below)* sample stayed in shape showing excellent water retention capacity. The opposite extreme of ploughing showed that it turned to slurry causing maximum soil erosion in simulated adverse weather conditions. It also shows that although minimum till (as described above) has great advantages, with the introduction of CTF even greater benefits can be achieved.

CTF with Zero till *Min till* *Plough*

A common mistake I have observed around the world is leaving soil bare. Some people state they do not plant cover crops so nutrients are not used up, or the weather is too hot, but surely this depends on the cover crop chosen?

One of the most impressive cover crop managements I came across was in the USA, where different cover crops were used according to the chosen following crop and any compaction issues. Randy Rick, a Nebraskan farmer, was combating the problems by using wheat, oats, barley, pea vetch, clover, lentils, soya bean, rye, turnips and tillage radish as possible cover crops.

Randy had a compaction issue from weather and traffic so he was using tillage radish, lentils and turnip as a cover crop to break the ground and remove compaction. The cover crop was sprayed off leaving a friable surface with nutrients available for the direct drilled crop. Keeping the ground continuously growing crops allows the following crop to use the root path of the previous one, so the new crop roots get to nutrients stored deeper in the soil allowing the farmer to be less dependent on spreading nutrients on the surface. The crop suffers less moisture stress in dry times because the roots are deeper. However, to utilise the root bowls of the crop, seeds must be planted adjacent to previous plants. Planting directly on top of the previous crop results in trash issues when drilling. Planting alongside avoids this problem whilst still allowing the plant to achieve the same benefits. It can be done by sight, but is not sustainable over a large area since it wholly depends on the accuracy of the human machine operator. This has now become more achievable because of the available accuracy of GPS technology.

The possible answer

Avoiding and controlling compaction is the easiest first step to zero till in Europe. As shown above, Controlled Traffic Farming is the mechanical answer to this problem while cover crops and rotation cropping offers an environmental balance.

Steps to adopting a successful CTF system:

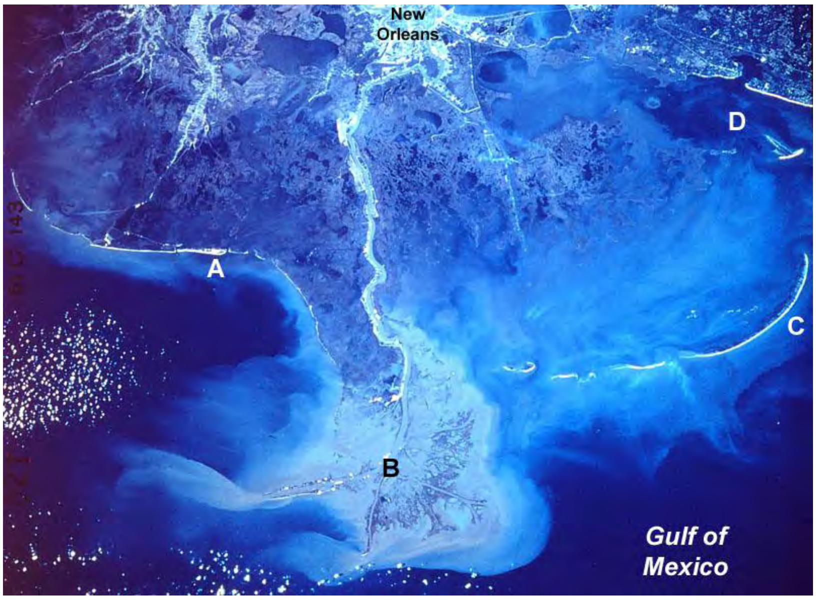
- Measure all machinery
- Establish a working width
- Map fields
- Boundaries and A B Lines recorded per field
- Tracking widths designed
- Use GPS equipment which is universal
- GPS implement steer
- Use or develop an RTK network

5. No till

No Till and Zero Till have been mentioned frequently in the previous chapter. Let us in *this* chapter concentrate in more detail on these practices.

Why do we cultivate the land every year to achieve a seedbed? What are we looking for and what do we not have when we look at a stubble field?

Travelling the world, it became quickly apparent that cultivating was a practice of the past. Reduced soil erosion from using a zero till system (growing crops from year to year without disturbing the soil through any kind of ploughing or tillage) was a huge environmental improvement. If you look at satellite images of the mouth of the Mississippi river, you can see the millions of tonnes of soil washed from the fertile fields of America.



Soil being washed from mainland USA via the Mississippi river into the delta

See overleaf for further pictures of soil being washed away.

Fertile top soil being washed into river by heavy rain and flooding

Heavy rain and flooding causing soil disruption in a river.

When I first returned to the family farm in 1999, being of an inquisitive mind I wondered why we ploughed. The justification was to bury trash, give the next crop a clean start and provide the drill with a trash free environment as well as removing surface compaction.

I asked a friend 'Why do you plough?' His reply was "We have always ploughed, my father ploughed and my grandfather ploughed". He even remarked that it was a stupid question to ask.

I personally felt that the lack of capable alternative machinery was causing this obsession for ploughing. The plough is a great all-rounder, copes well with all types of conditions, weather, soil types and high levels of trash. It seemed that manufacturers of other machinery could not come up with an appropriate replacement.

In addition, the increased amount of weed establishment when using minimum till caused reservations from many agronomists. They chose to advise farmers that the answer to heavy land weeds like blackgrass was to revert to ploughing to maintain a reduced weed environment. However, in my personal experience using minimum till compared with ploughing shows no difference in the level of blackgrass present. In fact letting the blackgrass seeds chit and then be sprayed off before planting the chosen crop has often shown a reduction.

As Falkner wrote in his book *The Plowman's Folly* (1942) '*There is nothing wrong with our soils, except our interference. It can be said with considerable truth that the use of ploughs has actually destroyed the productiveness of our soils*.'

The introduction of minimum tillage, or eco tillage, has mainly been driven by scale and an effort to reduce cost per hectare. Modern drills were coping with more trash allowing minimum tillage to take off. I saw that eastern counties farmers had been able to change their medium sized tractors to large track machines and big one-pass cultivators with all the benefits of increased speed of operations, and outputs were in line with the increased machine widths. These increases have also driven the requirement for higher horsepower which means tractors have increased from average horsepower in 1990 of 100hp to 200hp in 2010.

Higher horsepower has meant machinery weights increasing from 5 to 25 tonnes. This weight-to-power ratio is needed to put power down to the ground. Greater weight causes greater compaction and in turn makes the land more difficult to work. Therefore, from my grandfather's era when ploughing was done with horses that weighed 750 kg, to modern day equipment weighing 25 tonnes, there is a dramatic increase in pressure being exerted on the soil.

Horse powered ploughing compared with modern technology

People would argue that tyre and track technology has improved so the weight is spread over a larger area, but the weight is still pushed onto the soil. Therefore, we are in a vicious circle. We grow in scale, so we increase tractor horsepower and weight. We carry out some operations when conditions are not perfect because of weather-dictated time constraints, and because in England we have crops in the ground for 11 months so turnaround time to establish a seedbed is limited. All of these factors contribute to more compaction.

The reason 11 months crops are required is the limited availability of crop varieties necessitated by the European attitude to GM and Roundup-ready crops. It seems to me that very little R&D money is being invested in commercial agriculture and wheat production here in the UK. Whilst I was in Australia in 2010 they were trialling GM oilseed rape but this is not even on the UK horizon. The major companies are investing time, money and effort into grain maize and soya bean with a focus on the third world agricultural regions.

Attention to detail together with early adoption of chemicals and artificial fertiliser allowed my grandfather in the 1980s to be awarded the 10 tonne per hectare tie by ICI. Since then we have maintained that average across the whole farm but in my opinion the advancements we have made in the past 15 years to do not equal the groundbreaking changes my grandfather was able to achieve.

5a. Putting No Till into practice

At this point, it is important to understand the differences between traditional and more progressive options for preparing and planting a crop; the difference between using a plough, a topdown or a direct drilling. The plough cuts into the land causing lots of soil disturbance and turns the stubble over, the topdown causes surface disturbance only, with a slight mixing of stubble, and the direct drill means leaving the stubble intact and just planting seed straight onto the field.

On our Cambridgeshire arable farm, a standard crop rotation would be first wheat, second wheat, and oilseed rape. For this the cultivation regime today would be as follows.

> For first and second wheats: cultivate with a Vaderstad topdown – a minimum tillage tool – running at a 15-degree angle across the field to remove compaction, tramlines and to mix and bury trash.
>
> For oilseed rape: Either cultivate with the topdown and apply oilseed with a bio drill or direct drill.

Alternatively, some farms in the area would plough for second wheats or for all crops. In view of my investigations back in 1999, we have not ploughed since 2000. Oilseed rape would be direct drilled which is a no till operation. This was moved from a plough based seed bed to direct drilling with a Horsch drill moving 3" (7.5cm) of soil and drilling oilseed rape at 10mm with 30 kg/ha of granular nitrogen applied at the same time.

Attitudes to autumn nitrogen need to change for zero till to succeed. Nitrogen is applied as oilseed rape is sown to aid vigour and establish a strong plant able to survive winter. A healthy, strong, forward crop takes little management against slugs, flea beetle, rabbits and pigeons through the colder months. With direct drilling there is a cover of straw and trash left which absorbs the soil-held nitrogen in an attempt to break down the previous plant residue, also providing cover for slugs, and this is a harsh environment for a small seed to germinate in. This means a lack of existing nitrogen being available for the newly establishing seed, and therefore additional nitrogen needs to be supplied at planting time.

By using nitrogen in this way we have managed to get the same yield per hectare by direct drilling with a tine drill, compared to traditional operations.

