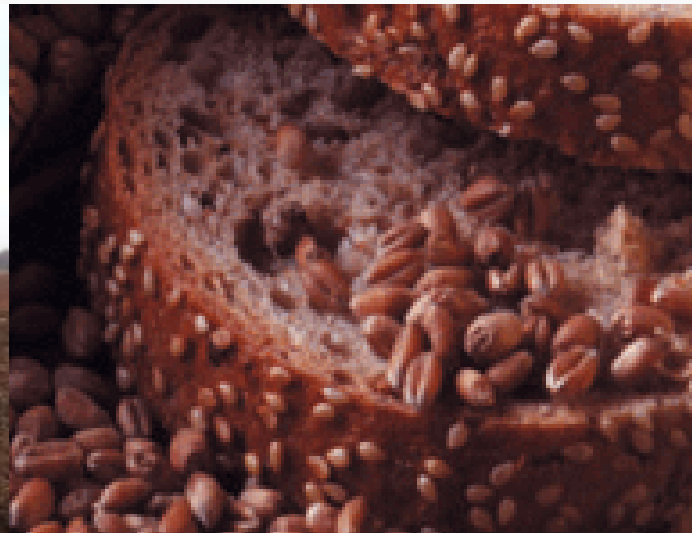


The Role of Soil and Water Management

Richard Godwin









The Future of Food and Farming:
Challenges and choices for global sustainability



Foresight Challenges

A. Balancing future demand and supply sustainably – to ensure that food supplies are affordable.

B. Ensuring that there is adequate stability in food supplies – and protecting the most vulnerable from the volatility that does occur.

C. Achieving global access to food and ending hunger. This recognises that producing enough food in the world so that everyone can *potentially be fed is not the same thing as ensuring food security for* all.

D. Managing the contribution of the food system to the mitigation of climate change.

E. Maintaining biodiversity and ecosystem services while feeding the world.



Major failings as indicated by Foresight



- **Many systems of food production are unsustainable.**

➢Without change, the global food system will continue to degrade the environment and compromise the world's capacity to produce food in the future, as well as contributing to climate change and the destruction of biodiversity.

➢There are widespread problems with soil loss due to erosion, loss of soil fertility, salination and other forms of degradation; rates of water extraction for irrigation are exceeding rates of replenishment in many places; over-fishing is a widespread concern; and there is heavy reliance on fossil fuel-derived energy for synthesis of nitrogen fertilisers and pesticides.

➢In addition, food production systems frequently emit significant quantities of greenhouse gases and release other pollutants that accumulate in the environment.

Royal Society's Report*:- suggests

- Scientific and technological advances in soil science and related fields.

  Relatively neglected in recent years, these offer the prospect for a better understanding of constraints to crop production and better management of soils to preserve their ecosystem functions, improve and stabilise output, reduce pollutant run-off and cut greenhouse gas emissions.

- Targeted research in modern crop and animal science, agro-ecology, agricultural engineering and aquaculture management.

  Research across a broad range of subjects, including areas that have received less investment in recent years, is critical to improving yields and sustainability at the same time.

** Reaping the Benefits*

The Role of Soil and Water Management

Challenge A: Balancing future demand and supply sustainably

- *Alternative Fertilizers, especially P (sewage sludge)*
- *Spatial variable application of fertilizers*
- *Irrigation & Water Supply*
- *Improved cultural method for weed and pest control (mechanical is green)*
- *Application from appropriate "Organic farming methods"*

Challenge B: Addressing the threat of future volatility in the food system

- *Addressing the Food v Fuel debate*
- *Issues in improved livestock production - to use control theory to prevent the "pig cycle"*

Challenge C: Ending hunger

- *Irrigation & Water Supply*
- *Salinity and Alkalinity Control*
- *Improved cultural method for weed and pest control*
- *Application from appropriate "Organic farming methods"*

Challenge D: Meeting the challenges of a low emissions world

- *Reduced Tillage/No-Till and still further enhanced tools*
- *Alternative Nitrogen sources*
- *Reduced compaction – Controlled traffic and lower ground pressure farming*
- *Lower weight harvesters and improved tyre & track systems*

Challenge E: Maintaining biodiversity and ecosystem services while feeding the world

- *Soil Conservation*
- *Drainage*
- *Flood Control*
- *Reduced compaction – Controlled traffic and lower ground pressure farming*
- *Organic practices and soil biomass/organisms*

Key areas of activity

1. Soil fertility, spatially variable application and waste utilisation
2. Runoff, soil erosion control, drainage and flood control
3. Irrigation and water supply
4. Improved management of soil structure including
   tillage – traction – compaction – controlled traffic
5. Weed control and organic practices
6. Salinity and alkalinity control (not dealt with today)

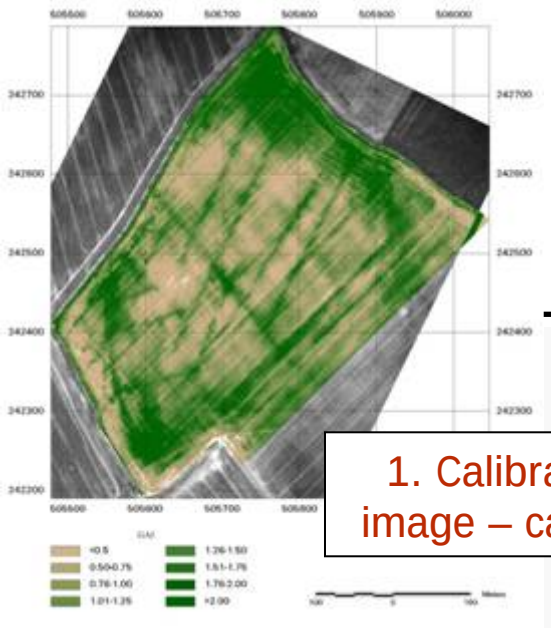
1. Soil fertility, Spatially variable application and Waste utilisation

- Agronomists and soil scientists need to work with engineers to optimise the soil structure for crop growth which encourages deeper rooting to exploit a greater volume of water and the nutrients available in the subsoil.

