High Yield Systems: Role of Placement and Timing

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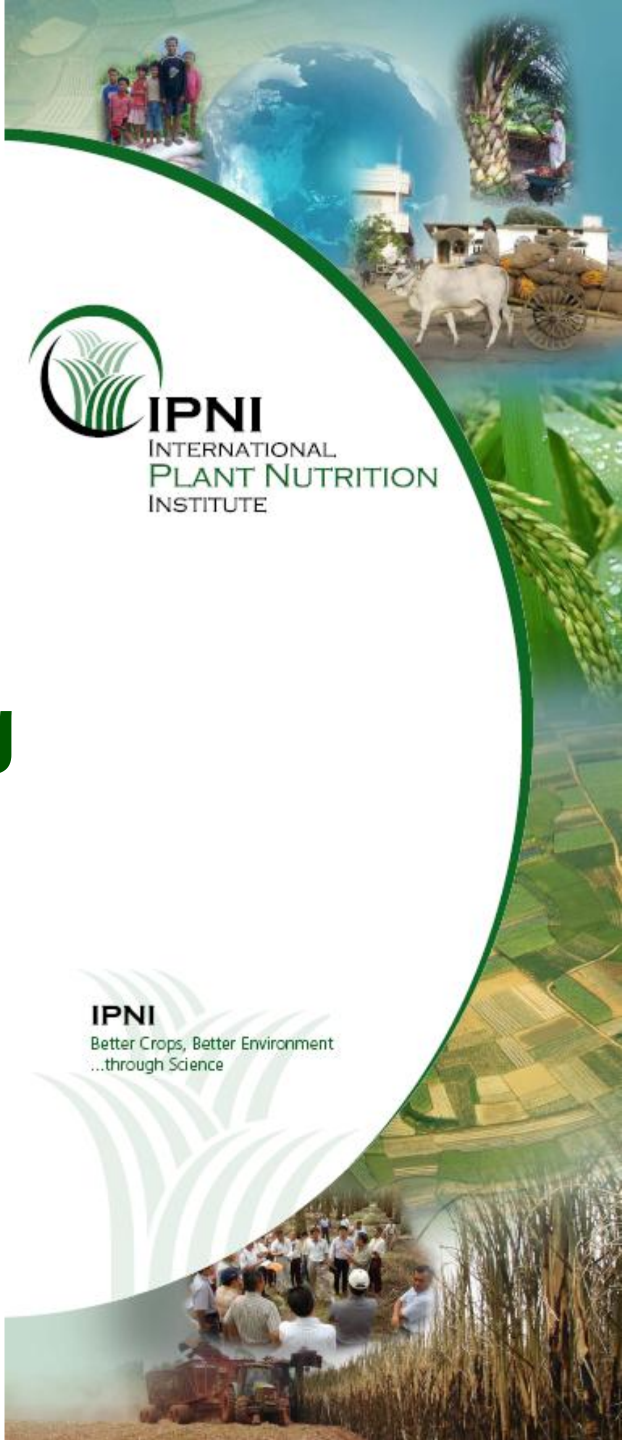

Outline

- How close are yields to those that are possible?
- Concepts to carry with you when working in high-yield systems
  - Short-term efficiency vs. long-term soil fertility management
  - Characteristics of young root systems
  - Root-nutrient interactions in bands
  - Spatial variability introduced by bands
  - Redistribution of nutrients in the soil caused by crop growth
  - Using banding to address economic constraints

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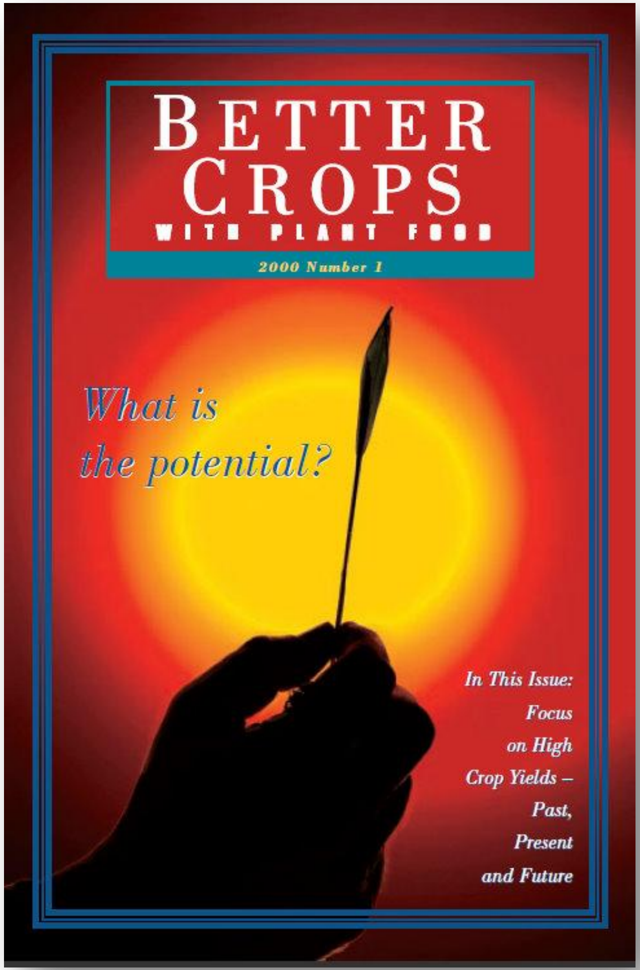
Yields:
Determining the potential

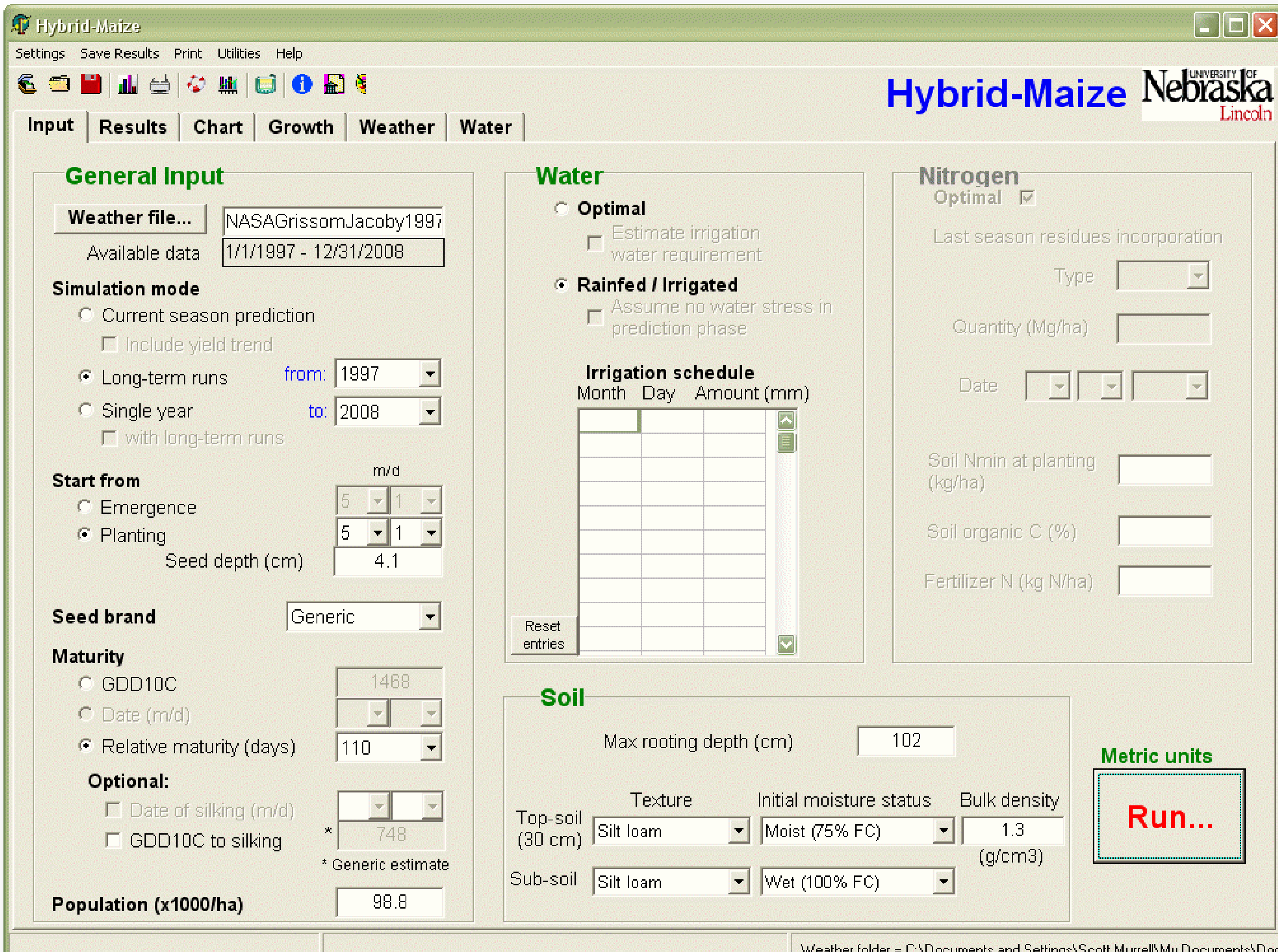
Yield goal vs. potential yield

- Farmers want to know how close their yields are to what is possible
- Yield goal:
  - Average of historical yields + _____%
  - "What has been done plus a little more"
  - Estimates for the coming season are used to determine "maintenance rates"
- Potential yield:
  - "…the maximum yield that could be reached by a crop in given environments" (Evans and Fischer. 1999. Crop Sci. 39:1544)
  - Estimated through crop growth models