Average UK Yields

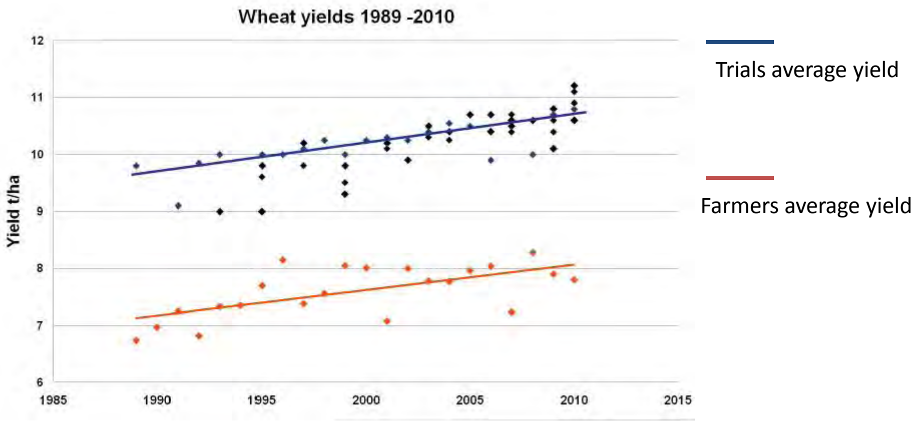


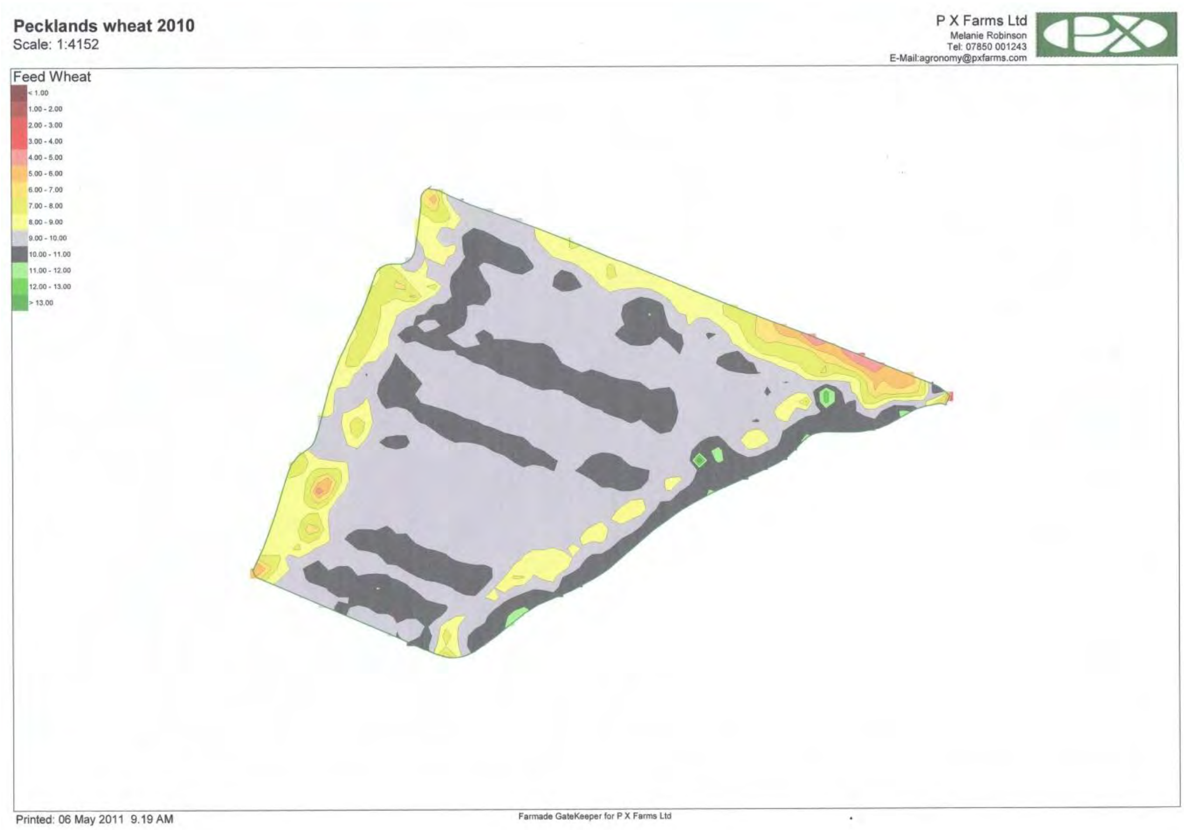
Figure 2: Average UK yields

Figure 2 shows the difference between farmers' average yields and trial recorded yields over the past 25 years. Each year as farmers we are encouraged to change seed varieties at huge costs to the business and to invest in new technology. But is the outlay justified when considering the results shown above and cost of change over a decade? I would suggest a lack of detailed information and financial analysis by farmers in their own businesses is the root of the problem.

The new advancements with GPS will make great strides to improve future decision-making. Farmers will gain easy-to-access, detailed information as well as more accuracy on the ground. Combine harvesters equipped with yield maps show the highs and lows plus the potential of fields and the variety used. Using the GPS equipment available enables farmers to use different farm trials with equipment or varieties in the same field and the equipment can measure the results to determine the worth of the experiment. (GPS is discussed in more detail in chapter 6, Precision Agriculture).

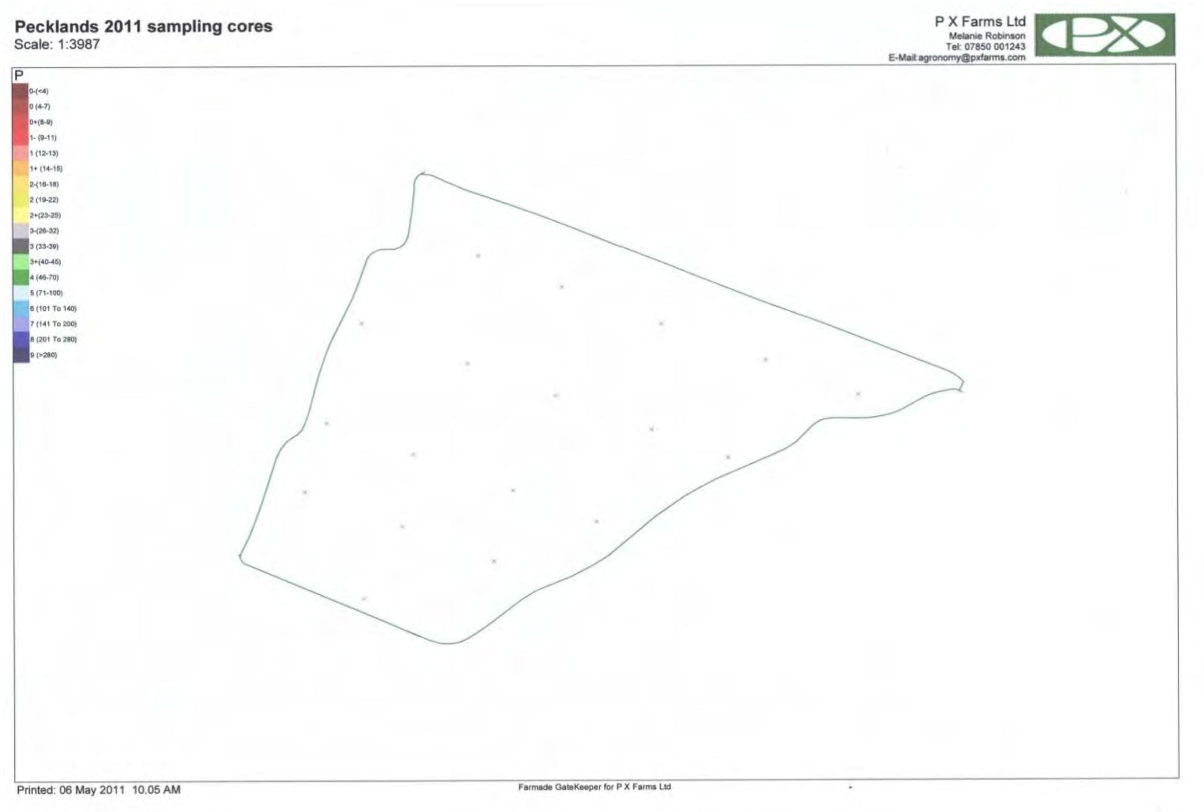
When analysing a yield map it is critical to determine all the factors that could produce varied results. For example, rabbit damage around a headland or compaction. Rabbit damage is easily identified visually and compaction can be determined by knowing the previous history of the field or using a penetrometer (a device to test soil strength).

The map on the next page is produced by our crop management software, supplied by GateKeeper, from information gathered by the combine harvester computer. It shows (excluding headlands) an even yield across the field. Parts of the outside are due to tree shading, rabbits and compaction from headland turning. Headlands are often overlooked but account for 25% of the field. This can reduce the overall yield by 0.7 tonne across the whole field area.



Also from this map, we can determine how much phosphate and potash fertiliser to apply. The higher the yield, the greater the offtake of phosphate and potash. Traditionally, farmers would spread an amount relating to yield evenly across the entire field.

GPS mapping has allowed the field to be accurately broken into hectare blocks and to have 20 core samples per one hectare taken to determine the indices. Locations of the samples can be pinpointed, shown on the Gatekeeper map below, and imported onto the GPS box in the vehicle allowing them to be physically located on the ground.

