Plant Nutrient Uptake Timing and Enhanced Efficiency Fertilizers

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MONTANA STATE UNIVERSITY EXTENSION

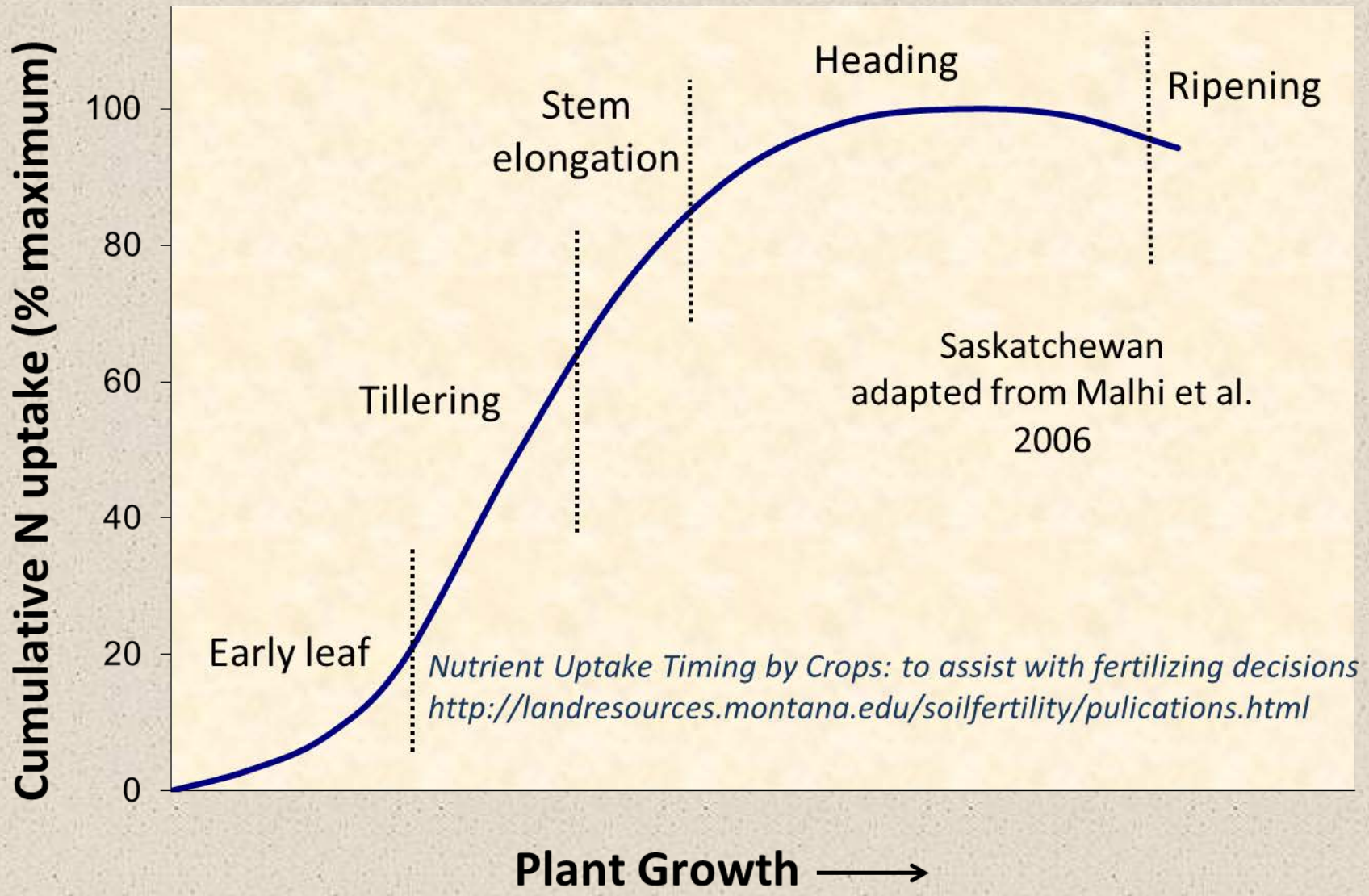
AGRICULTURE

MAKING A DIFFERENCE IN MONTANA COMMUNITIES

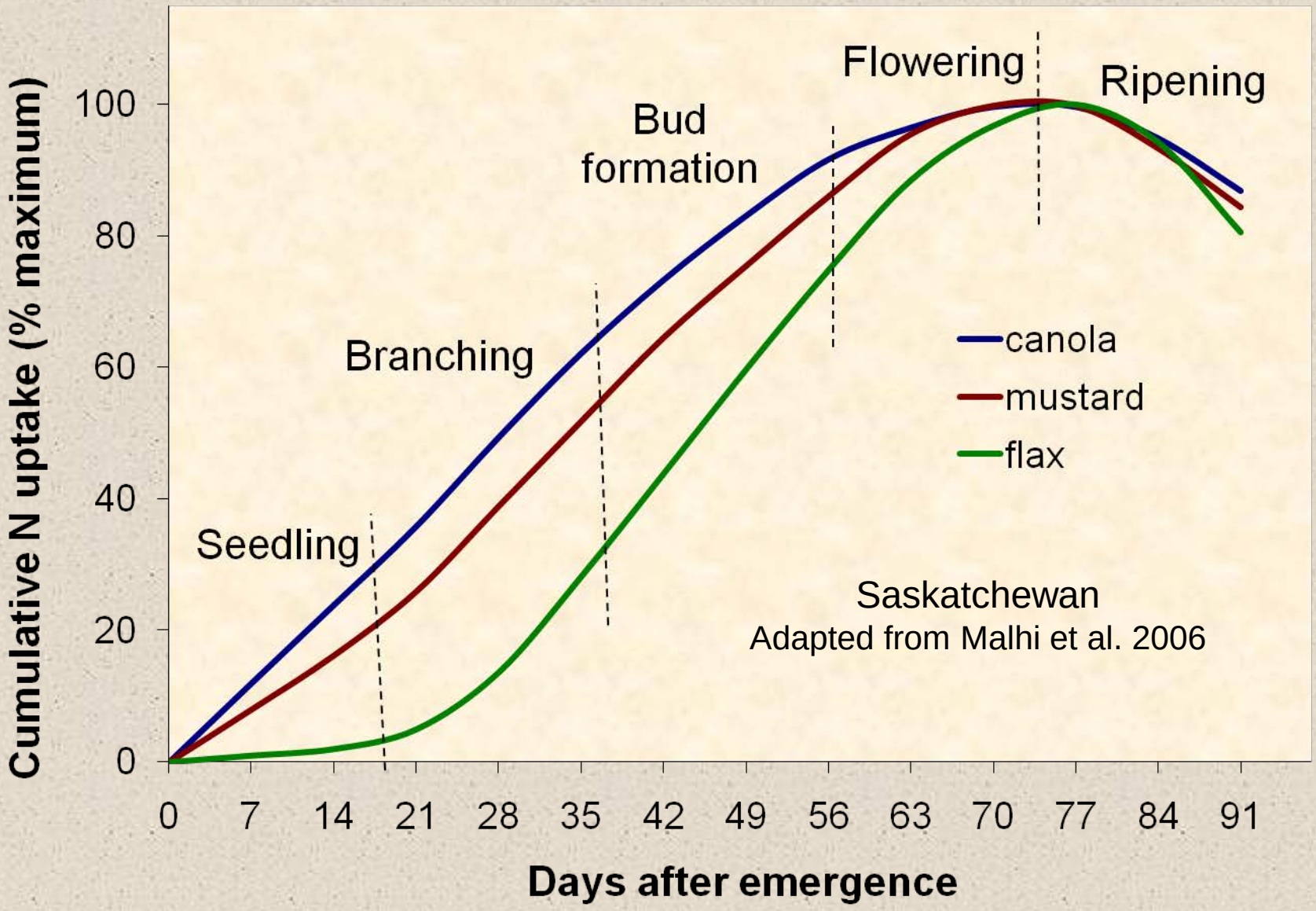
Objectives

- Illustrate crop nutrient uptake patterns
- Present fertilizer management options to better match nutrient uptake and INCREASE GRAIN PROTEIN
- Explain pros and cons of enhanced efficiency fertilizers (EEFs)
- Show research results for EEFs