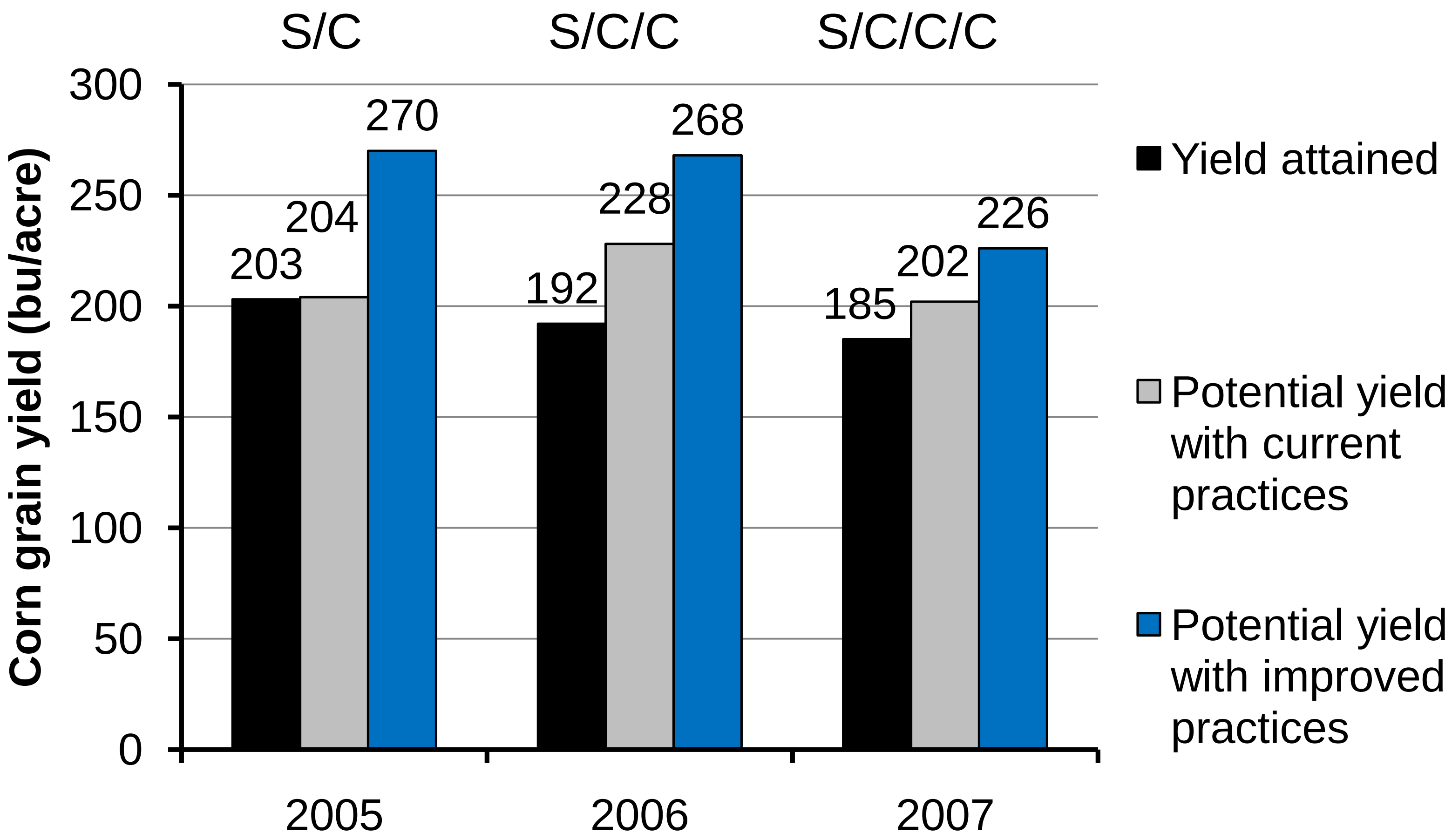


Estimating potential yield

Hybrid-Maize plant growth simulation software



Yield attained vs. potential yield



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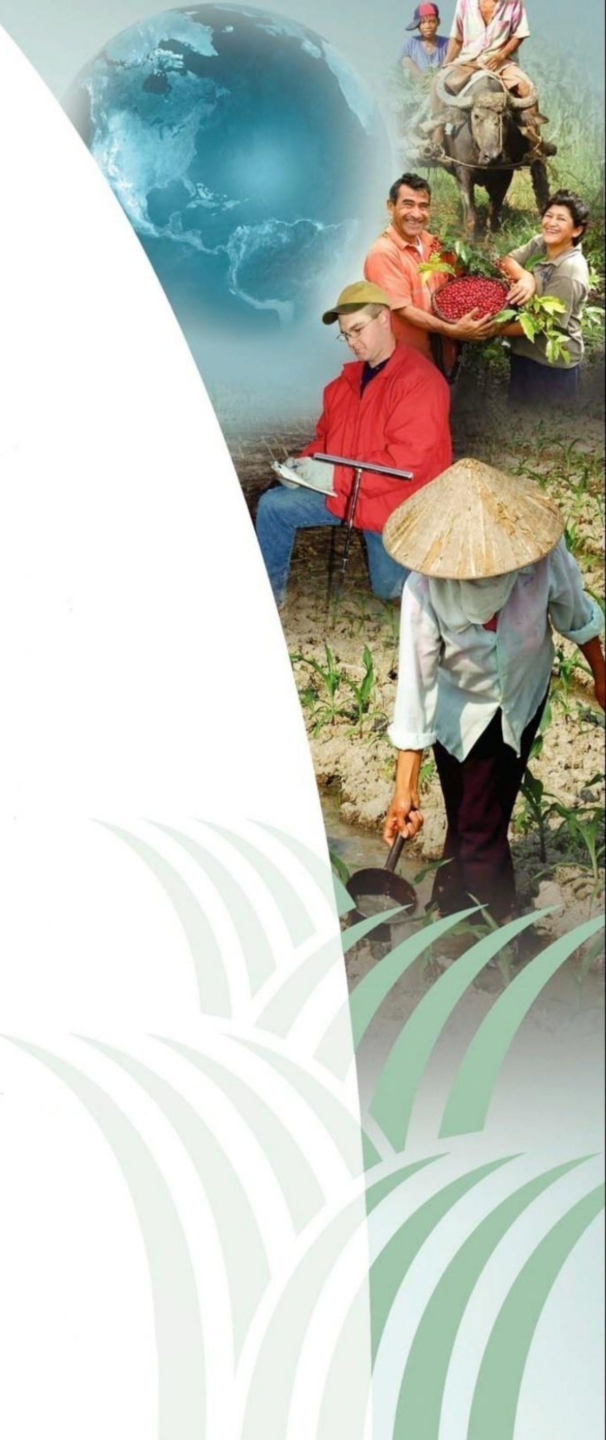


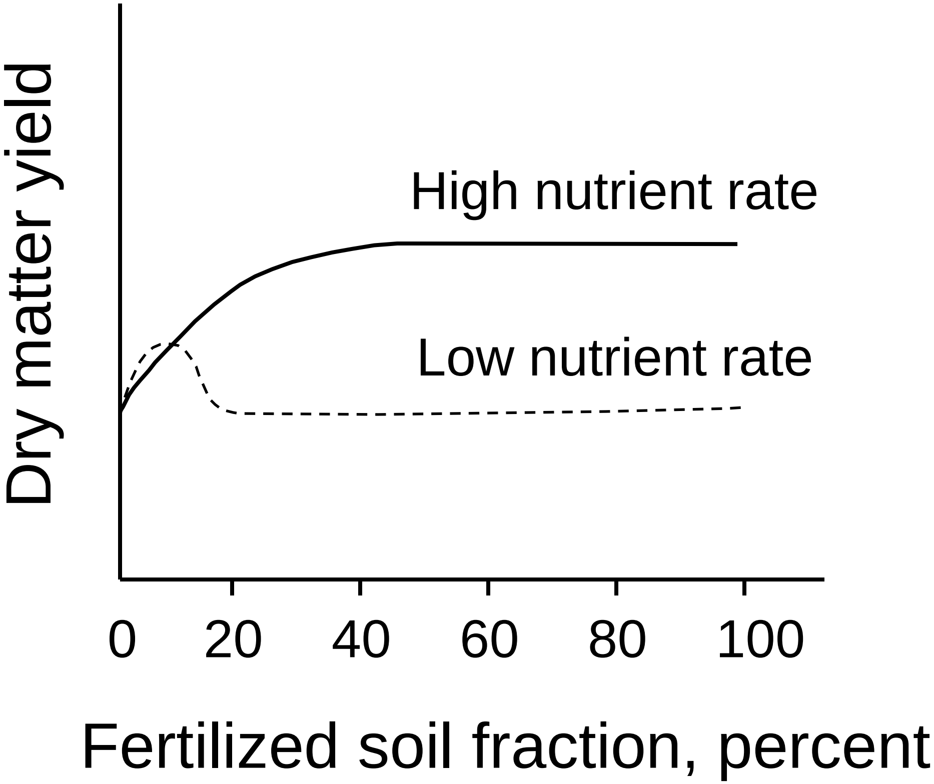
Banded applications:

Efficiency and soil tests

Nutrient placement considerations

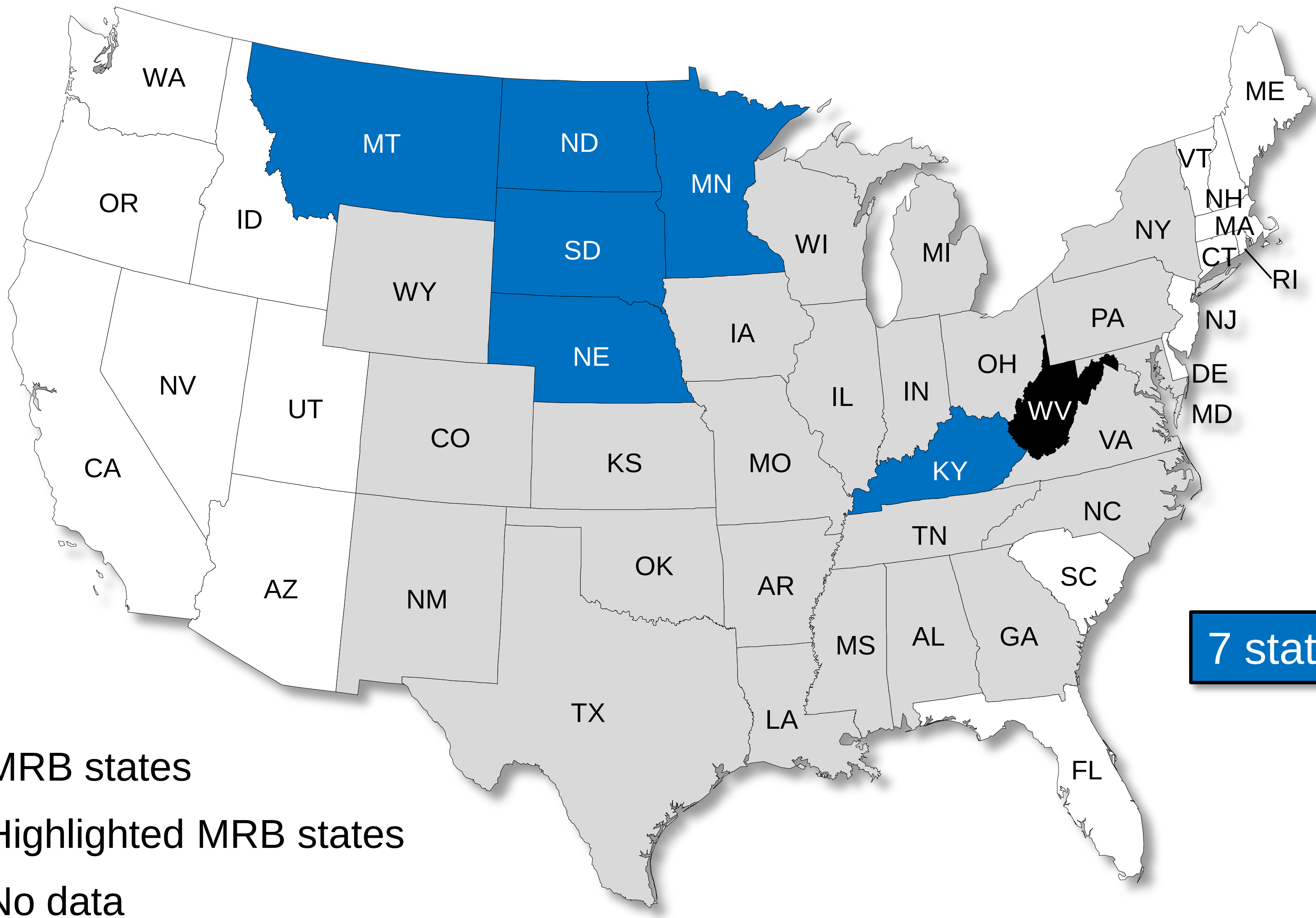
- Banding:
  - Less soil volume fertilized
  - Smaller portion of fertilizer is "tied up"
  - Roots proliferate where N and P are found
  - Rate may be too low to maximize yield
    - Fewer roots exposed to supply
    - Increase in influx rate by roots may not compensate for fewer total number of roots near P supplies