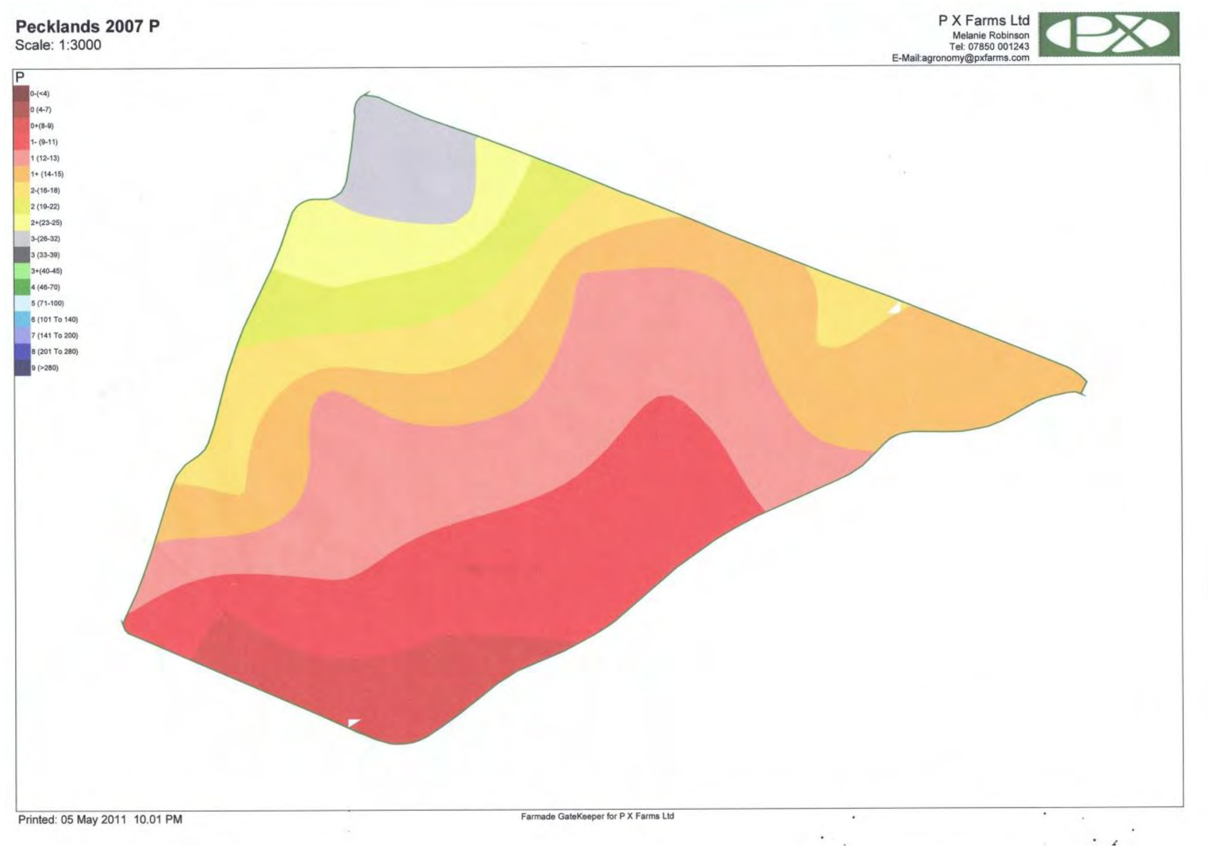


Once soil samples have been analysed by an external soil lab, the results (in parts per million) are put into Gatekeeper and variable maps produced to apply the correct amount of nutrients per hectare determined by these indices. These tests can be carried out for a variety of nutrients.

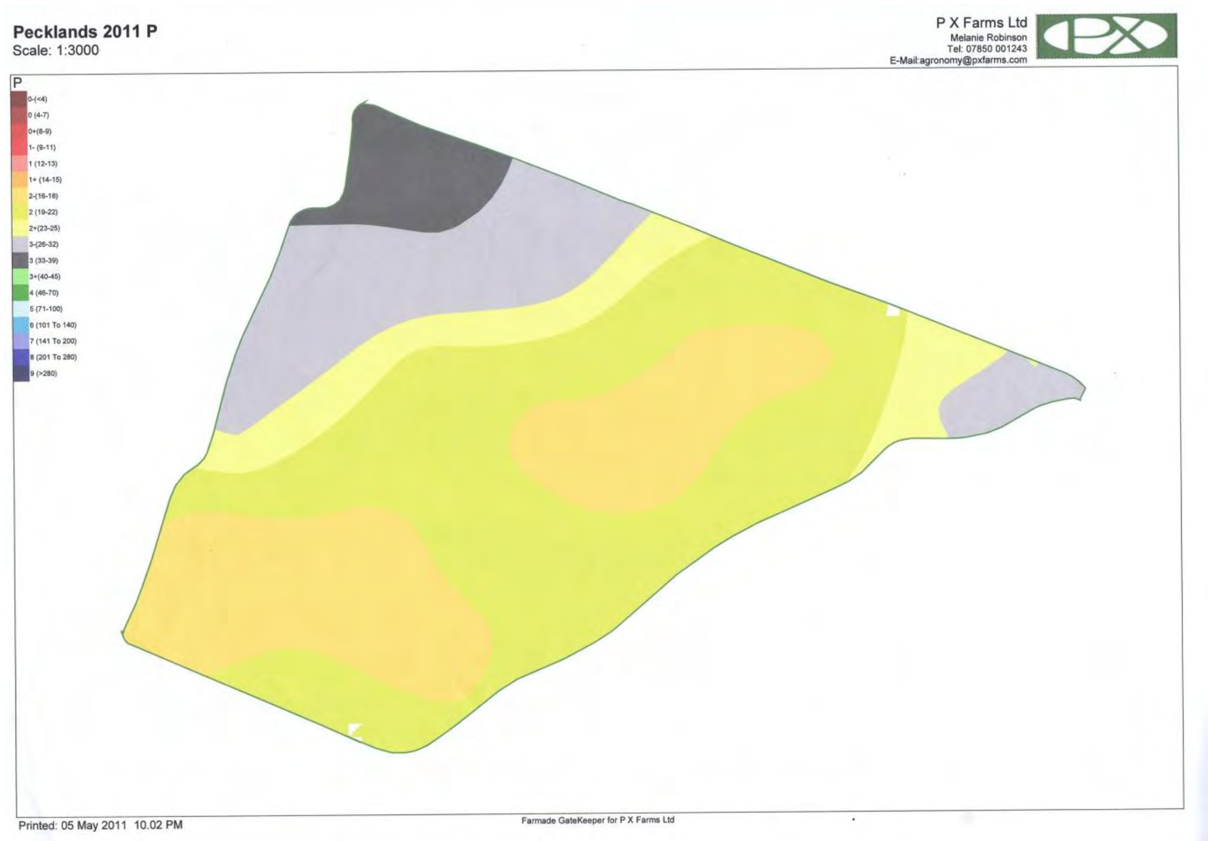
The map on the next page shows the different conditions in various areas across the Pecklands field in 2007 at Scotland Farm.

If we then look at the indices map in the lower half of the page, we can see the variation of phosphorous across the field in 2011, which shows a significant difference to the 2007 map above.

On my Nuffield travels I have learnt to take this system a stage further. This is explained on the page that follows the two maps.



The top map shows a field in 2007 and the lower map shows variations in phosphates in the same field in 2011



The maps show that applying a variable rate over the past five years has increased the phosphorous indices, but this will take more time to increase to the ideal growing environment of a 2+ average index as shown on the scale above.

The difficulty with this system for my business is that it is only a solution over a long-term. If we take on contract farming, or Farm Business Tenancy agreements and spend £80-£120 per hectare to increase phosphorous indices as described above, it does not necessarily increase yield directly in line with the areas shown on the maps. Financially contractor and landowner jointly invest in goodwill on the land, but a simple change of allegiance by the landowner means the contractor no longer farms the land and another party reaps the benefits.

Therefore, my Nuffield travels show that it is best to maintain the indices based on crop offtake and leave the land as you find it, unless the landowner is happy to invest personally to raise indices - which is a good farming practice. This is a system based on replacement rather than the increasing of nutrients and one that is often forgotten by agents and landowners when renting land out. A simple set of soil samples before and after a FBT arrangement can be used to ensure nutrients are not exported and thus deplete an initial high value. Use the combine yield map to identify nutrients that have been used to produce a given yield. This allows the area and the rate needed to replace those nutrients to be calculated and so maintain a constant soil condition. Every five years soil sampling should be repeated so that records can be kept showing that indices have not been depleted. If the landowner has chosen to invest it will produce evidence that money was well spent.

With fertiliser costs rising in general, we have seen a steep rise in our product of choice, Phosphate Triple Super Phosphate 46 (TSP). Cost has fluctuated from £180 per tonne in 2006 to £700 in 2008 and today £440. This product is a finite resource mined from the ground and applied with conventional granular spreaders. A phosphate maintenance approach can be reviewed annually on existing land and if additional farmland became available in the future, this type of logical approach to nutrient management could also be applied. This system would bring the hectare cost for phosphates back to £40 per hectare which is a reduction of £40-£80 per ha.

Areas on headlands that may have a low yield due to factors other than lack of nutrient (eg rabbits, tree shading and compaction) will not have large amounts of phosphates applied. Using the traditional scheme phosphates would be applied across the whole area in an attempt to increase yield, but would not be used up during the season due to poor crop growth. This would leave them in the soil and potentially lead to phosphate becoming locked up (if the soil pH levels are too far out of the optimum range, the plant roots may not be able to absorb and uptake nitrogen) in those areas.

Based on these observations, the investment approach I would recommend is nutrient replacement only. Use a standard diammonium phosphate (DAP) at drilling as a starter fertiliser at 44kg/ha which would give 8kg/ha of nitrogen and 20 kg/ha of phosphate. An additional autumn application will make good the base offtake calculated from the yield map. If the landowner has chosen to invest in increasing the indices, a greater amount of fertiliser would be applied at this time.

5b. Cultivations why?

When nature plants a seed it does not plough the land. European farmers do. Travelling around the world I have observed that great efforts have been made to manufacture drills able to cope with high levels of trash to establish crops. When asked why we do not develop these ideas here in the UK the automatic answer is: 'It won't work here'.

