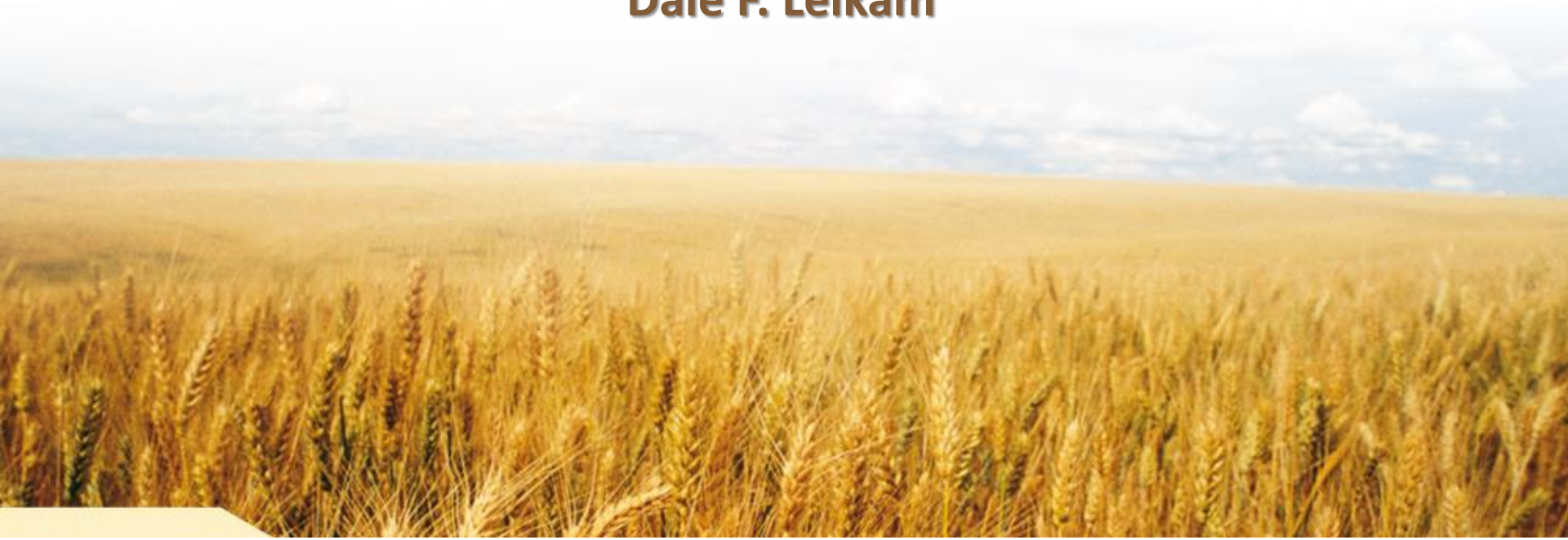
Fertility Management In Modern High Yielding Production Systems

Dale F. Leikam



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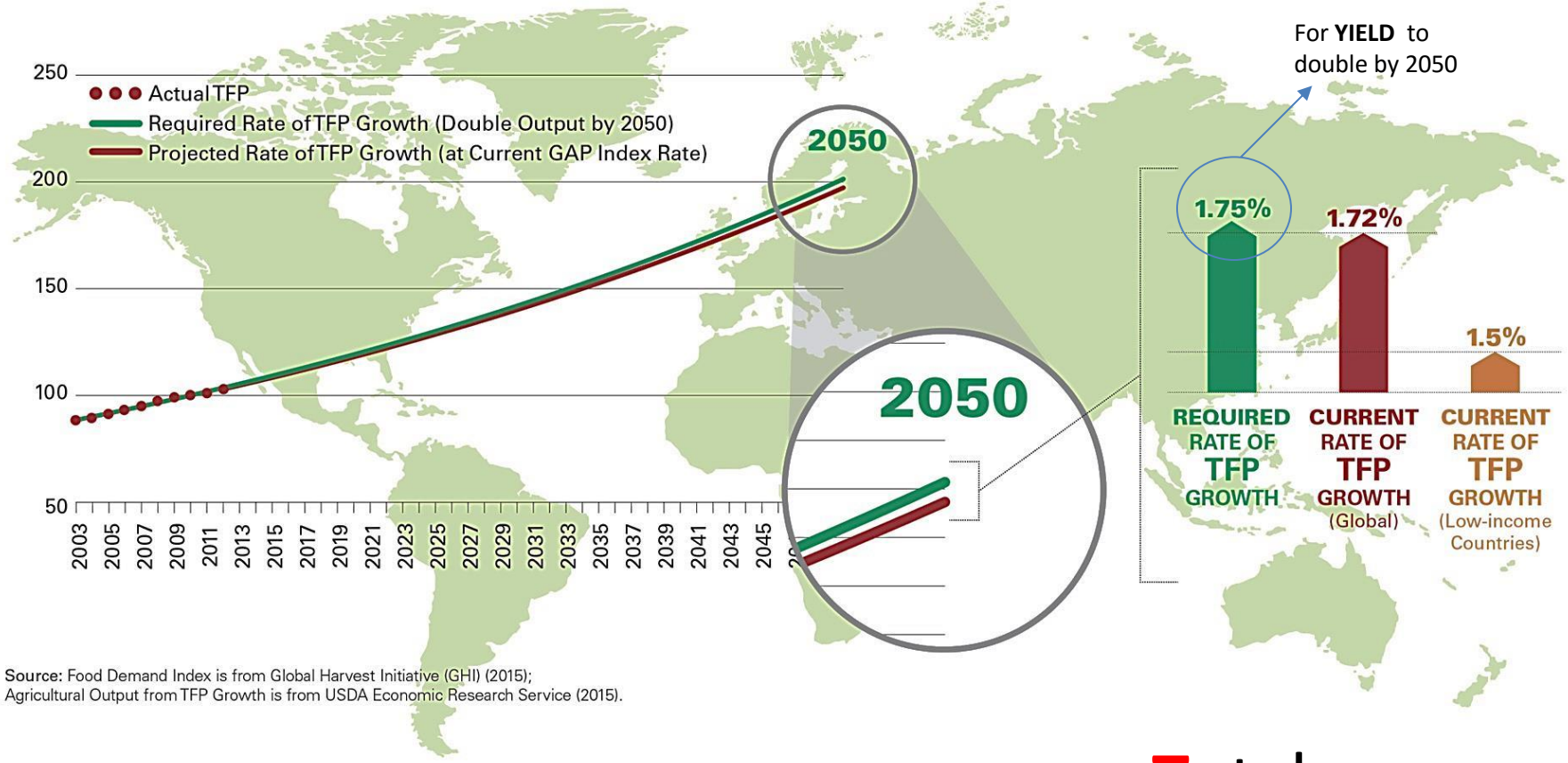
THE GLOBAL AGRICULTURAL PRODUCTIVITY (GAP) INDEX™



Source: Food Demand Index is from Global Harvest Initiative (GHI) (2015);
Agricultural Output from TFP Growth is from USDA Economic Research Service (2015).

