Institution of Agricultural Engineers
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Soil management technology to control runoff



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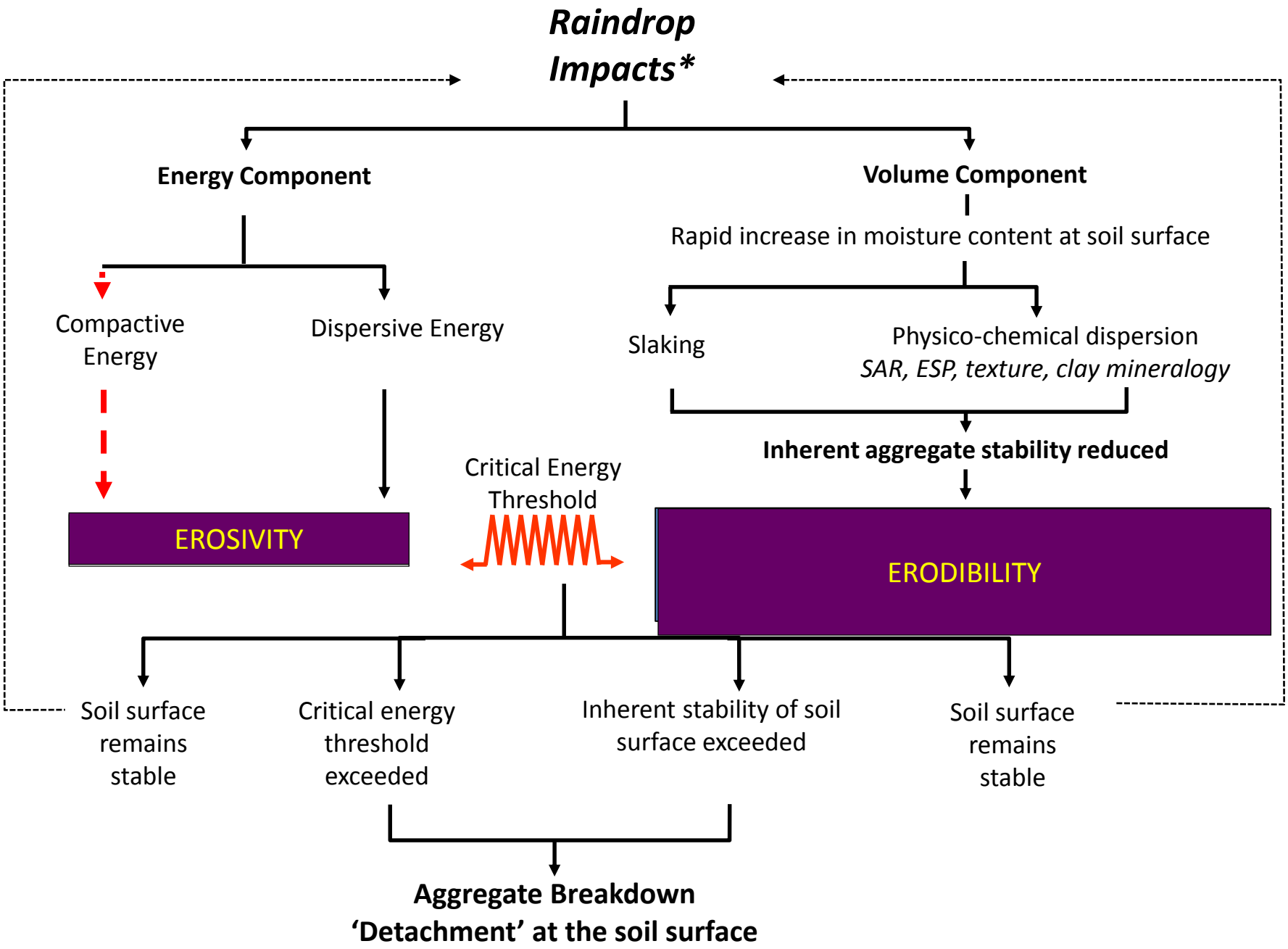




Outline

- Review of runoff generation processes and consequences
- Principles of runoff control
- Conclusions/Challenges





Source: Simmons (2015)

*Includes impacts of drops associated with irrigation guns/sprinklers

Review process of runoff generation

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Aggregate Breakdown
SEAL/CRUST FORMATION

↓ Infiltration rate → ↓ moisture re-charge → ↑ plant water stress

↑ Risk of runoff generation & erosion

Runoff generated

ENTRAINMENT of detached material

TRANSPORT of detached material

Principles of runoff control

1) Maintain/improve infiltration & hydraulic conductivity

2) Reduce runoff erosivity

3) Reduce runoff transport capacity

4) Control field scale water movements



Principles of runoff control

1) Maintain and/or improve infiltration

- Rational Method

$$Q = 0.0028\ C\ I\ A$$

Q = peak flow ($m^3\ sec^{-1}$)

