CASE STUDY

Soil management strategies to improve soil quality and cut operating costs in sweetcorn production

Figure 1. Barfoots of Botley Ltd. have implemented a reduced tillage and controlled traffic system

Key points

- **Controlled traffic farming (CTF) aims to restrict soil compaction from wheel traffic to the least possible field area. Within many horticultural systems, it is challenging to implement because of the wide variety of crops grown and machinery used. However, the potential benefits in terms of reduced operational costs and increased yield can be significant**
- **Transition to CTF within a high-value vegetable cropping rotation entails considerable thought and planning, and a timescale that fits in with the farm's normal machinery replacement policy**
- **Improvements in soil conditions may take time, and clear signs of compaction should be removed before full conversion to a reduced tillage, controlled traffic approach**
- **There is no reason to avoid or delay transition to CTF just because some machines do not immediately fit into the system – operational costs through lower tillage inputs can still be saved and benefits gained**
- **The growing of cover crops has clearly improved topsoil structure, but compaction in the 'transition layer' (between topsoil and subsoil) remains a challenge that can compromise production efficiency**
- **There are still many lessons to be learned about appropriate management during transition to CTF and thereafter**

Background

Barfoots of Botley Ltd. grow a wide range of high-value crops, including sweetcorn, tenderstem broccoli (TSB), courgettes, pumpkins, dwarf beans and broad beans, and have a keen interest in looking after their land for future generations. This philosophy has led them down the route of a three-pronged soil management strategy to improve production efficiency. This involves reducing tillage, growing cover crops and introducing controlled traffic farming (CTF) on their farms in Sussex and Hampshire. The other key principle that Barfoots follow is 'never to put a wheel where a seed would ever go'.

Neil Cairns, Barfoots Farm manager

Farm representatives attended a number of workshops and open days, understood the potential benefits of CTF and began to consider whether it was something they could adopt. They became aware of the importance of tyre pressures and noted that 75% of compaction can be created in the first machinery pass.

As part of the transition to CTF, Barfoots were keen to establish a base point from which they could measure the percentage reduction in tracking that they could be achieved within different rotations. The logical base width for their CTF system was 5 m because several of their machines would need little or no modification to fit into it. Having established CTF across two of their farms, it was of interest to determine the marginal costs associated with its introduction, i.e. how much extra they had spent within their normal machinery replacement policy to achieve a CTF system and what the monetary benefits are proving to be. Yield benefits have yet to be documented because no direct comparisons are possible; it will be a matter of monitoring yields over time.

Soil conditions during the transition to CTF

A study investigating soil conditions within sweetcorn fields for which the CTF system had recently been adopted, showed that the soil was firm to compact in a distinct layer from around 13 cm depth to around 30 cm depth; and that this was the case for sweetcorn rows next to wheelings and for rows in the growing bed.

There were no differences in crop height, total cob yield or number of marketable cobs between rows next to the wheeling and in the growing bed, indicating that growing conditions were similar, whether rows were next to wheelings or in the growing bed. Moreover, that it may take a number of years for soil in the bed to recover from a system of random traffic and deep cultivation, to a system with controlled traffic and reduced tillage.

Figure 2. Firm layer at 13–30 cm depth as assessed in (top) a soil pit and (bottom) in an extracted block of soil

Establishing the extent of tracking before CTF was introduced

Calculation of tracking was based on a rotation of sweetcorn, pumpkins, TSB and beans, and detailed information from all the machinery involved. This included the axle gauges (distance between wheels on an axle) of all self-propelled and trailed machines, as well as tyre sizes, and implement and operating widths. These data were used to establish an operational sequence of events on the farm within their existing system and as the basis for the new CTF system (Table 1).

Figures 3 and 4 show that existing tracking was very extensive, with most of the land being tracked more than seven times within the four-year rotation.

Irrigation tracking was not included, as this only occurred at around 70 m intervals and would have distorted the proportions of the tracking illustrations. Many operations also included a considerable degree of foot traffic, as in the case of TSB harvesting and, although vehicle tracking associated with this was included, it was rather indeterminate in its intensity. Calculations were based on parallel tracking, which reflected most of the operations on the farm, except subsoiling, which was assessed as a separate operation because it was carried out at an angle of 45 degrees to all other operations. This accounted for an additional tracking of between 39% and 50%, depending on whether a 3 m or 4 m subsoiler was used. Research has shown that, although significant loosening of the soil can be achieved during these operations, it is by no means guaranteed to improve soil conditions, and it is quickly compromised by subsequent traffic, and the residual effects of compaction may remain for some years (Chamen, 2011).