Global Harvest INITIATIVE

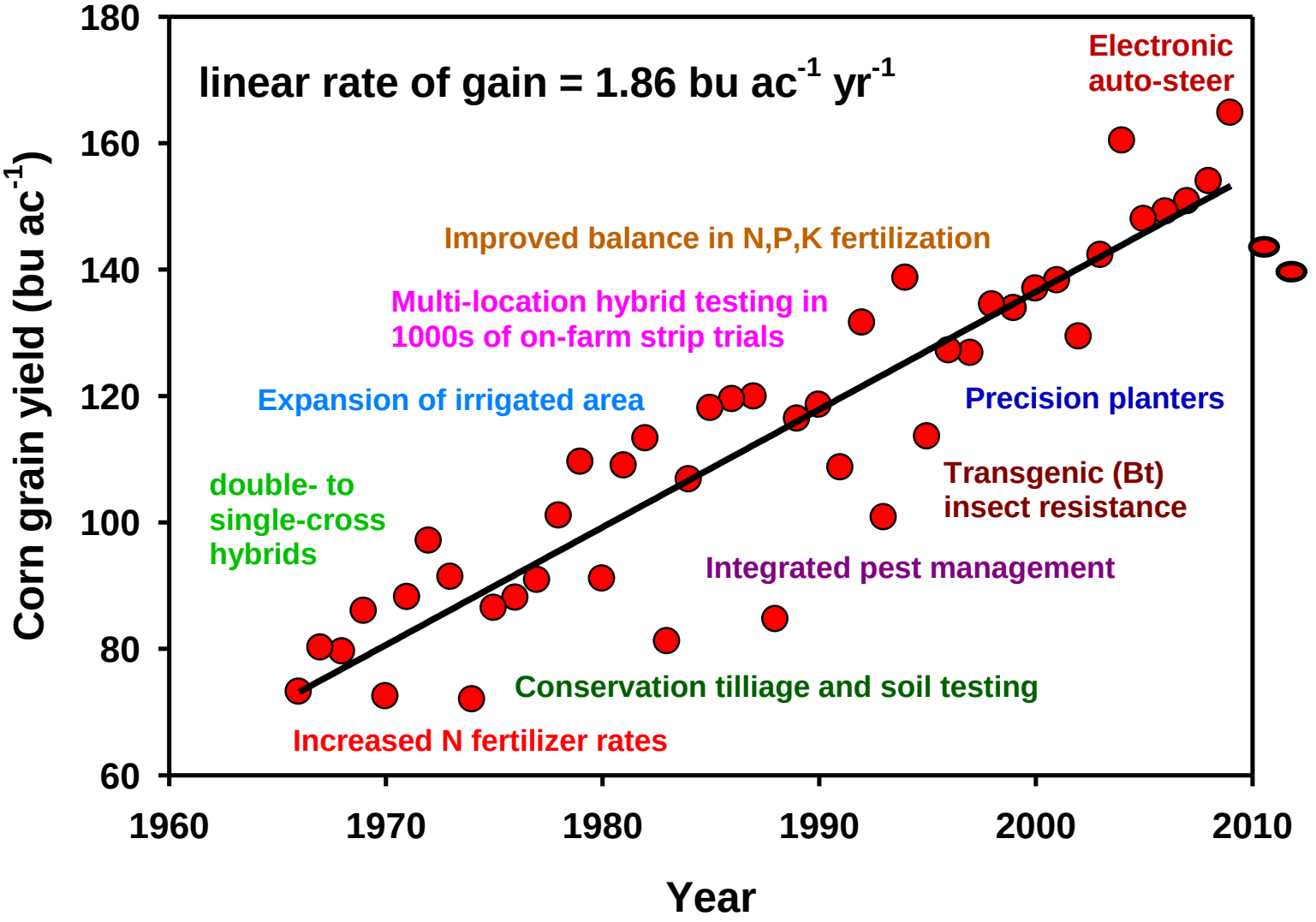
2015 GAP Report®

Total
Factor
Productivity

BRANDT

USA Corn Yield Trends, 1966-2009

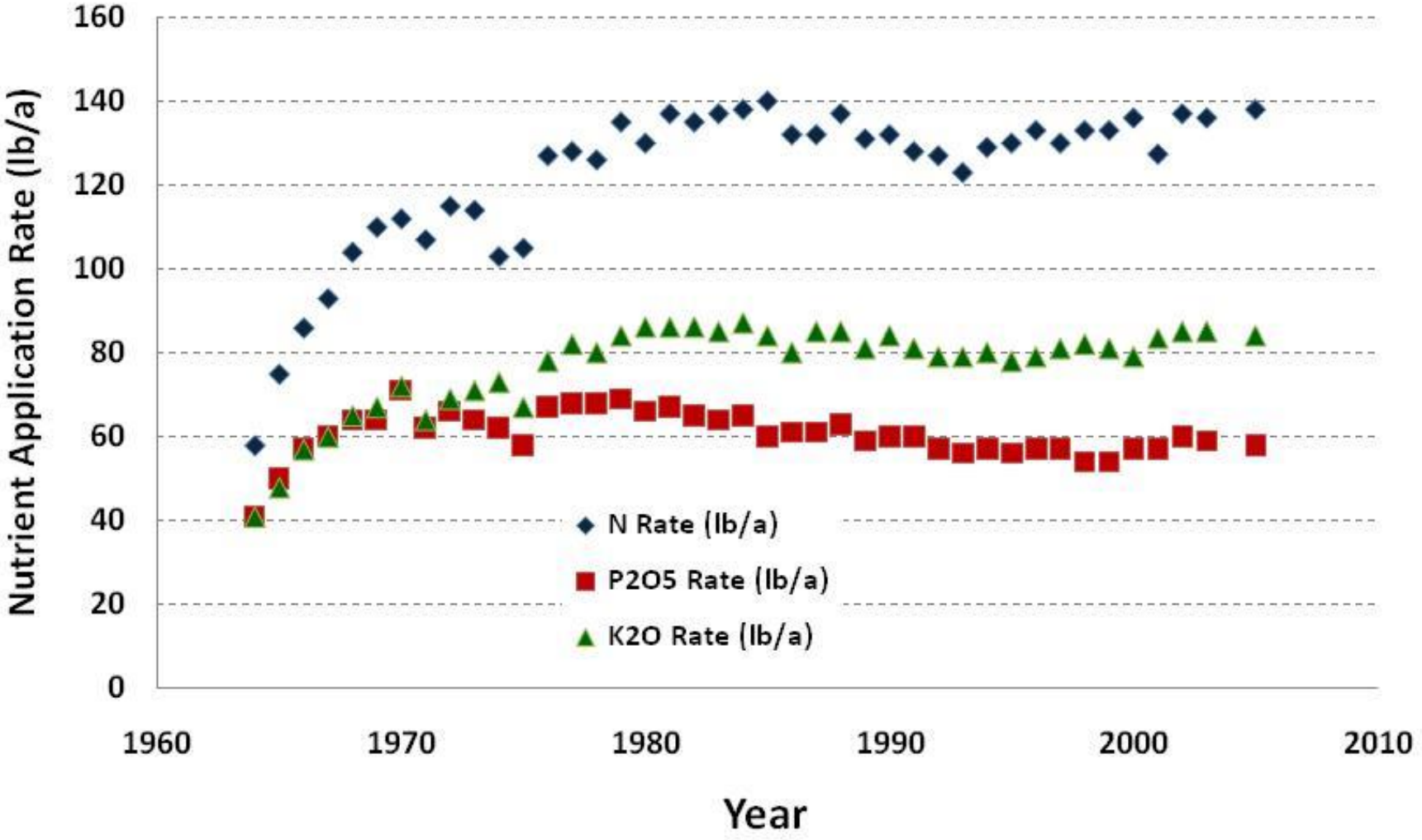
(and supporting science and technologies)



Modified from: Cassman et al. 2006. Convergence of energy and Agriculture. Council on Agriculture, Sci. Tech. Commentary QTA 2006-3. Ames, Iowa

Fertilizer N, P and K Application Rates For Corn

Average For U.S.



U.S. Corn Yield and Nutrient Applications

- Three Year Averages 1983-85 vs. 2003-05

Years	U.S. Corn Yield	Nutrient Application Rates			Rates per Bushel		
		N	P_2O_5	K_2O	N	P_2O_5	K_2O
	Bu / A	- - - - - *Lbs / A* - - - - -			- - - - - *Lbs / Bu* - - - - -		
1983-85	101.9	138	63	85	1.36	0.62	0.84
2003-05	150.1	137	59	83	0.91	0.39	0.55

Sources: Compiled from ERS, TVA, AAPFCO, TFI data.

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Corn Nutrient Uptake by Stage of Growth