C = the runoff coefficient

I = rainfall intensity ($mm\ hr^{-1}$) for a duration equal to the time of concentration (Tc)

A = catchment area (ha)

$Q = 0.0028\ 0.8 \times 60 \times 6.794$

$Q = \mathbf{1.64}\ (m^3\ sec^{-1})$

$Q = 0.0028\ 0.6 \times 60 \times 6.794$

$Q = \mathbf{0.82}\ (m^3\ sec^{-1})$

Principles of runoff control

2) Reduce runoff erosivity

- Controlling slope length at which runoff becomes erosive

$$L_c = \frac{Vt^{5/2} . \quad n^{3/2}}{(r - i) \sin^{3/4} \ S. \cos S.}$$

where L_c = Critical slope length at which runoff becomes erosive

Vt = Maximum permissible velocity

n = Mannings roughness coefficient

*r = rainfall intensity (m/hr)

i = infiltration capacity (m/hr)

S = slope (degrees)

*Includes impacts of drops associated with irrigation guns/sprinklers

Principles of runoff control

3) Reduce runoff transport capacity

- Transport by flow (Morgan, 1980)

$$T_f = 0.0061 Q^{1.8} s^{1.13} n^{-0.15} D_{35}^{-1}$$

where T_f = net sediment transport by overland flow

Q = discharge of water

s = slope angle (degrees)

n = (Manning's *n*) coefficient of roughness

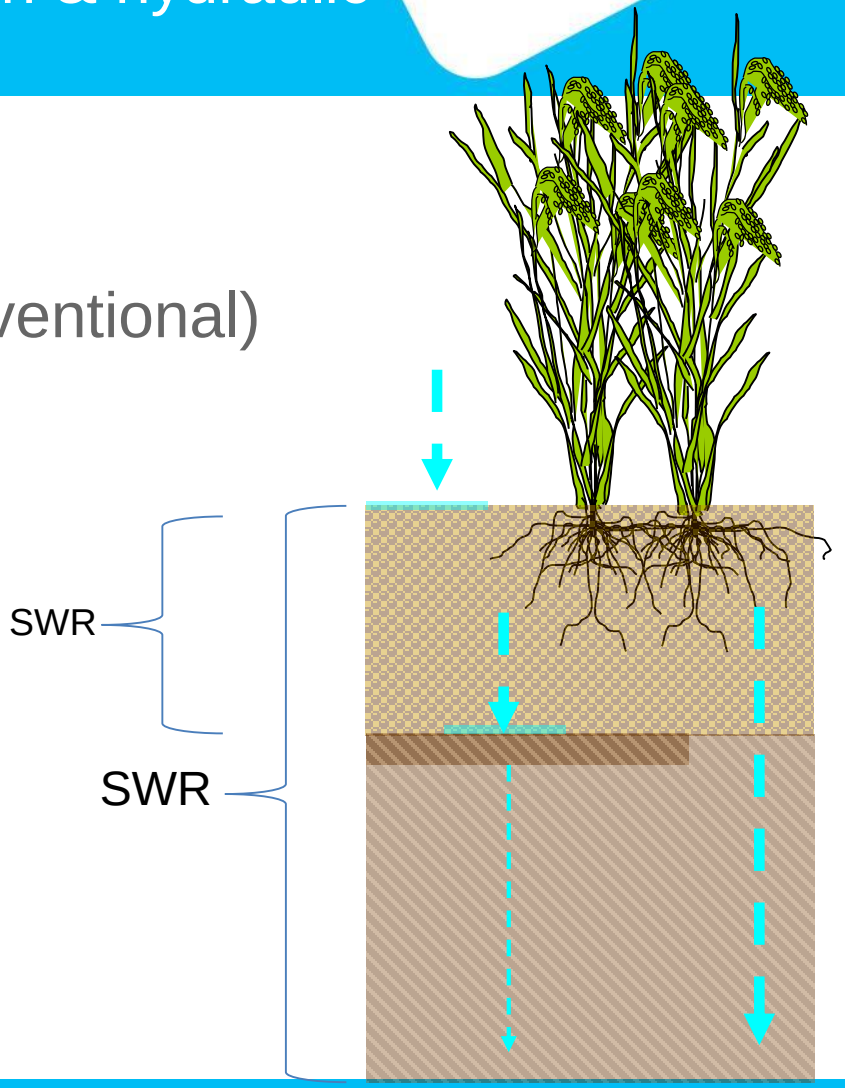
D_{35} = particle size of the surface material at which 35% of grains are finer

Principles of runoff control

1) Maintain and/or improve infiltration & hydraulic conductivity

a) Maintain/improve soil structure

- Tillage options (conservation/conventional)
- Minimise risk of compaction
- Prevent sealing/capping
- Cover crops*
- Organic matter management

