
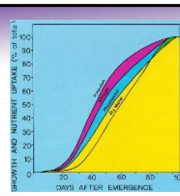

Grain Sorghum Fertility Management

Lucas Haag Ph.D., Asst. Professor/Northwest Area Agronomist
K-State Northwest Research-Extension Center, Colby

With Cooperation Of:

Dorivar Ruiz Diaz, Associate Professor, Soil Fertility Management
K-State Department of Agronomy, Manhattan

Augustine Obour, Ph.D., Asst. Professor, Soil Science
K-State Agricultural Research Center, Hays

Alan Schlegel, Professor and Agronomist-in-Charge
K-State Southwest Research-Extension Center, Tribune

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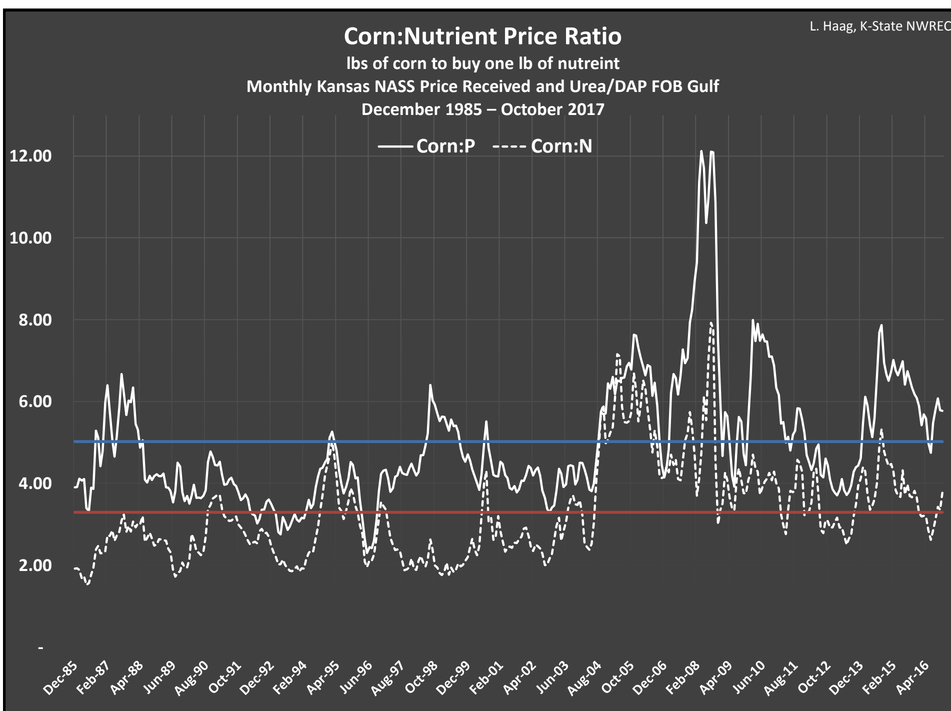
Knowledge for Life



Soil Fertility Essentials

In Nutrient Management, the Primary Objectives of Soil Testing are:

- Determine the fertility and pH status of an area, field or farm, with the goal of removing fertility as a yield limitation
- Predict where fertilizer responses <u>will</u> or <u>will not occur</u>
  - Increase the return on our fertilizer investment
  - Increase the efficiency of fertilizer use
  - Reduce the potential for environmental injury

Consider the accuracy and reliability of individual soil tests

- What constitutes a good soil test
  - Good relationship between soil test level and yield
  - Accurately predicts nutrient needs
  - Simple
  - Inexpensive
  - Precise
  - Reproducible

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Useful soil tests in Kansas

- Profile Nitrate-N
- Bray P-1 Extractable P
- Olsen Extractable P
- Mehlich III Exractable P
- Exchangeable K
- DTPA Extractable Zn
- Chloride
- Sulfur/Sulfate
- Soil pH
- Lime Requirement / Buffer pH
- Soil Organic Matter

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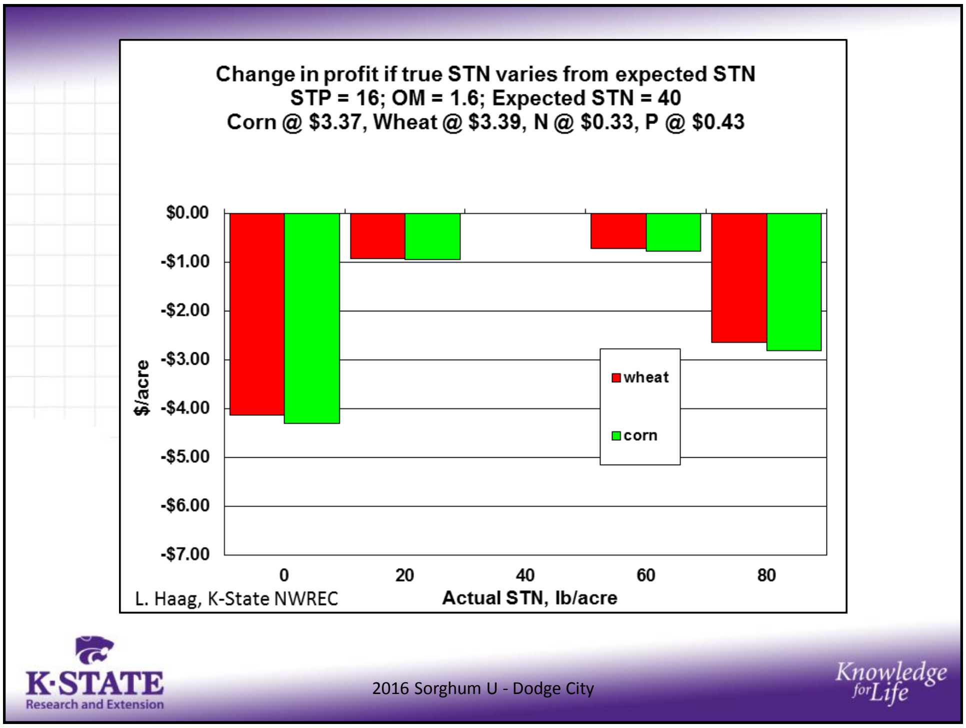
Phosphorus Soil Test Methods

- Bray P1 roughly equivalent to Mehlich III, use for soil pH < 7.0
- Bray P2 – NOT USEFUL!, Developed for rock phosphate applications in Indiana
- Olsen Bicarbonite – Developed at CSU for high pH soils especially > 7.0
- Mehlich III, equivalent to Bray P1, but valid over a wider range of soil pH

Economics of Soil Testing

Does it pay?


