Basic Physical, Chemical, and Biological Factors Affecting N Transport in Soils

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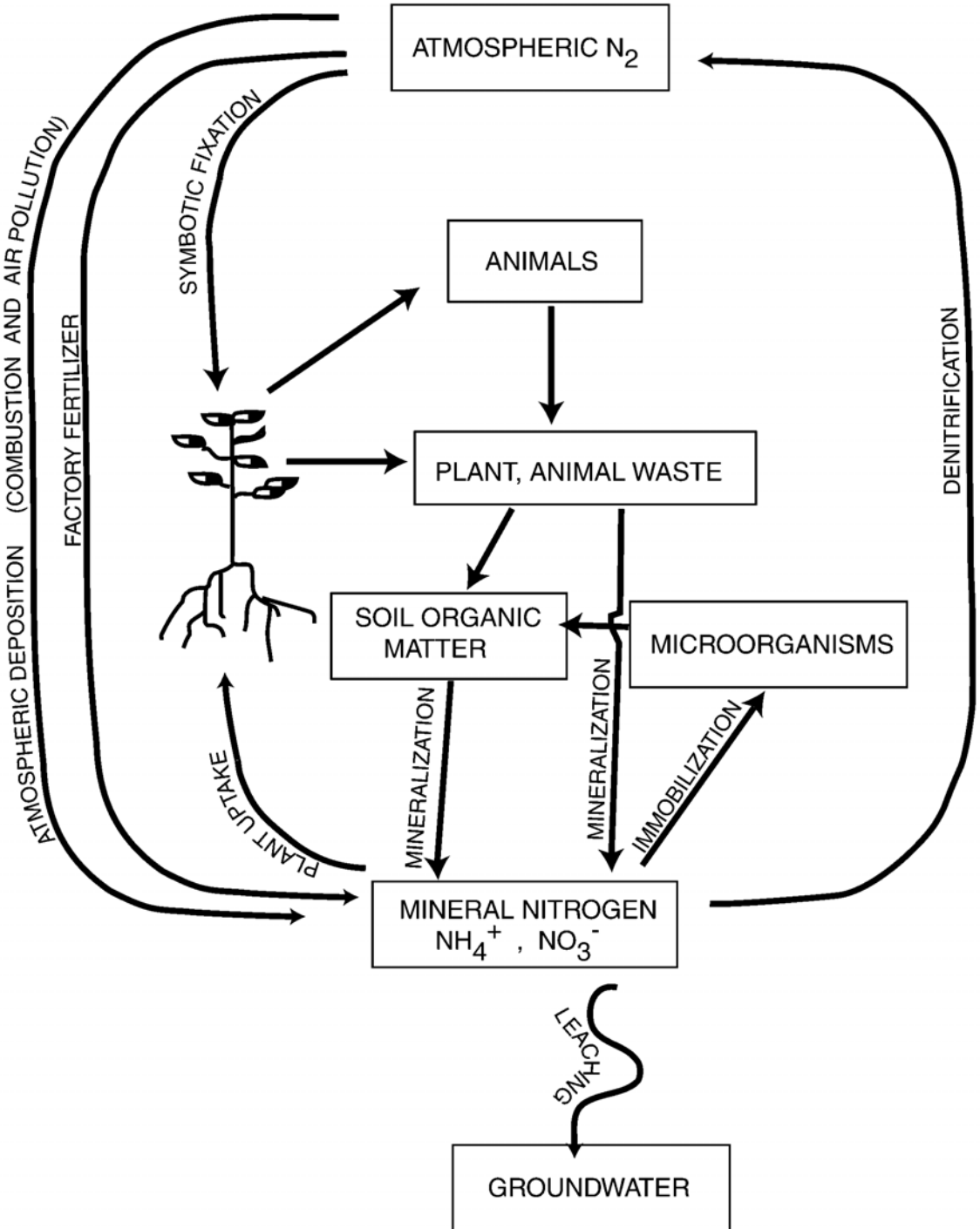
Contents

