Corn Early Nutrient Uptake and Yield as Affected by In-Furrow Fluid Potassium Starter

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Plant Roots and P - K Uptake

- Relatively immobile nutrients, main uptake mechanism is slow diffusion through soil water to roots from a short distance
- Actively growing large root system with fine roots is key for P and K uptake
- Limited P and K uptake with
  - cold, dry, compacted, or loose soil
  - diseases and pruning by insects

Physiological-Root Growth Effects

- Fertilizing a fraction of the root zone
  - Uptake compensation function
  - Higher uptake per unit root surface
  - Increased root growth/proliferation in the zone and also outside the zone
- Reduced effects at high rates
  - upper limits for uptake rate, salt damage effects, crop differences

Fertilizer-Soil-Plant Interactions

- Does reaction with soil really decrease P and K availability? If so:
  - Banding increases uptake beyond mass action flow, enhanced uptake by unit root surface, induced root proliferation
  - This can compensate for a reduced volume of fertilized soil and roots, laterally or vertically

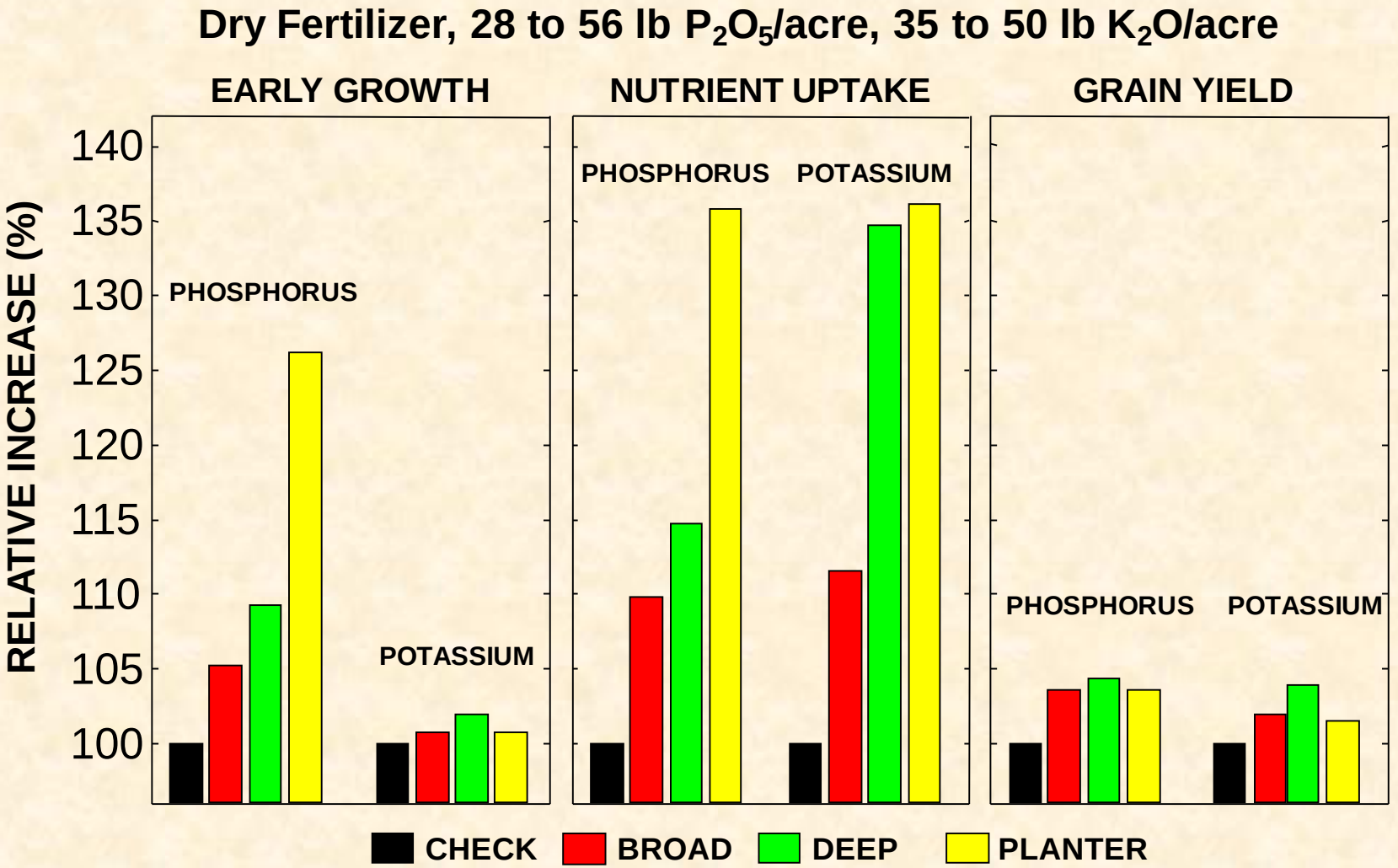
Residue Cover and Drought

- High residue cover
  - In spring colder and wetter soil may limit plant growth, P-K diffusion
  - In summer increased water infiltration and cover improves uptake efficiency
- Frequent dry surface soil
  - Shallow roots are impaired and subsurface placement can enhance P and K uptake

Iowa P-K Placement Research

- Corn and soybean, granulated or fluid fertilizers, side band, deep band, in-furrow, for different tillage systems
- No consistent crop response to band P
- Corn response to deep-band K with ridge-till, sometimes no-till or strip till
- Banding may be better at very low rates and/or soil-test values that limit yield and the efficacy of crop production