Change in profit if true STN varies from expected STN
STP = 16; OM = 1.6; Expected STN = 40
Corn @ $3.37, Wheat @ $3.39, N @ $0.33, P @ $0.43
$0.00
-$1.00
-$2.00
-$3.00
-$4.00
-$5.00
-$6.00
-$7.00
$/acre
wheat
corn
0
20
40
60
80
Actual STN, lb/acre
L. Haag, K-State NWREC
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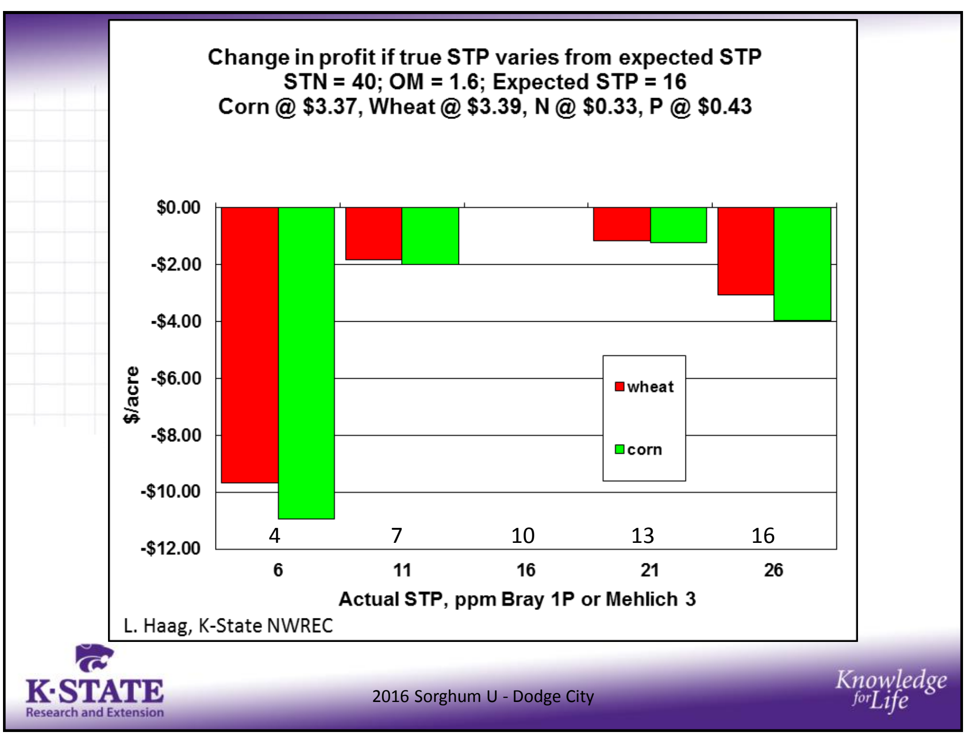
Change in profit if true STP varies from expected STP
STN = 40; OM = 1.6; Expected STP = 16
Corn @ $3.37, Wheat @ $3.39, N @ $0.33, P @ $0.43
$0.00
-$2.00
-$4.00
-$6.00
-$8.00
-$10.00
-$12.00
$/acre
wheat
corn
4
7
10
13
16
6
11
16
21
26
Actual STP, ppm Bray 1P or Mehlich 3
L. Haag, K-State NWREC
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Data Quality

- The proceeding economics are based on having good data, as good of a representation of "truth" as we can reasonably obtain.
- Good decisions require good data
- Good soil test data comes from good procedures in the field

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Number of Cores to Make a Good Sample

- Soils vary across very short distances in nutrient supply due to many factors including:
  - Position on the landscape
  - Past erosion
  - Parent material of the soil
- We also induce variability on the soil
  - Band applications
  - Livestock grazing
- To account for this variation you should take 10-20 cores per sample

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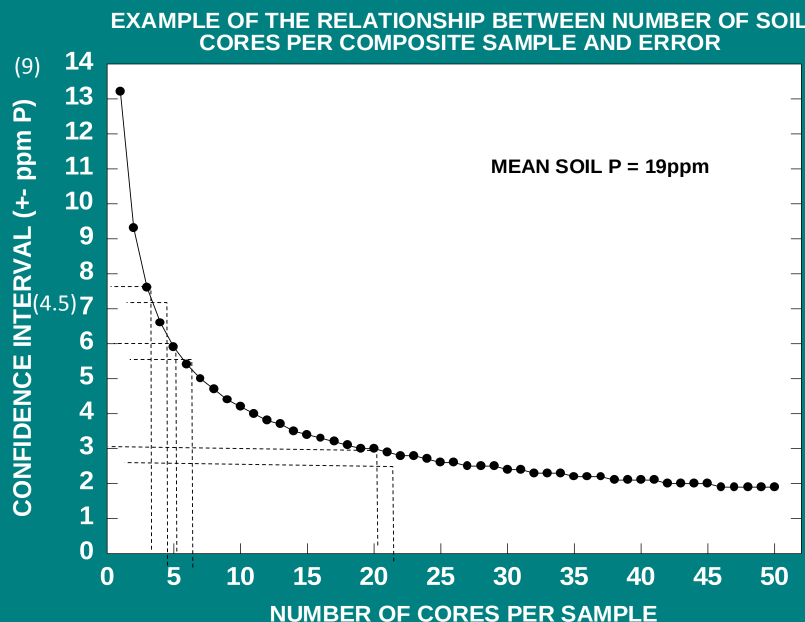

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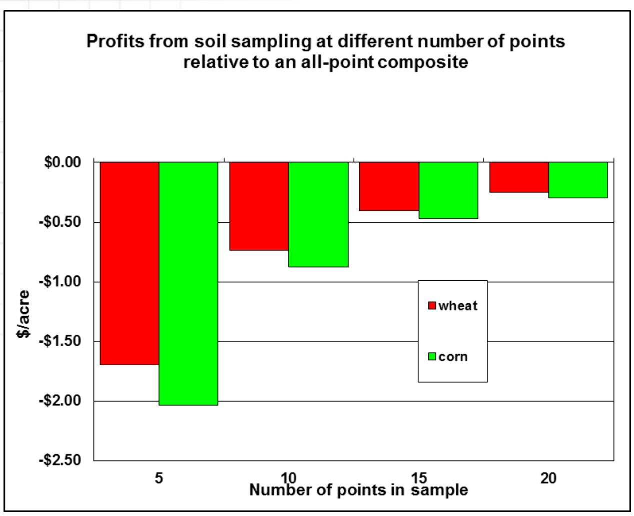
Economics of Accuracy



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Sampling Depths for Mobile Nutrients

- While P and K are relatively immobile in soils and accumulate in the surface few inches, Nitrate-N, Sulfur (S) and Chloride (Cl) are mobile and move through the soil profile.
- We recommend a 24" Profile Soil Sample to test for mobile nutrients such as nitrate-N in the soil. 10-15 cores are still needed to give a high quality sample

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When to Take Soil Samples

- P, K, Zn and pH always the same time.
- Focus on times when soil conditions are good, long enough before planting to really use the information.
- Be consistent.
- Late fall, winter and early spring-November through March are good.

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When to Take Soil Samples

- For N, S and Cl
- Summer crops: after harvest in the fall, but before the soil warms in the spring.
- Fall crops: before planting in the fall.
  - Spring or winter samples to predict topdress N needs don't work real well.

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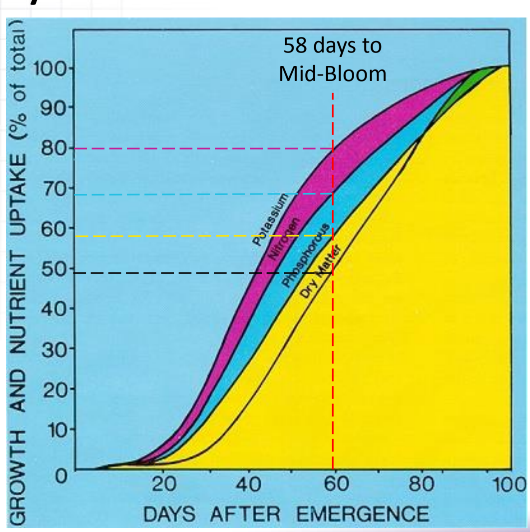
Grain Sorghum N, P, K, and dry matter accumulation



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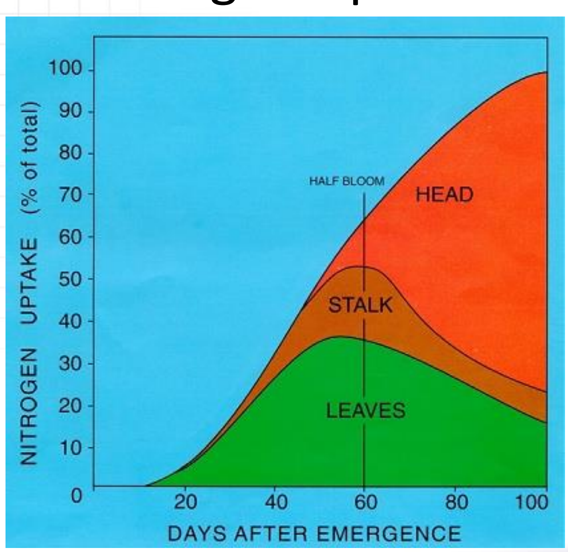
Nitrogen Management