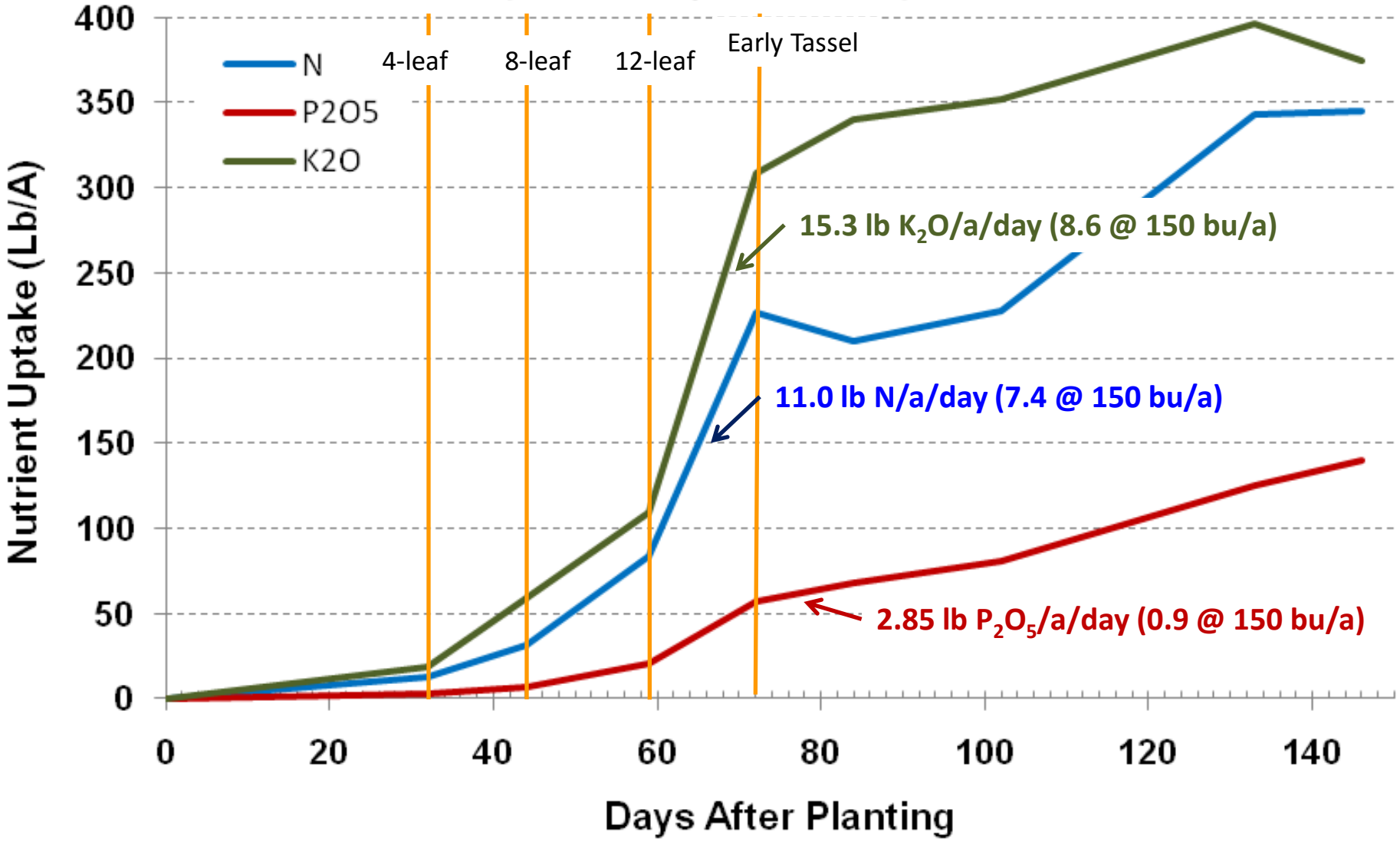
Days after Planting	Growth Stage	N	P	K
		- - - *lbs/A/day* - - -		
30	4”	1.5	0.15	1.3
40	waist high	6.0	0.60	7.4
50	ear develop.	7.4	0.90	8.6
60	silking	4.7	0.80	3.3
70	pollination	1.9	0.47	0.5
100	black layer	2.0	0.23	0.4

Mengel and Barber, Purdue University

~ 150 bu/a

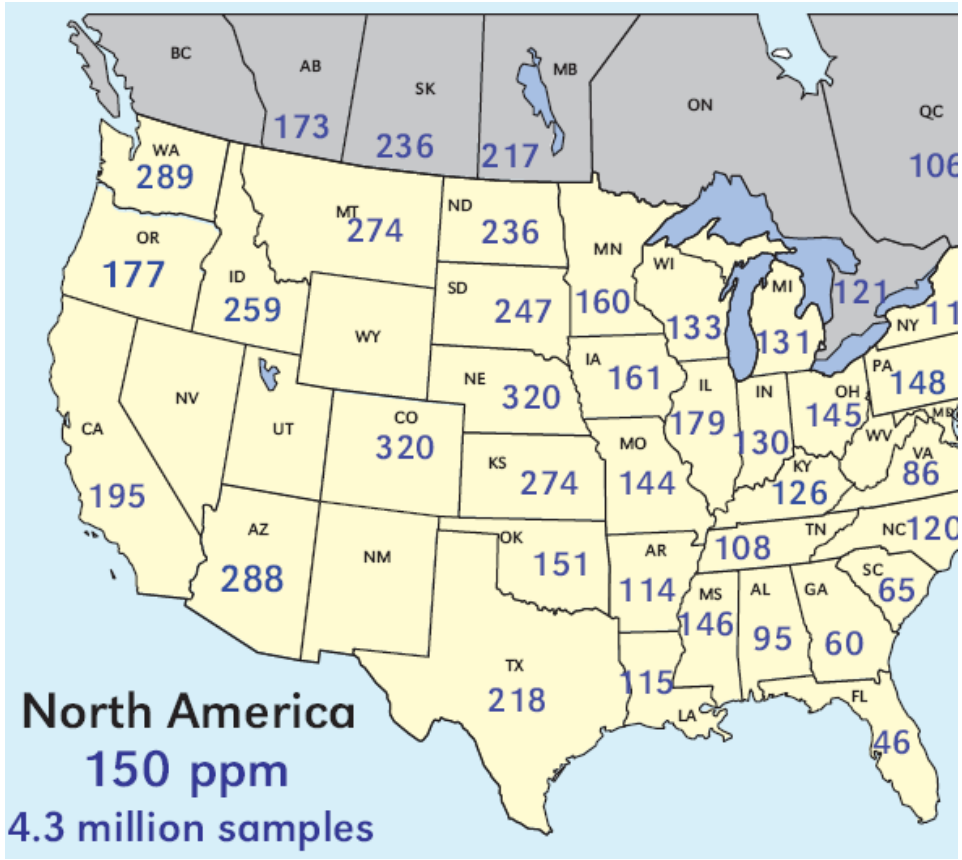
Nutrient Uptake For High Yield Corn

(R. Flannery - 308 Bu/A)

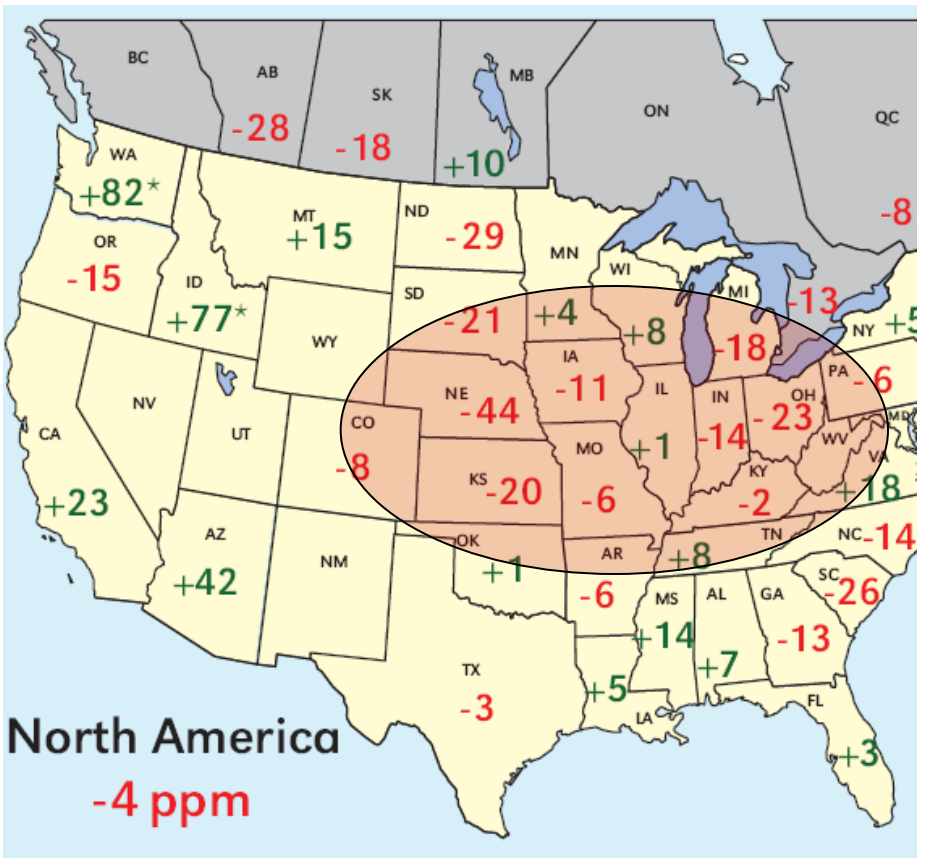


Keep The Longer Term In Mind

Median soil test K levels in 2010 (IPNI)



Change in median soil test K levels from 2005 to 2010 (IPNI)



