Phosphorus Response, Placement, and Movement

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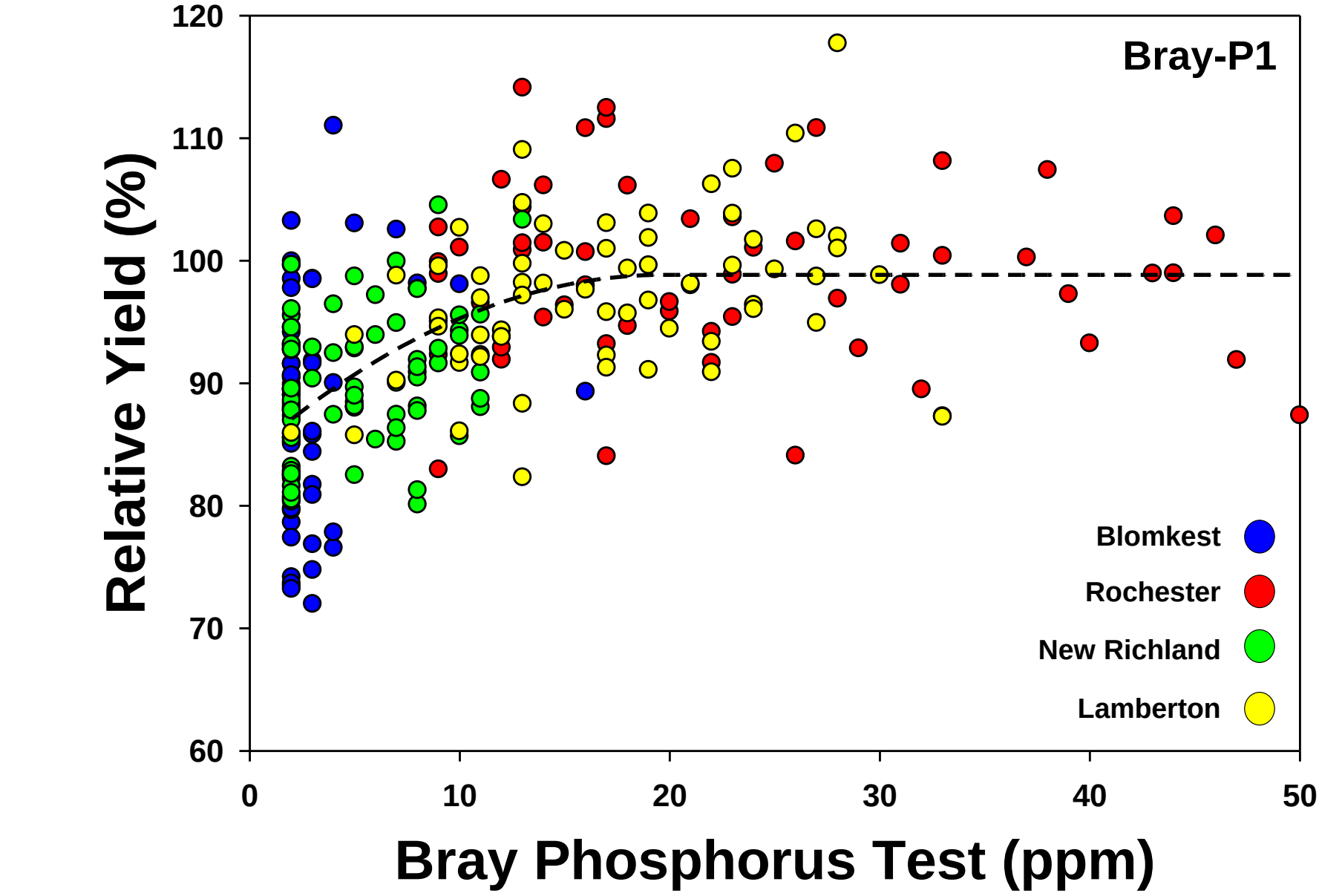
Phosphorus in Soils

- Chemistry is complex – bonds with many metal cations
- Exists in many pools
  - Labile, moderately labile, non-labile
- Pools are in a state of equilibrium
  - As plants take up P, mod. labile P may become available
- Absence in water limits algal growth



