Soil&Water Management Centre

Harper Adams University

Presentation 2

Subsoiling and Soil Management

Dick Godwin

Outline

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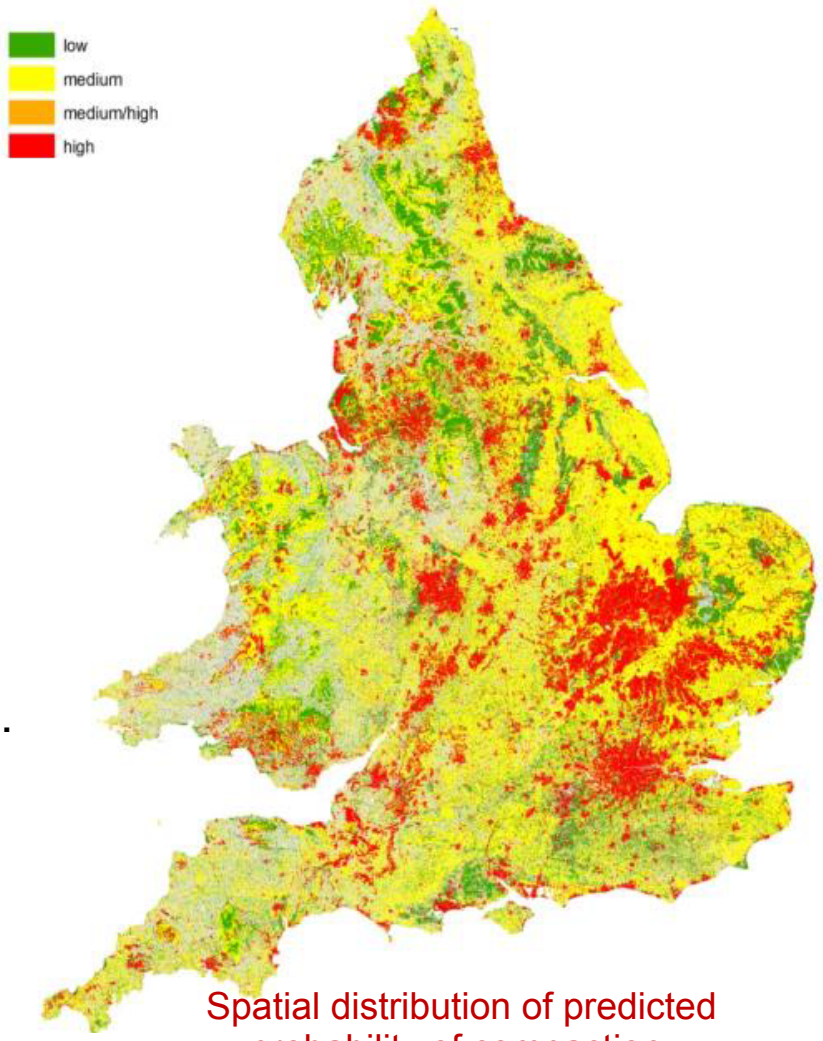
- Effects of structural damage
  - Yield
  - Tillage
  - Runoff/Erosion/Flooding
- Assessing structural damage
- Repairing structural damage
  - Moling and
  - Subsoiling
- Aftercare
  - Controlled traffic
  - Lower Ground Pressure
- Concluding comments

Cost of soil degradation in England and Wales

The assessment explored the total costs of soil degradation:

- The total quantified costs of soil degradation are estimated at between $1.5 bn and $ 2.0 bn per year.
- Compaction and loss of soil organic content account for 39% and 45% respectively of annual costs.
- Silts and sands account 67% of total estimated erosion costs, and clays and sands for 91% of compaction costs.
- Almost 80% of total quantified costs occur offsite.
- In terms of soilscapes, arable farming accounts for over 70% of erosion and compaction related costs.

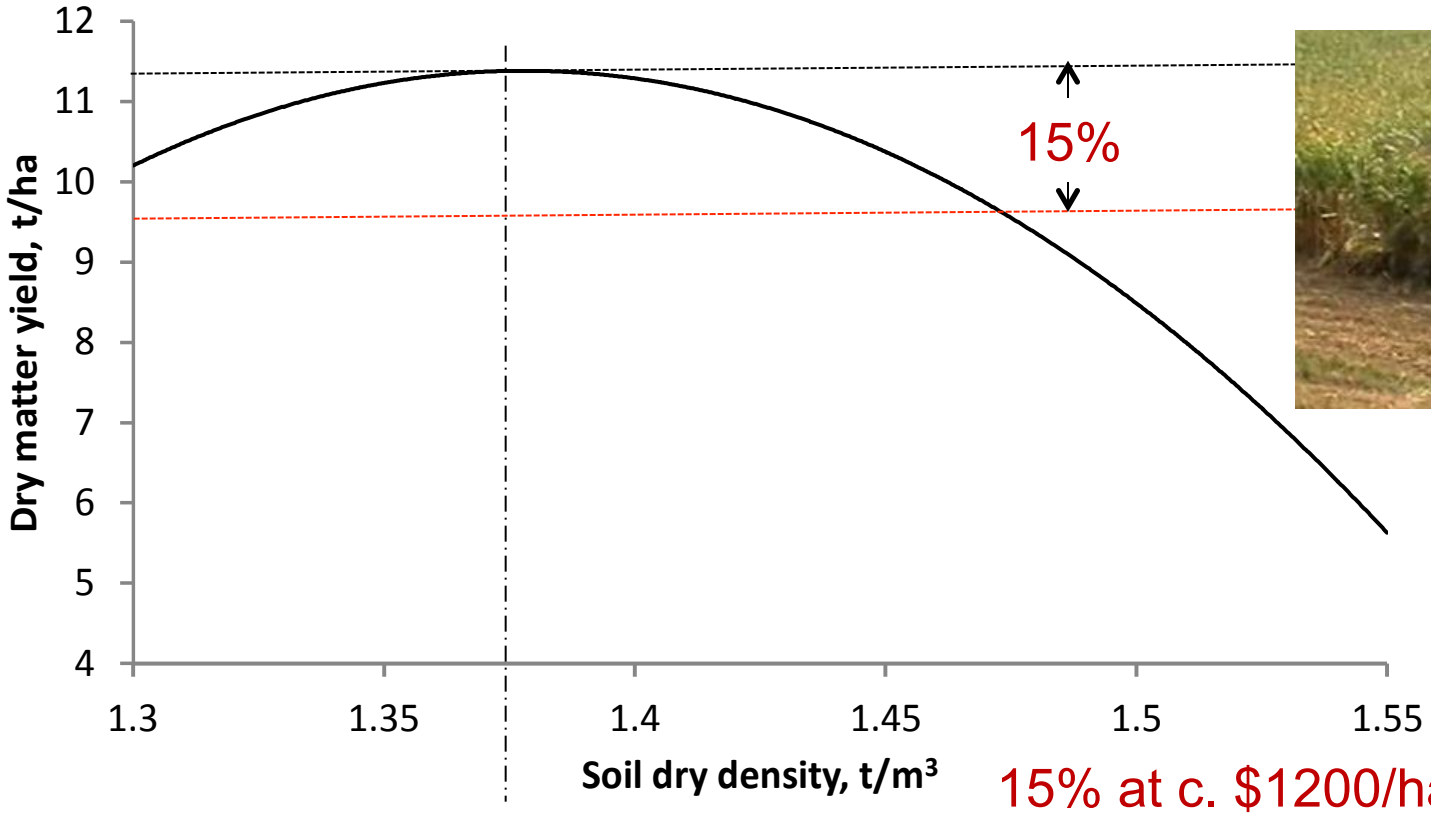


Spatial distribution of predicted probability of compaction

Defra Report CTE0946 by Cranfield University, 2011

Relationship between maize silage yield and soil bulk density (Quebec)

