CTF Workshop Report

Joint meeting: Unilever CTF Focus Group and the IAgR E Soil and Water Technical Group

10 April 2008 at Unilever R&D Colworth

Summary of the day’s agenda

Morning

Presentations included effects of soil strength on crop growth, tillage and land use issues, soil biodiversity in potato production and introductions to CTF at Colworth and soil structure effects on water movement.

Afternoon

Attendees were divided into three groups which sequentially:

1. Visited 8 fields under CTF management guided by Andy Coggins, the Farm and Estate Manager at Colworth.
2. Inspected, with expert guidance from Bob Palmer, soil pits dug in three fields sown to spring barley, two under conventional traffic management, the third under CTF.
3. Attended an indoor session where Tim Chamen presented soil and crop aspects of CTF and random traffic farming (RTF) on the Colworth site.

Welcome

Andy Coggins (Unilever R&D Farm and Estates Manager) welcomed us to Lee Farm, which has a long history of field experimentation as part of the Colworth centre. Andy provided a brief history of Unilever at the site and pointed us to freely available publications.

Summary of presentations

All the presentations from the morning’s proceedings are available in the Member’s area of the CTF Europe website, but the following are summaries of the main points.


We all know that high soil strength can limit crop growth, but what we don’t know is how much of the effect is due to drying and how much to the inherent soil strength, much of which is caused by compaction.

Chris provided compelling evidence in his presentation that it is indeed soil strength that causes the greatest limitation to crop growth. As the soil dries, so this strength becomes a greater feature (Fig. 1) and so does the contrast between compacted and non-compact ed soils (Fig. 1a).

1 Growing for the future – Unilever and Sustainable Agriculture: The Colworth Project – putting sustainable agriculture to the test
Fig. 1. Left: penetrometer resistance in moist soil conditions following wheeling with up to 8 passes. Right: change in penetrometer resistance under one and four wheel passes as the soil dries showing the increasing contrast in resistance.

Their work at Rothamsted has also identified a close correlation between soil strength, as indicated by a small rotating penetrometer, and crop growth and yield (Figs 2 & 3).

Fig. 1a. Penetrometer pressure for a sand (a) and a loam (b) showing non-compacted plots (open symbols) and compacted plots (solid symbols) against time for different crops, including no crop (see Plant and Soil, (2008) 306: 237-247).

Fig. 2. Effect of soil water content on penetrometer resistance and potential for root growth.
Fig. 3. The influence of soil strength (as indicated by resistance to a small rotating penetrometer) on crop yield as controlled by irrigation, field traffic and soil type

Chris’s conclusions from the work were that:

- high soil strength can occur in relatively wet soils (as evidenced by Tim’s video clip in the afternoon!);
- that irrespective of soil type, structure and water status, soil strength gives a good prediction of crop yield;
- irrespective of whether increased strength is due to drying or compaction, it limits crop growth.

2. Land use and management issues, Brian Keeble, Writtle College

Brian’s interest in land management issues was prompted by news of muddy floods and the rationalisation that as most land is controlled by farmers, most flood water must be coming off the land and therefore research into land management practices could help avoid problems such as those shown in Fig. 4.

Brian broke his talk down into three aspects:

1. Land issues – how we use the farm
2. Soil management – how we use the soil
3. Profitability – inputs against outputs

Although Fig. 4 shows an erosion event on relatively level land, most occurred on more extreme slopes and are a land use issue. Because of the close relationship between land management and runoff Brian determined that he would look at this more closely on their farm at Writtle, particularly as increased profitability appeared to reflect reduced runoff (Fig. 5).