Minnesota Agricultural Fertilizer Research & Education Council

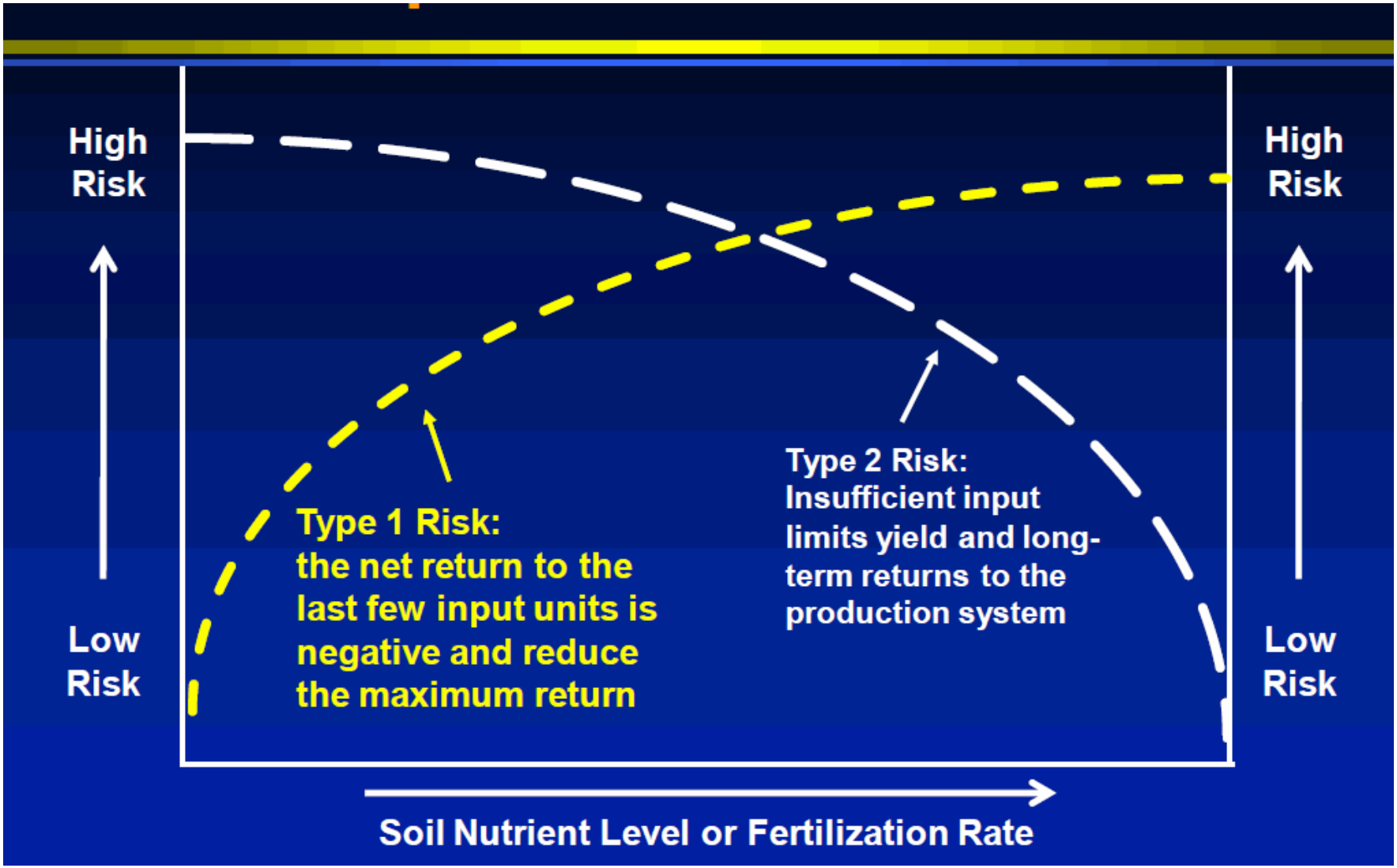
P Response

- Most studies agree on a critical soil P level around 20 ppm (Bray-P1)
  - May change from year to year
- Assessment of P availability only as good as the soil test taken
- Due to uncertainties a range of soil P may have to be maintained
- Agronomic maintenance for P should be around 30 ppm or less (Bray-P1)