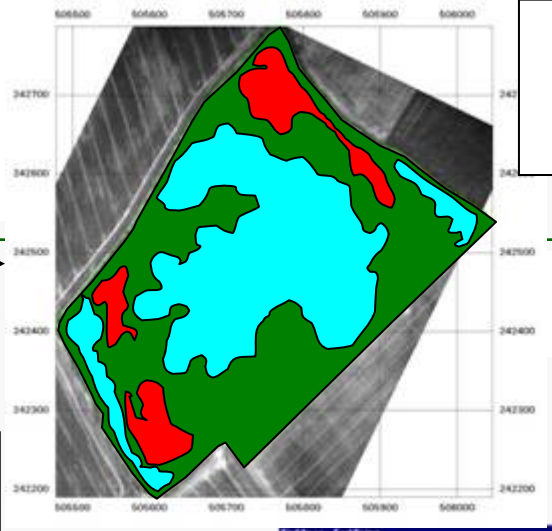
Other key areas of activity for engineering inputs are listed below:

1. Improved coulter design for the optimum placement of fertilizer alongside the seed of row crops grown in clay soils. This should allow the base level of P to be reduced, however, replenishment rates would have to be maintained..
2. Increase the levels of P and K in the subsoil to encourage deeper rooting
3. Perfect the manufacture of sewage sludge pellets and
4. Educate the public with respect to the use of sewage as a sustainable source of P fertiliser.