P & K Placement for No-Till Corn

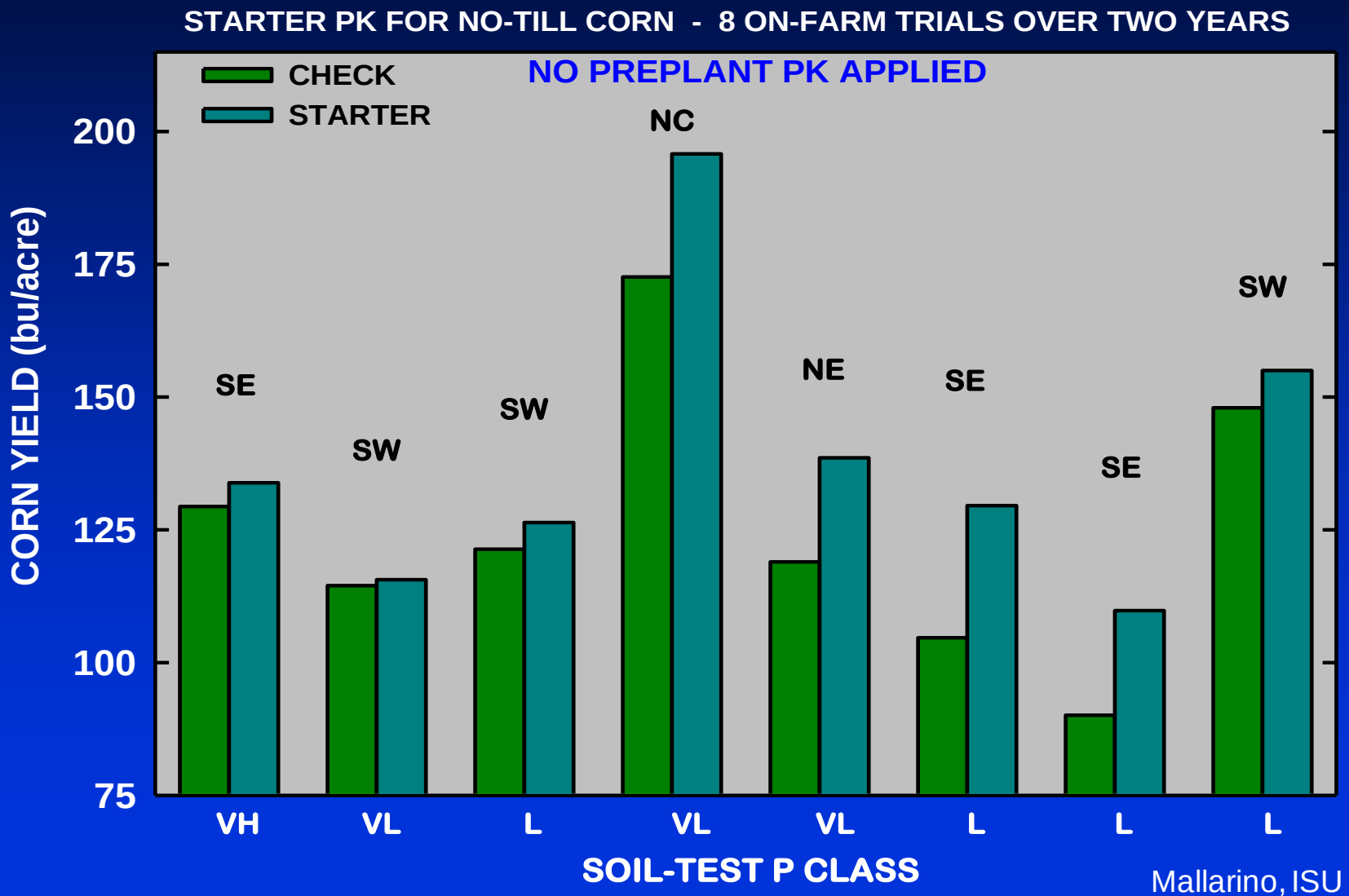


Mallarino, Bordoli, Borges, Barker (ISU)

Banding and Starter: Confusion

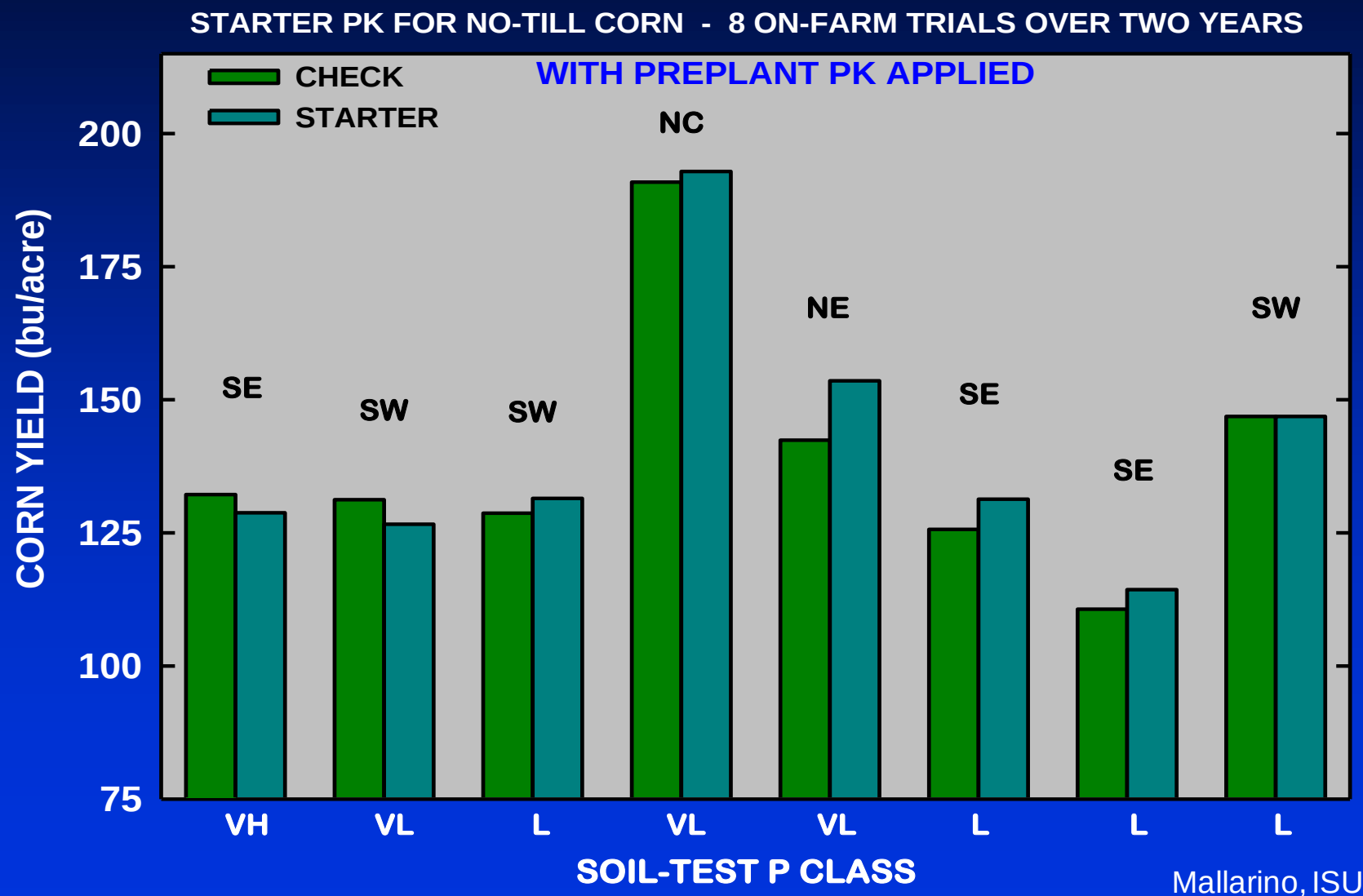
- **What does “starter” mean?**
  - ***A small amount of fertilizer in the root zone to supplement primary fertilizers when needed, necessarily a band***
- **Fertilizer can be banded with planter attachments or other tools. Can't apply too high rates with the seed due to salt effect and/or ammonia toxicity**
- **So banding in the furrow or in the root zone may have a starter effect**

