Synergy between Gypsum and Polyacrylamide (PAM) in Reducing Runoff and Erosion from Disturbed Areas

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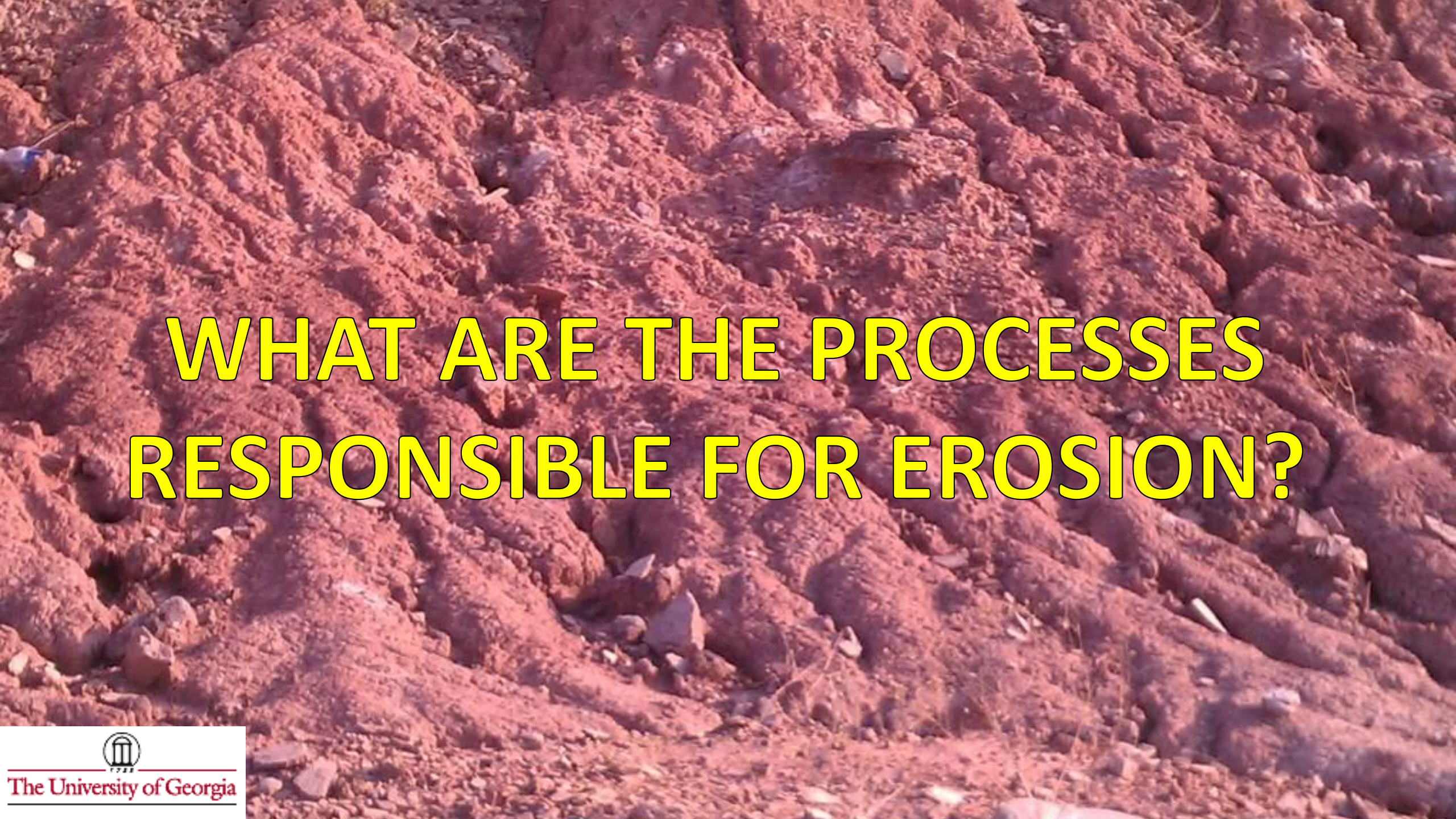

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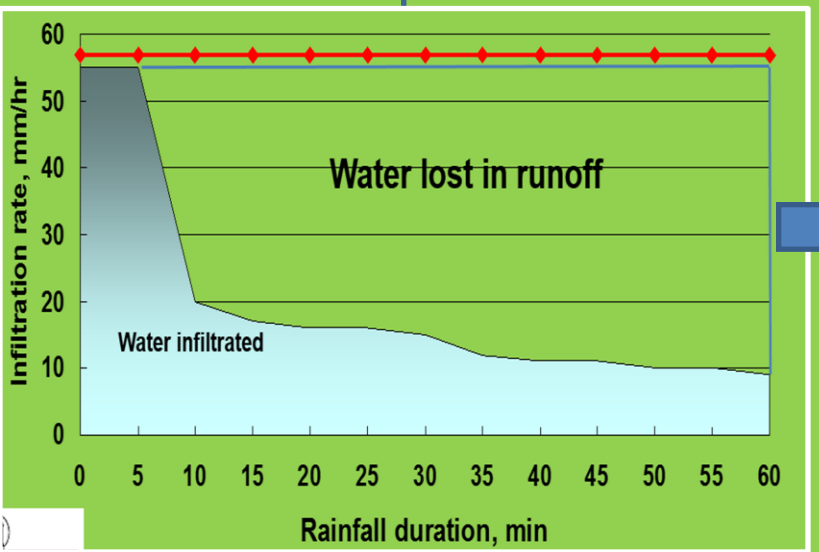
Dispersible clay

Raindrop impact (energy)

Crust (seal) formation

Initiation of runoff



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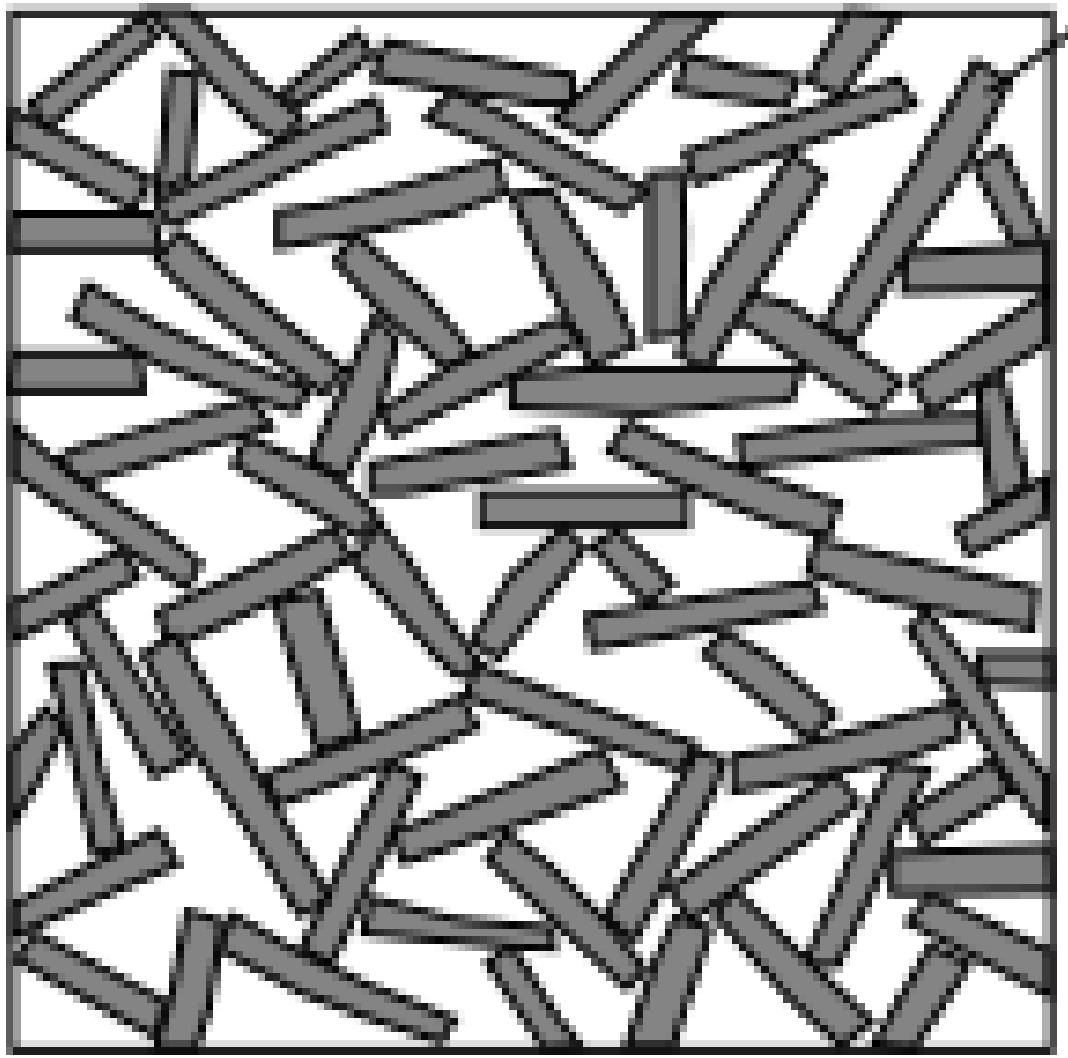
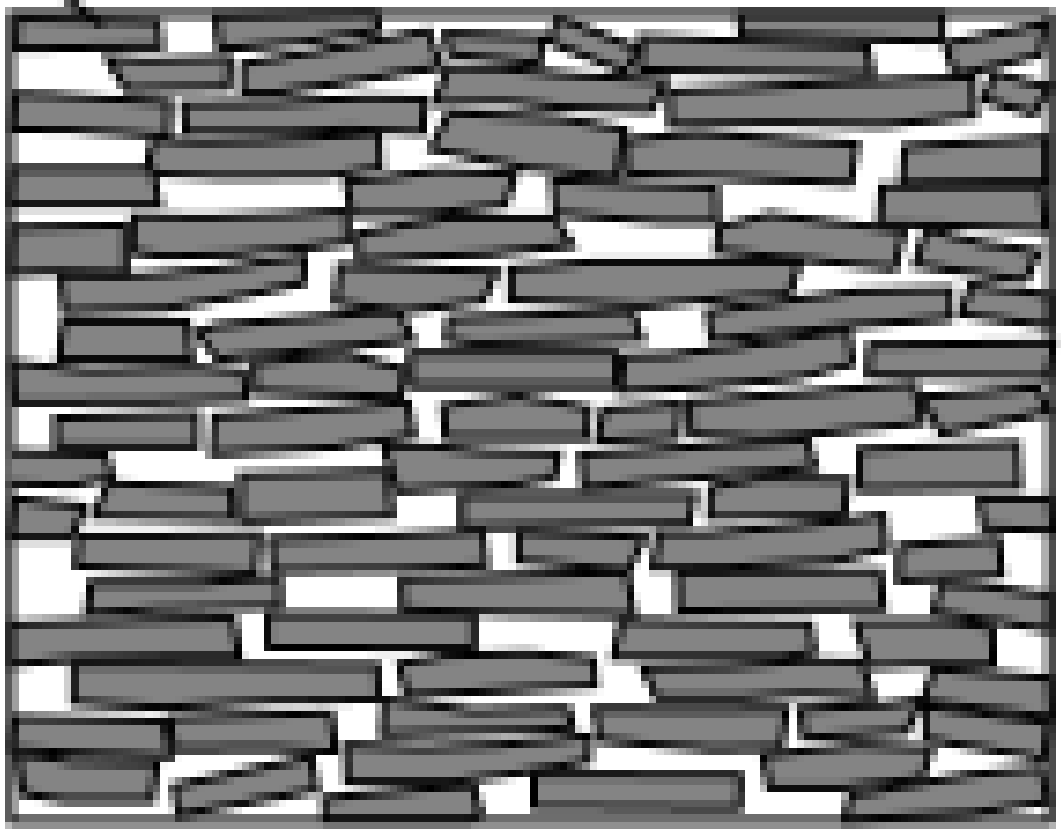
Clay Particles