Johnston (2012), Rothamsted Research



1. Calibrated ADP image – canopy size

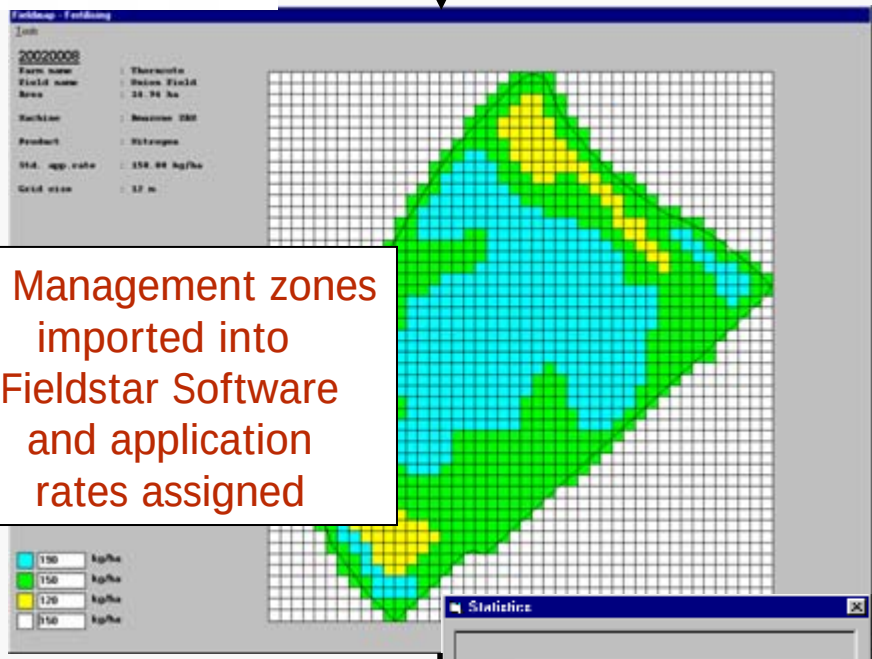


2. Image processed into management zones according to canopy size

Canopy Size

- Above-target
- On-target
- Below-target



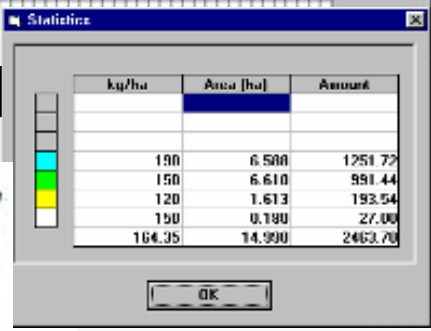


3. Management zones imported into Fieldstar Software and application rates assigned



4. Application plan implemented



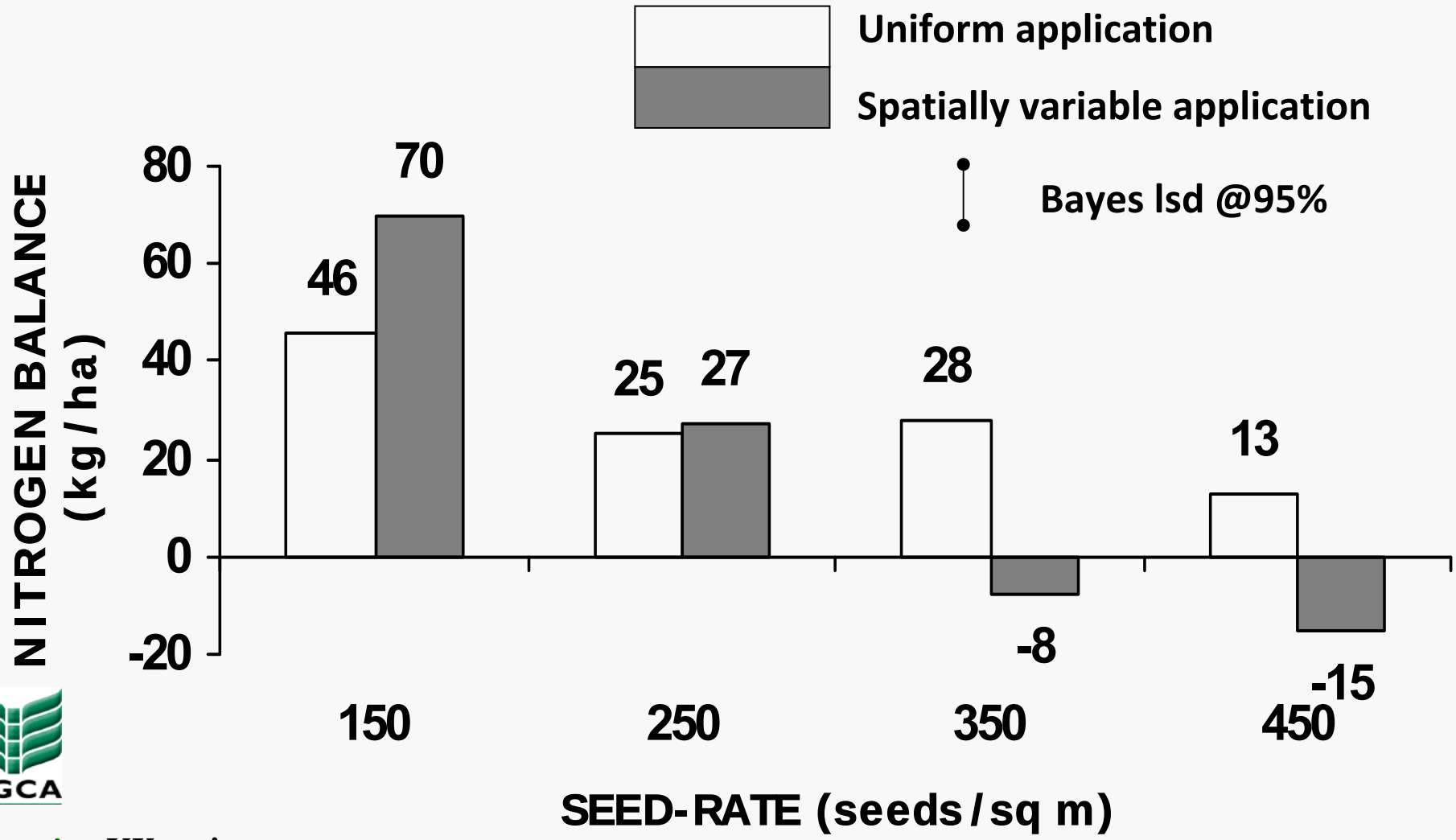


5. Economic Benefit - £22/ha (Euro 32/ha)

After: Wood, Godwin, Earl and Taylor, 2003

Nitrogen savings from spatially variable rate application

On average residual N reduced to 1/3 of uniform rate



HGCA

Supporting *UK grain*

After: Godwin et al, 2003

Organic wastes as a fertilizer

Semi – Solid



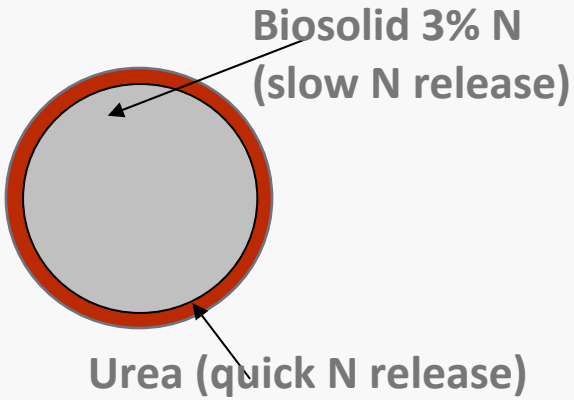
Liquid



30% could come from compost, *(Kokkoras, 2008)*

Pellets - Organo Mineral Fertilizer or “Super Poo”







United Utilities

After: Antille, Sakrabani and Godwin, 2008

2. Runoff, soil erosion control, drainage and flood control







- Poor soil condition is widespread in South West
- Soil condition can radically affect rate of overland flow and can exacerbate surface water flooding
- Soil loss – no protection 3-5 t/ha/year - Soil regeneration 1 t/ha/year
- Drainage installation1980 c 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

Soil conservation practices

- Contour tillage >



- Wind breaks >



- Grass waterways >



Need good practical engineers to design and implement the appropriate systems

Land drainage and crop yield



Crop failure – during growth, in this case ~25% loss
Soya beans, Illinois - July 2008



Effect on crop growth – Denchworth Soil
FDEU studies at Drayton 1970 -74 Winter Wheat

Yield	~4.5 t/ha
Drains & Moles	+ 1.0 t/ha
Drains No moles & subsoiling	+ 0.6 t/ha



Studies at Brooksby showed + 0.5t/ha from moling

FDEU Annual Report 1975



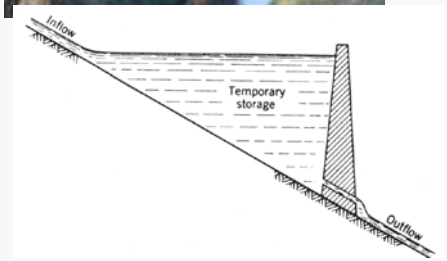
Birds Eye lost 40% of pea yield in summer of 2007 due to poor trafficability

Flood control









Storage mechanism	Equivalent depth (mm)	Storage volume (x 10^6 m^3)
1. Soil pores to a depth of 0.5 m	50	78
2. Surface depressions for a ploughed field	10	16
3. Drainage ditches	2.75	4
4.100 detention ponds of 25,000 m^3	1.5	2
TOTAL	64	100

N.B. 1 in 2 year 5 day event is 62 mm or approximately 100 x 10^6 m^3

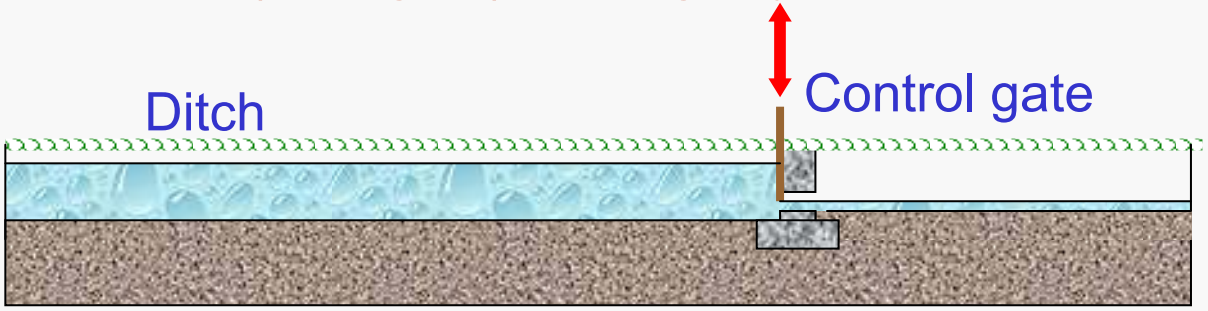
After: Soil and Water Management in the Parret Catchment , Godwin and Dresser, 2003