Sandy loam soil



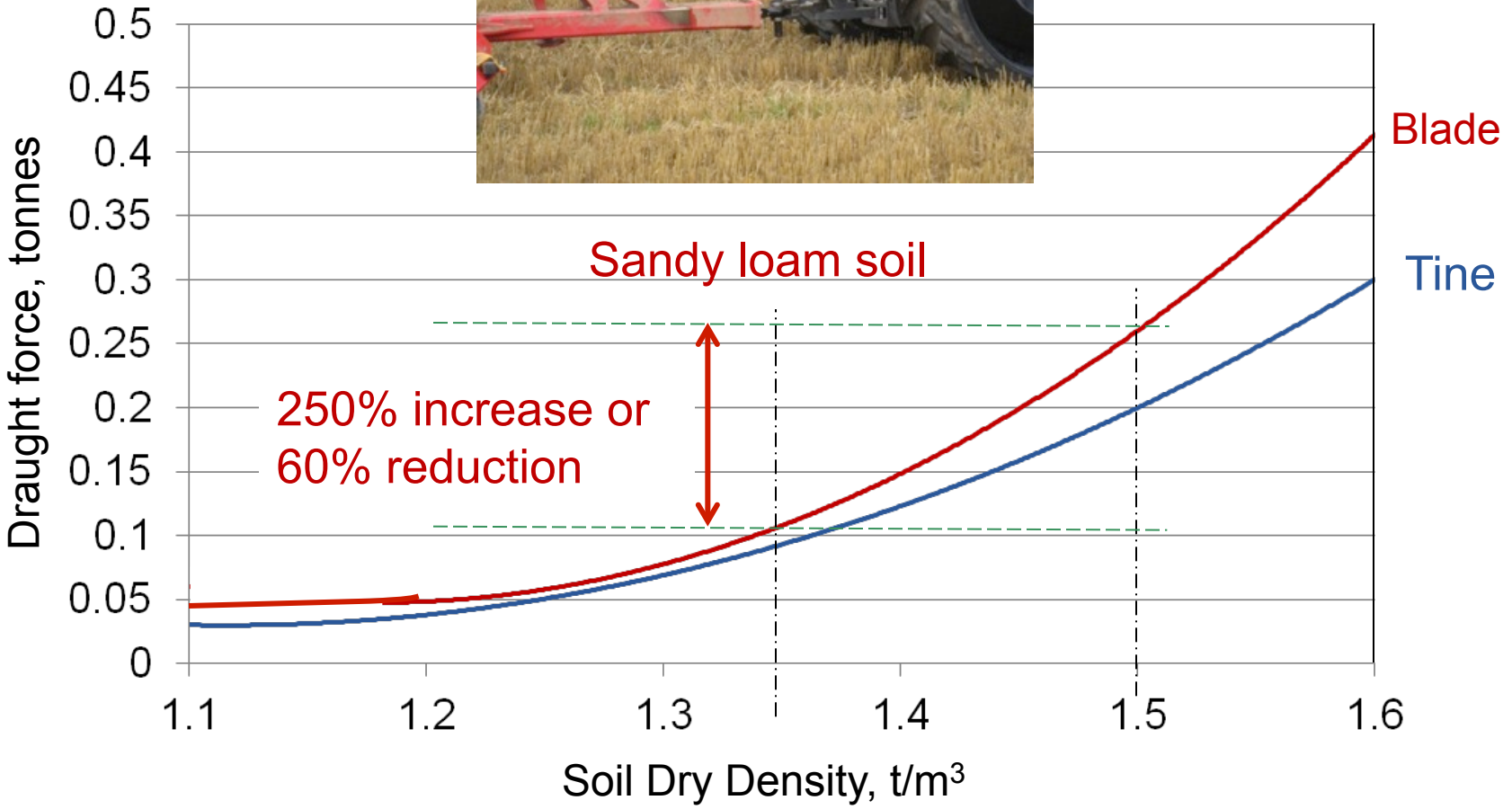
15% at c. \$1200/ha* = \$180/ha

1.7 t/ha (dm) at \$130/t** = \$220/ha

After: Negi et al, 1981

** Nix, 39th Edition **IGER Date???*

Relationship between draught force and soil bulk density



After: Godwin, 1974

Traffic control effects on energy/costs requirements (kWh/ha) (£/ha*)

**After: Nix 43rd Edition (2013) c.25p/kWh at 65% Tractive efficiency (Innes and Kilgour, 1980)*

No traffic		Trafficked	
Shallow plough 13 ($8)		Shallow plough 32.5 ($21)	
Harrow	7.0	Spring tine	16.0
Drill	7.5	Power Harrow	30.0
Roll	7.5	Harrow	8.0
		Drill	8.6
		Roll	8.4
TOTAL	22 ($15)		71($50)

A 60% reduction

A 70% reduction

After: Chamen, 1992

A serious problem

Runoff – Erosion – Poor Drainage – Flood Management

- Soil condition can radically affect rate of overland flow and can exacerbate surface water flooding, *Richard Smith, EA*
- Poor soil condition is widespread in South West, *Richard Smith, EA*
- Soil loss – no protection 3-5 t/ha/year - Soil regeneration 1 t/ha/year
- Drainage installation 1980 ~ 150,000 ha/year - Now 5,000 ha/year
- 40,000 homes and 7,000 businesses in Severn region were affected by flooding in June-July 2007