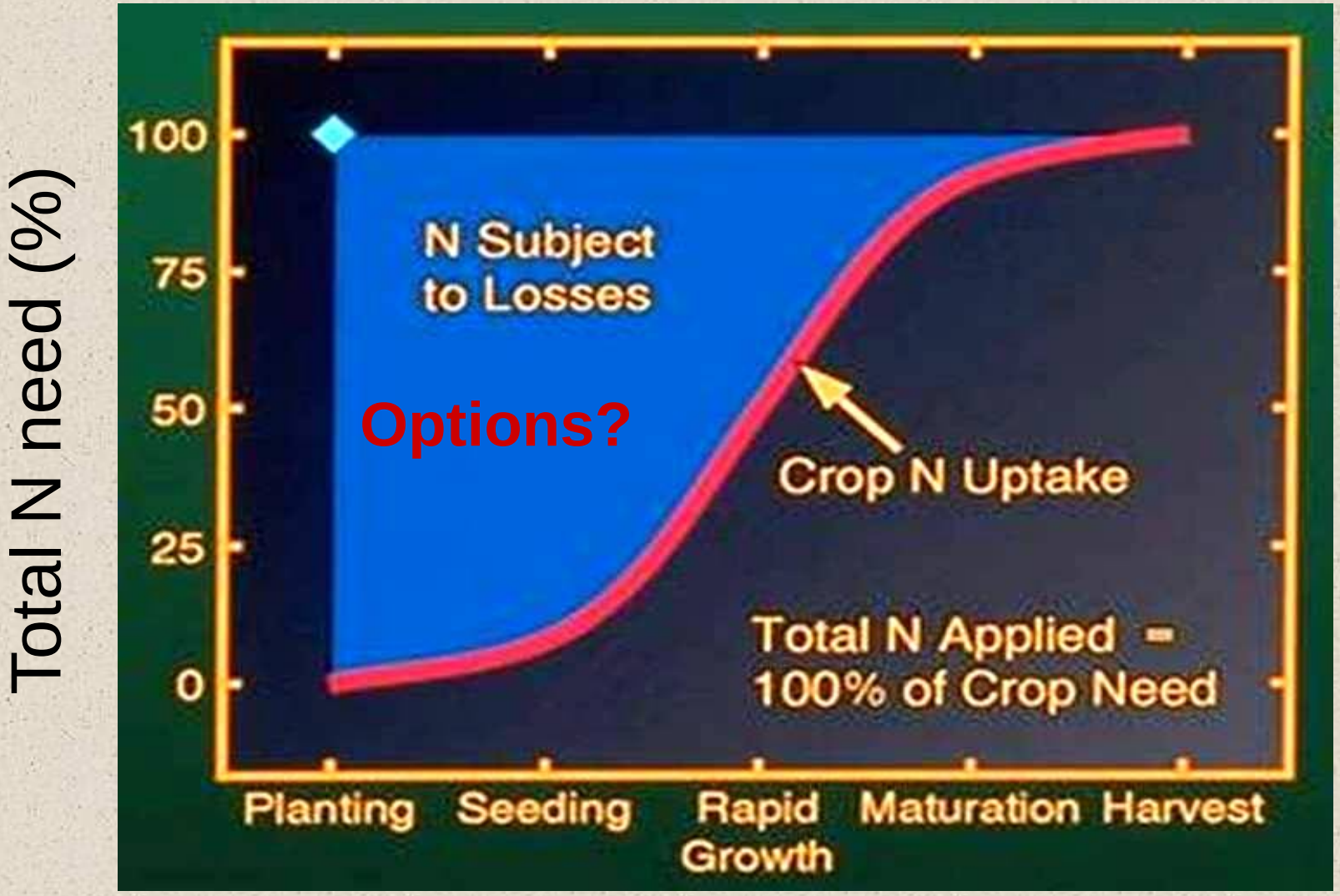
Cumulative N uptake by wheat



N uptake by oil seed crops



Single application of conventional fertilizer

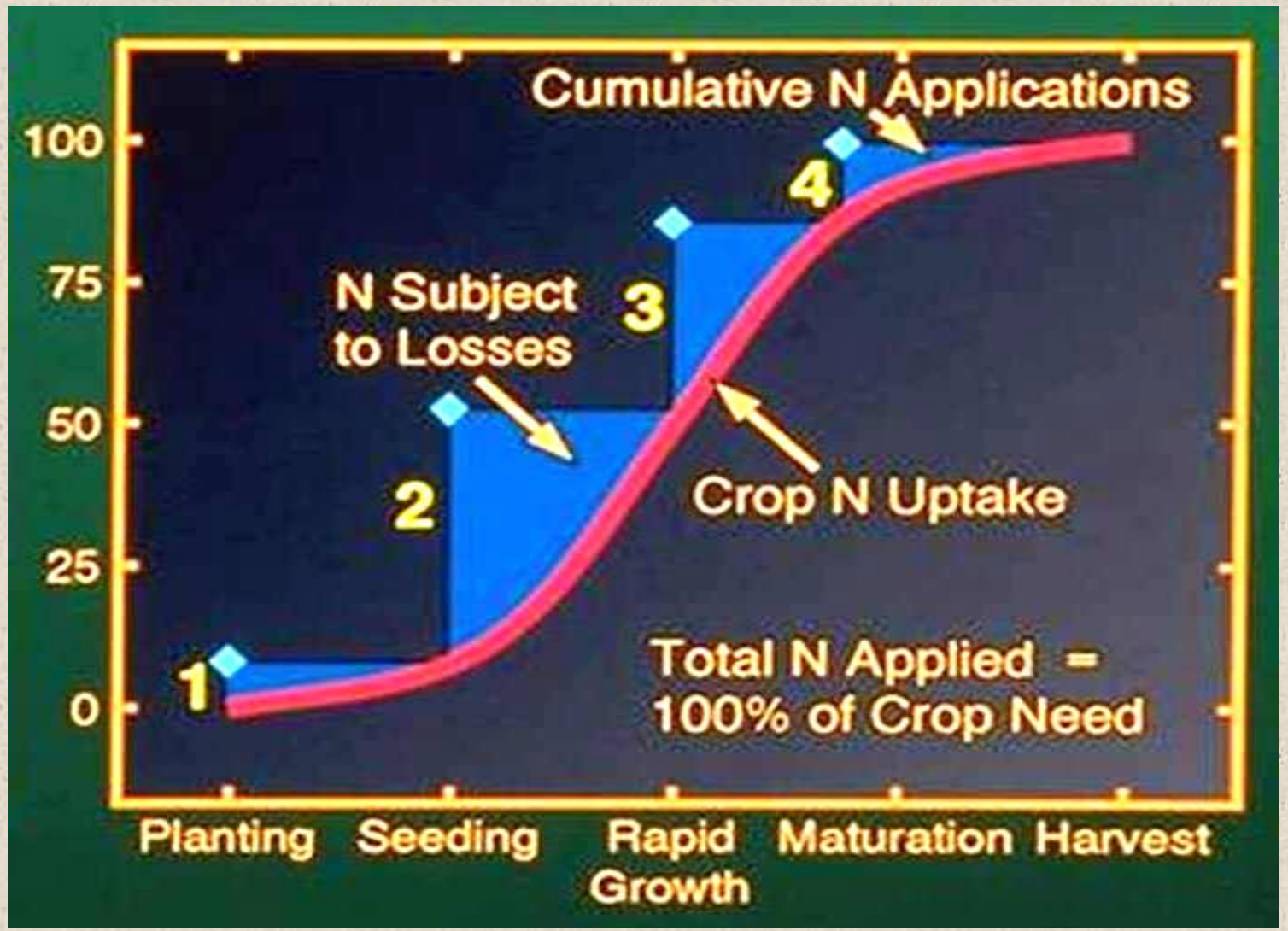


Modified from HortTechnology. 9(4): 603.

How can you better match N release to reduce potential losses and increase yield?

- Use split application (pre-plant and topdress or just topdress)
- Use an “enhanced efficiency fertilizer”

Reduction of potential N loss through split applications



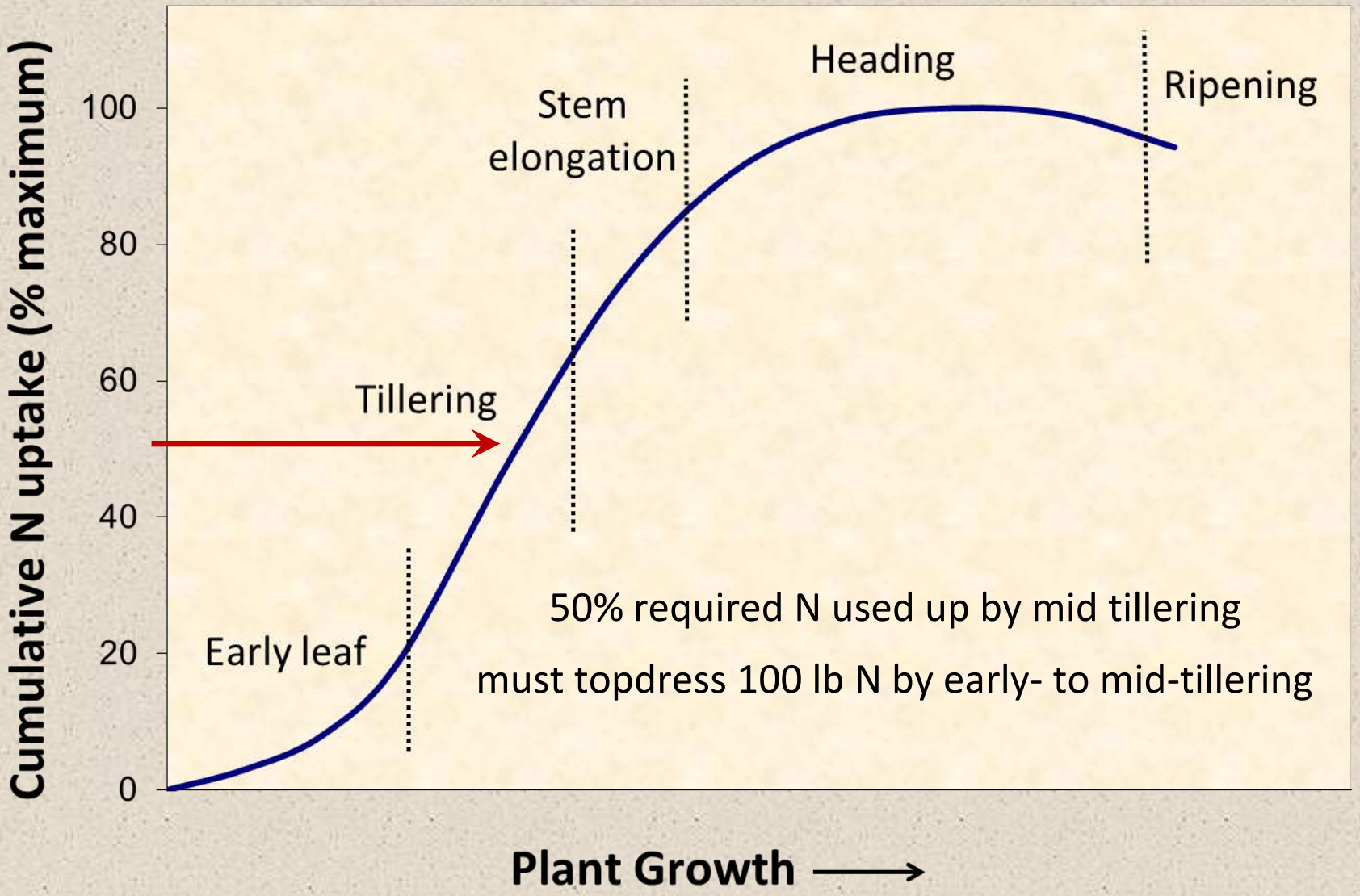
Modified from HortTechnology. 9(4): 603.