Conceptual model (nutrient deficient soil)



Anghinoni and Barber, 1980

Mississippi River Basin (MRB) states recommending rate reductions with banded applications



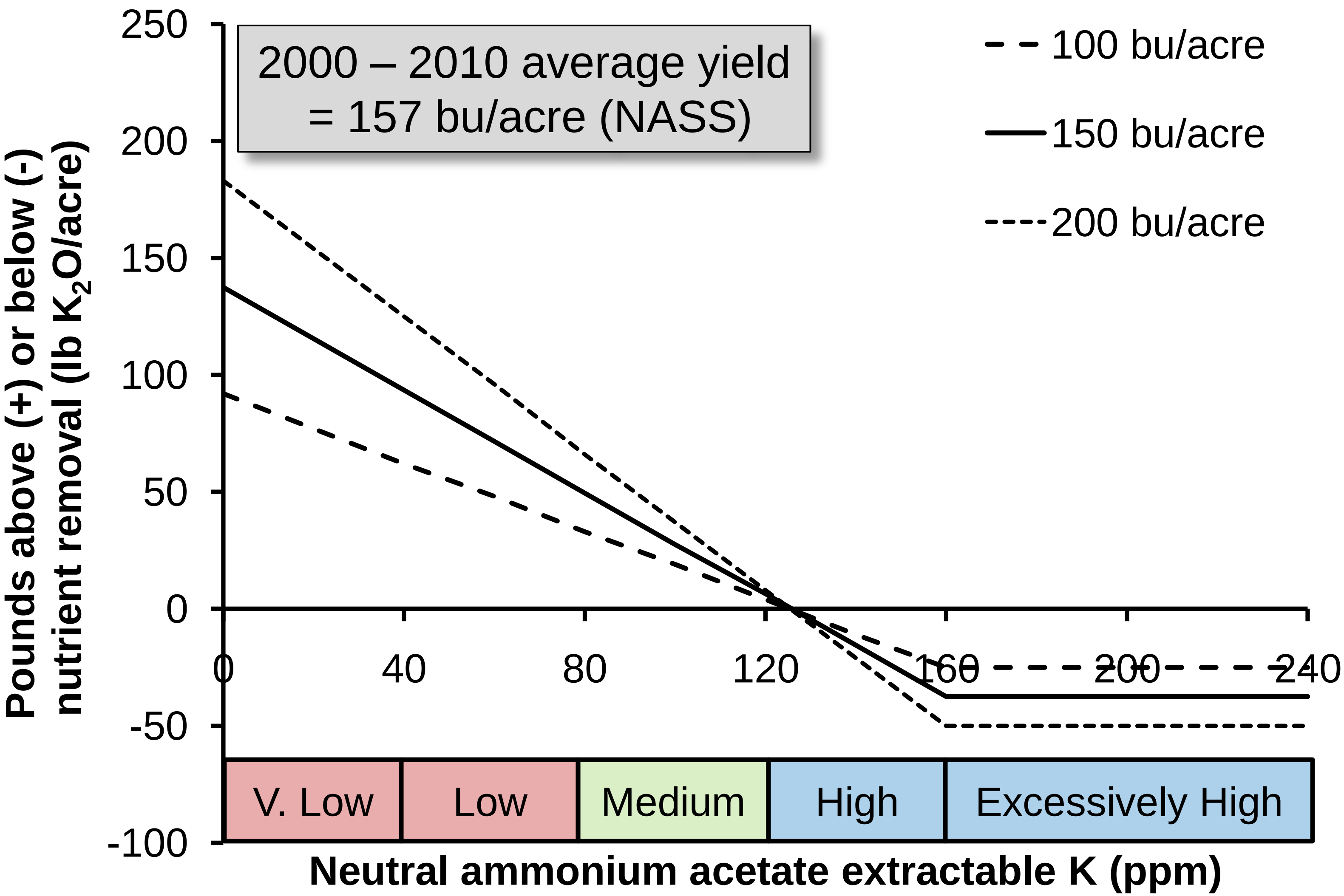
7 states

MRB states

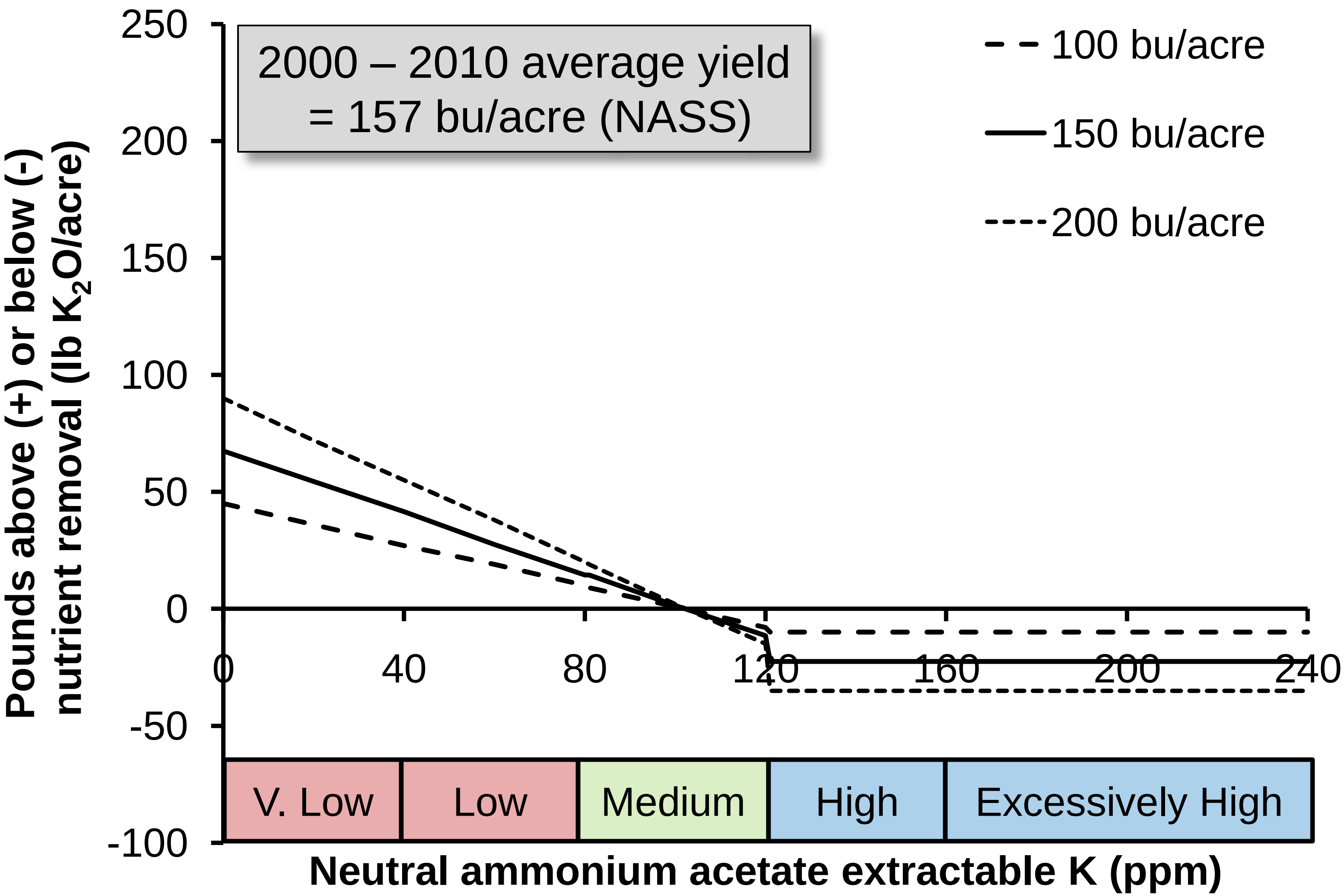
Highlighted MRB states

No data

A K recommendation that does consider yield goal:
Example: MN – broadcast application



A K recommendation that does consider yield goal:
Example: MN – banded application (40% reduction)



Monitoring nutrient removal

- Short-term improvements in efficiency must be weighed against long-term impacts on soil fertility
- Consider creating a local database of crop removal rates for crops in your area

Year	Yield	N_lb/bu	S_lb/bu	P_2O_5_lb/bu	K_2O_lb/bu
2009	160	0.625	0.041	0.303	0.153
2009	160	0.719	0.047	0.326	0.167
2009	175	0.610	0.040	0.296	0.158
2009	200	0.677	0.045	0.345	0.185
2009	175	0.672	0.041	0.308	0.165
2009	167	0.648	0.044	0.306	0.203
2009	170	0.691	0.041	0.261	0.132
2009	171	0.729	0.045	0.331	0.161
2010	174	0.521	0.044	0.344	0.251
2010	197	0.506	0.045	0.037	0.282
2010	186	0.516	0.045	0.335	0.252
2010	184	0.539	0.047	0.301	0.242
2009	150	0.696	0.044	0.326	0.183
2009	175	0.658	0.044	0.311	0.182
2009	178	0.596	0.045	0.274	0.149