Relationship between compaction and infiltration rate

1.42 1.58 1.62 1.62

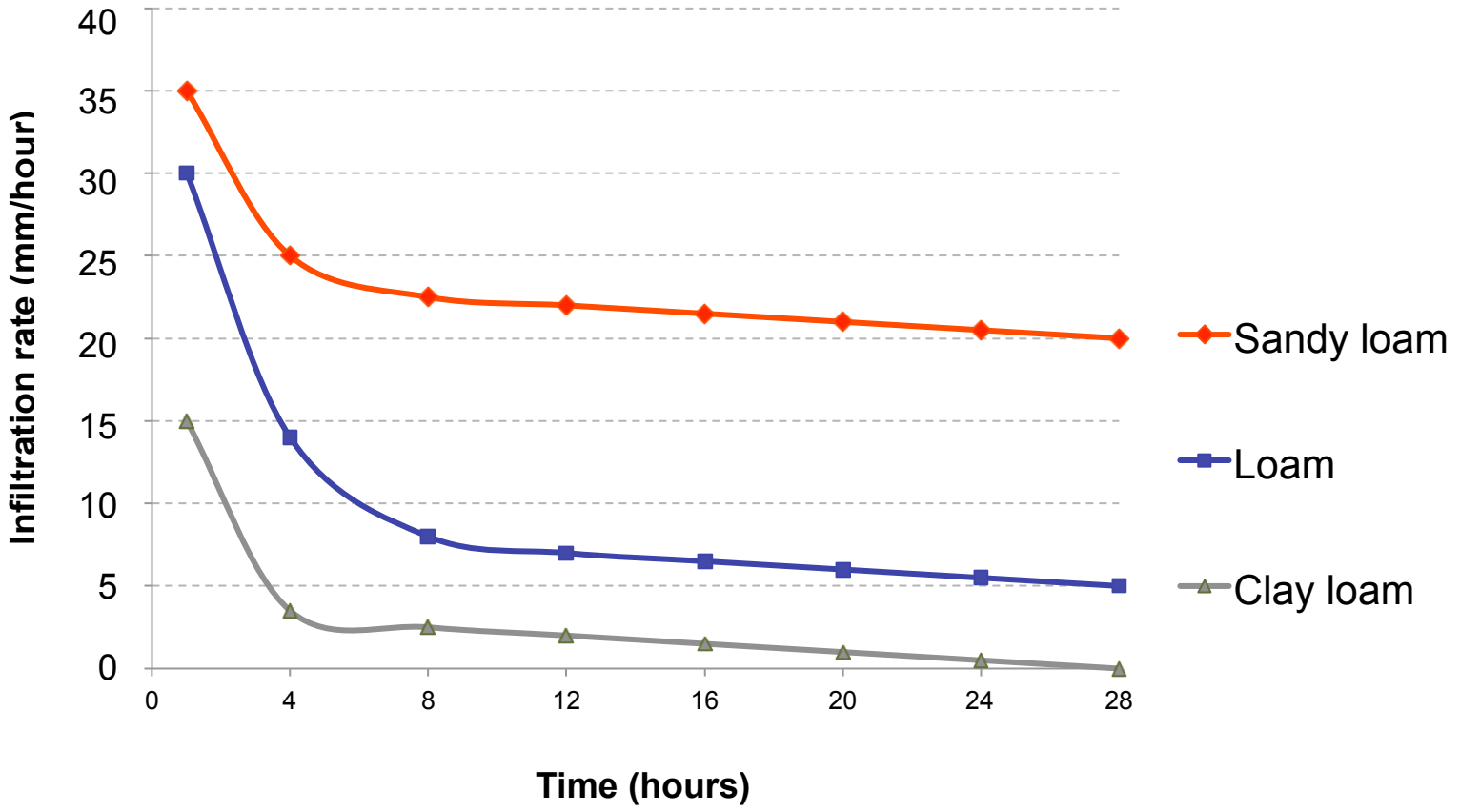
Soil Density g/cc

After: Chyba, 2012

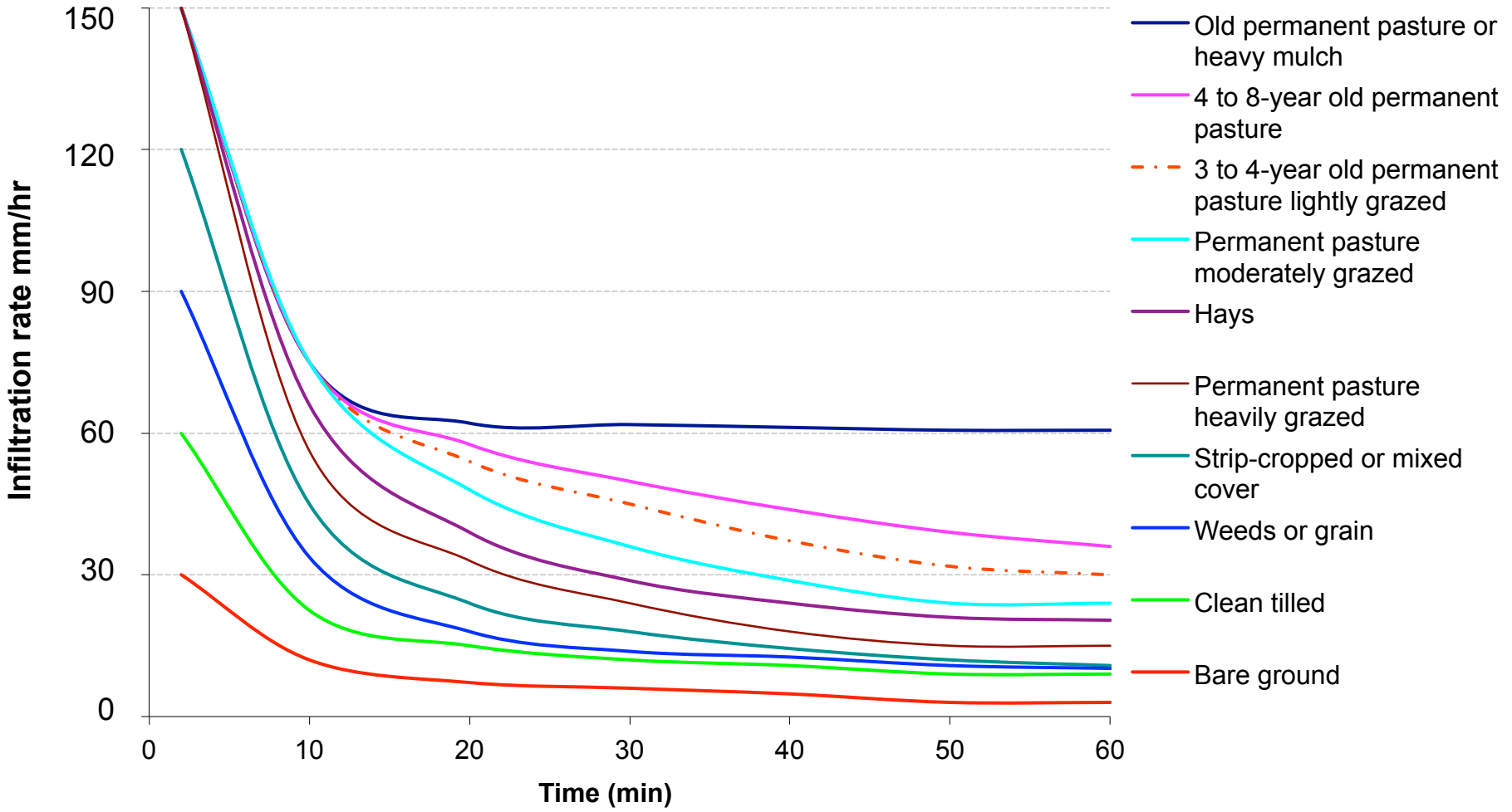
Infiltration ~ soil type

Main factors affecting infiltration

- Soil type
- Vegetation/surface cover



Infiltration ~ surface cover



Effect of infiltration rate on runoff

Parrett and Tone Catchment, Dorset/Somerset @ Haselbury Plucknet/Chiselborough

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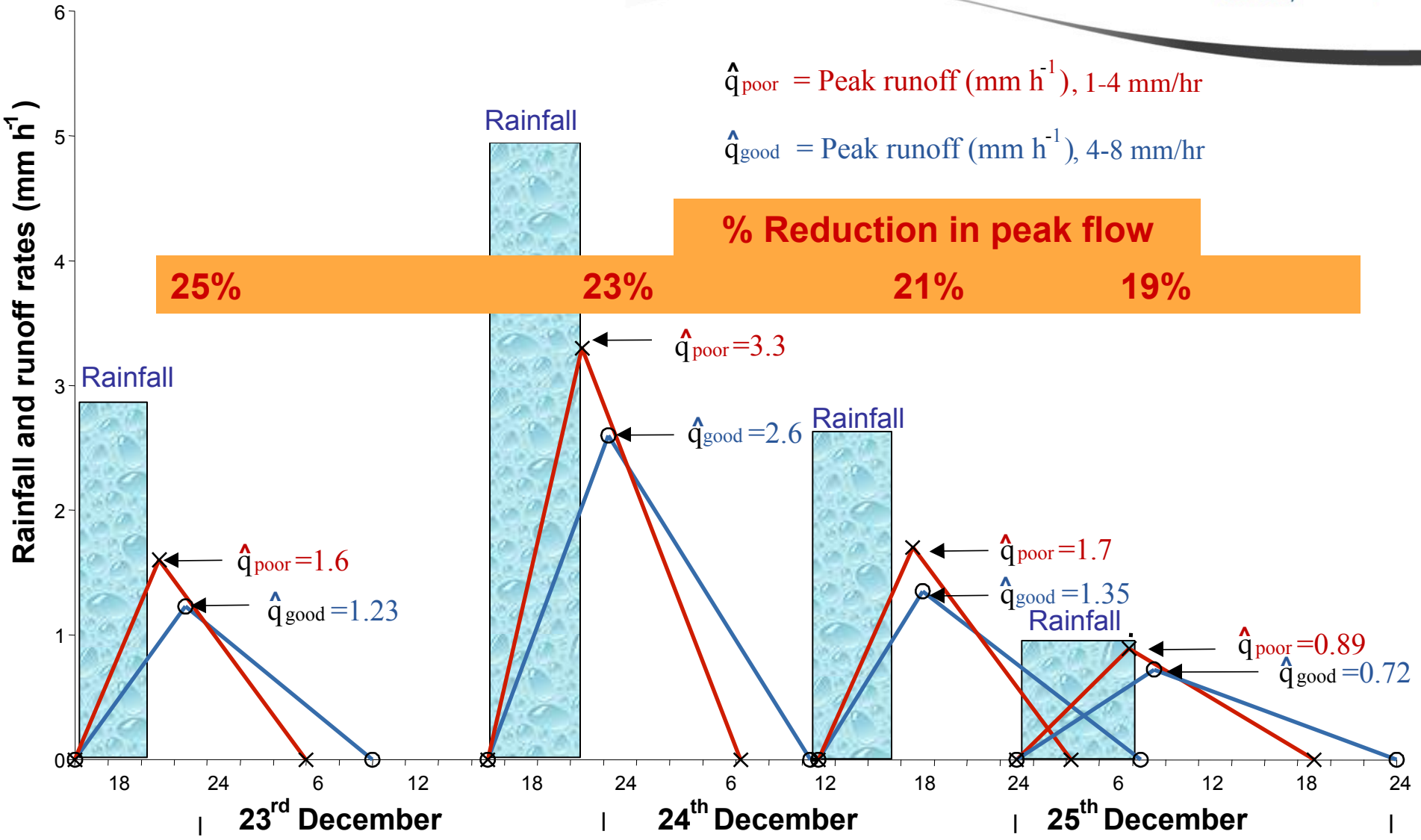

After: Godwin and Dresser, 2003 *From: Schwab et al., 1993*

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Assessing soil structure

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Root development

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Evaluation of structural damage

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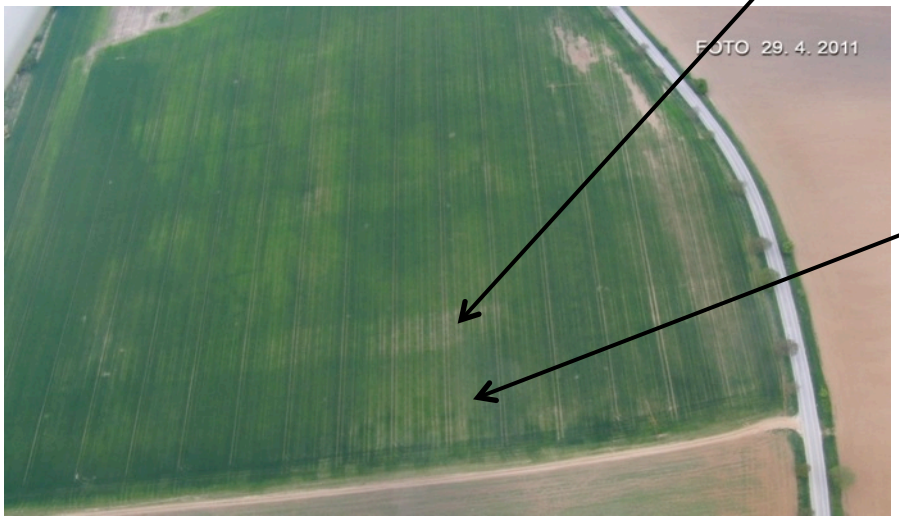
Profile pit