Nitrogen Uptake



K-State Grain Sorghum Nrec

- Nrec = YG * 1.6 – (% OM x 20) – Profile - Other

Fertilizer N Required At Various Yield and Soil Organic Matter Levels Assuming Profile N Test Is Not Used (includes 30 Lb N/A residual default) [1]

Yield Goal (Bu/A)	Soil Organic Matter Content (%) 1.0	1.5	2.0	2.5	3.0	3.5	4.0
	- - - - - - - Lb N/A - - - - - - - -						
40	14	4	0	0	0	0	0
80	78	68	58	48	38	28	18
120	142	132	122	112	102	92	82
160	206	196	186	176	166	156	146
200	270	260	250	240	230	220	210

N Rec[2] = (Yield Goal × 1.6) – (% SOM × 20) – Profile N – Manure N – Other N Adjustments + Previous Crop Adjustments

[1] *Total N requirements presented include only Yield Goal and Soil Organic Matter Adjustments assuming profile N test not used. N rate should also be adjusted for Previous Crop, Manure and Other Appropriate N Rate Adjustments (see N rate adjustments for warm-season crops).*

[2] *A minimum fertilizer N application of 30 lb N/A may be appropriate for early crop growth and development.*

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Consider your crop rotation, use of cover crops, etc.

Source	% Carbon	% Nitrogen	C:N Ratio
Alfalfa	40	3.0	13:1
Soybean Residue	--	--	15:1
Cornstalks	40	0.7	60:1
Small grain straw	40	0.5	80:1
Microorganisms	50	6.2	8:1
Soil O.M.	52	5.0	10:1
Grain Sorghum	40	0.5	80:1
Manure	--	--	<20:1
Wood Chips	40	0.1	200:1

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Corn and Sorghum Trials Established 1961