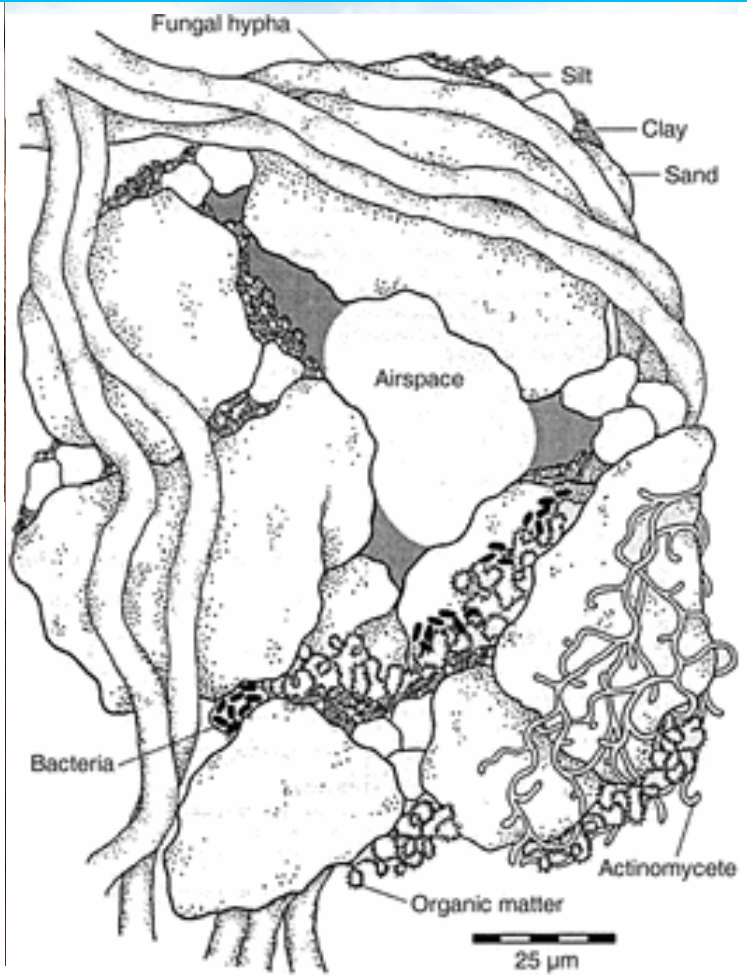


Principles of runoff control

1) Maintain and/or improve infiltration

b) Prevent aggregate breakdown

- Cover crops*
- Residue Management
- Organic matter management
- Polymer-based options