Penetrometer

Electromagnetic Induction

Conductometer 0.3m and 0.9m ranges

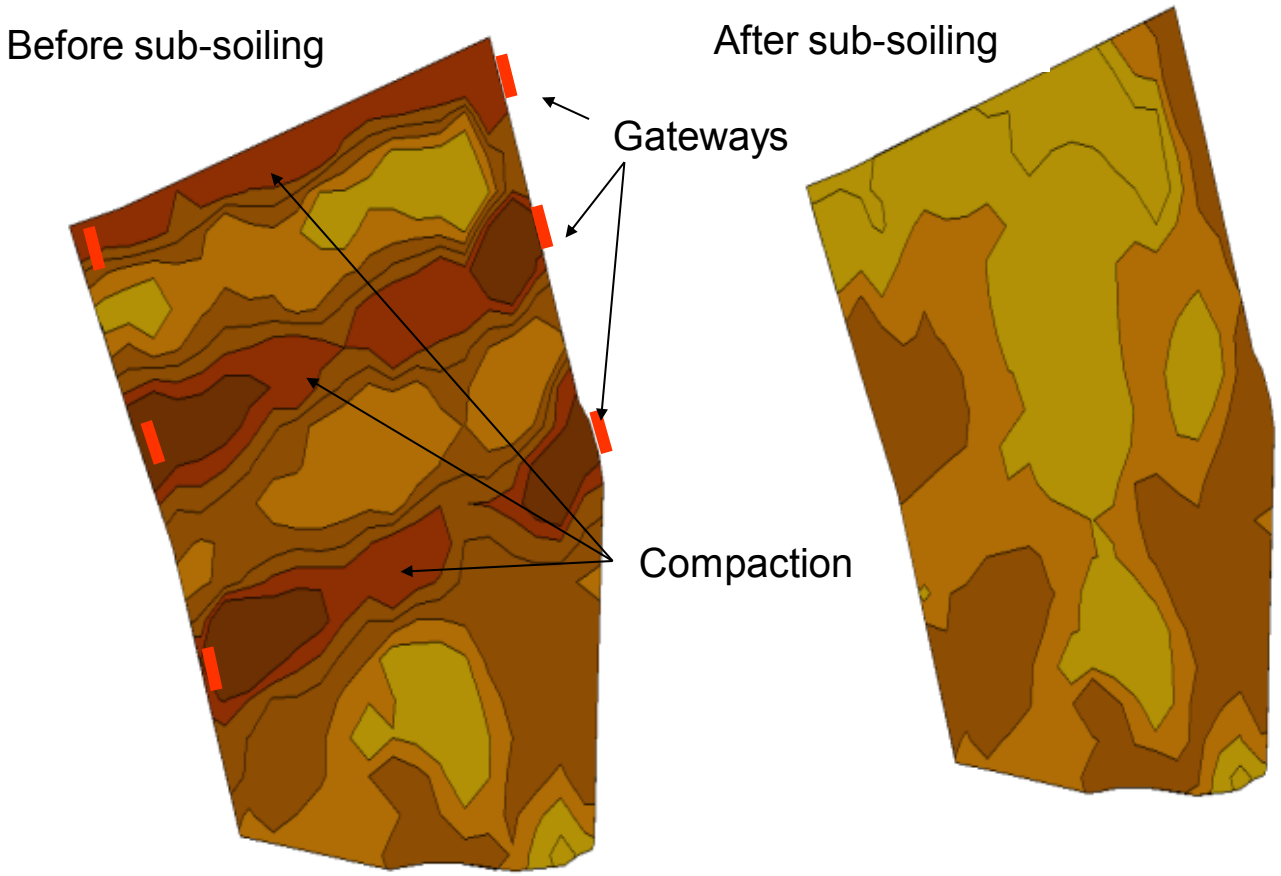
Assessing soil structure



Source: Chamen, 2011

EMI survey data.

(After: Smith, 2001)

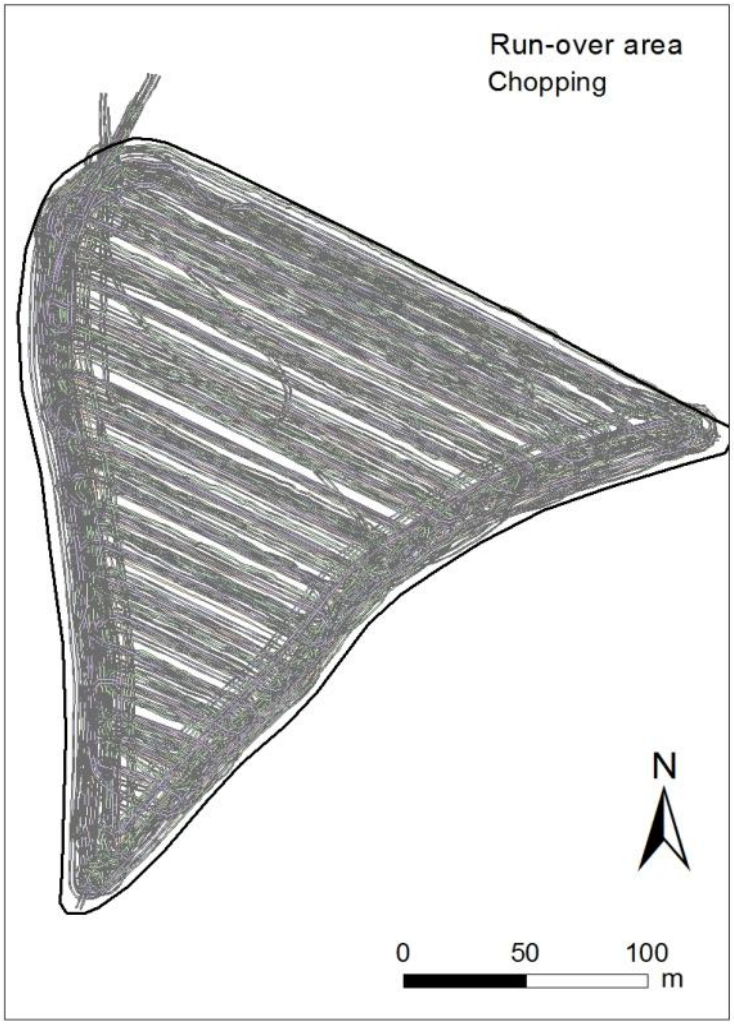


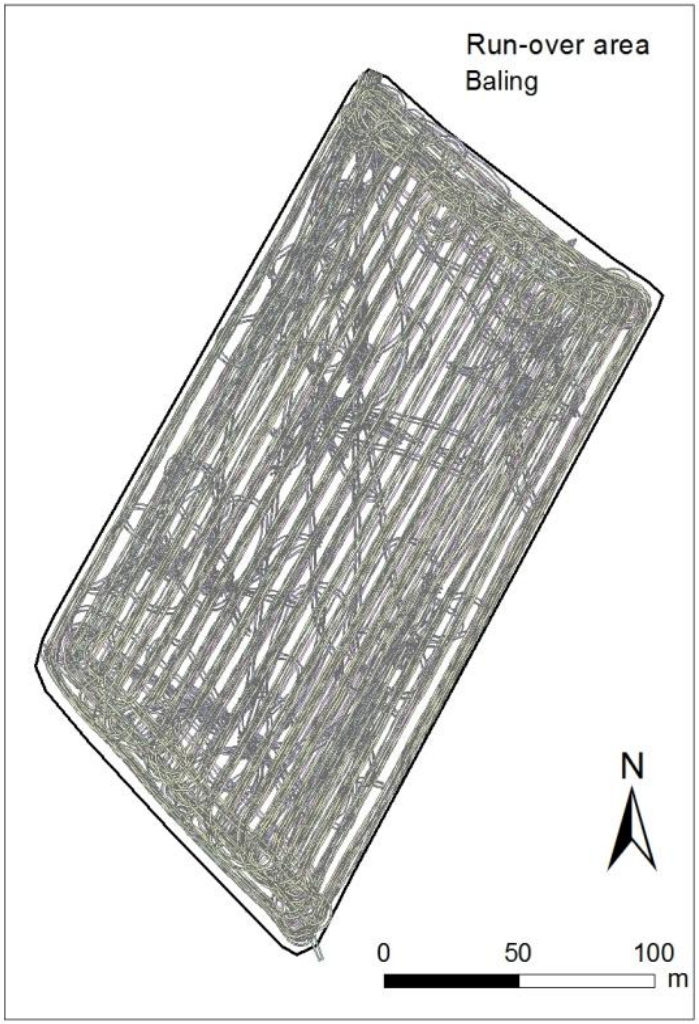
Wheel traffic

Chamen, 2015

Comparison of forage chopper harvester and round baler traffic

63.8% and 63.4% respectively





Subsoiling

Plain tine

Wide point, high lift wing

Narrow point, low lift wing

After: Spoor and Godwin, 1978

Soil looseners

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Chisel tine (Shakerator)