Exchangeable K

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Nutrient Utilization

ppm Soil Test Values

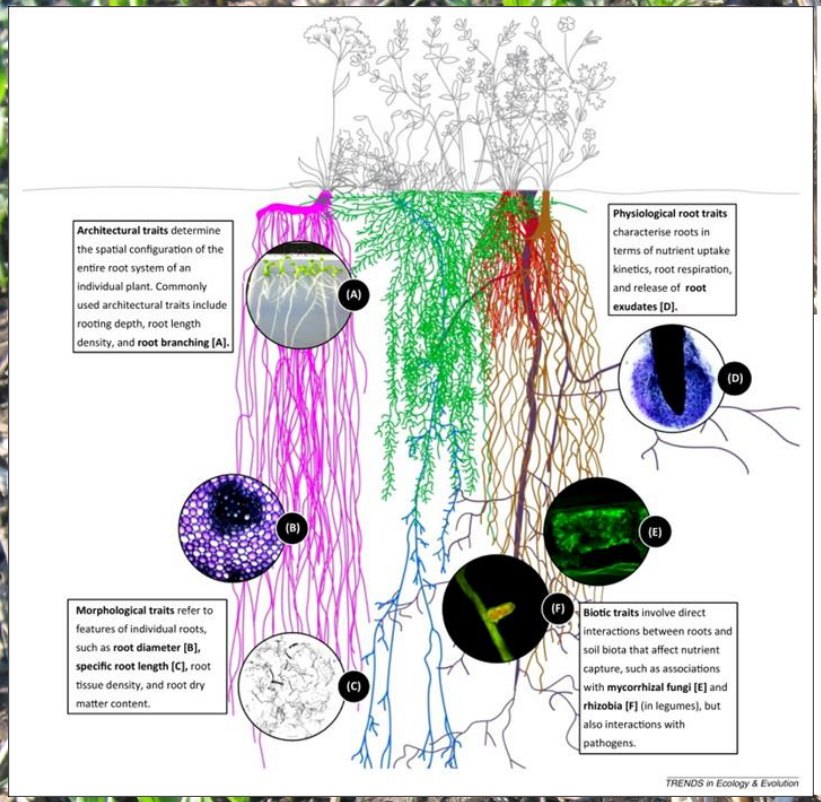
vs.

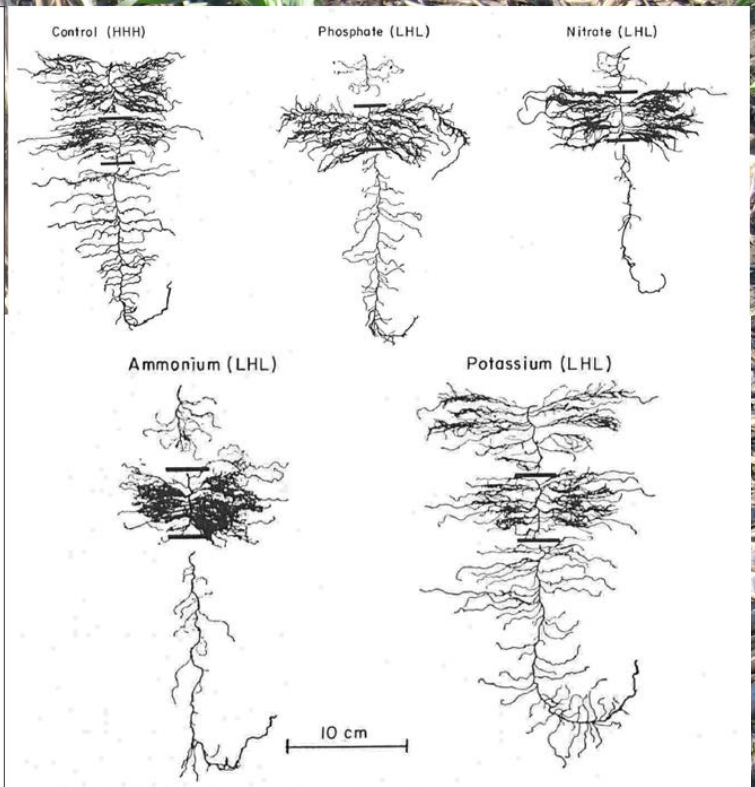
Annual Crop Removal

vs.

Nutrient Demand per Day

ROOTS


Architectural traits determine the spatial configuration of the entire root system of an individual plant. Commonly used architectural traits include rooting depth, root length density, and root branching [A].
Physiological root traits characterise roots in terms of nutrient uptake kinetics, root respiration, and release of root exudates [D].
Morphological traits refer to features of individual roots, such as root diameter [B], specific root length [C], root tissue density, and root dry matter content.
Biotic traits involve direct interactions between roots and soil biota that affect nutrient capture, such as associations with mycorrhizal fungi [E] and rhizobia [F] (in legumes), but also interactions with pathogens.
(A)
(B)
(C)
(D)
(E)
(F)
TRENDS in Ecology & Evolution


Control (HHH)
Phosphate (LHL)
Nitrate (LHL)
Ammonium (LHL)
Potassium (LHL)
10 cm

Higher Yields & High Population: Impact on Root Mass & Nutrient Uptake?

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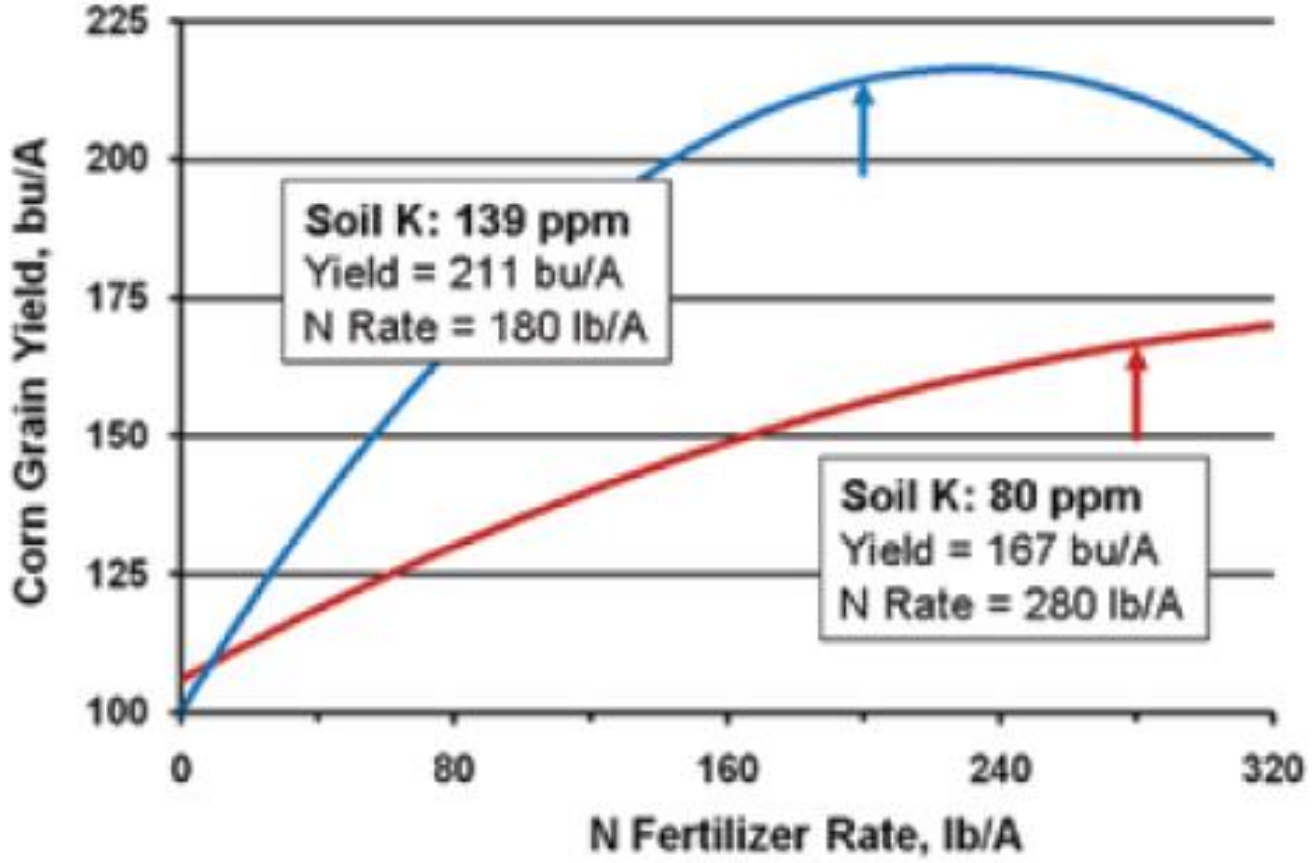


