

Improving Soil and Water Management Practices

Richard J. Godwin



Outline



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1. Costs of poor soil management

- Yield loss
- Tillage energy increases
- Runoff/Erosion/Flooding

2. Restoration principles

3. Traffic management

4. Concluding comments



Background

Cost of Compaction in England & Wales



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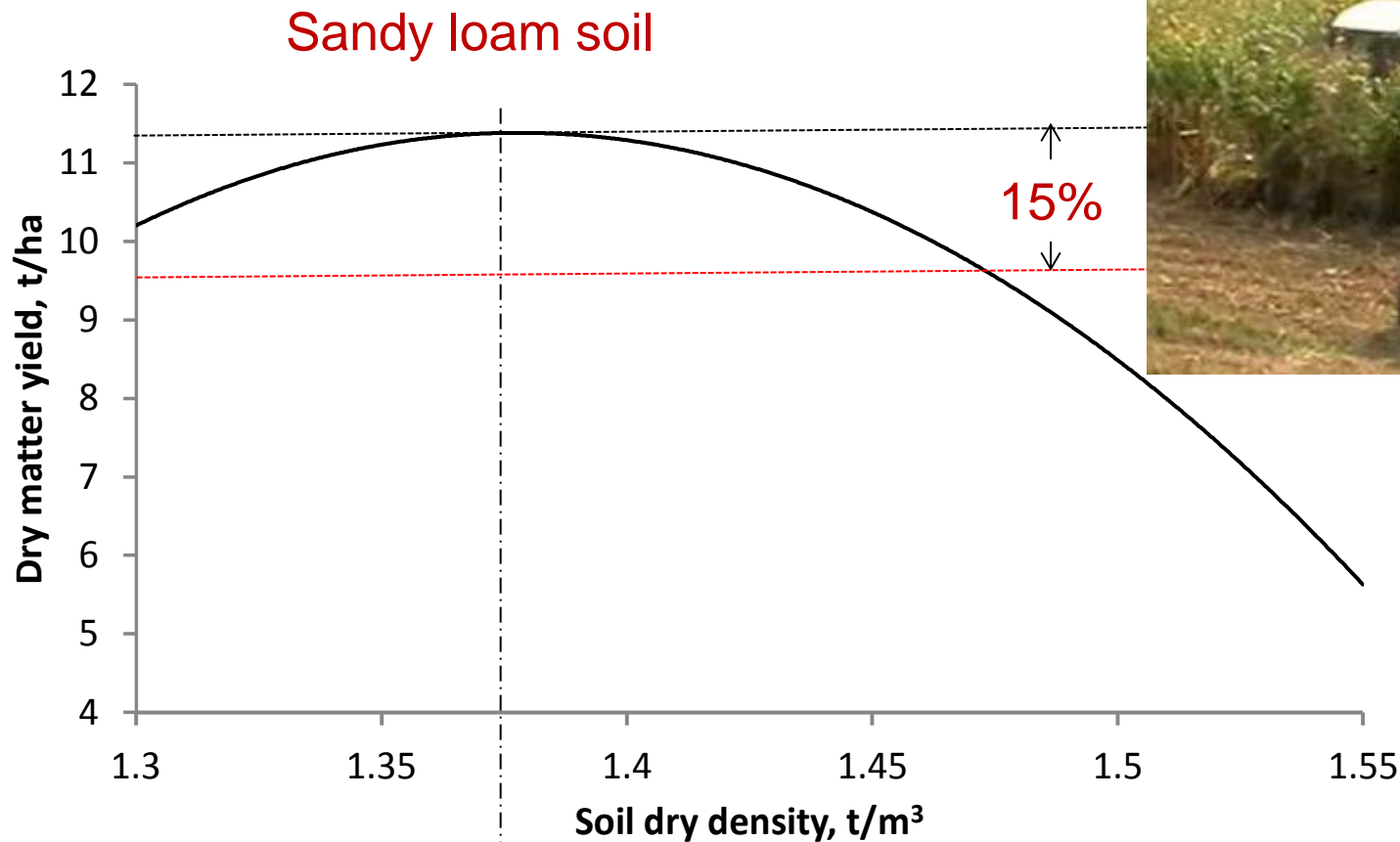
€1.5bn – €2bn/year

(After: Cranfield University, 2011)

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



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15% yield loss* = €150/ha

After: Negi, McKyes, Raghavan & Taylor 1981

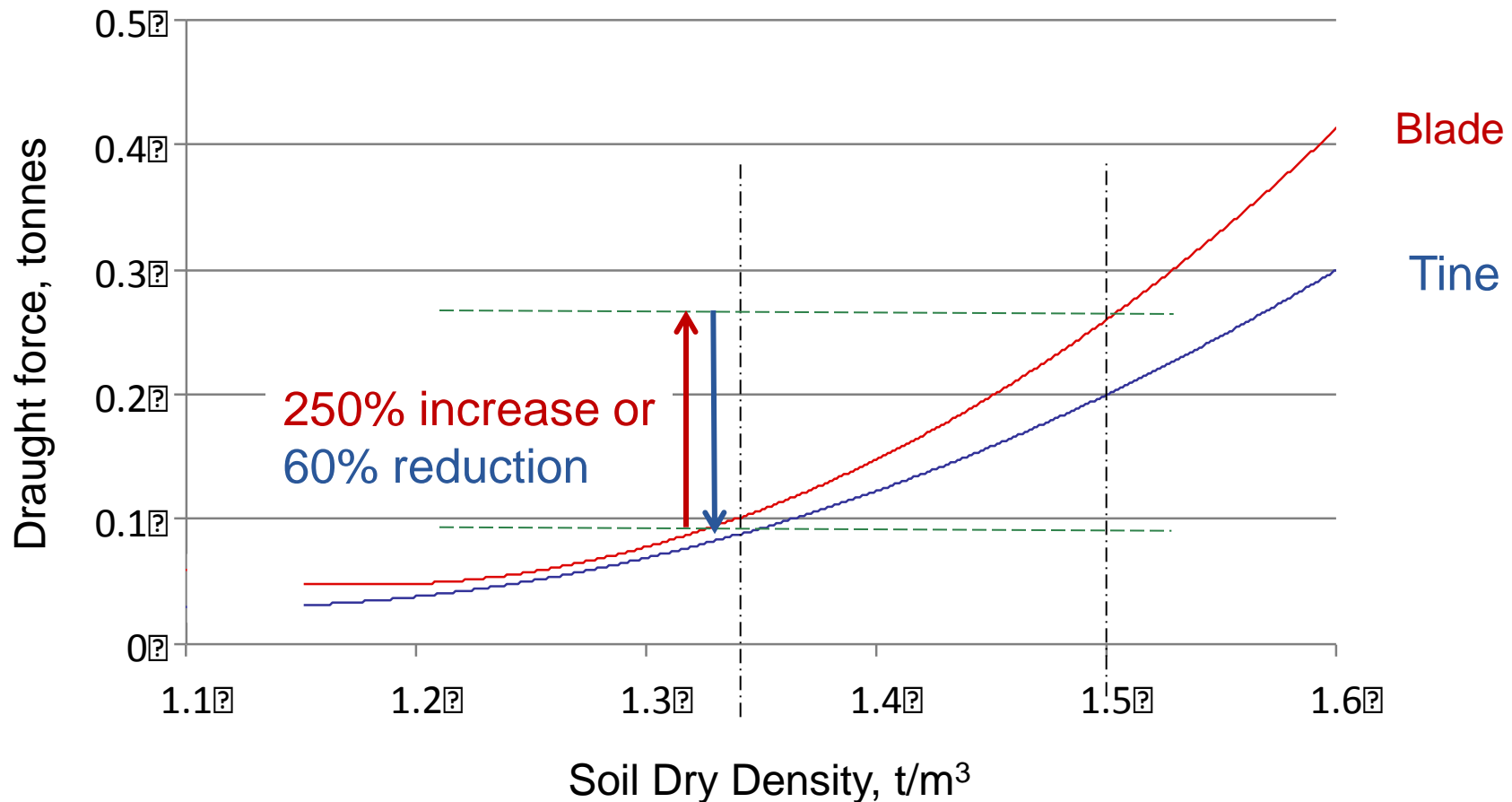
** Nix, 39th Edition*

Relationship between draught force and soil bulk density



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Sandy loam soil



After: Godwin, 1974

Traffic control effects on energy requirements (kWh/ha)