Conventional Subsoiler

High lift Winged Subsoiler

Low lift wings + leading disc

Paraplow

Moleplough

Soil failure

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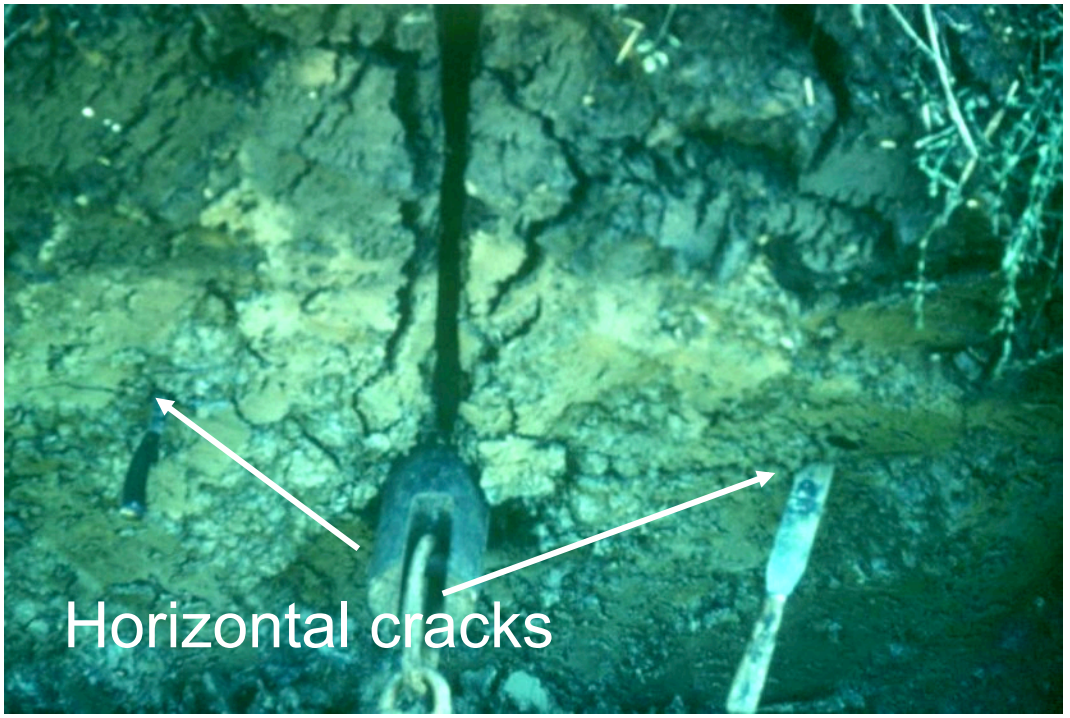
Herringbone cracks



After: Spoor and Godwin, 1978

Mole plough & Herringbone cracks

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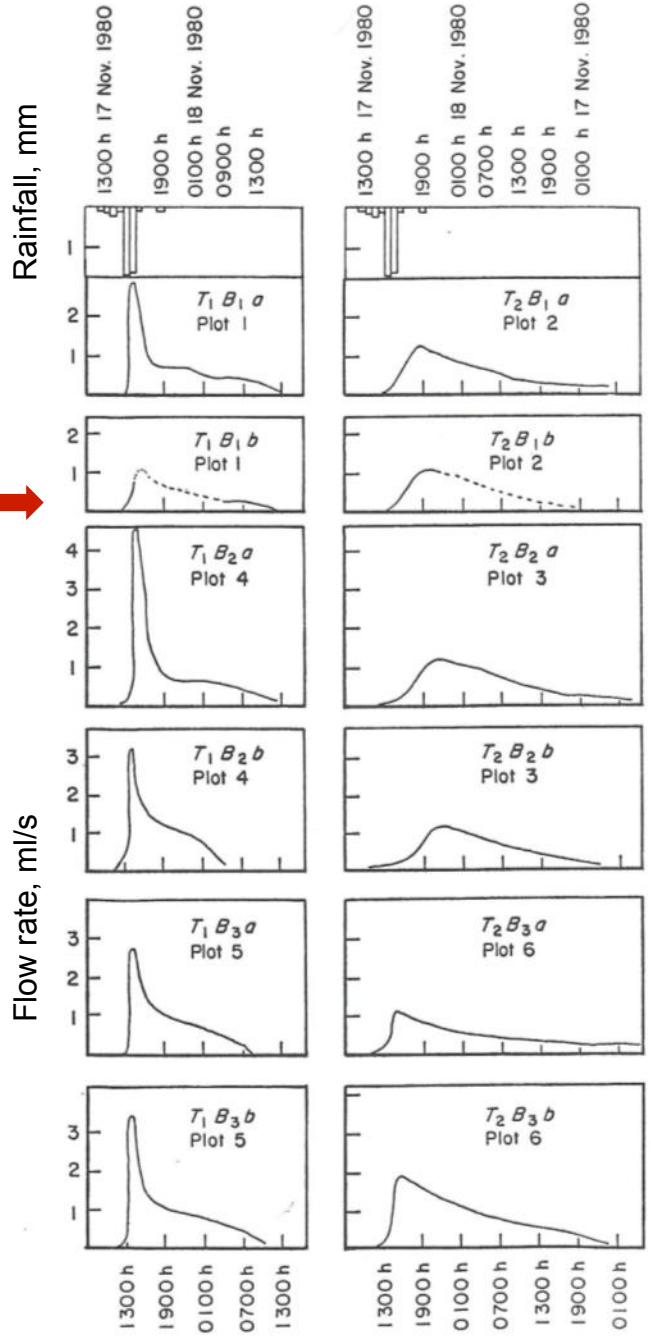
Hydrograph of mole drain discharge with leg fissures



Hydrograph of mole drain discharge without leg fissures

After: Leeds Harrison, Spoor & Godwin, 1982

Subsoiler
Draught Force. v. Depth

Subsoiling after rubber tracks at 350mm 88hp

Subsoiling after tyres at 450mm 240 hp

63% Reduction

Draft force (kN)

0 5 10 15 20 25 30 35 40

0 100 200 300 400 500

Depth (mm)