Fully Irrigated

N rates:
0, 40, 80, 120, 160, and 200 lb/a

P_2O_5 rates:
0 and 40 lb/a
80 lb/a on corn since 1992

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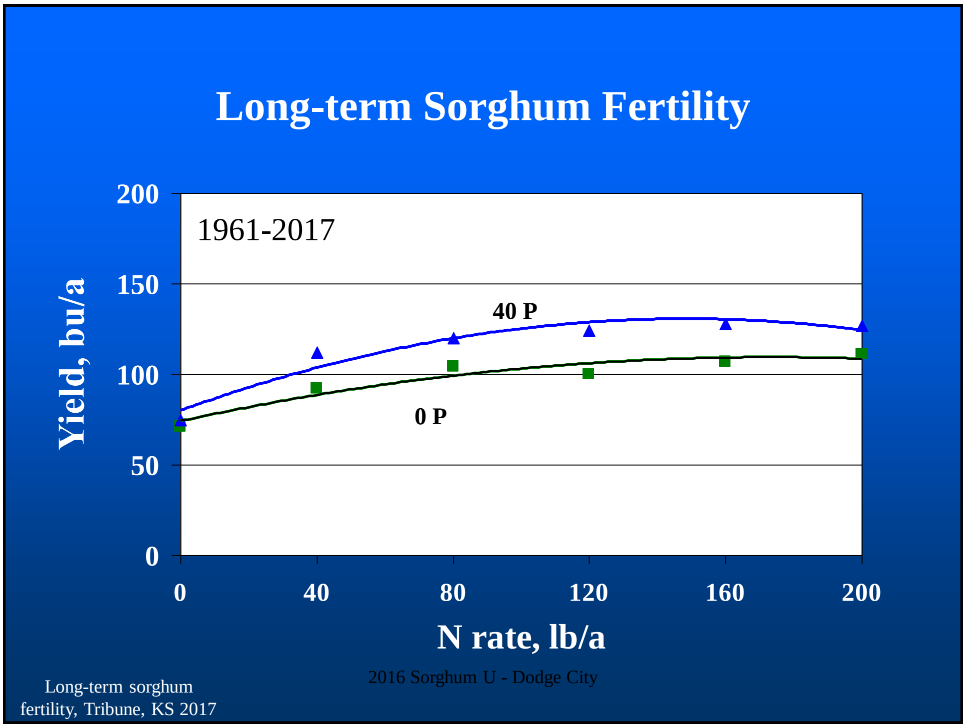
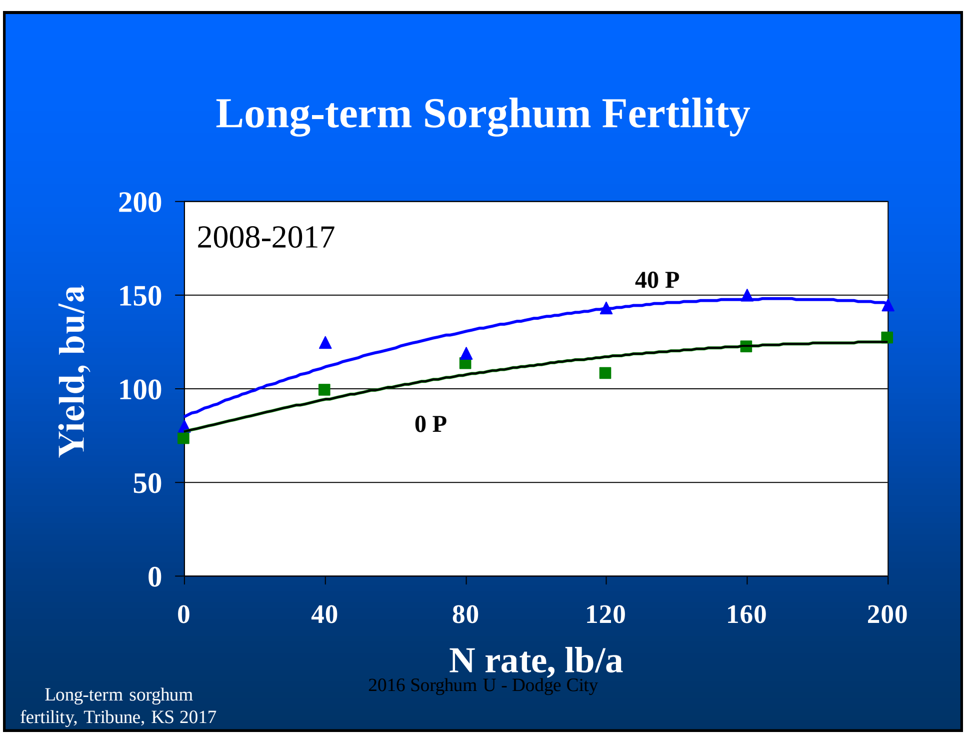
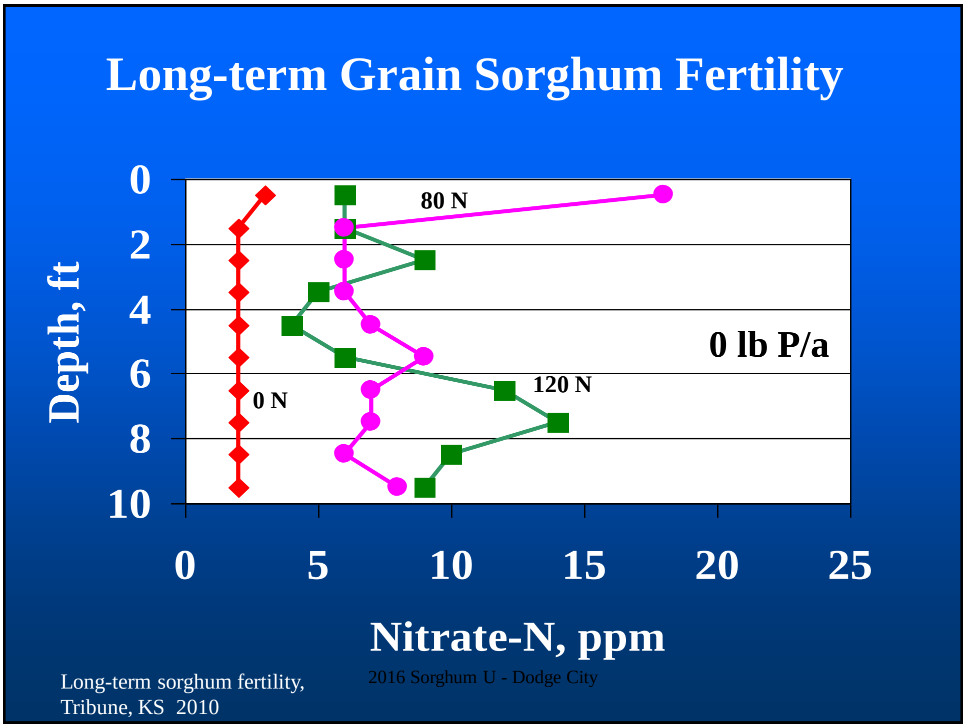
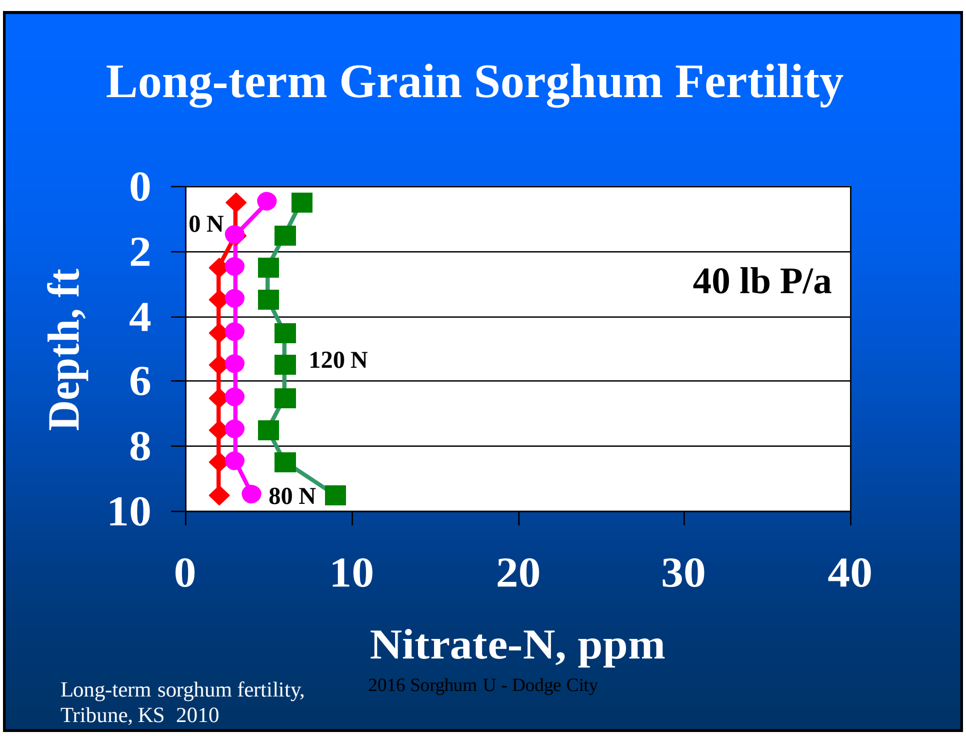
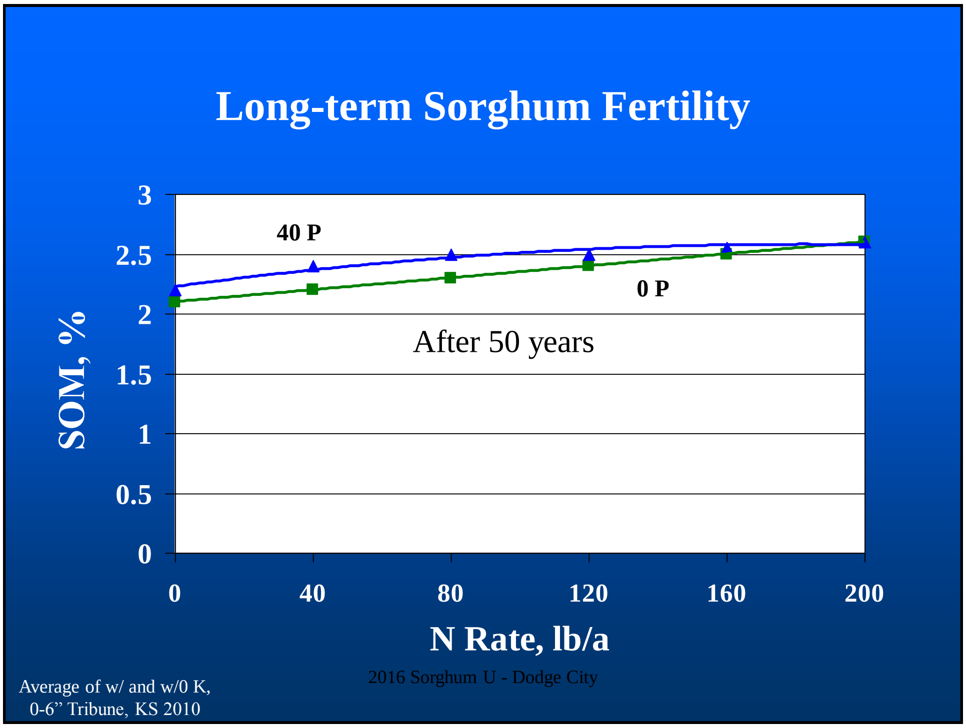

Long-term Sorghum Fertility
1961-2017
40 P
0 P
Yield, bu/a
200
150
100
50
0
0
40
80
120
160
200
N rate, lb/a
Long-term sorghum fertility, Tribune, KS 2017
2016 Sorghum U - Dodge City


Long-term Sorghum Fertility
2008-2017
40 P
0 P
Yield, bu/a
200
150
100
50
0
0
40
80
120
160
200
N rate, lb/a
Long-term sorghum fertility, Tribune, KS 2017
2016 Sorghum U - Dodge City


Long-term Grain Sorghum Fertility
Depth, ft
0
2
4
6
8
10
80 N
0 lb P/a
120 N
0 N
0
5
10
15
20
25
Nitrate-N, ppm
Long-term sorghum fertility,
Tribune, KS 2010
2016 Sorghum U - Dodge City


Long-term Grain Sorghum Fertility
Depth, ft
0
2
4
6
8
10
0 N
40 lb P/a
120 N
80 N
0
10
20
30
40
Nitrate-N, ppm
Long-term sorghum fertility,
Tribune, KS 2010
2016 Sorghum U - Dodge City