To Build or Not to Build

- Cannot argue that higher soil test P will give greater yield
- Many philosophies will try to build to a certain point
  - Current U of M – 10-15 ppm (Bray-P1)
- Main argument
  - Can soil P + fertilizer P maximize yield?
  - How much fertilizer to apply

Risk and Response



Response Curves

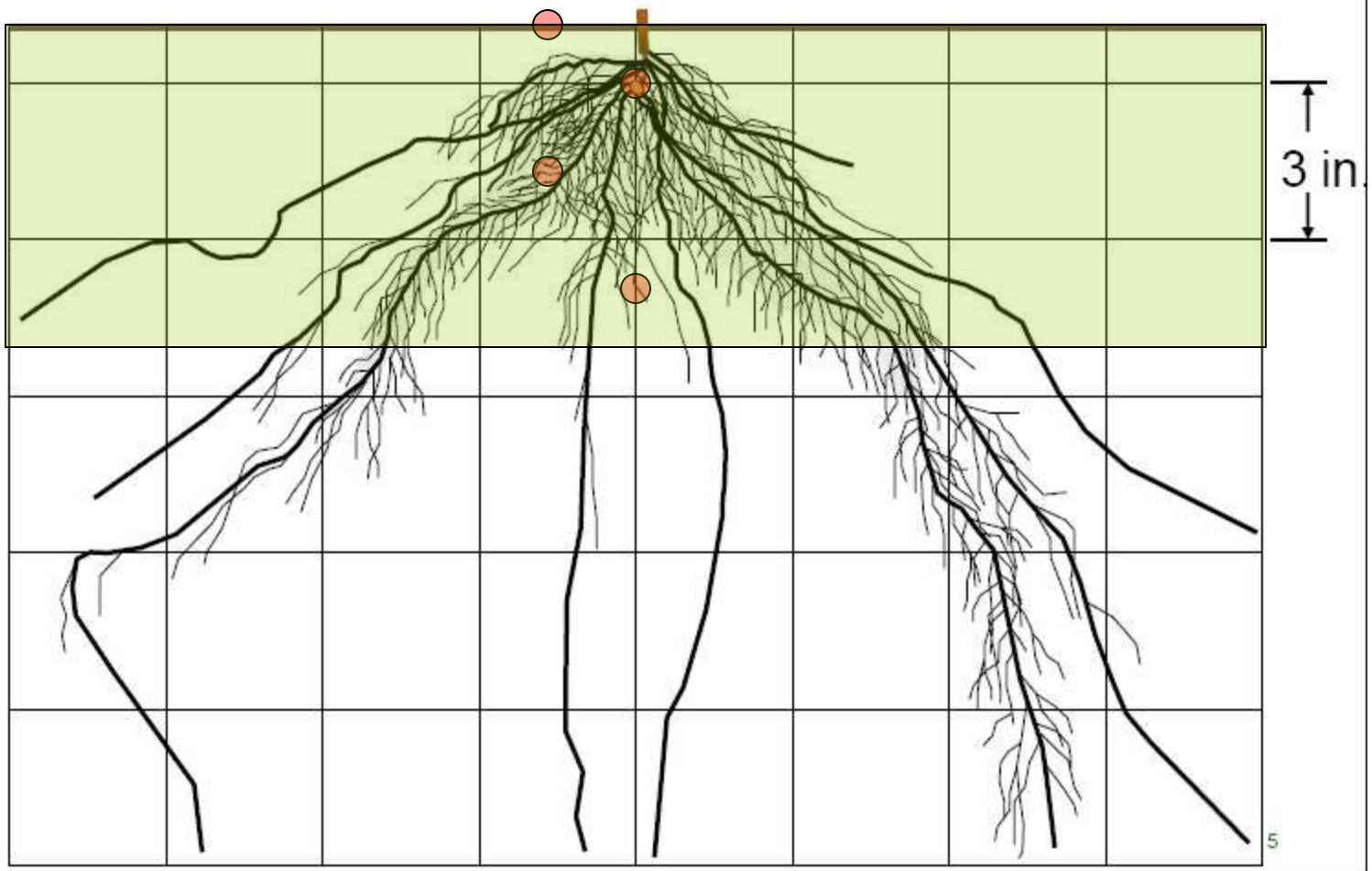
- Provides two key pieces of data
  - % of maximum yield
  - Probability of response
- Use to develop a management strategy
  - Based on attitudes toward risk
- Key points to remember
  - Yield tends to never be 0
  - Soil test declines tend to not be rapid