- N cycle and transformation processes
- N sources and plant uptake
- N transport and leaching
- Irrigation/water management effect on nitrate leaching
- Summary


ATMOSPHERIC N_2
SYMBOTIC FIXATION
ANIMALS
FACTORY FERTILIZER
ATMOSPHERIC DEPOSITION (COMBUSTION AND AIR POLLUTION)
PLANT, ANIMAL WASTE
DENITRIFICATION
SOIL ORGANIC MATTER
MICROORGANISMS
PLANT UPTAKE
MINERALIZATION
MINERALIZATION
IMMOBILIZATION
MINERAL NITROGEN
NH_4^+ , NO_3^-
LEACHING
GROUNDWATER

Nitrogen Sources

- **Global extent--**introduction to terrestrial system from atmosphere: symbiotic fixation, lightening, commercial fertilizer.
- **Site specific--**all of above, animal waste, inherent soil sources.

Nitrogen Transformation

- **Mineralization:**
  - **organic to mineral form: Org-N to NH_4^+ (weeks to years)**

- **Nitrification:**
  - **From NH_4^+ to NO_3^- (rapid, days)**
  - **Done by selective bacteria in presence of oxygen**

Nitrogen Transformation

- **Denitrification**
  - $NO_3^- \rightarrow NO_2 \rightarrow N_2O\uparrow \rightarrow N_2\uparrow$ **(rapid, days)**
  - **Need bacteria done in absence of oxygen**
- **Immobilization**
  - NH_4^+ **or** NO_3^- **to plant**

Nitrogen Transformation

- **Ammonia volatilization**
  - **$NH_3\uparrow$ from animal waste**
  - **NH_4^+ in alkaline solution $\rightarrow NH_3\uparrow$**
- **Emission from combustion engines and transformed in the atmosphere.**

Nitrogen Transport in Soil & Water

- **Organic:** not very mobile
- **NH_4^+:** not very mobile, electrostatic attraction to soil
- **NO_3^- :** very mobile, repelled by negative surfaces, soluble in water R ≈ I.