Tyre

Track

After: Ansorge and Godwin, 2007

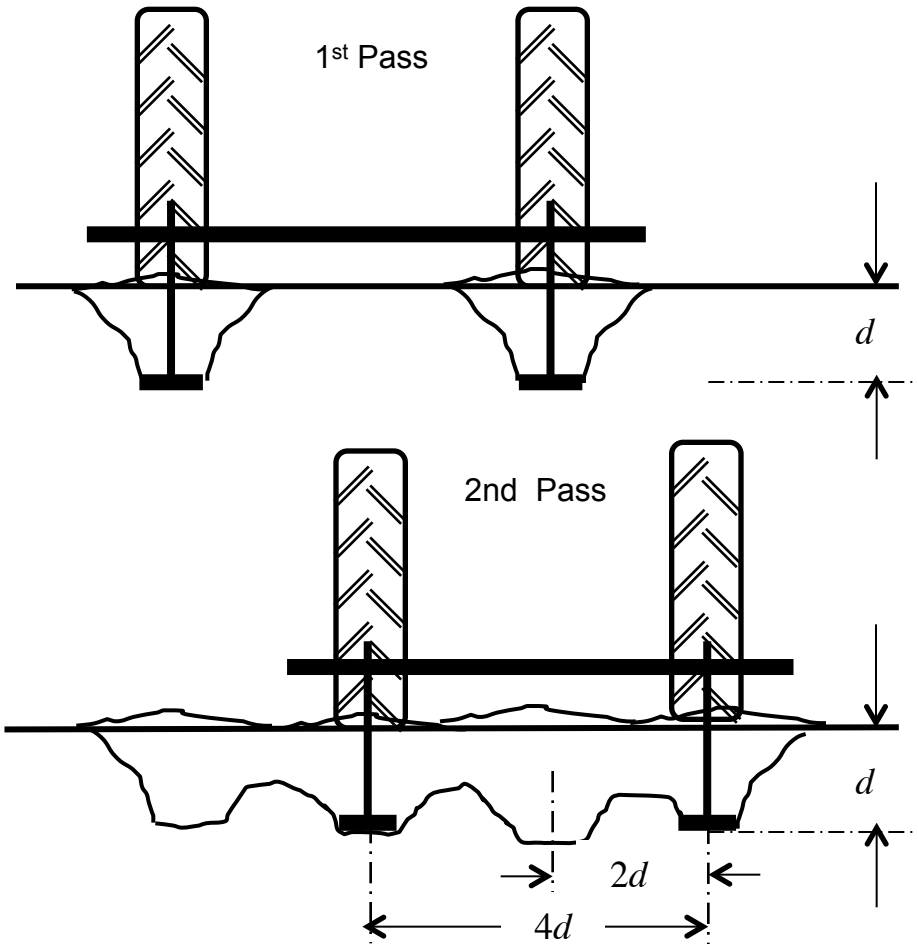
Tractor Implement Matching

Table 5.1. Approximate Wheeled Tractor Capability for operating loosening tines.
After: Spoor and Godwin, 1990.

Tractor size		**Capability**	
Engine power, hp/kW	Ballasted weight, tonnes	Working depth, m	Number of tines, n
150/110	7.50	0.50 – 0.60	1
		0.35 – 0.45	2
		0.30 – 0.35	3
250/185	12.50	0.45 – 0.55	2
		0.40 – 0.45	3
		0.35 – 0.40	4
		0.30 – 0.35	5
350/260	17.50	0.45 – 0.55	4
		0.40 – 0.45	5
		0.35 – 0.40	6
		0.30 – 0.35	7

Track-laying tractors, of similar power pull 50% more tines at the same depth
or
tine depth can be increased by up to 20%.

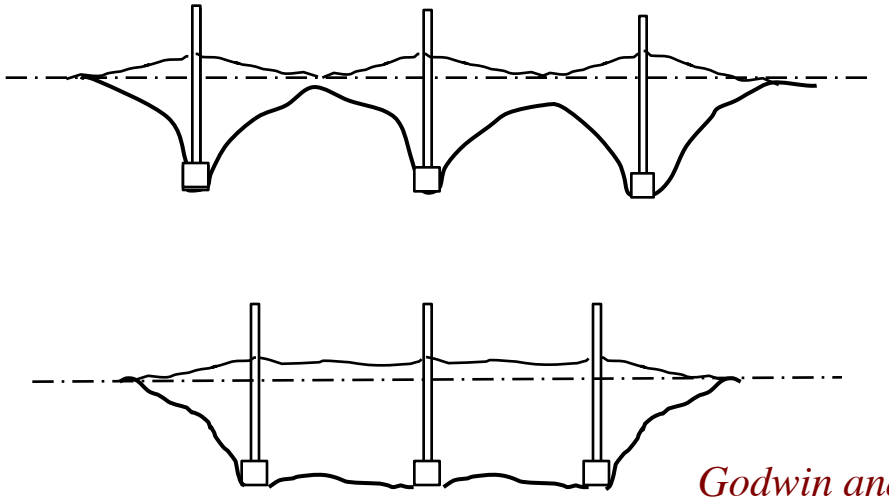
Double pass system



Godwin and Spoor, 2015

In field evaluation of effective loosening

- Visual evaluation need not be conducted in every field if soil types and conditions are similar.
- The visual assessment of surface level provides a simple guide as to the appropriateness of tine spacing.
- If the surface elevation appears to show distinct heave then tine spacing is too wide.
- An even lifting of the soil surface usually indicates a uniformity of loosening and porosity increase.



Godwin and Spoor, 2015

In field evaluation of effective loosening

The following procedure has been found to be effective:

1.Observe the soil flow and surface level during and after a short test run. Where the whole soil area between adjacent tines lifts uniformly, soil breakout at depth is likely to be fairly complete.

2.Excavate a trench across two tines or more to below their working depth. Facing the direction of implement travel, the disturbed soil can be pulled away from the face with a spade to expose the limits of soil disturbance.

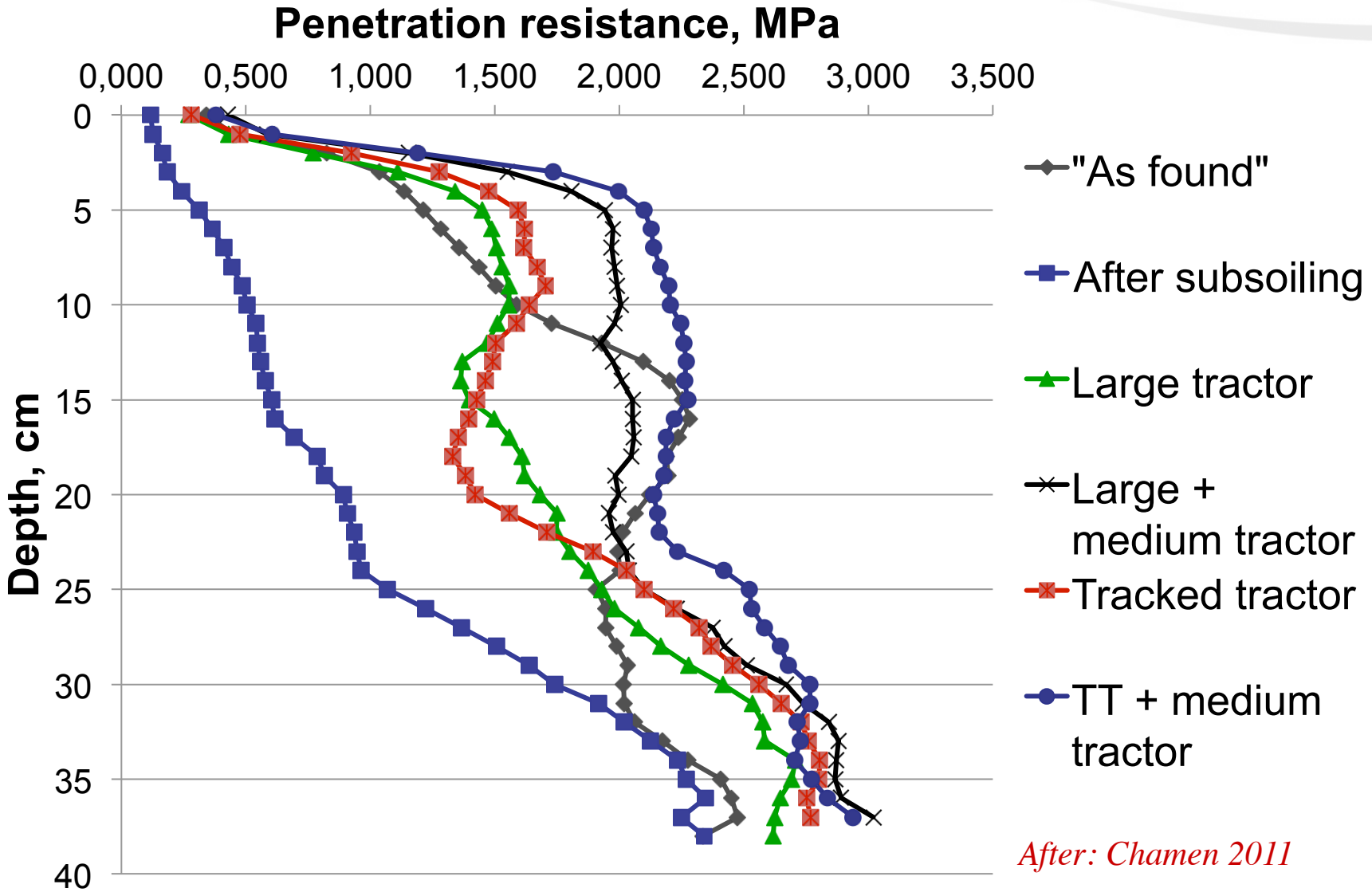
3. Following any adjustments, repeat the run, making surface observations as before. Checks on any new disturbance boundary at depth can be made by pushing a rod or penetrometer into the loosened profile.

4. Use a crow bar or fencing stake to partially take the weight of the leg whilst sliding the tine along the toolbar.

5.This process is repeated until the implement setting appears correct, after which a final trench excavation is made for confirmation of the result.

Godwin and Spoor, 2015

Subsequent traffic can destroy good loosening!