P Placement

- After determining how we want to manage P then we need to decide how to apply it

- Broadcast
- Band
- Foliar

Corn roots: V5



Source: Murrell - IPNI

Soil Exploration

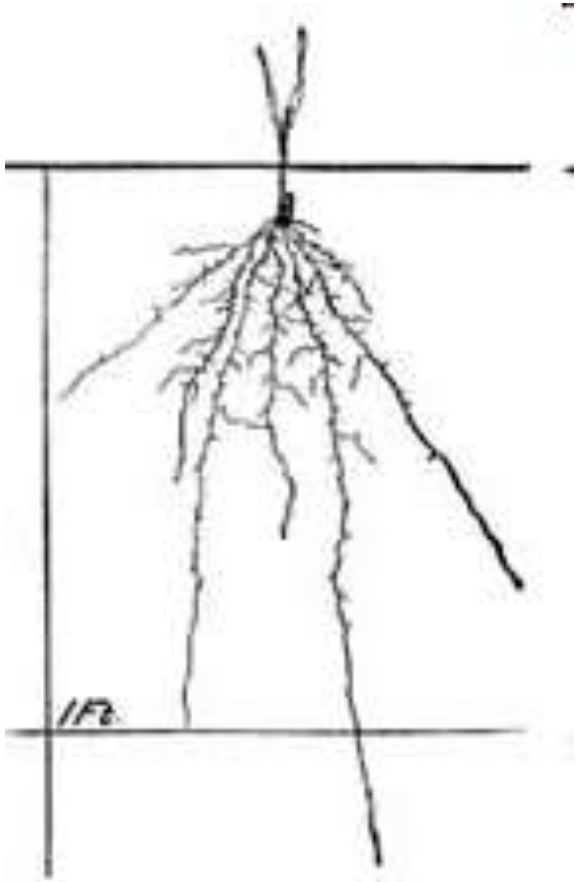
- Most crops only occupy <1 to 2% of the total soil volume
- Species will significantly differ in their rooting habits
- Must continually grow new roots to locate immobile nutrients

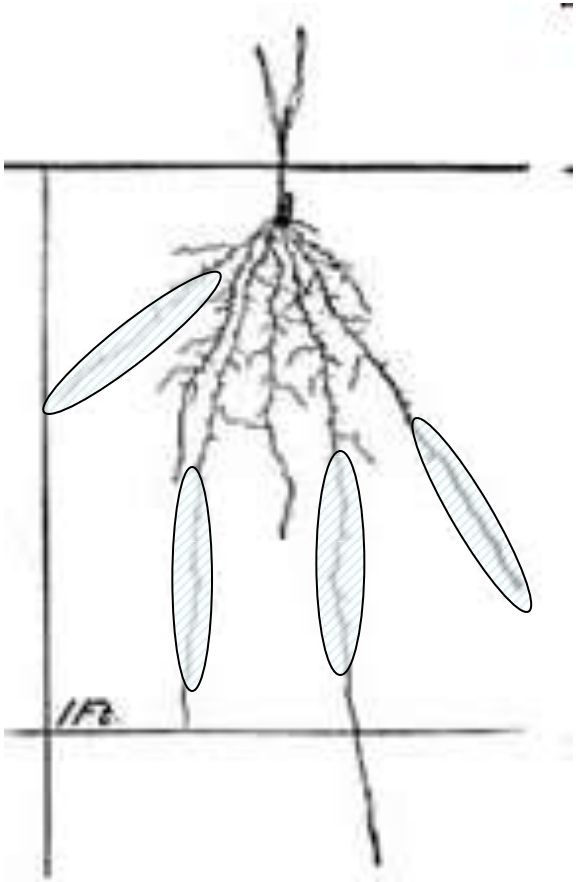
Percentage of the Total Soil Volume Occupied by Plant Roots of Different Crops
(in the surface 8-inches of soil)