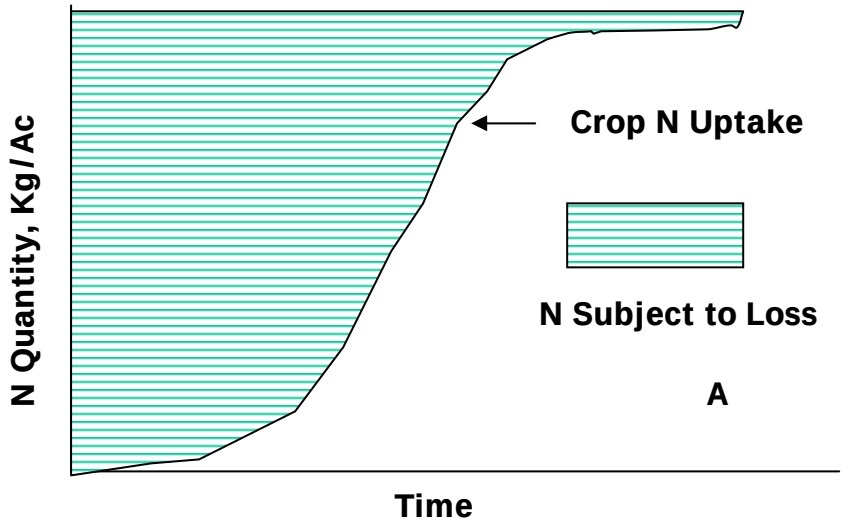
N Transport to Roots

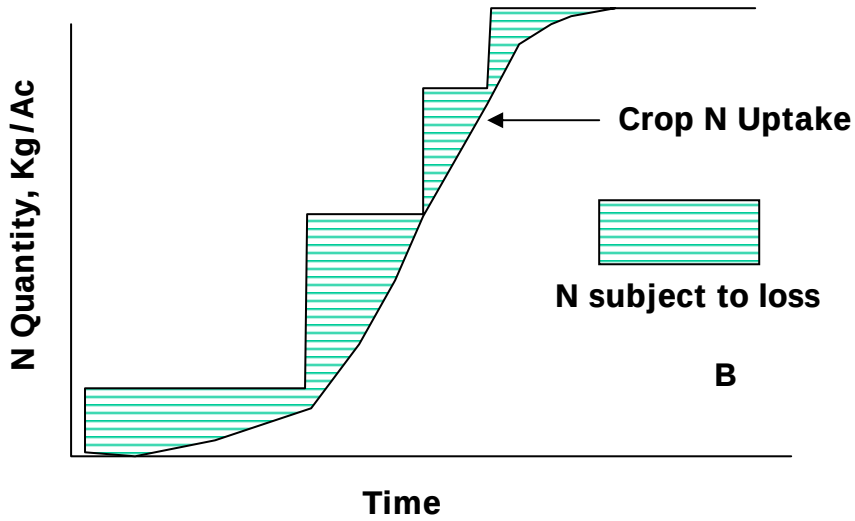
- **Convection –** N moves to root surface through water flux (driven by ET).