Response to Starter P-K Alone



Mallarino, ISU

Response to Starter After Broadcast

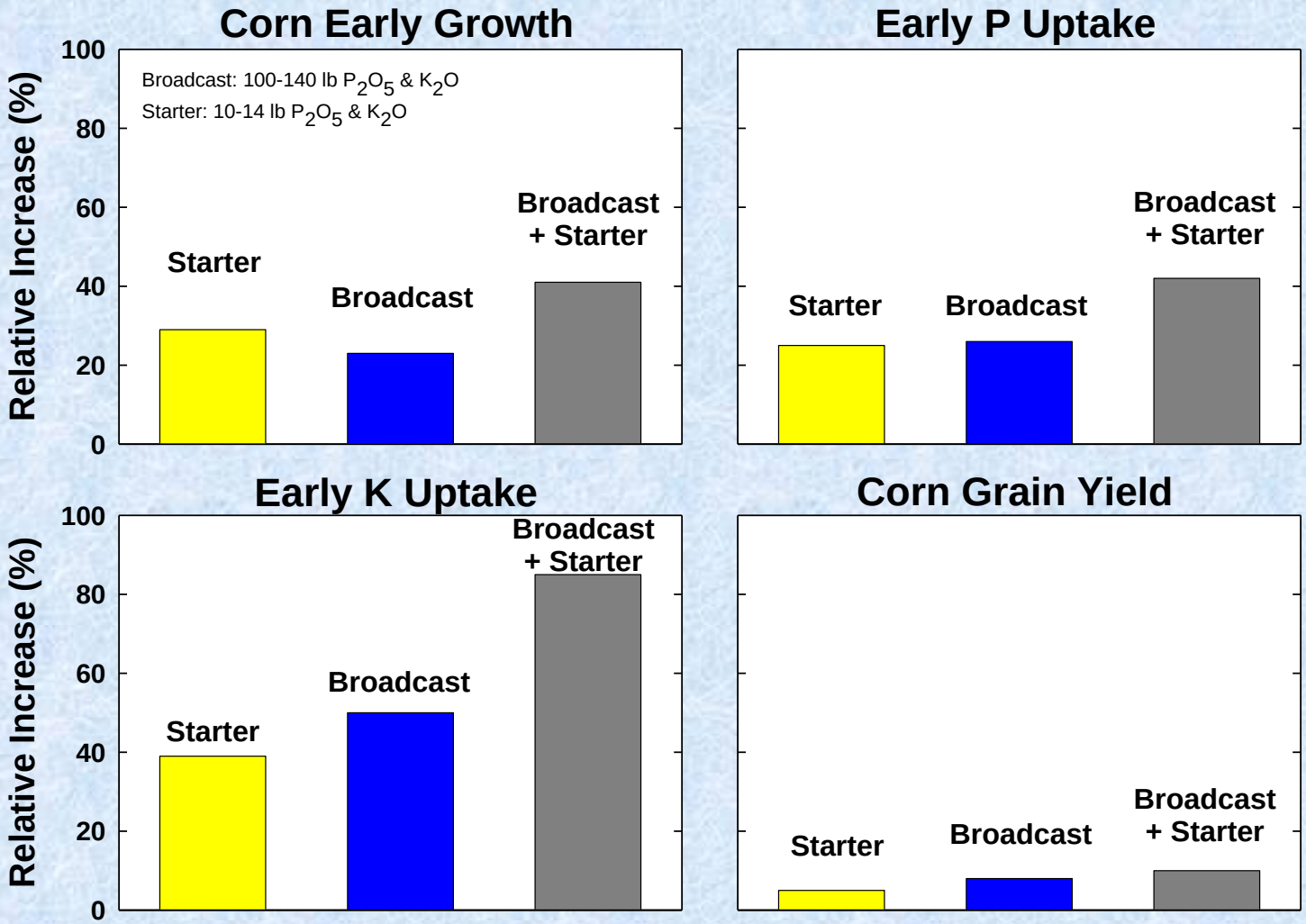


Mallarino, ISU

When is a True Starter Effect Likely?

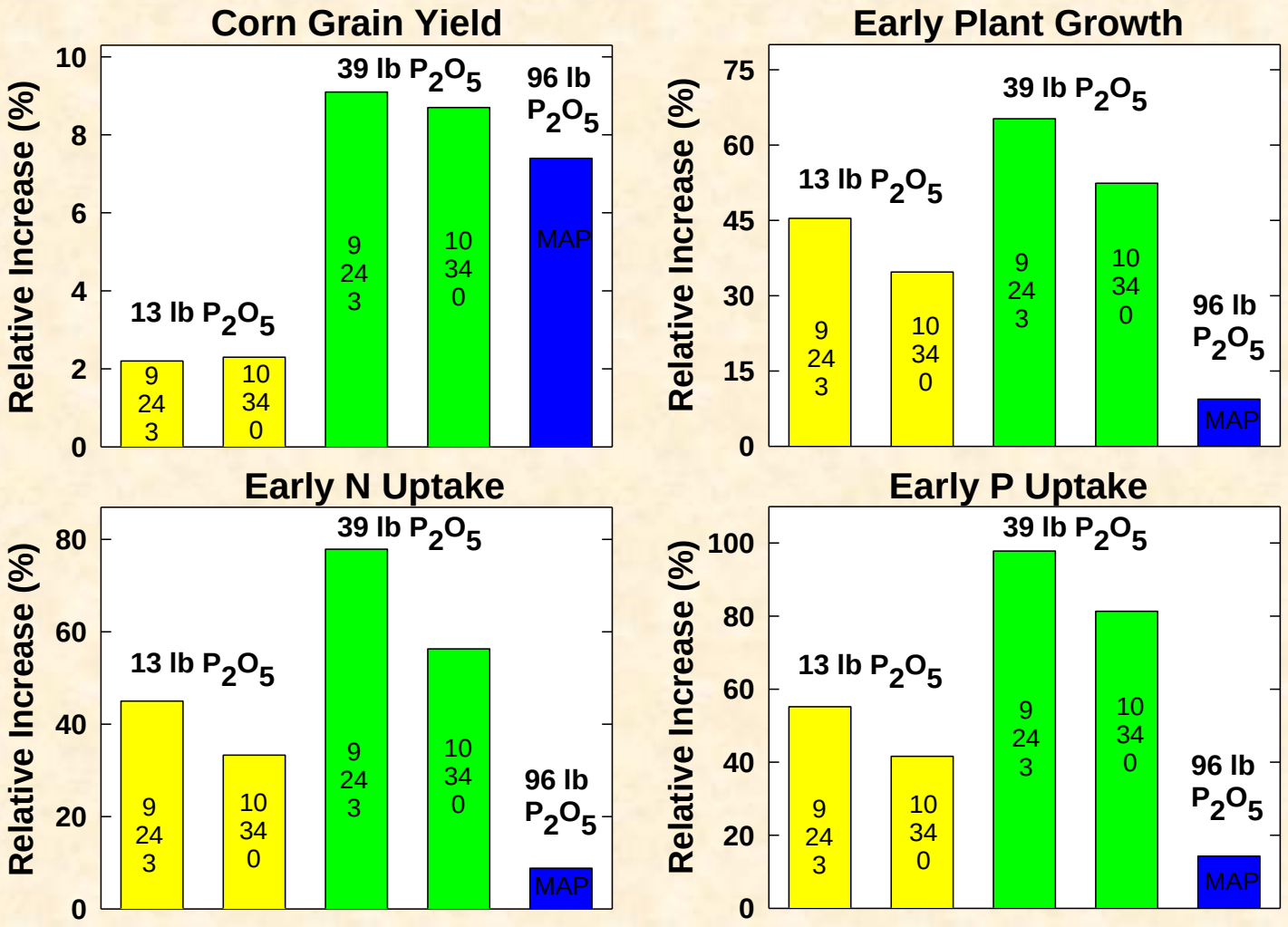
- When an early plant growth delay can't be offset during the season
- Applied nutrients aren't in the seedling root zone (in topsoil or too deep).
- Cold and wet soil or disease/pests limit early root growth and nutrient uptake
- Unlikely when broadcasting only once P and K needed by corn and soybean, the most common practice in Iowa