Flocculated



Dispersed



“House of Cards” Structure
Porous

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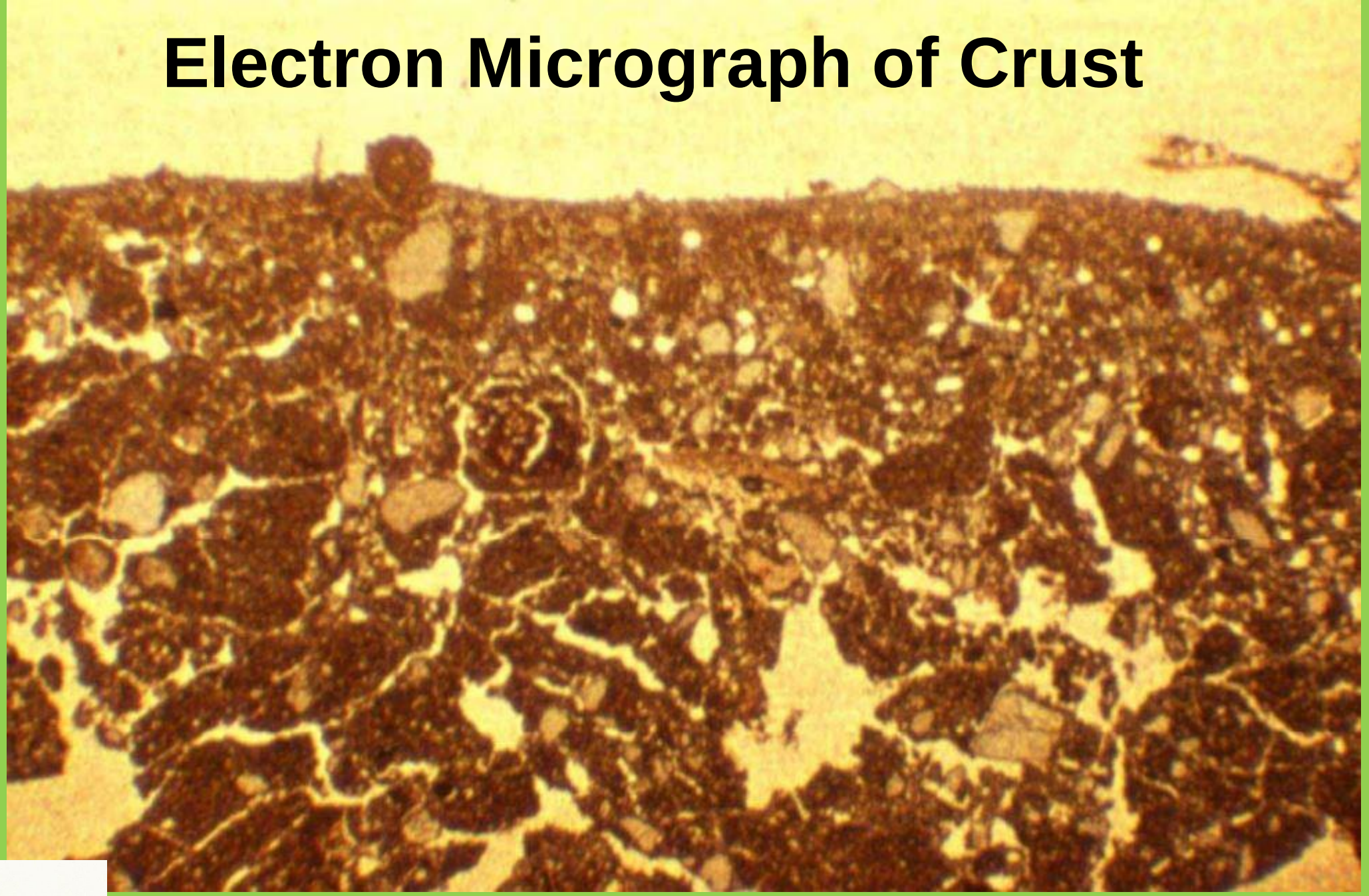
Laminar Structure
Less Porous

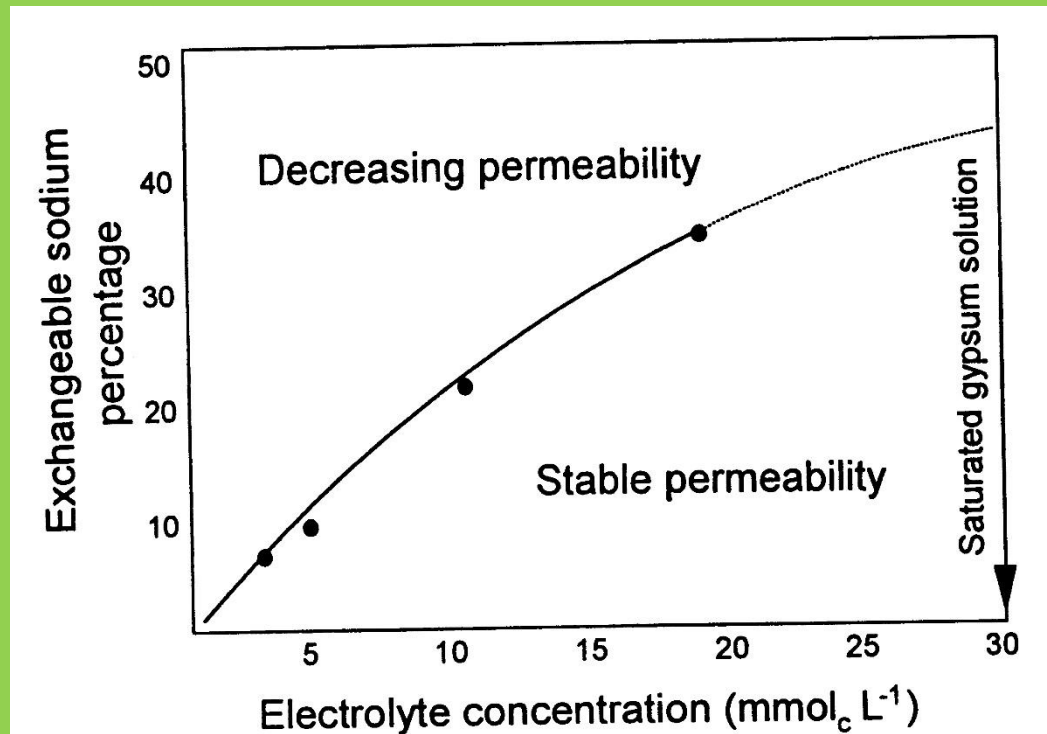
Electron Micrograph of Crust



Norton and Rhoton (2007)

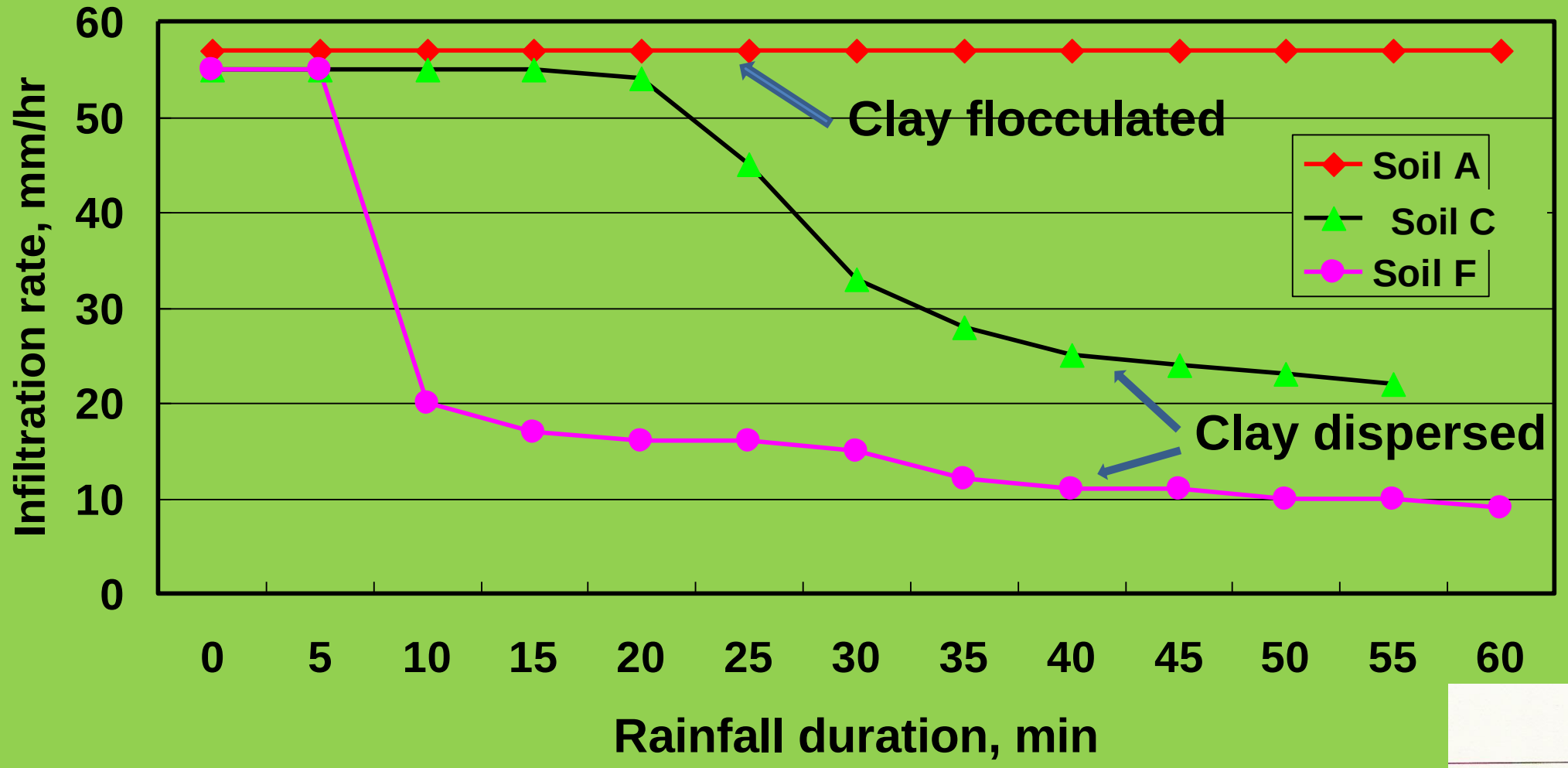
Clay Dispersion and Flocculation

- **Chemical in nature but key to soil physical behavior**
  - **Cation valence and concentration control dispersion/flocculation**
    - **Monovalent (Na^+, K^+) and low electrolyte concentration are dispersive**
    - **Divalent (Ca^{2+}) and high electrolyte concentration promote flocculation**
- **Soil stability diagram**
- **Every soil has a unique diagram**