Use Nutrient Uptake figure to time top-dress

Example on per acre basis:

- 200 lb N total need, 40 lb N in soil, 60 lb preplant N
- soil and preplant supply 100 lb N = 50% total N required
- (200 – 100) = 100 lb N top-dress

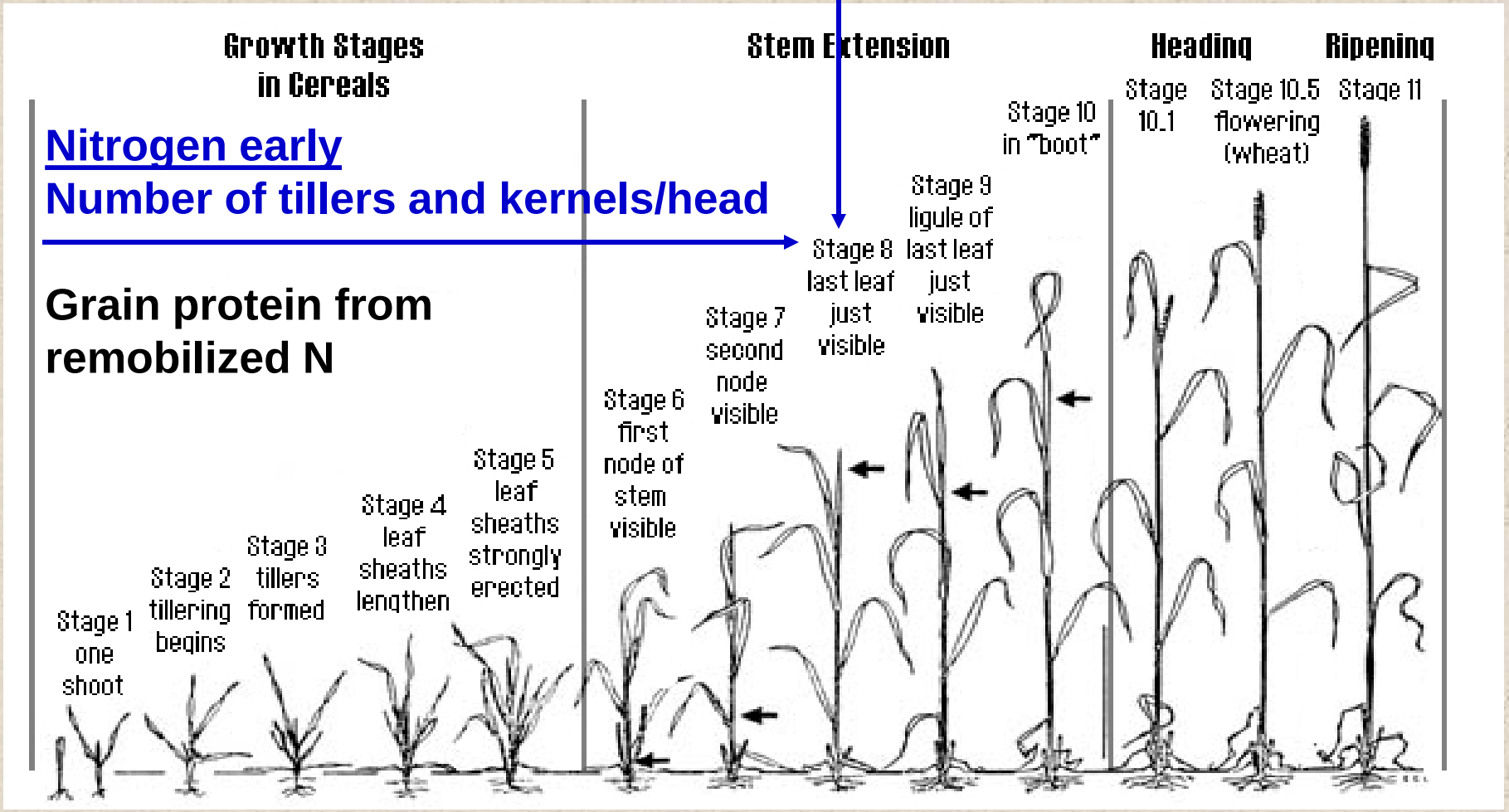
Top-dress amount and timing based on plant growth stage



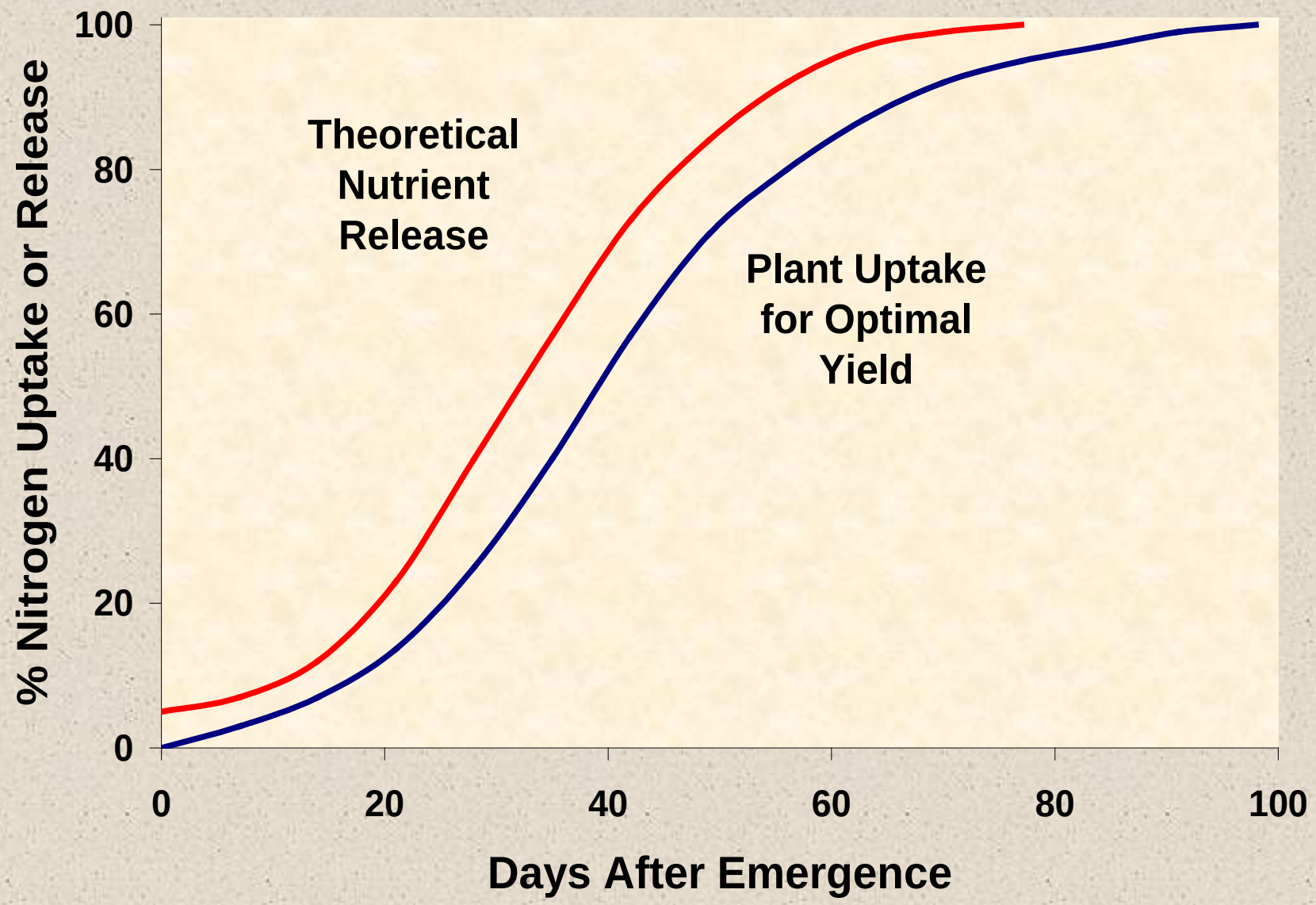
N application timing effects on yield and protein

Nitrogen late
Weight/kernel

Higher grain protein



Nutrient availability from ideal fertilizer



Enhanced Efficiency Fertilizers EEFs

- Any fertilizer designed to:
  - Increase fertilizer availability
  - Decrease fertilizer losses
- 3 major methods of action
  - Stabilized - alter soil microbial or enzymatic reactions
  - Slow release - have additives which require chemical or biological decomposition to release nutrients
  - Controlled release - a semipermeable coating, usually a polymer, regulates release

