Machinery, soils and tillage for potatoes

Dick Godwin
Harper Adams University
Background
The effects of soil compaction

- Reduces crop yield
  \((\text{Negi} & \text{McKyes}, 1978)\)

- Increases draught forces
  \((\text{Godwin, 1974; Chamen et al, 1992})\)

- Reduces infiltration rates
  \((\text{Chamen 2011; Chyba, 2012})\)

Economic cost of compaction in England and Wales:
c. £0.4 bn/annum

\textit{Morris et al. - Cranfield University, 2011}
Effects of load and inflation pressure on pressure distribution

Pressure has the greatest influence on the degree of compaction and load influences the depth of soil compaction.

After: Soehne, 1958
Random traffic problems

Non-controlled

Extensive areas of the field are exposed to trafficking

Random Traffic

+ Plough = 85% covered
+ Minimum Tillage = 65% covered
+ Direct Drilling = 45% covered

Wheat, Czech Republic

Potatoes, UK 84% establishment

Kroulik, M., 2012, Sabbatical Study at Harper Adams University,
All operations horizontal
Except
Ploughing and spreading

Kroulik, M. et al., 2012
Options for compaction reduction

Reduced pressure tyres, tracks, reduce axle weight and central tyre inflation pressure systems (for EvoBib)

Controlled traffic
Sub-soil pressure at 0.3m deep

Challenger 765C 16t

MF 8480 Tractor 12.2t

Front/Rear

0.7/0.7 bar

1.2/1.5 bar

0.7/0.7 bar

Front Axle               Time                      Rear Axle

MachXbib High

Axiobib Low

Challenger

Human walking

Compaction reduction - Rubber tracks

Displacement (mm)

Depth (mm)

900 followed by 700
900 followed by 500
Track followed by 700
Track followed by 500
Dominator
LSD

After: Ansorge and Godwin, 2007
Subsoiler – Draught forces in combine ruts

After: Ansorge and Godwin, 2007
Simple concept

Soil structure
  ✓ Infiltration + 400%

Crop yields
  “CTF (+LGP) = +10 to 15% yield”

Fuel, time and machinery cost savings
  “70% reduction between trafficked & untrafficked”

GPS guidance and Auto - steering

Track width and harvester width matching

Source: CTF Europe
The effect of controlled traffic on soil physical properties and tillage requirements for vegetable production.

Potatoes grow better in soft soil
Wheels work better on roads
Improved soil structure

Soil structure score after broccoli harvest

<table>
<thead>
<tr>
<th>Method</th>
<th>Score 3-4</th>
<th>Score 7-8</th>
<th>Score 9-10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional traffic &amp; tillage</td>
<td>3 - 4</td>
<td>7 - 8</td>
<td>9 - 10</td>
</tr>
<tr>
<td>Controlled traffic</td>
<td></td>
<td>7 - 8</td>
<td></td>
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<tr>
<td>40 year pasture fence line</td>
<td></td>
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</tbody>
</table>

Score 1 – 2
Large compact clods (50 - 100 mm) with few fine aggregates. Clods are angular or plate-like with smooth sides and no pores.

Score 3 – 4
Mainly firm large clods (20 – 50 mm) that are angular with smooth faces and no pores. Clods and overworked soil break into loose powdery soil.

Score 5 – 6
Few medium and large firm, rounded aggregates (5 – 30 mm) with mostly finer aggregates (< 2 mm) and some powdery unaggregated soil.

Score 7 – 8
Friable soil with many rounded aggregates (5 – 20 mm). Many fine rounded aggregates (< 2 mm) but little powdery unaggregated soil.

Score 9 – 10
Porous loose soil with many rounded, irregular shaped aggregates (2 – 10 mm). Large aggregates have many holes for good aeration and drainage. Little or no powdery unaggregated soil. Often has abundant very fine roots.

McPhee et al., 2015
Scottish Study


No wheel effects

2.8m/112”/9.3’
Soil conditions in the ridges were similar. Soil below the ridge was weaker for zero traffic.