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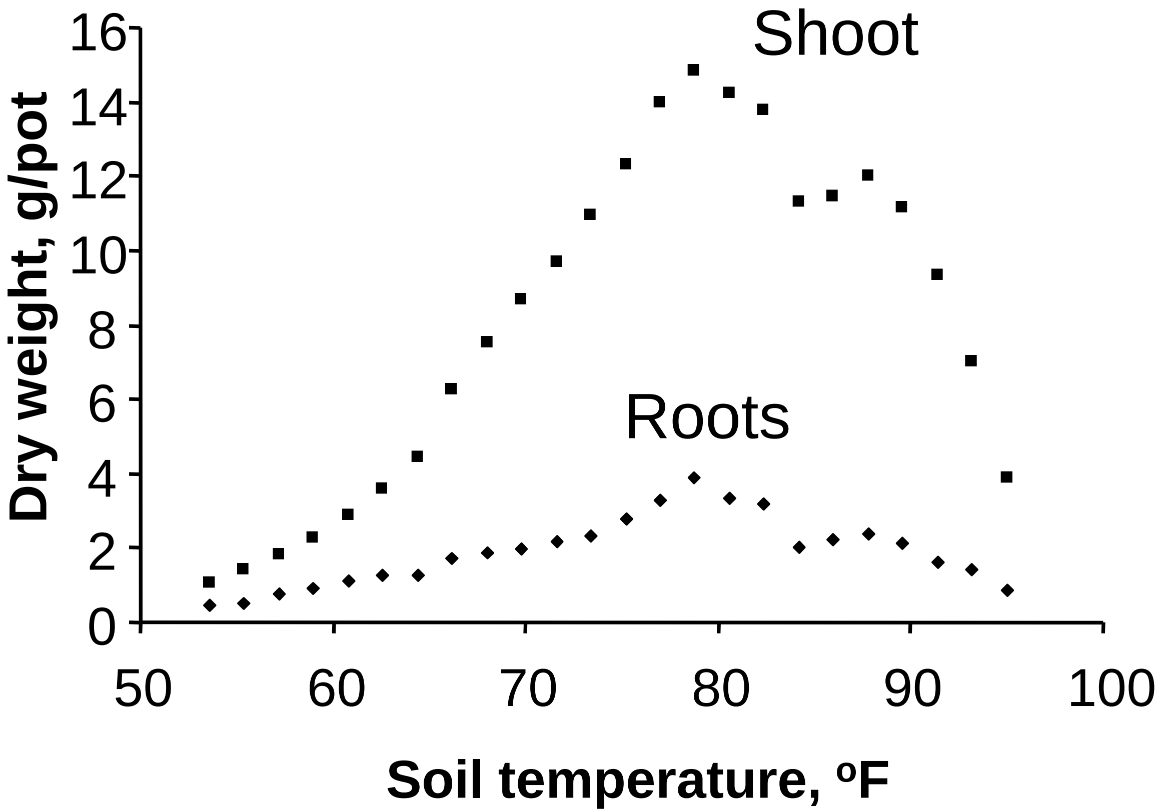
Banded applications near the seed at planting