How tracking has changed with the introduction of CTF

Table 1 shows that it has been possible to fit most machines into the CTF system, with the exception of the bunker harvester (4 m) and trailed bean harvester (1.67 m). With these two machines still in the system, tracking was reduced from well over 100% (numerous coincident passes) to 70% overall (Figure 5). However, the bunker and bean harvesters only operate on a small proportion of the harvested area and without them (or if they could be modified), tracking is reduced to just 37% of the total area, as illustrated in Figure 6.

Figure 3. Overlays of tracking for all crops prior to CTF. 100% of area was tracked at least once – see Figure 2 for more detail

Figure 4. Intensity of tracking – number of coincident passes for all crops prior to CTF

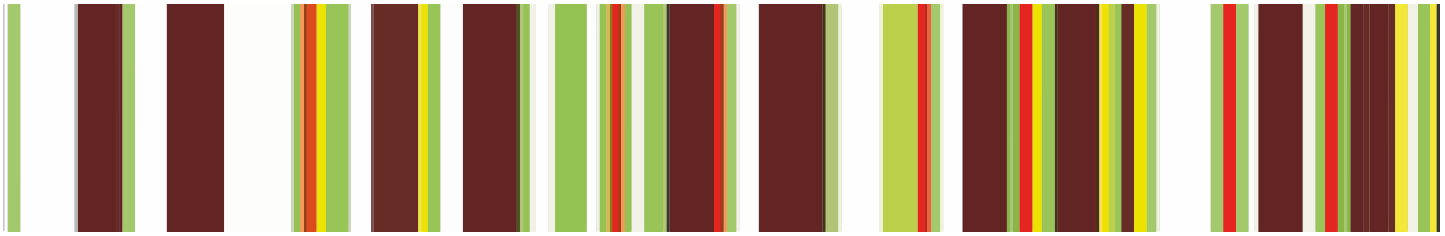

Figure 5. Intensity of tracking – (number of coincident passes) after introducing CTF and including the bunker and Oxbo harvesters

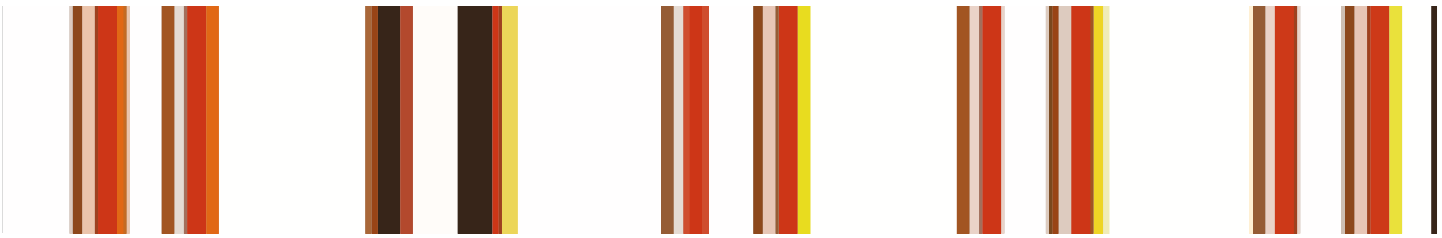

Figure 6. Tracking for all crops without the 4 m bunker harvester or trailed Oxbo harvester. Tracked area is just under 37%

Table 1. Operations before and after the introduction of CTF in a rotation of sweetcorn, pumpkins, tenderstem broccoli and beans

Crop/area with CTF	Operations Before CTF	Width (m)	After CTF	Operating width (m)
All	Subsoiler	3	Multipurpose cultivator	5
	Subsoiler	4	Power harrow	5
	Plough + tine cultivation	3	Spraying	25
	Power harrow	5	Fertilising	25
	Rolling	6	Irrigation	70
	Spraying	24	Topping post-harvest	5
	Fertiliser	24	Targeted decompaction	5
	Irrigation	72		
	Topping post-harvest	6		
Sweetcorn 650 ha	Drilling	4.5	Drilling + plastic layer	5
	Plastic laying	4.5	Plastic removal	5
	Plastic removal	4.5	Hoeing	5
	Hoeing	4.5	Hand harvesting to rigs	10
	Hand harvesting to rigs	10	Self-propelled harvester	5
	Self-propelled harvester	4.5	Bunker harvester	4
	Offloading SP to trailer	2.5		
	Bunker harvester	4		
Tenderstem broccoli 100 ha	Planting	5	Planting	5
	Fleece removal	15	Fleece removal	15
	Hoeing	1.67	Robotic hoeing	5
	Hand harvesting to rigs	15	Hand harvesting to rigs	15
Pumpkins 75 ha	Drilling	4.5	Drilling only	5
	Hoeing	4.5	Hoeing	5
	Harvesting		Hand harvesting into boxes	25
Beans 67 ha	Drilling	5	Drill + roll	5
	Hoeing	1.67	Hoeing	5
	Trailed harvester	1.67	Trailed harvester	1.67
Cover crops			Drilled with multipurpose cultivator	5
			Rolling	15

What has been the cost of introducing CTF?