Crop	Root Volume (%)
Kentucky Bluegrass	2.8
Winter Rye	0.9
Oat	0.6
Soybean	0.4 - 0.9
Corn	0.4

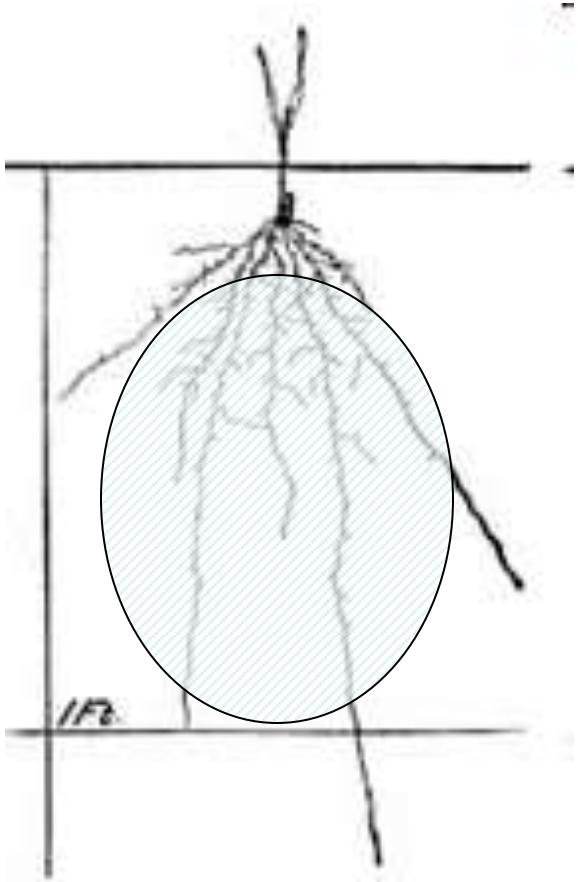
Adapted from S. Barber, *Soil Nutrient Bioavailability*, 1984