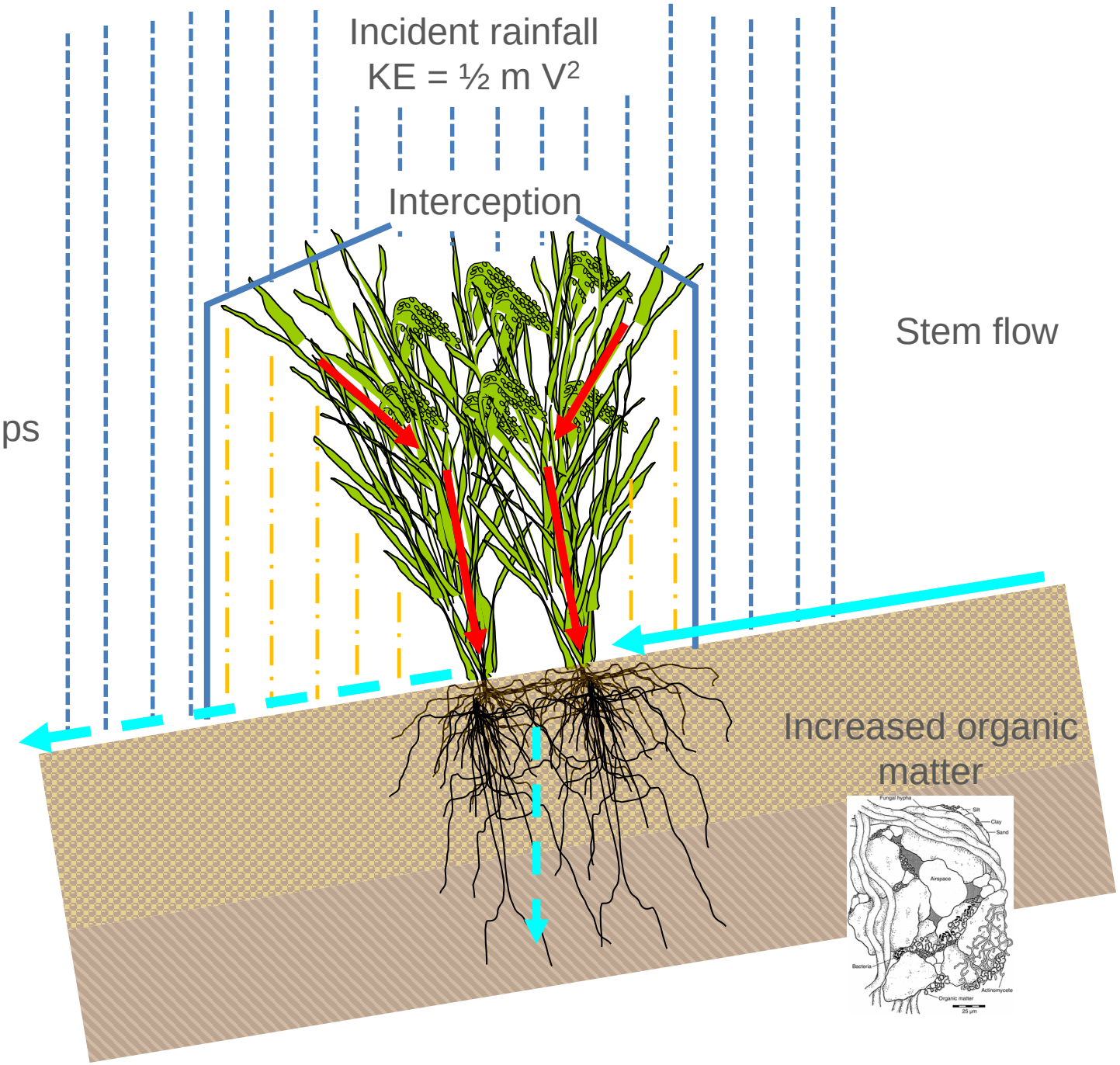
Principles of runoff control

1) Maintain and/or improve infiltration

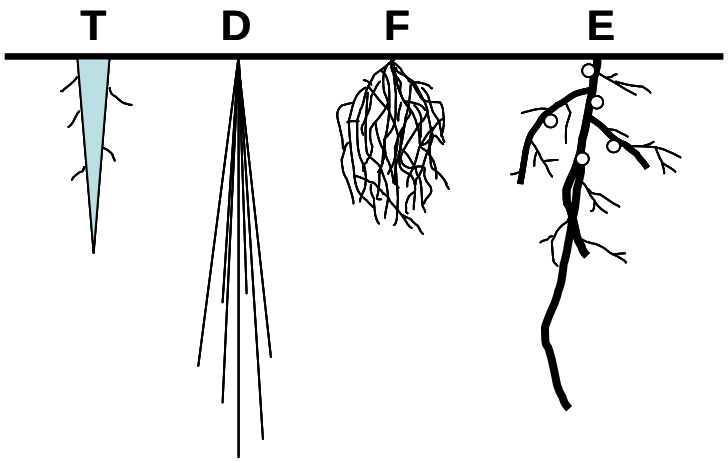
- Polymer-based options
  - polyacrylamide (PAM)
  - polyvinylacrylic-latex (PVAL)
  - polyvinylacetate (PVA)



- Cover crops


Incident rainfall
KE = ½ m V²
Interception
Stem flow
Leaf drip
Shattered raindrops
KE = ½ m V²
Stem induced roughness
Increased organic matter
Fungal hypha
Silt
Clay
Sand
Airspace
Bacteria
Actinomycete
Organic matter
25 µm

- Cover crops





Spp	Root Type	Root traits postulated to influence soil structural conditioning
Wheat	D	Fibrous vigorous deep roots
Rye	D	Deep fibrous roots
Oats	D	Aggressive deep roots
Italian ryegrass	F	Fibrous root system
Lucerne	E	Deep and aggressive rooting
Phacelia	F	Prolific root system but more confined to surface
Fodder radish	T	Tap root, long and extensive root hairs on laterals
Chicory	T	Tap root
Sweet clover	E	Vigorous and extensive multi-order lateral branching,
Field bean	E	Large, strong roots
Lupin	E	Tap root

(Ritz, 2014)