In-Furrow 3-18-18 Fluid Starter



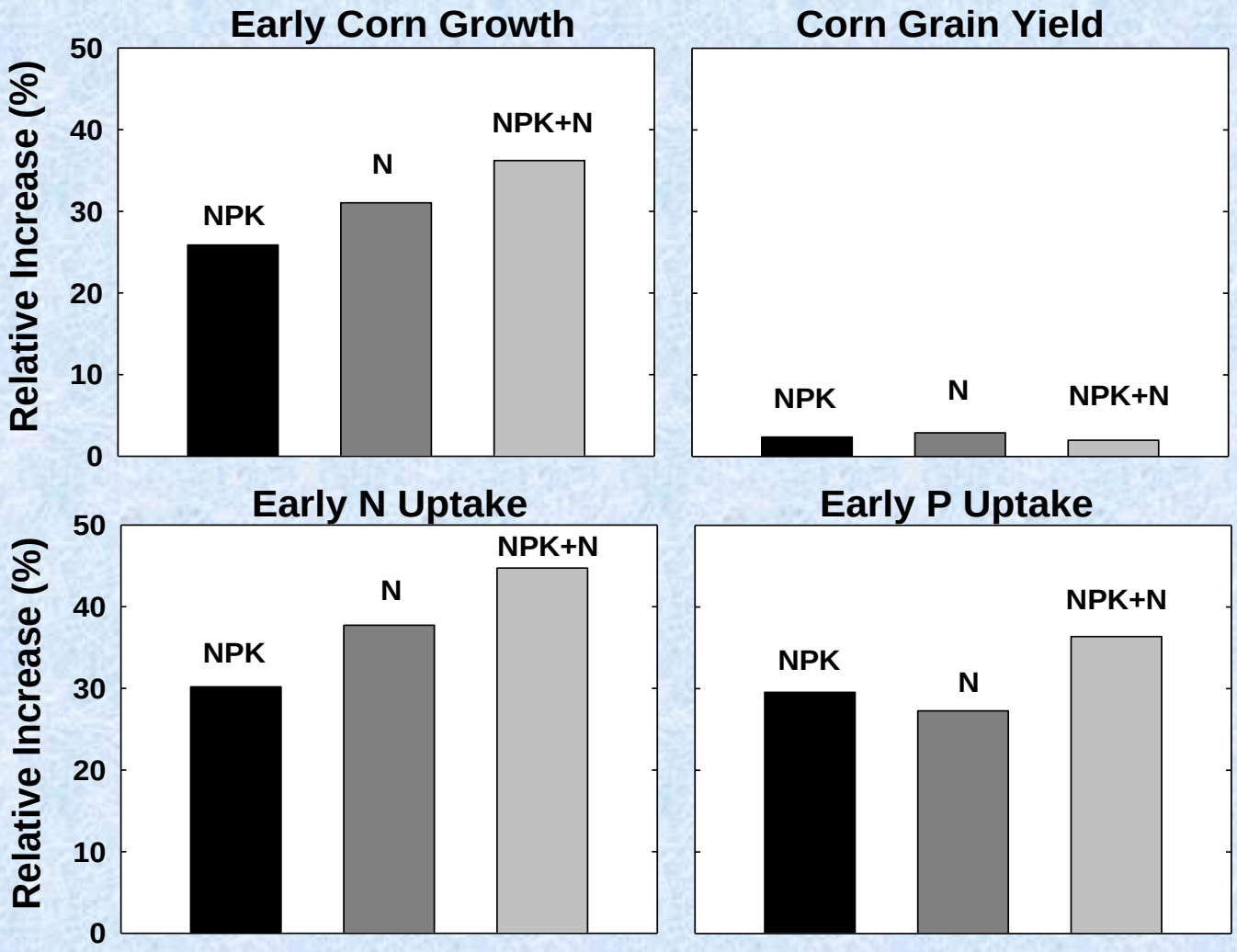
16 Iowa sites. Kaiser, Mallarino, and Bermudez, 2005

In-Furrow Starter N-P Sources



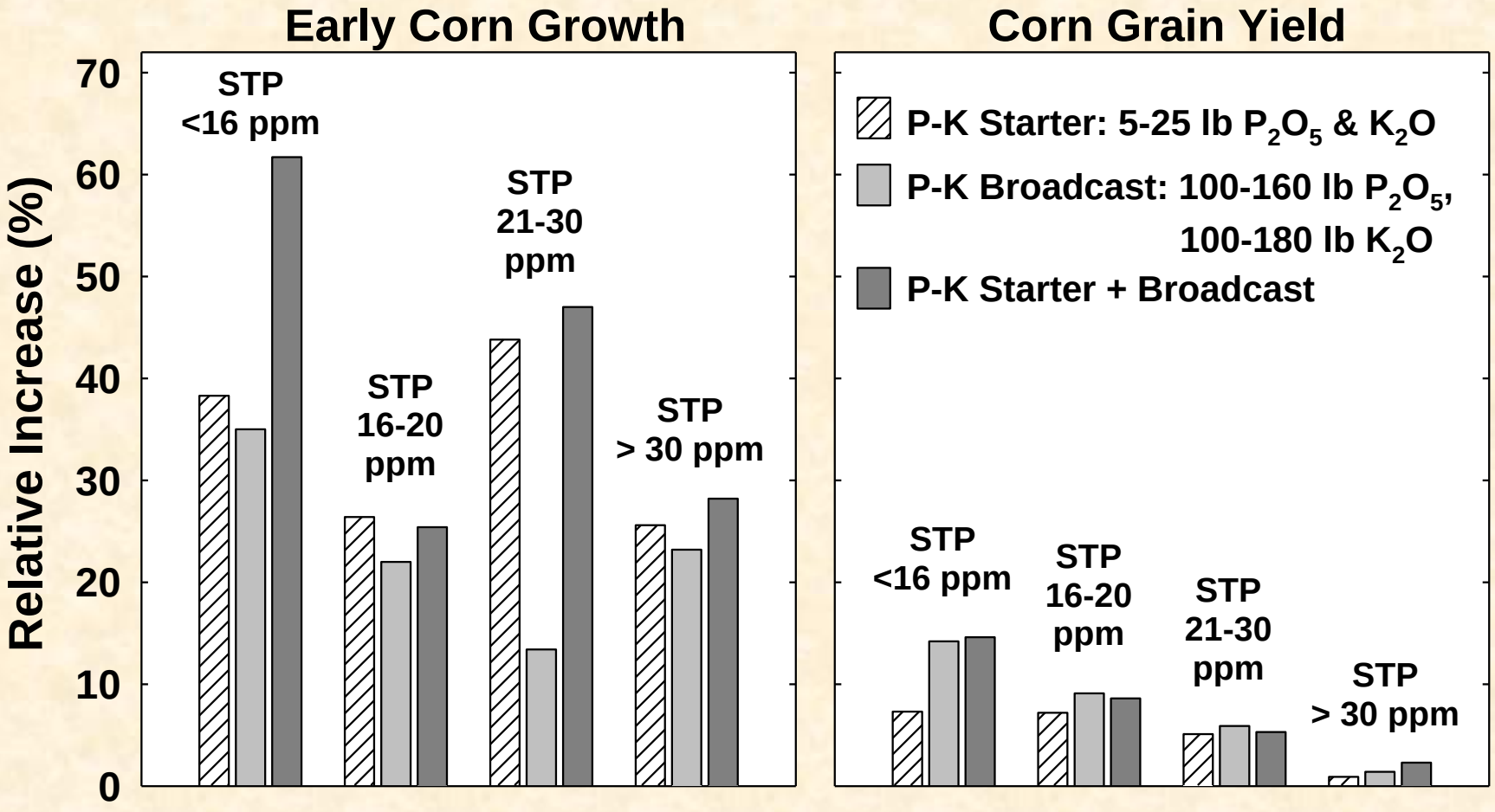
Six Northern Iowa sites. Kaiser, Mallarino, and Bermudez, 2005