Soil management was primarily about essential profit and this mostly went hand in hand with good soil health, as indicated by soil fauna, topsoil stability, profile permeability and good root penetration. Profit is all about reducing unit production costs and ensuring
maximum output through good timeliness, the latter largely dictated by good soil management. Good soil management, Brian considered, was all about maintaining soil cover in the form of residues, farmyard manure and compost and by minimising traffic. Worms were a key part of maintaining soils in good health, creating drainage channels and mixing...
residues, while bacteria and fungi recycled organic matter to increase soil stability.
Woodland soils tended to exhibit all the positive features needed and yet when were they
last cultivated and when did the water last run brown off them?
The Writtle cultivation trial had three contrasting crop establishment systems, but was
treated identically thereafter. The treatments were:
1. Direct drilling (with conventional and custom drills)
2. Minimum tillage
3. Ploughing
Profitability calculated purely on costs, income and returns without allowances for
differences in timeliness, suggested that the average over three years and three different
crops was:
Min Till £460/ha
Direct drill: £438/ha
Ploughing £368/ha
The order of CO₂ production was greatest with ploughing and least with direct drilling.
With 3.4 million ha of combinable crops, a change to direct drilling could save around
0.6 M tonnes of CO₂ annually. Worms were also more prolific on direct drilled soil but
had the lowest population under ploughing.
Fig. 6 shows that the percentage of rain running off fields was greatest under ploughing
and that this also resulted in the greatest erosion.

The trial had produced some interesting results and Brian was presently seeking further
funding with the objective of producing more stringent and statistically verifiable results
and the inclusion of green compost. As ever, the problem was money, and in his case,
someone to take over from him after his imminent retirement.
We wish him well in both quests and also for his retirement.
3. Soil and biodiversity in modern potato production. Graham Colborne (FWAG) and Peter Harkett (McCains)

Graham described the Sustainable Agricultural Initiative (SAI Platform) under which he and Peter had been working. The aim of the initiative is to deliver sustainable practice, which is embodied in production, environment and support for local communities. In this pilot action for potatoes, biodiversity is addressed through an Action Plan with annual updates and surveys of soil profiles and their earthworm populations. Graham went on to report first year results from the surveys.

Three quite different pilot farms were monitored:

1. Shropshire – Ludlow on Devonian siltstones in scarpland ridge/vale incorporating Bromyard and Munslow series soils.
2. Shropshire – Wellington on Glacial till and Triassic sandstone in gently undulating country incorporating Salwick and Bromsgrove + Salwick series soils.

**Ludlow soils**

Areas of these soils were found to be unsuitable for potatoes in terms of erosion risk, primarily because of slope. Equally, remedial action after harvest revealed from soil pits had been largely ineffective, either because of insufficient depth of operation, incorrect tine spacing or too moist conditions or a combination of all of three. Fig. 7 shows the Ludlow profile and the fact that some adjustment of the subsoiler would have been beneficial – perhaps deeper working with a closer spacing between the tines.

![Fig. 7. Profile from the Ludlow soil showing that much of the topsoil remained compact and that smearing below the subsoiler wings had occurred](image-url)
**Wellington soils**

These showed high levels of compaction in both 2006 and 2007, little of which had been dealt with effectively by subsoiling. Fig. 8 shows that much of the field area had been compacted and that this extended well into the subsoil.

![Fig. 8. Measurements taken from a profile of one of the Wellington soils. This showed severe levels of compaction which had not been removed by subsoiling](image)

Fig. 9 illustrates how traffic compaction had extended into the subsoil and the effect of this on soil structure at this depth (inset). The worst compaction was also on soils with only moderate permeability.

**Rugeley**

Measurements showed that there was only a modest increase in resistance in the compacted compared with non-compacted zones, namely from 3.0 kg/cm² to 3.8 kg/cm².

Overall, Graham’s thoughts following the first year of sampling were along the following lines:

- Could the harvester and trailer wheels be shifted off mid-bed?
- Could wider beds be used?
- Could tracks rather than wheels be used more widely?