Principles of runoff control

1) Maintain and/or improve infiltration

c) Remediation options

- Busting ‘caps’
- Sub-soiling
- SSD/mulch options







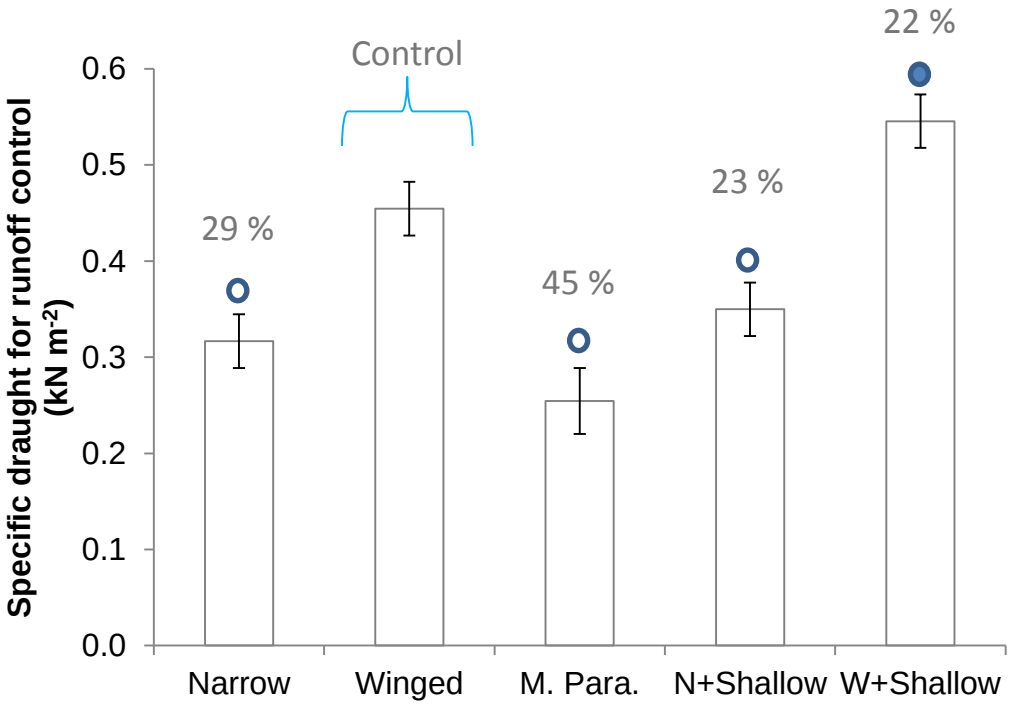


Optimising soil disturbance and mulch attenuation for erosion and runoff control (J. Niziolomski)

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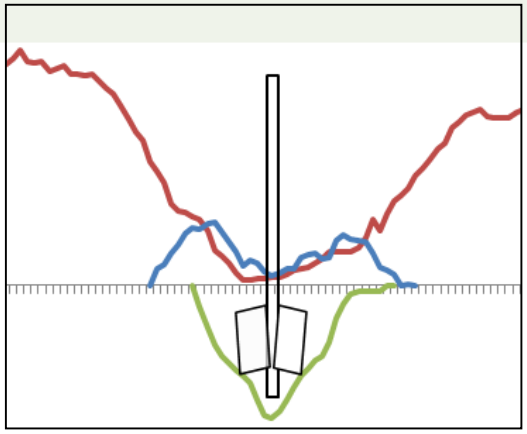
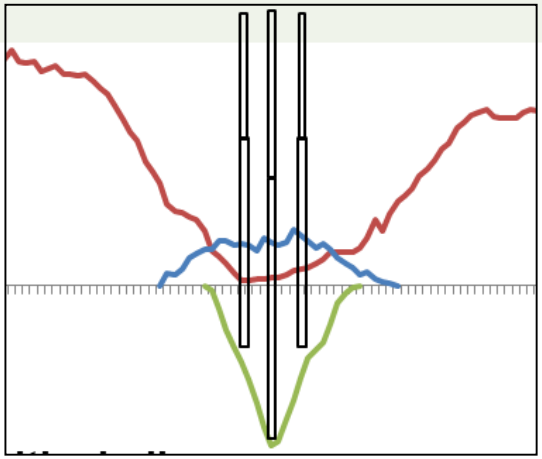
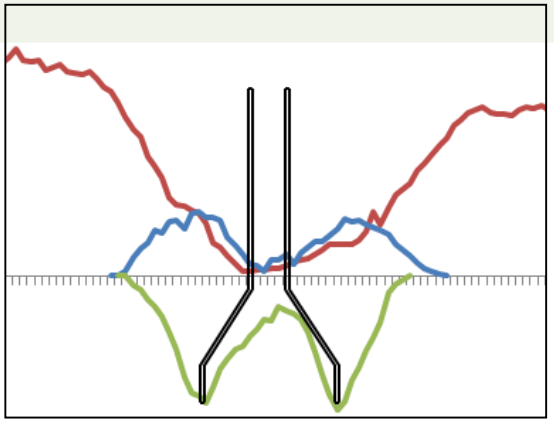
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- Winged with shallow is 22 % less efficient than the winged tine.
- Modified para-plough is the most efficient at 45 %.