Zones of Nutrient Uptake





Immobile Nutrients



Mobile Nutrients

Diffusion – Main Mechanism of P Movement

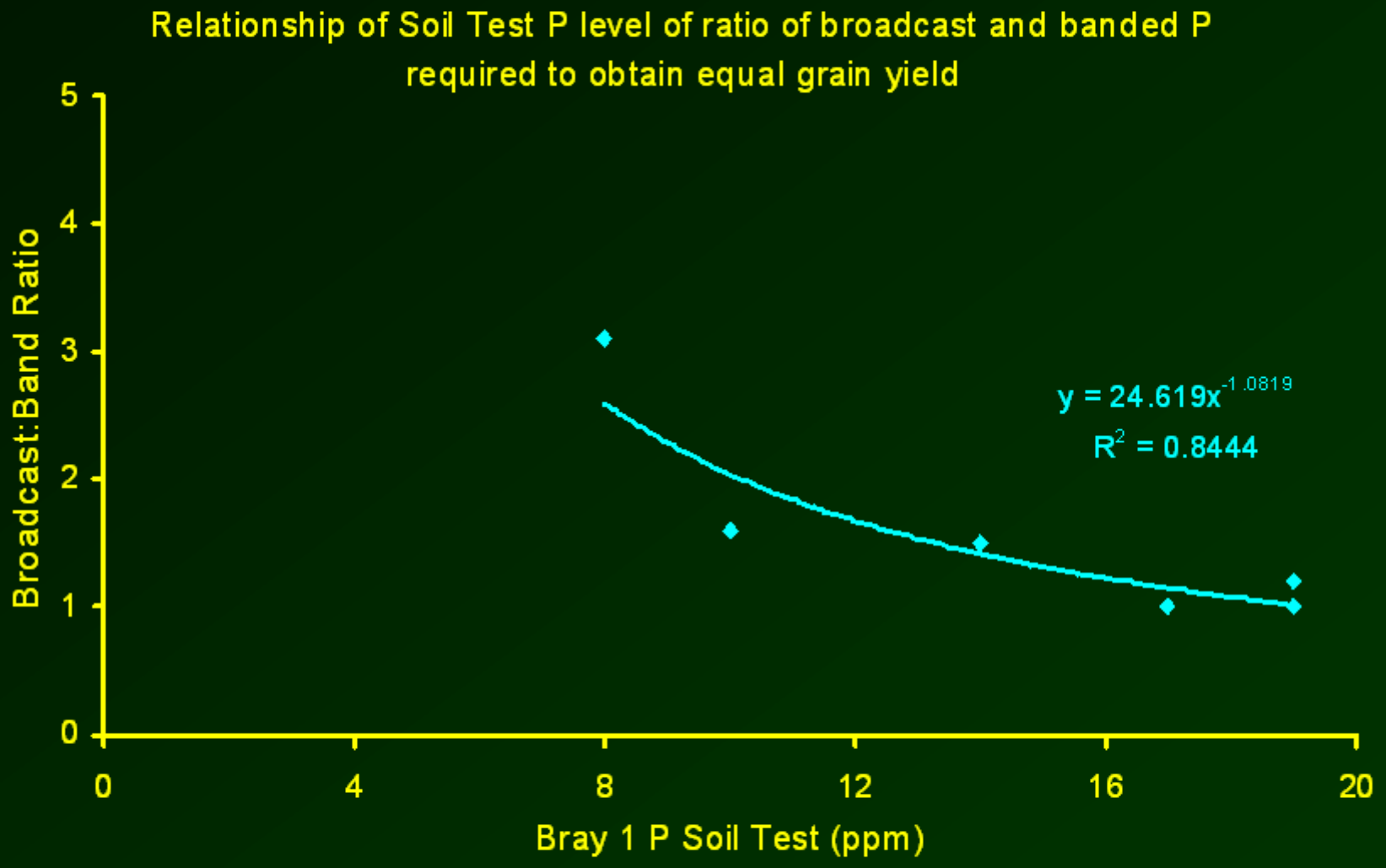
- *Diffusion distances are very short*
  - *K ~ 0.2 cm*
  - *P ~ 0.02 cm*
- *Size and density of plant root systems is very important for nutrients supplied by diffusion*
- *Soil temperature is also important*
- *Has implications for fertilizer placement*

Soil Volume Fertilized:Root and Top Growth

Soil Volume Fertilized	Tops	Roots
%	gms/plant	feet/plant
3	5.1	120
6	4.3	148
12	4.3	139
25	4.0	104

Soil Test P=low; 32 days after planting

How Effective is Banding vs Broadcast?



Peterson et al., 1981. Agronomy J.

Phosphorus Enhancers

	Phosphorus (P_2O_5) Rate						
	Starter			Bdcst		Product†	
	0	10	20	100		J	A
	---------bu/ac--------						
Sibley	228	225	229	228		+1	+4
Y. Medicine	163	166	172*	164		+3*	-1
Polk	164	166	172*	171		-1	-1

†Response to P enhancer; J, Jumpstart; A, Avail.