I have now seen conditions in countries around the world that local people consider as an acceptable seedbed; though to European eyes they would be viewed as a nightmare in which to establish a crop and needing endless passes of cultivations to bury the trash.

In Argentina and Australia a high trash and general covering of the ground suppresses weeds and retains moisture. The ground underneath the mat is friable (easily reduced to smaller pieces with little effort) and a perfect seedbed to aid seed establishment.

The drills I have seen around the world enable the seed to be planted through high quantities of trash. A standard tine works as a rake on narrow spacing, so the progressive Australians and Canadians have developed widened tine spacings to allow trash to flow through, rather like the Seed Hawk (shown below) now marketed in Europe as a Vaderstad machine.

I discuss drills in more detail in Chapter 7, see page 52.

Vaderstad Seed Hawk

Disc drill seen in Argentina

A large majority of Canadians is still cultivating or using a rake pass which was a surprise to me since the alternative technology is available to them, but their justification was the additional benefit of the old system for warming up the soil for germination due to their cold winters and limited drilling period.

Most countries have a long period available for harvest (due to consistent weather conditions) and do not plant in autumn but wait until spring. In Europe it gets wetter during our autumn drilling window and drier in spring but the opposite way around in the southern hemisphere, hence spring-drilled crops there. The wetter conditions here at drilling time help seed to establish but can hinder the physical drilling operation.

The USA and South America use a disc drill (*pictured on previous page)* which cuts into the land with minimal disturbance (less than a tine drill).

Dwayne Beck at the South Dakota Research Farm would advocate that a disc drill is the only drill to have since a tine drill causes compaction. The tine breaks up the soil structure because it disturbs the soil, whereas a disc drill cuts in causing very little compaction.

So my observation on why do we cultivate must be because we can afford to. European agricultural support payments have stagnated progress and advancements. Why do the countries around the world zero till? Because they have had to survive being unsubsidised by reducing costs and increasing yields.

The advantages of zero till are:

- lower long term capital investment,
- lower diesel usage
- more timely applications
- improved soil structure
- higher yields
- conserving moisture
- lower fertiliser costs
- utilising fertiliser from greater soil depths.

What issues do we need to address to conquer the objection to zero tilling?

- Compaction
- Residual chemicals

- Trash
- Fertiliser placement
- Weed management
- Soil structure
- Management
- Attitude

Therefore, with this in mind, I can see our challenge is to get away from the obsession of tilling the soil whilst addressing the issues above. The potential cost reductions are massive. They range from reduced diesel usage to lower capital expenditure and increased yields.

- **CTF on its own can achieve an 18% yield increase due simply to reducing compaction and traffic.**
- **The benefits achieved by employing No Till techniques would be on top of this 18%.**

Each year farmers go to trial sites to look at new varieties to find at most a 2% yield increase. What a waste of time! The tools are available to increase yield by 2 tonnes per hectare simply by using CTF and No Till yet we continue to buy seed hoping that all the answers are in the bag.

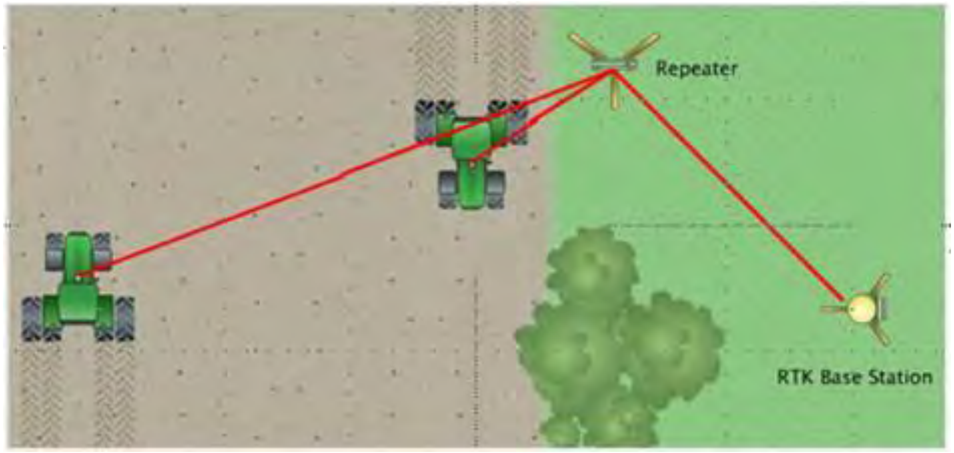
6. Precision Agriculture (PA) including spraying

Precision agriculture techniques (PA) underpin all the advances I describe in this report.

For example GPS functionality is required for a successful direct drilling system.. Residual chemicals, in particular late applications, will stay at the soil surface. This can cause a problem when direct drilling places the seed into this banding. The result can be the new crop being killed off, particularly on overlaps where there is double the residue. Overlaps occur on headland areas where the sprayer has travelled twice to make sure all the area is covered. The picture below shows where oilseed rape was direct drilled using a Seedhawk direct drill. The crop died completely on the overlaps. If this seed bed had been cultivated, the soil would have been mixed and residue from the previous crop broken down. To avoid this problem and still be able to direct drill, fitting a sprayer with GPS technology to control nozzles and automatically shut off individual ones to minimise overlap is vital.

Oilseed rape direct drilled showing seed killed off on the overlaps

The ideal solution for accuracy would be RTK. These systems use a correction signal provided by a single base station receiver and a number of mobile units installed in farm equipment. The mobile units compare their own position with the one sent from the fixed base station, which is used in conjunction with GPS signals from satellites that are constantly moving. The typical accuracy for an RTK system is 1 centimetre ± 2 parts-per-million (ppm) horizontally and 2 centimetres ± 2 ppm vertically. *See diagram below.*



A repeater can be used to improve or extend base station signal coverage (normally about 12 miles) around obstacles such as trees or rolling terrain. More than one repeater can be used with one base station, and recent developments allow them to receive a signal from each other in a daisy-chain configuration. *(Picture below is described on next page).*

The RTK systems need to have the same zero or there is the risk of being off track by 0.5 metres. The picture on previous page clearly illustrates this type of discrepancy. We downloaded the A B lines from a John Deere RTK unit into a Trimble box and it ran 0.5 metre off track but in the same heading. To simply side shift is not acceptable and only works if a previous track has been created to shift to.

I have installed a John Deere RTK network which turns out to have been the wrong decision for our situation. The system was at the time perceived to be the best, but subsequently has resulted in restricting machinery purchases mainly to John Deere's own. So at the present I do not have the freedom to purchase machinery that suits my operation and fit GPS that shares the same signal. For harvest 2011 we have hired a John Deere mobile RTK network. We fitted this to a Lexion 600. The idea was that it used the signal from the mobile network and fixed towers. This in principle was a fantastic idea where we could go anywhere and use RTK. As we operate over a large area this meant that we could get RTK signals and repeatability without investing in base stations and repeaters. The upshot has been that the mobile signal has not always been reliable to the extent that, as we have been combining, the line has changed two metres over and then returns some 4 hours later to the same line. When unloading into a chaser bin with 0.5 metre gap next to the combine header, this is somewhat dangerous.

The other problem we have had is that on a Saturday we had no signal due to the high demand on the mobile voice network and when the school holidays started this continued into the week. This is not appropriate for a harvest business operating during these times. How can this be a true RTK network with this behaviour?

The cost of putting these kits onto machinery can run from £15,000 to £45,000 per machine. When the issues of signal or system failure are reported, we are told: that is computers, they all do it and we should just accept it. Until these issues are addressed moving to a GPS Controlled Traffic Farming system has limited benefits in terms of functionality, is costly and causes disappointment. **The future lies in this technology** and early adopters bear the most cost as innovators often do.

RTK Farming is a government-funded network where you have to pay for membership to use their signal. They have used the Trimble signal and are setting up over the Cambridgeshire area. Trimble offers kits to fit most makes of machinery but they are difficult to obtain due to high demand. There are two Trimble suppliers, one in Cambridgeshire and the other in Scotland, but with the explosion in demand for systems, they were unable to supply and fit until after the season. Even purchasing equipment already fitted to machinery from branded dealers appears to suffer from lack of training on how the system works. The Trimble agent is not compelled to provide support since the equipment has passed through a reseller leaving the user without adequate help. In addition second hand GPS equipment is also difficult to sell and under-valued.

A more professional approach and structure is needed for the future. Similar to the mobile phone network and high street shops expansion, as the demand for technology grows management will reach unmanageable levels unless properly structured. Imagine if every tractor had a new system fitted and each operator called every few days to ask how to do something? Even with manufacturer training, suppliers would be unable to meet demand. Until GPS systems become like mobile phones, where people can adapt to the technology without instruction, I see the next five years being very difficult for suppliers in the UK.

6a. Implement Tracking

Whilst in the USA I saw a demonstration of an implement being independently steered. As well as the tractor using GPS, a second GPS positioning dome was mounted on the centre of the implement to adjust its path directly in line with the tractor. The implement was steered by large diameter discs on the rear as shown in the photograph below. This technique has since been commercially launched by Trimble as an aftermarket attachment to trailed implements.

Implement being independently steered by GPS

Passive steering launched by John Deere moves the tractor to get the implement in place. This works well out of a controlled traffic system and on sloping ground.