Theoretical principles

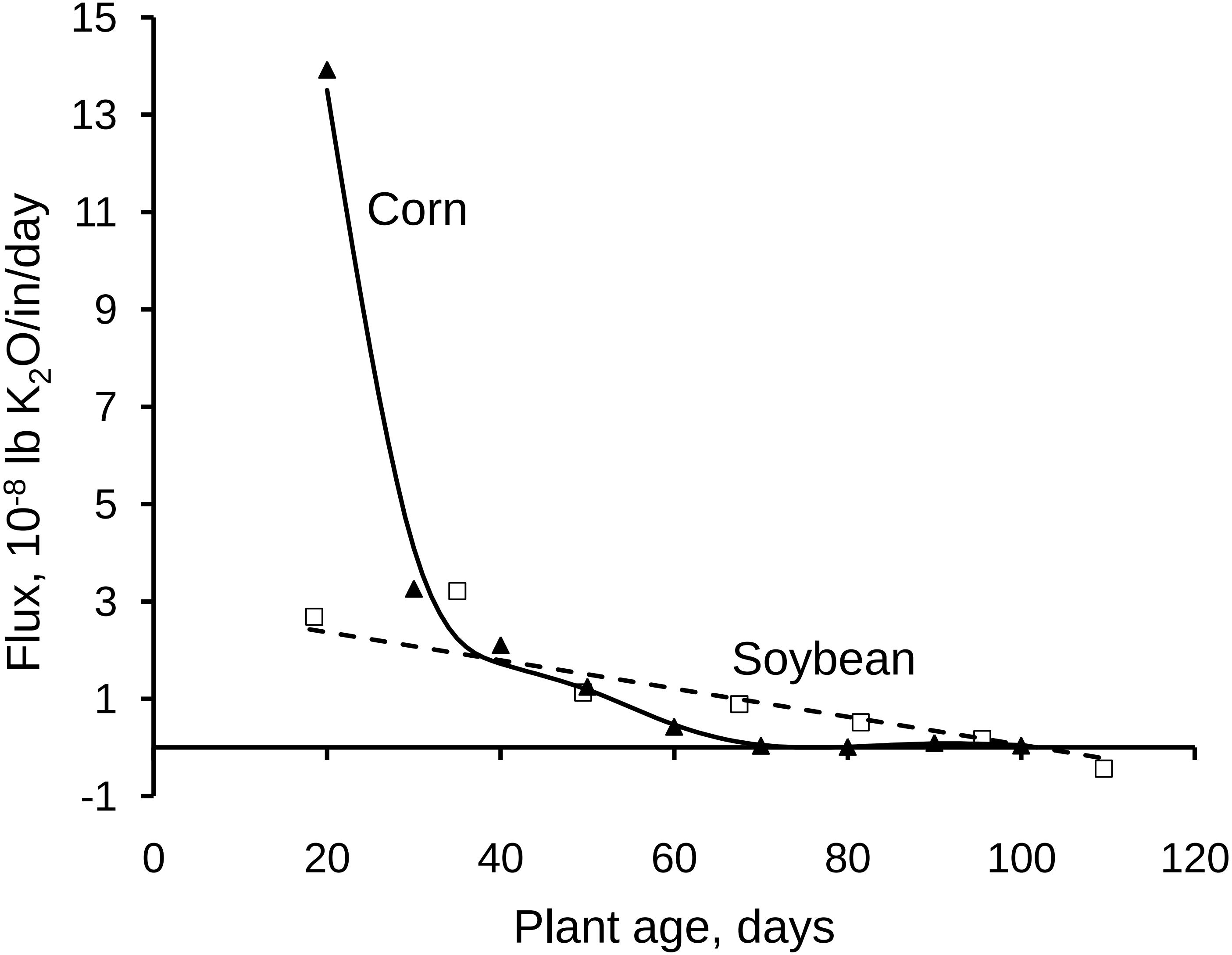
Environmental effects: soil temperature

- Air temperature held constant at 77ºF
- 23 day old corn seedlings measured



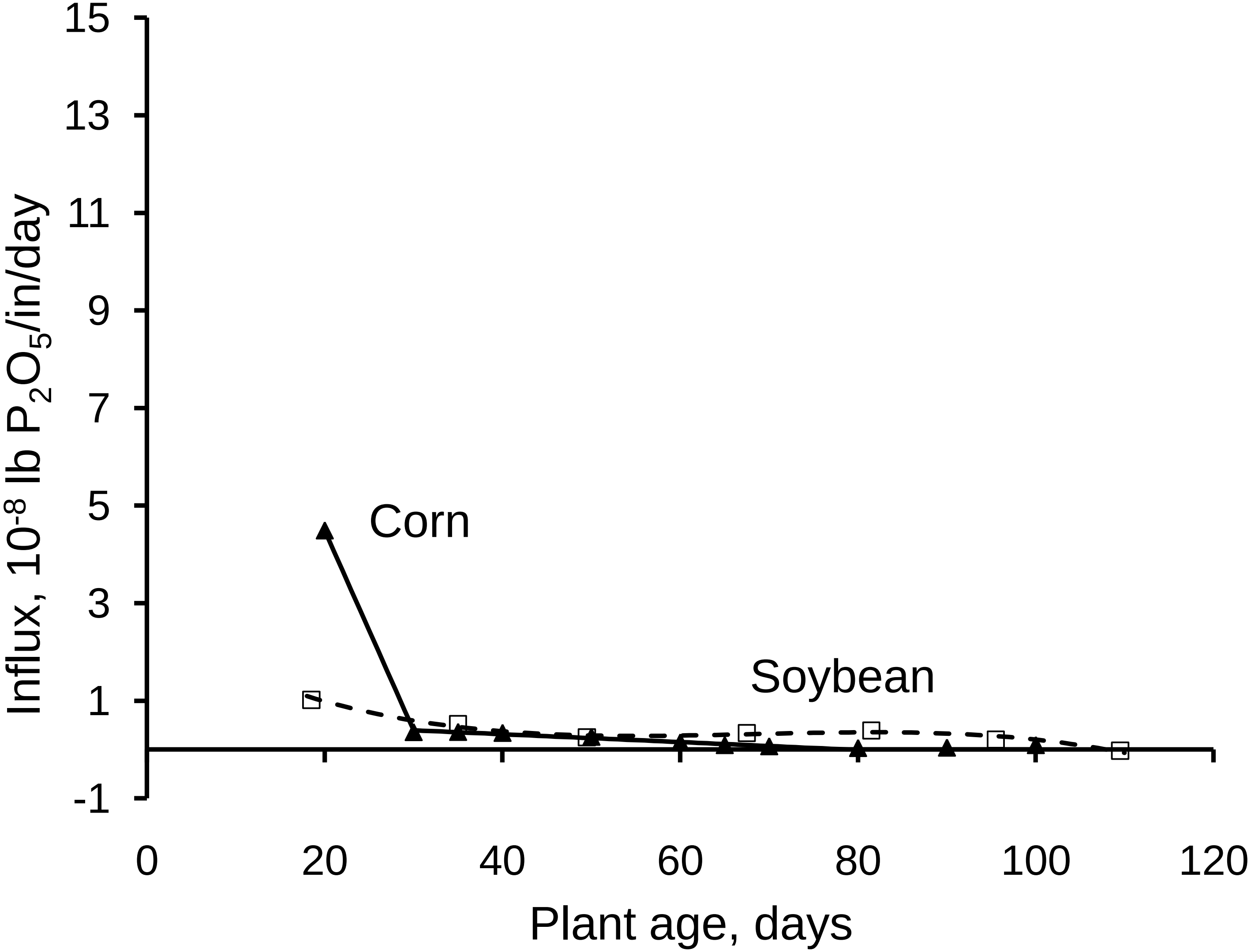
Walker, 1969

Rate of K uptake by roots differs with plant age



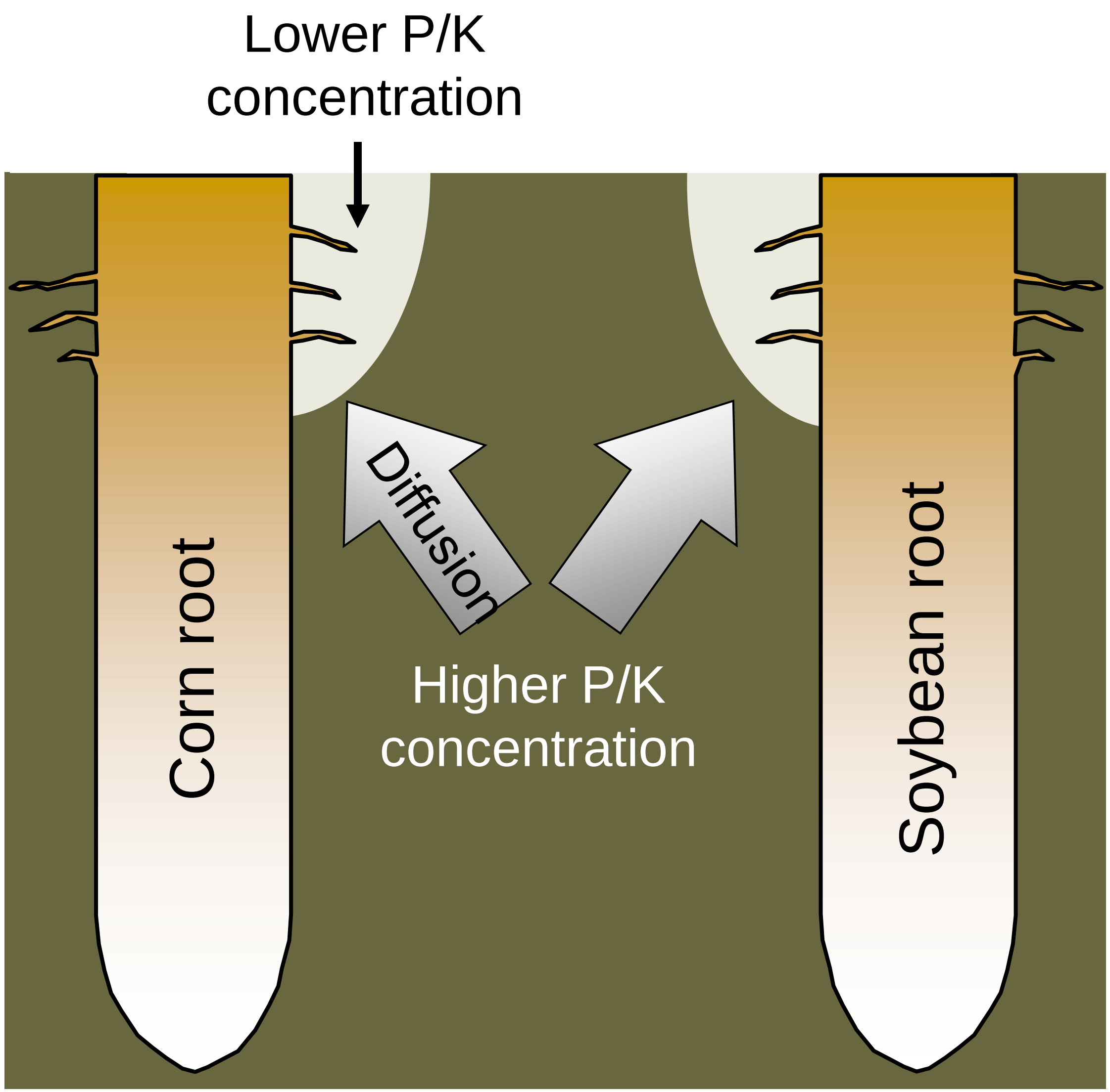
Barber, 1978; Mengel and Barber, 1974

Rate of P uptake by roots differs with plant age



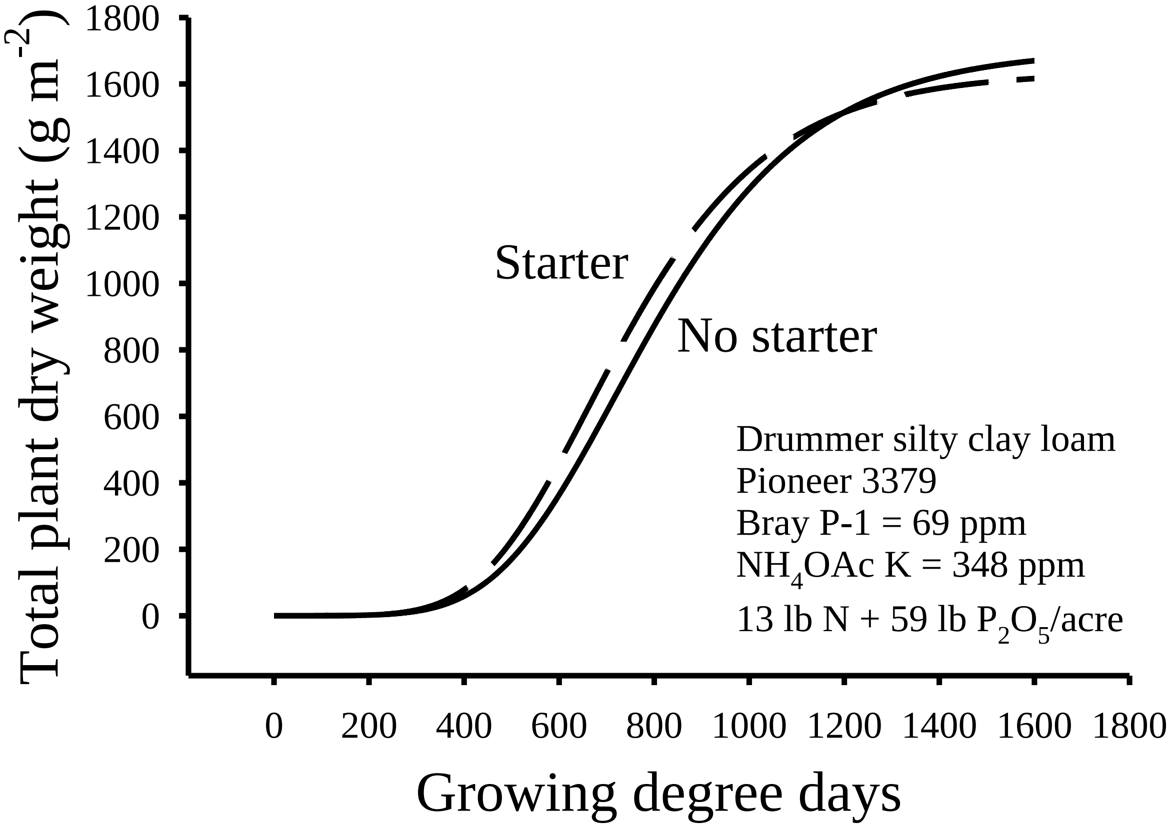
Barber, 1978; Mengel and Barber, 1974

Flux rate affects the rate of nutrient depletion



Early growth response does not necessarily translate to increased yield

- Larger plant dry weight from 500 to 1200 GDD
- Final plant dry weight not affected by starter
- Starter hastened:
  - Develoment
  - Maturation
- No yield increase



Bullock et al., 1993 (Illinois)

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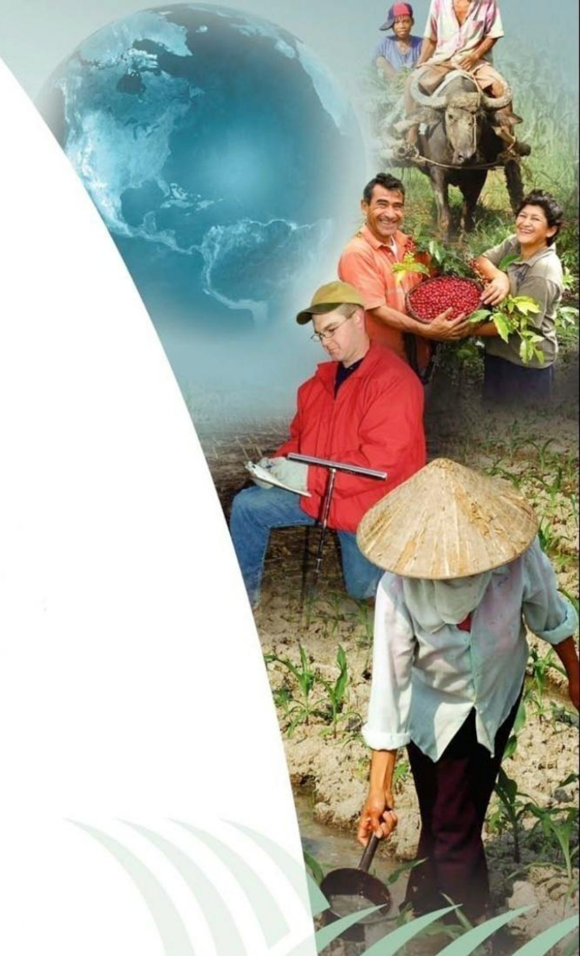
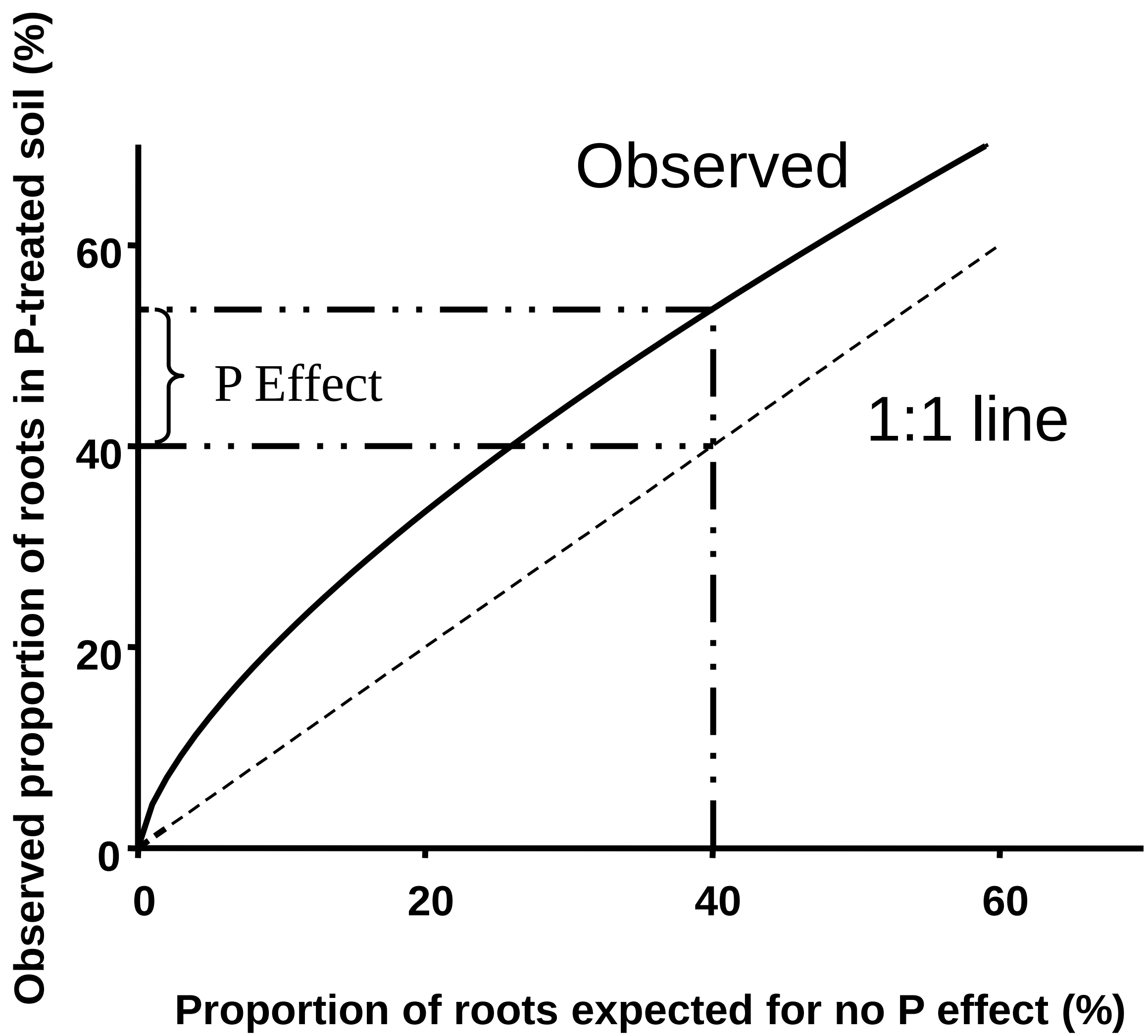