& COSTS (€/ha*)

**After: Nix 43rd Edition (2013) c.€0.45/kWh
at 65% Tractive efficiency (Innes and Kilgour, 1980)*



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No traffic

Trafficked

Shallow plough 13 (€8.5)

Shallow plough 32.5 (€22)

A 60% reduction

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)

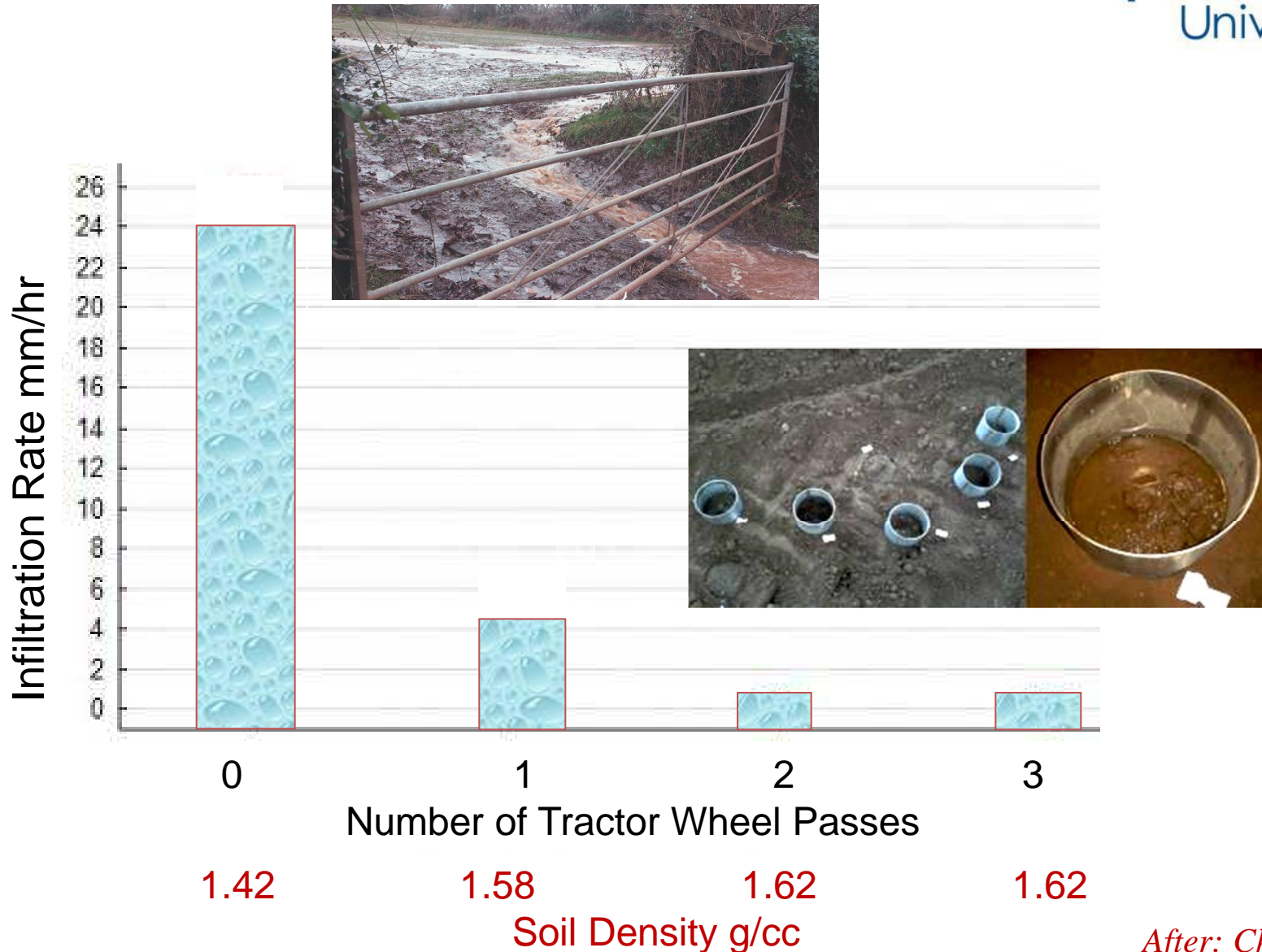
71 (€50)

A 70% reduction

Relationship between compaction and infiltration rate



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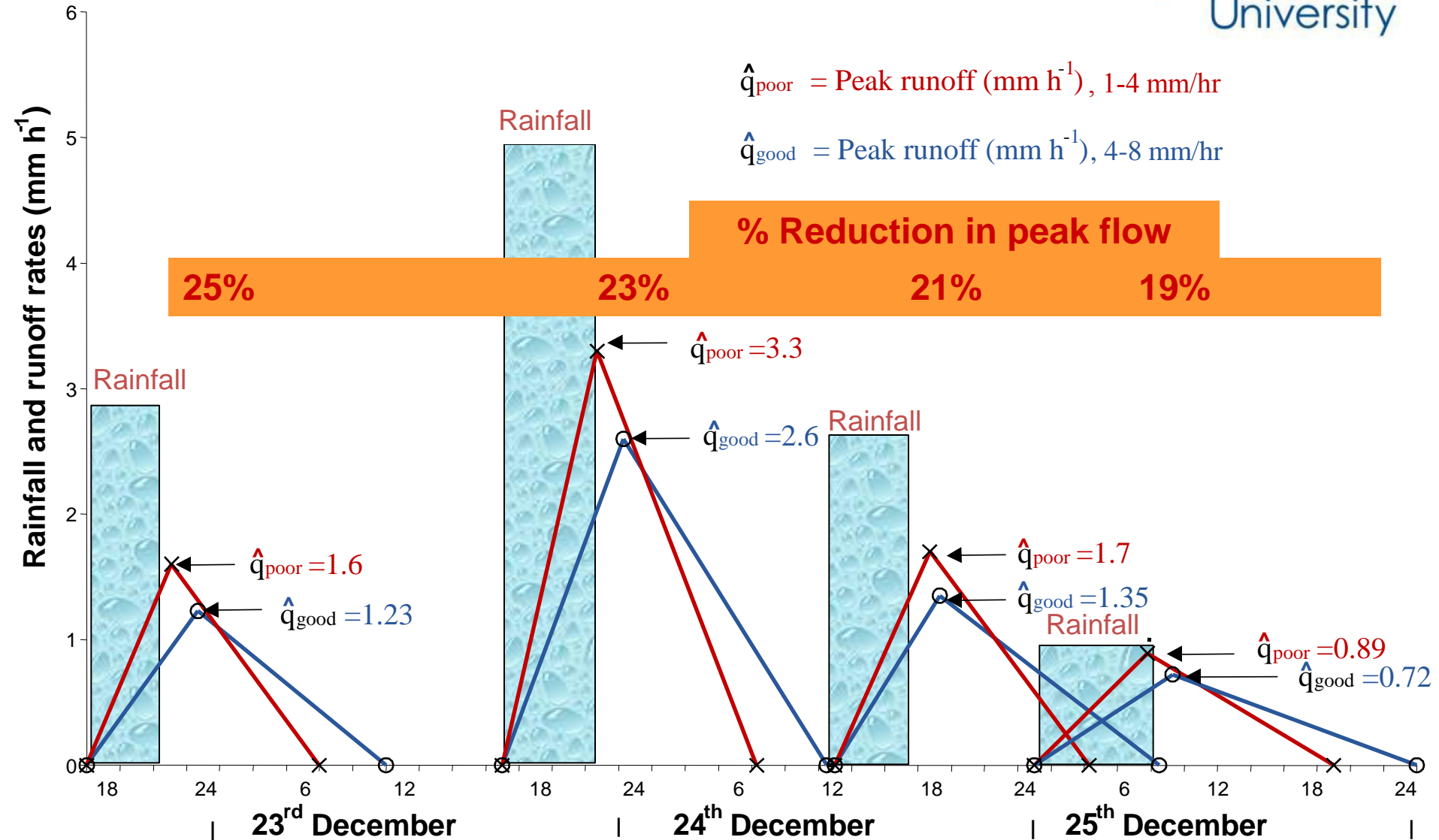


Effect of infiltration rate on runoff

Parrett River Catchment, England
USDA SCS Model (*Schwab et al., 1993*)