Soil management and flood control



Improved management by

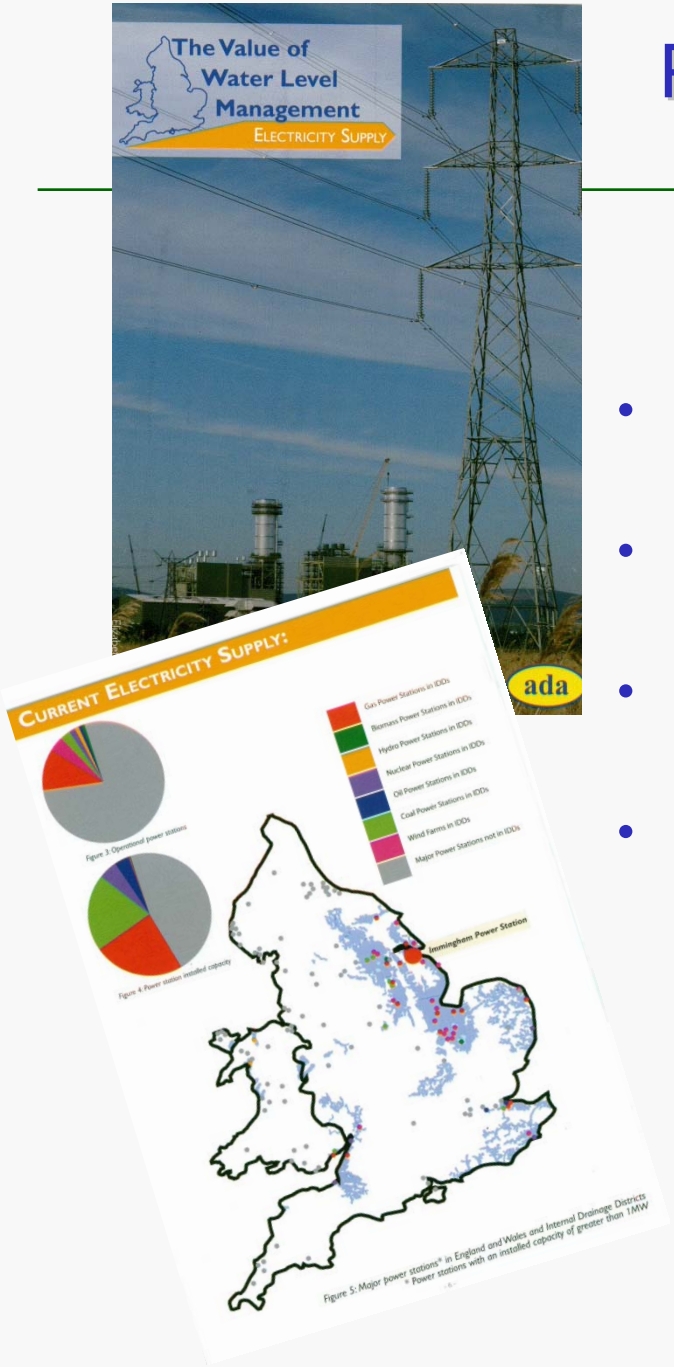
- Reducing compaction by the selection of appropriate tyre/track systems
- Managing residues with tillage implement selection and settings
- Maintaining the drainable pore space for water storage by the use of controlled (intelligent) drainage systems



reduces runoff and peak flood flows

– There is evidence that the peak flood flow could be reduced by the order of 20 - 25% with minor soil management improvements

After: Soil and water management in the Parret Catchment , Godwin and Dresser, 2003



Potential impact on infrastructure

- 28% of Power Stations are located in an Internal Drainage Board (IDB) district
- 53% of installed capacity of major Power Stations are located within an IDB
- Potential demand for more electrical power will see further development in areas of flood risk
- The new developments will therefore call on good water level management.

Venables, Association of Drainage Authorities, (2011)

3. Irrigation and Water Supply





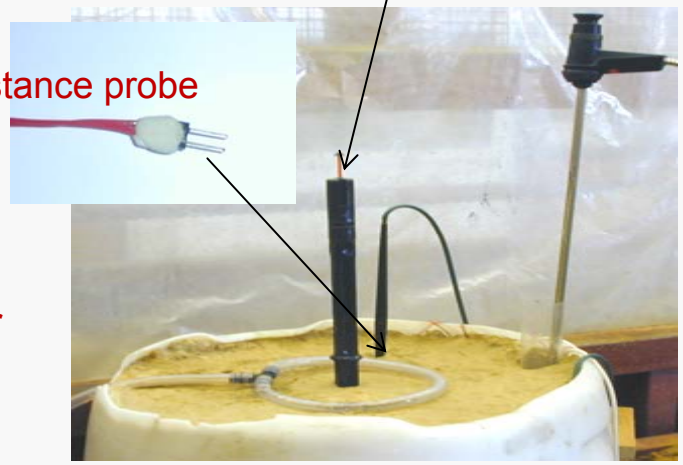


Issues

- Minimise water use
- Linking Irrigation to soil variability
- Soil structural problems around emitters
- Need for “Smarter emitters” and control systems
- Recycle “grey” water