After: Chamen 2011

Issues of aftercare

A single mouldboard ploughing operation, can re-compact the soil to a greater density than before loosening.

To overcome this:-

1.Adopt a single pass system: deep loosening + surface cultivation + drilling where the seed is dribbled down within the working width of the subsoiler.

2.As soil loosening after mouldboard ploughing is not an easy operation use a mouldboard plough fitted with “under-buster” tines.

Other alternatives are to:

1.Reduce the weight and inflation pressure using lo[illegible] systems, or

2.Restrict field traffic to pre-determined lanes within the field, controlled traffic.

Random Traffic Problems

Extensive areas of the field are exposed to trafficking

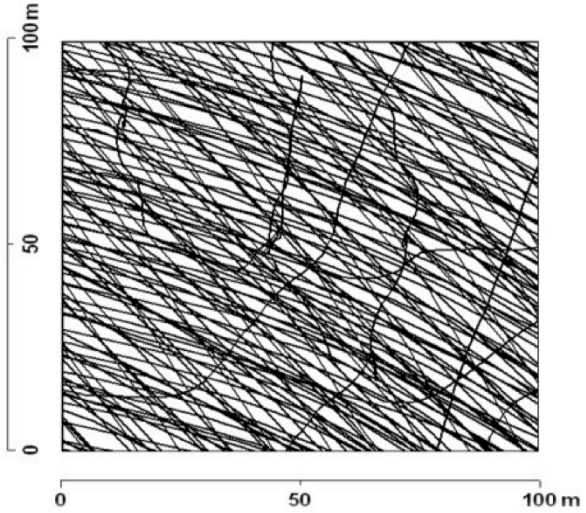
Random Traffic

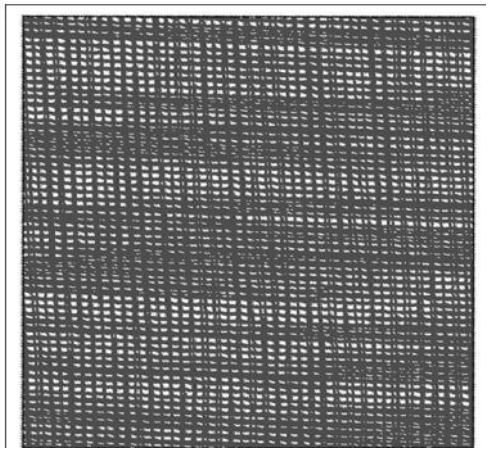
+ Plough = 85% covered

+ Minimum Tillage = 65% covered

+ Direct Drilling = 45% covered

Wheat, Czech Republic





Potatoes , UK

Kroulik, M., 2012, Sabbatical Study at Harper Adams University,

Lower Ground Pressure: Tyres and Rubber Tracks

+ Simple

+ Cheap

+ Less working time and improved fuel economy, trafficability and manoeuvrability

- Pressure is applied (but lower)

Extra costs tyres

Tractor - 280 hp : Ultraflex tyres extra = $1.5/ha

Combine: Ultraflex = $0.75/ha

Price offset by fuel savings (c.20%)

Personal communication: Mozziconacci, Michelin

Extra costs tracks

Combine: + $5 to $6/ha for 5 - 7 year life

Price offset by improved trafficability, narrower operating widths & operating up and down hills

Personal communication: Tyrell, Claas UK

Whole Machine Comparison

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11 t

Deformation (mm)

0 40 60 80 100 120

Depth (mm)

0 100 200 300 400 500 600 700 800

30 t

900 followed by 500
900 followed by 700
Track followed by 500
Track followed by 700
Dominator 130
LSD

33 t

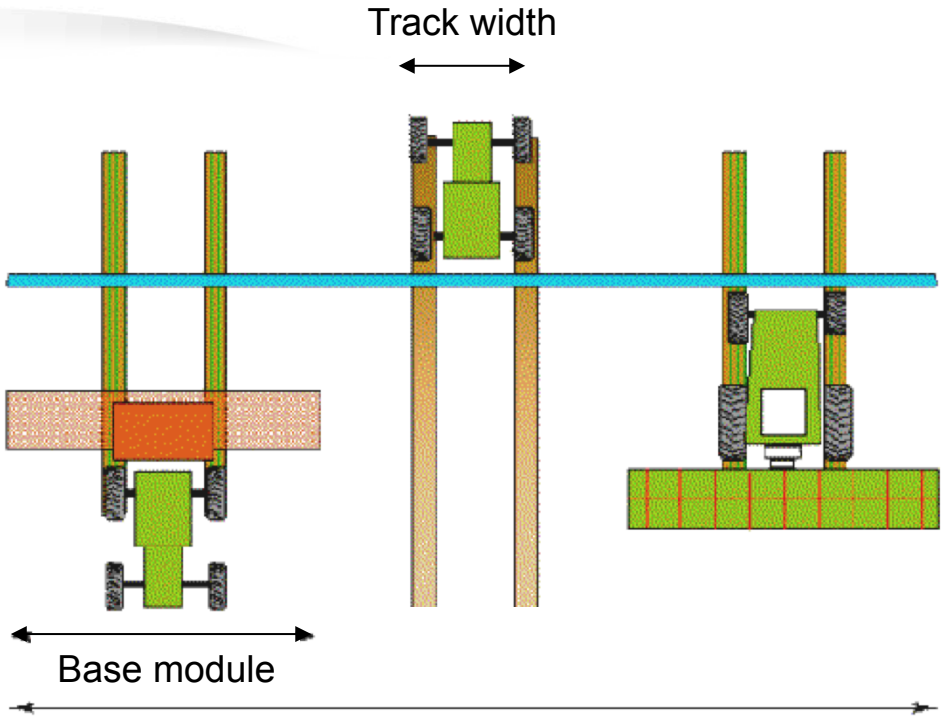
Sub-soil Pressure
at 0.3m deep

Challenger 765C 16t

MF 8480 Tractor 12.2t

Smith, E., Misiwicz, P. A., White, D. J., Chaney, K and Godwin, R. J., 2013,
Effect of traffic and tillage on soil properties and crop yield. Paper No 1597846, ASABE International Meeting, Kansas City.

Controlled Traffic Farming



- ✓ **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 steering
- ✗ **Track width** and **harvester width** matching

Source: CTF Europe

Traffic and Tillage Systems Study

Harper Adams University

Aim: To compare the effects of alternative traffic and tillage systems on crop yield, energy and economics, water holding and infiltration rates over an extended period circa 10 years.

- 3 x 3 Factorial
- 4 blocks
- 9 treatments

  80m x 4m
- Long term trials

  10 years+
- Prepared site

Tillage	Random High Pressure Traffic	Controlled Traffic	Random Low Pressure Traffic
	Conventional	Conventional	Conventional
	Minimum	Minimum	Minimum
	Direct drill	Direct drill	Direct drill

Smith, E., Misiwicz, P. A., White, D. J., Chaney, K and Godwin, R. J., 2013, Effect of traffic and tillage on soil properties and crop yield . ASABE International Meeting, Kansas City.