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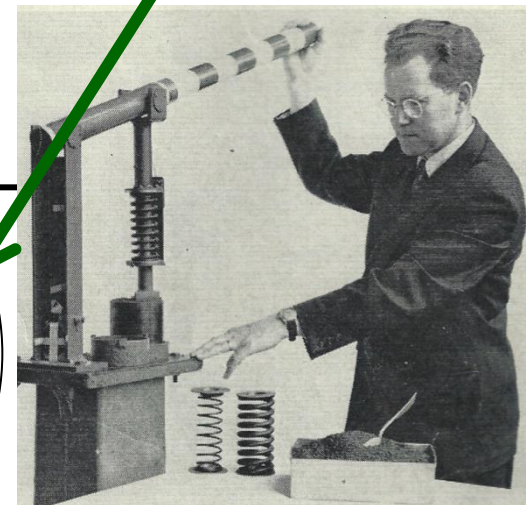
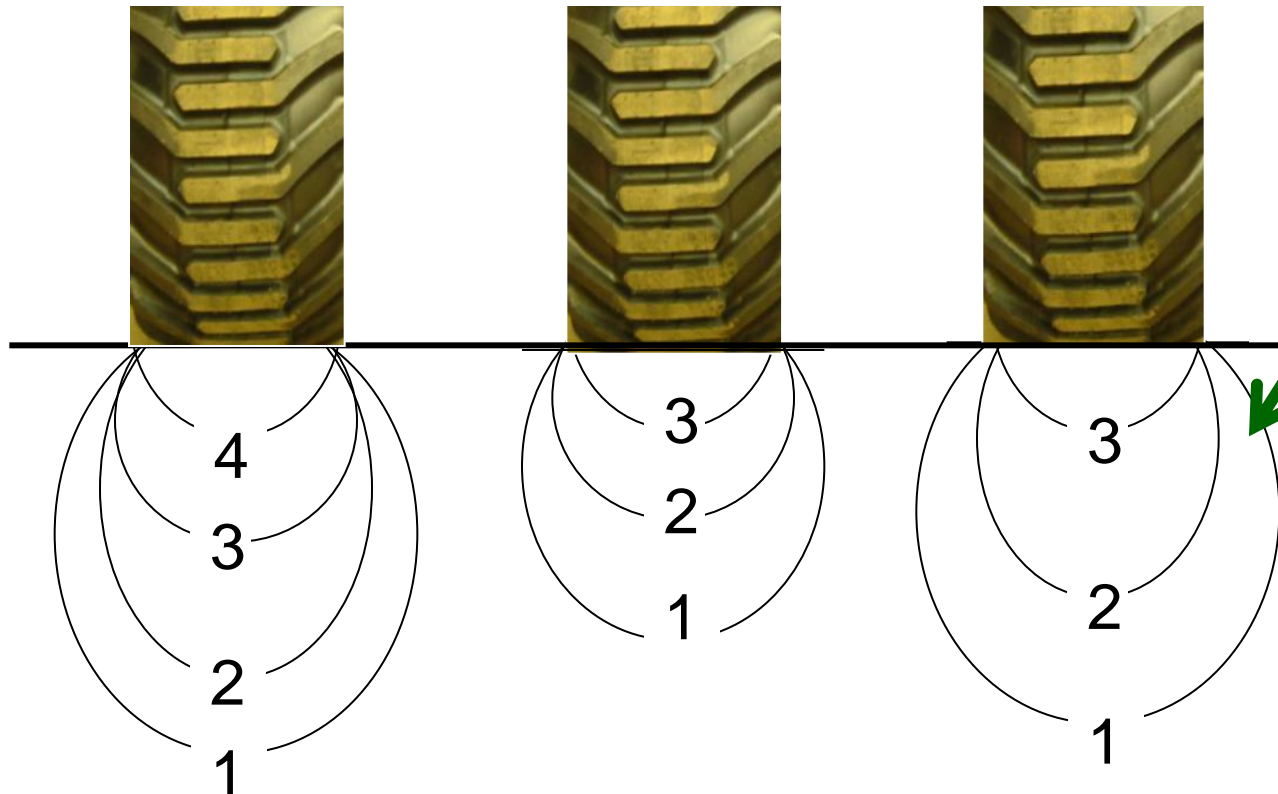
After: Godwin and Dresser, 2003

Effects of load and inflation pressure on soil pressure distribution



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| | | |
|---------------|--------------|--------------|
| Weight Low | Weight Low | Weight High |
| Pressure High | Pressure Low | Pressure Low |



After: Soehne, 1958

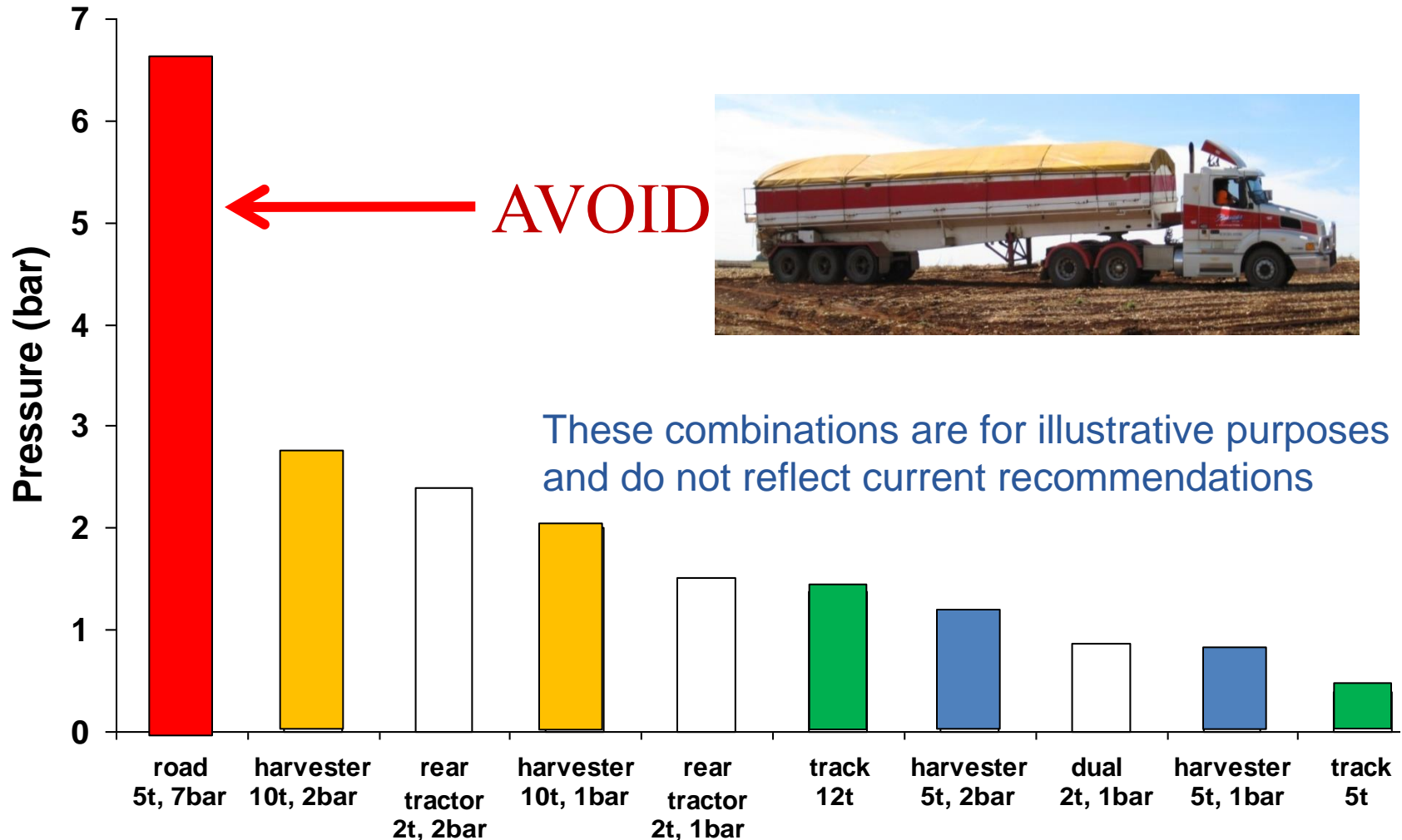
- The pressure in the upper soil layer is determined by the specific pressure at the surface, which depends upon the inflation pressure and the soil deformation (*i.e.* size of contact area).
- The pressure in deeper soil layers is determined by the amount of load.