Side shift frame in New Zealand

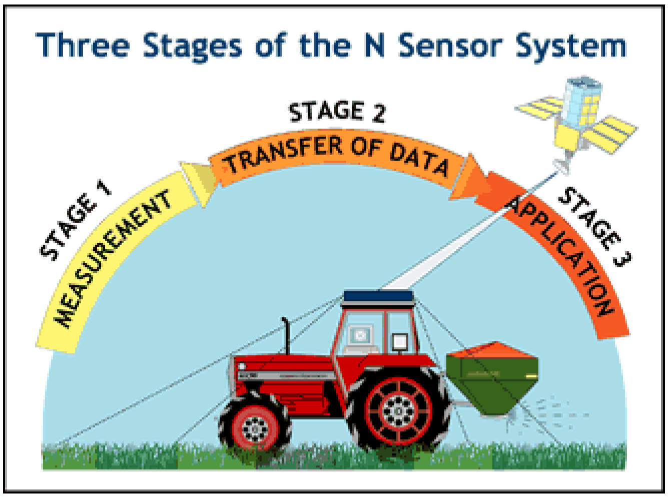
To mount implements on three-point linkage I came across a side shift frame in New Zealand. It works rather like a forklift. It moves the mounted implement side to side on the hydraulic operated frame. *See picture above.*

The new 12 metre drill we are currently looking at purchasing will be steered by the axles on the seed cart rather like an articulated, rear-steer bus.

Picture taken in New Zealand of a mechanical hoe.

6b. Spray management and application of effective chemicals

The sprayer shown above seen in NSW at David Brownhill's farm has two lines of nozzles and two tanks as shown on the previous page. The first line of nozzles have the weed seeker fitted which turns the sprayer nozzle on and off each time it sees a plant. This can result in a reduction of 80% of chemical used across a field. The second line can be spraying a pre emergence chemical while the first line applies Roundup. The Australians primarily use this system for spraying seed beds with Roundup. I can see this working in the UK on the same basis but also applying herbicides.



With technology like the Yara UK N Sensor shown above or the Trimble Green Seeker, it is possible to determine a crop's density by measuring the crop's light reflectance as the tractor passes over. As the sprayer passes over a crop of wheat there will be areas of blackgrass. These areas will show a high density due to the two different plants competing for the space. If the second nozzle sprays

75% of a recommended total dose and the second nozzle only switches on in these areas then the blackgrass gets a double dose. The overall effect is the blackgrass gets focused attention, hopefully dies and avoids resistance, while the overall chemical allocation for the field is not over the guidelines.

To avoid weeds growing in the tramlines a simple nozzle fitted behind the wheel *(as shown below*) to spray Roundup as the sprayer passes through the field with a small tank will solve this problem.

Simple nozzle fitted behind the wheel

Swathing is a system which cuts the crop stems, but then allows the cut crop to fall back onto long stubble and remains with all stems orientated in the same direction. The crop is then left to cure and the time to harvest is reduced by this cutting of the plant stems. This is not widely practised in the UK due to combine harvester header improvements but remains in wide scale use in Australia. The swathing machine can trail a sprayer as shown below to spray Roundup onto weeds at soil level under the canopy of lying crop. Nozzles are fitted along the header to spray before the swath is placed on the ground.

Swathing machine trailing a sprayer

Trevor Postlewaite had built a weed wiper to fit a sprayer boom. This was simply a climbing rope which works as a wick. You charge the rope with Roundup from the sprayer tank until it becomes wet and glistens in the sunlight. If you over charge the wick it starts to drip which kills the crop. This is shown in the picture on next page.

With technology allowing auto boom height, I can see weed wipers in the future fitted to booms that will apply Roundup when the weed is above the crop. For example, when blackgrass is above the wheat by at least 5 cm this would be an ideal time to kill the plant before it spreads viable seeds or the combine spreads it. The sensors would have to be very responsive to avoid crop destruction.

Rope charged with Roundup and used as a weed wiper

7. Drills

Under a No Till system the machine to which the most thought needs to be given is the seed drill.

Traditional seeding in the UK takes place at 4” apart (on 4” rows). To be able to reduce the number of passes or to adapt minimum till with tine seeders, the spacing has to be increased to 8” or wider. The tine works as a rake. The wider the coulters or greater the distance between the tines in both directions, the more it allows the residue to travel freely through the drill. The disc drill also needs space and a separate disc in front of the disc coulter to be able to cut through the residue and part it before seed placement.

Coulter pressure is an important factor and is dependent on surface compaction and soil type. If there is a mat of residue it will cause a rake effect through the seeders and hair pinning[1] when using a disc drill. The management of controlled traffic farming, zero tilling or reduced cultivations starts at harvest.

There is no doubt that the ultimate solution to seeding in no till systems in the long term is the disc drill. The difficulty is getting the conditions right for seeding. Due to compaction from traffic and current structure of our land, I believe that the tine drill is the correct approach initially. Moving forward over the next seven years, once the basics are in place and land is more structured, the disc drill can be introduced. That appears to be the essential solution in the longer term.

The nature of the tine is to remove compaction and penetrate through the soil. The disadvantage is the tine corrects compaction through heaving (like the action of a pitchfork) of the soil. I have been working with Michael Horsch, Director of Horsch Maschinen GmbH, since I believe to rectify this issue we need to develop a tine that is rather like a narrow knife. The aim is a tine that runs at 150mm. Ideally it would be narrow, eg 12mm with a flange each side on the bottom. This will cut through land without huge soil disturbance and will remove compaction and create a good root zone. Any vertical smearing of clay will, in time, dry and crack but the land is not compacted horizontally.

[1] Hair pinning is the term used when the crop residue is not effectively cut but instead folds under the pushing force of the disc blade into the furrow created. Hairpinning results in seeds being placed in close contact with the residue and in poorly closed furrows. This exposes seed to a high risk of phytotoxicity and drying of the seed zone.

The closest I have seen to this approach was in the USA where anhydrous ammonia was being applied to the soil on Jim Kinsella's land. We need to put nitrogen and phosphate in a DAP or MAP format at the bottom of the tine point and the seed placed above.

In Western Australia, I saw seeders that worked on a similar basis and one is illustrated on the next page. This drill in Western Australia is called an Ausseeder and has a knife blade tine at the front with a liquid fertiliser pipe behind. The seed is placed, the following tine seals the groove up and a granular fertiliser pipe follows.

The Ausseeder in Western Australia

I have spent a lot of time looking at row spacing and its effect when adopting no till cultivations. The ideal would be a direct drill with narrow spacings, but as discussed already, existing technology means tine drills with wider spacing to enable trash flow. Moving to wider spacing than the current UK standard of 4" may lead to reduced yield. For example, wheat yields reduce by 100kg per ha for every inch the spacing is wider than 4". Acceptance of a lower yield may be necessary during conversion to no till. This is another goal in our own seven year plan of moving from tine to disc drilling: a disc drill can operate efficiently at narrower spacing than a tine drill, but not quite as narrow as 4" in the current format. In drier climates the crop has to be spaced wider to survive with limited moisture. I have seen maize spaced 1.2 metres apart. In South Africa as I drove down a long highway I could clearly see that the maize spacing got wider the further away from the coast I travelled.

Trials have shown no yield decrease on wide spacings in OSR. in fact it has a positive effect as the plant bushes out to cover the extra area available and sunlight can penetrate the canopy, but still close enough for the crop to have a competitive edge over weeds. Agronomists are nervous of wider spacings as it gives less weed competition from the crop but on balance it does give chemicals greater contact.

In Australia I saw crops on wider rows to enable a cover sprayer (*see photograph below*) to operate between rows of combinable crops. This allows Roundup (broad-spectrum herbicide with the active ingredient glyphosate) to be used to reduce the herbicide cost. With RTK or GPS it could be sprayed accurately allowing a commercial crop to have a reduction in herbicide use. A second tank and nozzles would be fitted so specific herbicide could be sprayed outside the banded sprayer path. This greatly reduces the amount of chemical used due to the area having been dramatically reduced and only applying above the crop. This has a positive benefit for the environment.

A cover sprayer able to operate between rows of combinable crops

Having rows wider apart enables a second crop to be planted between the rows without the trouble of trash. On alternate years, an additional tine may be needed on one side, as the drill will be offset to run down between the previous crop. A low cost approach would be to offset the hitch by 4" so that the tractor stays in the same path but passive steering is not needed because the drill runs to one side.

8. Weed management

Weed management is a concern for any farmer. In the UK ploughing has long been the automatic choice for many as their first step to control weeds because they have convinced themselves that it is the only effective method. Other cultivation methods produce clods where weed seeds hide and appear long after the crop has been drilled. Over the past 15 years a growing number of farmers has accepted that establishing a seedbed and waiting for the weeds to chit before spraying with Roundup is a successful practice, particularly in combating blackgrass in the eastern countries with a min till approach.

Reducing the seed bank or not disturbing the soil has been the focus in Australia. Ryegrass is to the Australians what blackgrass is to an eastern counties farmer in the UK. (Blackgrass is a weed that affects cereal yield, and also suffers from ergot fungus (*Claviceps purpurea*)which can result in grain contamination at harvest and rejection by merchants).

The rear of modern combines has choppers which straw passes through. Rotating and static knifes leave straw cut to lengths of 2 inches and smaller. This is then spread out of the rear of the combine to the width of the header. Chaff spreaders take chaff from the sieves and spread it over a similar width but in practice this width is often greatly reduced as these particles are mostly light and prone to wind. The chaff often contains weed seeds which are not wanted back on the field.

Chaff spreaders are considered to be responsible for spreading 96% of the ryegrass seeds which are such a problem in Australia. Spreading across the full width of the header, the spreader sends the seeds right across the whole field. The problem becomes progressively worse over the years. Often a small focus of weed infestation in one part of the field will spread across the rest and even into neighbouring fields.

One Australian method that I did not like was the chaff cart. Chaff is blown from the combine to a chaff cart and when the cart is full it drops the contents in a pile waiting to be burnt three months later. Whilst I stood and watched this process, a wind came along, blowing chaff out of the piles. Other people have invented a machine to collect these piles and take to a central burning site.