Stabilized Urease Inhibitors

N_2 and N_2O

Plant Uptake

Volatilization

Plant Uptake

Denitrification

NH_3

NO_3^-

Nitrification

NO_2^-

Leaching

NH_4^+

slow urea hydrolysis here, most common is NBPT

Urea

UAN

Stabilized Nitrification Inhibitors

N_2 and N_2O

Plant Uptake

Volatilization

Plant Uptake

Denitrification

NH_3

slow conversion to nitrate here

NO_3^-

Nitrification

NO_2^-

NH_4^+

Leaching

Urea

UAN

Slow and Controlled Release

N_2 and N_2O

Plant Uptake

Volatilization

Plant Uptake

Denitrification

NH_3

NO_3^-

Nitrification

NO_2^-

NH_4^+

Leaching

control release here

Urea

UAN

slow release here

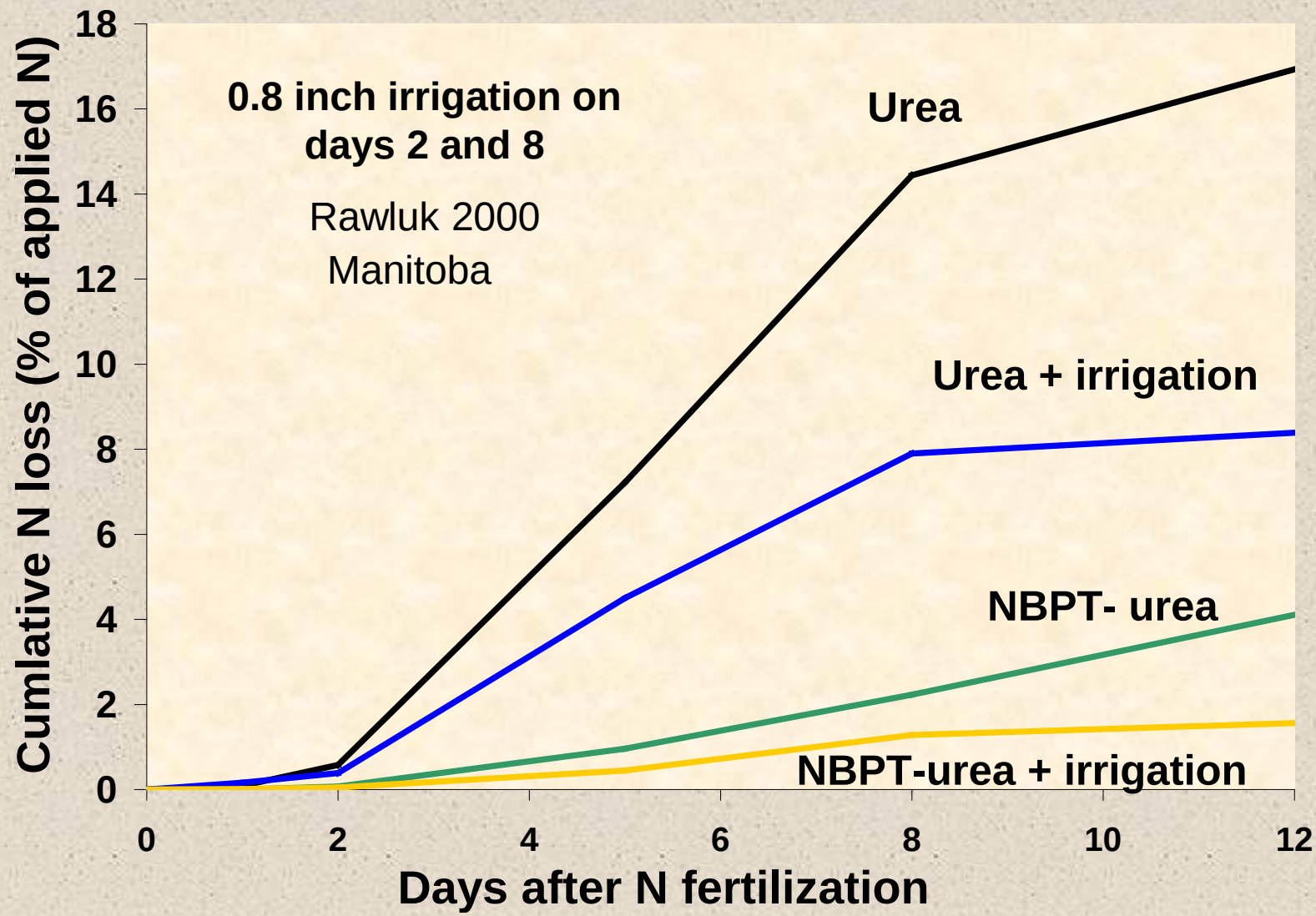
Questions?

Under what growing conditions would you expect EEFs to work better?

- High potential volatilization loss
  - **coarse soils**
  - **moist surface**
  - **warm temps**
  - **long time between application and incorporation**

- High potential leaching
  - **coarse soils**
  - **high moisture content/irrigation/rainfall**

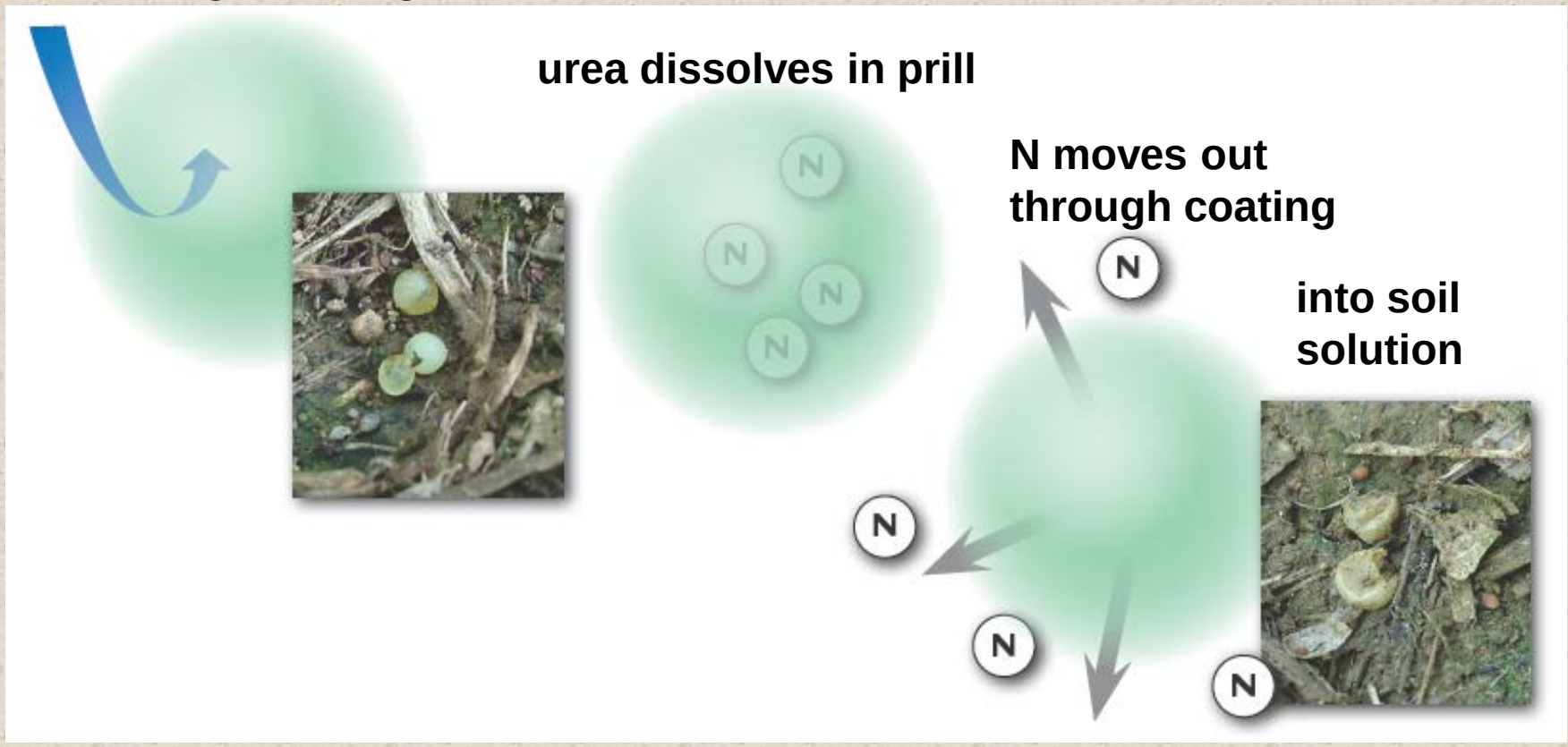
Effect of irrigation and NBPT on volatilization



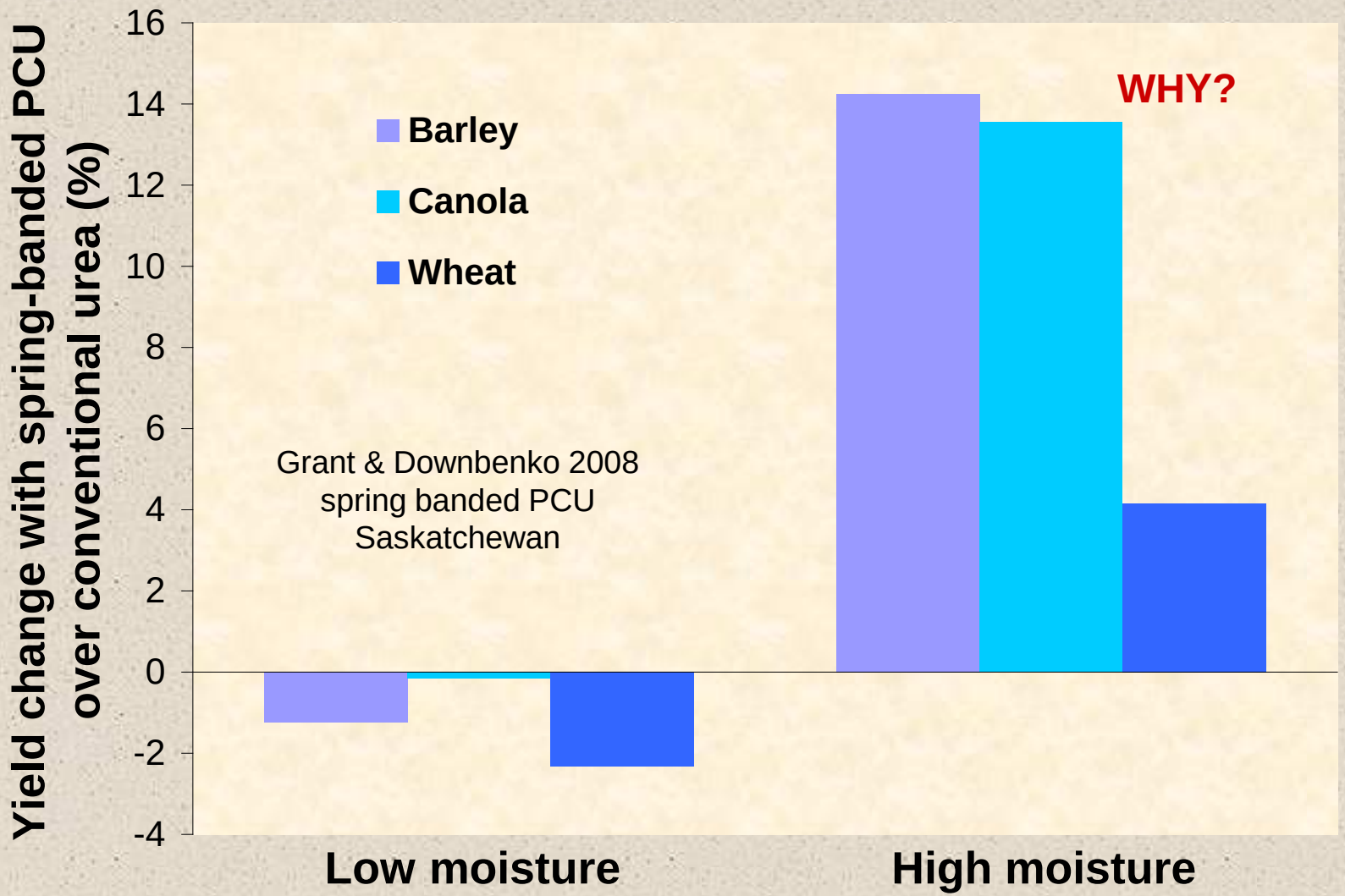
NBPT uses

- Can minimize urea volatilization for several weeks
- ‘Buys’ time for rainfall, irrigation or mechanical incorporation to protect urea
- Warm weather top-dressing
- Cool weather broadcast