Fluid (2x2) N-P-K or N Starter



Eight Iowa high-testing no-till sites. Mallarino and Bermudez, 2004

Starter P-K and Broadcast P



Mallarino, 2009

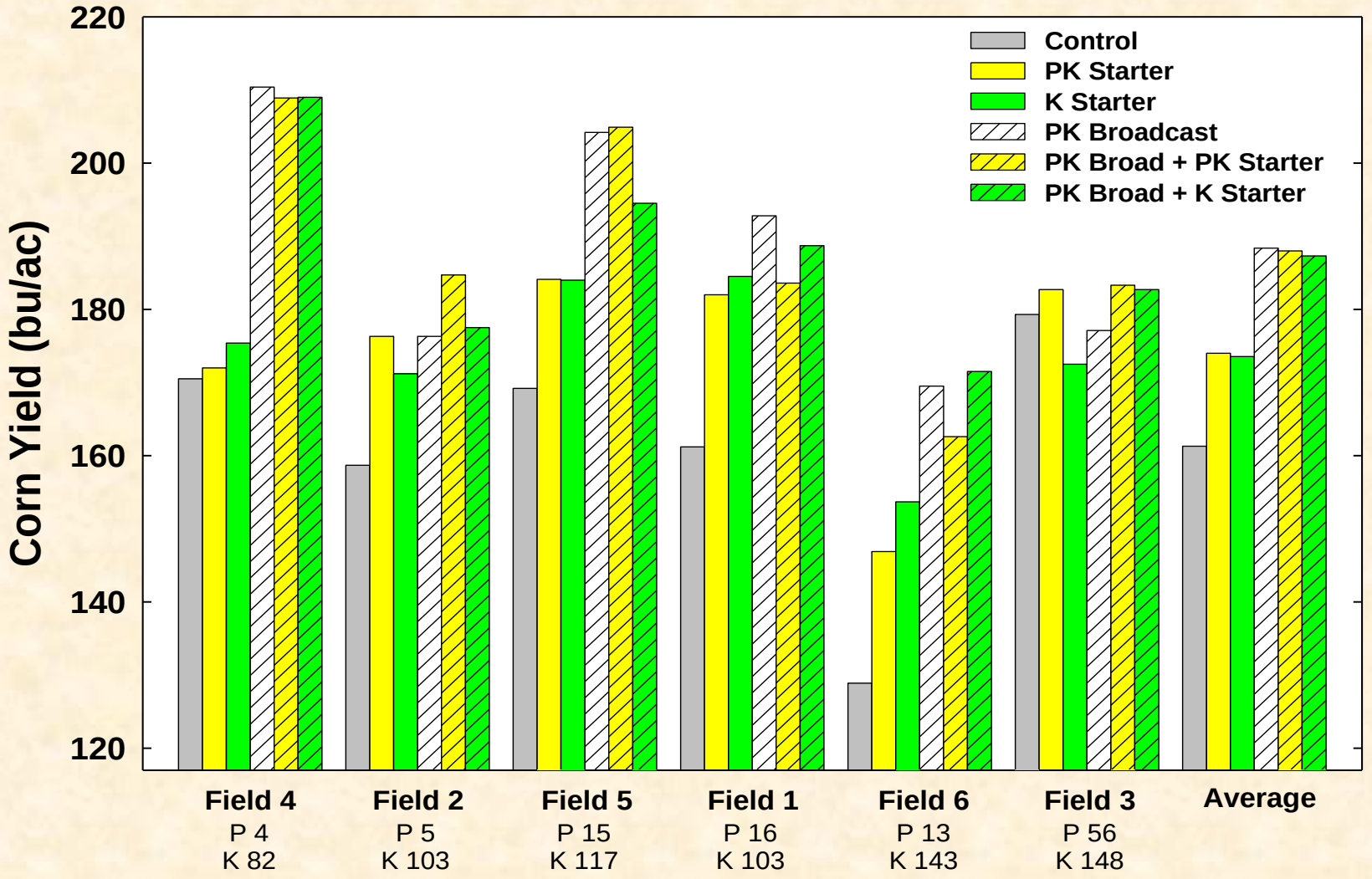
Response to Starter N, P, or K?

- Potentially higher early response to increased N and P in the root zone than for K
  - K diffuses a greater distance than P
  - Upper limit of early uptake rate/unit root surface for K than for P, but earlier root zone depletion
  - More root proliferation for P than K
  - Higher total plant uptake of K than P

In-Furrow Starter P-K and Starter K

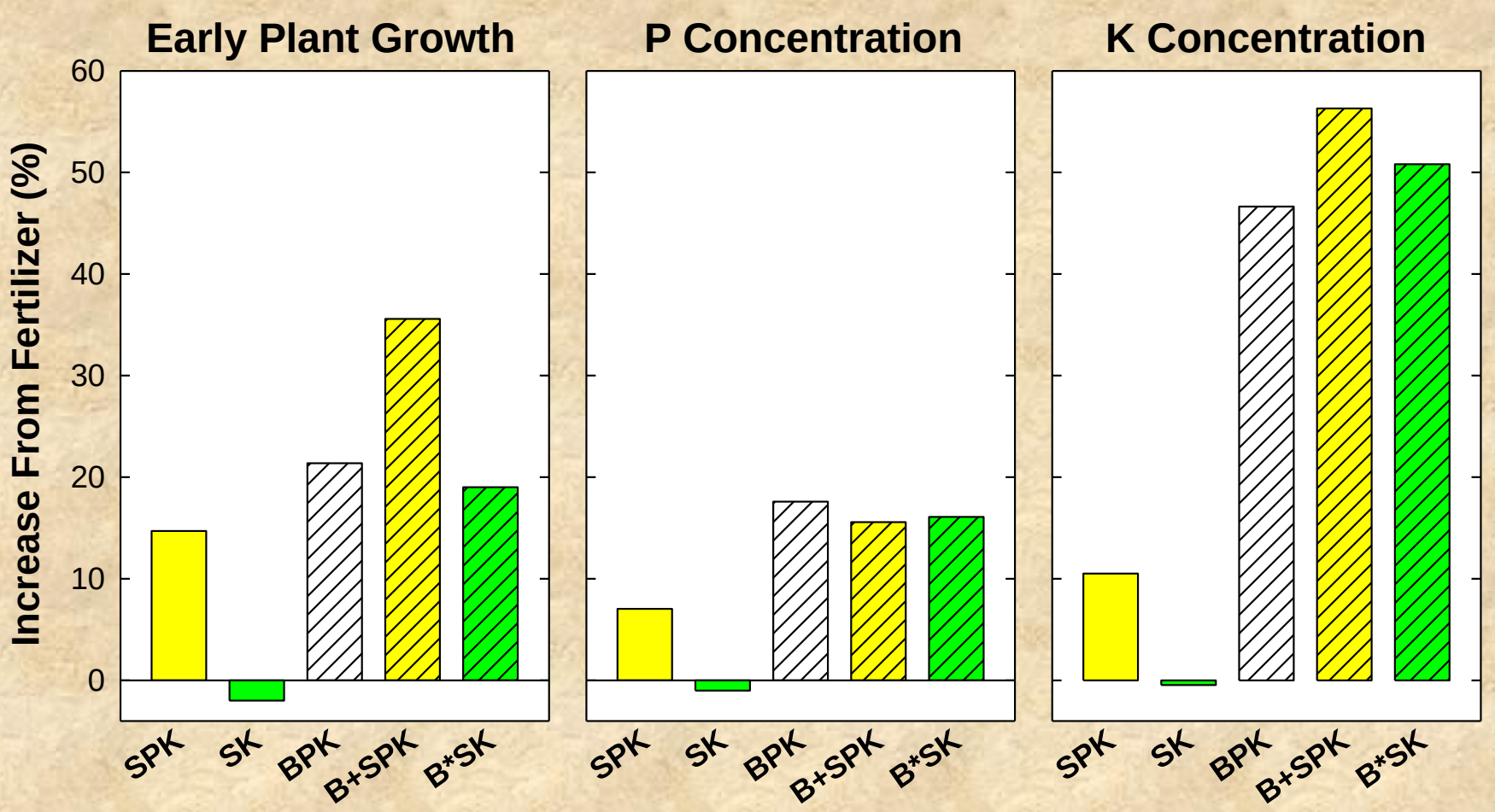
- Conventional small plots, six trials
- Six treatments, four replications
  - control, 3-18-18, 0-0-30, broad PK, broad + 3-18-18, and broad + 0-0-30
- NAS 3-18-18 and NAS 0-0-30 applied at 10-14 lb of P_2O_5 or K_2O/acre
- Broadcast PK: Current recs to apply before corn of corn-soybean rotations
- Uniform N preplant and sidedressed