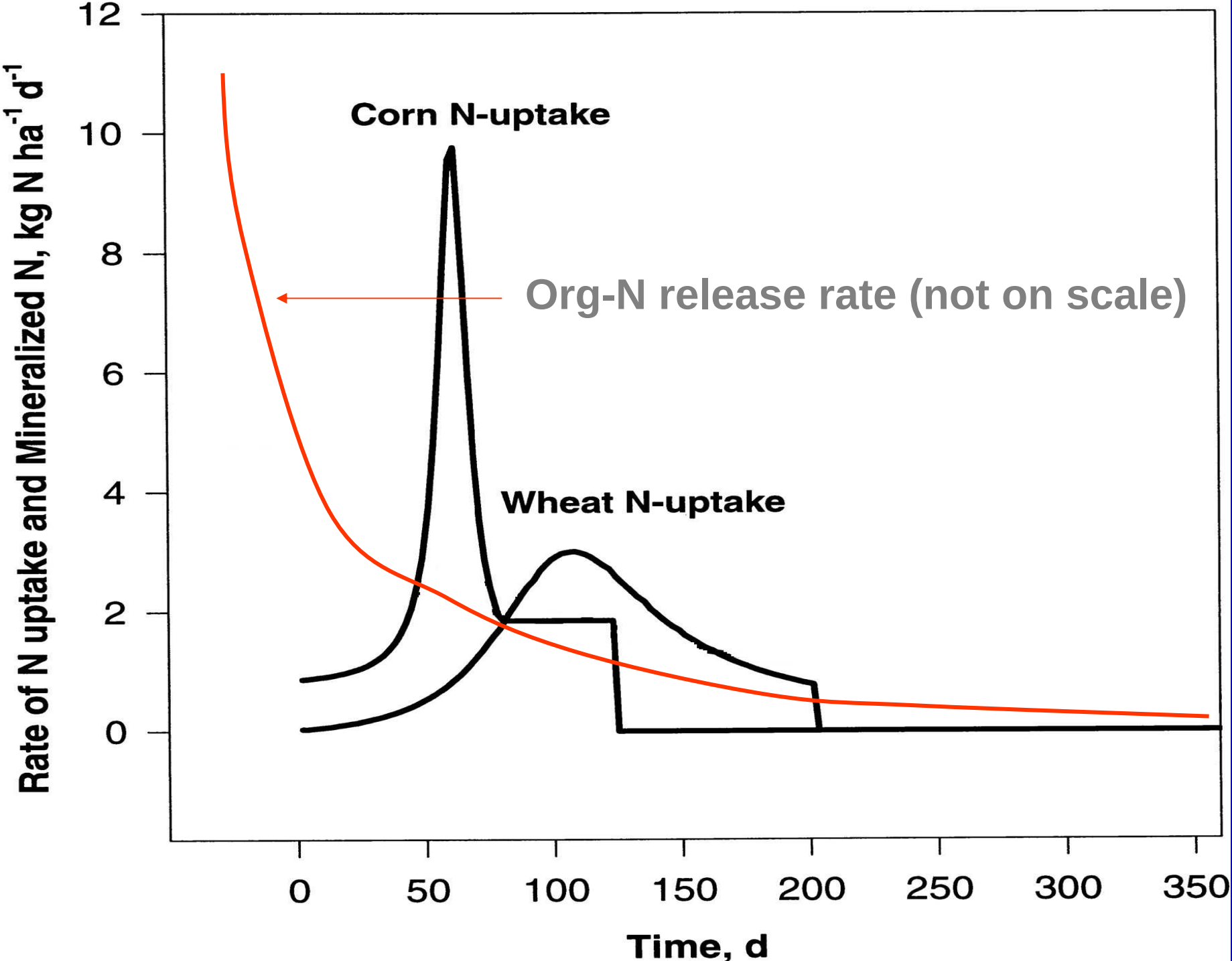
- **Diffusion –** When N supply by convection is not sufficient, N concentration at the root surface is lower than the soil solution, concentration gradient develops.