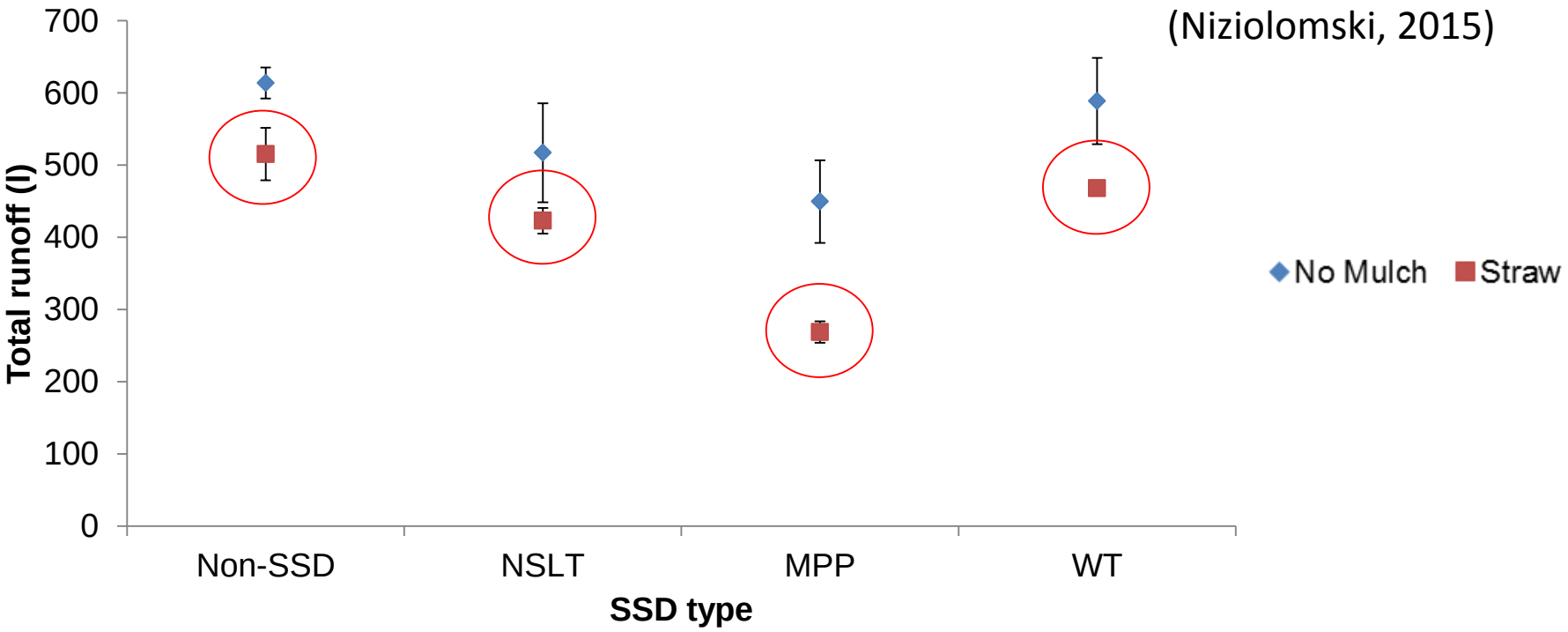
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Shallow soil disturbance (175 mm) both with and without straw mulch (6 t ha^{-1}).

Winged tine	Narrow with two shallow leading tines	Modified para-plough
		
		

Soil disturbance field trial results
Total runoff volume (l)

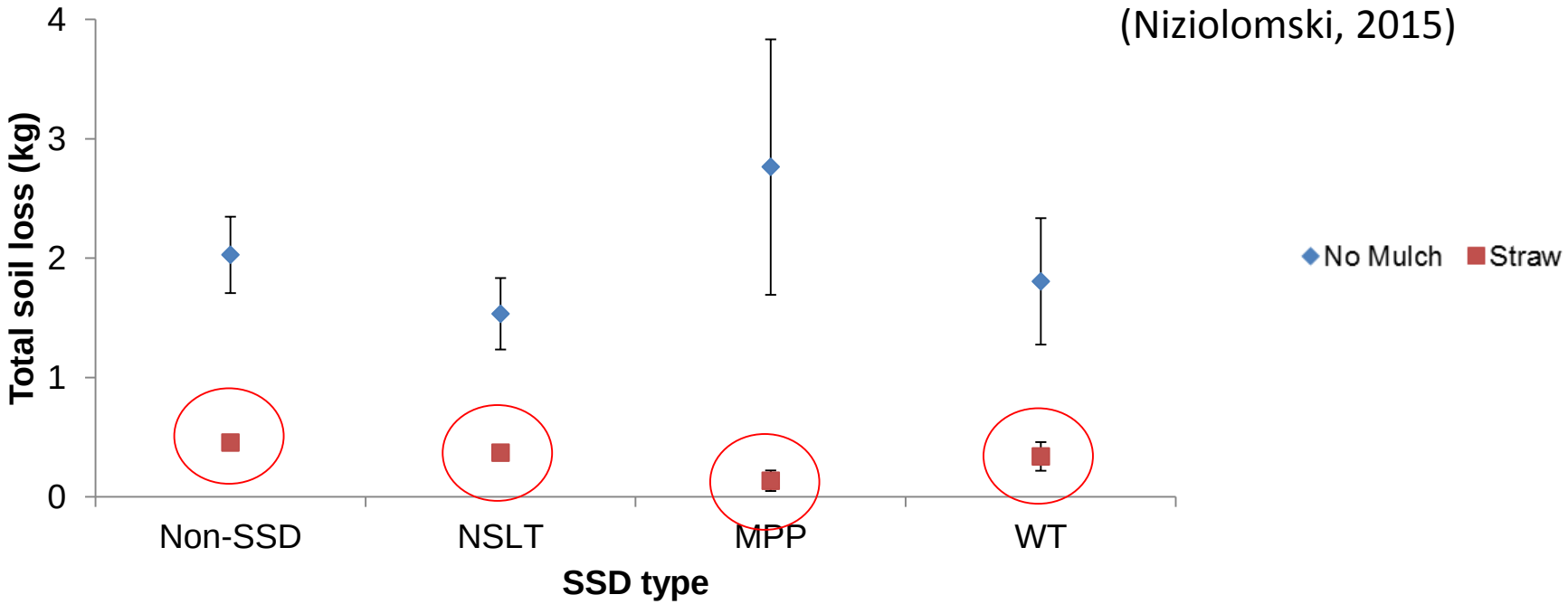
(Niziolomski, 2015)