Long-term Sorghum Fertility
SOM, %
3
2.5
2
1.5
1
0.5
0
40 P
0 P
After 50 years
0
40
80
120
160
200
N Rate, lb/a
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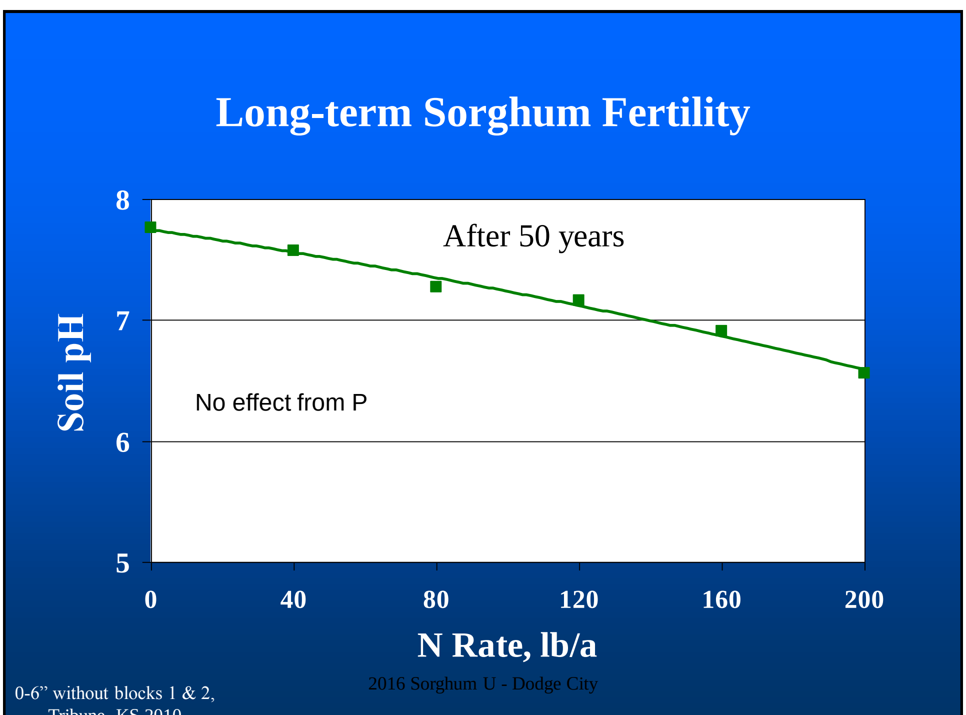
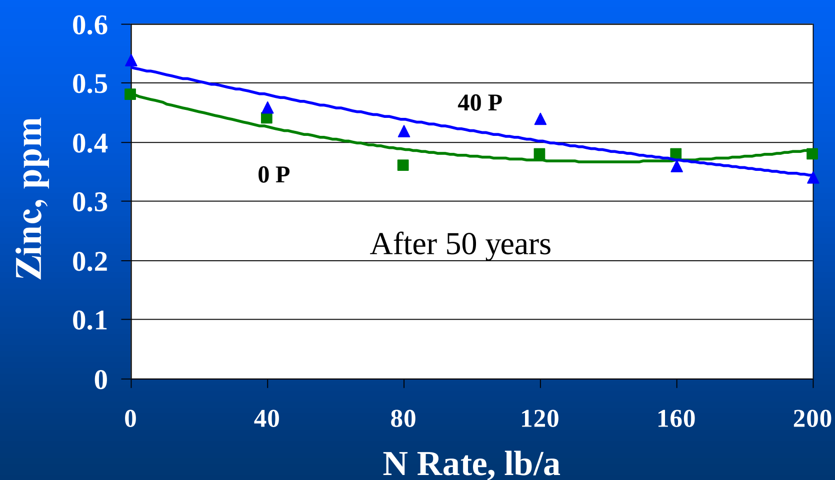
Average of w/ and w/0 K,
0-6" Tribune, KS 2010


Long-term Sorghum Fertility
Soil pH
8
7
6
5
After 50 years
No effect from P
0
40
80
120
160
200
N Rate, lb/a
2016 Sorghum U - Dodge City
0-6" without blocks 1 & 2,
Tribune, KS 2010

Long-term Sorghum Fertility



0-6” Tribune, KS 2010

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Summary – Grain Sorghum

pH decreased ~ 1.2 unit by N

SOM increased ~ 0.5% by N & P

Soil test P increased with 40 P

NO_3 increased by N, particularly when N rates above optimal

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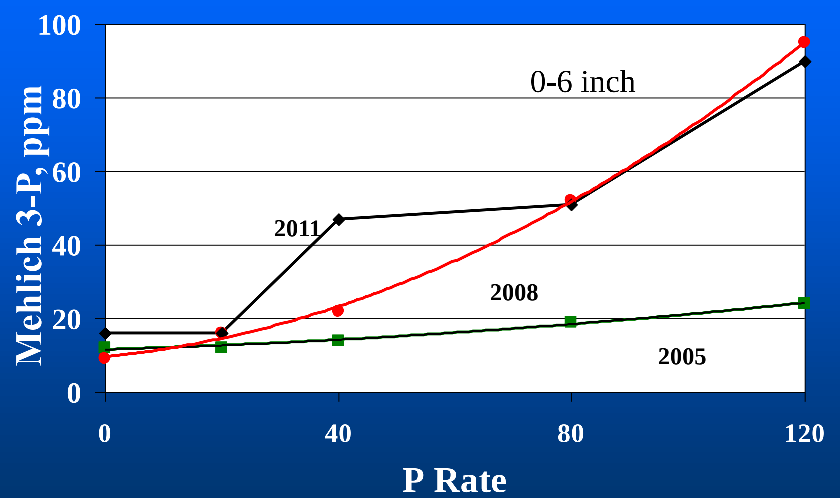
Sorghum P Study



Sorghum P Study, Tribune, KS
2004-2011

Sensors for Nitrogen management in sorghum

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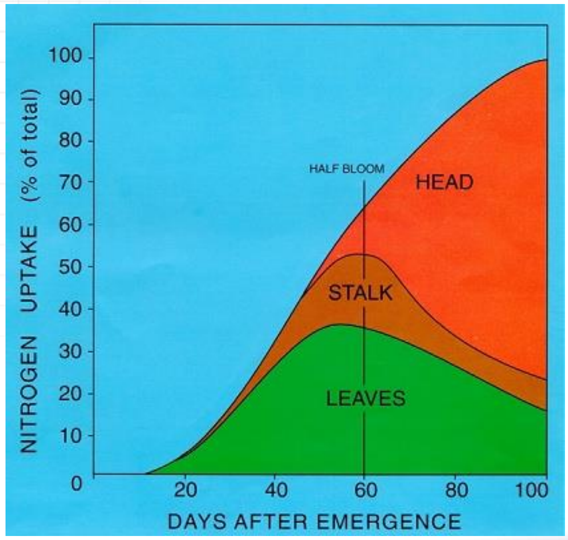
Knowledge for Life

Nitrogen Uptake



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Knowledge for Life

Sensor based vs soil test based N recommendations

Location	Actual Yield	Soil Test Rec.	Sensor Rec.	Actual N Resp.	Soil Test Diff.	Sensor Diff.
Belleville	96	40	0	0	40	0
Manhattan	155	60	33	33	27	0
Partridge	32	42	57	55	-13	2
Tribune	128	30	24	15	15	9
Manhattan	109	130	98	105	25	-7
Partridge	70	40	15	20	20	-5
Tribune	79	54	0	0	54	0
Manhattan	128	77	45	45	32	0
Ottawa	64	56	55	60	-4	-5
Partridge	123	41	30	15	26	15

Mengel, 2008

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Knowledge for Life

K-State sorghum N rate calculator

Farmer Inputs	
NDVI Reference Strip	0.6
NDVI Farmer Practice	0.55
Max Yield for Area bu/ac	150
Days from planting to sensing where avg. temp > 63 F	35
Grain Price, $/Bu	5.8
Nitrogen Price, $/lb actual N	0.6
Application Cost, $/Ac	6
Expected Nitrogen Efficiency, % Recovery	50
Outputs	
Expected Response Index of Grain Yield	1.44
Yield Potential of Reference Strip bu/ac	100.1
Yield Potential without N bu/ac	69.7
N Rec. lbs N/Ac unadjusted for G:N price ratio	57.8
N rec. lbs N/Ac adjusted for G:N price ratio	63.5
Gross Return (no Nitrogen) $/ac	404.35
Gross Return (using N Rec) $/ac	554.21