N Management Goal

The rate of plant available N supply to be equal to the rate of plant uptake.


N Quantity, Kg/Ac
Crop N Uptake
N Subject to Loss
A
Time


N Quantity, Kg/Ac
Crop N Uptake
N subject to loss
B
Time


Rate of N uptake and Mineralized N, kg N ha-1 d-1
12
10
8
6
4
2
0
Corn N-uptake
Org-N release rate (not on scale)
Wheat N-uptake
0
50
100
150
200
250
300
350
Time, d

N Sources and Release Rates

- **Consider all N input sources:**
  - Soil N
  - Irrigation
  - Atmosphere
  - Fertilizers
- **N Release**
  - Typically, Org-N releases fastest when incorporated into soil and tends to decrease exponentially.
  - Slow release N fertilizers behave similarly to org-N, but with higher release rates.

Nitrate Leaching

- **Leaching:** NO_3^- (lb) = C (lb/Ac-in) x Deep Percolation (Ac-in)
- **Nitrate concentration:** Higher conc., greater potential for leaching.
- **Water Management:** Excess water moving out of the root zone
- Excess water, N supply > crop demand, lower water holding capacity promotes nitrate leaching!

Irrigation Management

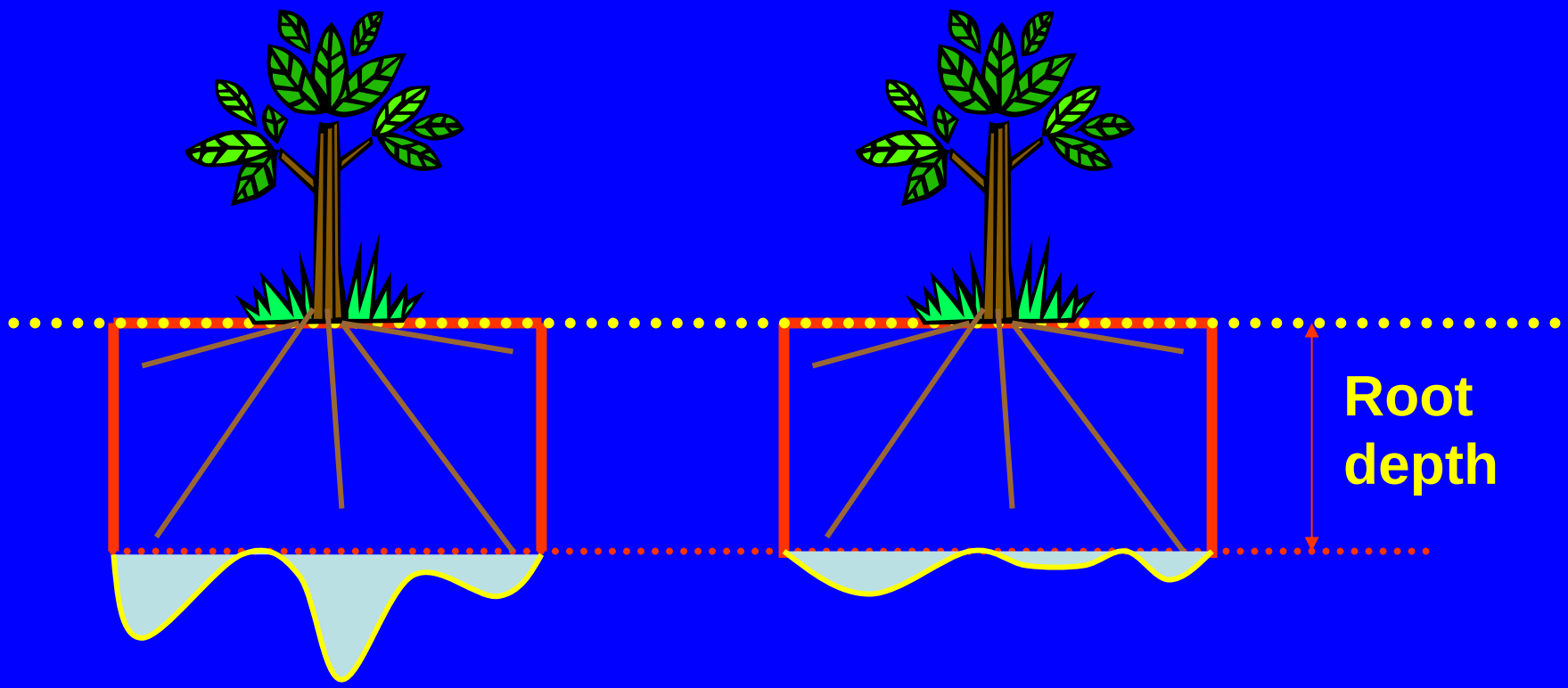
- ET_o (climate based)
- Water application rate according to soil infiltration capacity
- Timing and frequency vs. soil water holding capacity
- Uniformity