- Straw mulch reduced runoff as compared with no mulch.
- MPP with straw most reduced total runoff as compared with all other treatments.

Phase 2 field trial results

(Niziolomski, 2015)



- Modified para-plough with straw most reduced soil loss
- Little significant difference was observed between SSD (different tines) and Non-SSD.
- Straw mulch decreased total soil loss as compared with no mulch.

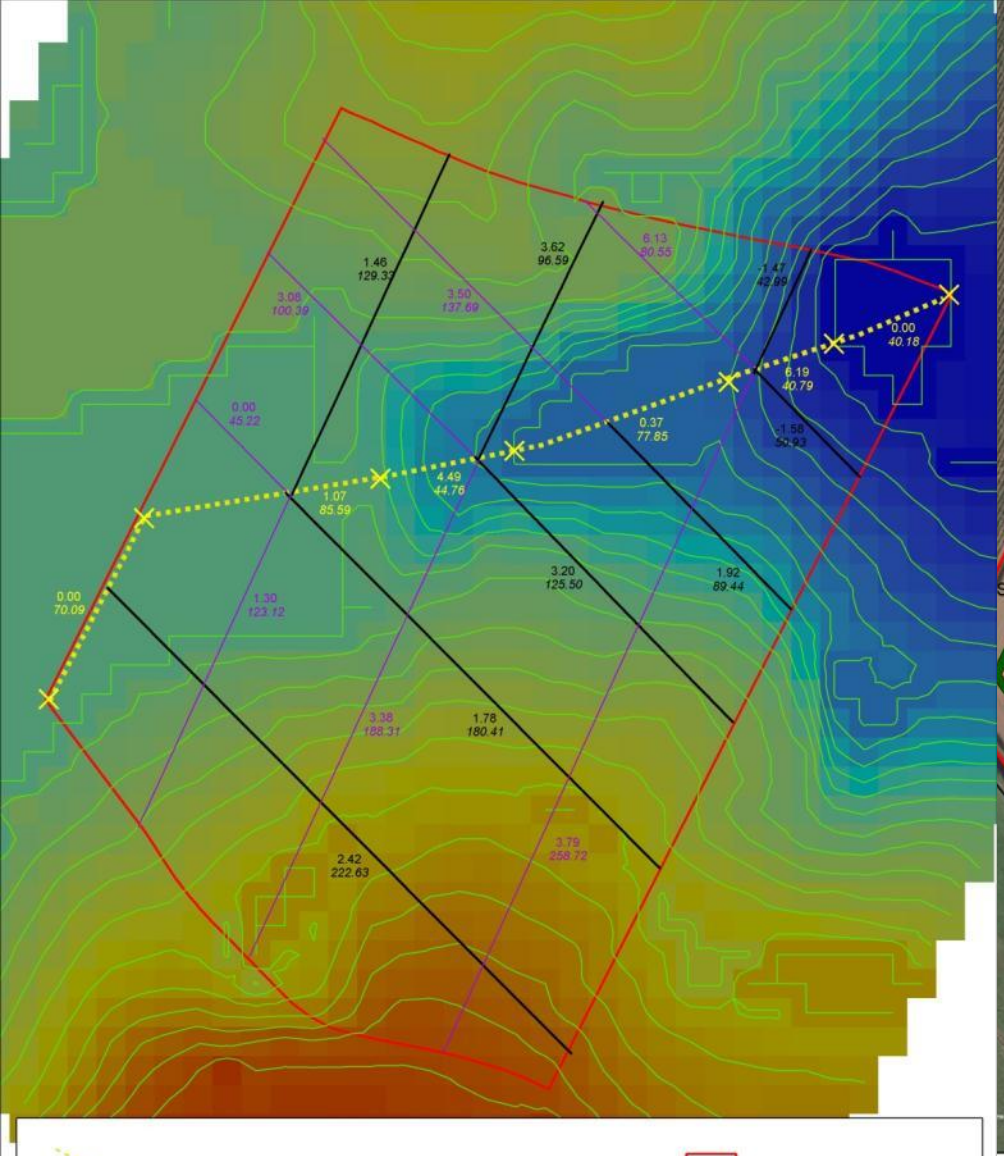
Grassed-Waterways

Field-specific design specifications (too much)











Proposed grass waterway centreline

Option 1: Bed orientation

Option 2: Bed orientation (extension across field)

2.42
222.63
Slope angle (degrees)
Slope Length (m)

Field Boundary

1m Contour

10m DTM
High : 83.9
Low : 59

0 20 40 80 Metres

N

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rass waterway

ltivated areas

rassed areas (Asparagus planting not recommended due to slope)

verflow bund

ack

eotextile runoff apron