Corn Grain Yields by Site



Mallarino and Kaiser, ISU

Comparative Response Across Sites



Mallarino and Kaiser, ISU

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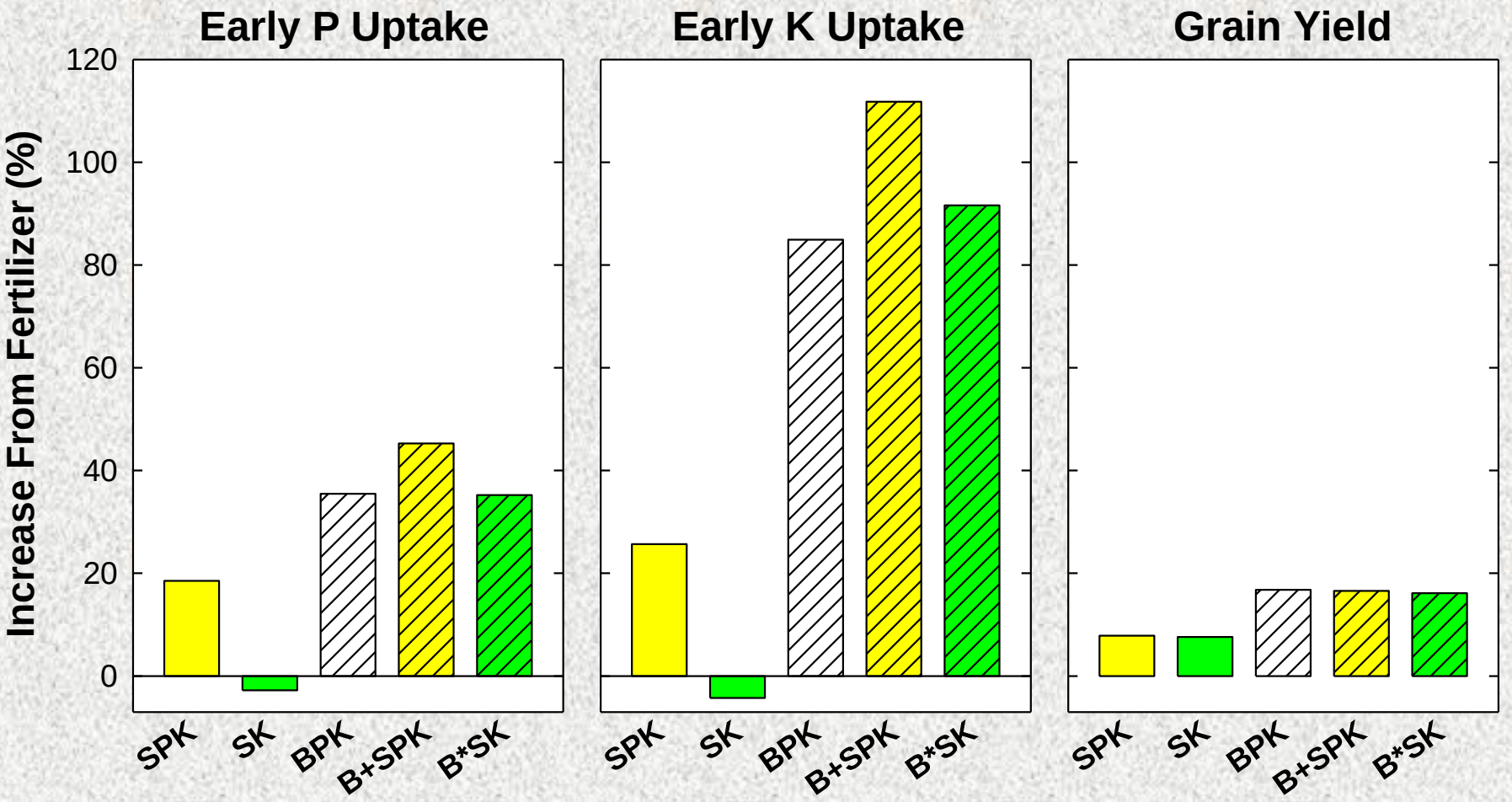
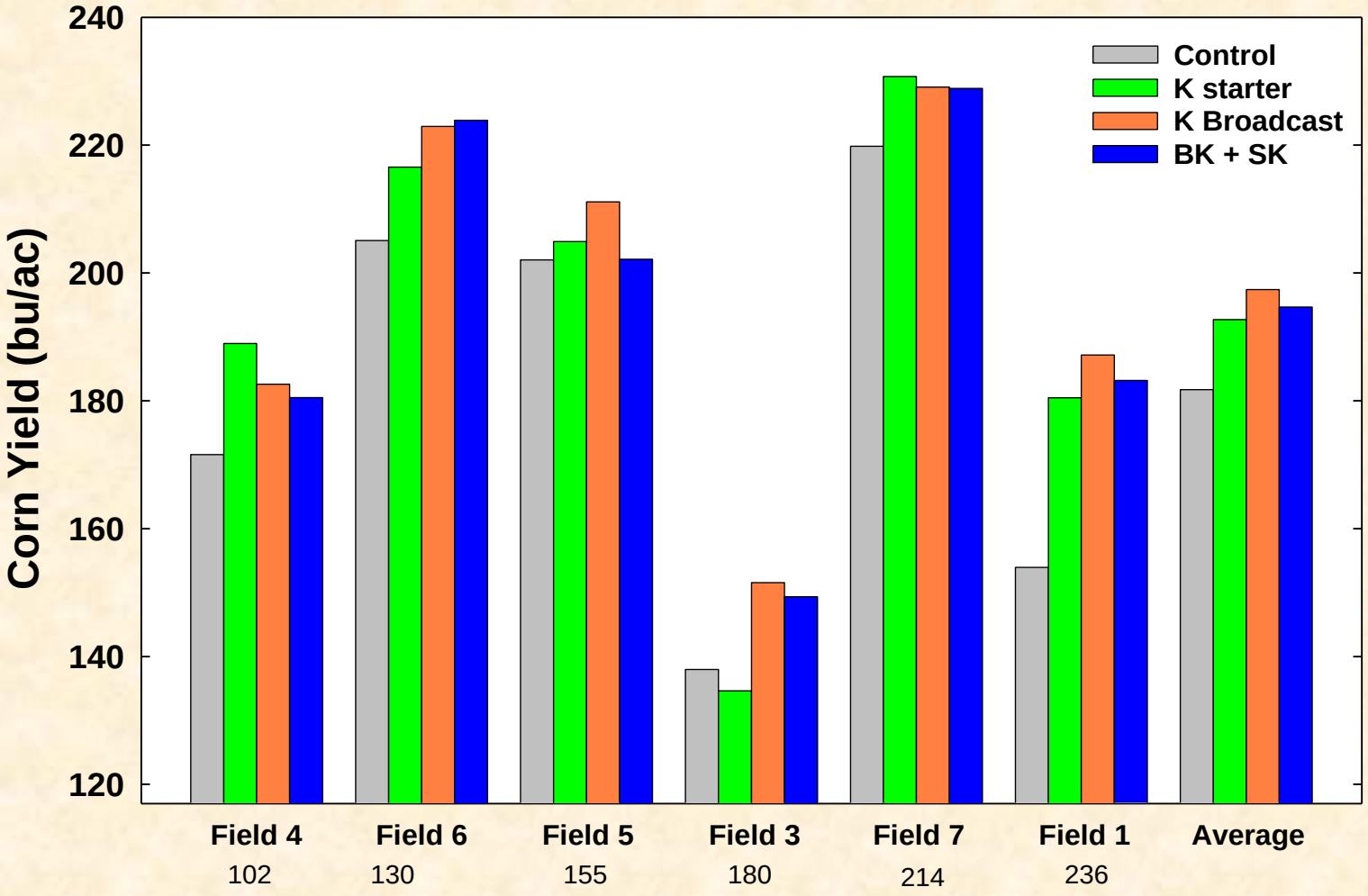