Mark Wandel, a farmer in Western Australia, had adapted his combine to place the chaff down behind his wheel on the combine as shown in the photo below. He was working on a 9 metre CTF system. The line laid with trash did not grow a crop but ryegrass flourished. Mark referred to this strip as a sacrifice strip. Over the course of the year he would use a shield on his sprayer to spray Roundup along this line.

Chaff cart in operation also showing piles left on previous runs to the right of the machine

Concentrating the chaff in one place allows selective control and as a consequence the weed seed numbers begin to reduce. The strip, which is a tramline wheeling, can be challenging for the spray operator when wet as you only have traction on one side.

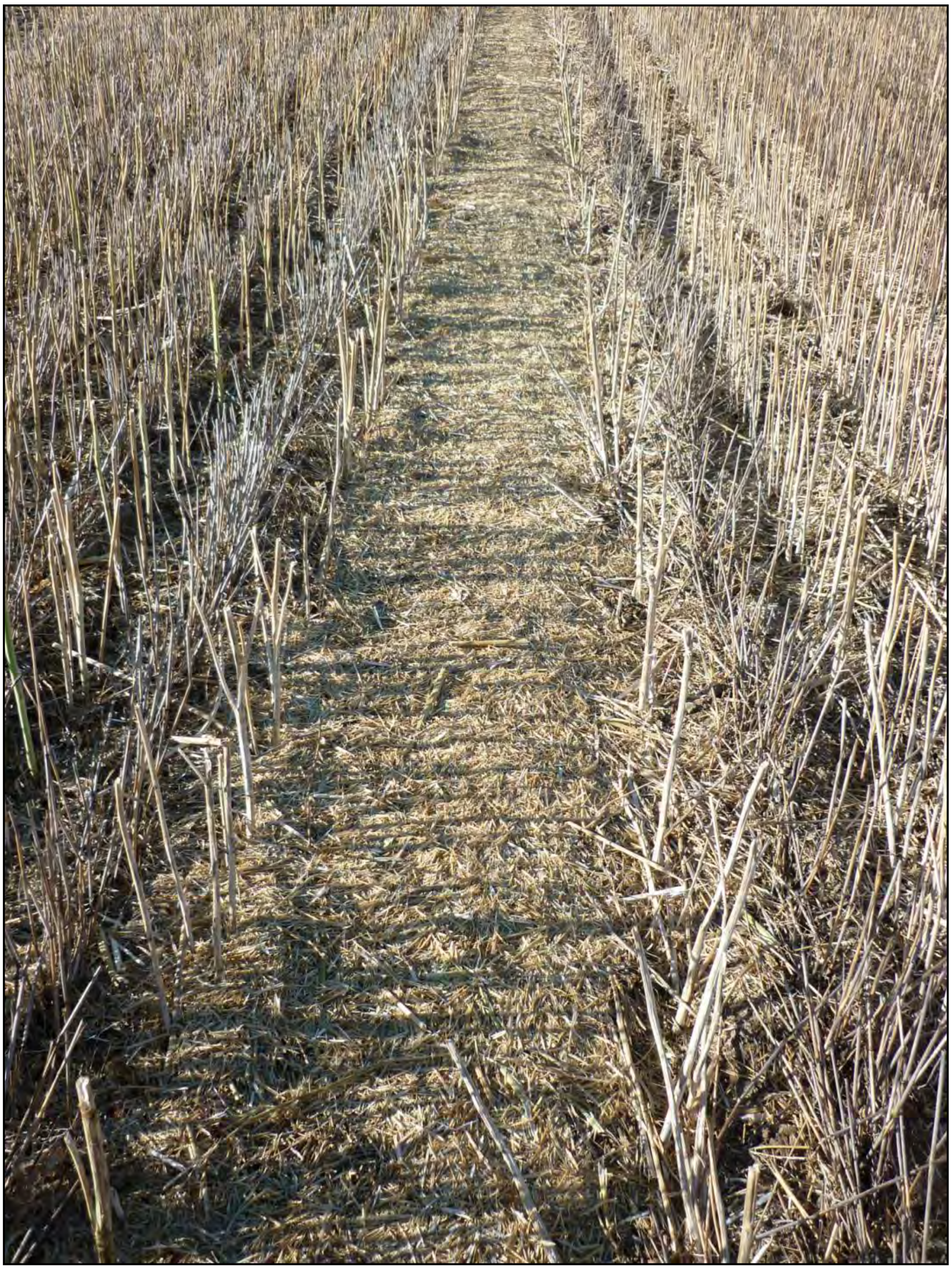
This line of chaff up the field is referred to as the sacrifice strip. This area stays un-seeded throughout the growing season. Weed seeds like ryegrass will grow in the area and it is important to control these with non-selective herbicides as, untreated, these will flourish and would be spread through the combine in the following year. This approach is reliant both on the accuracy provided by the RTK network and that the areas are controlled. Looking at Mark's crops it was obvious to see the high standards and attention to detail with which he approached weed management.

During harvest 2011 I spent time looking at chaff spreaders and their role in Australia. Baling chaff using the conventional approach leaves a 4 ft line up the field where the weed seeds are spread in a concentrated area directly onto the good tilth. This is shown in the photograph on next page.

Advances in technology mean that the modern chaff spreader at least tries to spread the weed seeds over a larger area.

Chaff cyclone to spread weed seeds in a concentrated area directly onto the good tilth

The photo on next page shows the sacrifice strip just before harvesting barley. The green line shows the ryegrass is determined to grow. Mark was swathing barley to avoid the heads dropping off.



Sacrifice strip just before harvesting barley

Sacrifice strip in barley crop

I went to visit another Western Australia farmer who had taken weed management and chaff placement a stage further. His observation was: why place chaff if you can destroy it?

Ray Harrington in Western Australia produced an interesting machine with great promise. The idea came from a machine used in the mining industry which has rollers inside which can crush rocks. He has converted it to disintegrate ryegrass seeds into dust. The machine is towed on the back of the combine with a separate power unit.

The chaff spreadings are piped into the machine and then pass into the mills. The straw is passed on to a rubber belt and spread out the back.

He had also built a machine with a rotary straw chopper attached. On enquiring about the machine I had reservations - until I saw it in operation. Ray took me out in the crop where I saw a low population of ryegrass plants in the standing crop. I stood on the back of the destructor and he took a panel off the pipe from the chaff spreaders. As he combined the pipe began to fill with ryegrass seeds. I grabbed handfuls out of the pipework. Without any doubt it came out the back as dust sprayed into the atmosphere. Not a single seed survived this process. With modern combines having such high horsepower capability, I see that it would be possible to integrate this type of equipment onto the combine itself.

Ray Harrington's seed destructor in Western Australia

Looking at the weed seeds that our own chaff spreaders spread, I would be very pleased to see this attachment on combines in the future. For non baling systems, if horse power was not a limiting factor, then the straw could also pass through this mill.

Another way to export the weeds from your land with the benefit of an income attached is to bale the straw and chaff together.

Baler fitted to the back of the combine in Western Australia

The Shields family in Western Australia has invented a baler to fit on the back of the combine. It bales both straw and chaff into Hesston (large rectangular) bales. Collecting straw from the back of the baler rather than the floor increased the straw weight by 23%. The horse power requirement to tow and bale is 100 hp. The straw cropper requirement on most combines uses 100 hp- so there would be no net extra hp requirement if using the Shields' invention. This method not only reduces compaction and capital cost by not using a tractor, but also bales the straw as you combine so no loss of timeliness. Two concerns need addressing if using this system. Firstly the connections between baler and combine need to be properly sealed so weed seeds do not fall out. Secondly, when the bale hits the floor and is collected, seeds can fall out producing patches of ryegrass.

Considering what chaff spreaders do in spreading weed seeds, this was a clever approach; working towards alleviating the problem and also generating an extra income (with 20+% gain in volume of straw collected).

I believe this system needs to be tried in the UK. In this 2011 UK harvest, we ourselves have had some straw baled for the first time behind combines. The Claas Lexion 480 produced 3 Hesston bales per acre and the Claas Lexion 600 produces 1 bale per acre both on oilseed rape straw. This difference is due to the 600 combine destroying the straw and the swath then lies on the ground and the baler can only collect a percentage whereas behind the 480 it left it on top of the straw. If a baler is towed this would mean an additional £4.50 per acre income just by collecting wasted straw caused by machinery constraints on a conventional system.

9. Environmental measures

As stated at the beginning of my report when I was outlining the background to arable farming as of 2011, the current payment for land kept out of production is a deterrent to any larger acreage farmer in the eastern counties. Any move by Defra to make set aside compulsory is unattractive to farmers in general.

This is not to say that farmers are against protection of the environment – far from it. But there are better methods available which could benefit all environmental organisations and deliver real benefits – not just a half-hearted attempt - to the countryside and overall environment.

If Controlled Traffic Farming and No Till were adopted, water logging, run off and soil leaching would all be much improved and no payments need be made to farmers.

The benefits to the land and soil would make it both possible and more economic for more spring grain to be grown. This would leave stubbles untouched through the winter period and so satisfy the demands of the RSPB.

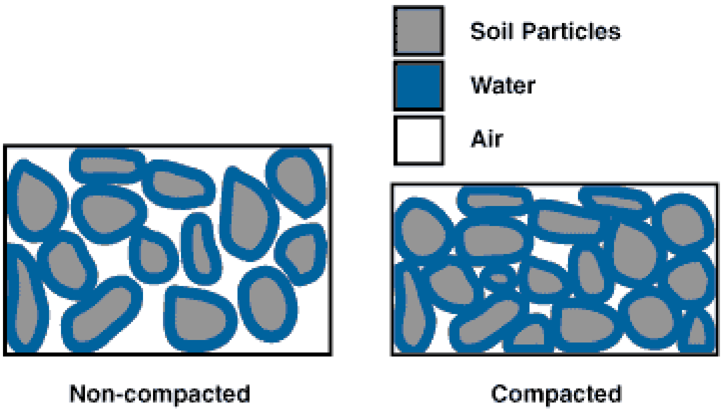
I have spelt out the benefits of these techniques in previous chapters so I will not repeat them again here.