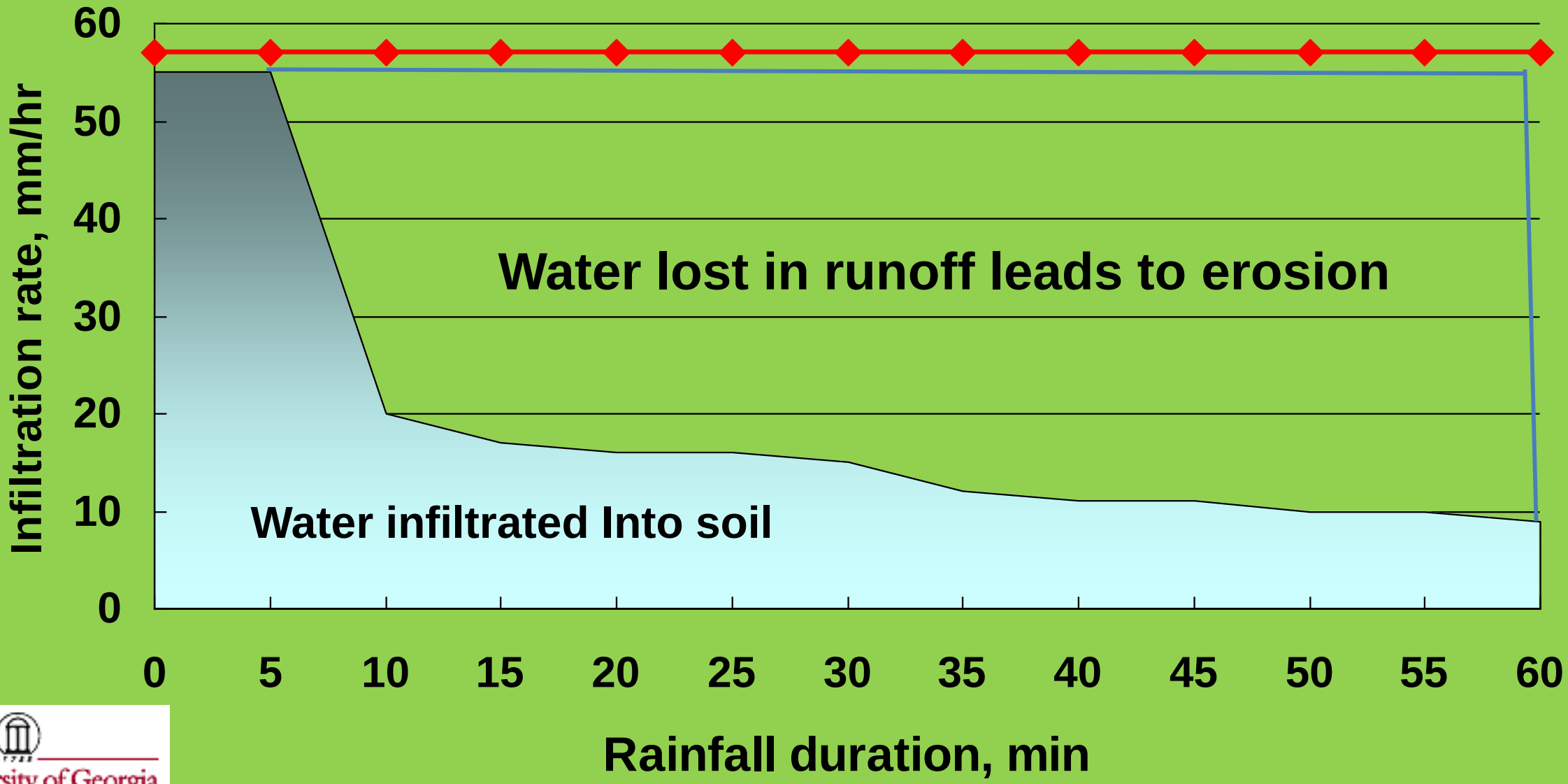


CONSEQUENCES OF DISPERSED CLAY

1. Reduced infiltration rate
2. Increased surface runoff



CONSEQUENCE



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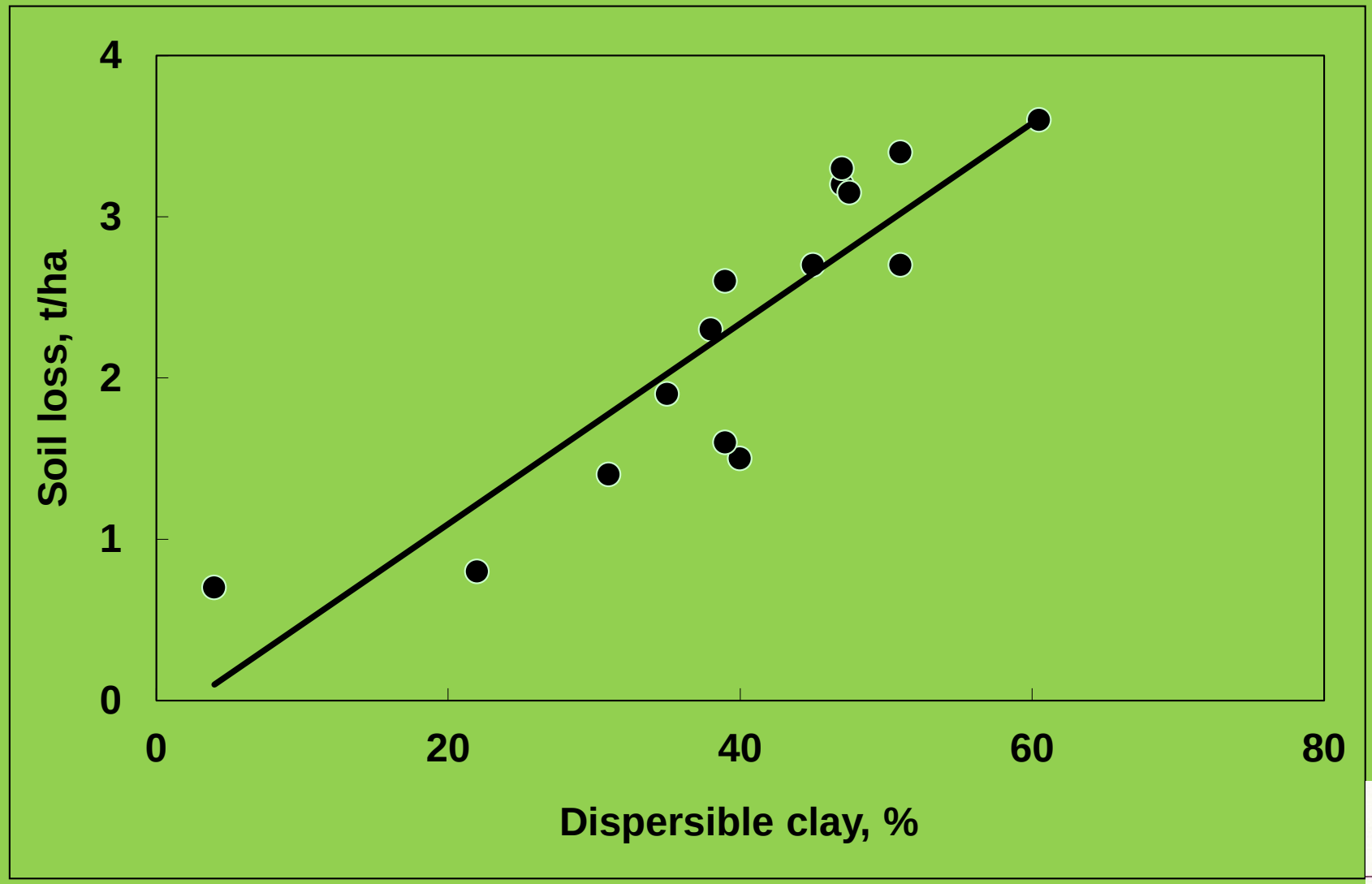
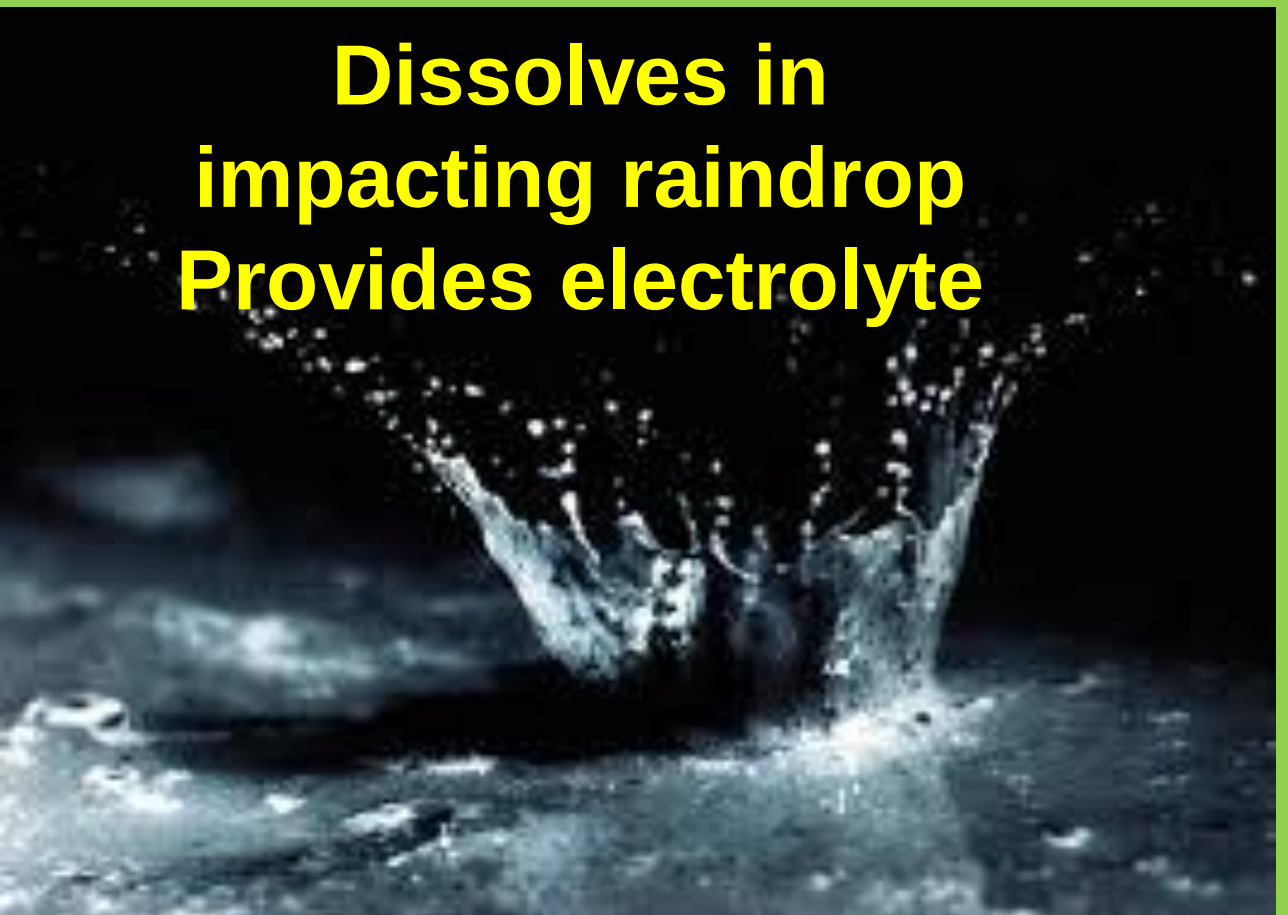
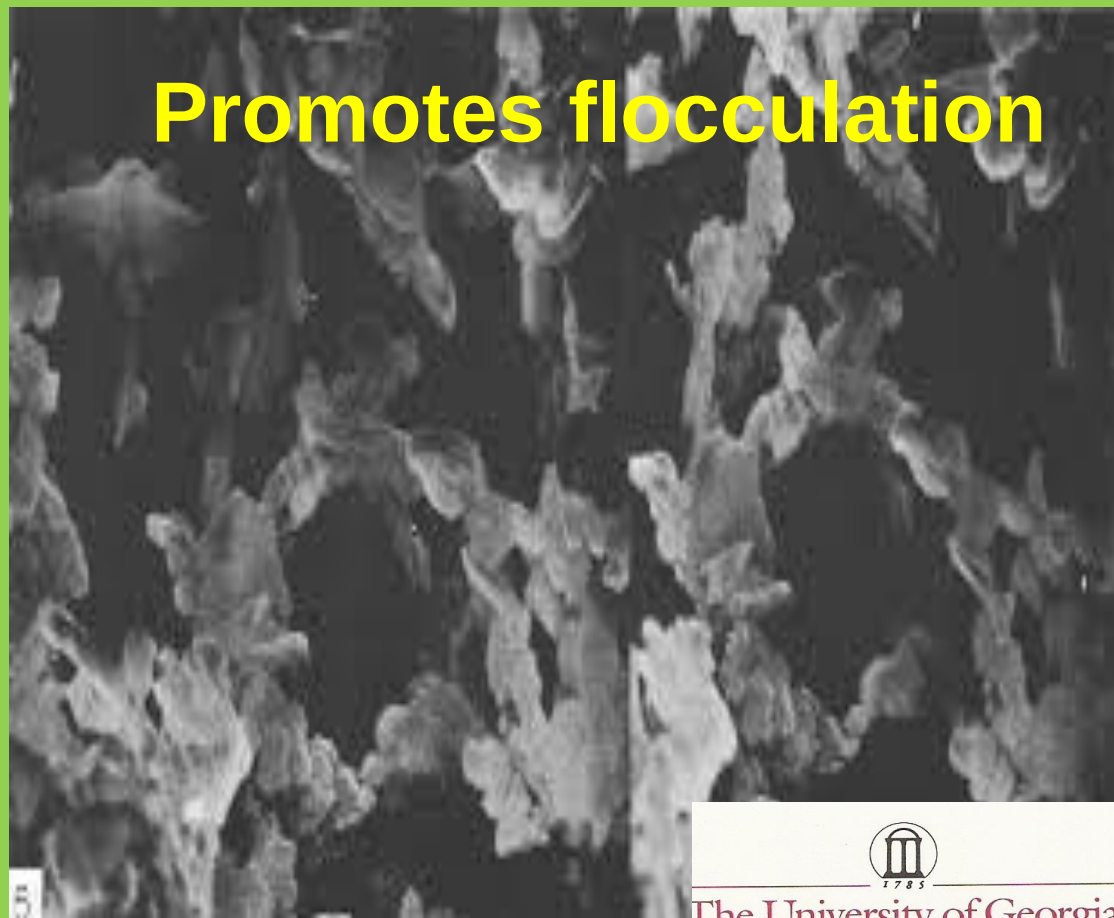
Soil Loss Proportional to Dispersible Clay