Godwin (2003) Report to DPI Victoria

Griffith Wetting Front Detector

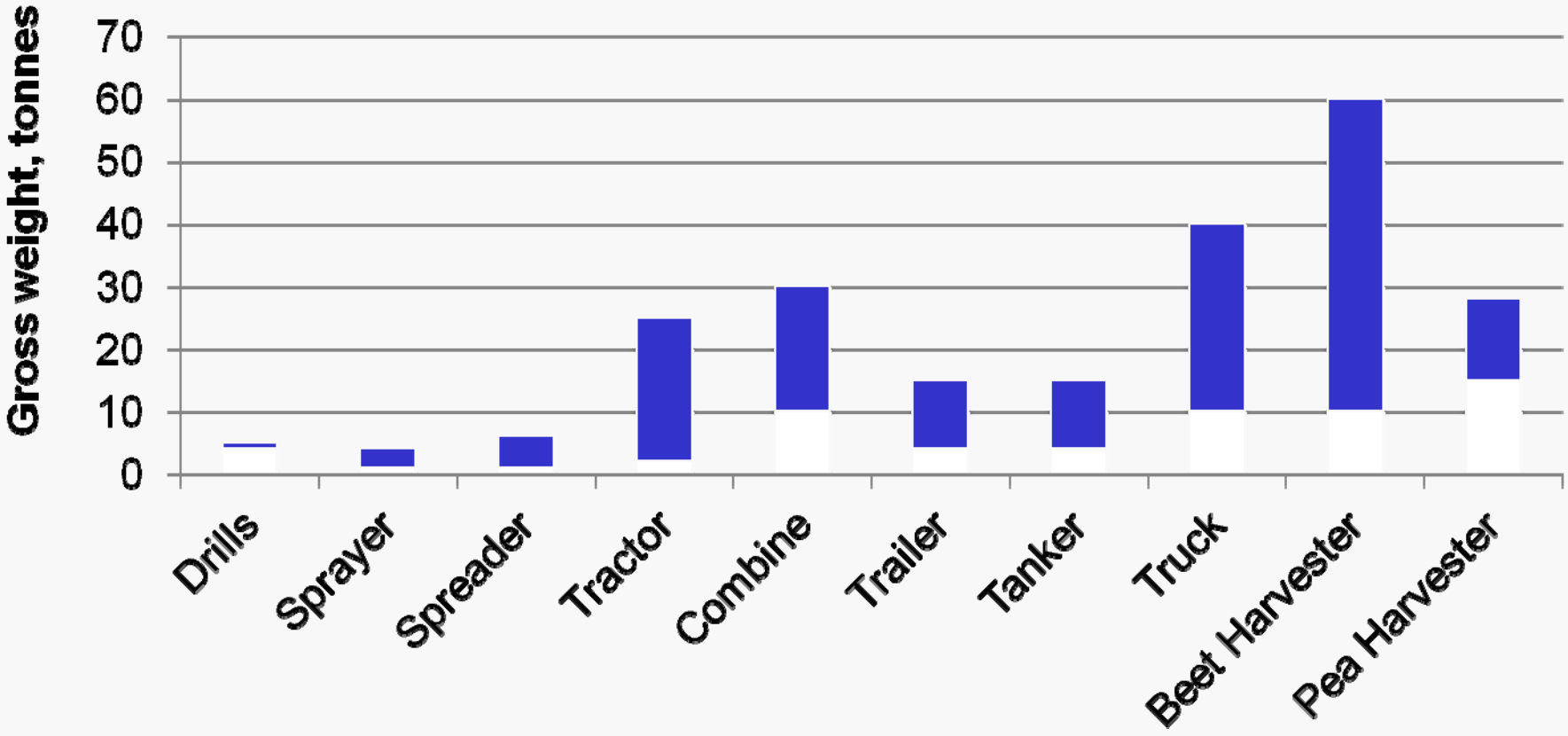


- ➢ Interlinking of alternative water resources
- ➢ Increased on-farm water storage
- ➢ Automatic control of in-field distribution systems for precision to increase uniformity and accuracy

Weatherhead (2012), Cranfield University

4. Improved management of soil structure

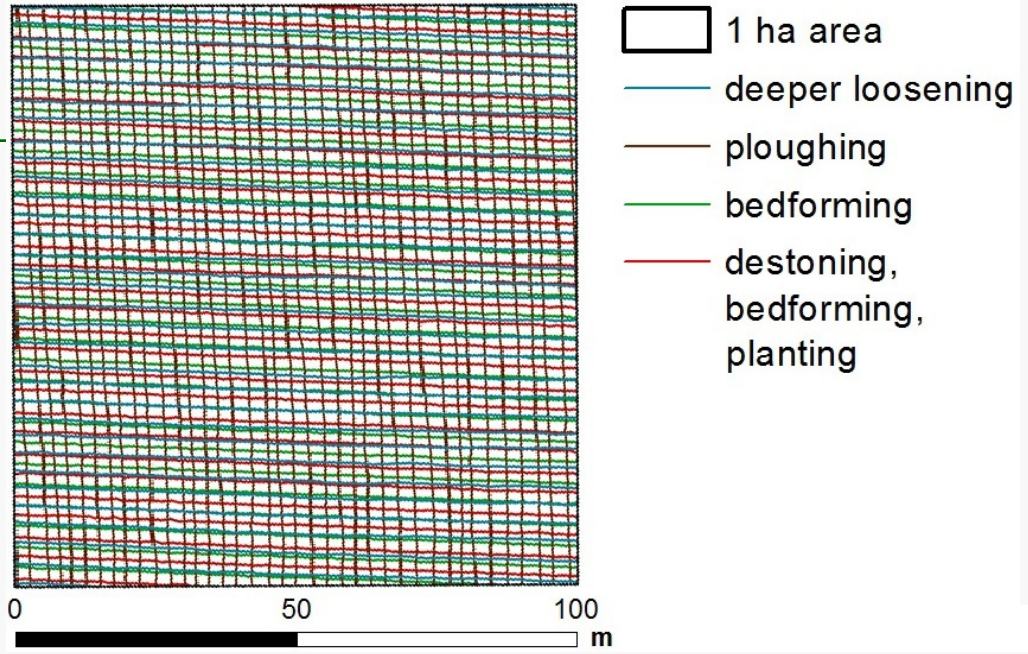
tillage – traction – compaction – controlled traffic



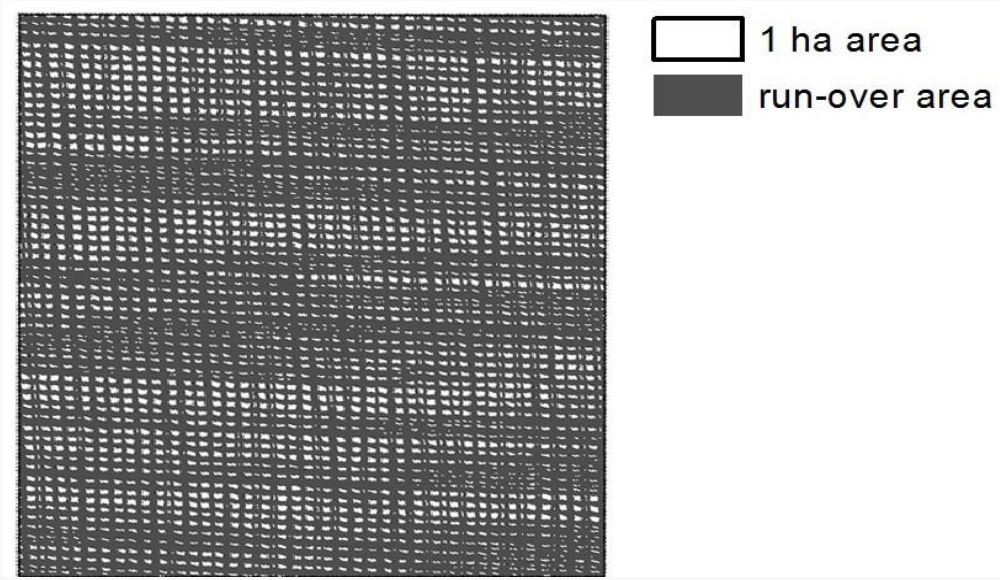
After: Erickson et al 1974, updated by Godwin 2005