Dickson, J.W., Campbell, D.J., Ritchie, R.M., 1992

McPhee et al., 2015
Yield depressions and clod yield higher on either side of sprayer tramlines.

Dickson, J.W., Campbell, D.J., Ritchie, R.M., 1992

Potato Yield, t/ha

Zero traffic

Conventional traffic

Standard Error

= Tramline wheel passes
= Number of wheel passes planting to harvest
Potato yield

Zero traffic mean yield 14% higher

Dickson, J.W., Campbell, D.J., Ritchie, R.M., 1992
Marketable Potato Yield

Zero traffic marketable yield 18% higher

Dickson, J.W., Campbell, D.J., Ritchie, R.M., 1992
Soil clod yield

Clod yield 25% less for zero traffic

Dickson, J.W., Campbell, D.J., Ritchie, R.M., 1992
Benefits from New Zealand

- 4t/ha (45%) less soil to the pack house
- Reduced transport costs, washing time, energy and “waste soil”
- Reduced fuel use, hence increasing area under CTF

See also
YouTube video CTF for Potatoes.
Simon Wilcox
Run-off after harvest Tasmania

Conventional

Controlled traffic

McPhee et al., 2015
Reduction in subsequent tillage operations

<table>
<thead>
<tr>
<th>Crop transition</th>
<th>Conventional</th>
<th>CTF</th>
</tr>
</thead>
<tbody>
<tr>
<td>green manure – potatoes</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>potatoes – green manure</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>green manure – broccoli</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>broccoli – green manure</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total number of operations</strong> (57% reduction)</td>
<td><strong>14</strong></td>
<td><strong>6</strong></td>
</tr>
</tbody>
</table>

No-till potatoes after onions Tasmania

MCPhee et al., 2015
Practical application for field vegetables

RTK-GPS enables \(< \pm 20 - 30 \text{ mm positional error}\). Issues of repeatability and cost are being addressed

After: Chamen (2007)

Controlled traffic system for vegetable production using RTK-GPS and 300 mm wide rubber tracks. Track positions are at 3.15 m centres

After: Vermuelen (2006)
CTF for Potatoes

More than half way there!

Other crops in the rotation

One suggestion is the TwinTrac System

Example given

Implement width = Harvester track gauge + Tractor track gauge

= 3.66m + 1.83m = 5.49m (ok for 6m TopDown?)

Chamen, CTF Europe, 2017
Match sprayer to combine

- Match sprayer to 3 x combine cutting width
  - trailers/chasers always run in tramlines
  - may need to extend combine unloading auger
  - may need to modify sprayer

9.14 m (30’) used at 8 m

Chamen, CTF Europe, 2017
Deep soil loosening
Beds-Beds 1983

Bed Preparation Pass

Or plough “on-land” with under-buster tines

Or 2 tines at row spacing

Godwin and Spoor, 2015
CTF in vegetable production
More gains but greater challenges

• Example
  – System based on 1.83 m (72”)
  – Suits onion and potato production
  – All new machines based on 3 x 1.83 m
  – 5.49 m bed former

Chamen, CTF Europe, 2017
CTF in vegetable production

- **Example**
  - System based on 1.83 m (72”)
  - Suits onion and potato production
  - All new machines based on 3 x 1.83 m
  - 5.49 m bed former
  - 5.49 m planter
  - 5.49 m topper
  - 27.45 m sprayer
  - 9.15 m (30’) combine
Non – controlled Harvest Traffic
Controlled traffic harvest
New Zealand
CTF in vegetable production

• Maintaining CTF during onion harvesting
  – outrigger wheel hydraulically retractable
  – elevator modified to give greater reach

From Jones Engineering

Chamen, CTF Europe, 2017
Aftercare/Repair

Shallow leading tines reduce clod size

Spoor and Godwin, 1978
Recommendations

• Minimize machine weight and contact pressure
  – Safely reduce inflation pressures, use ultra-flex tyre options
  – Spread the load with multi-axle and tracked vehicles

• Think about traffic intensity, match wheelings
  – Concentrate wheel traffic
  – If possible adopt Controlled Traffic Farming practices