Effect of wheel/track system on soil pressure

250mm deep



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Random Traffic Problems



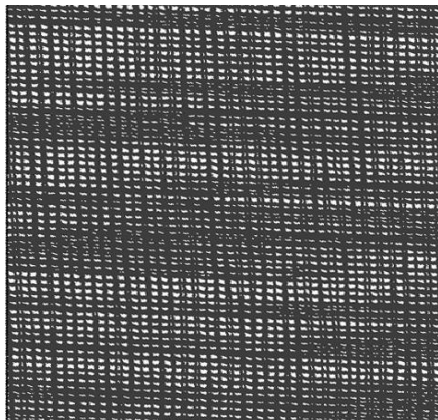
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Extensive areas of the field
are exposed to trafficking

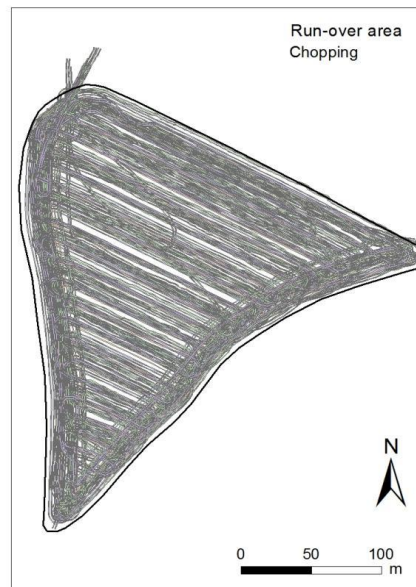
- Random Traffic + plough
= 85% covered
- Minimum Tillage
= 65% covered
- Direct Drilling
= 45% covered



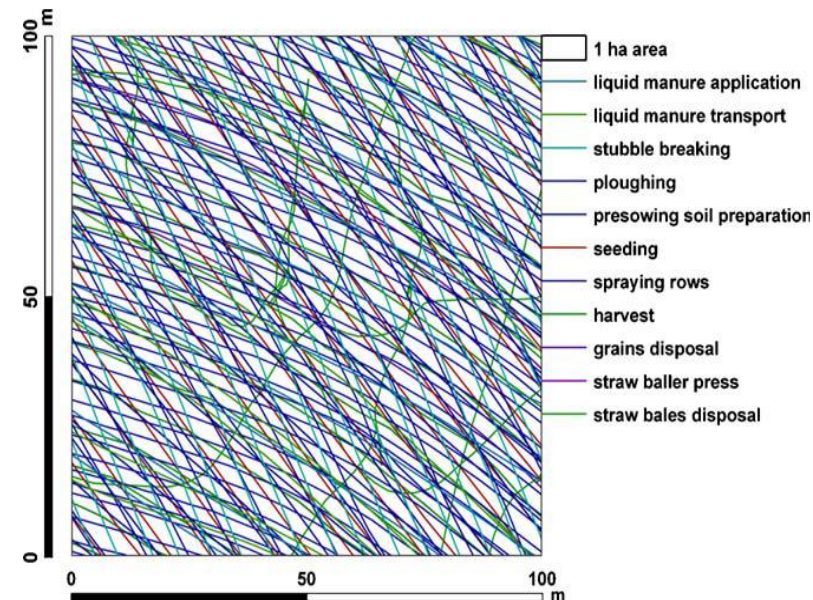
Potatoes - UK



Grass - UK



Winter wheat – Czech Republic



Subsoiling or Deep Soil Loosening



Simple tines

Wide point,
high lift wing



Narrow point,
low lift wing

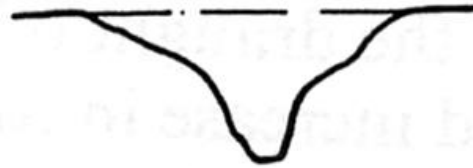


After: Spoor and Godwin, 1978

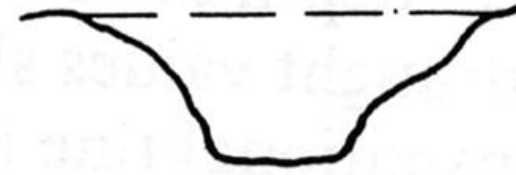
Effect of wing attachments



0.35 m



Conventional subsoiler
 $\alpha_1 = 82^\circ$



Winged subsoiler
 $w_3 = 0.30 \text{ m}$

Draught

20.43 kN

26.58 kN

Disturbed area

0.098 m²

0.184 m²

Specific resistance

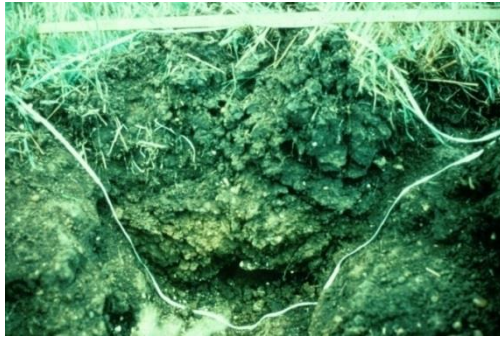
208 kN/m²

144 kN/m²

Soil disturbance



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Wing tine only

Draught
Force
(kN)

23.9

Area of
disturbance
(m²)

0.24

Specific
resistance
(kN/m²)

99.58

Plus shallow leading tines

23.5

0.42

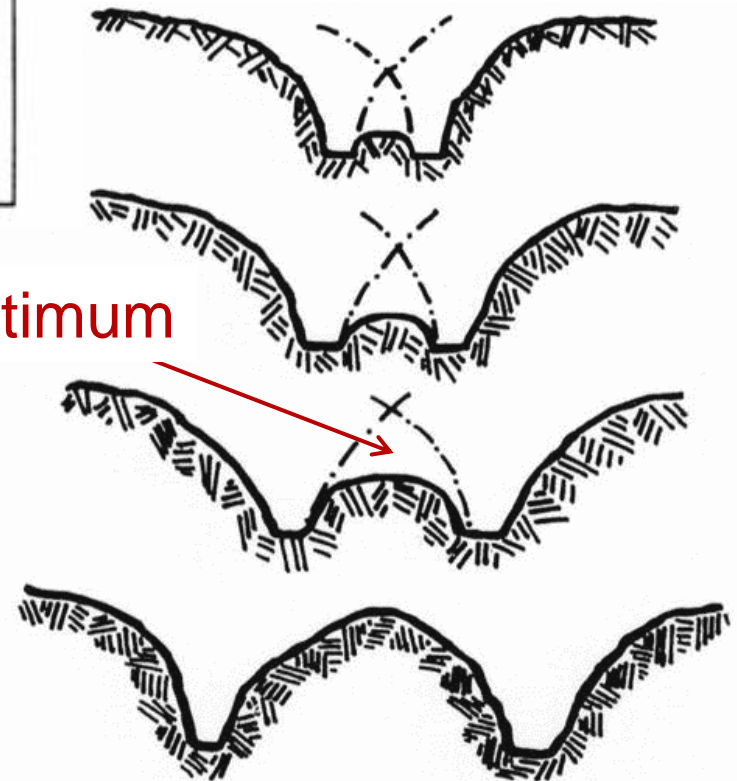
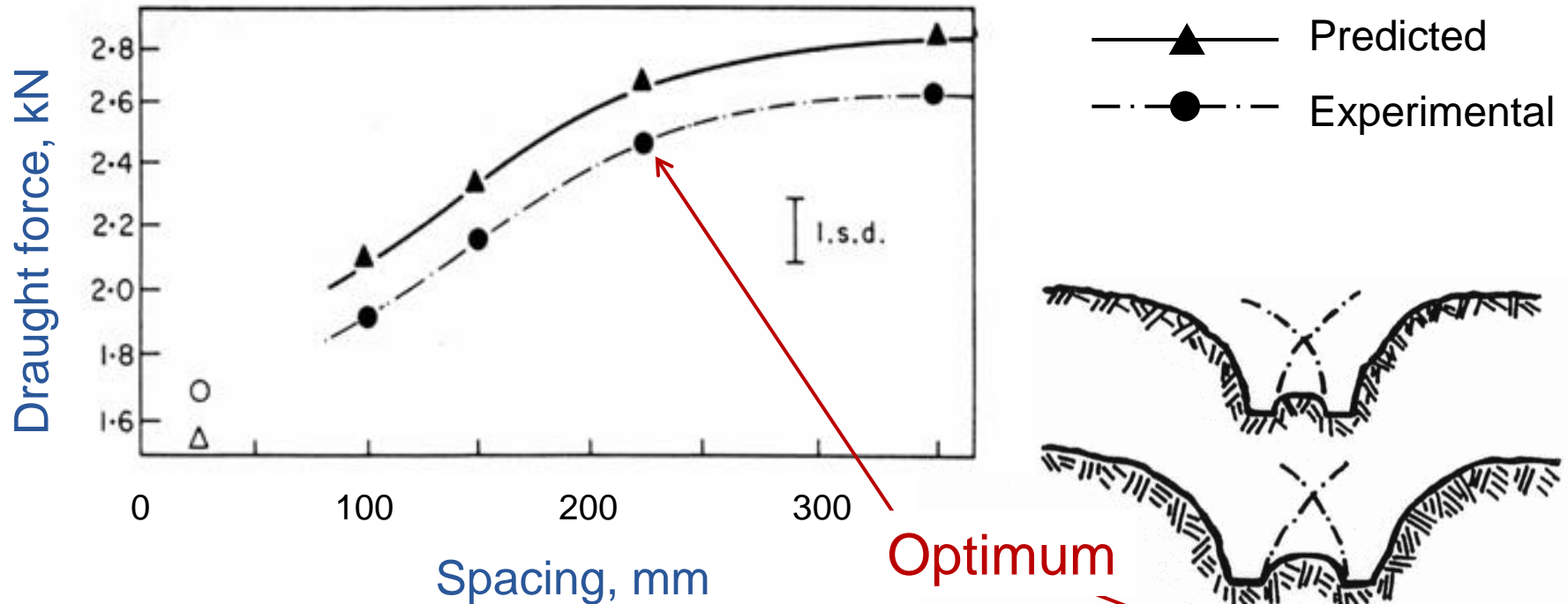
55.95