▶ **Fig. 1. High yields of corn are obtained with less N when other nutrients, such as K, are present in adequate concentrations (Ohio). Balanced nutrition is key to improving yields and minimizing N fertilizer loss.** *SOURCE: Murrell and Munson. 1999. Better Crops 83(3):28–31.*

Effect Of Bray P Soil Test Level On Corn Yield and Response To P Fertilization. (Gyles Randall, Univ. of Minnesota)

Application Method	P Rate [1]	Low P Soil
	$Lbs\ P_2O_5/A$	
None	0	148.0
Pop-Up	25/20	158.1
Deep Band	25/20	157.7
Broadcast	25/20	166.4
D. Band + Pop-Up	25/20 + 25/20	171.5
Pop-Up	50/40	165.7
Deep Band	50/40	166.0
Broadcast	50/40	167.0
	p > f	< 0.001
	$LSD_{(0.05)}$	10.5
	Average	162.6
	Bray P1 Soil Test	6-9 ppm

[1] Rates are for Low Test Site/High Test Sites

Effect Of Bray P Soil Test Level On Corn Yield and Response To P Fertilization. (Gyles Randall, Univ. of Minnesota)

Application Method	P Rate [1]	High P Soil
	$Lbs\ P_2O_5/A$	
None	0	192.8
Pop-Up	25/20	191.6
Deep Band	25/20	196.4
Broadcast	25/20	196.2
D. Band + Pop-Up	25/20 + 25/20	189.0
Pop-Up	50/40	194.5
Deep Band	50/40	186.4
Broadcast	50/40	190.2
	p > f	0.84
	LSD (0.05)	NS
	Average	192.1
	Bray P1 Soil Test	20-27 ppm

[1] Rates are for Low Test Site/High Test Sites

Effect Of Bray P Soil Test Level On Corn Yield and Response To P Fertilization. (Gyles Randall, Univ. of Minnesota)

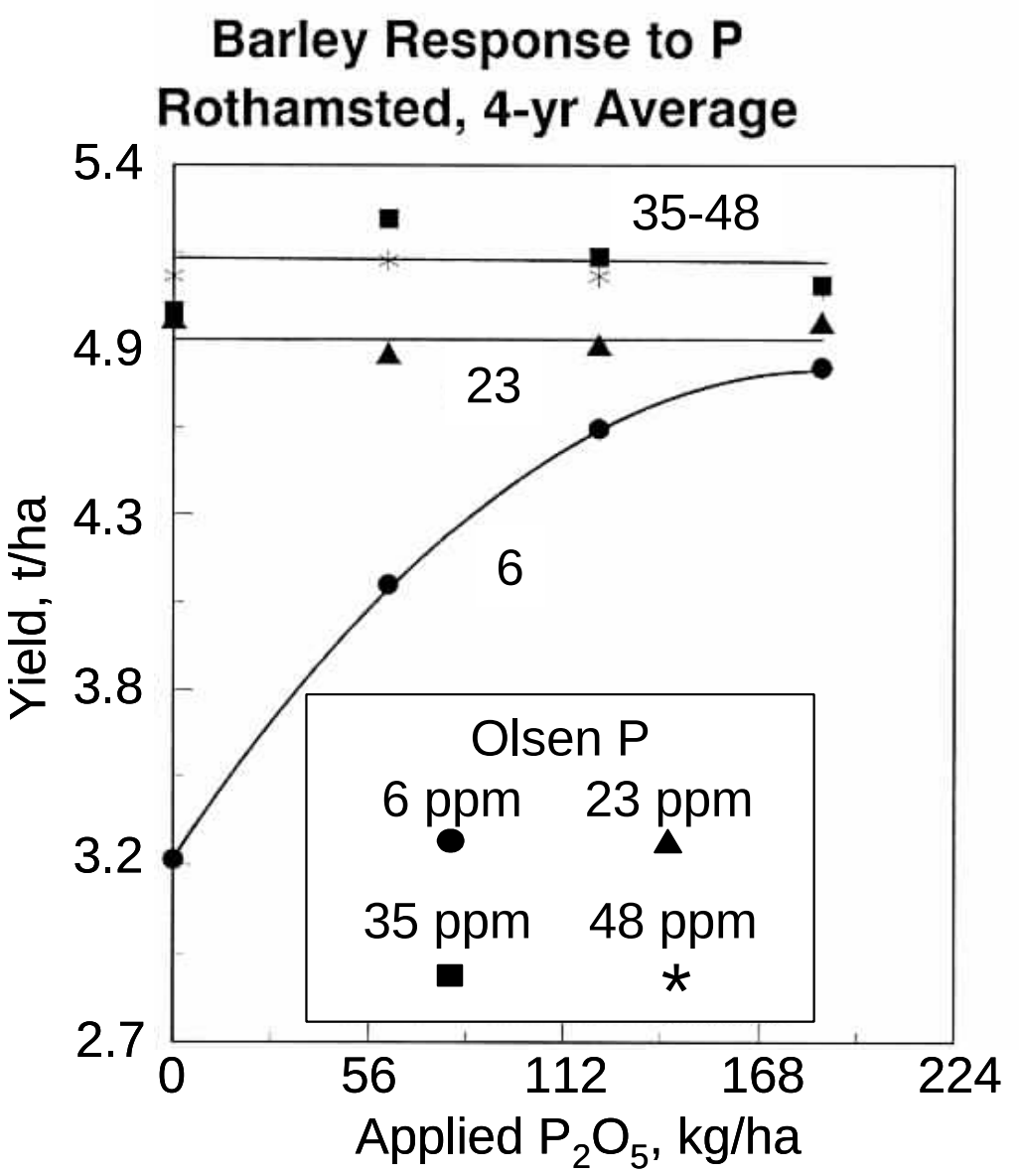
Application Method	P Rate [1]	3-year Average Corn Yield: Low P Soil	3-year Average Corn Yield: High P Soil	High P Advantage	
	Lbs P_2O_5/A	- - - - - *Bu/A* - - - - -		*Bu/A*	*%*
None	0	148.0	192.8	44.8	30.3
Pop-Up	25/20	158.1	191.6	33.5	21.2
Deep Band	25/20	157.7	196.4	38.7	24.5
Broadcast	25/20	166.4	196.2	29.8	17.9
D. Band + Pop-Up	25/20 + 25/20	171.5	189.0	17.5	10.2
Pop-Up	50/40	165.7	194.5	28.8	17.4
Deep Band	50/40	166.0	186.4	20.4	12.3
Broadcast	50/40	167.0	190.2	23.2	13.9
	p > f	< 0.001	0.84	- - -	- - -
	LSD (0.05)	10.5	NS	- - -	- - -
	Average	162.6	192.1	29.6	18.2
	Bray P1 Soil Test	6-9 ppm	20-27 ppm		

[1] Rates are for Low Test Site/High Test Sites

Effect Of Bray P Soil Test Level On Soybean Yield and Response To Residual P Fertilization. (Gyles Randall, Univ. of Minnesota)

Application Method	Residual P Rate [1]	3-year Average Soybean Yield: Low P Soil	3-year Average Soybean Yield: High P Soil	High P Advantage	
		- - - - - Bu/A - - - - -		Bu/A	%
None	0	34.5	49.1	14.6	42.3
Pop-Up	25/20	36.4	49.1	12.7	34.9
Deep Band	25/20	34.7	48.8	14.1	40.6
Broadcast	25/20	36.7	50.3	13.6	37.1
D. Band + Pop-Up	25/20 + 25/20	40.8	49.3	8.5	20.8
Pop-Up	50/40	38.2	48.9	10.7	28.0
Deep Band	50/40	38.5	49.1	10.6	27.5
Broadcast	50/40	37.1	48.4	11.3	30.5
	p > f	0.39	0.01	- - -	- - -
	LSD (0.05)	NS	3.5	- - -	- - -
	Average	37.1	49.1	12.0	32.4
	Bray P1 Soil Test	6-9 ppm	20-27 ppm		