As discussed in the next chapter, if subsidies were to be removed there would be many areas of land left unfarmed because such a regime cultivations would be unprofitable. This would be a benefit to wild life and the environment.

10. Discussion

10a. Misconception of CTF

It is important to realise that control traffic farming is not zero till. CTF is a system that can work with cultivation methods that range from ploughing to zero tilling. I believe the rate of CTF uptake over the next decade will be staggering. CTF is the first stage in combating compaction, improving soil conditions and so improving yields. The diagram below showing compacted and non-compacted soils



Once seedbeds have regained a non-compacted structure under a CTF system , the increased rate of adoption to no till will be at a similar rate to what it was during the stubble burning era. Conversion to direct drilling dropped off rapidly once stubble burning was banned in June 1993, when available machinery used was not suited to direct drilling into trash. The necessity to remove crop residues using a different method rather than burning resulted in farmers resorting back to ploughing to overcome the major hurdles of trash and weed management.

It is also important to have a rotation to suit practice, not a practice to suit the rotation. With the increase in available horsepower and traction, compaction which had become an issue due to random driving was being addressed on a yearly or rotational basis, but the fundamental cause was not addressed. CTF adoption will tackle this issue.

10b. Crop choice working with cultivations

Diverse rotation will be a challenge as the cropping in the UK, especially the eastern counties, is perceived to be limited. Consider having highly profitable wheat in the rotation only once every seventh year. We would need to consider growing or adapting crops for our conditions and for new markets to become established. This was the message that Dwayne Beck at South Dakota Research Farm USA drummed into me. To seed with no till after OSR (oilseed rape) or beans is not taxing due to the lack of trash and available soil contact. However, drilling after a first wheat is more challenging and almost impossible when wet due to the high volumes of trash.

To adopt a rotation of wheat and oilseed rape only is not sustainable long term due to disease pressures. Signs of verticillium wilt are already increasing at an alarming rate around the country and this is believed to be due to close rotations. Beautiful potato growing land in the East Anglian fens where rotations were narrowed from a minimum of six years to every four years for profitability reasons (due to cereal crops prices then being at an all time low) is already showing signs of land becoming potato sick and yields dropping off. With wide spacing on the drill, sowing an OSR crop after wheat in dry times is easily achievable. As the structure of land improves due to controlling compaction through removing cultivations, traffic and better roots structure, crop rotations become easier to manage.

10c. Subsidies

The most difficult justification I was asked to make during my trips was: why are farmers in Europe subsidised? Any payments made are swallowed up by machinery manufacturers, higher variable costs and increased land rents. Why is it possible for that same tractor to be sold outside of a subsidised agriculture for 35% less?

How many businesses survive on the payments and could not make a profit without them due to uncontrolled overheads? The industry is stifled by these payments, they encourage little innovation and farms are not driving forward but carry on being inefficient. Scale will be hampered whilst they exist. Europe is pursuing capping the payments to benefit smaller farms, which would further hinder the expansion of farming businesses, and encourage inefficiency by maintaining unsustainable small sized farms. **The level of innovation around the world where there is no subsidy is staggering.** This British quote is true: 'Why do you plough? Because we can'. This reflects the attitude.

If the question is ever broached 'could we survive without payments?' people become excited. I see no basis for this because the positive effects of stopping payments have already been demonstrated in a similar agricultural area. In New Zealand payments ceased completely in 1984. As a result young people have been encouraged to go into agriculture, innovation has flourished and land values are higher than in the UK. This directly contradicts many concerns of European farmers. When you travel around the world and see acres of ground not being cropped or grazed, it is interesting to learn that the reason is simply that it is not viable for profitable agriculture.

How many fields in Europe do you see out of production? If there was no payment, this would change and the environmental pressure groups would have these unprofitable areas for wildlife habitats for free. How many farmers want to continue filling in subsidy forms for payments that do not arrive on time? But farmers feel they have to or they will only disadvantage themselves. I am proud to say that in all my contracting agreements the landowner keeps the payment as the first part of his rent and I farm without direct subsidy. I could write a Nuffield on Subsidy and its stifling effects but I would be at risk of being hung from an oak tree! My comments above are only because I felt compelled to prompt people to question in their own minds: why?

For people who read this and say: what a ridiculous idea, that is fine. But take the payment out of your accounts and if that leaves a deficit ask yourself : do I have the right to farm? Is the problem lack of scale or the size of the overheads? What is my cost of production? When I have voiced this before, people reply by saying “Go farm where there is no subsidy if it bothers you”. My point is: what is wrong with wanting to farm here in the UK whilst trying to make my business and the farming industry as a whole stronger?

10d. Collaboration between manufacturers

Regarding my discoveries in the areas of Controlled Traffic Farming and the development from standard cultivations to zero till, Europe needs manufacturers to work together to stop producing machinery that is marketed as having such and such a working width when it is actually 5% smaller. How long as an industry will we allow manufacturers to advertise and sell machinery that is not technically accurate and therefore not fit for the purpose for which it was bought?

What I observed around the world is that the skills that have benefited agriculture in the past are now partly to blame for our difficulty in moving forward. A farmer’s ability to adapt, use innovative ideas for problem solving and to physically fabricate parts or machines required has meant that while local benefits have been achieved, external providers such as machinery manufacturers and high technology developers have continued to provide a format that does not necessarily have the answers.

Rather like the mobile phone network and handsets, we need the GPS systems to become non-proprietary so farmers have the freedom to buy the best system that suits their specific application and to be able easily to lease the signal for RTK nationwide. Imagine if the World Wide Web could only be accessed by one specific make of computer? This locking of networks and different signals is driven by pure greed and fear of fair competition. Manufacturers run the risk of driving farmers away from them due to their reluctance to work with others to provide maximum flexibility. Unless any contractor you use has the same system as yourself, it disadvantages both of you and your whole farming system.

GPS field mapping will have to take place. It is the basis for all the new techniques I have outlined. The direction of A B lines should be carefully planned to reduce the number of turns so running at maximum efficiency. Remember, reducing the number of headlands will increase overall yield and reduce compaction.

Controlled traffic farming has the potential to deliver a 50% decrease in fuel use and an 18% increase in yield. To move to a zero till farming takes seven years to show full benefit as the structure of the land gradually improves.

The demand on management in a controlled traffic farming regime is greater and provides an excellent opportunity for the younger person wanting to make their mark in a business to push forward. The skill set of the traditional farm advisor and agronomist will also have to change accordingly.

I can demonstrate that the plough is not a solution but an antiquated action. We have taken on farms which were on a plough based regime and the level of blackgrass was extraordinary. Weed management is about timing and reducing the weed population. We have successfully reduced this burden on a min till system.

However, the farmer will not make the transition until manufacturers produce machinery that makes it possible, including the requirement that it can travel down European roads. Inventors who design machinery and develop techniques for manufacturers to put into production ultimately shape the industry.

We carried out a trial last year on direct drilling versus conventional farming on a second wheat crop. We cultivated one half of the field with a Horsch Terrano tine cultivator and then used a Rexius twinpress. We then drilled this part of the field with a Vaderstad Rapid conventional drill and Cambridge rolled. On the same day we direct drilled the other side using a Vaderstad Seek Hawk tine drill and rolled in the same way.

The map below illustrates lower yield on the headland and where additional turning took place in the corners, but very similar yield results inside the field. Before we all rush out and buy direct drills though, we need to continue with trials and consider other factors raised in this report.

10e. The next ten years

Over the next ten years we will see the industry evolve greatly from where agriculture is today, with revolutionary technology making the greatest headway. The last 10 years were focused on tractor numbers and size of machinery, but the next decade will be on where they drive and how many passes are required. This in turn will see the HP burden on many businesses decrease. The farm employees of the future will have to be a new breed with more focus on technological ability which, in turn, will create greater opportunities within the industry.

10f. Plant population to combat nutrient and weed control

Plants per square metre and seed rate control by variable application need to be managed for low and high nutrients, soil variability and weed competition. Using GPS control and pre mapped fields, the application of variable costs can be monitored and applied with precision. Further investigation is needed to look at the link between compaction, nutrients and blackgrass.

We have started to monitor conditions at Scotland Farm where we believe low or unavailable phosphate, combined with compacted and wet areas, result in blackgrass. This seems to stem from compaction, where weed seeds are trapped in clods and then released later in the year.

Compaction is consistently more of a problem in wet areas. The low and unavailable nutrients means the weed has little competition. Controlled Traffic Farming, nutrient placement and variable seed rates used together can combat this problem. The CTF removes compaction and the soil becomes friable and less prone to forming clods, so weeds become controlled by a sterile seed bed approach. Using variable seed rates allows an increase of plants per square metre giving the weed increased competition.

We will continue the trial but I would like to see official industry trials on this topic and would recommend other farmers to urge HGCA to take up this type of investigation for the benefit of all.

10g. GPS Technology break down

The big drawback of these high technology systems is being too dependent on them. When the system fails and possibly the weather is against you, what will you do? What is your fallback plan and how will that affect your overall farming system? As employees become reliant on these systems will the staff, particularly the younger generation, have the basic skills and ability to operate without?