N release by polymer-coated fertilizers



Effects of over-winter moisture conditions on effectiveness of PCU

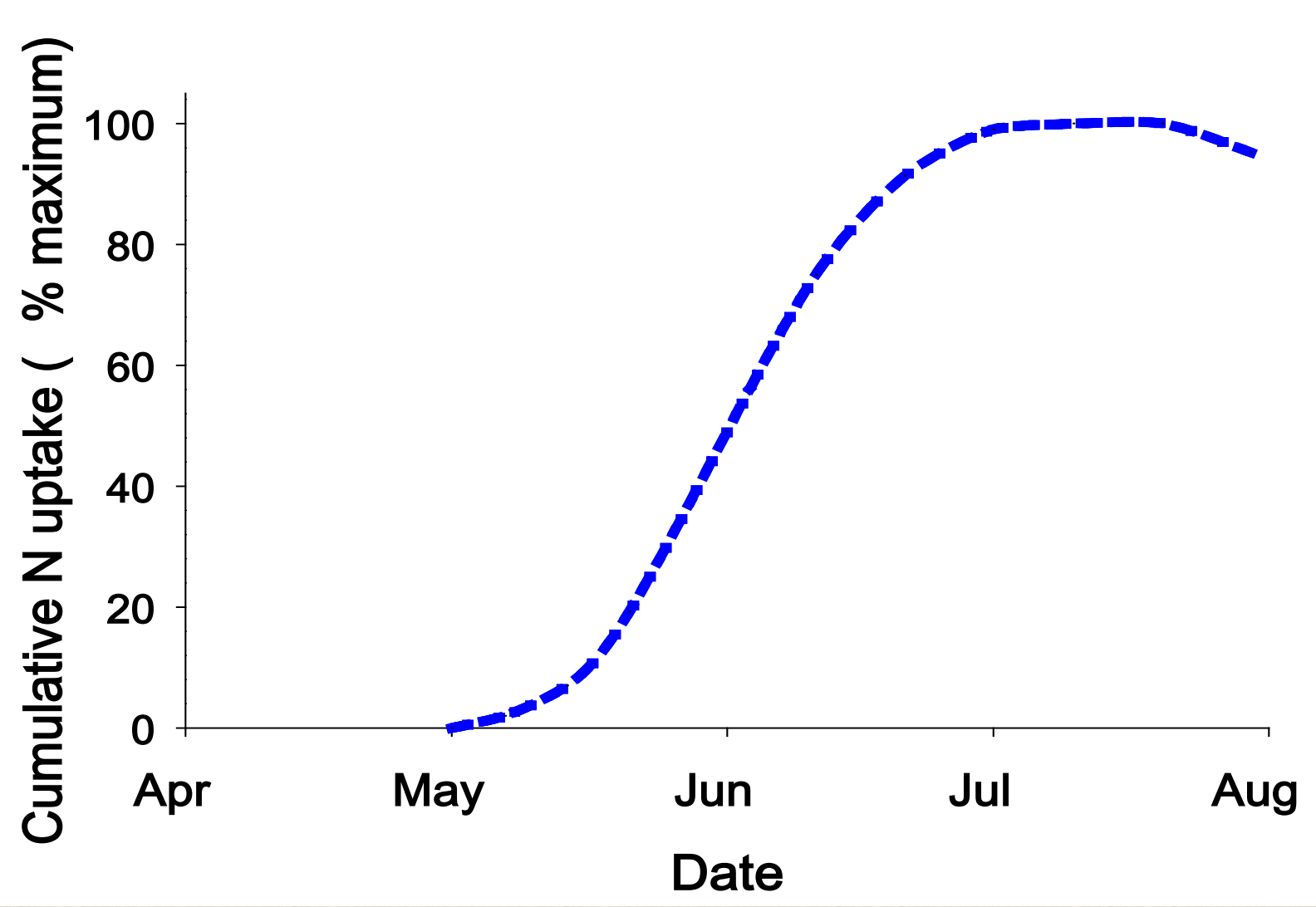


What type of crops would you expect slow release to work better?

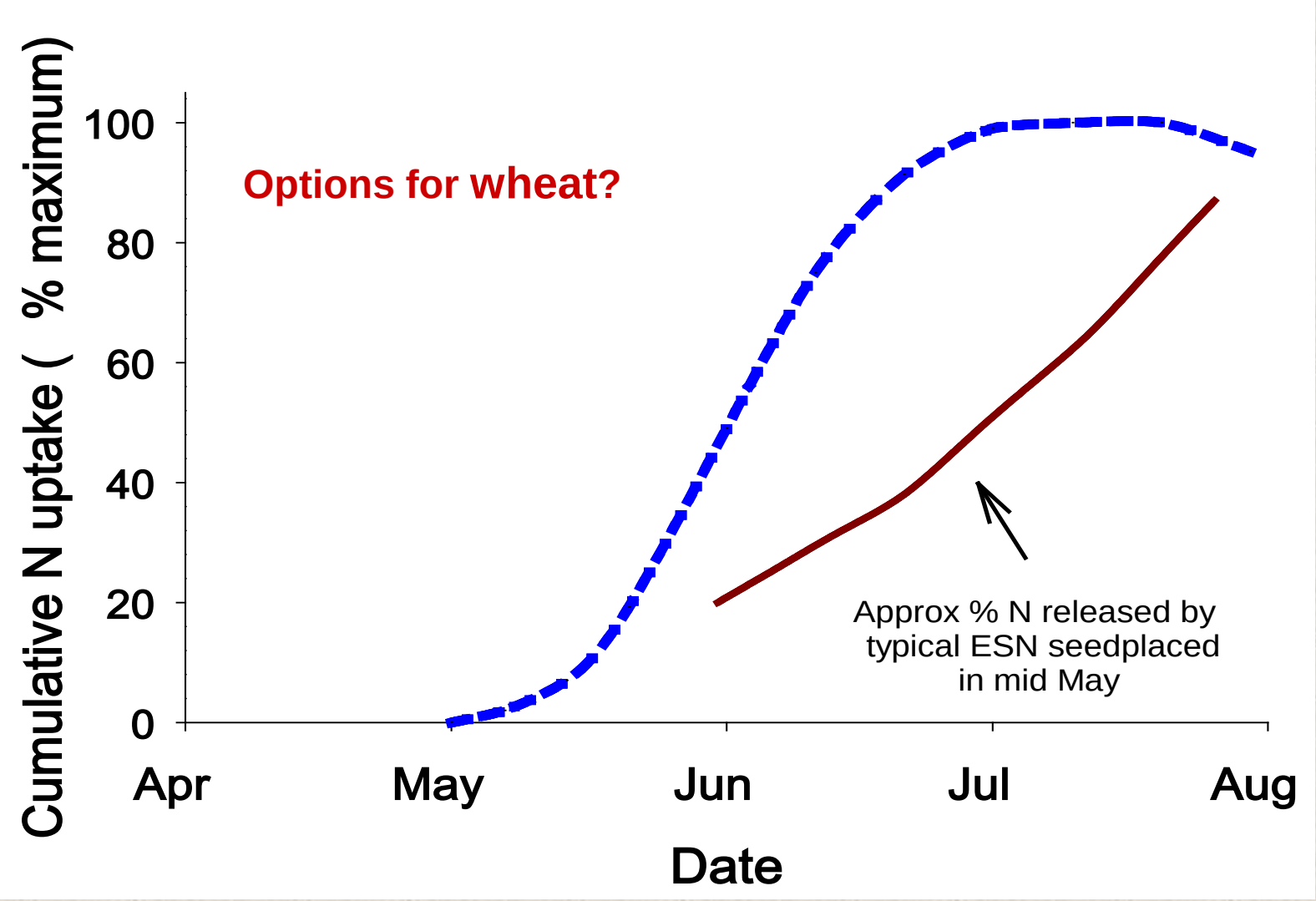
- Irrigated
- Warm season

What about dryland cool season crops?

Timing of N uptake by wheat



Timing of N uptake by wheat and ESN® N release



How does PCU work for small grains?

- Fall/winter pre-plant works well. PCU is in soil long enough to dissolve in time for plant need.
- Late winter/spring broadcast PCU does not - may dry out, release is too slow.
- Incorporation is important, especially late winter/spring.
- Blending is recommended with late winter/spring surface applied PCU.