Mengel, 2013

Handheld versions- low cost

http://hollandscientific.com/

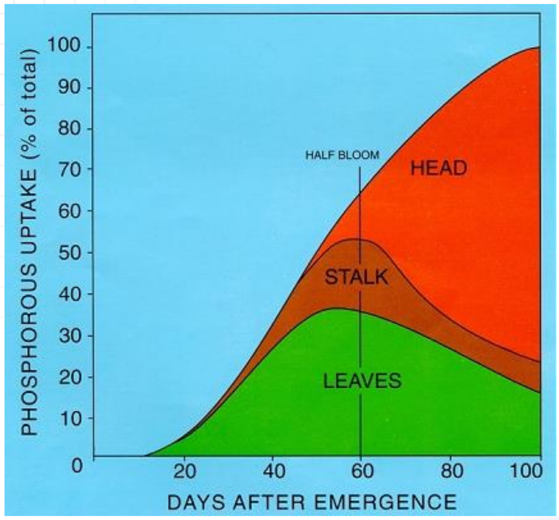
http://www.trimble.com

Nitrogen – management factors

- Timing – as close to utilization as possible
- Rate – determine accurate application rates
- Placement – apply below the soil surface if possible
- Fertilizer source – AA, UAN, Urea
- Specialty fertilizers and additives
  - ESN
  - Agrotain – urease inhibitor
  - N-Serve – nitrification inhibitor
  - Super U – urease and nitrification inhibitor

Phosphorus Management

Phosphorus Uptake



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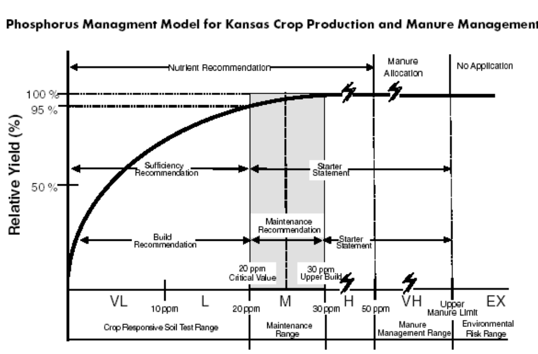
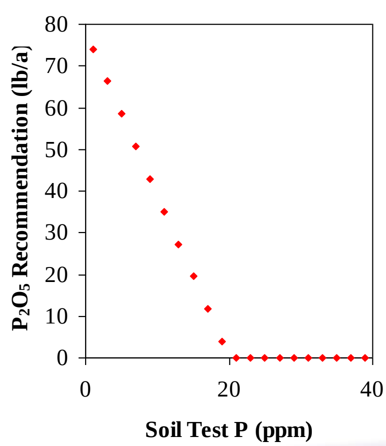
P Example





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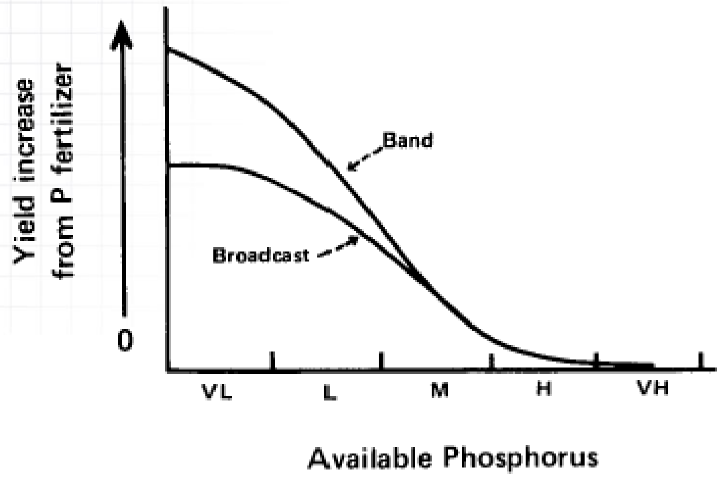
Soil test P and application method



Common generalized depiction of broadcast vs. band

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Phosphorus removal values

Crop	Unit	P_2O_5 (lb)
Corn	bushel	0.33
Grain Sorghum	bushel	0.40
Wheat	bushel	0.50
Sunflowers	pound	0.02
Oats	bushel	0.25
Soybeans	bushel	0.80

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Crop Removal – the next step

- Calculate crop removal
- Depending on over/under applications after crop removal, soil test levels will change.
- 18 lbs P_2O_5 is required to change STP one ppm.

- One cycle of a W-S-F rotation (using field averages)
  - Wheat yield = 60 bu/a, Sorghum yield = 110 bu/ac
  - STP = 22 ppm, P_2O_5 applied during seeding = 30 lb/a
  - Wheat Removal = 60 * .50 = 30 lbs P_2O_5 removed
  - Sorghum Removal = 110 * .40 = 44 lbs P_2O_5 removed
  - Total Crop Removal = 30+44 = 74 lbs P_2O_5 removed
  - STP change = [30-74]/18 = 2.4 ppm drop
  - Final STP = 22 – 2.4 = 19.6 ppm
- Just perform this process at every point in the field

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Knowledge for Life

Crop Removal – the next step

- Perform crop removal and STP calculations at a site-specific scale for the field
- Potential Decision Rules
  - Land ownership/tenancy makes a difference
  - Decisions based on STP
    - IF STP > 30 then apply 0 or very minimal amount (intentional mining)
    - IF STP is >20 and <30 then apply removal rates
    - IF STP is <20 then apply removal + build (build rate?)
- VRT apply P to meet management goals

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Keys to P management

- Soil Test regularly, every 2-4 years
- Use P placement to enhance availability at low ST (<20ppm). For low application rates (maintenance), band application is preferred.
- Consider crop removal in the rotation, removal sound be replaced or ST levels will drop.
- Choice of fertilizer product depends on preference and equipment.

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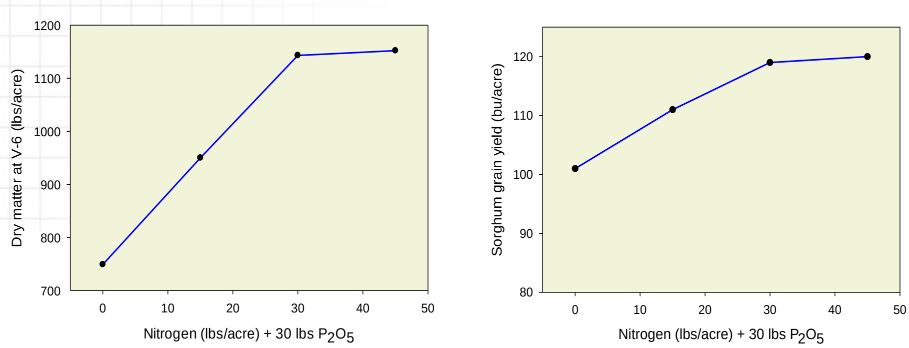
Phosphorus and N starter fertilizer



Liquid surface dribble Gordon, 2001

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Knowledge for Life

Pop-up and surface dribble

- Adapted to economically adapting planters
- Most commonly utilizes fluid fertilizers
- Pop-up:
  - Limited to low rates because of potential germination/stand establishment issues
- Surface dribble:
  - Refers to 'dribbling' liquid fertilizer in a coarse stream on the soil surface beside or above the closed seed furrow at planting time

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In-furrow starter: Reduce injury

- Limit to 10 lb N + K_2O/ acre
- Avoid high salt carriers
- No urea, UAN
- Use caution on sandy or dry soils

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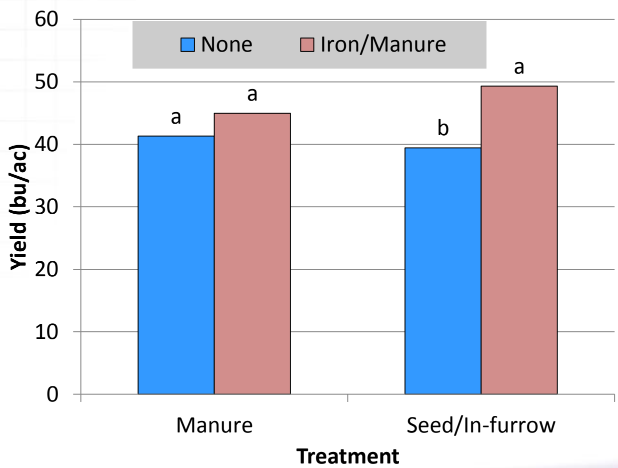
Micros

Secondary and micronutrients for sorghum

- The most common issues in Kansas are iron, zinc and sulfur.
- Research have shown response to chloride in low testing soils.
- Zn, S, and Cl have good reliable soil tests that translate well into anticipated yield response.