Traffic patterns

Field traffic in establishing potatoes in Shropshire 2012

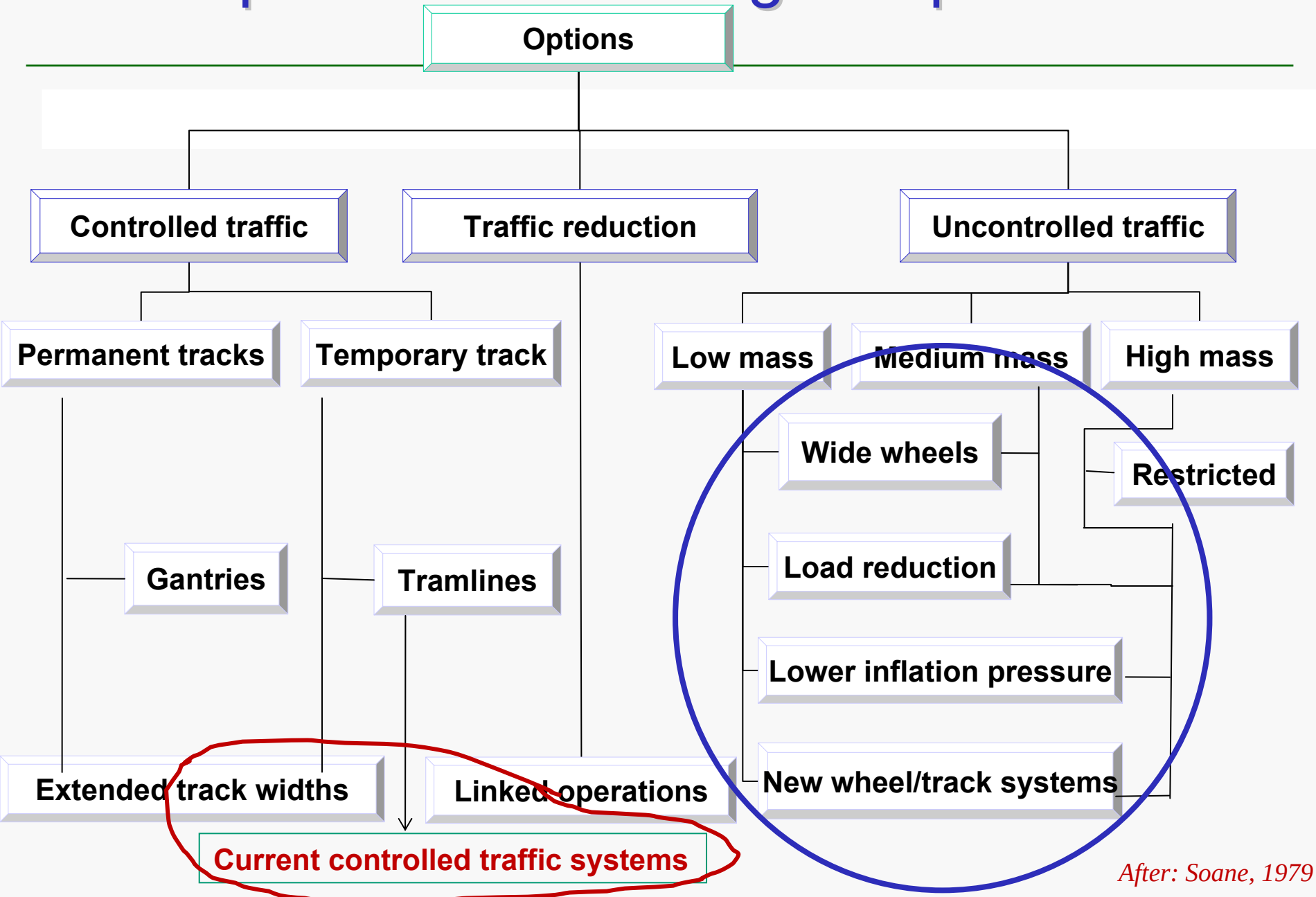


84% of land covered with a tyre



Kroulik et al (2012)

Options for reducing compaction



After: Soane, 1979

Compaction reduction

Controlled Traffic Systems: Aim <10% surface wheeled





After: Tullberg et al (2003)

Reduced pressure/axle weight and central tyre inflation pressure control systems







Traffic control effects on energy (MJ/ha) requirements

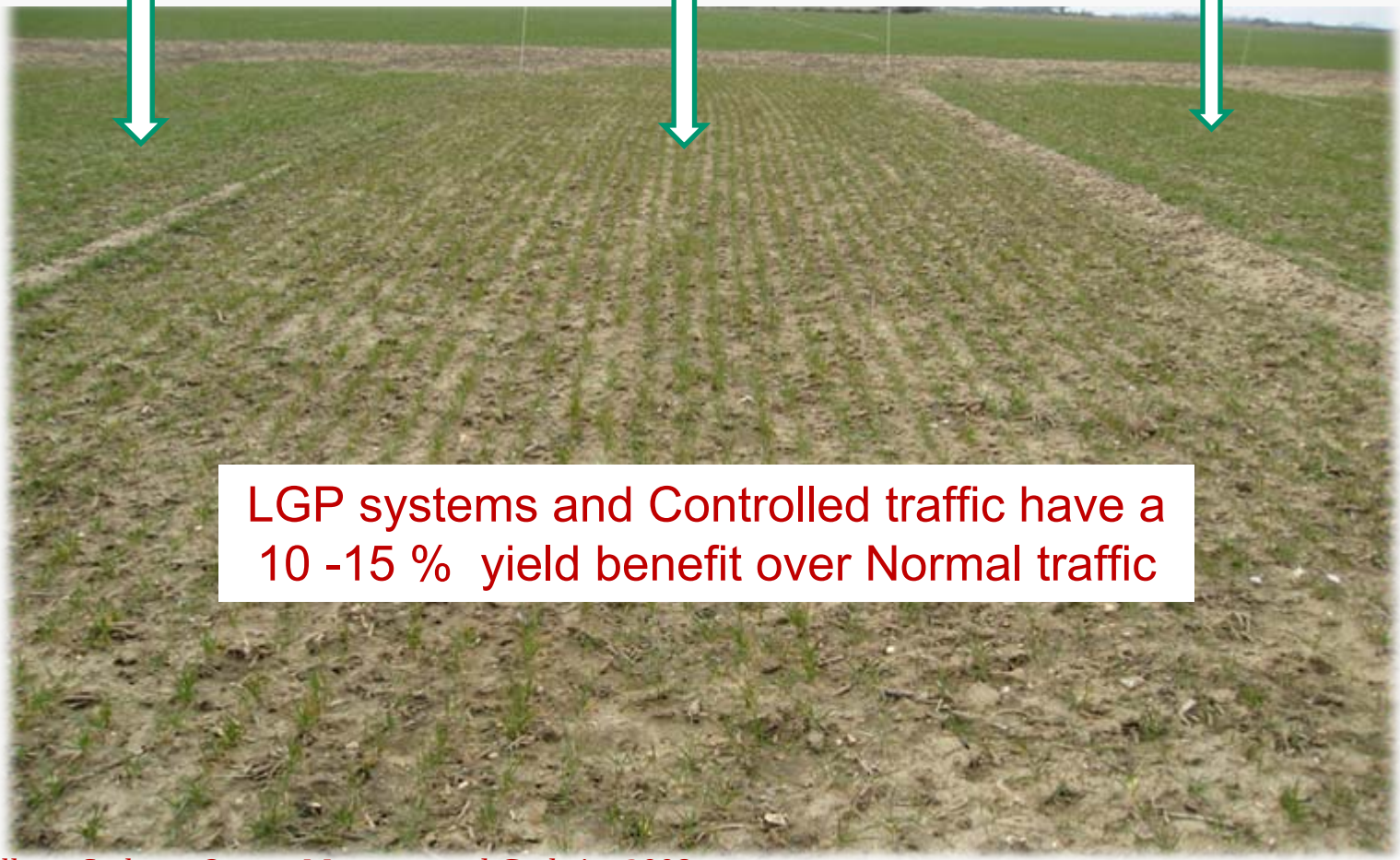
No traffic		Trafficked	
Shallow plough	47	Shallow plough	117
		A **60%** reduction	
Harrow	25	Spring tine	57
Drill	27	Power Harrow	108
Roll	27	Harrow	29
		Drill	31
		Roll	30
TOTAL	79		255
		A **70%** reduction	