Irrigation Uniformity & Water Management

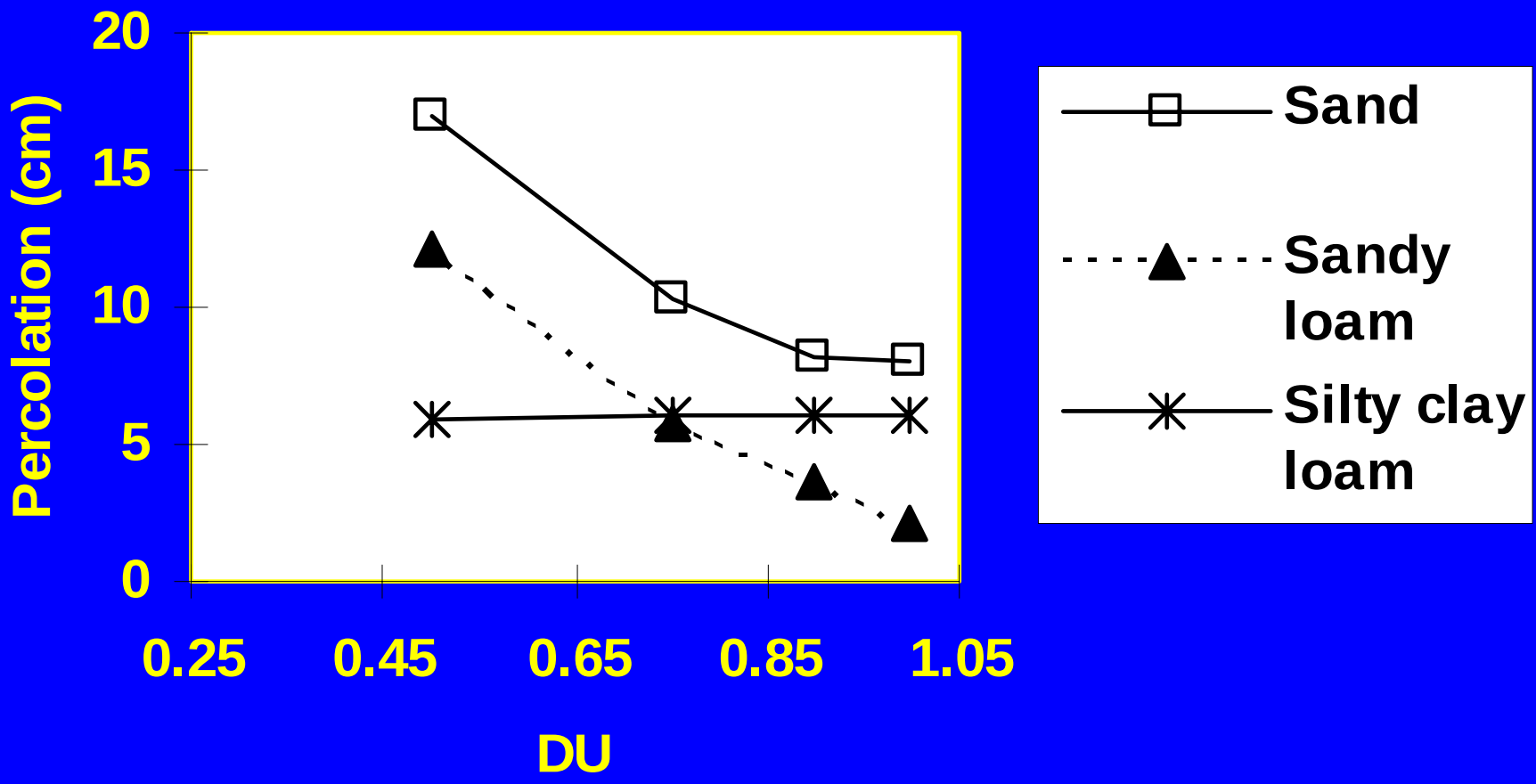
- **Higher uniformity reduces water application and leaching potential**
- **Irrigation based on CIMIS**

  ETa = Kc * ETo
  - Generic, ignore specific conditions such as N deficiency and high salinity