• Target subsoiling operations
  – Focus on headlands, gateways and tramlines
  – Use traffic maps to identify hidden wheel/track passes

• Do not operate on recently loosened soil!
CTF can be achieved at many levels

– start with the combine – it’s probably your heaviest machine
– familiarise yourself with the options (join CTF Europe; £30/year)
– complete an inventory of the machines you might use
– check actual dimensions of any machines you plan to buy
– stick to your normal machinery replacement policy but buy matching widths
– ensure you have an auto-steer system with an RTK correction
  • you do not need for all operations - Simon Wilcox

Chamen, CTF Europe, 2017
Thank you for your attention

and thanks to

Tim Chamen (CTF Europe),
Milan Kroulik (Czech University of Life Sciences)
John McPhee (Tasmanian Institute of Agriculture)

Next 3 slides on TopDown and depth measurement
+ Some proposal ideas for Demonstration for 2018
According to our records, Dillington have a 6m TopDown, which has one depth wheel on each folding wing as well as the two main ones within the centre frame.

Lifting the packer out of work (or removing it) leaves just the wheels to control working depth.

The drawbar adjustment is to set the frame level (front to back to ensure equal working depth along the length of the machine) and is not used subsequently in the general operation of the machine.

It is not unusual for both the packer and the wheels to be used in combination as depth control with the potential to leave a reasonably open/weatherproof finish without leaving wheelings.

It is also worth noting that even/consistent working depth is also aided by keeping a close eye on the wearing metal…uneven point wear is an often-overlooked cause of inconsistent effective working depth across the machine width.

I am also copying this reply to our relevant field-based colleagues….a visit to help better set up the TopDown and look at working applications should be helpful for Dillington and we may learn something ourselves at the same time.

Michael Alsop, MD Vaderstad, UK
Disturbance Depth measurement

1. Excavate a trench across two tines to below their working depth.

2. Facing the direction of implement travel, pull the disturbed soil away from the face to expose the limits of soil disturbance.

3. Following adjustment of depth/spacing. Check on any new disturbance boundary at depth can be made by pushing a rod or penetrometer into the loosened profile.

Surface level rises - bulk up by about 20%
Prepare soil with Deep Loosening Tines and/or Under-buster tines +/- surface wheels at high and low pressures and rubber tracks(?)

1. Excavate soil profile as see and photograph mid-term benefits
2. Use structure score technique to quantify benefits
3. Use penetrometer and infiltrometer to show/record benefits & if possible
4. Evaluate potato response.

Demonstration for 2018

Rubber Track | Low GP | High GP
---|---|---
Water + Stop watch
Effect of tracks and tyres on soil strength

Penetration resistance, MPa

Control
Track
Tyre

Can be removed with plough/tine
Requires subsoiling

After: Ansorge and Godwin, 2007
Effect of inflation pressure on soil strength

Penetration resistance, MPa

Depth, cm

- Unwheeled soil
- 13 psi Inflation Pressure
- 33 psi Inflation Pressure

Dresser, Stranks, and Godwin, 2006
Soil looseners

- Chisel tine (Shakerator)
- Conventional Subsoiler
- High lift Winged Subsoiler
- Low lift wings + leading disc
- Paraplow
- Moleplough
Effective subsoiling

Limited evidence of crop response to general deep loosening soils unless for spring sown crops in sandy soils in years with low rainfall

After: Spoor and Godwin, 1978
Effect of wheel/track system on pressure at 250mm deep

After: Dresser and Godwin, 2006
Lower ground pressure:

+ Simple
+ Relatively inexpensive
+ Less working time and improved fuel economy, improved trafficability and manoeuvrability

- Pressure is applied (but lower)

Extra costs/tyres

Tractor - 280 hp : Ultraflex tyres extra = £1.50/ha
Combine: Ultraflex = £0.75/ha
Price offset by fuel savings (c.20%)

Personal communication: Brooks, Michelin

Extra costs tracks/combine

Combine: + £4 to £5/ha for 5 - 7 year life
Price offset by improved trafficability, narrower operating widths & operating up and down hills

Personal communication: Tyrell, Claas UK