↑ Similar: ↑ Almost double: ↑ 44% reduction



After: Spoor & Godwin 1978

Effect of tine spacing



After: Godwin, Spoor and Soomro, 1984

Multiple tine spacing



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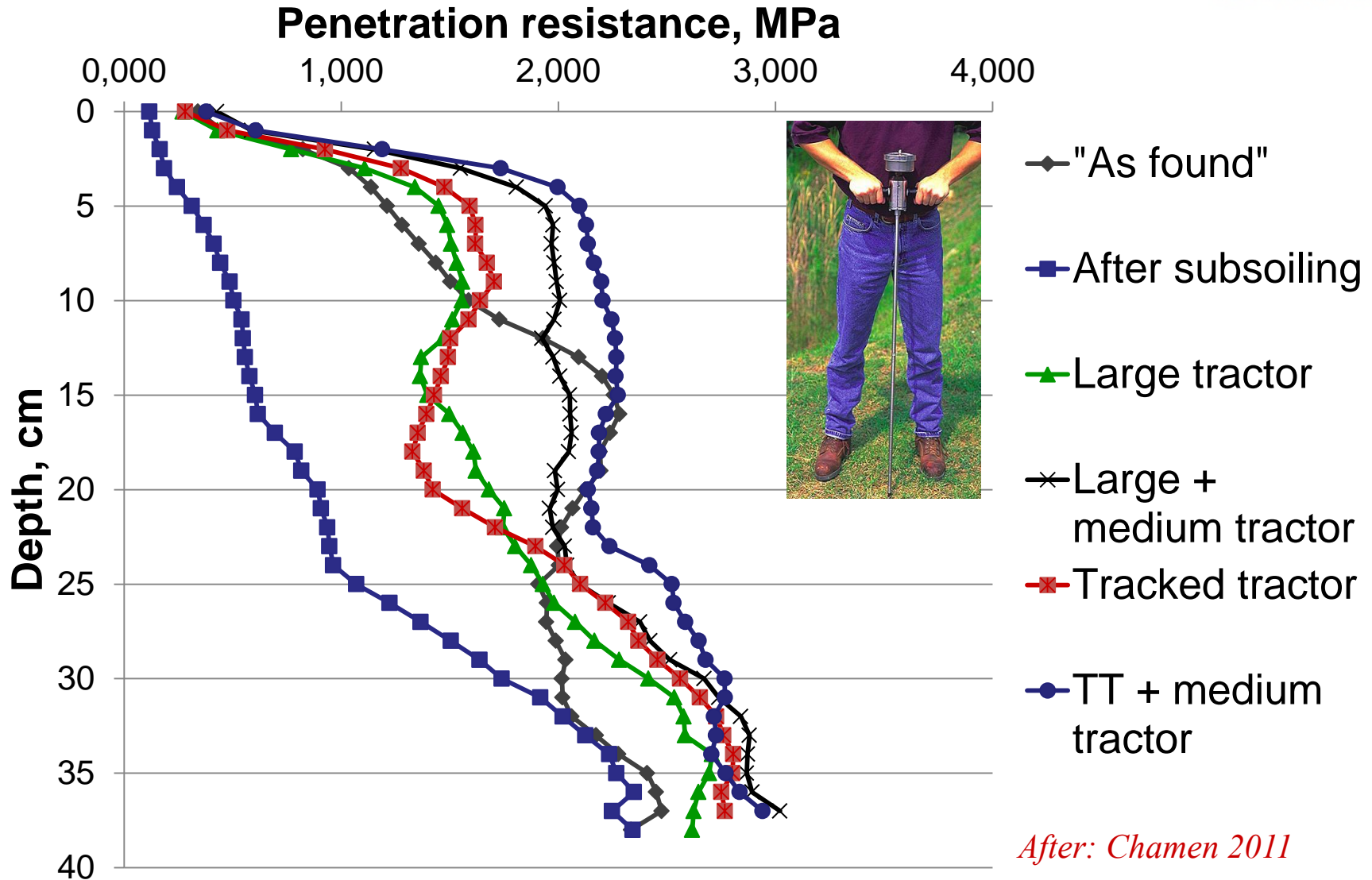


- Simple tines = $1.5 \times \text{depth of work}$
- Winged tines = $2.0 \times \text{depth of work}$
- Winged tines + leading tines = $2.5 \times \text{depth of work (of shallow deeper tine)}$

Subsequent traffic can destroy good loosening!



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Issues of aftercare



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A single surface 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.

2. Use a mouldboard plough fitted with “under-buster” tines.



Other alternatives are to:

1. Reduce the weight and inflation pressure using low ground pressure systems, or

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

Options for compaction reduction



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Controlled traffic



After: Tullberg et al. 2003

Source: CTF Europe

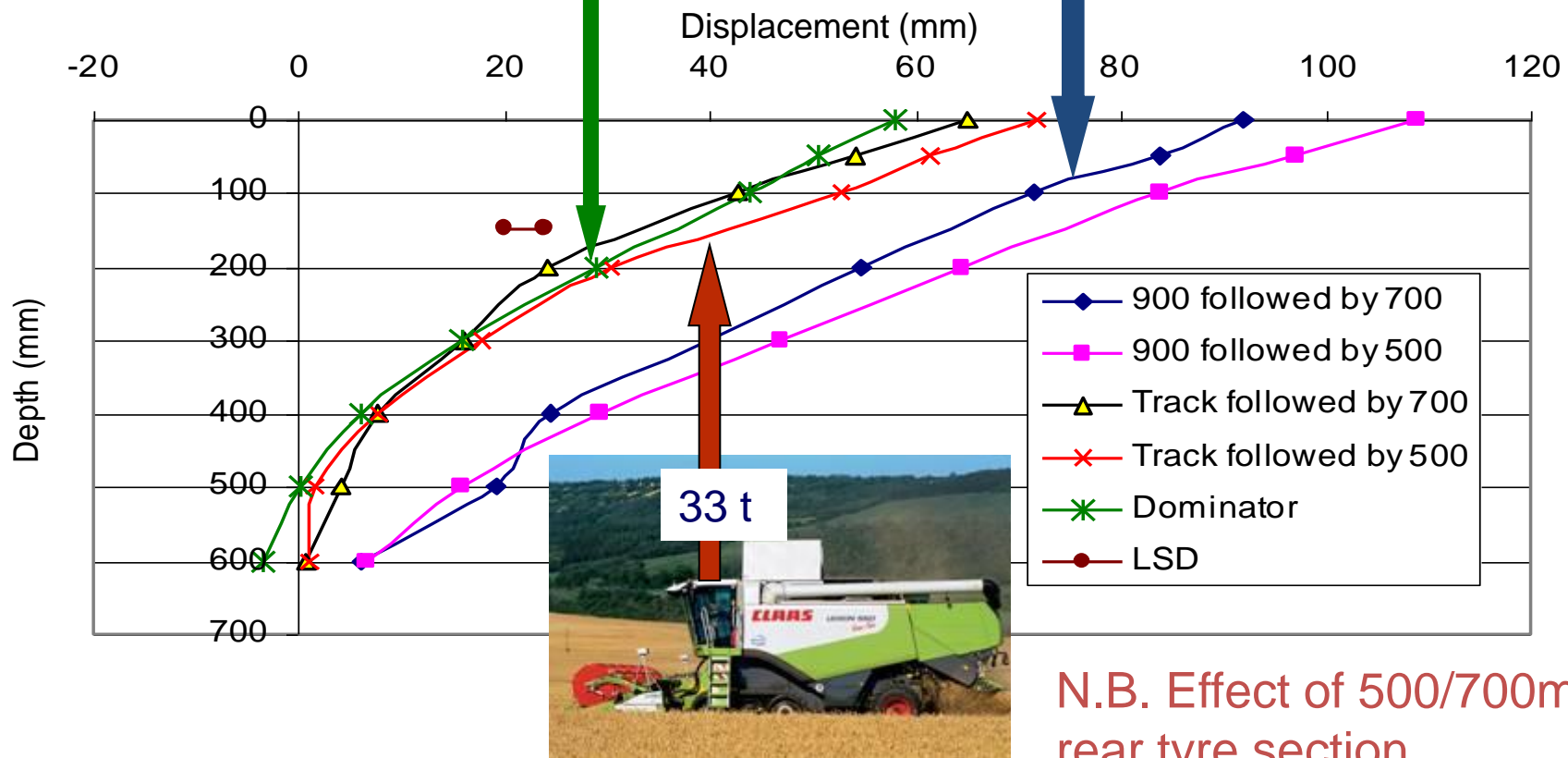
Reduced pressure/axle weight and central tyre inflation pressure control systems (may not be needed now with ultra-flex technology)



Compaction reduction - Rubber tracks



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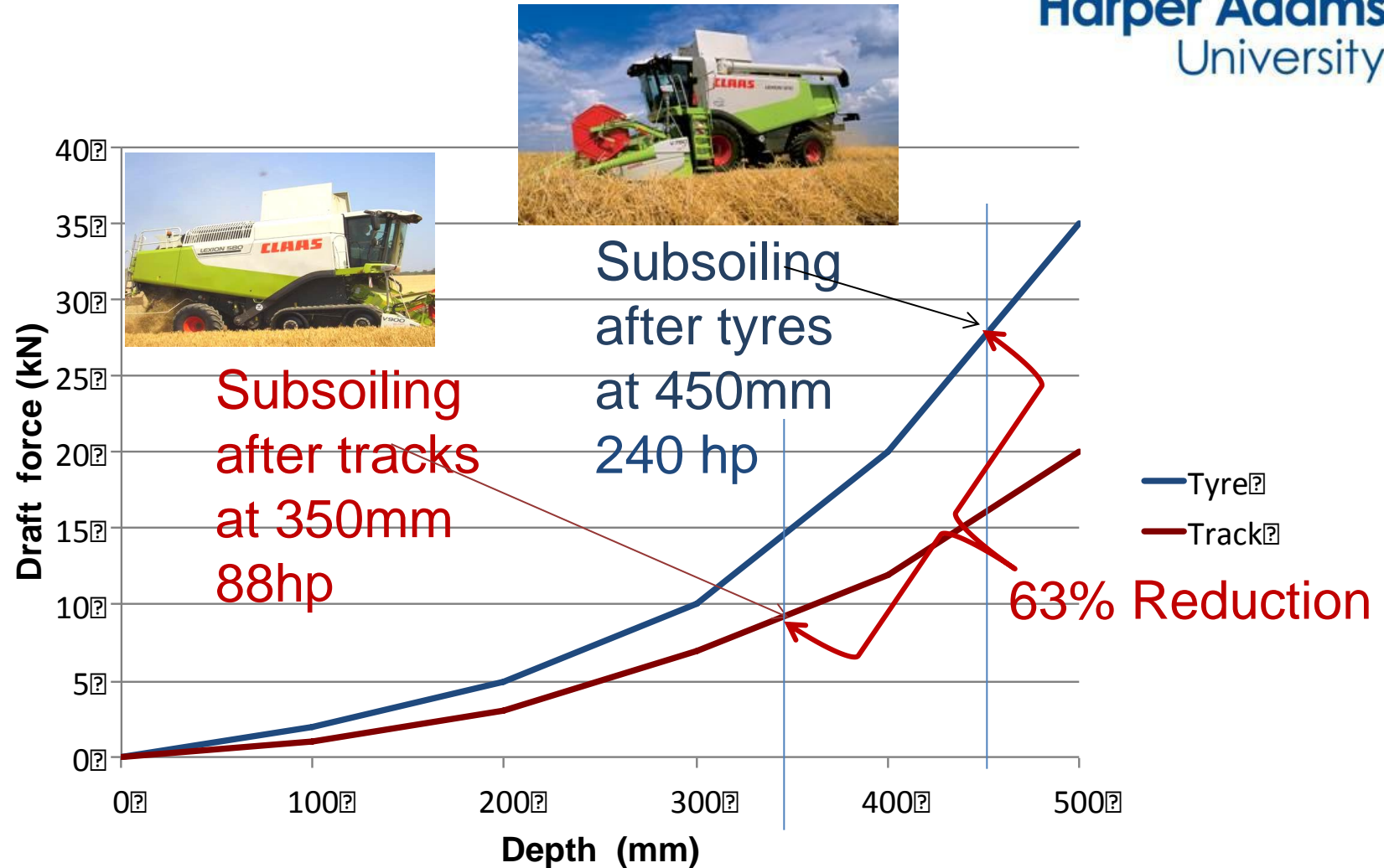


N.B. Effect of 500/700mm wide rear tyre section

Subsoiler – Draught forces



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Lower Ground Pressure (LGP)



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- + Simple
- + Relatively low cost
- Pressure is applied
- + Less working time, improved fuel economy, trafficability and manoeuvrability



Extra costs

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

Combine: Ultraflex = €0.75/ha

Price offset by fuel savings (c.20%)

Mozziconacci, Michelin



Combine: + €4 to €6/ha for 5 - 7 year life

Price offset by improved trafficability and narrower operating widths

Tyrell, Claas UK

Controlled Traffic Farming (CTF)



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- Area exposed to wheels < 30-40% & could be <20%
- Improved soil structure
- Reduced input costs: time; fuel; machinery - Down 22%
- Operating profit up 8% (€100/ha without yield addition)
- Increased crop yields from non trafficked soils + 9 to 16%
- Infiltration increased by circa 400% in UK

Pros

- + Simple concept
- + GPS steering/guidance

Cons

- Standardise wheel centres
- Industry resistance to change in broad acre crops
- GPS reliability
- Harvester widths