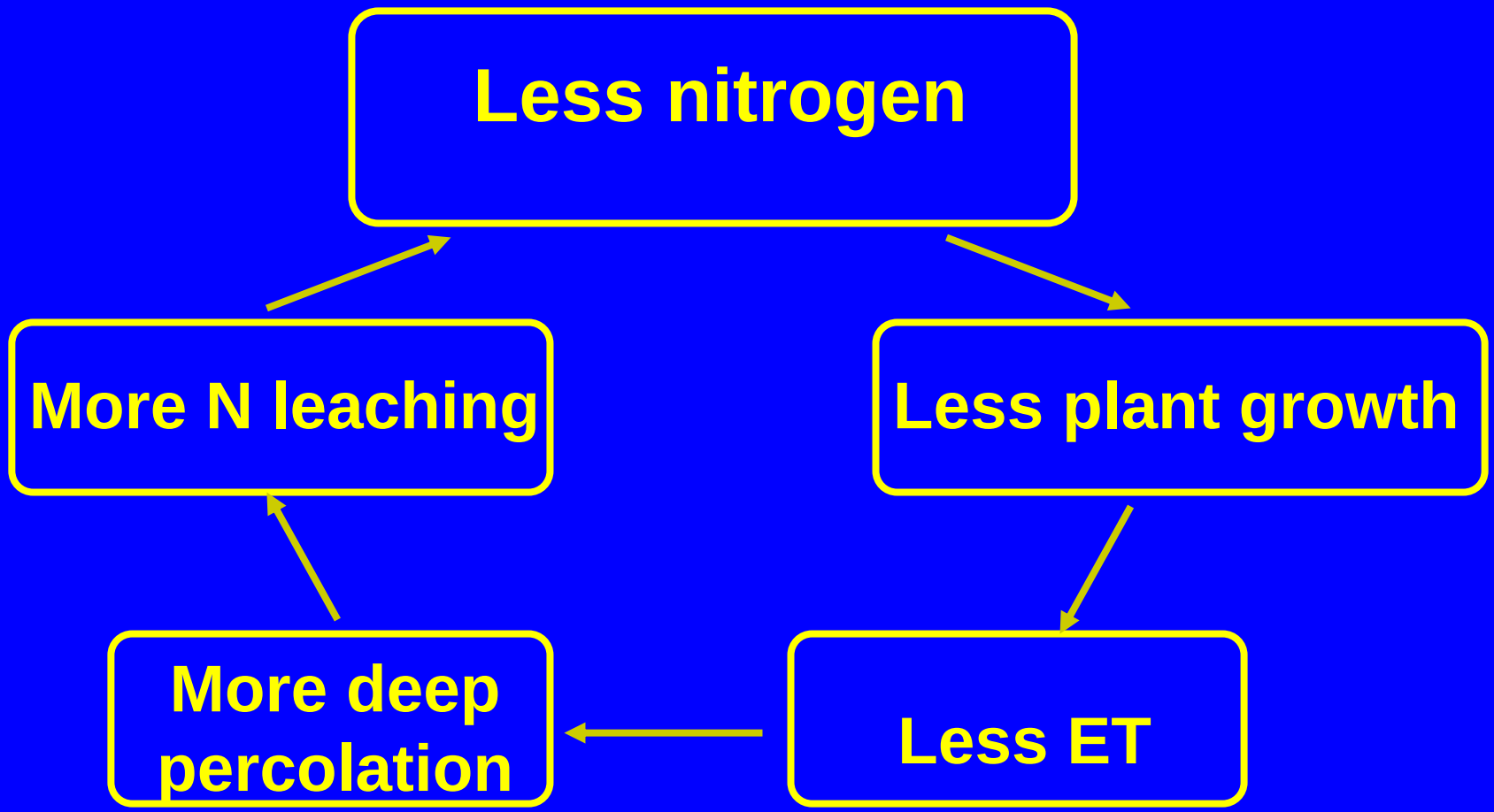
Irrigation uniformity affects leaching



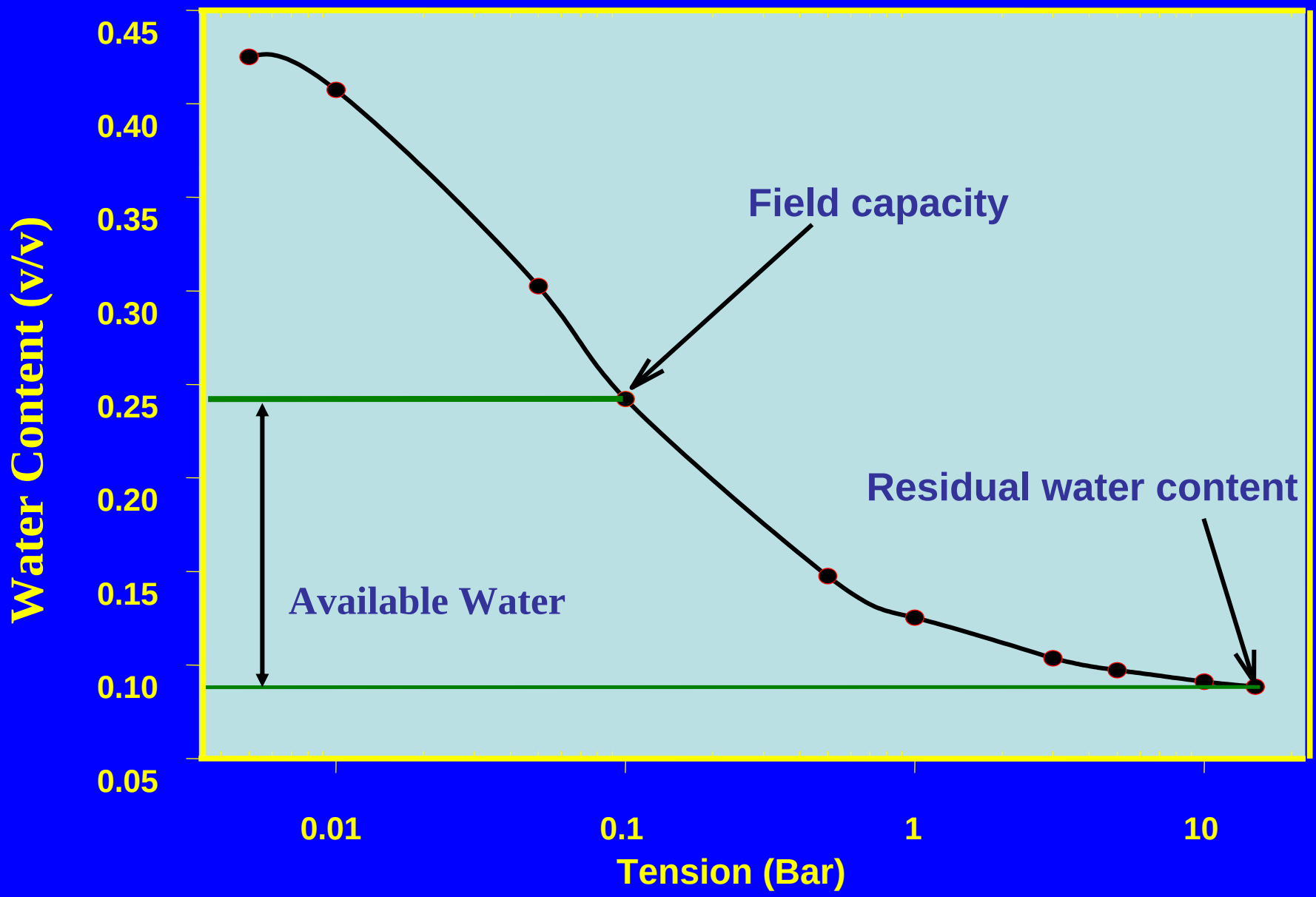
Percolation right below the root zone as influenced by DU



Effect of Plant Growth on Leaching



Effect of soil on leaching: Water retention capacity



Ranges of available water for three soil textural groups

Textural group	Available water (in./ft)
Coarse (sand, loamy sand, sandy loam)	¼ to ½
Medium (fine sandy loam, loam, silt loam)	1 to 2
Fine (clay loam, silty clay loam, clay)	1½ to 3

**** Allowable depletion***

Summary: Fertilizer Application

- Try to match N supply to N demand as much as possible.
- Applying less fertilizer but more frequently, especially in soils of high leaching potential (sandy soils).
- Use new technologies to improve N utilization rate.

Summary: Irrigation Management

- Improve irrigation uniformity
- Avoid applying excess water to generate deep percolation
- If leaching is necessary to control soil salinity, leach the soil while soil residual N is low.
- Upgrade irrigation system.

Summary

To reduce nitrate leaching potential, one should consider:

- **soil conditions,**
- **plant characteristics, and**
- **irrigation practices.**