Mallarino and Kaiser, ISU

In-Furrow Starter K Alone

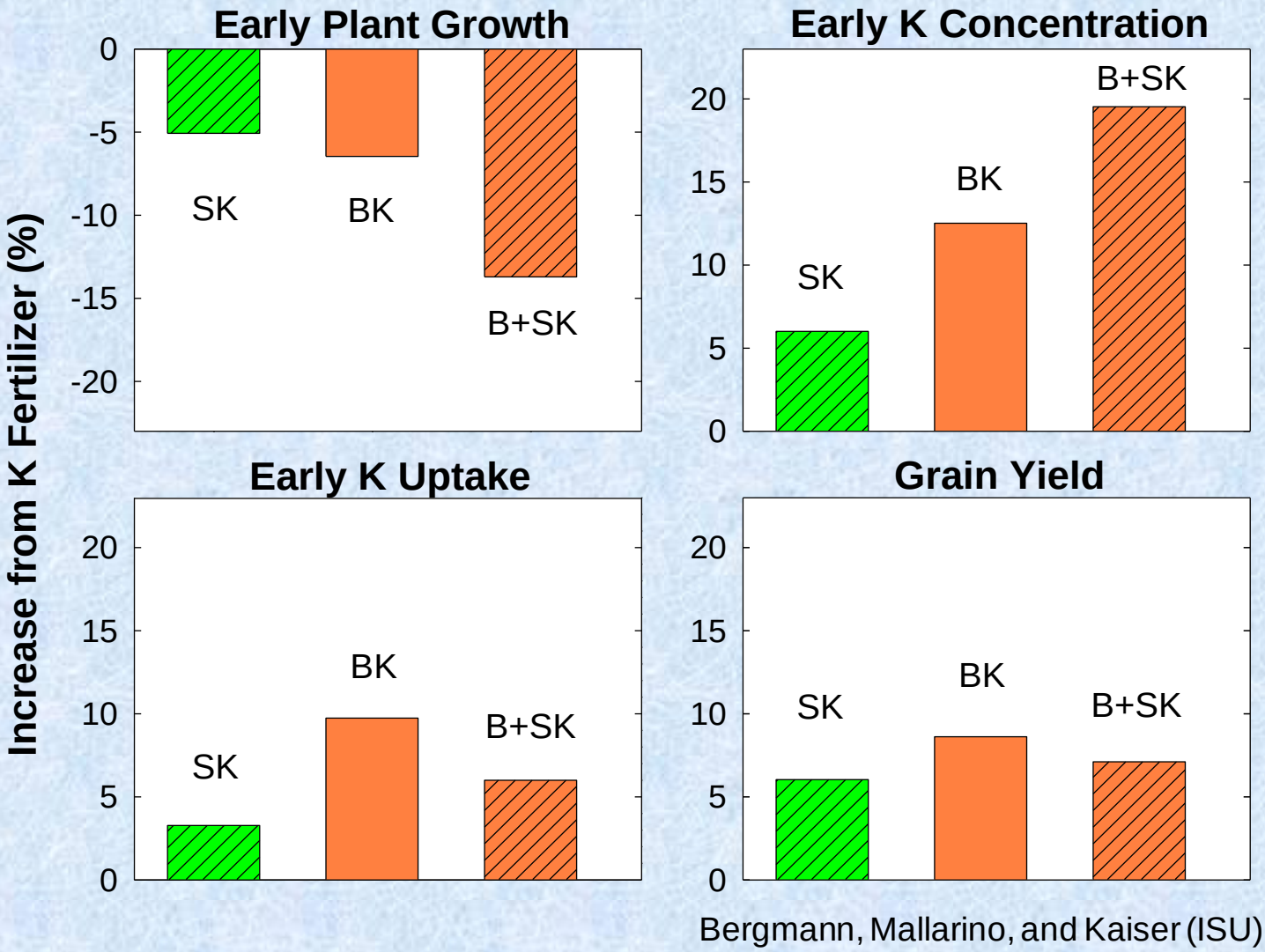
- Eight replicated strip trials, 2 years, managed with GPS, yield monitors, GIS
- Spit plot, 4 treatments, 3 replications:
  - No K, broadcast K at 120 lb K_2O/acre
  - Split into no starter or NAS 0-0-30 at 15-22 lb K_2O/acre
- Strip width 40 - 90 feet
- Strip length 960-2200 feet

Corn Grain Yield by Responsive Soil



Bergmann, Mallarino, and Kaiser (ISU)

Comparative Response Across Sites



Bergmann, Mallarino, and Kaiser (ISU)

Is There a True Starter K Effect?

- K has no true starter effect or is much smaller and much less frequent than for N and P
- Early corn growth response is a very poor index of soil K deficiency and yield response to K fertilization, "hidden hunger" very often
- This doesn't mean that small starter K rates may not be useful

Liquid Starter in High-Testing Soils

- The most clear comparative advantage of small starter rates over broadcast
- Small probability of crop response, but many farmers apply unneeded high removal-based rates
- Small starter rates are sufficient to catch any unlikely small corn response, and much better for water quality