Ca^{2+} Ions in Solution Crucial

- **Speed of FGD gypsum dissolution in raindrop (very low EC)**
  - **Determines whether clay disperses on raindrop impact**
    - **Dispersed clay ⟶ Reduces infiltration ⟶ Increases runoff & erosion**
    - **Flocculated clay ⟶ Increases infiltration ⟶ Decreases runoff & erosion**





Ca^{2+} flocculate clay

But There is Synergy between PAM and Gypsum

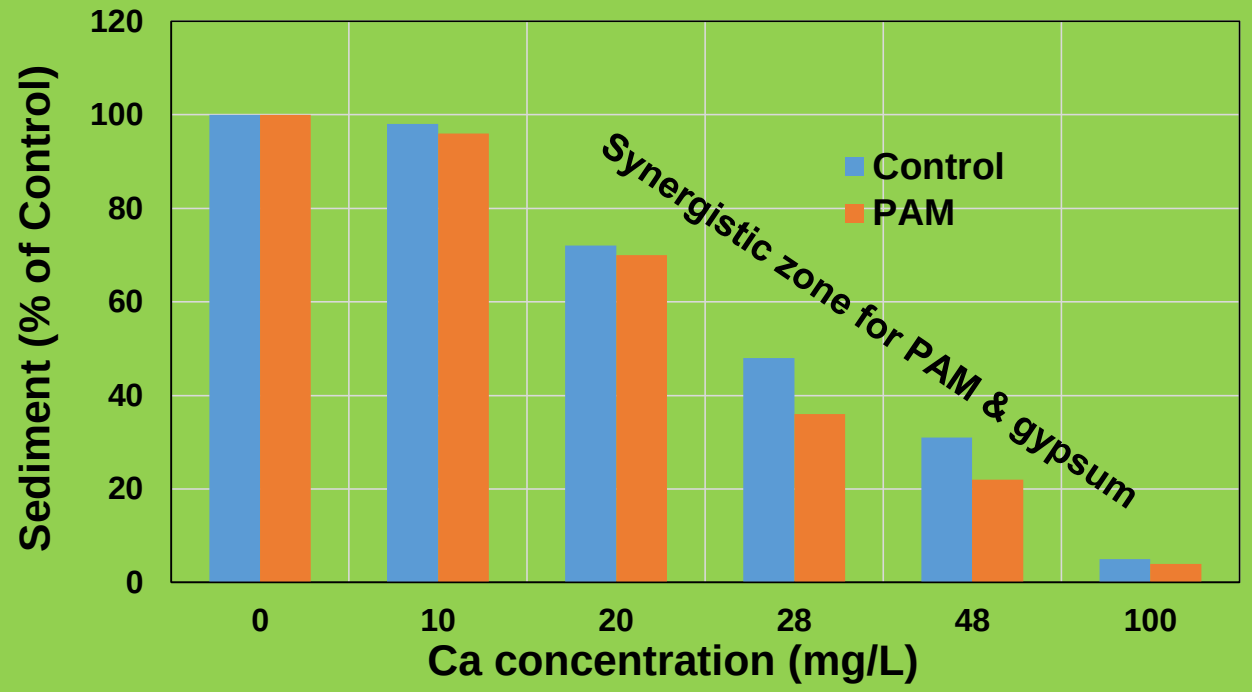
How to Stabilize the Flocculated Structure

- With polyacrylamide through divalent cation bonding (Ca^{2+})
- Facilitated by gypsum that supplies the Ca^{2+} cations

$$CaSO_4.2H_2O + H_2O \longrightarrow Ca^{2+} + SO_4^{2-}$$

Gypsum | Water | Calcium ions | Sulfate ions

- Critical interdependence between Ca^{2+} and PAM



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Synergy of Gypsum and PAM on Slaking

- **Aggregates < 4mm >2 mm**
  - **Sprayed with saturated gypsum solution and/or 0.05% PAM solution**
  - **Air-dried**
  - **Placed in distilled water**
- **PAM plus gypsum prevent slaking and stabilize aggregates**

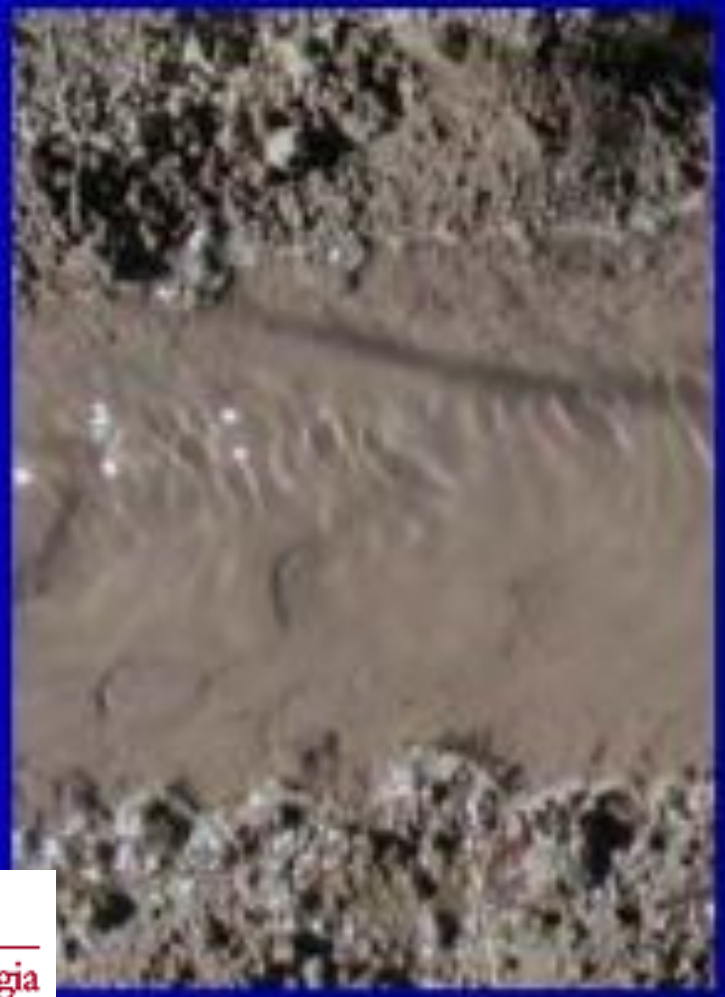
OUTCOME

- **Physical properties improved**
  - **Clay is flocculated**
  - **Better infiltration**
  - **Better percolation**
  - **Less runoff and erosion**