At Barfoots, one of the farms made progressive changes to machinery and operations, while the other made a more complete transformation of machinery to CTF in 2016, involving significant investment, including global navigation satellite systems (GNSS), autosteer and a standard track gauge for all machinery. Progressive change has limited expenditure to a large degree, with the marginal cost being any extra that the farm has had to pay, to ensure that replacement machines fit into the CTF system. Table 2 provides an overview of these costs for one of the farms, together with explanatory notes. Several machines were either already the required width or could be adjusted without modification. The latter included 6 m toppers, for example, which were simply used with an overlap, while fertiliser spreaders had an adjustment to increase their spreading width to 25 m.

Table 2. Marginal (additional) costs associated with conversion to CTF

Year	Task and machine	Marginal cost, £	Comments
Sussex farm			
2013	GNSS & auto-steer	50% of total	Planned adoption upgraded to RTK, giving greater accuracy and improving field efficiency
2013	Replacing plough and subsoiler with multipurpose cultivator	15,000	Fewer passes and less fuel, despite bigger tractor
2013	Spraying	Minimal	Section control and blanking of some nozzles
2015	Sweetcorn drilling	None	Natural progression, saved 1 tractor and 4 people by virtue of new technology
2013	Sweetcorn hoeing	1 day labour	Moved hoeing elements to fit
2013	Specialist sweetcorn harvester	3 day's labour	Altered the header
2016	Replaced 4 m subsoiler with 5 m subsoiler	Natural progression	Lower cost per unit area worked, assisted by non-trafficked soil
Hampshire farm			
2016	GNSS	50% of total	As for Sussex farm above
2013	Replacing plough and subsoiler with multipurpose cultivator	15,000	Fewer passes and less fuel, despite bigger tractor
2016	Sprayer	£600 + 1 day labour	Added extension to the boom
2016	Sweetcorn drill & poly layer replaced with specialist multi-activity drill	None attributed	Needed replacing and was natural progression, took 4 people and a tractor out of the operation
2015	Sweetcorn hoeing with sweetcorn hoe	1 day labour	Extended leg spacing to fit new system
2015	Harvesting with specialist sweetcorn harvester	3 day's labour	Header width altered
2016	TSB hoe replaced with inter-row precision cultivating weeder	£50,000	Total cost £107,000, marginal cost to gain extra width to fit CTF system, which also covers more ground. Reduces need for hand weeding
2017	Rolling, 6 m rolls	None attributed	Existing rolls needed replacement and natural progression was to 15 m

From the table above, the total marginal capital costs associated with a change to CTF on the Sussex farm were:

- £50,000 for GNSS and autosteer. This related to a base station and ten rover receivers and ancillary equipment shared with the Hampshire farm
- £7,500 for plough replacement
- £680 for 4 days labour

This is a total cost of £58,180, which represents about 60% of the total investment in GNSS and machinery replacement during the four-year period.

On the Hampshire farm, the equivalent marginal costs were:

- £50,000 for GNSS and autosteer (50% share with Sussex farm)
- £7,500 for plough replacement (50% share with Sussex farm)
- £600 for spray boom extension
- £850 for 5 days labour

This is a total cost of £58,950, which represents about 30% of the total investment in GNSS and machinery replacement over the four-year period.

Set against these costs are savings in labour, fuel and power. Savings in labour are difficult to quantify because they have taken on more land during this period. In terms of fuel, there has been an estimated 10–15% reduction per hectare, while power demand has dropped by 25–30% from about 6.2 hp/ha to 4.5 hp/ha.

Conclusions

- The traditional system involved many machines without a common width or axle gauge. The move to a 5 m-based CTF system has therefore involved significant planning to achieve, but has already resulted in a permanent 30% reduction in tracked area across the whole farmed area and a 63% reduction over the majority of the area. Careful choice of tyres or their replacement with rubber tracks could reduce the area still further
- The introduction of cover crops will conserve nutrients, improve topsoil structure and reduce erosion on sloping land
- A minimum tillage approach has reduced fuel use and could reduce operational costs further if soil conditions improve over time. However, the challenge will be to target deeper cultivations (in terms of timing and depth) and use cover crops to reduce the compaction inherited from the previous system
- Return on investment in CTF is difficult to quantify at this early stage but savings in fuel, labour and power have been identified

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