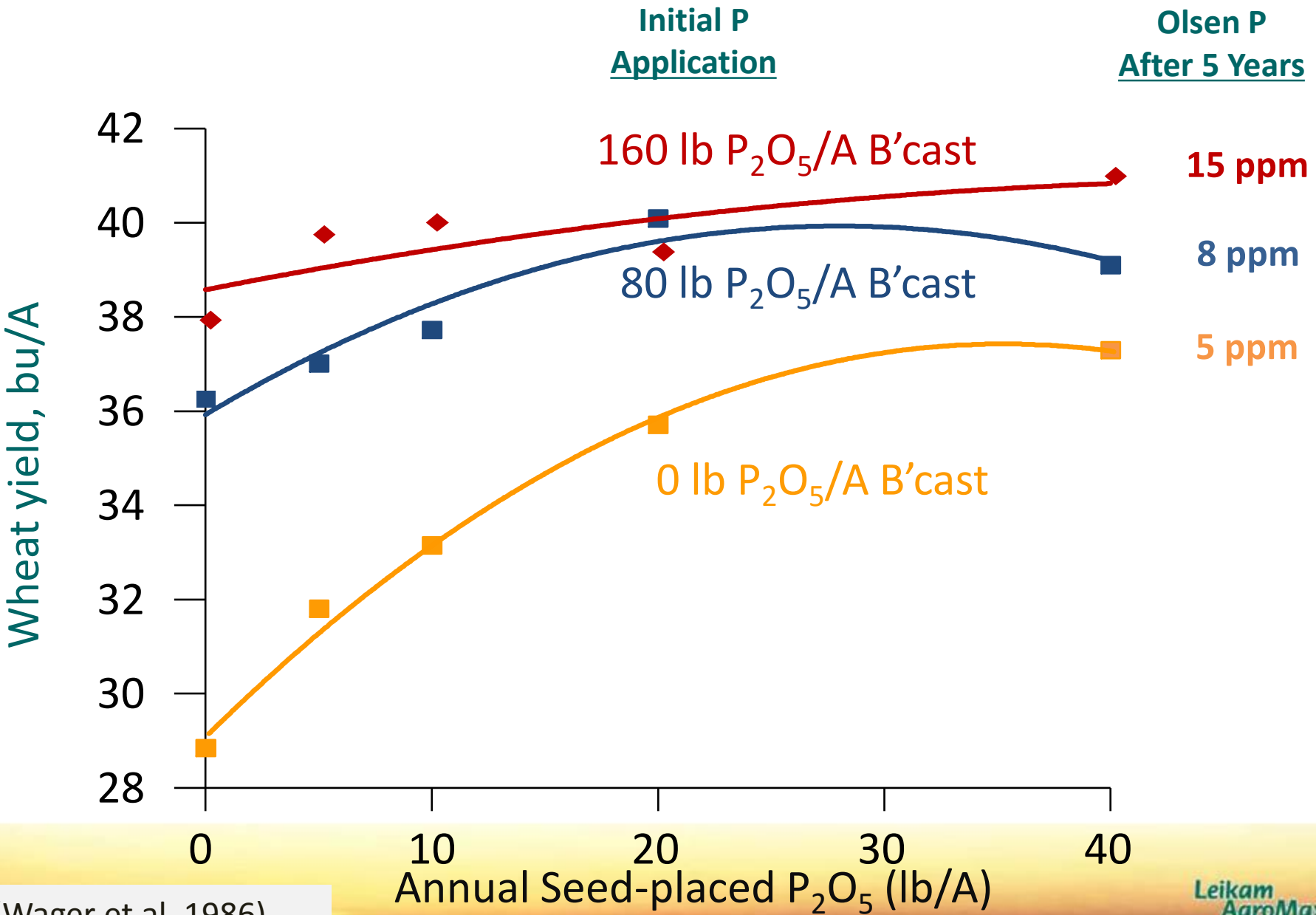
[1] Residual Rates are for Previous Corn Crop Low Test Site/High Test Sites



"On impoverished soils (<10 ppm P) even the largest fresh applications of broadcast P did not raise yields to those achieved on enriched soils (>25 ppm P) in the absence of fresh phosphate."

A.E. Johnston, 1986

Will Fertilizer Substitute For Higher Fertility?



(Wager et al. 1986)

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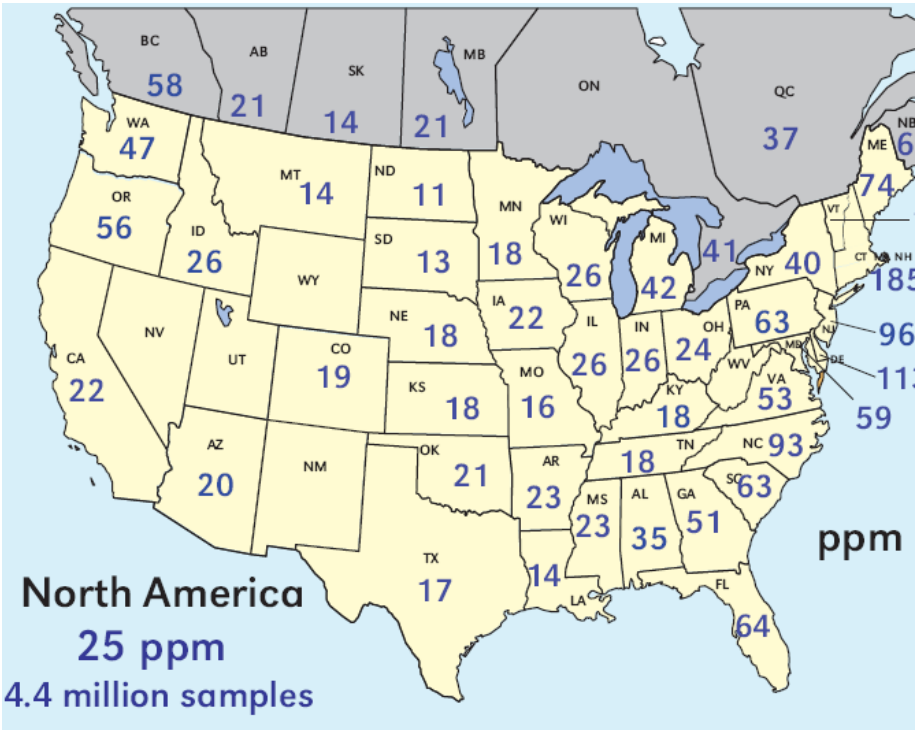
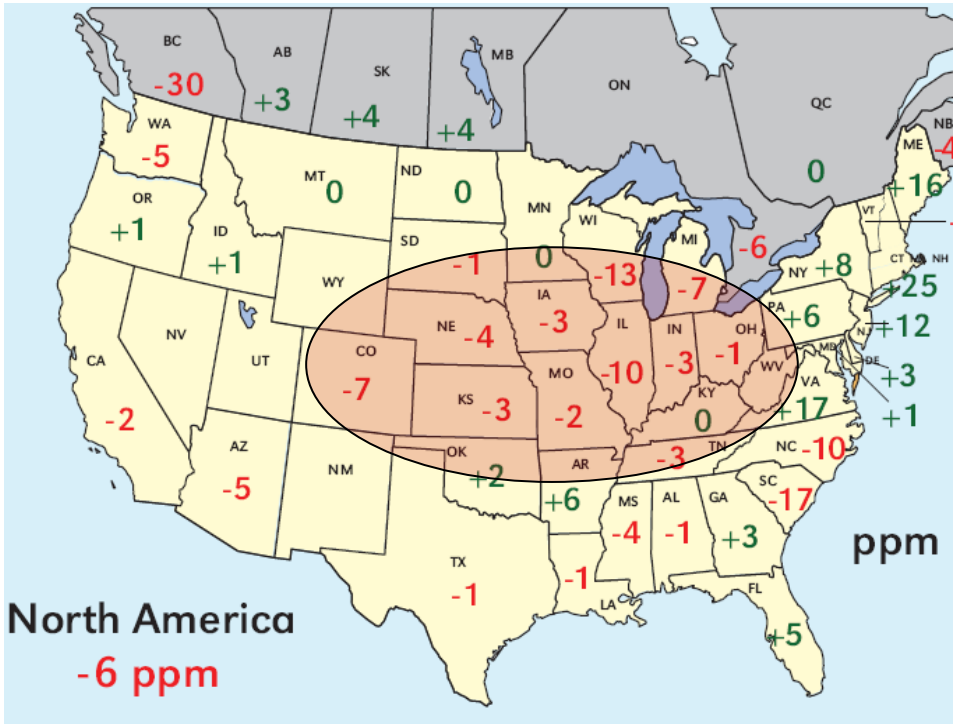
Keep The Longer Term In Mind

Median soil test P levels in 2010 (IPNI)



Change in median soil test P levels from 2005 to 2010 (IPNI)



Extractable P

We ‘Know’ That Fertilizer Applications (rates and method) Should Be As Efficient As Possible In The Year Of Application ?