Gypsum plus PAM Prevent Slaking

Effect of PAM and Gypsum on Soil Structure

Result of soil slaking



PAM + Gypsum preserve soil pores

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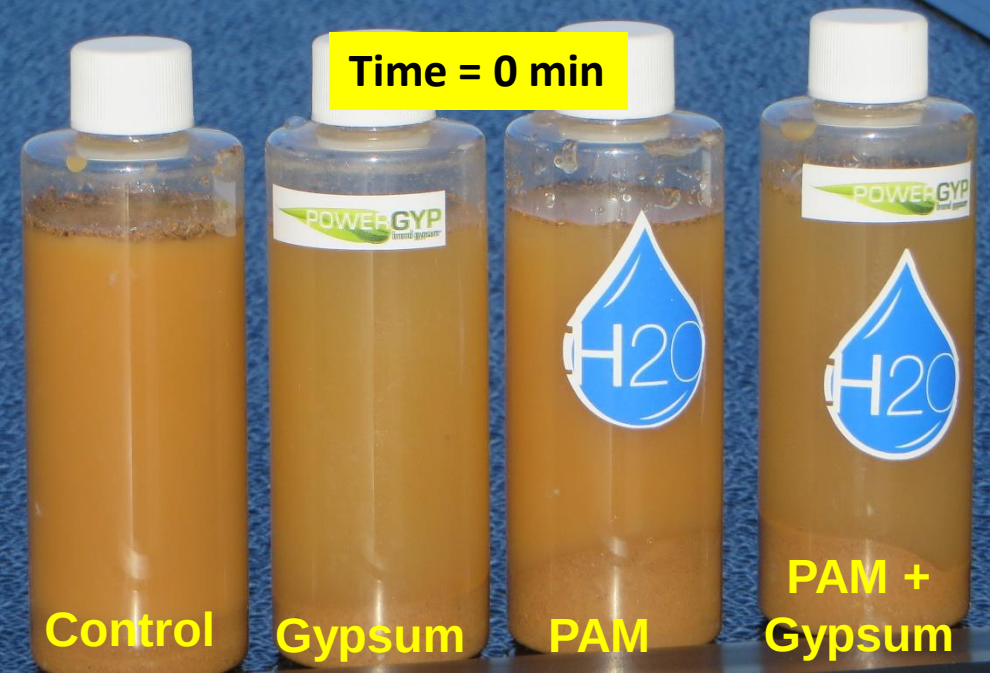
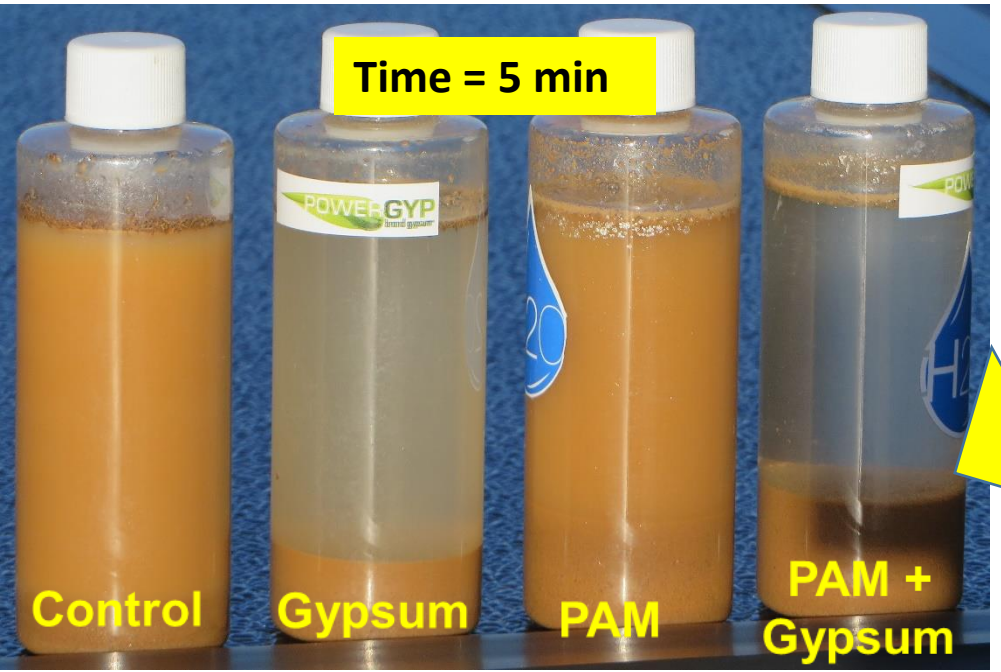
Lentz (2008)

Flocculation with PAM and FGD Gypsum





Note flocc volume vs gypsum

PAM + gypsum improve porosity

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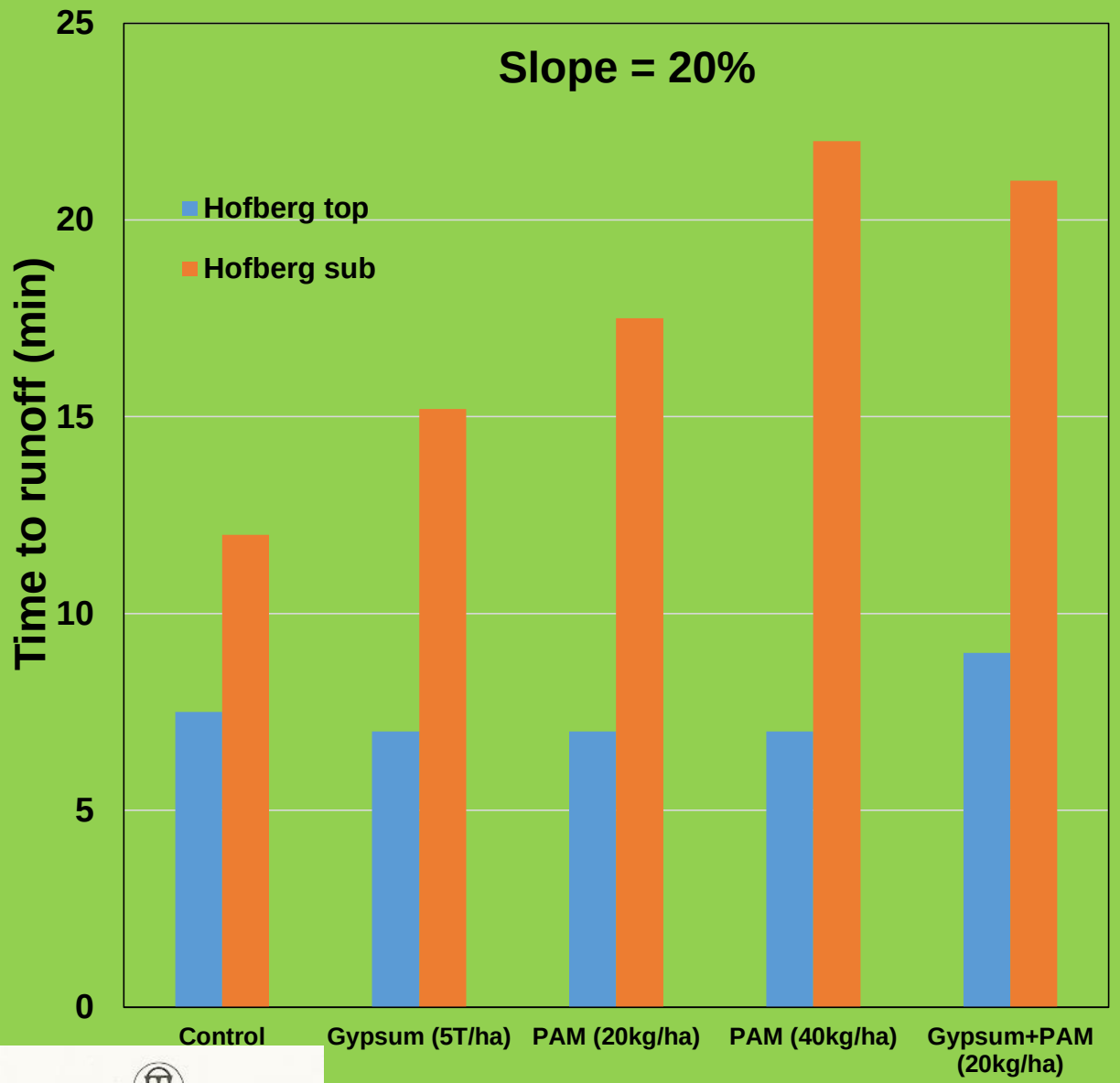
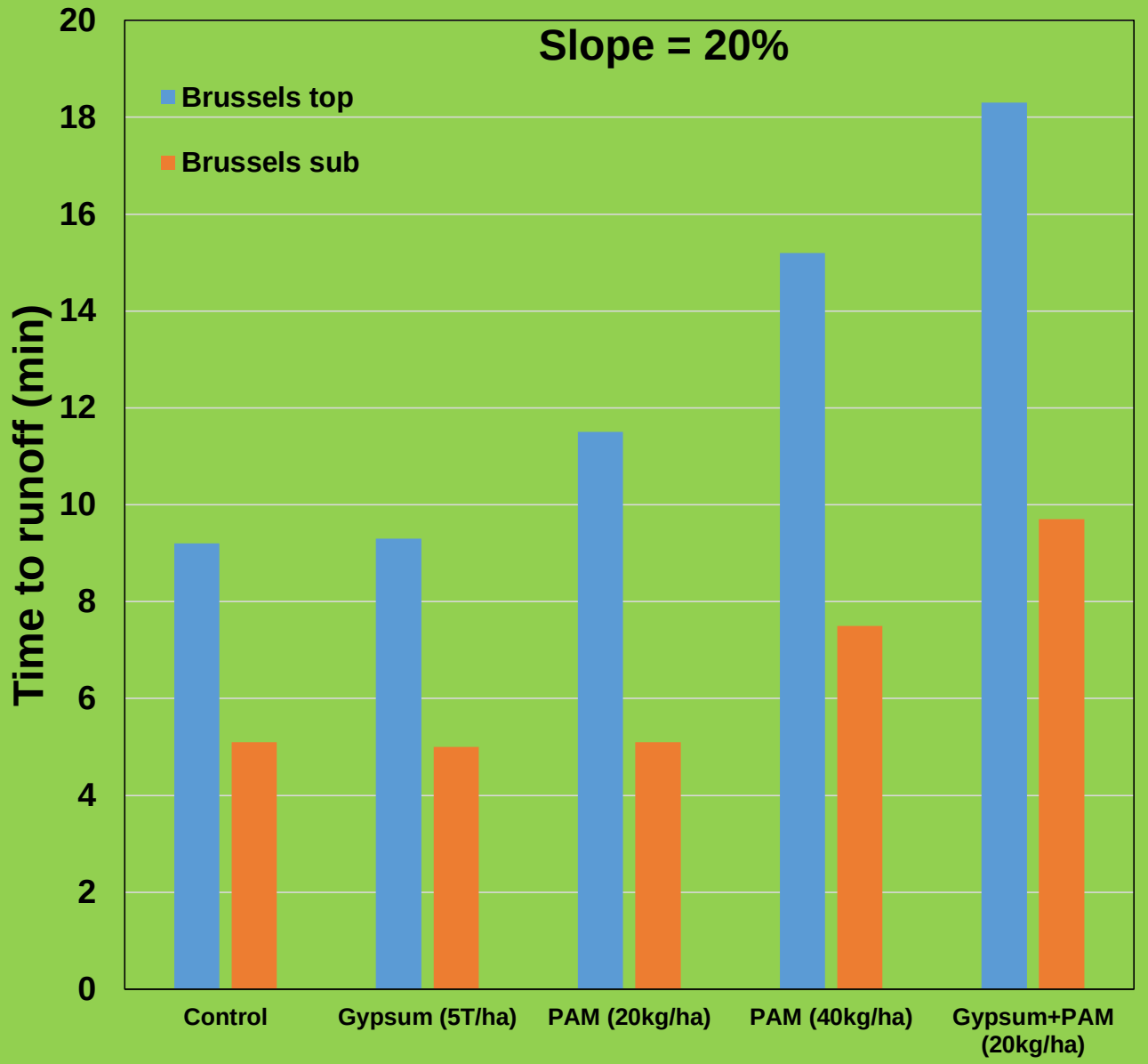
Synergy of Gypsum and PAM on Time to Runoff