Source: Chamen, 2011

CTF/Low Ground Pressure Study

Winter Wheat yield - England

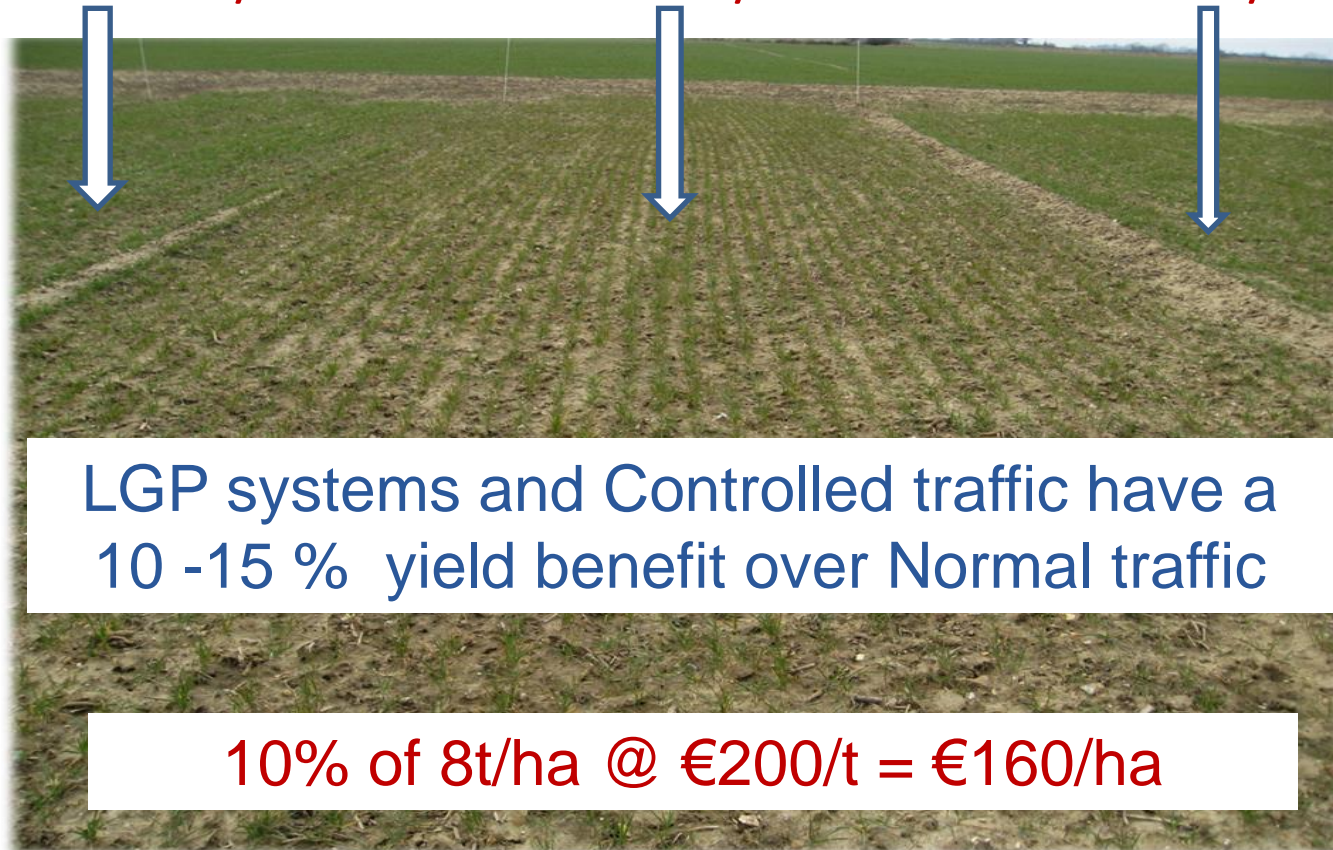


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Zero Traffic
12.52 t/ha

Normal random traffic
10.84t/ha

Zero traffic + tracked vehicle
12.14t/ha



LGP systems and Controlled traffic have a
10 -15 % yield benefit over Normal traffic

10% of 8t/ha @ €200/t = €160/ha

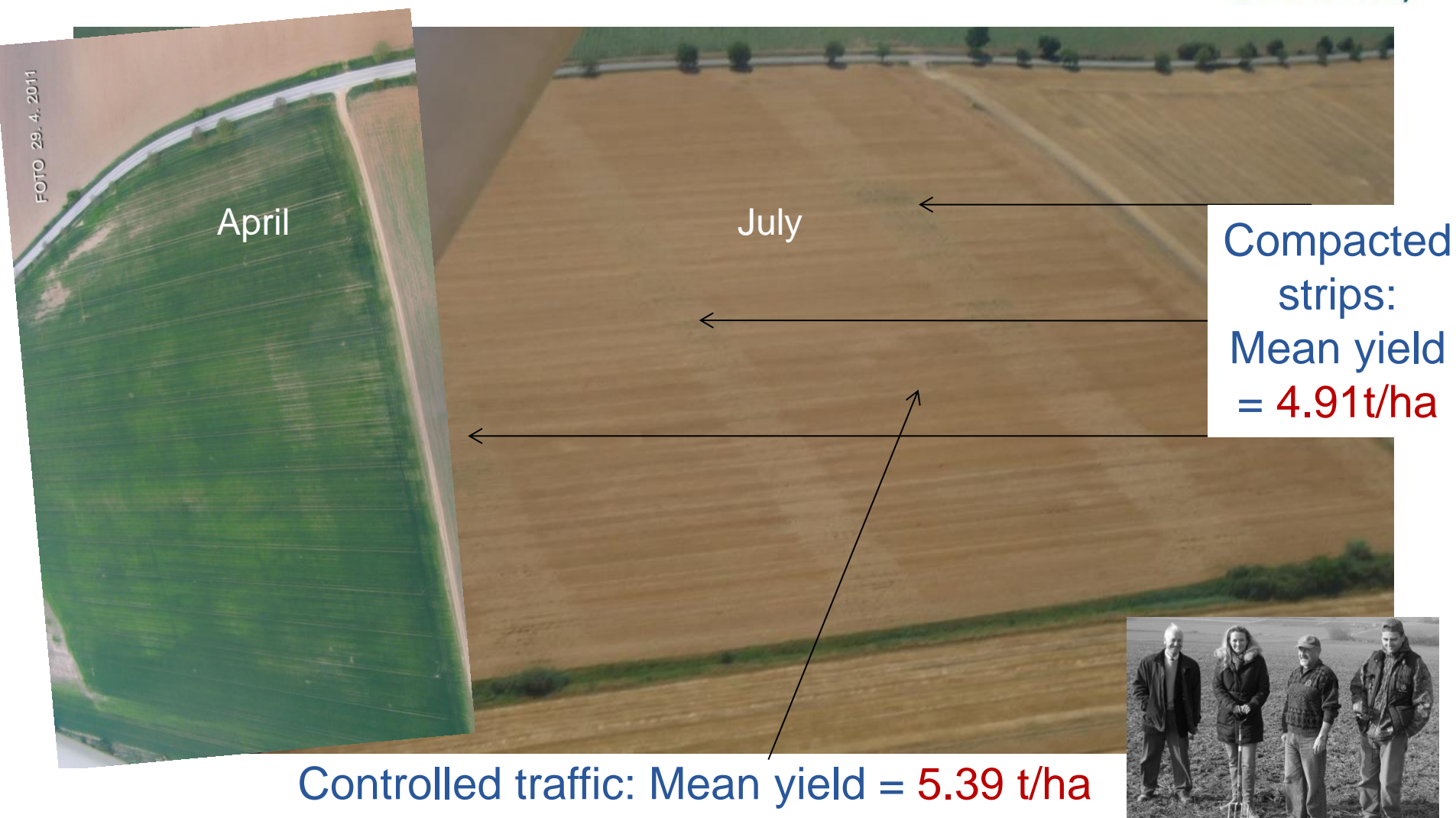
Benefits of Controlled traffic

Field Scale Studies: Slovakia



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10% Wheat yield improvement in 2012



After: Galambosova, Rataj, Macak, Chamen and Godwin, 2012

Traffic and Tillage Research England



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3 x 3 factorial design

**9 treatments replicated in 4 blocks
= 36 plots in total (each 4m wide)**

2011 - 12: Winter Wheat
(normalisation year)
2012 - 13: Winter Wheat
2013 - 14: Winter Barley
2014 - 15: Oil Seed Rape

| Traffic Tillage | Random Traffic Farming | Low Ground Pressure | Controlled Traffic Farming |
|--------------------|------------------------------|---------------------------|----------------------------------|
| Deep tillage | 250mm | 250mm | 250mm |
| Shallow tillage | 100mm | 100mm | 100mm |
| Zero tillage | 0mm | 0mm | 0mm |



After: Smith, Misiewicz, Chaney, White and Godwin, 2014

Winter wheat crop – 29th May 2013

RTF Deep Tillage



RTF Shallow Tillage



RTF Zero Tillage



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**Zero tillage
has a
problem in
wheel marks
in all traffic
systems**