Banding nutrients together

Theoretical principles

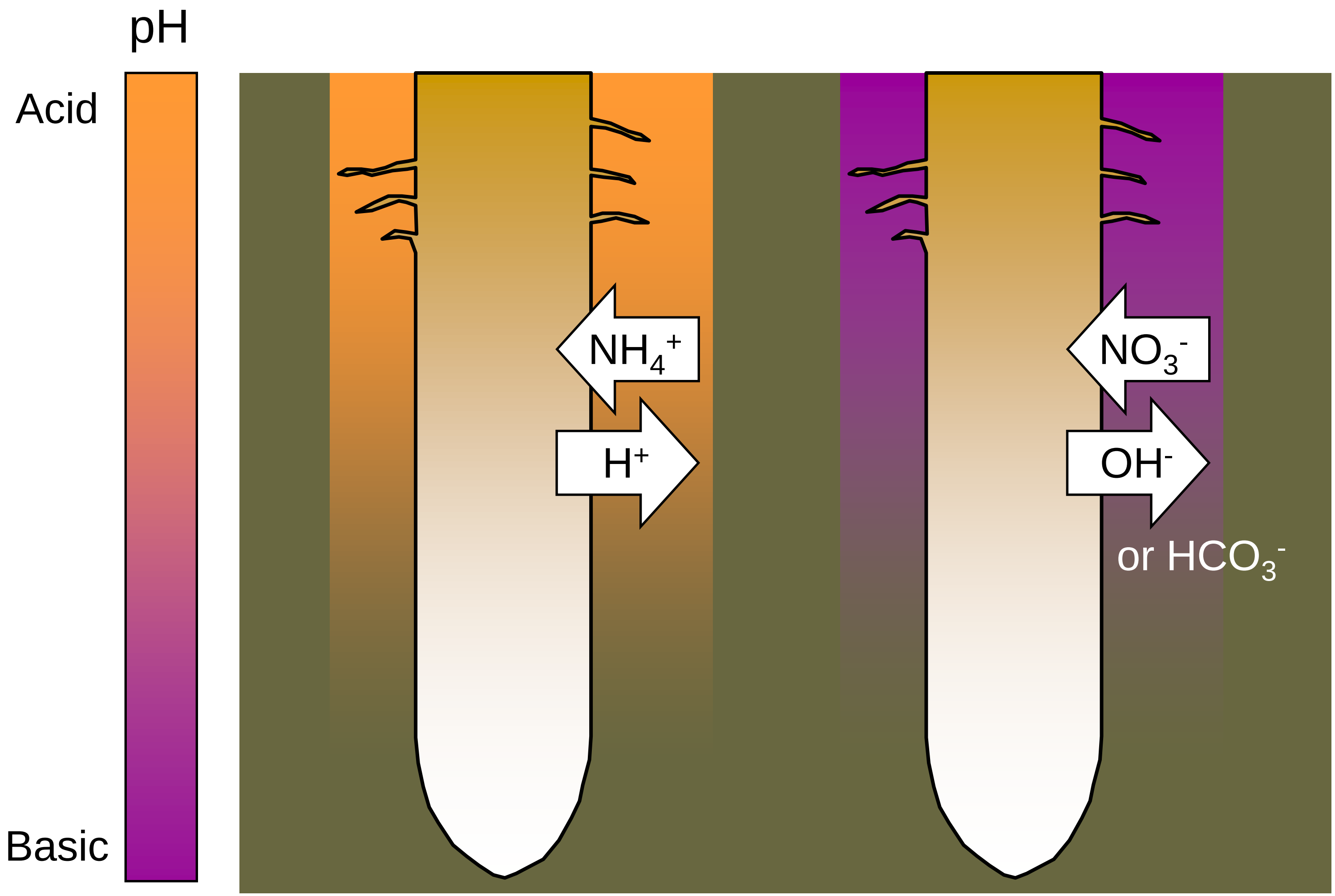
N and P cause roots to “proliferate”

- Split-root experiment
- Percent of the total root system on the side with P was greater than that on the side without P



Anghinoni and Barber, 1980

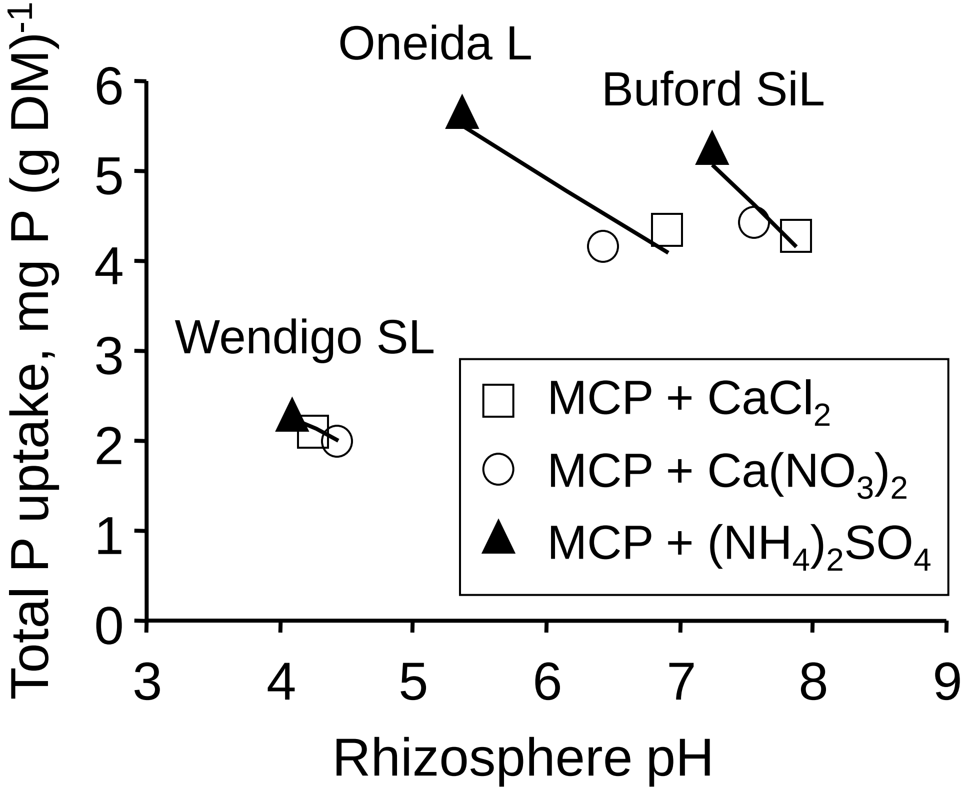
Ammonium and nitrate: rhizosphere pH differences