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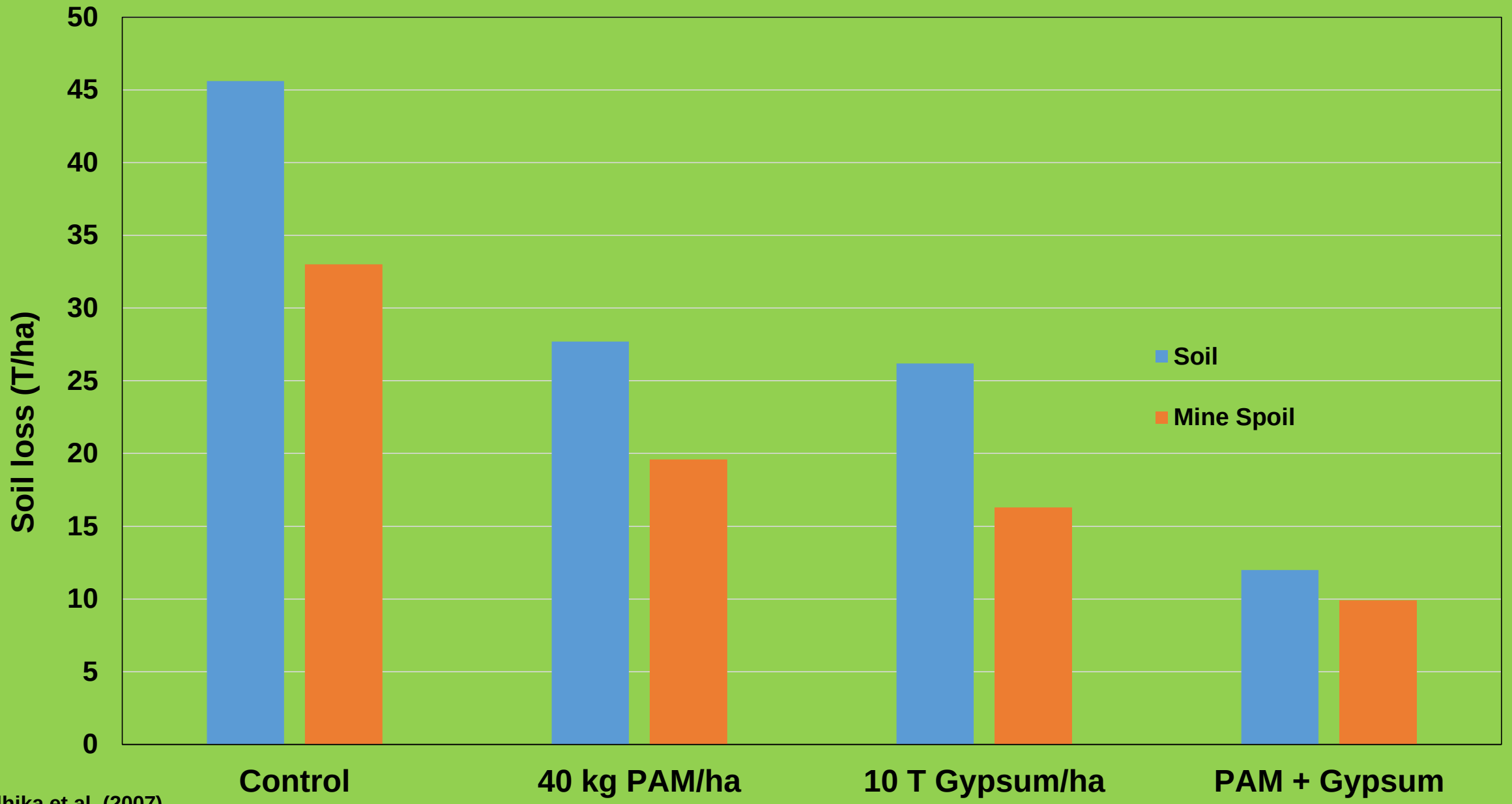
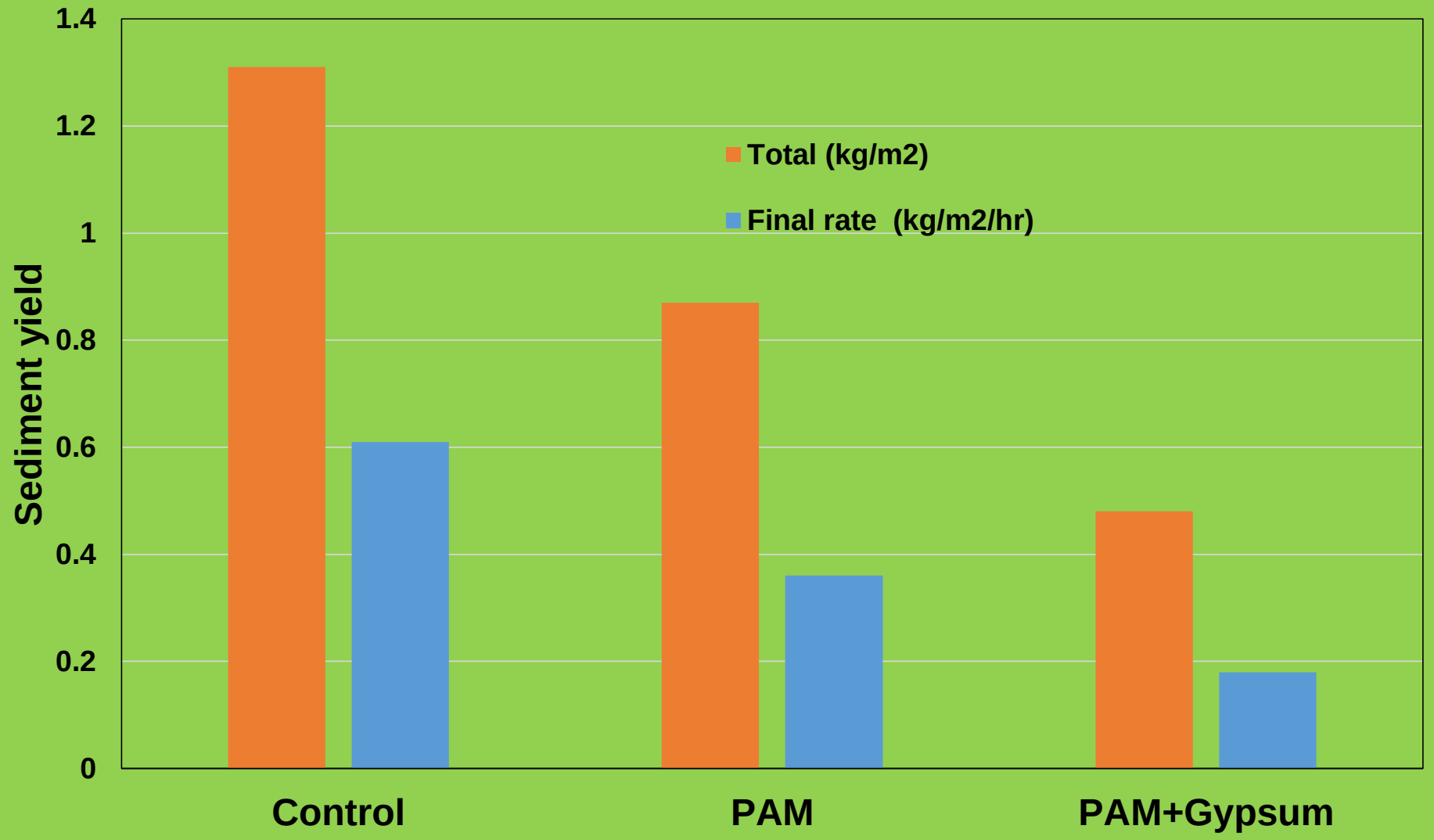
Lee et al. (2003)