P, K, Zn Application Rate

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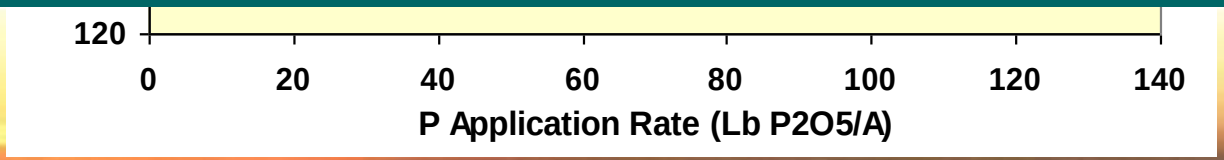
We ‘Know’ That Potassium Has To Be Placed Where We Want It In The Root Zone Since It Does Not Move In Soil ?

We ‘Know’ That Phosphorus Has To Be Placed Where We Want It, In The Root Zone Since It Does Not Move In Soil ?

Leikam, KSU, 2004



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We ‘Know’ That Starter Fertilizer Has To Be Placed Where We Want It In The Root Zone - With Or Below The Seed?

LSD (0.05)		6

Lamond, KSU Manhattan
Soil Test P = Medium-High

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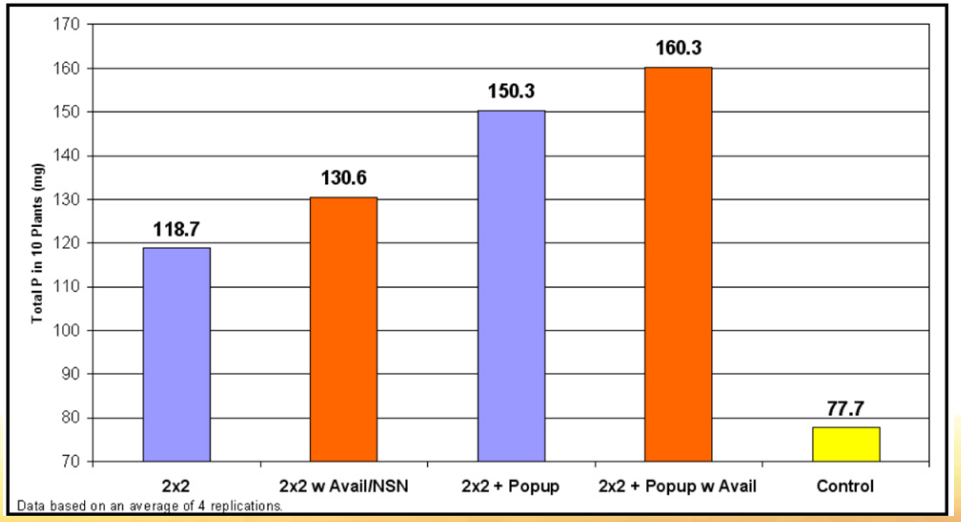
In-furrow and 2x2 Starter Combinations For Corn

M. Bauer, Michigan

Starter Method	Additive	Plant Vigor	Grain Yield	Tissue N	Tissue P
			bu/a	- - - - % - - - -	
None	None	7.0	197.8	3.46	0.33
2 x 2	None	8.0	204.5	3.60	0.38
2 x 2	Avail + Nutrisphere-N	8.5	211.4	3.66	0.37
In-furrow	Season Pass	8.0	203.2	3.54	0.38
In-furrow ***plus*** 2 x 2	Season Pass	8.5	213.4	3.71	0.38
	p > f	<0.001	<0.001	<0.001	<0.001
	$LSD_{(0.10)}$	0.5	2.7	0.03	0.01



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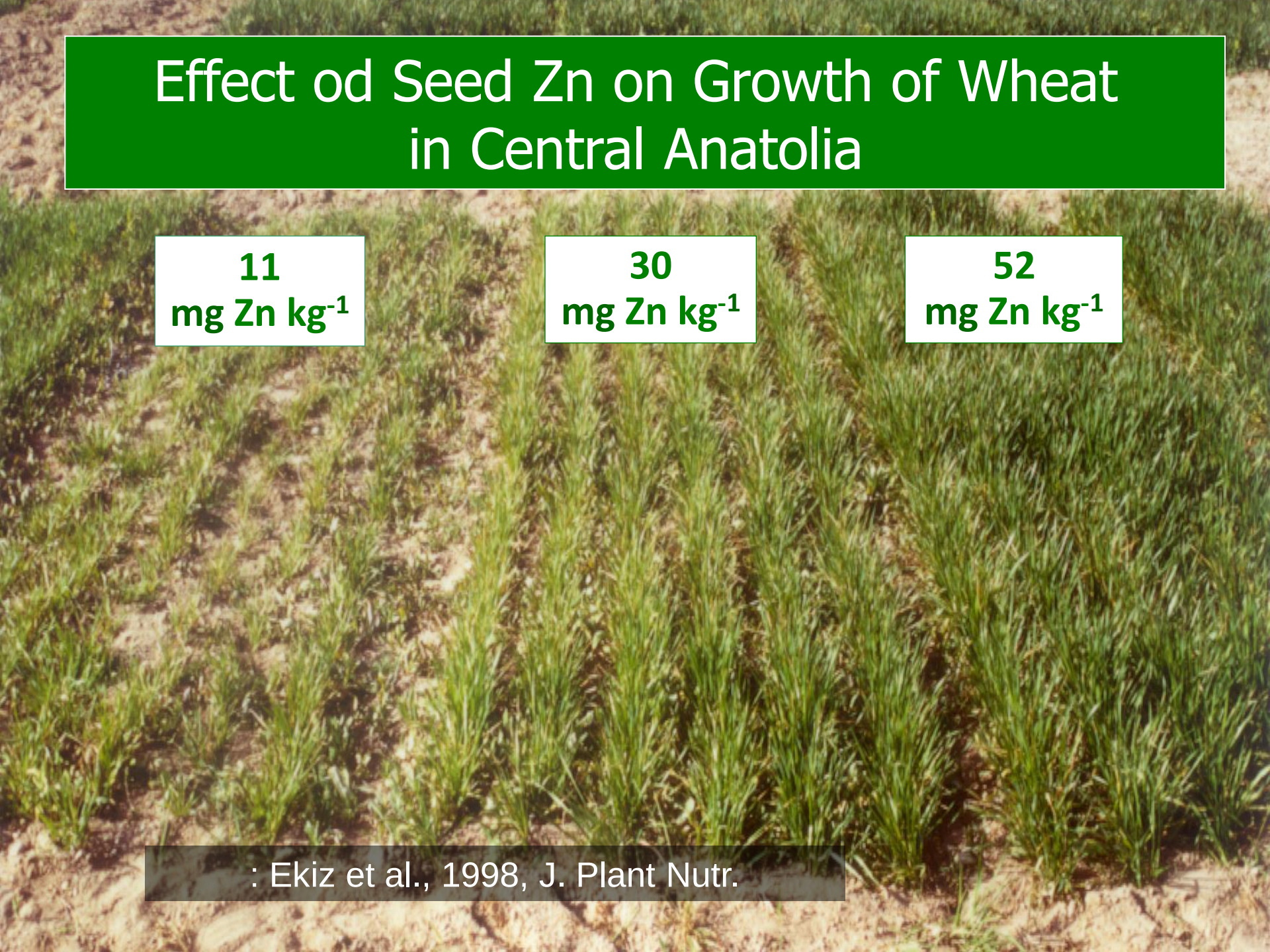
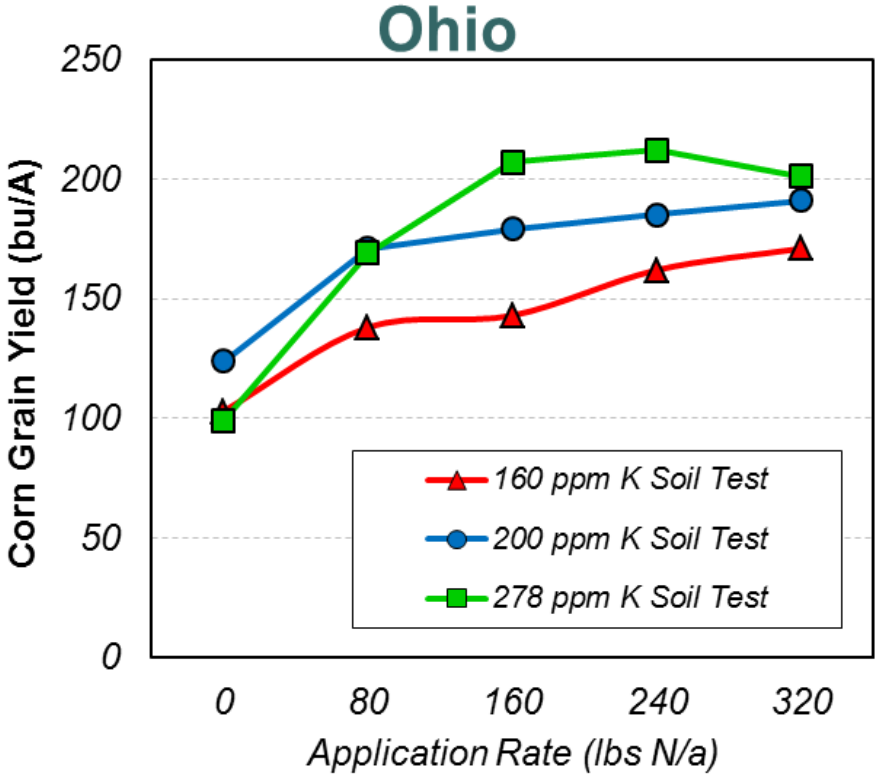
We ‘Know’ That Zn Oxide Fertilizer Products Are Not Appropriate In The Plains Because Their Solubility is Too Low ?