![Fig. 9. Severe compaction in one of the Wellington soils showing the effect on the upper subsoil (inset)](image)

Bob started his career as a surveyor with the Soil Survey of England & Wales and then gained soil assessment experience with the Soil Survey & Land Research Centre at Cranfield. Here, amongst other things and before becoming an independent, he conducted surveys of groundwater vulnerability, shrink-swell potential and since 2000, soil structural degradation caused by modern farming techniques. He has studied flooding in 15 different catchments looking at the effects of soil types and crops.

Bob, in his talk as a prelude and background to the afternoon’s in-field survey, described the soil features affecting enhanced run-off from field soils. These included:

- Capping
- Compaction
- Changes in vertical wetness gradient
- Structural change – shape, size and degree of development

Changes in vertical wetness gradient, for example, where there is a sudden change from wet to dry with depth or vice versa, indicate a problem with soil structure. All of these features have an effect on crop growth, yield and water run-off.

To help understand these effects, Bob took us through the basic features of soils, their constituents (Fig. 10) and most interestingly, the proportions of water available at different tensions in a typical loamy soil (Fig. 11) as well as the amount of water held at different depths in a well structured profile (Fig. 12). From these we learned that plant available water was that held at a tension of between 5 kPa and 1500 kPa, the latter representing the permanent wilting point of plants. The vertical drainage shown in Fig. 12 is the drainable porosity and represents the water readily drained from the profile in 24 – 48 hours. Sands have around 15% drainable porosity, clays tend to have much less. This porosity is the first to be lost when the soil is compacted.

**Fig. 10. Typical constituents of a soil**

Bob then went on to describe the different structures identifiable in many soils, highlighting the inherent features of sands and clays and the ones that we should be aiming for. Granular and subangular blocky were the most favourable and platy and prismatic the least. Prismatic tended to be associated with subsoils, while subangular was more porous than angular, which was more dense. He then went on to show examples of capping, compaction and anaerobic conditions caused by compaction, most of which occurred in soils with poor structural development, such as Apedal. This is a massive structure which when stressed, breaks apart like cheese and exhibits structural damage. Structure is important because if it is poor, it can impede root growth and water movement.
Bob’s presentation was extremely interesting, illuminating and pertinent and I recommend clicking on the link above to look at it for yourselves!

**Hydrological terminology**

- **Retained water >5 kPa**
- **‘Non-mobile’ water >1500 kPa**
- **Extractable water 5 - 1500 kPa**
- **Drainable porosity < 5kPa**

*Fig. 11. Proportions of water held at different tensions in the soil and that available for extraction by plants*

**Fig. 12. The distribution of different components of soils with depth. Soils with a good structure can hold up to 40% water by volume**

5. **An introduction to CTF at Unilever R&D Colworth, Tim Chamen, CTF Europe Ltd**

Tim provided a brief overview of the CTF project at Colworth, particularly for those for whom this was the first visit or contact with CTF. Initially however he acknowledged the sponsorship of Unilever in providing all the facilities for the day, including lunch, to the IAgrE for our soil’s expert expenses and to CTF Europe Ltd for the planning and administration. Tim made particular mention of the Land-based Technician Accreditation (LTA) scheme just launched by the IAgrE in partnership with many others, and with the
objective of improving the training and status of land-based technicians, who provide a vital service to agriculture.

CTF, Tim said, works on a very simple principle – the confinement of all traffic to the least possible area of permanent traffic lanes. It is non-prescriptive, tends to preclude ploughing as an operation but has many different farm-specific solutions. The CTF project at Unilever R&D Colworth was aimed at proving the practical feasibility of CTF, seeing what works and what doesn’t and providing a protocol to make it easier for others to achieve. In the longer term it was also designed to assess the economics of conversion to and sustainable running of CTF on typical farms.

Tim continued by describing the 3/8 m system which had been adopted. All equipment was on a matching 3 m track width with implements 8 or 24 m wide (thanks to John Deere, John Dale Drills and Berthoud). Mention was made of a planned change later this year to an OutTrac system which would obviate the need for a wide axle tractor. The total area under controlled traffic was now 73 ha divided between nine fields and crops including wheat, spring barley, oilseed rape and field beans.