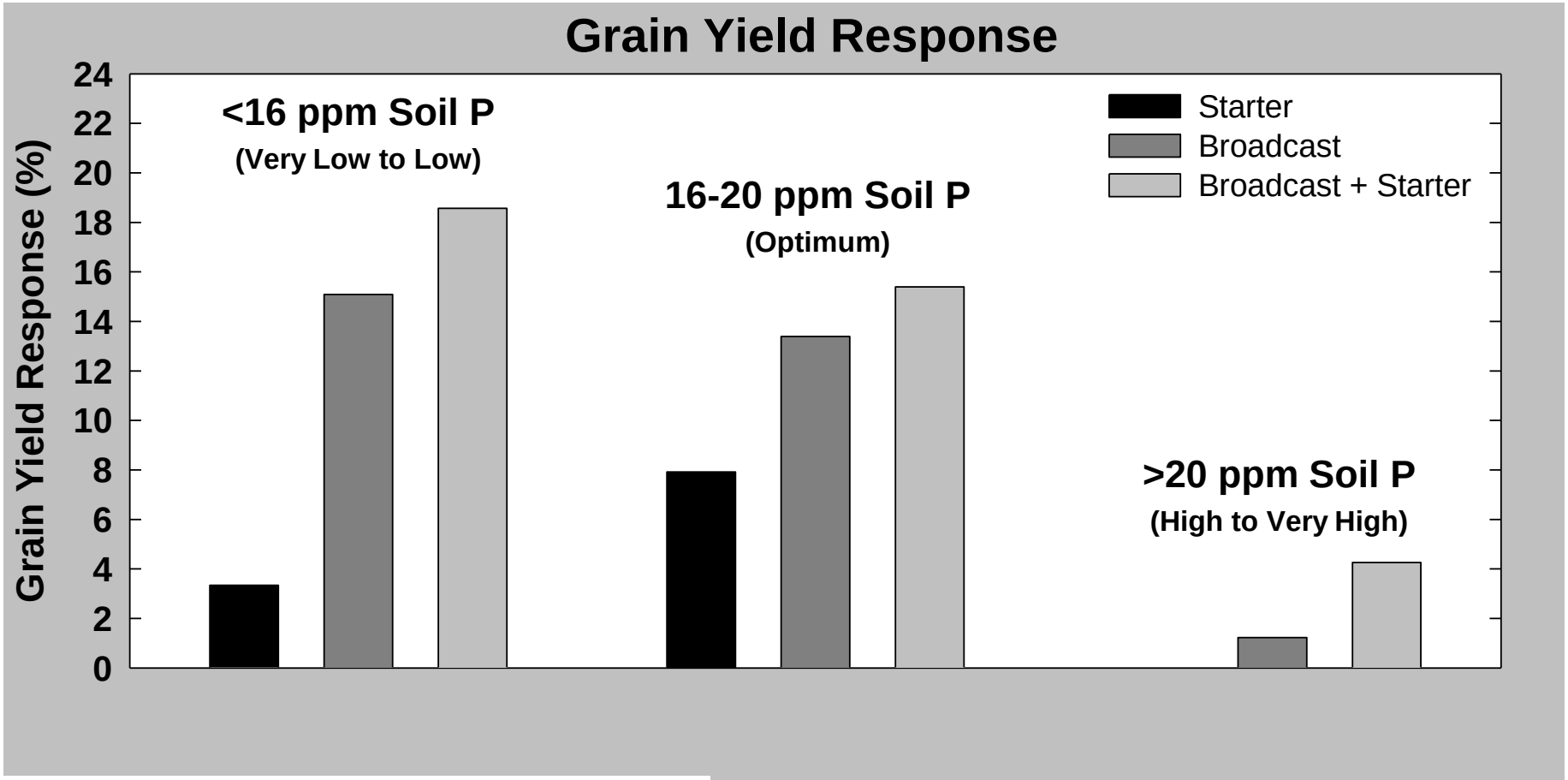
*Response was significant

Corn Data: Rehm U of M

Fertilizer Strategy -- Morris

Treatment	Phos Rate	Phos Cost	Ave Yld	STP
	lb./acre	$/acre	bu./acre	ppm*
control	0	0	169.0	4.0
removal	49	44.10	174.0	8.0
U of M bdcst	35	31.50	174.8	7.7
U of M band	25	22.50	175.0	5.0

Considerations for Second Year Crop - Soybeans



Acid Soils: Low P fixing capacity
Starter 5-6 GPA 3-18-18 – in furrow
Broadcast 100 lbs P_2O_5 & 120 lb K_2O

Mallarino & Kaiser - ISU

Band vs. Broadcast

- Banding low rates at times can produce the similar yields to higher broadcast rates
- Efficiency is likely related to:
  - Soil test P
  - P fixing capacity of soils
- Soil testing becomes more difficult with banding
- Banding is more management intensive

Banding

- Building soil test levels is likely not feasible
- Can be more cost effective
  - Good for producers who want to maximize return per acre
- Places nutrient under the surface where there is less risk for runoff loss