10h. To Summarise : Reasons to look into change (ie the benefits):

- Positive environmental impact
- Reduction in erosion
- Reduction in capital expenditure
- Lower cost of production
- Reduction on world resources, fertiliser and fuel.
- Increased gross margin
- Weed control

continued on next page

10i. Changes of attitude required from:

- Machinery manufacturers
- Agronomy
- Management
- Government bodies
- Pressure groups
- Fertiliser and nutrient timing and application
- GPS Headland turn management
- Scale

10j. Message to industry

- Market and supplier required for GPS second hand equipment
- Agronomists should be linked to mapping services

11. Summary of Conclusions and Recommendations

- The adoption of Controlled Traffic Farming will increase rapidly and will be the principal driver of improved techniques and profit in arable farming in the next decade.
- Technical advance in arable farming over the next decade will come largely from mechanical developments, not seed breeding. The last 10 years were focussed on tractor numbers and size of machinery, but the next decade will be on where they drive and how many passes are required.
- Farmers wishing to benefit from CTF need first of all to GPS-map their fields.
- CTF works regardless of whether cultivation is No Till, Min Till or conventional
- Yield increase due to adoption of CTF can be up to 18%, plus a 50% decrease in fuel usage.
- CTF compacts only 18% of the area of a field, whereas conventional equipment can compact 140% of the area.
- Endless attention needs to be given to selecting machinery of the correct width to suit your chosen CTF system. That system must be a 6, 9 or 12 metre one.
- The demand on management in a CTF system is greater and provides excellent opportunities for the highly trained young person to make his/her mark in a business. Farm advisors and agronomists will similarly need to up their skills.
- Converting to No Till takes careful management – and, usually, extra nitrogen in the first 2-3 years. It take 7 years to develop full benefit.
- When converting to No Till, drilling may have to be at a wider interval than the customary 4" for wheat, to enable trash clearance. This will reduce yield somewhat.
- In other parts of the world great efforts have been put into manufacturing seed drills able to cope with high levels of trash in the seedbed.
- Disc drills can operate effectively at narrower spacing than a tine drill so should be considered for grain. OSR yields are not affected by wider drill spacing.
- If the farmer is not prepared to give huge attention to detail he's better off sticking to plough and cultivator.
- Subsidies should be removed
- A positive approach to weed control will reduce the burden. CFT allows for non-selective chemicals to be used.

12. A Nuffield Farming Scholarship is an ongoing adventure …….

My Nuffield Scholarship has been one of my greatest achievements. I thank everyone who has helped me reach my goal and particularly the generous sponsorship from the John Oldacre Foundation. Over the past 15 months I and the company have matured with significant developments in the scope of the business. During my Nuffield year we have expanded with an additional lorry in contract and negotiated a venture contract farming agreement on an additional 1,550 acres. I have purchased my first piece of land after being convinced on my tour that ownership of land was key. We are constantly experimenting with, and developing, the ideas and techniques I brought home with me from my study tour.

We made an initial exploration into renewable technology when we developed and constructed a 50 kW solar system, the first commercial tracker system in the country, the inspiration for which came from the Contemporary Scholars Conference in Pennsylvania. My latest project is working with local company Z Tech to design and produce the first fully automatic grain dryer saving PX Farms an estimated £40,000 a year. (See Appendix 2)

Travelling around the world has encouraged me to question why we do things a certain way and what the alternatives are. I am learning to take the blinkers off and discovering that the Scholarship is only the start to my journey. A couple of us have already planned to travel in December to Brazil since, due to time constraints, we didn't get the chance during the scholarship period. Wider opportunities have also presented themselves and I have been asked to return to Canada in January 2012 to talk at the FarmTech conference on UK arable farming as well as giving several local talks about my Nuffield adventures.

In my personal life, the level of support I received whilst travelling the globe was paramount to the success of my Nuffield Adventure. Away from the day-to-day excitement it gave me time to reflect and focus. The maturity during this time brought me to a decision to which I had been avoiding for many a year. On June 4th which coincided with my 35th birthday, Fiona my long suffering young lady and I were wed at Dry Drayton Church; a day to remember and hopefully an anniversary I won’t forget.

When people ask how I managed to take so much time away, I reply: excellent staff and how could I afford not to? Nuffield is a chance in a life time - seize the opportunity and see where it takes you.

James S. Peck

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James Peck at the family farm, standing in front of the first solar trackers in the UK

13. Appendix 1 : GPS mapping

If a farmer wishes to adopt CTF and/or any aspect of precision agriculture the essential prerequisite is to have his fields GPS-mapped.

I recommend any farmer engaging a GPS-mapping company to check that the following guidelines are followed:

1. Zero base stations when installing
2. Full farm setups : A-B lines and field boundaries
3. Consider if areas of ELS will be changing/removed in the future. (I personally would map the gross area).
4. Versatility of GPS provider to adopt to different makes of machinery.
5. Signal provider to aid any future contracting areas.
6. Recommend not to own your own base station.
7. Check offset is correct and direction when driving boundaries.
8. Use a tractor with your purposed signal to drive around fields and farms to check any pitfalls before signing up.
9. HP equipment over 5 years, update after term, allows managed payments/cost to the business.
10. Set up all tractors with fields and implements in advance.
11. Staff should only have to press the field and implement, all other information, i.e. boundaries and A B Lines should be done in advance.
12. GPS kits can be moved onto different machinery when your replacement policy requires.

After GPS mapping has been undertaken a farmer would need to purchase a relevant software programme to process and utilise the basic GPS data, or engage with a company or agronomist to do this as a service, which is the preferred route.

Information abstracted is only as good as the controls put in place. If you want yield mapping to be accurate, use a stamped weighbridge to determine weights. Calibrate equipment.

14. Appendix 2 : Fully automatic grain dryer

We made an initial exploration into renewable technology when we developed and constructed a 50 kW solar system on our home farm, the first commercial tracker system in the country, the inspiration for which came from the Contemporary Scholars Conference in Pennsylvania.

Key statistics are:

Total capital cost	£185k
Rated peak output	48kW (varies with light quality, has exceeded 48 kW
Predicted production kWh/annum	58,000 – 67,000 (declining by 0.7% of year 1 output per year)
Capital cost per kWp	£3850
Capital cost per kWh/annum	£3.20 - £2.76
Extra capital cost over fixed array	+/-30%
Extra output over fixed array	Average to date = 35% (based on actual comparison with nearby static array)
FiTS Rate	Year 1 = 23.9p/kWh generated – indexed (rpi)
Net cost of electricity generated	Year 1 = 5p to 10p per kWh Year 20 = 0p to 1p per kWh (depends on output and export/own use ratio)
Return on investment	9% - 16% (over life of the project, before tax, after depreciation, depends on assumptions re output, indexing and value of electricity)
Panel area	5 x 70m^2 = 350m^2 42 panels/tracker, 210 panels total
BP solar panels	
Deger dual axis trackers	
Sunny Tri-Power inverters	

See next 2 pages for details of Z-Tech


GRAIN DRYER SOLUTIONS
Introducing the Z-Tech grain dryer control system: the first to use microwave moisture sensors for accurate grain moisture monitoring and control.
Install the basic monitoring system yourself, or we can fit it for you!
For total grain dryer control we have developed a dual sensor system which measures both the intake grain moisture and the out-feed moisture, then controls the dryer speed to ensure optimum moisture content*. We can retro-fit into most dryers to update your control system without changing the whole unit.
As featured in FARMERS WEEKLY
*our pre-production trials saw consistent accuracy of +/- 0.1% across the cycle.
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GRAIN DRYER AUTOMATION


Z-TECH MONITOR & ALERT
£4995 (DIY) AND
FROM £5995 (INSTALLED)
The Z-Tech Monitor and Alert is the first option in our series and gives a cost-effective solution to reduce labour costs.
Install the system yourself, following our detailed illustrated guide, or we can fit it for you from £1000.
The unit features a graphical interface which monitors the grain moisture content after the dryer and sends you a text if its tolerances change from the programmed settings – this means you no longer need someone present to take regular readings.
The unit has a self-calibrating function which means that you can easily set it to whatever product is going through your dryer and alter the text alert settings to your own tolerances.
Z-Tech Monitor and Alert comes with:
one microwave moisture sensor
one Z-Tech Control Module
all cabling, installation guides and support
FREE first year subscription to the Z-Tech text alert service**
** text alert and data service for year 2 is a fixed cost of £8/month and £10/month respectively and subject to standard network charge increases thereafter.
Z-TECH MC1
FROM £9995 (INSTALLED)
Incorporating all the features of Z-Tech's Monitor and Alert, the MC1 offers the increased benefit of automated control which is custom mapped to your dryer.
The single sensor arrangement measures the out-feed moisture content and alters the dryer speed automatically, reducing the need for intervention if set tolerances are exceeded.
Our control module sends you a text if set tolerances are exceeded, or there is an abnormality in the moisture content.
Due to the frequency of the measurements taken, this system is more accurate than most continuously-manned dryers and once the dryer is started, it will run itself, saving on labour costs.
Fitment of the Z-Tech MC1 is custom to your individual dryer and as such a DIY option is not available.
MC1 will display time-related graphical data which can be viewed via our website and phone 'app'.
FREE data service for the first year**
Z-TECH MC2
FROM £18995 (INSTALLED)
Incorporating the features of Z-Tech's MC1, MC2 is our deluxe system and features two sensors fitted on the in-feed and out-feed of your dryer.
Suitable for farmers and farm contractors who deal with grain from different sources, this system recognises variable moisture content and alters the drying process to guarantee constant moisture levels in output. Fitted by our own trained Instrument Technicians, the system is custom-fitted to most dryers.
We also include time-related graphical data which can be viewed via our website or by our phone 'app' – this means you are able to monitor the status of your grain from any location and keep accurate records for quality purposes.
FREE data service for the first year**
Contact us for more information or to place an order.
Note: MC1 and MC2 require an initial site visit; incurring a charge of £300 - this is redeemable against the purchase price.
All equipment carries a full 12 month warranty and technical support.
Z-TECH
iPhone App
Monitor the status of your grain from any location with our iPhone app, available for Z-Tech's MC1 and MC2.
1:22 PM
Grain Dryer Monitor
Current reading at: 13:22:18
15.2 %
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