**Afternoon sessions**

Attendees divided into three groups and proceeded to the different sites.

**Indoor session**

*Colworth soil and crop update, Tim Chamen, CTF Europe Ltd*

Tim started his update by showing some of the adverse effects of compaction that had occurred at Colworth under traditional practice last year. The Hanslope clay soils on the site had been very wet pre harvest and retained their moisture throughout the autumn. Good seedbeds had been produced, but at the expense of severe compaction below the cultivated layer (Fig. 13).

![Fig. 13. Tilth produced under a minimum tillage system at Colworth in autumn 2007. The inset shows typical conditions just below the tilled layer, which was detected easily with the spade](image)
Similarly in this field, the tracks of the combine harvester could be easily be detected as yellow lines in the emerging crop (Fig. 14). Infiltration measurements taken in February suggested a 30% reduction on trafficked no-till compared with the CTF equivalent. This reinforced earlier measurements and were supported by noticeable differences in surface wetness soon after a significant rainfall event. As further evidence of the tightness of trafficked soil,

Fig. 14. Tracks of the harvester showing as yellow lines in this traditionally managed field

Tim showed a video clip of trying to remove a spit of soil from trafficked compared with non-trafficked soil, both of which had been in no-till for three years. The contrast was extreme with the trafficked soil resisting all attempts to lever it out. (see www.?) He then ran through photos of the crops under CTF at Colworth including first and second wheat, beans and oilseed rape. The latter had established well, but had been grazed extensively by pigeons, resulting in crop at very different stages of growth. The presentation concluded with slides showing the various farm systems that had either been adopted by CTF Focus Group members or were in the planning stages. Tim has also extracted large soil samples from a random traffic min till field and a CTF no-till field, the latter converted in summer 2006. These were presented without identification and Tim suggested people look at these and decide which was which. This was difficult because although they dug quite differently in the field, differences in structure are often difficult to detect and the random traffic sample, because it was difficult to dig out, had broken up more than the CTF sample. Most people however differentiated them correctly.

**Soil pits**

*Inspection of three pits under guidance from Bob Palmer*

The first pit visited was in field (22) that had been managed with traditional traffic and was under a non-inversion tillage regime. The latter had varied between disc and tine tillage but this spring had been mole ploughed and followed by power harrowing and a tine drill to establish spring barley. Bob’s description of this profile ran as follows:
Fig. 15. Relative positions of the three fields where soil inspection pits had been dug

<table>
<thead>
<tr>
<th>Depth (cm)</th>
<th>Details of soil structure in field 22 (Random traffic, min till)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-8</td>
<td>Moist; moderately porous clay loam; strongly developed very fine and fine angular blocky structure; loose soil strength but moderately firm ped strength. Typical wetting-drying and/or freeze-thawing surface tilth of a cultivated Hanslope series</td>
</tr>
<tr>
<td>8-24</td>
<td>Very moist; very slightly porous clay loam; semi-deformable; structureless massive but a tendency to part horizontally rather than vertically; very firm soil strength</td>
</tr>
<tr>
<td>24-35</td>
<td>Very moist; very slightly porous clay; deformable; structureless massive, locally weakly developed very coarse platy structure; moderately strong soil strength</td>
</tr>
</tbody>
</table>

The second pit was on an adjacent field (28) converted to CTF and predominantly no-till in 2004 and in which spring barley had been direct drilled. Bob observed subtle differences in this profile, but only to a depth of around 18 cm, as indicated below:

<table>
<thead>
<tr>
<th>Depth (cm)</th>
<th>Details of soil structure in field 28 (CTF no-till)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-18</td>
<td>Moist; slightly porous clay loam; weakly developed very coarse and coarse angular blocky structure; moderately firm soil strength.</td>
</tr>
<tr>
<td>18-24</td>
<td>Very moist, very slightly porous clay loam; semi-deformable; structureless massive but a tendency to part horizontally rather than vertically; very firm soil strength</td>
</tr>
<tr>
<td>24-35</td>
<td>Very moist, very slightly porous clay; deformable; structureless massive, locally weakly developed very coarse platy structure; moderately strong soil strength</td>
</tr>
</tbody>
</table>

The third profile was in another adjacent field managed traditionally and under no-till for the same period as the CTF field. Here only two horizons were distinguishable as described below:

<table>
<thead>
<tr>
<th>Depth (cm)</th>
<th>Details of soil structure in field 23 (Random traffic, no-till)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-24</td>
<td>Very moist; very slightly porous clay loam; structureless massive but locally tendency to very coarse platy; moderately strong soil strength.</td>
</tr>
<tr>
<td>24-35</td>
<td>Very moist; very slightly porous clay; deformable; structureless massive, locally weakly developed very coarse platy structure; moderately strong soil strength</td>
</tr>
</tbody>
</table>
Bob’s conclusions from these three profiles were as follows:

The degree of structural degradation below 18 cm depth and in upper subsoil layers was the same in all fields. These layers had moderately strong soil strength (3 cm cube of soil could not be broken between thumb and forefinger) and were structureless and massive consistent with repeated compaction under farm implements/machines. Even if the episodes of soil compaction are removed from the management regime the improvement in structural conditions in these soils that readily shrink and swell with changes in moisture content, is likely to be very slow and take many years. Mechanical intervention (well controlled subsoiling in suitable soil conditions and at suitable depth to ensure shattering) will be required to restore structure to these layers in a reasonable period of time.

There were differences in soil structure in the topsoils of these three fields. The random traffic field that had been power harrowed this spring (field 22) was the only field with a well developed cultivation tilth (from freeze-thaw and/or wetting-drying cycles) in the 0-8cm depth zone. The controlled traffic field (28), although having moderately firm soil strength resulting from repeated compaction in the past had weakly developed very coarse angular blocky structures in the 0-18 cm layer indicating a degree of restructuring taking place. Field 23, which was managed by direct drilling with random traffic was structureless and massive throughout its topsoil and upper subsoil.

The adjacent photos provide an essence of the occasion and together with a pictorial guide to the field walk below, round off this report!

Tim Chamen, CTF Europe
5 May 2008
Walk across CTF fields

The field walk was guided by Andy Coggins, the Farm and Estates manager at Unilever R&D Colworth. Andy was able to provide first-hand knowledge and experience of CTF operation, but I was unable to take part in this activity so can’t give an account of observations or comments! I include here a few selected photos of the crops taken on 2nd May 2008. RTF is an abbreviation for “Random Traffic Farming”, in other words, conventional practice. DL is abbreviation for deep loosening just before going into CTF.

Fig. 16. 2nd May 2008. Left: Field 37-40. CTF since 2006, DL, 1st wheat after osr
Right: Field 34-38. RTF, Min till, 1st wheat after osr

Fig. 17. 2nd May 2008. Left: Field 44-46. CTF since 2006, DL, 2nd wheat
Right: Field 42. CTF since 2006, 2nd wheat

Fig. 18. 2nd May 2008. Left: Field 41, CTF since 2006, winter beans after spring wheat
Right: Field 45, CTF since 2006, DL, 1st wheat after winter beans
Fig. 19. Field 43, CTF since 2006, oilseed rape after set-aside. 
This field has had a chequered RTF history and was severely grazed by pigeons over-winter –
hence the present very variable crop growth stages

Fig. 20. 2nd May 2008. Top left: Field 22, RTF Min till, spring barley after winter wheat
Top right: Field 23, RTF, no-till, spring barley after winter wheat
Bottom: Field 28, CTF since 2004, spring barley after winter wheat
(These three fields were the ones in which the pits were dug)