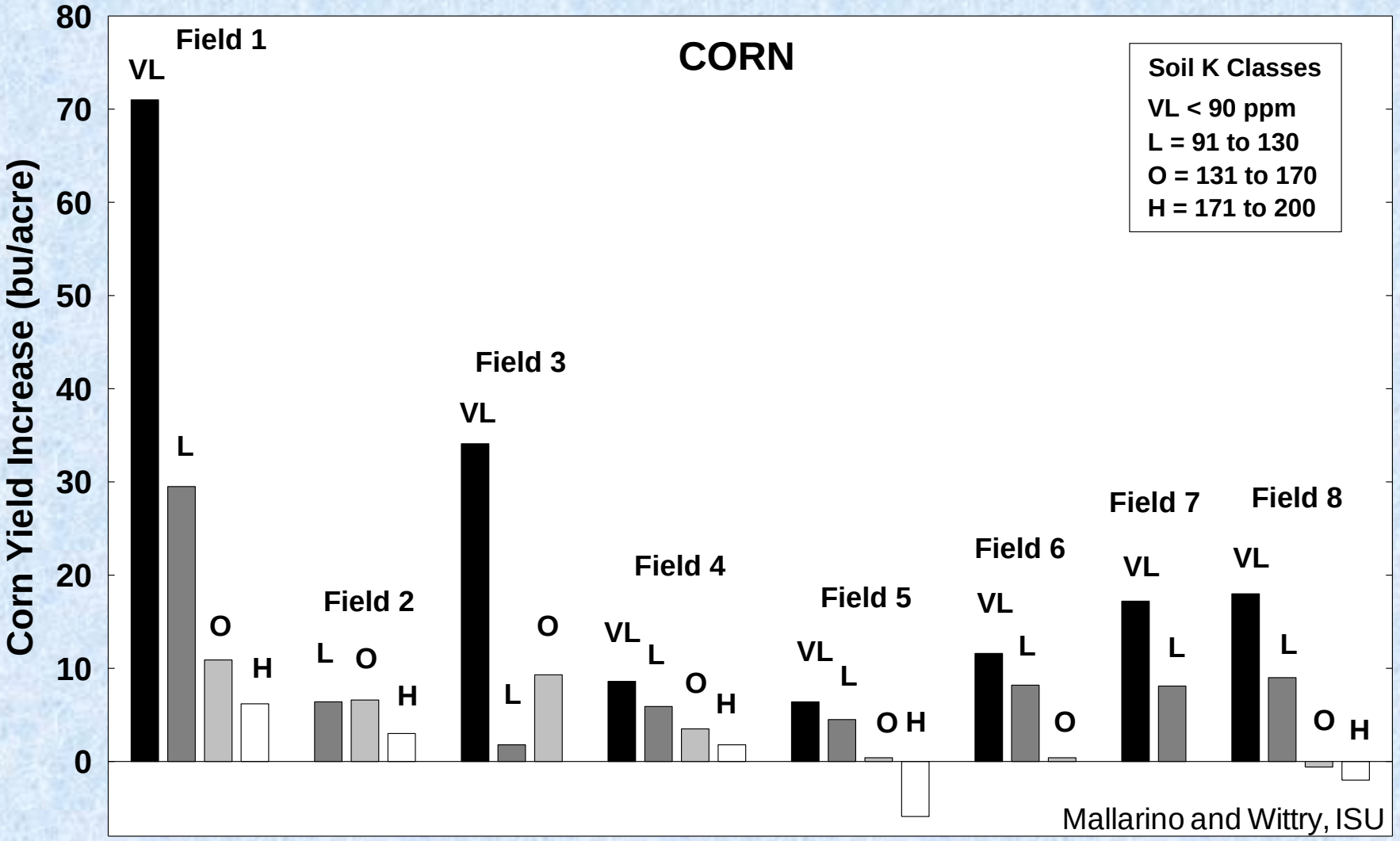
Liquid Starter with Optimum Test

- Low probability of small or moderate crop response, maintenance based on removal is recommended for long-term profitability and reduced risk
- Starter or low broadcast rates catch any response and is more profitable in the short term, but will not maintain soil test levels over time
- Flexibility, various options depending on prices, land tenure, and philosophy

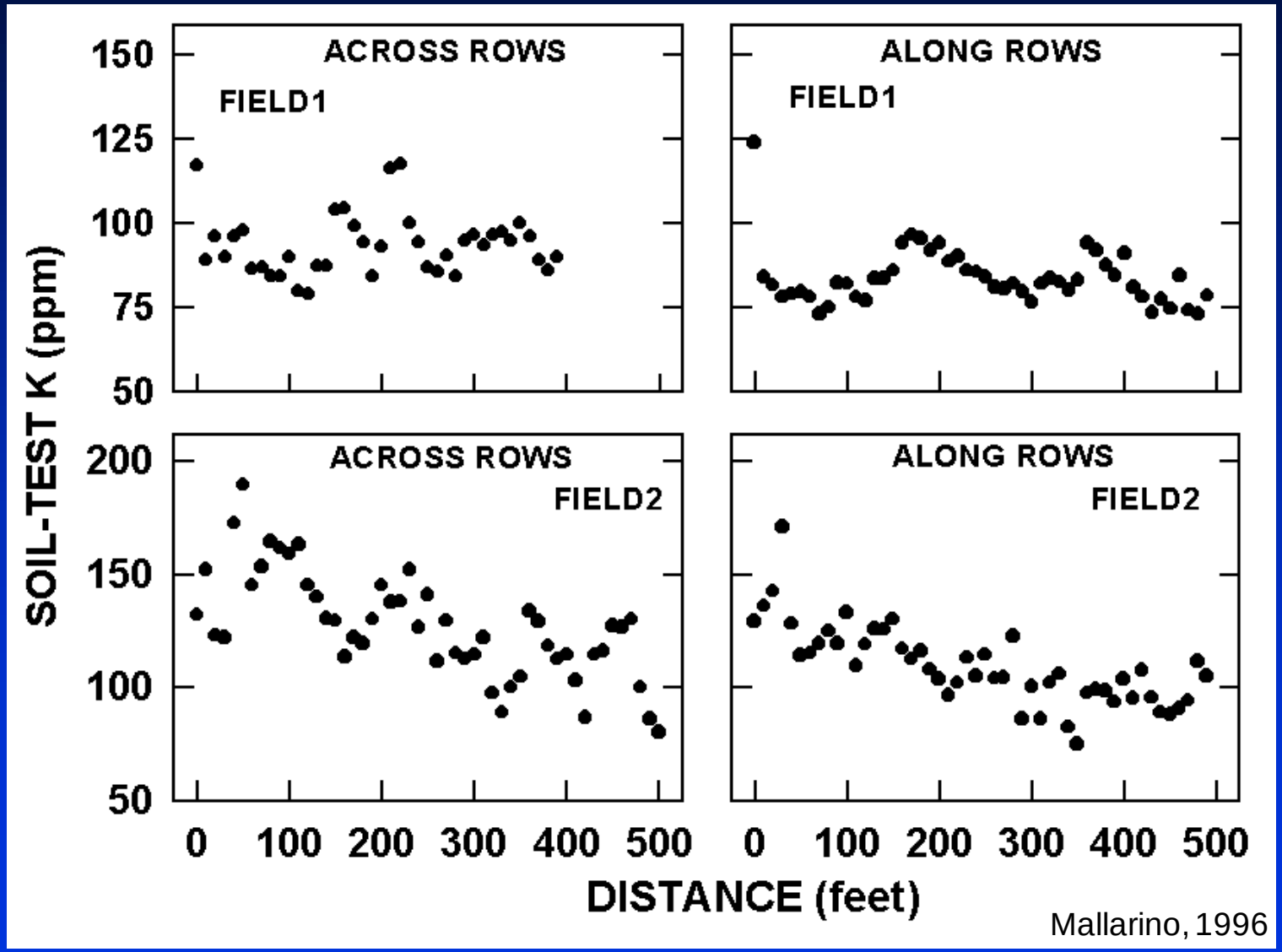
Liquid Starter in Low Testing Soils

- High probability of a large response, broadcast fertilization and buildup is a safe investment in most soils
- Starter rates usually don't apply enough P and K. Why risk limiting yield?
- Very unlikely response to starter when 2-year rates are applied before corn
- May be a response to starter in some conditions when "one crop rate" or lower broadcast rates are applied

Within-Field Response Variation



High Small-Scale Soil-Test Variation



Mallarino, 1996

Another Possible Role for Starter

- Much of the very small-scale variation in many fields may not be fixed or managed with large bulk dry fertilizer applicators
- A small amount of liquid starter applied across an entire field may be an effective low-cost insurance to avoid yield loss in small but perhaps frequent field areas

Acknowledgements

- Early research (2000 - 2005)
  - Nachurs/Alpine Solutions
  - Agroculture Fertilizers
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- Recent research (2006 - 2009):
  - Fluid Fertilizer Foundation
  - Na-churs/Alpine Solutions
  - International Plant Nutrition Institute