Sorghum iron chlorosis



Ruiz Diaz, 2013

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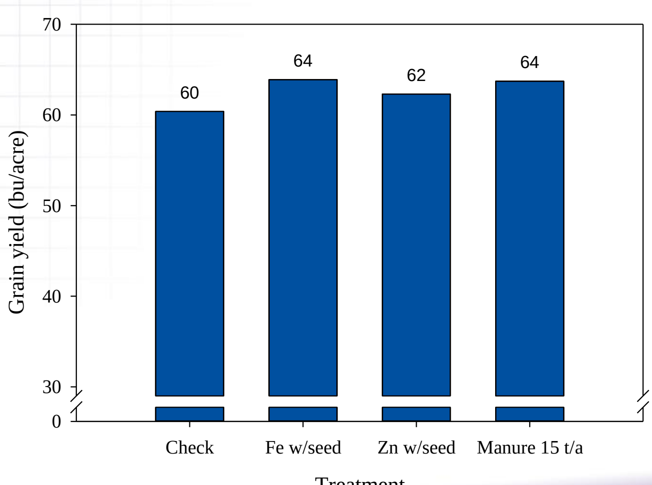
Sorghum iron chlorosis



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Ruiz Diaz, 2013

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Sorghum iron chlorosis

- Manure application show some benefit.
- In furrow chelated Fe fertilizer also contribute with yield increase.
- Previous studies evaluating foliar Fe application show limited response.
- Hybrid selection can help (limited information on iron chlorosis ratings).

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Knowledge for Life

Field Studies

- Three locations: KSU SWREC in Garden City and Tribune, and a producer's field near Garden City
- Treatments:
  - Four chelate rates (0, 3, 6 and 6 lb split)
  - Five sorghum hybrids (Pioneer 86G32, 87P06, 85Y40; Golden Acres 5613, and Sorghum Partners NK5418)

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A. Obour, 2015

Knowledge for Life

Producer's field (60-days after planting

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A. Obour, 2015

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Chelate application reduced IDC in susceptible hybrids

NK5418-Check

NK5418- 6lb split

Pictures at 60-days after planting

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A. Obour, 2015

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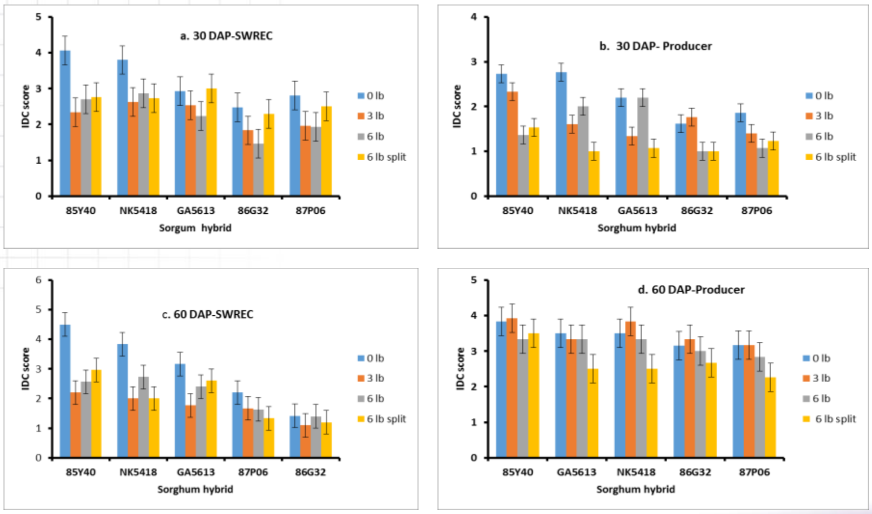
Knowledge for Life

Iron chelate application and grain sorghum hybrid effects on IDC in grain sorghum



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A. Obour, 2015

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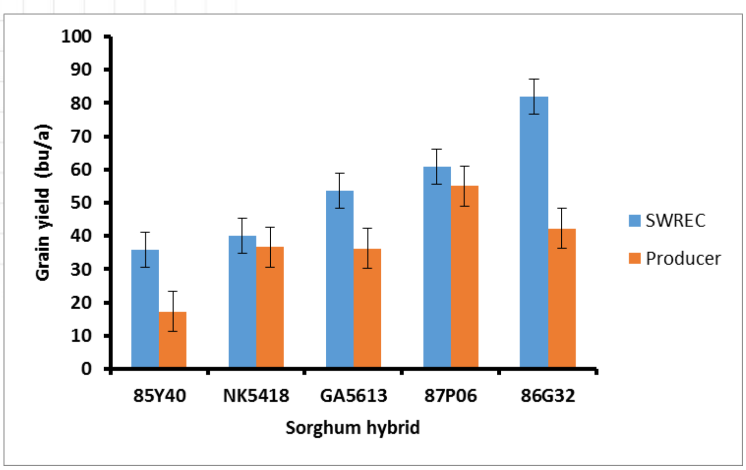
Grain yield of sorghum hybrids at SWREC and a producer's field in Garden City, KS



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A. Obour, 2015

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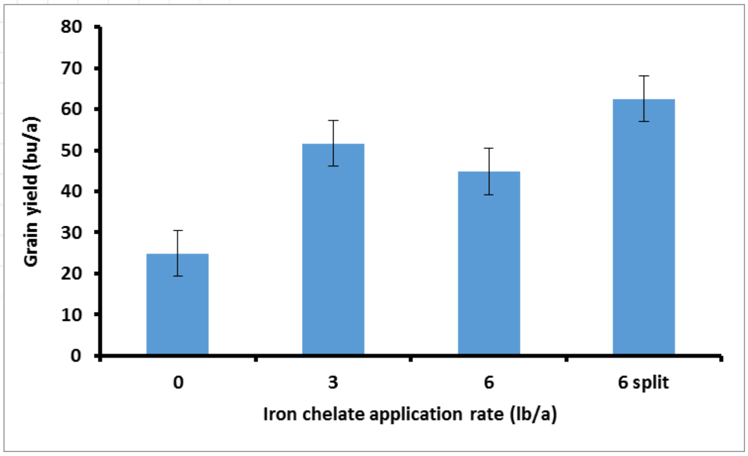
Sorghum grain yield as affected by iron chelate application (two-dryland locations in Garden City, KS)