Effect of EEF source and application method on winter wheat yield

Location: Beiseker, Alberta

Soil: silt loam, 4.5% organic matter

Precipitation: 13.5 in. seeding to harvest

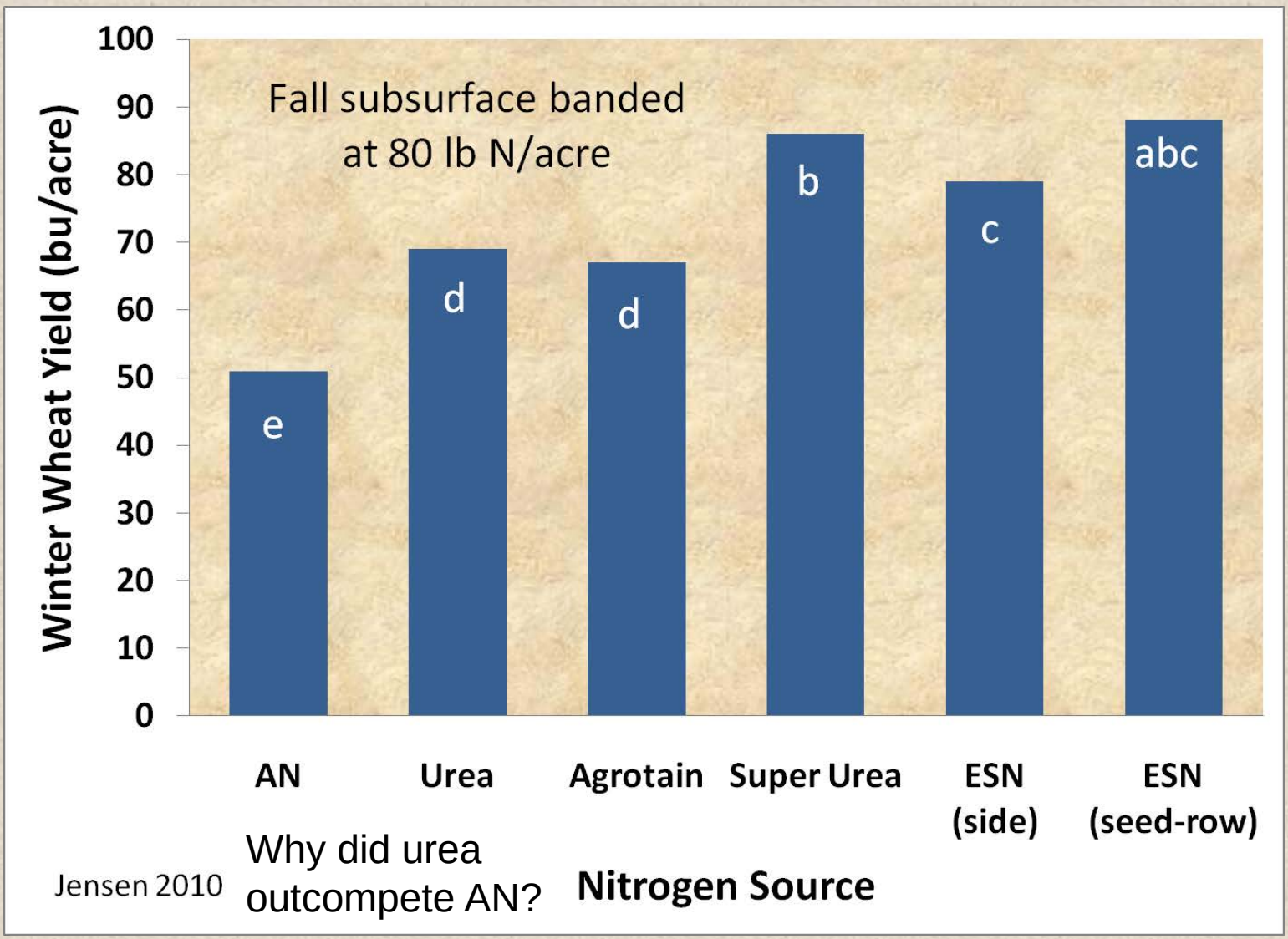
5 N sources:

- AN – ammonium nitrate
- Urea
- Agrotain® treated urea – urease inhibitor
- Super Urea® – urease and nitrification inhibitor
- ESN® – polymer coated urea

Rate: 80 lb N/ac

Subsurface side-banded (1.2” below and 1” side of seed) at seeding or broadcast in spring

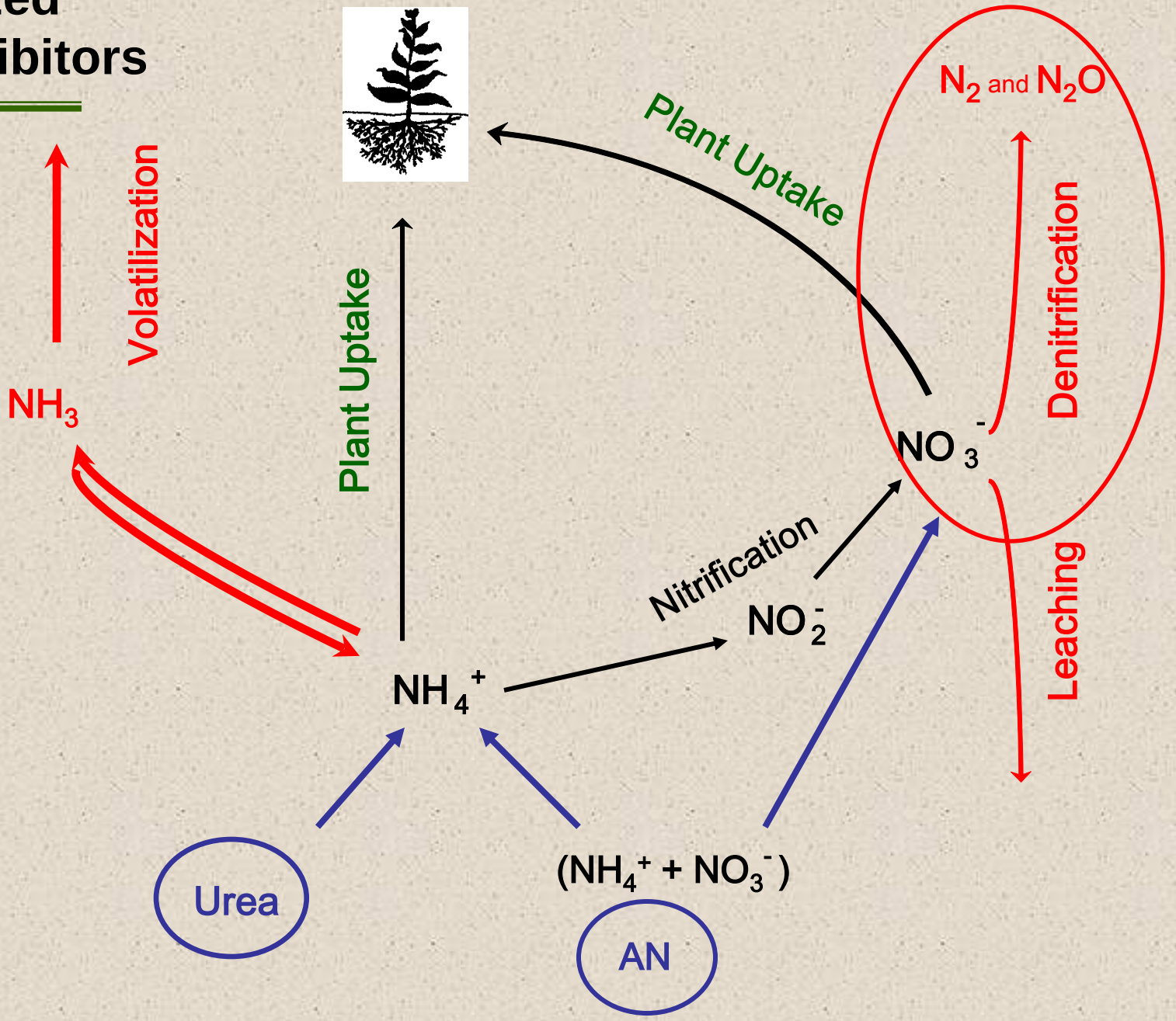
Yield with N fall subsurface side-banded



