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

Antonio P. Mallarino
Iowa State University

Fluid Fertilizer Foundation Forum
February 14-16, 2010
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
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)

Dry Fertilizer, 28 to 56 lb P₂O₅/acre, 35 to 50 lb K₂O/acre

EARLY GROWTH

PHOSPHORUS

POTASSIUM

NUTRIENT UPTAKE

PHOSPHORUS

POTASSIUM

GRAIN YIELD

PHOSPHORUS

POTASSIUM
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

STARTER PK FOR NO-TILL CORN - 8 ON-FARM TRIALS OVER TWO YEARS

CORN YIELD (bu/acre)

NO PREPLANT PK APPLIED

SOIL-TEST P CLASS

Mallarino, ISU
Response to Starter After Broadcast

STARTER PK FOR NO-TILL CORN - 8 ON-FARM TRIALS OVER TWO YEARS

CHECK STARTER WITH PREPLANT PK APPLIED

SE NE SW NC SW SE SE SW VH VL VL VL L L L

SOIL-TEST P CLASS

CORN YIELD (bu/acre)

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

Corn Grain Yield

- 13 lb P$_2$O$_5$
- 39 lb P$_2$O$_5$
- 96 lb P$_2$O$_5$

Early Plant Growth

- 13 lb P$_2$O$_5$
- 39 lb P$_2$O$_5$
- 96 lb P$_2$O$_5$

Early N Uptake

- 13 lb P$_2$O$_5$
- 39 lb P$_2$O$_5$

Early P Uptake

- 13 lb P$_2$O$_5$
- 39 lb P$_2$O$_5$
- 96 lb P$_2$O$_5$
Eight Iowa high-testing no-till sites. Mallarino and Bermudez, 2004
Starter P-K and Broadcast P

Early Corn Growth

Starter P-K: 5-25 lb P2O5 & K2O
Broadcast: 100-160 lb P2O5, 100-180 lb K2O

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$_2$O$_5$ or K$_2$O/acre
- Broadcast PK: Current recs to apply before corn of corn-soybean rotations
- Uniform N preplant and sidedressed
Comparative Response Across Sites

Early Plant Growth

- SPK
- SK
- BPK
- B+SPK
- B+SK

Increase From Fertilizer (%)

0
10
20
30
40
50
60

P Concentration

- SPK
- SK
- BPK
- B+SPK
- B+SK

K Concentration

- SPK
- SK
- BPK
- B+SPK
- B+SK

Mallarino and Kaiser, ISU
Comparative Response Across Sites

Early P Uptake

Early K Uptake

Grain Yield

Increase From Fertilizer (%)

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$_2$O/acre
  - Split into no starter or NAS 0-0-30 at 15-22 lb K$_2$O/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

- **Early Plant Growth**
  - SK: -20%
  - BK: -10%
  - B+SK: 0%

- **Early K Concentration**
  - SK: 0%
  - BK: 10%
  - B+SK: 20%

- **Early K Uptake**
  - SK: 0%
  - BK: 5%
  - B+SK: 10%

- **Grain Yield**
  - SK: 0%
  - BK: 5%
  - B+SK: 10%

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

Corn Yield Increase (bu/acre)

Field 1
Field 2
Field 3
Field 4
Field 5
Field 6
Field 7
Field 8

Soil K Classes
VL < 90 ppm
L = 91 to 130
O = 131 to 170
H = 171 to 200

Mallarino and Wittry, ISU
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
  - Leopold Center for Sustainable Agriculture

● Recent research (2006 - 2009):
  - Fluid Fertilizer Foundation
  - Na-churs/Alpine Solutions
  - International Plant Nutrition Institute