show the slope angle in degrees

N

0 20 40 80
Metres

Conclusions/Challenges

- Runoff can be controlled by
  - Maintaining/improving infiltration & hydraulic conductivity
  - Ensuring that runoff does not attain an erosive velocity
  - Reducing the transport capacity of runoff

Conclusions/Challenges

- Challenges/Engineering solutions
  - Field scale band application of PAMs over drill lines
  - Application of compost/residues to multiple wheelings.
  - Rapid and accurate placement of within field runoff control barriers

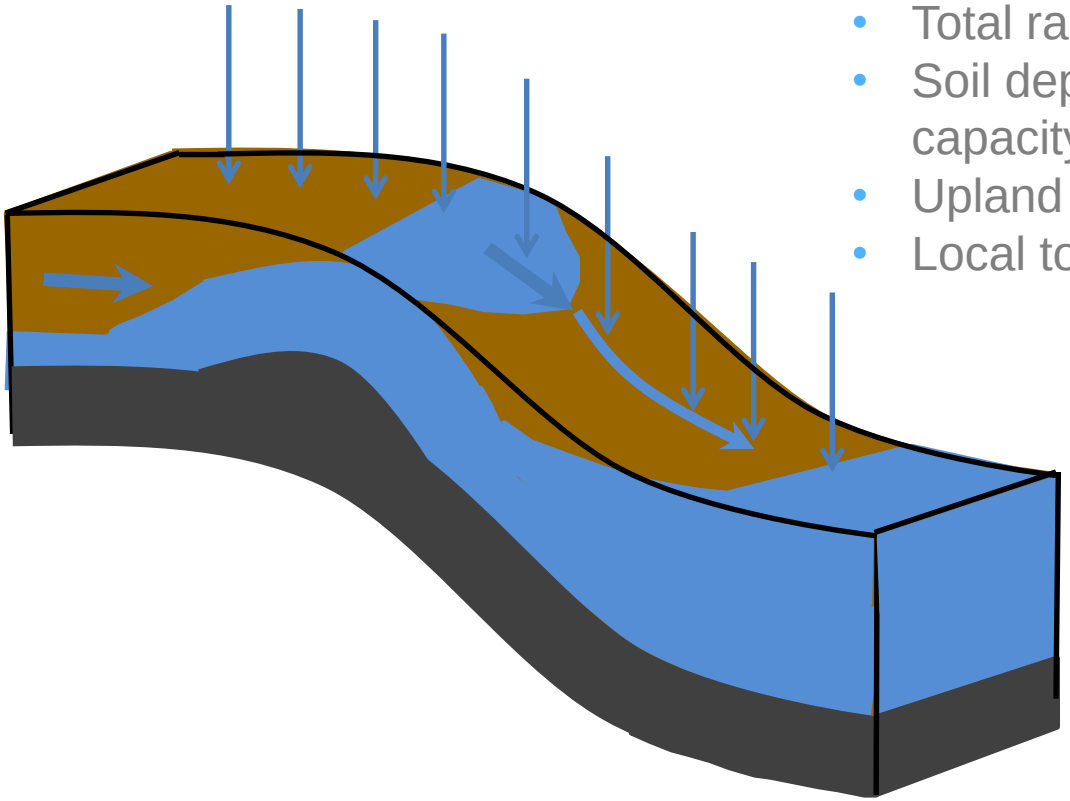
Long term sustainable soil management in a rotational context

Questions

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Saturated excess overland flow



Independent of WSR. Instead:

- Total rainfall amount (including I>WSR)
- Soil depth (i.e. available water storage capacity)
- Upland watershed area
- Local topography

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