RTF Deep Tillage

RTF Shallow Tillage

RTF No-till Tillage

LGP Deep Tillage

LGP Shallow Tillage

LGP No-till Tillage

CTF Deep Tillage

CTF Shallow Tillage

CTF No-till Tillage

Harper Adams University

No-till had a problem in wheel marks in all traffic systems

Drilled late (November 9th 2012) into wet soil with disc drill

Winter wheat – 29th May 2013

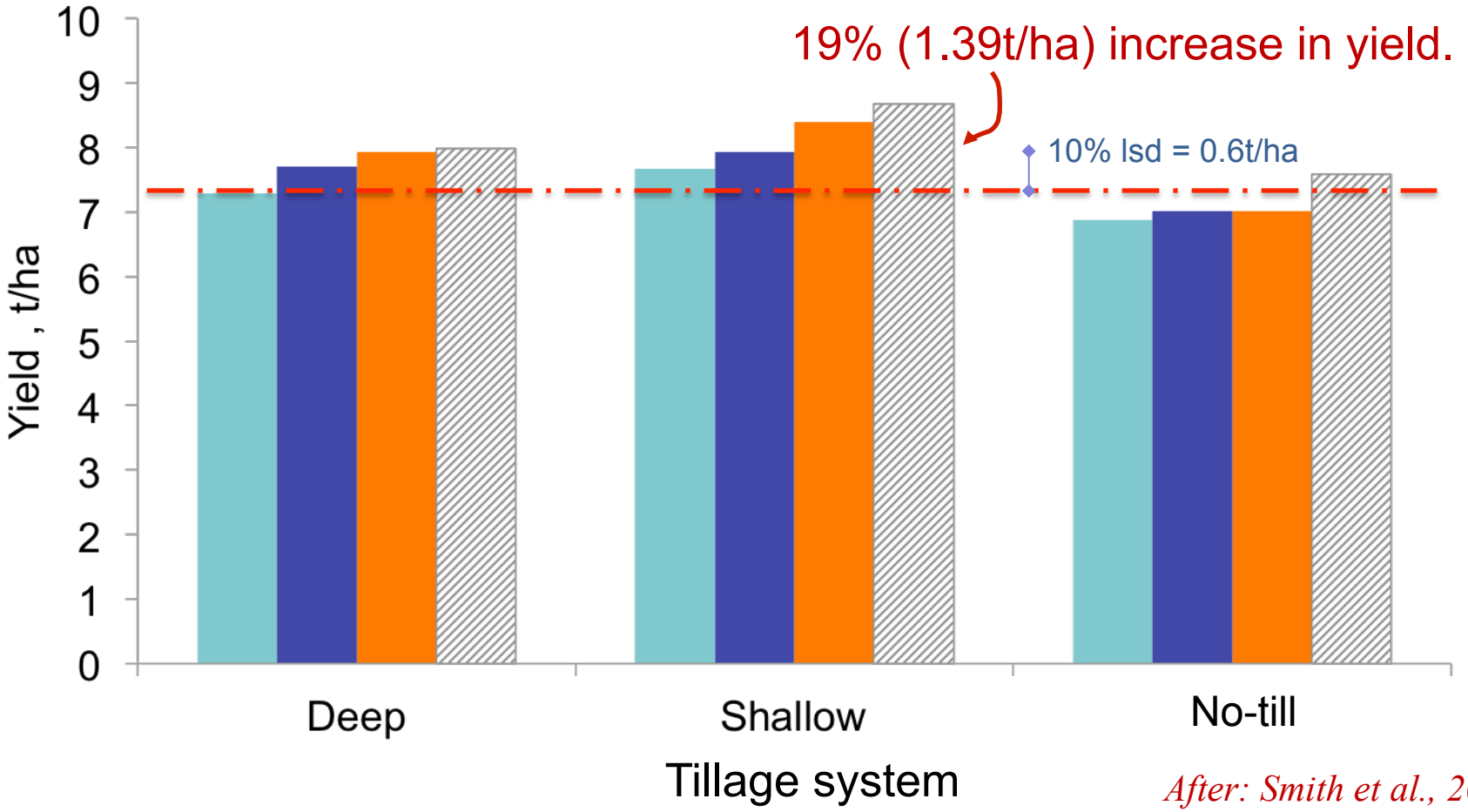
After: Smith, Misiewicz, Chaney, White & Godwin, 2013

Tillage v Traffic Study
Winter Wheat Yield

Combine harvester results

Harper Adams University

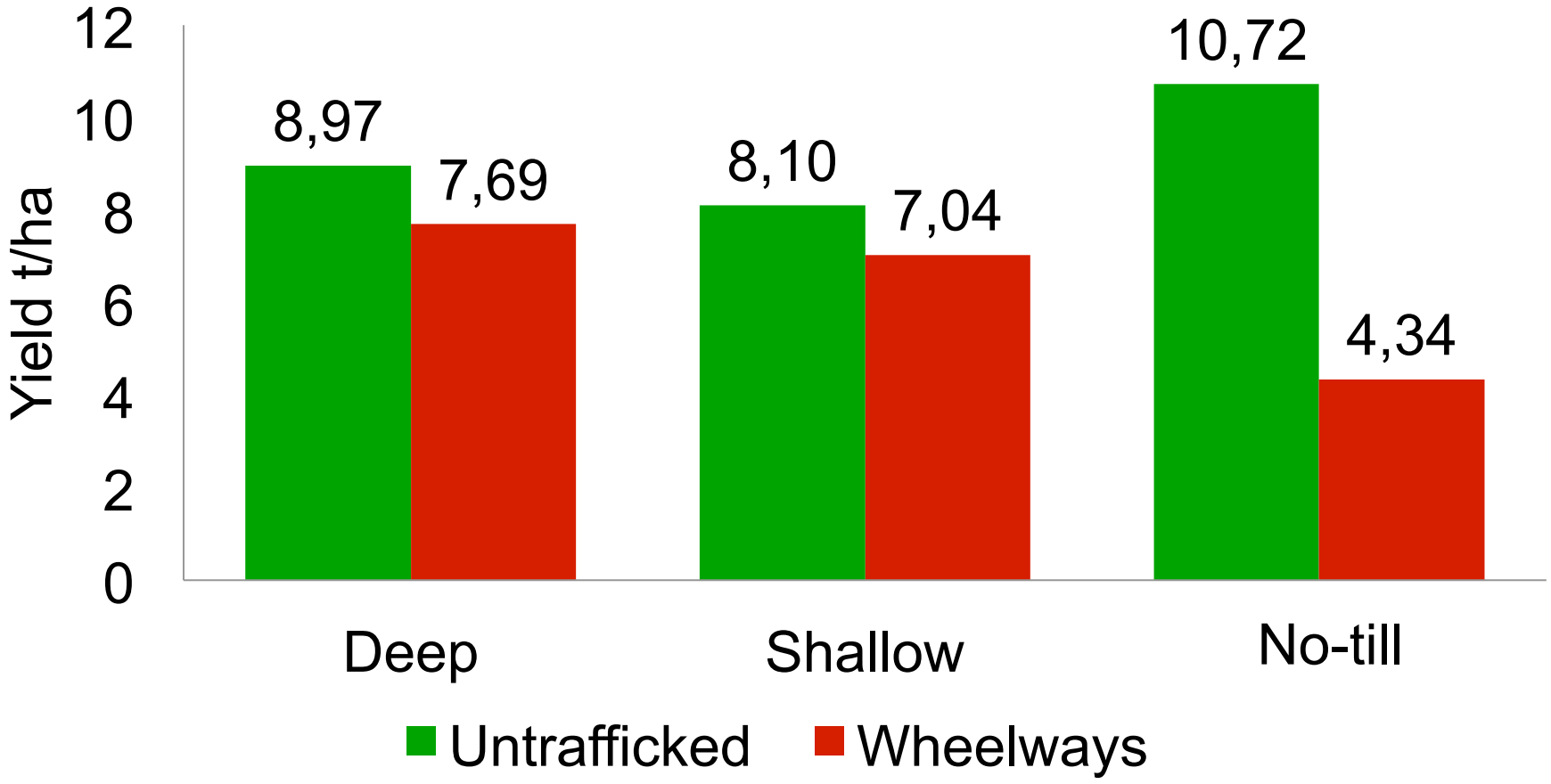
RTF LGP CTF 30% CTF 15% (Estimated)



After: Smith et al., 2014

Tillage and Traffic Study
Winter Wheat Yield
Hand Sample Results

Harper Adams University



Untrafficked yields significantly higher than wheelways ($p<0.05$)

CTF can make a difference to soil structure

After: Chamen, 2011

Concluding remarks

- Compaction
  - Can reduce yield by 10-15%
  - Increases tillage energy, time and costs by 200-300%
  - Reduces infiltration by and hence increases runoff and flooding
- Improved soil and water management is achieved by
  - Reducing contact pressure, and
  - Reducing traffic intensity
  - These costs are small in comparison to the potential economic benefits
  - Ensure adequate drainage
- Remember prevention is better than cure
  - However, if all else fails equipment/techniques are available to alleviate compaction
  - But take care on freshly loosened soil as it is vulnerable to re-compaction.

Final Reflection

"Man has only a thin layer of soil between him and starvation".

Anonymous

"The nation that destroys its soils, destroys itself".

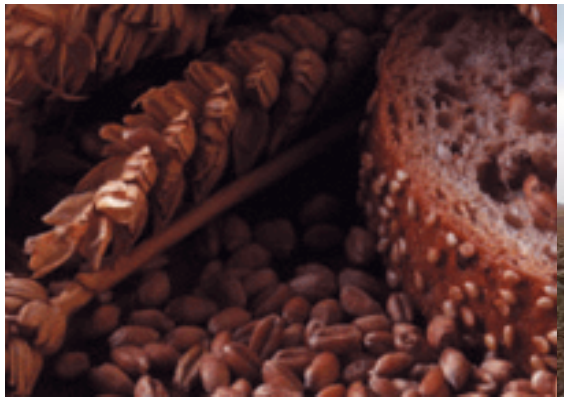
F. D. Roosevelt

"There can be no doubt that a society rooted in the soil is more stable than one rooted in pavements"

Aldo Leopold

"To forget our soil is to forget ourselves"

Ghandi



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