LGP Deep Tillage



LGP Shallow Tillage



LGP Zero Tillage



CTF Deep Tillage



CTF Shallow Tillage



CTF Zero Tillage



*After: Smith, Misiewicz,
Chaney,
White and Godwin,
2014*

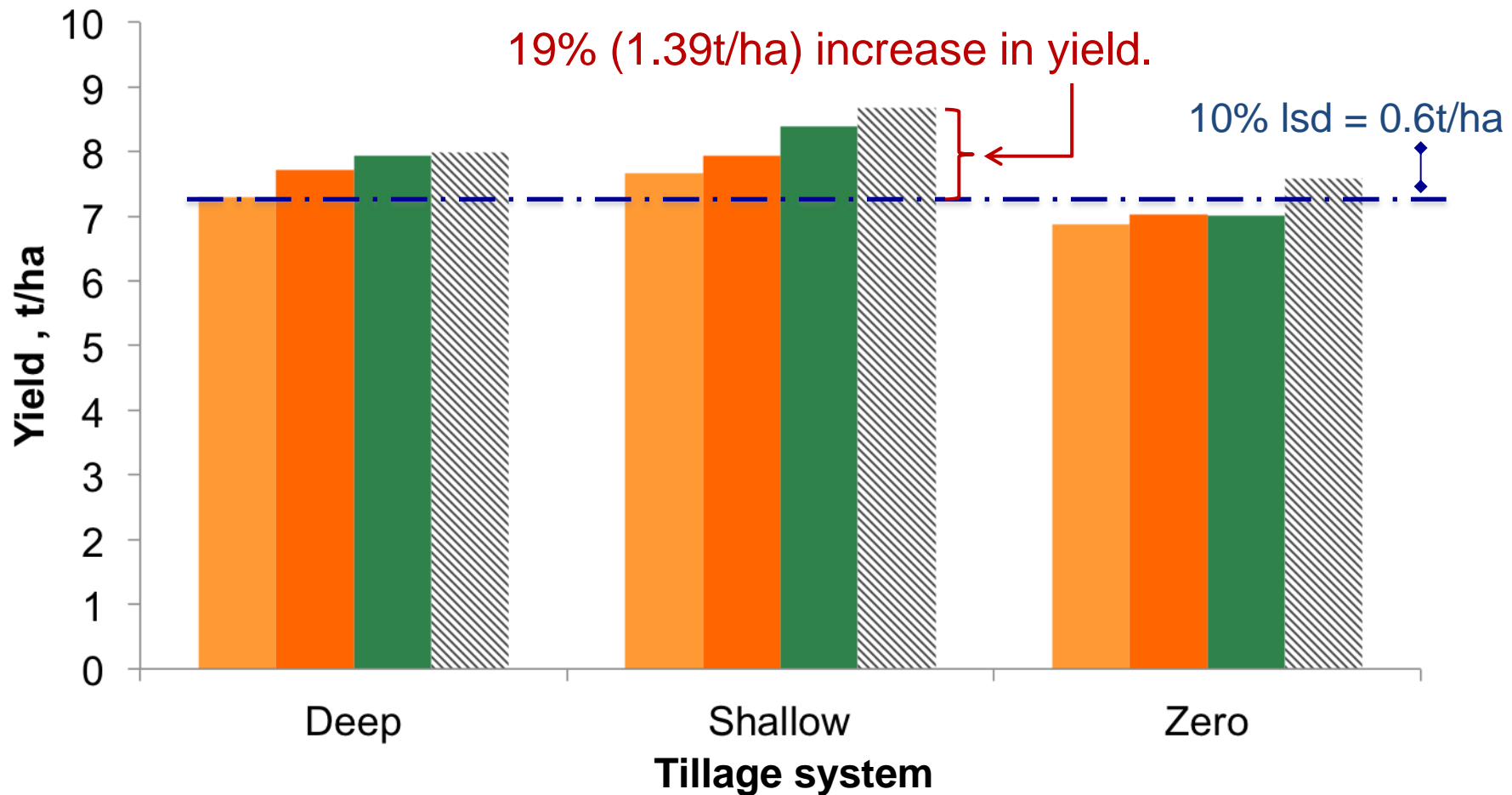
2013 Winter Wheat Yield

Combine Harvester



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RTF LGP CTF 30% CTF 15% (Estimated)

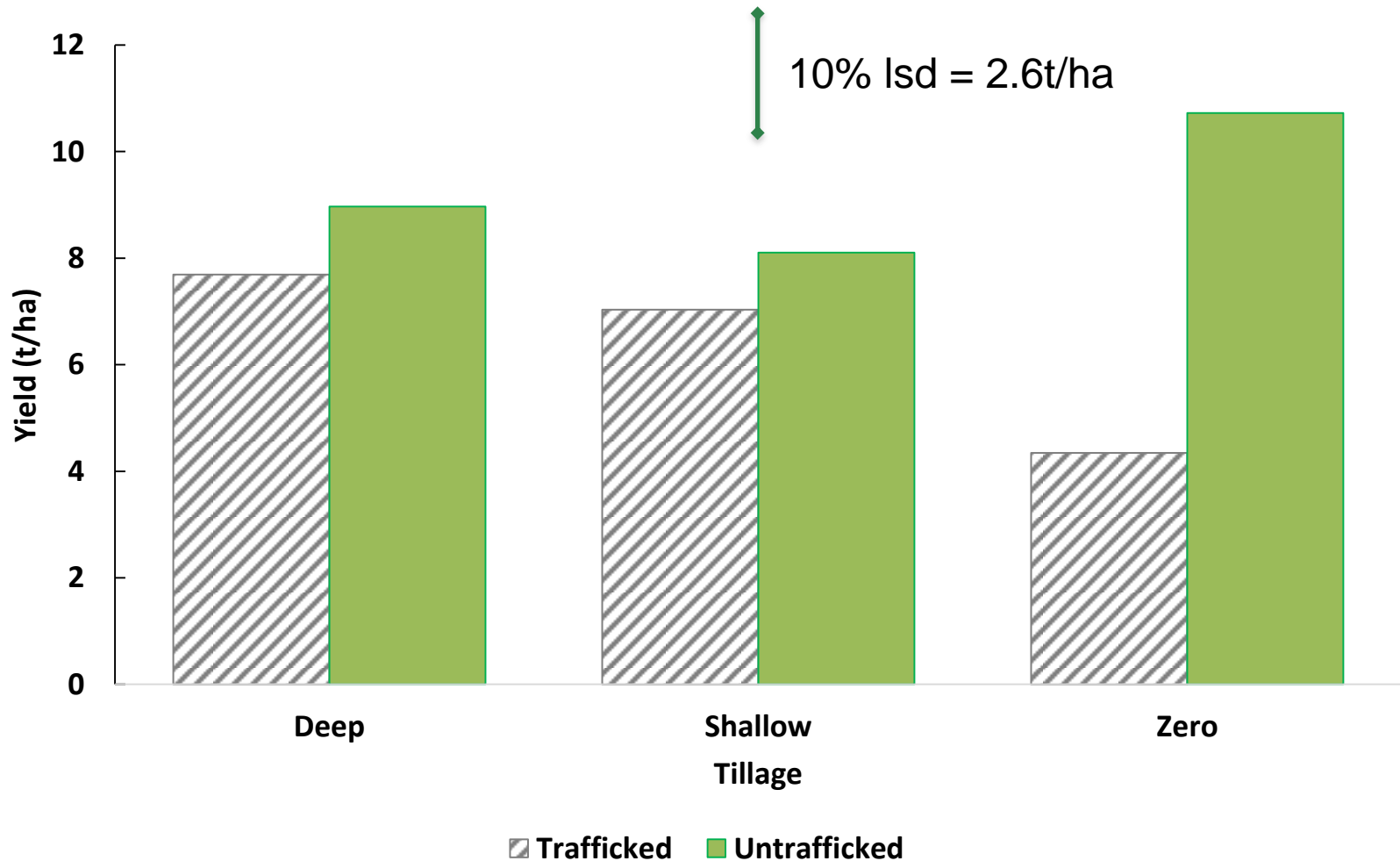


After: Smith, Misiewicz, Chaney, White and Godwin, 2014

2013 Winter Wheat Yield: Hand Harvested



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After: Smith, Misiewicz, Chaney, White and Godwin, 2014

Concluding remarks



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- **Compaction**
 - Can reduce yield by 10-20%
 - Increases tillage energy, time and costs by 200 - 300%
 - Reduces infiltration rate to almost zero and hence increases runoff and flooding
- **Improved soil and water management is achieved by**
 - Reducing contact pressure (and vehicle weight by improved design and materials)
 - Reducing traffic intensity by controlled traffic systems
- **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. Tread on it lightly or not at all!

Final Reflection



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“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