After: Chamen, 1992

Infiltration rates up 400% *After: Chamen, 2011*

Yield from Low Ground Pressure Trial at Morley

Plot 7 Zero Traffic	Plot 8 Normal traffic	Plot 9 Zero traffic +tracked combine
12. 52 t/ha	10.84t/ha	12.14t/ha



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

After: Phillpot, Stobart, Orson, Mouasen and Godwin, 2008

Benefits of reduced tillage?

Independent 07/08/07 * *Not in the Independent*

The main reasons to use of reduced tillage are:



- To reduce energy consumption
- To reduce labour costs
- To conserve moisture
- To retain plant cover to minimize erosion
- Minimise loss of organic matter and improve soil structure*

- Each point is very appealing to the farmer who wants to make the best profit margins in terms of field efficiency, fuel economy and work rate.
- Reduced tillage is also appealing to the farmer who wants to look after the land.
- However, reduced tillage farmers are most affected by poor weather conditions.
- For anybody new to min-till, *one of the best tools in your tool box for min-till is patience*.
- The best advice is to wait until conditions are ideal for sowing. There is no point in sowing a crop (especially winter barley) into a compacted or smeared seed bed.

5. Mechanical weed control and organic practices

Reduced herbicide use





Treated

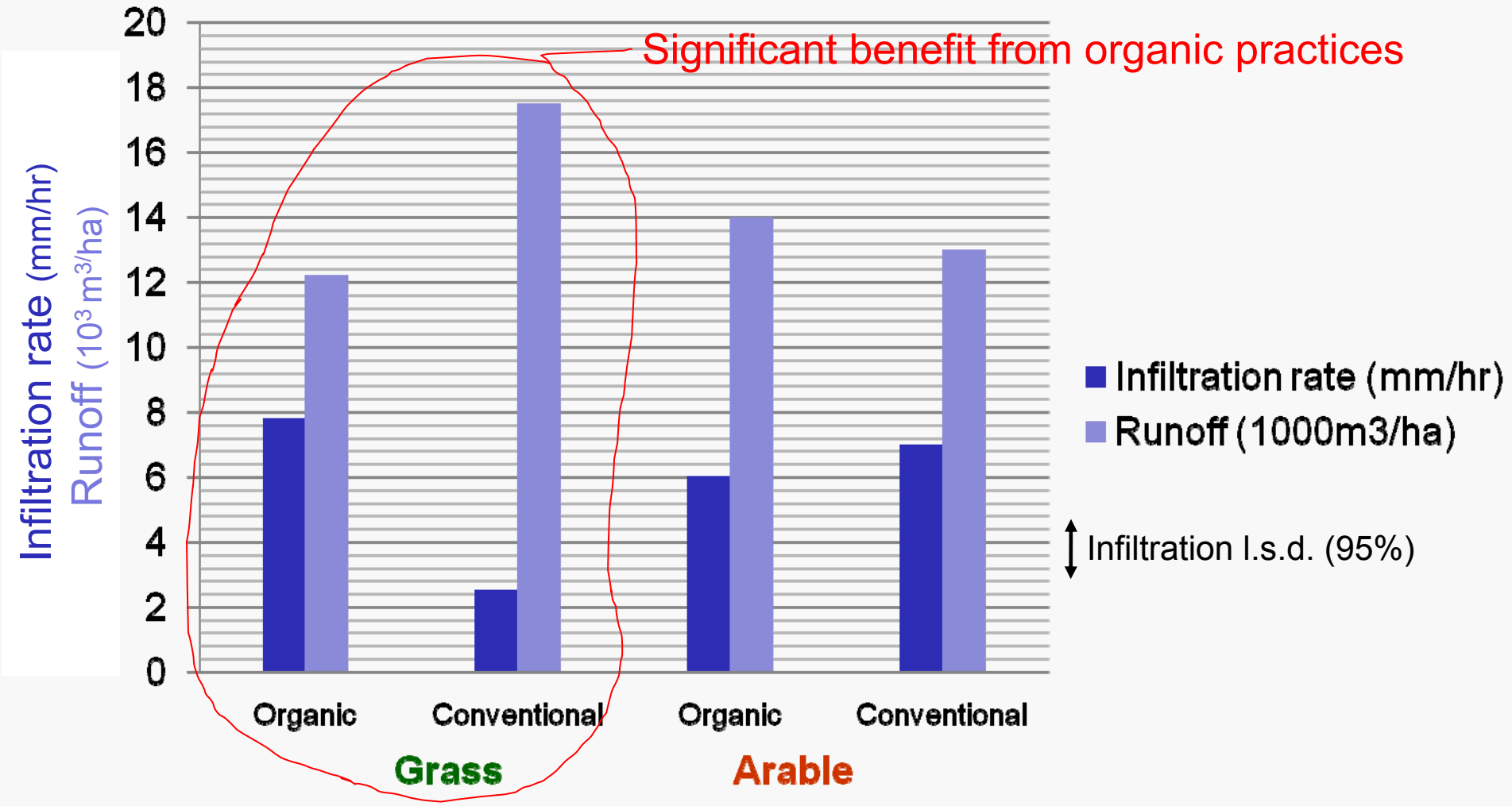


Untreated



After: Dedousis et al (2007), O'Dogherty et al (2007) and Tillett et al (2007)