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A. Obour, 2015

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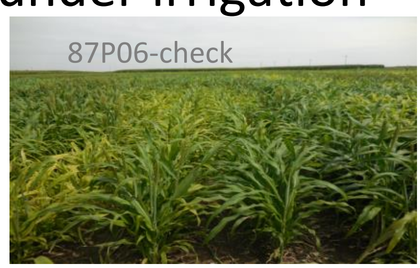
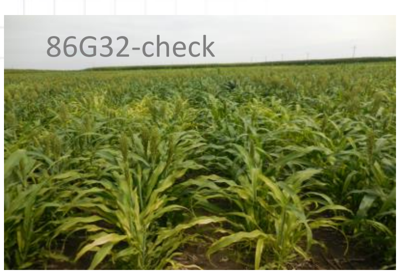
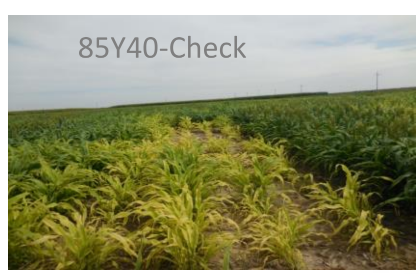
Results-Tribune under irrigation







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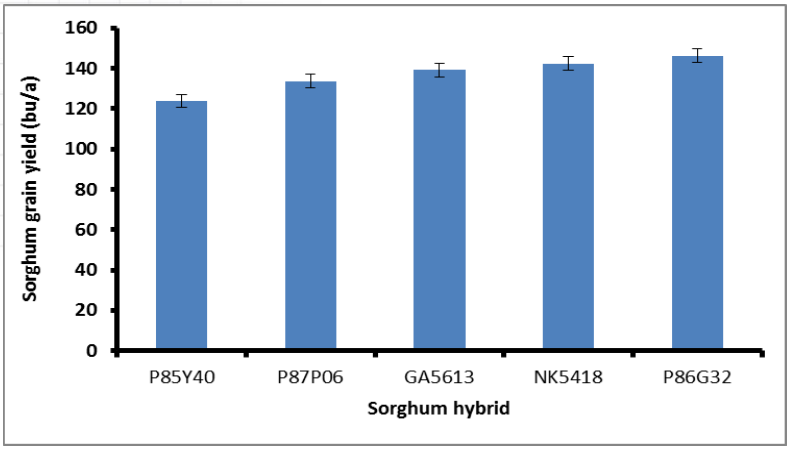
Knowledge for Life

Grain yield of sorghum hybrids (Tribune)



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Chelate effects (Tribune)

85Y40-check

85Y40-3 lb product

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Chelate effects (Tribune)

87P06-Check

87P06-3 lb product

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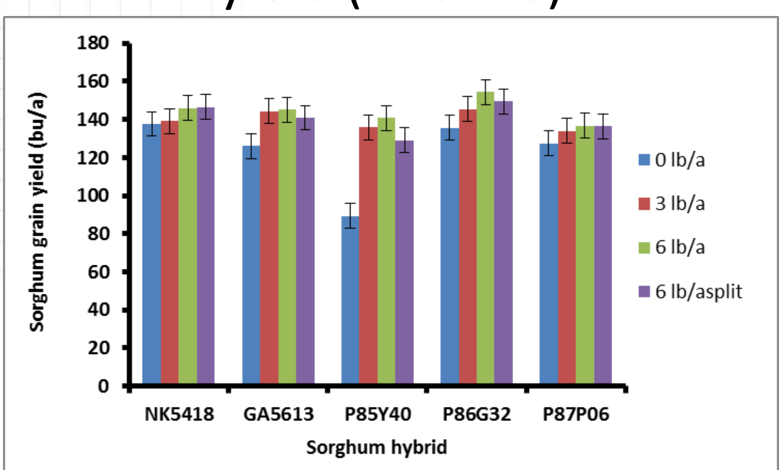
Chelate by hybrid effect on grain yield (Tribune)



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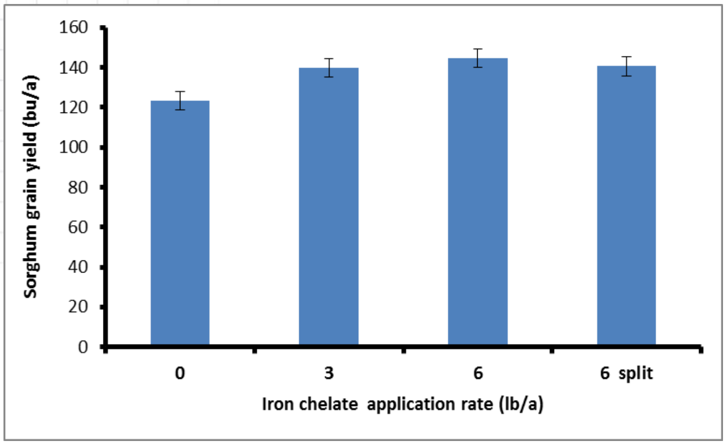
Chelate effect on yield-average across hybrids



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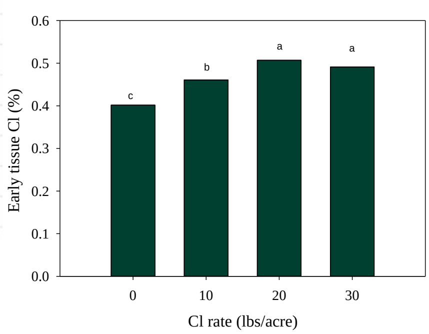
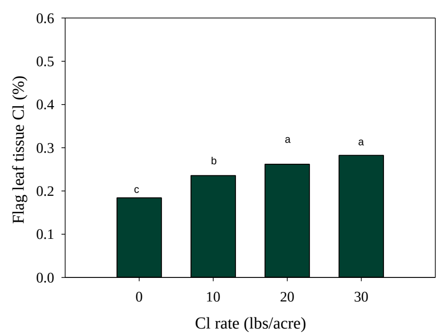
Chloride for sorghum





Ruiz Diaz, 2014. 8 sites

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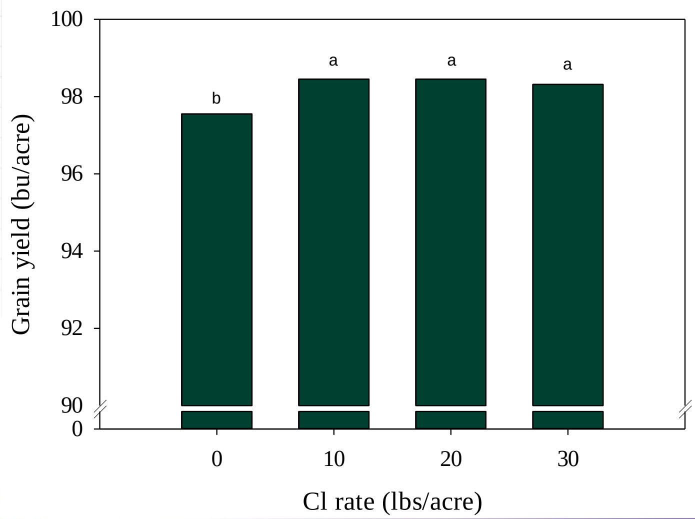
Chloride for sorghum

5 of 8 sites had profile soil test Cl < 6 ppm



Ruiz Diaz, 2014. 8 sites

Chloride for sorghum – profile soil test

Category	Soil chloride		Cl recommended
	lbs/acre	ppm	lbs/acre
Low	< 30	< 4	20
Medium	30-45	4-5	10
High	> 45	> 6	0

Summary

- Nitrogen and P are generally the most limiting nutrients.
- Iron, Cl and S in some cases for sorghum.
- Fertility requirements are best determined by soil testing, estimated crop removal and experience.

Cover Your Acres Conference January 16th and 17, Oberlin

A Historical Look at Climate Variability	Profitability Opportunities & Pitfalls
Making the Right Crop Insurance Choices	Smart Spending of Your Fertility Dollar
Maximizing Your Rangeland	Soil Health & Profitability in Dryland Cropping
Moisture Probes: Measurement to Management	Surviving & Thriving in Tough Times
NWKS Agronomy Research Update	Weed Management Strategies


Clump planted sorghum study
Stanton County, KS 2009
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