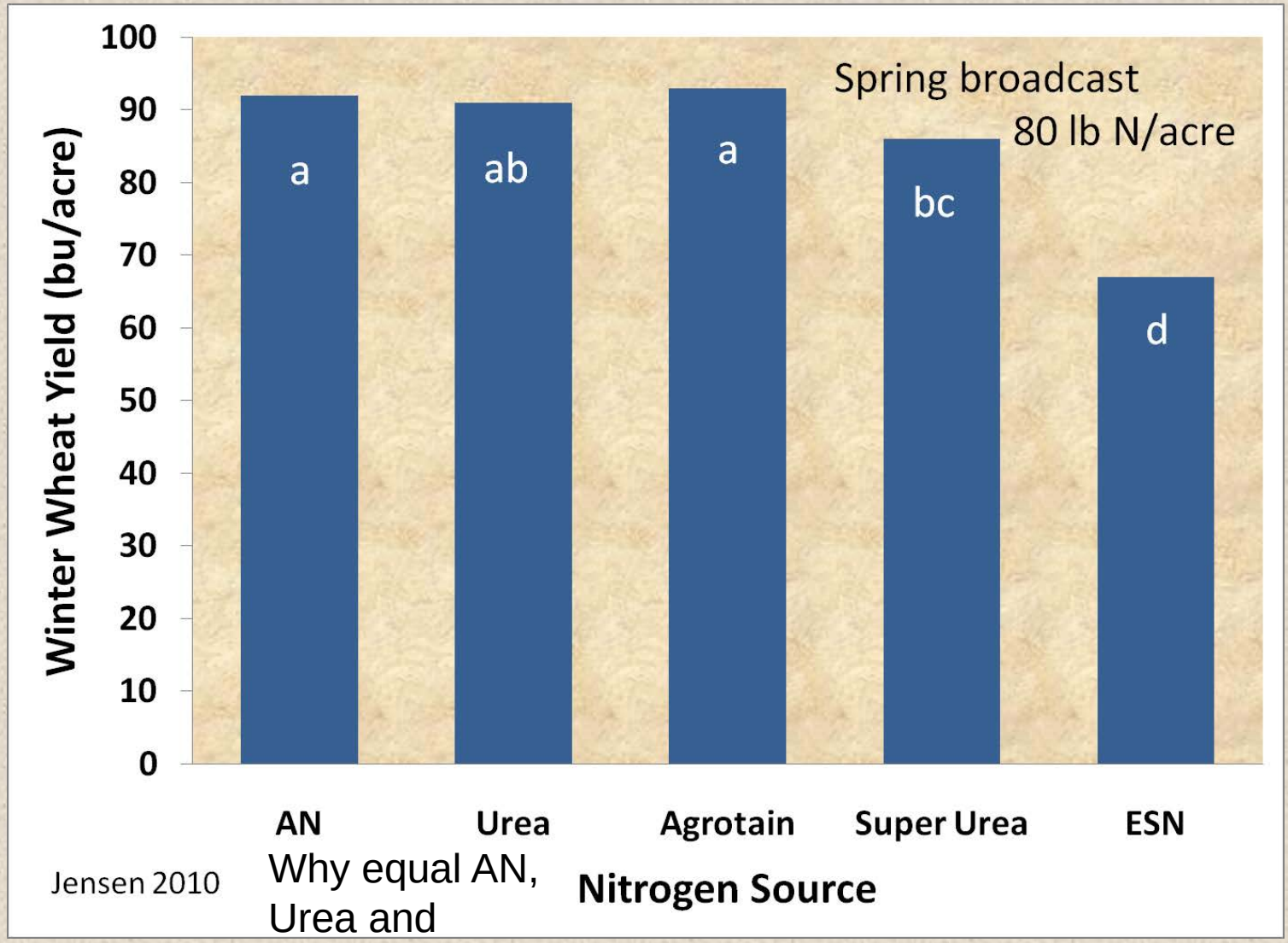
Jensen 2010

Why did urea outcompete AN?

Stabilized Urease Inhibitors



Yield with N spring broadcast



Jensen 2010

Why equal AN, Urea and Agrotain yields?

Alberta Study Summary

Each form of N is suitable – if used properly

- Urea and Agrotain®-urea best used in spring
- Super Urea® best fall banded
- ESN® best side- or seed-row banded in fall – advantage likely less in MT. Why?
- Blend urea with ESN® to ensure early N availability (50/50?)

Winter wheat with Nutrisphere-N® (NSN) side-banded at seeding

Location: North of Conrad (WTARC)

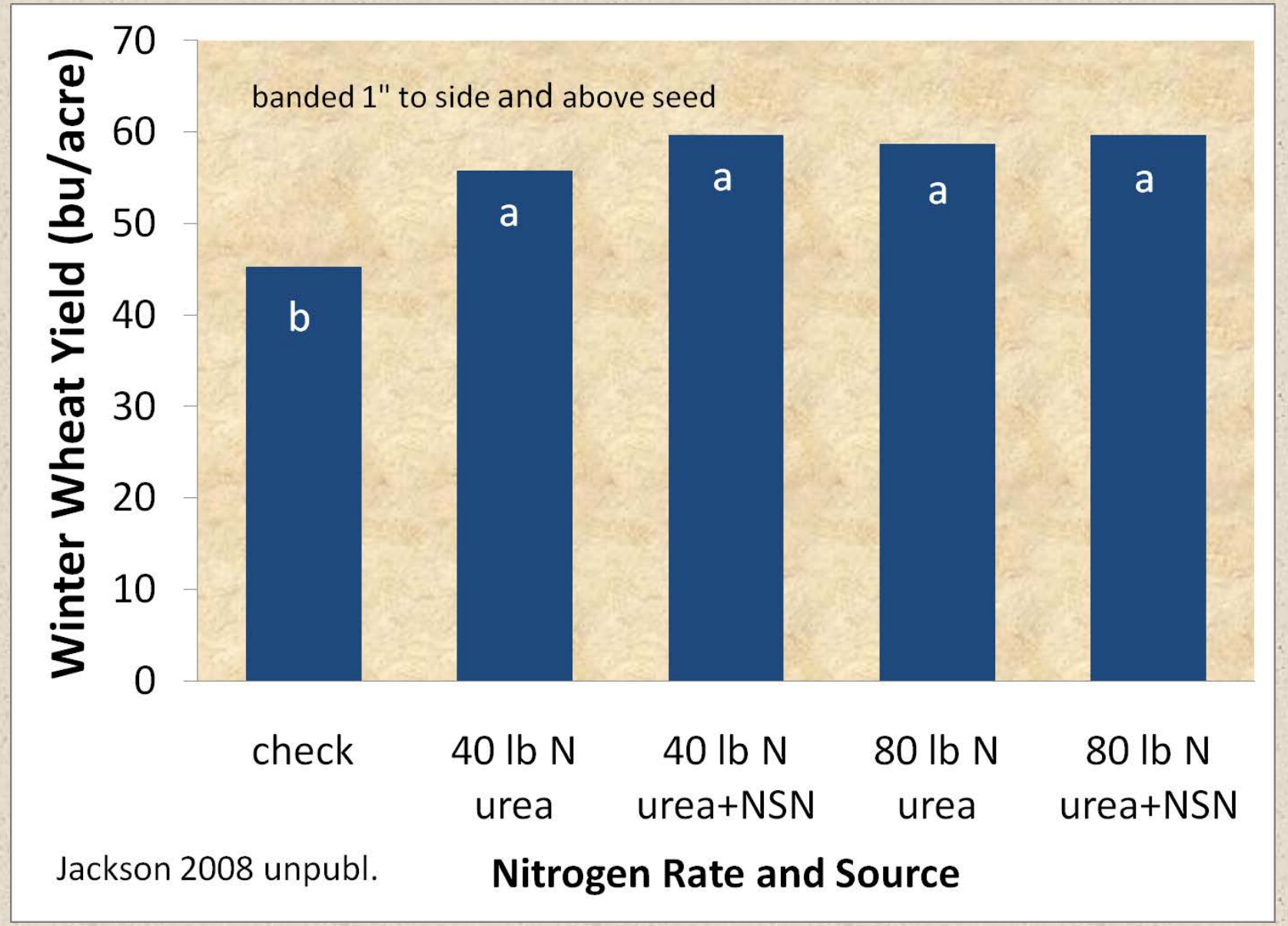
2 N sources:

- Urea
- Nutrisphere-N® – urease and nitrification inhibitor

Rate: 40 and 80 lb N/ac

Subsurface side-banded (1” above and to side of seed) at seeding

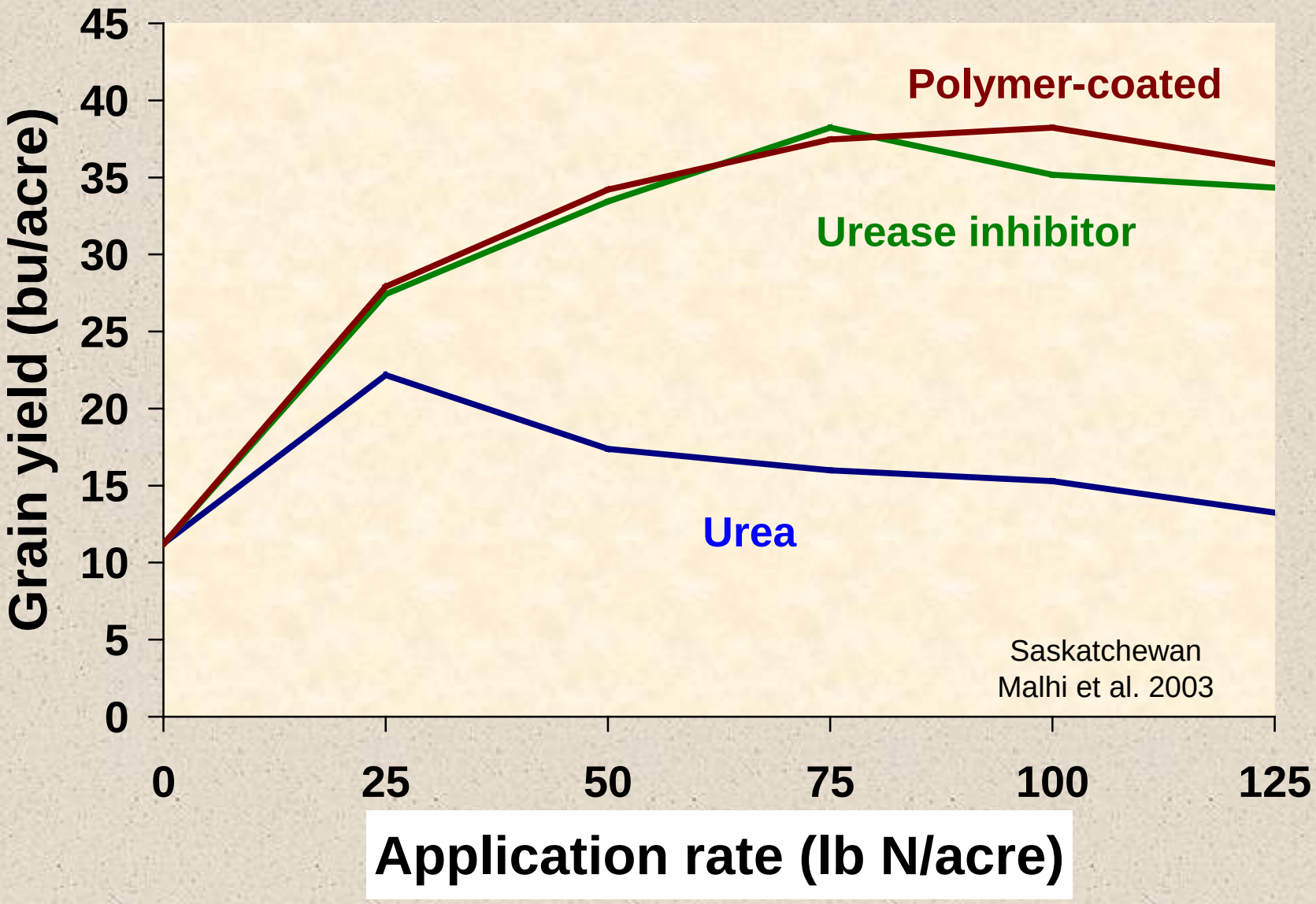
Yield with NSN treated urea side banded



Seed placing EEFs

- Can apply ~ 2 – 4x as much slow release product as urea directly with small grain seeds
- Saves on field passes – fuel, labor, soil disturbance