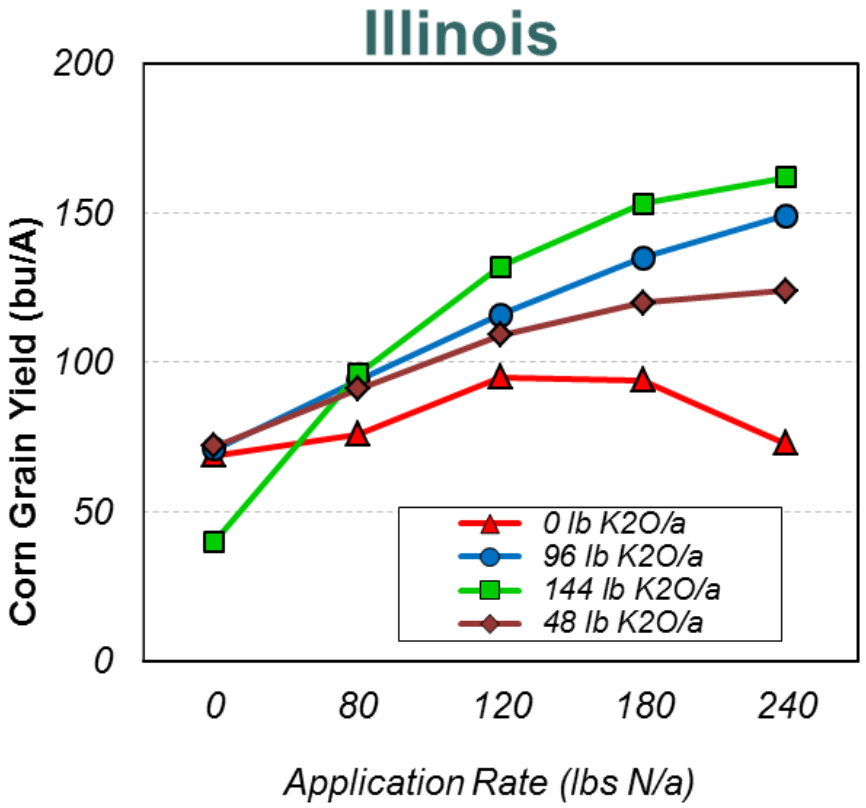
Effect od Seed Zn on Growth of Wheat in Central Anatolia



: Ekiz et al., 1998, J. Plant Nutr.

Interactions





Interaction Of New Technologies/Practices With Corn Yield

F. Below, University of Illinois

	Traditional Program	Enhanced Program
	208 bu/a	274 bu/a
Yield Increase Attributed To Individual New Practice:		
	- - - - - - bu/a - - - - -	
Additional P, S, Zn (MEZ)	**7**	**18**
Additional Sidedress N	**16**	**24**
Higher Plant Population	**-15**	**14**
Fungicide Application	**-4**	**12**
Genetics - Triple Stack	**8**	**27**

Traditional Program - University of Illinois Recommendations Without Any Enhanced Input
Enhanced Program - University of Illinois Recommendations Plus All Enhanced Inputs

Higher Nutrient Levels Required For Plant Population Response

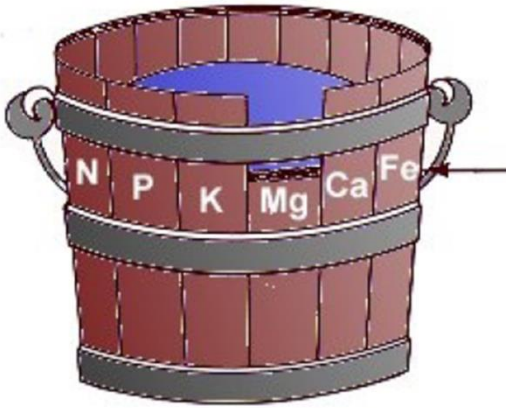
Kansas State University

Plant Population	Traditional [1] Fertility	Enhanced [2] Fertility	Corn Response
28,000	202	225	23
42,000	196	262	66
Response	-6	37	

[1] 230 lb N/a, 30 lb P_2O_5/a

[2] 230 lb N/a, 100 lb P_2O_5/a , 80 lb K_2O/a and 40 lb S/a

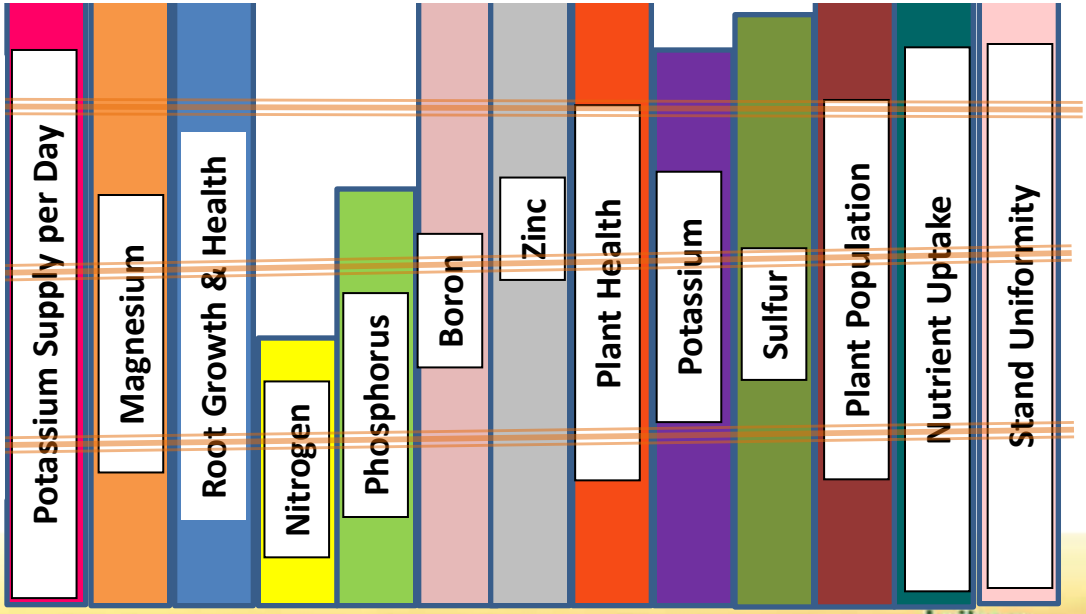
P and K Soil Tests = High



The wooden bucket represents the soil's nutrient supplying capacity

The Law of the Minimum

Law of The Minimum



Crn

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Continuing To Move Yields On Up

- Fresh Mindset & Attitudes - Vatren
- Recalibrate Thinking (it's not 1985 anymore)
- Be Open To New Ideas/Products (open minded)
- Think For Yourself – Interpretation (assumptions and bias)
- Nutrient Utilization vs. 'Availability'
- Think Crop Nutrition Not Just 'Soil' Fertility
- Don't Forget The 'Small' Things

“All truth passes through three stages:

1. First, it is ridiculed.
2. Second, it is violently opposed.
3. Third, it is accepted as being self-evident.”

Arthur Schopenhauer

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