Synergy of PAM and Gypsum on Soil Loss



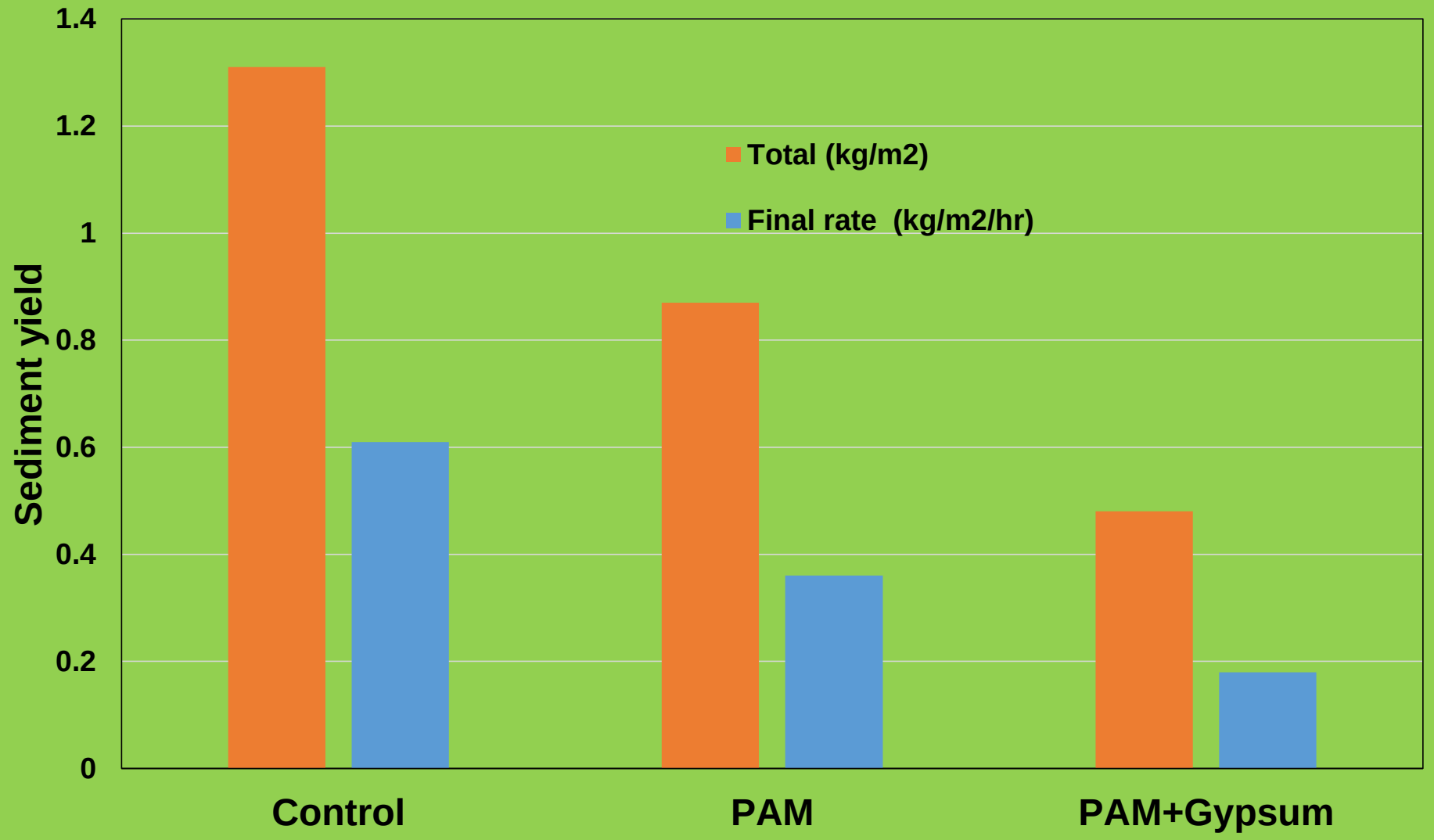
Mahardhika et al. (2007)

Synergy of PAM & Gypsum on Sediment Yield



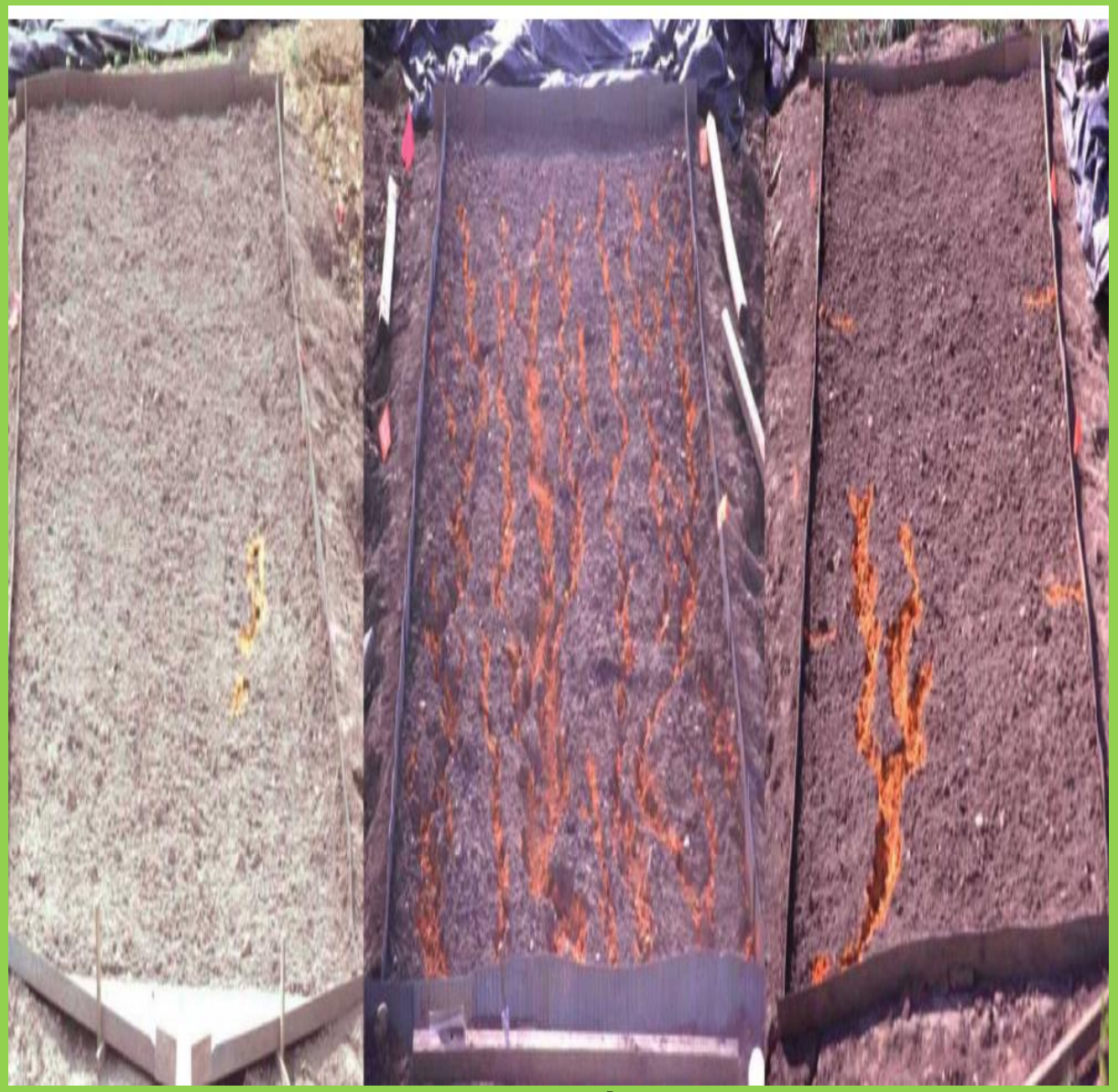
Peterson et al. (2002)

Synergy of PAM & Gypsum on Sediment Yield

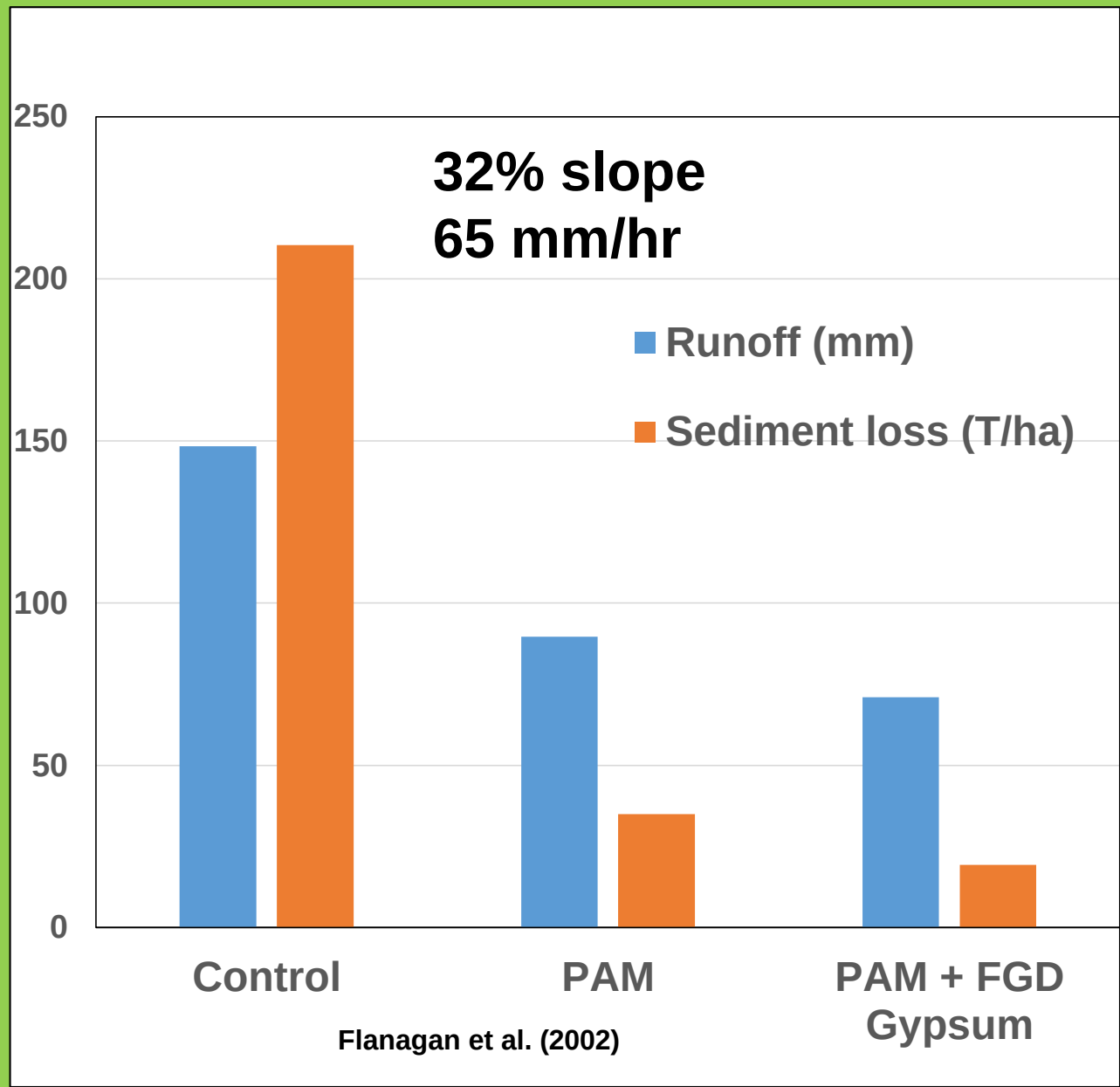


Peterson et al. (2002)