Effect of N source applied with the seed on dryland spring wheat yield

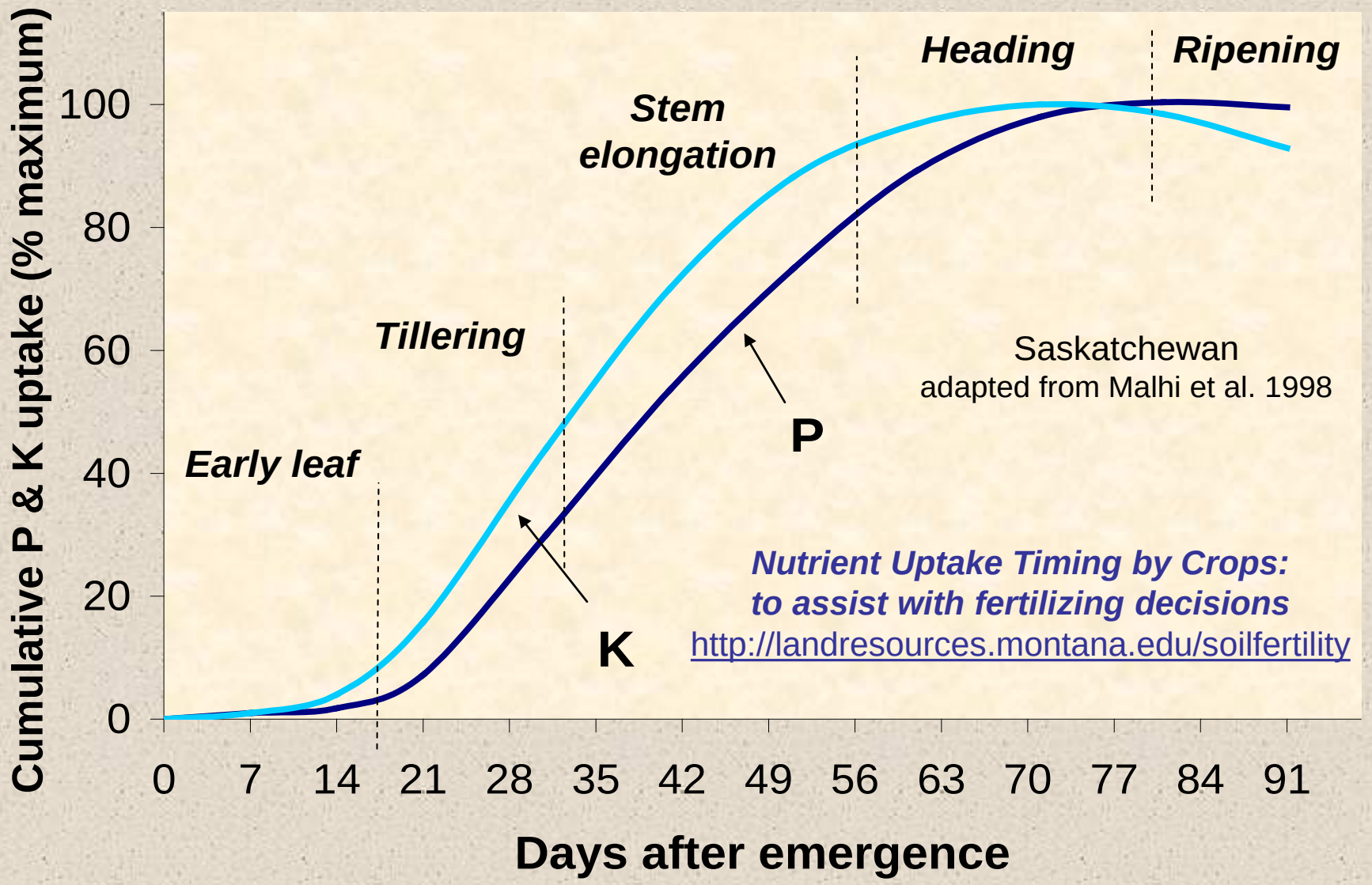


How to manage PCUs

- Apply several weeks before peak crop demand
- Incorporate into the soil or seed place
- Blend with conventional fertilizer
- Adjust rates, blends and application timing for handling abrasion

Questions on N?

Cumulative P and K uptake by small grains



P and K fertilization considerations

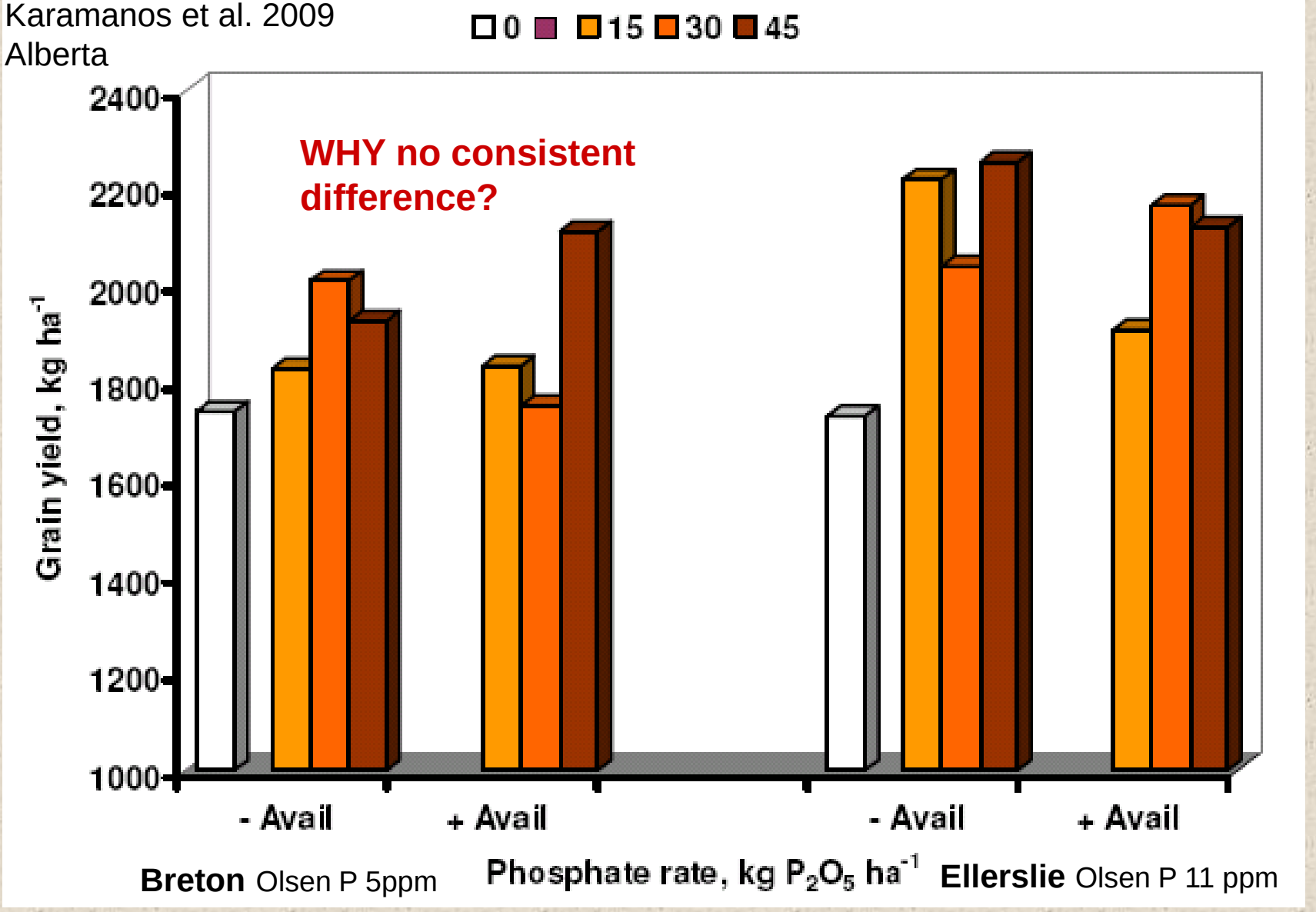
- P and K are not readily lost from the system, so they can be:
  - Placed with seed or banded early in season to ensure availability
  - Built up over time in the soil
- P and K bind strongly to soil surface so less effective topdressed than N
- Avail® is an EEF designed to extend P availability

Phosphorus EEF

- Types
  - Polymer coated
  - Avail® which reduces the rate of P mineral formation
- Limited regional research
  - Soil P levels often above critical

Wheat response to P and Avail®

Karamanos et al. 2009
Alberta



Potential limitations of Avail®

- Mechanism may have difficulty in highly calcareous soils
- Existing soil properties may outweigh product ability

Ex: 100 lb MAP with Avail® contains < 0.25 lb of organic acids – the active ingredient

Organic acids occur naturally in soil, and are elevated in the root zone

Conclusions

- Crops' highest rates of N, P and K uptake are during tillering and branching.
- N, P and K must be available early in growing season for optimal production.
- If all the needed N is applied at seeding there is higher potential for N loss.
- Options are to split applications or use EEFs

Conclusions

- Improved EEFs and blending with conventional fertilizer may provide a good match between crop uptake and fertilizer availability.
- More EEF can be placed with the seed than conventional fertilizer, possibly saving a fertilizer pass and fuel costs.
- EEFs can reduce N losses.

Additional info in:

Nutrient Uptake Timing by Crops (EB0191)

Enhanced Efficiency Fertilizers (EB0188)

http://landresources.montana.edu/soilfertility

Go to Fertilizer Information