Effect of organic practices on infiltration and runoff*

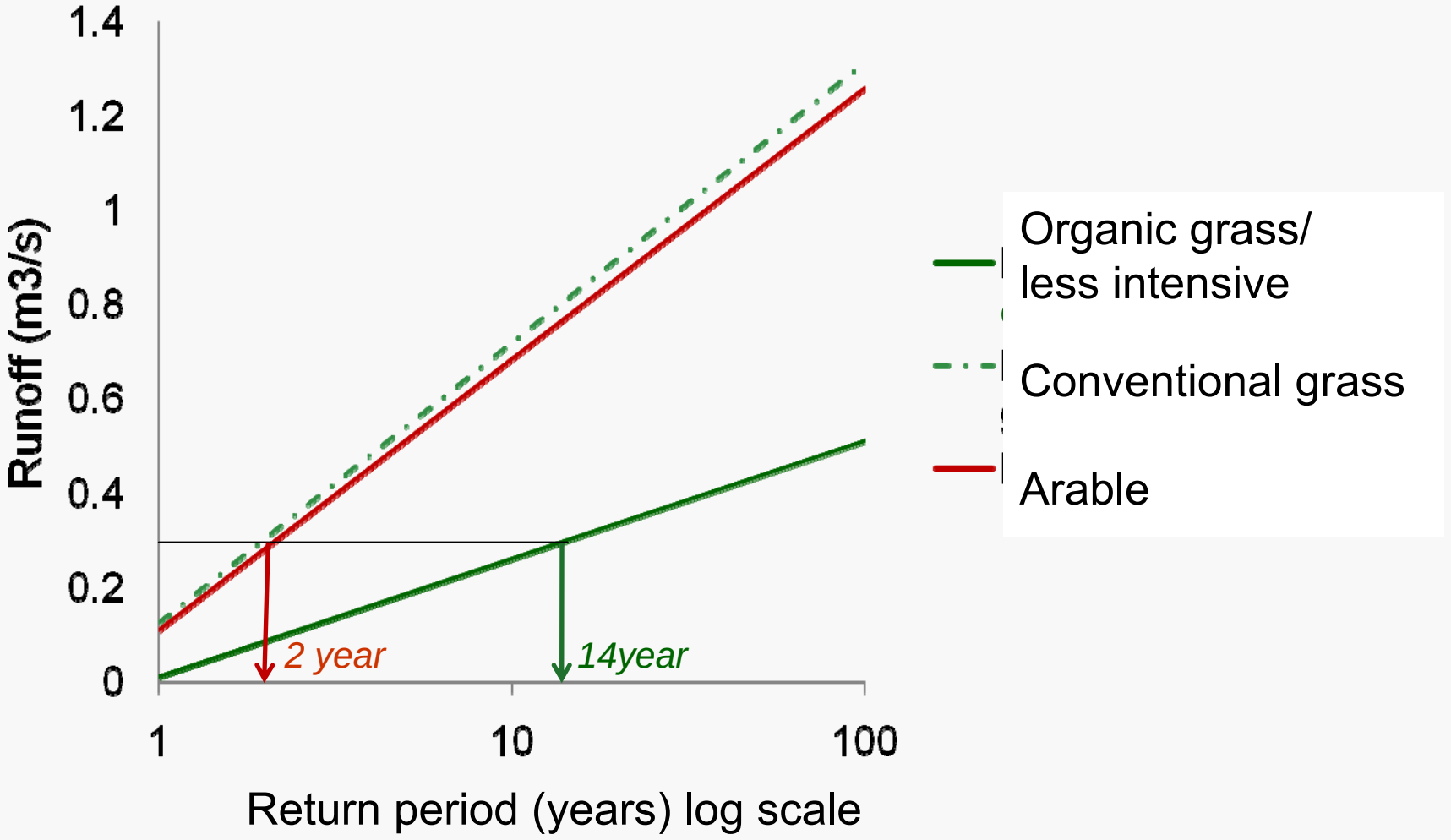


After: Hathaway-Jenkins and Godwin, 2010

* for a 20mm/hr storm - NERC, 1975

Estimated runoff rate and flood return period

for a 550ha sub-catchment with an average slope of 0.5° in the Midlands



After: Hathaway-Jenkins and Godwin, 2010



Conclusions

Good soil and water management:-

- Enhances/maintains crop yield
- Improves infiltration
- Reduces runoff and peak flood flows
- Maintains the landscape
- Protects the infrastructure
- Reduces pollution
- Utilizes waste
- Reduces energy use

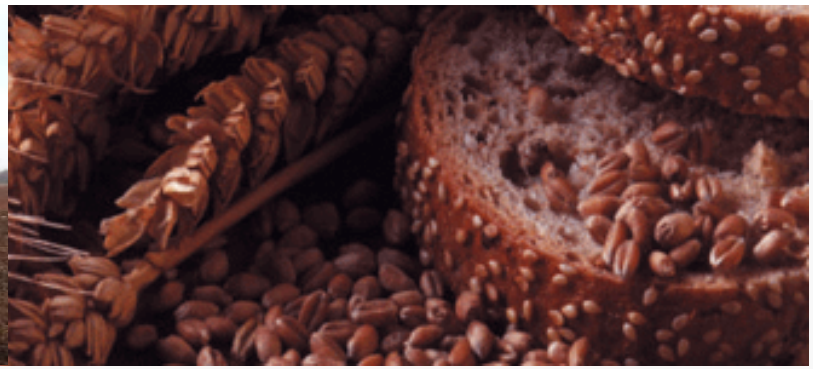
And as a result improves food and environmental sustainability

Engineering can deliver relatively quick solutions -

which is not always dependent on waiting for “NEW SCIENCE”







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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