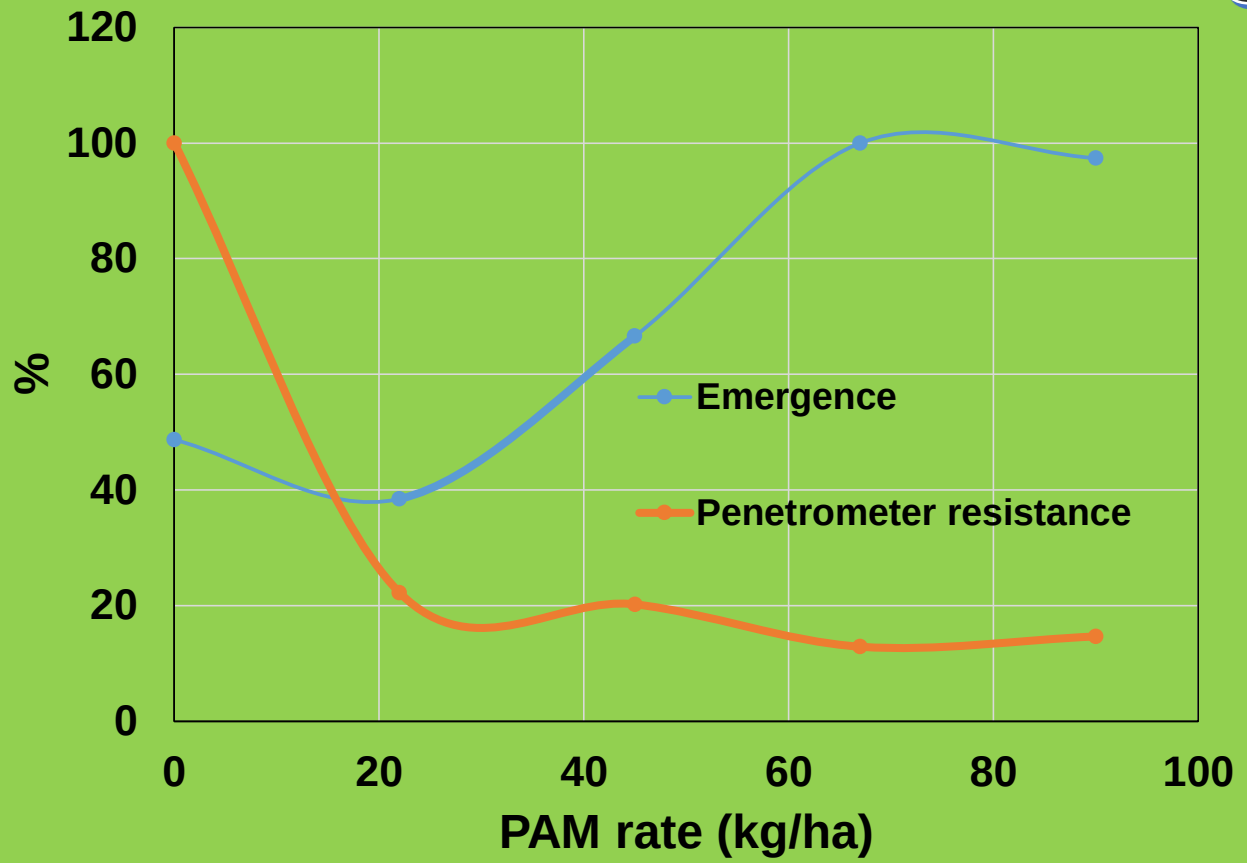
Further Synergy of PAM and Gypsum

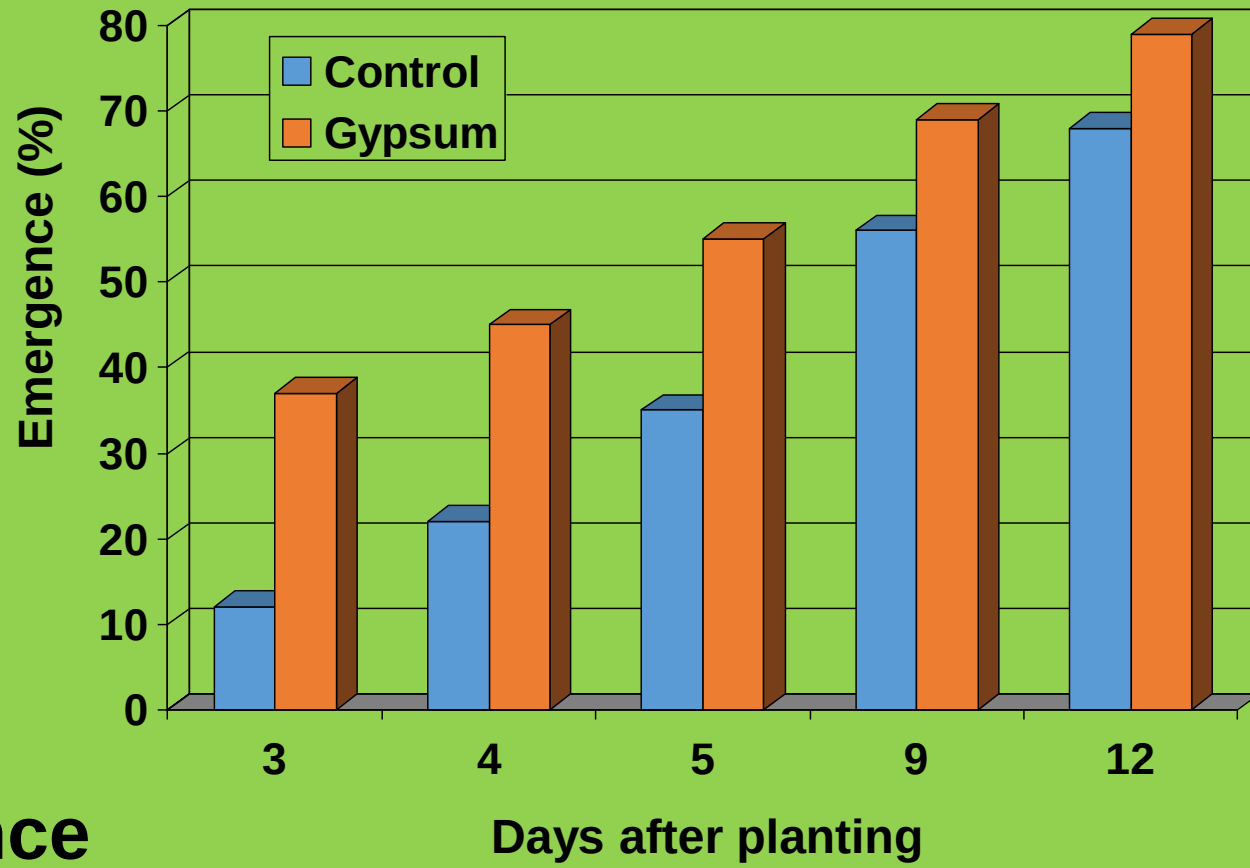


PAM + Gypsum Control PAM



Effect of Gypsum and PAM on Seedling Emergence



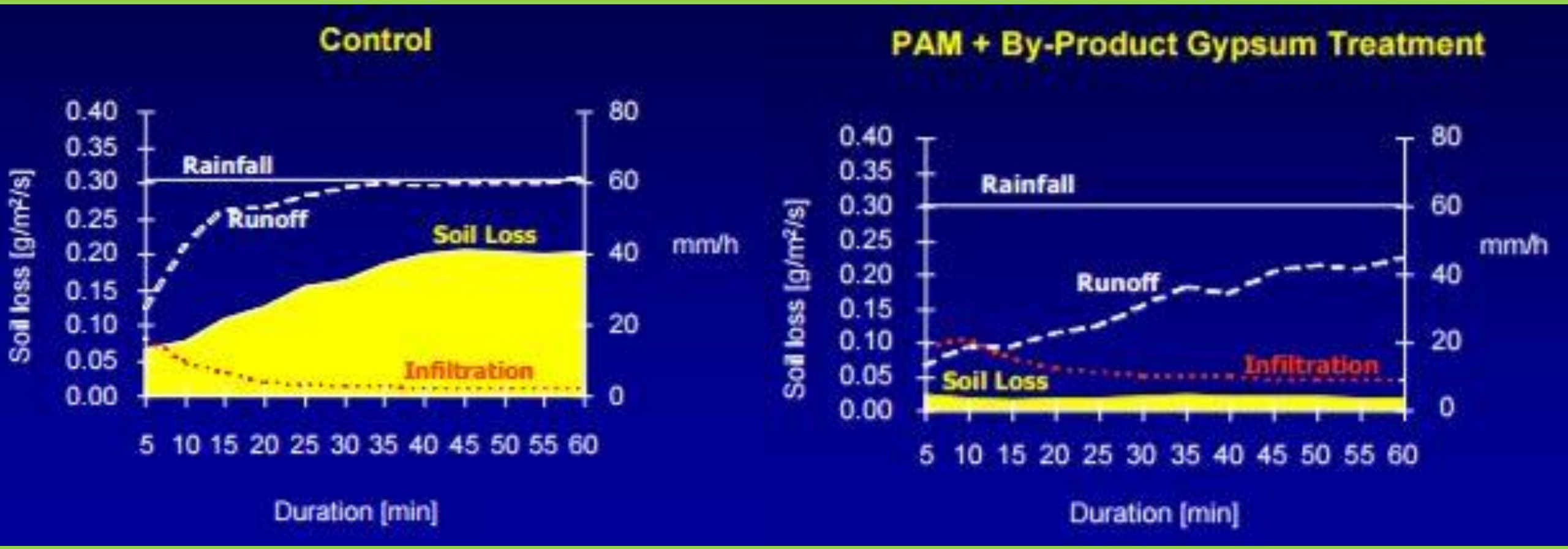


- **PAM & gypsum promote emergence**
- **No experiments on synergy**
- **Highly likely**

Cook and Nelson (1986)
Miller (1996)

Case Studies

Fayette silty clay loam from DeWitt, Iowa.



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Flanagan et al. (2008)

Drummond Site, AL

Before PAM

After PAM

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Drummond Before
Drummond After
FGD gypsum
PAM + FGD gypsum
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Effect of PAM and Gypsum on Vegetation Establishment

- **Site 1**
  - **INDOT cutslope**
- **Site 2**
  - **Landfill slope**
- **Seed mix**
  - **Fescue, ryegrass, red clover**

Flanagan et al. (2002)

Conclusions

- **PAM and FGD gypsum together**
  - **Promote clay flocculation**
  - **Stabilize soil structure**
  - **Reduce crusting**
  - **Reduce runoff**
  - **Reduce nutrient loss**
  - **Increase infiltration**
  - **Decrease erosion**
  - **Promote seedling emergence**

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