Marschner, 2002

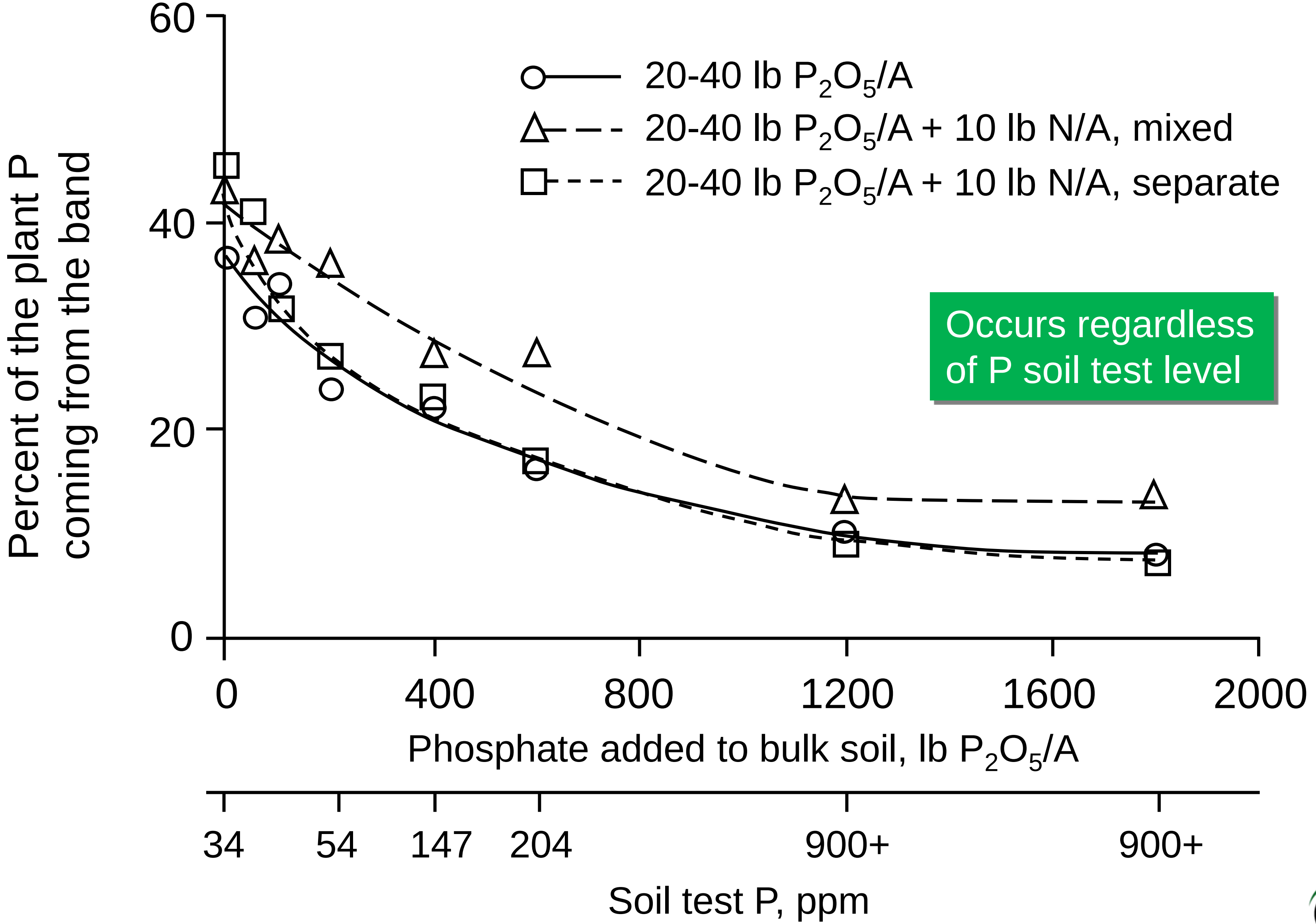
Rhizosphere pH affects P uptake by corn

- 11 day old corn
- Ammonium source reduced rhizosphere pH and increased P uptake



Soon and Miller, 1977

Starter fertilizer: NH_4^+ and P should be placed together



Miller and Ohlrogge, 1958

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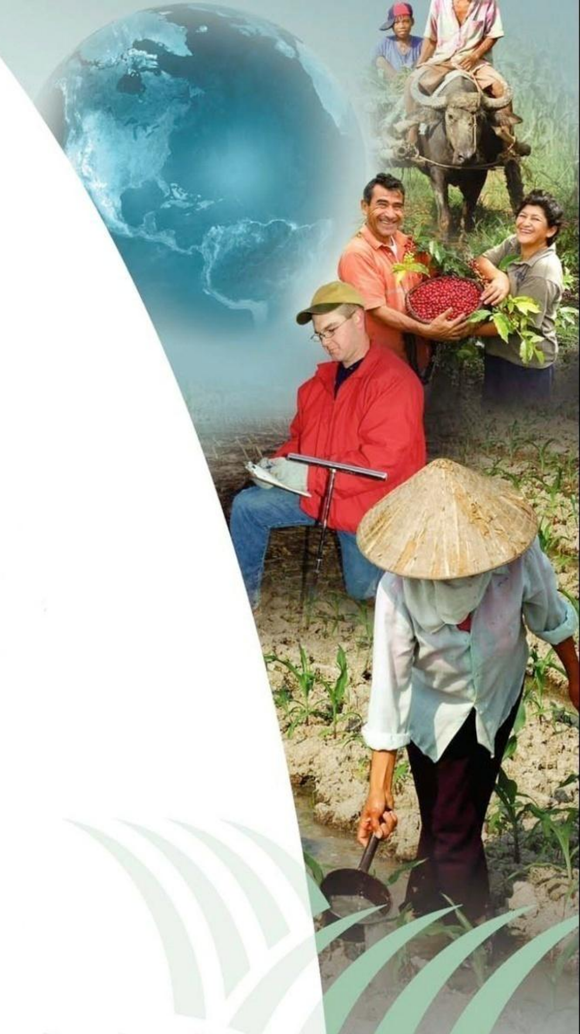
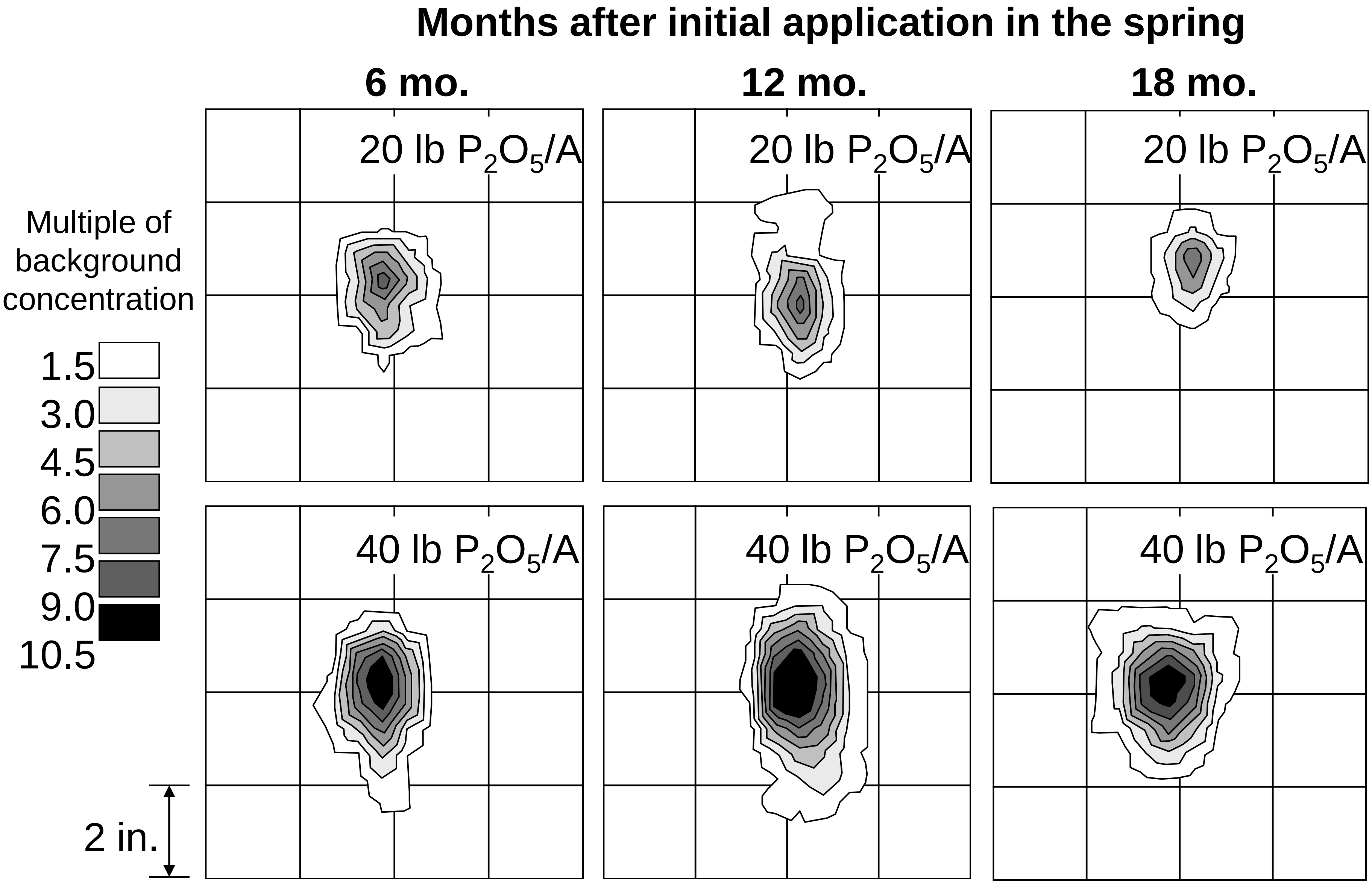
Impact of banded applications on spatial variability

Theoretical principles

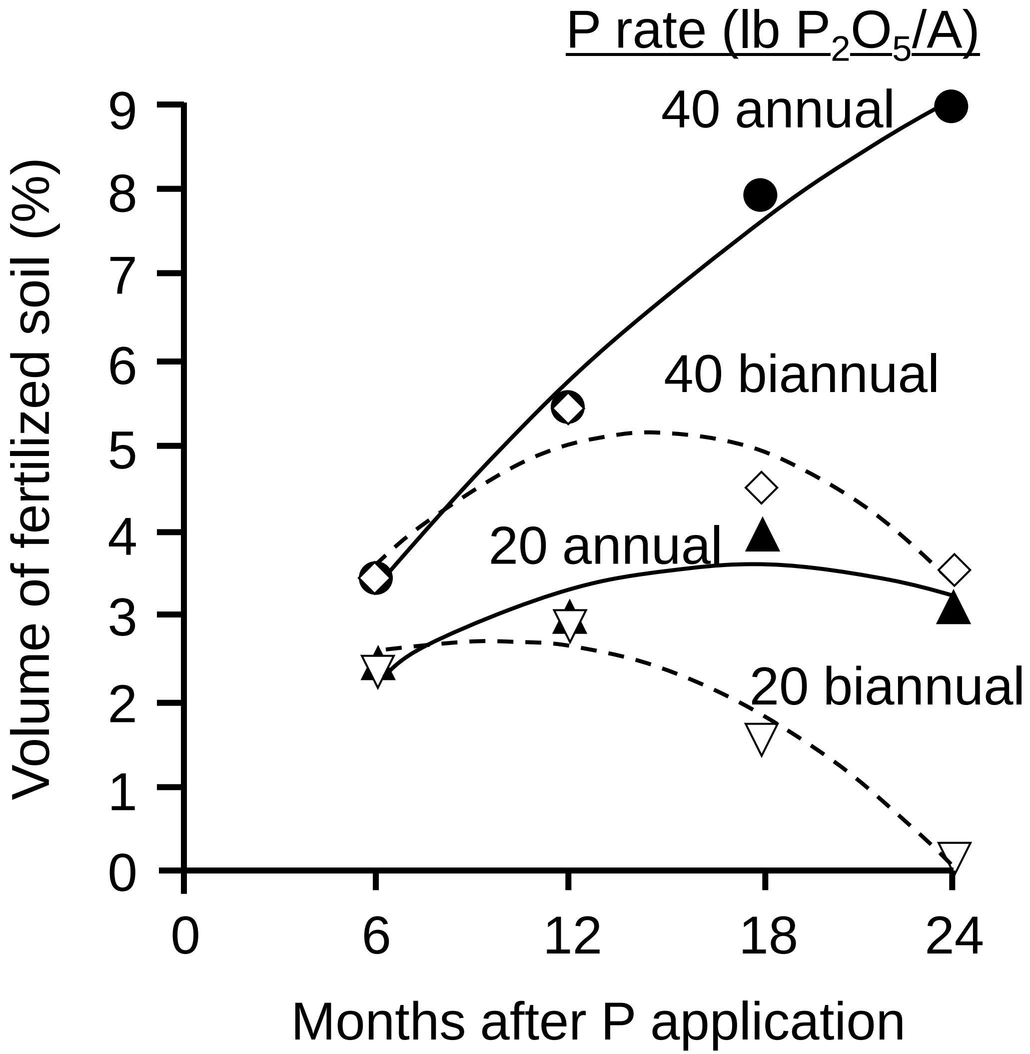




Stecker et al., 2001

Impact of successive banding

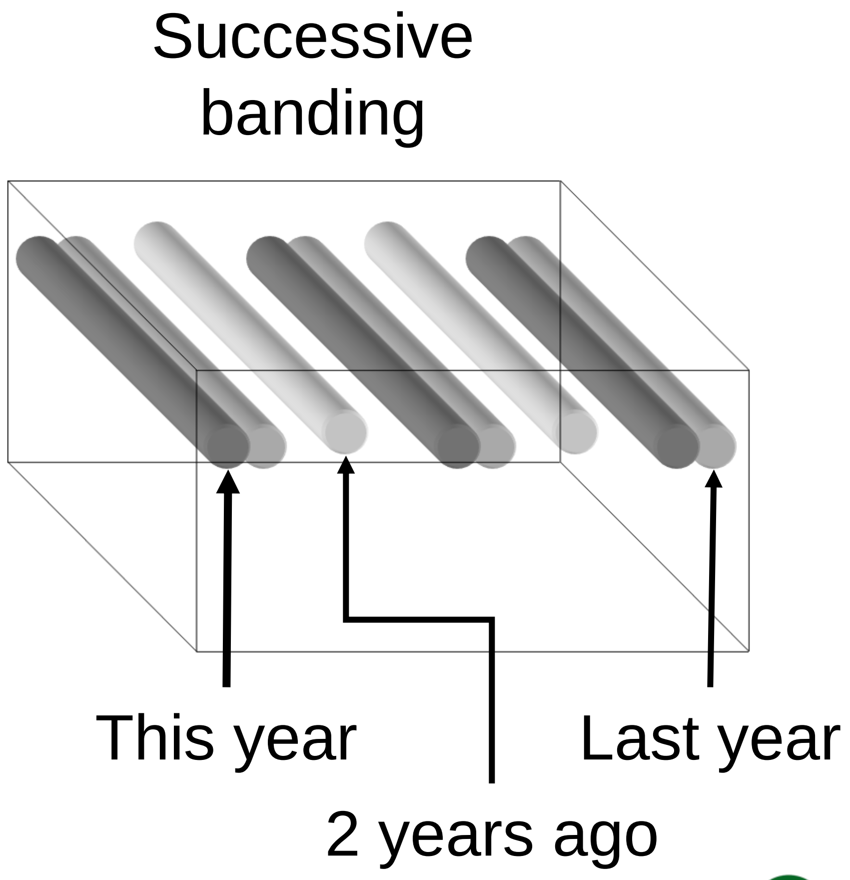
- Mexico silty clay loam soil
- Single 20 lb/A band fertilizes 2.6% of soil volume
- Volume assumed to be additive
- Annual applications stay ahead of volumetric reductions of specific bands over time



Stecker et al., 2001

Successive banding in different places creates concentrated zone that decay over time

- Placing bands in different places over time can lead to a greater volume of fertilized soil over time



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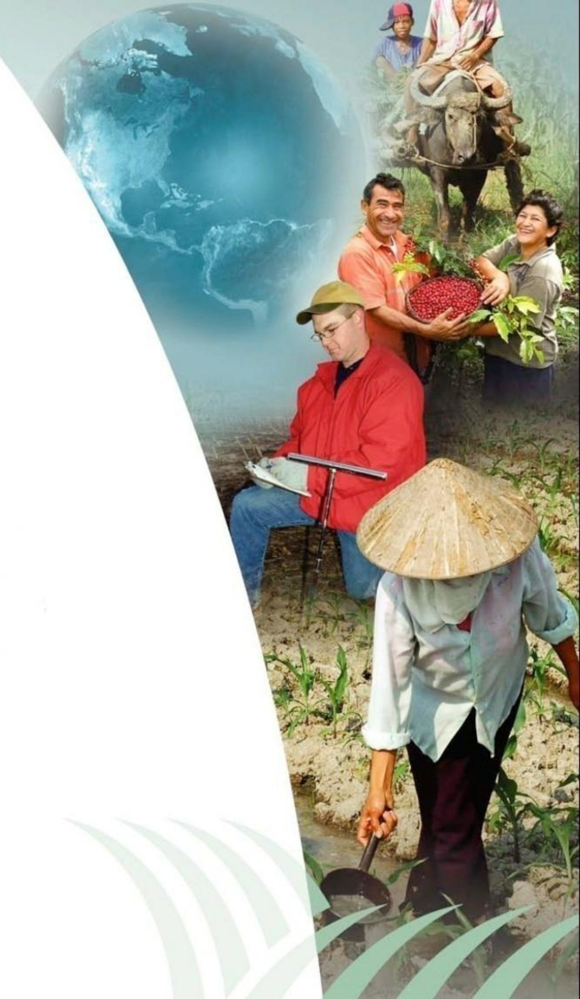


Impact of crop uptake and on spatial variability

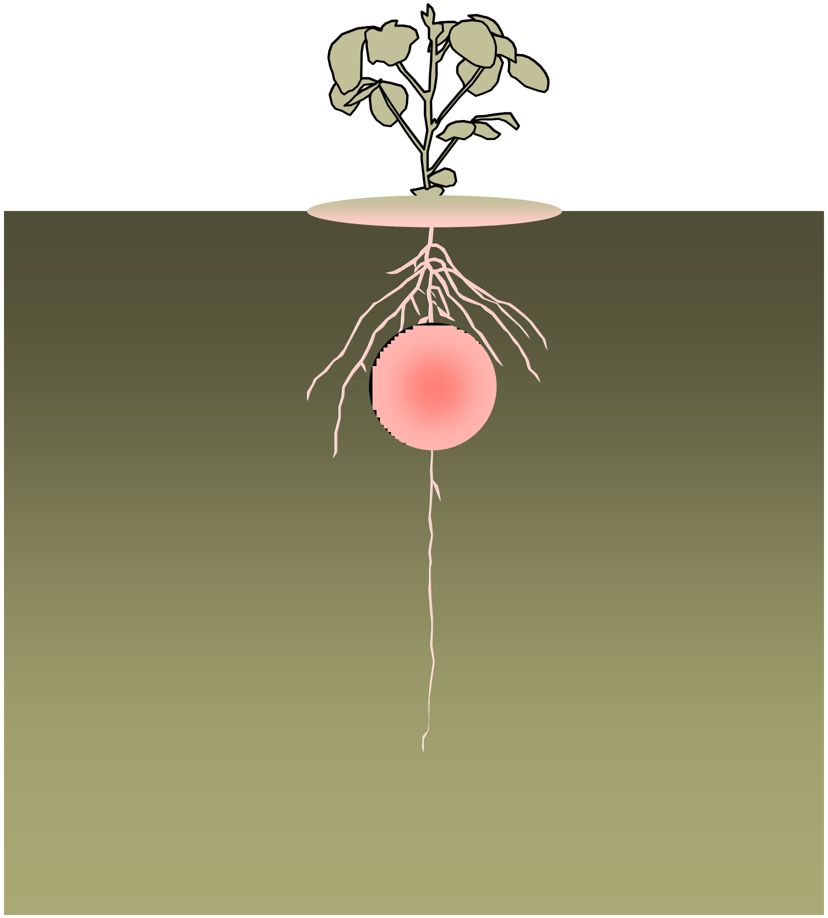
Theoretical principles

Transport of banded K

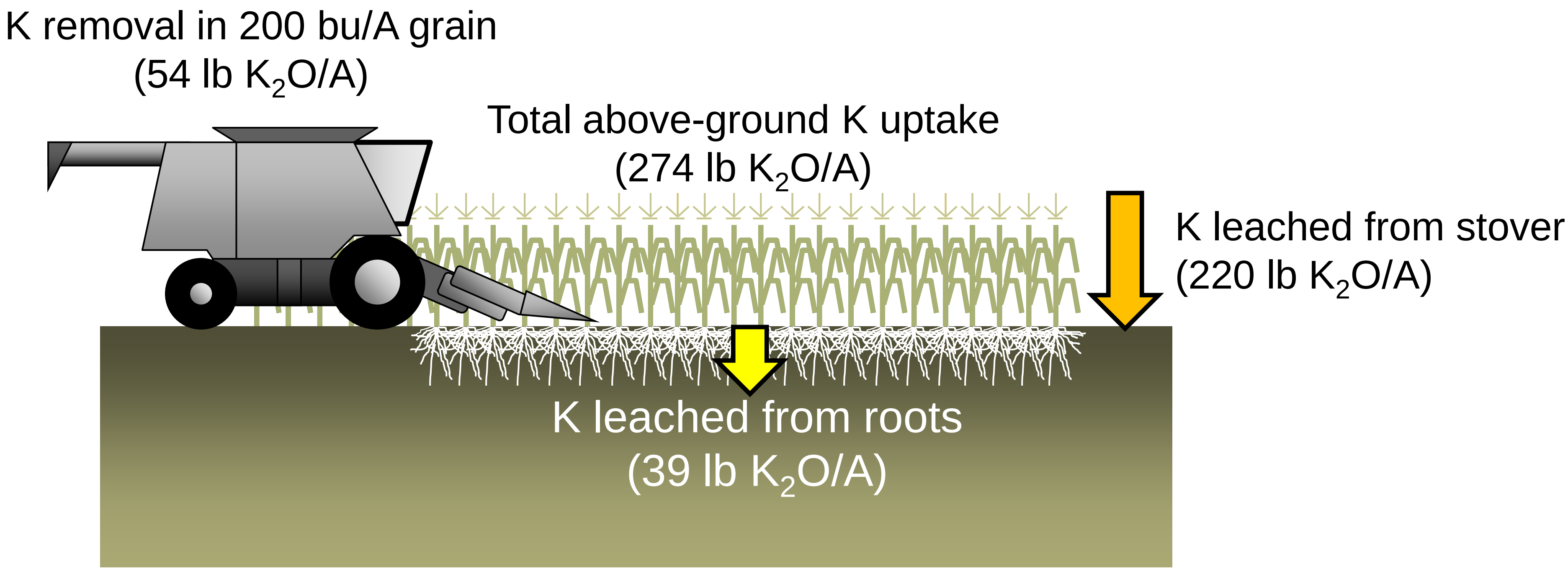
Nutrient uptake

Deposition and leaching

Diffusion



K uptake and leaching by a corn crop: Estimated quantities



Murrell and Vyn, 2010

The role of starter fertilizer under economic constraints

Theoretical principles

Combination for maximum profit:

Wheat response to N and P