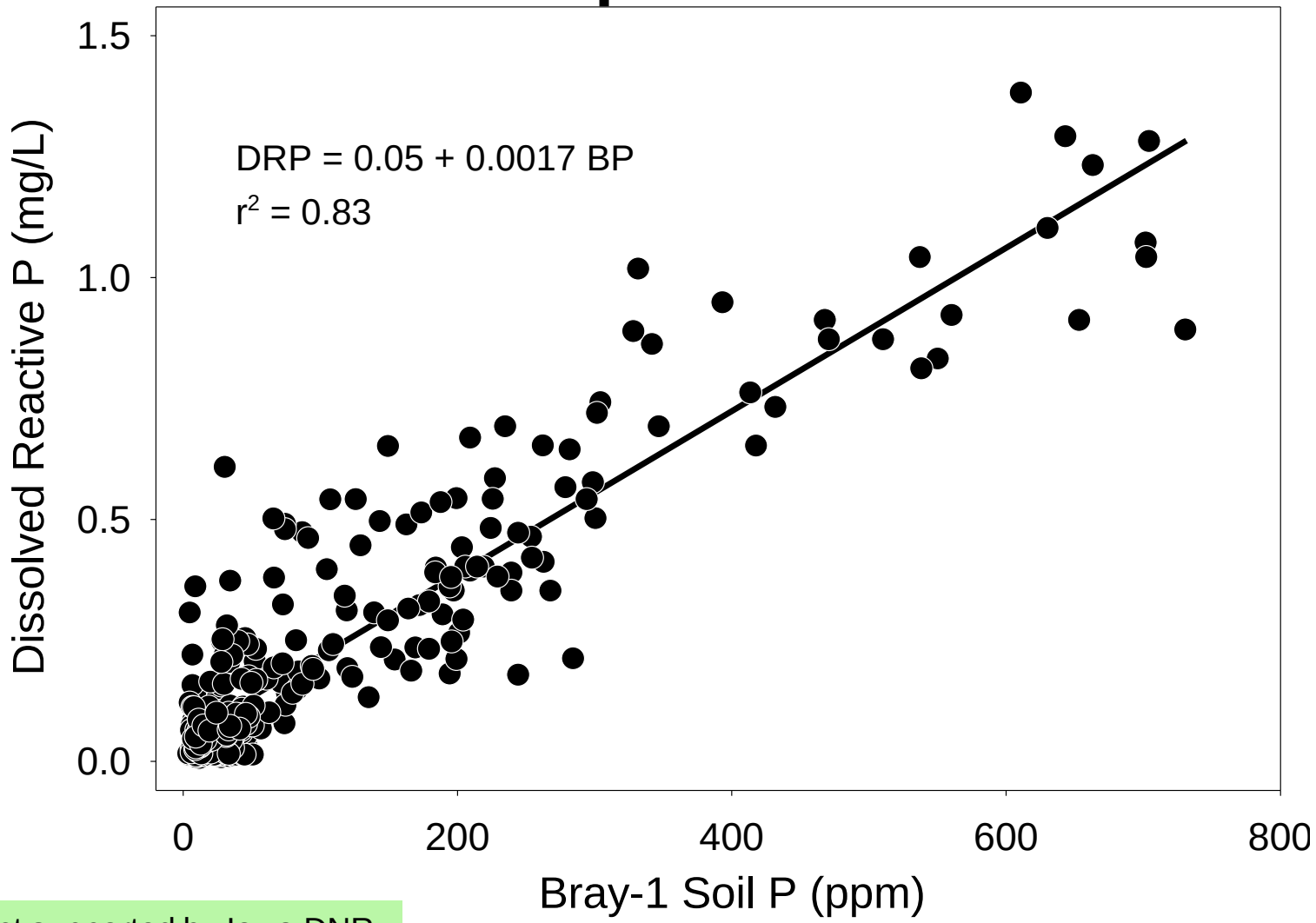
Methods of P Loss

- Surface runoff – erosion
  - Bound P – erosion
  - Manure or Fert. – Dissolved P
- Tile loss
- Crop uptake
- Fixation??

P Movement in Soils

- Most, if not all, P movement occurs with runoff
- Dissolved P is highly reactive with many elements within the soil
  - Downward movement only occurs if metal cations are not present
  - Or if the soil is saturated with P
  - Soil acts as essentially a filter for P
- Risk for dissolved P increases as soil test P increases
  - This DOES NOT mean there is necessarily a problem!

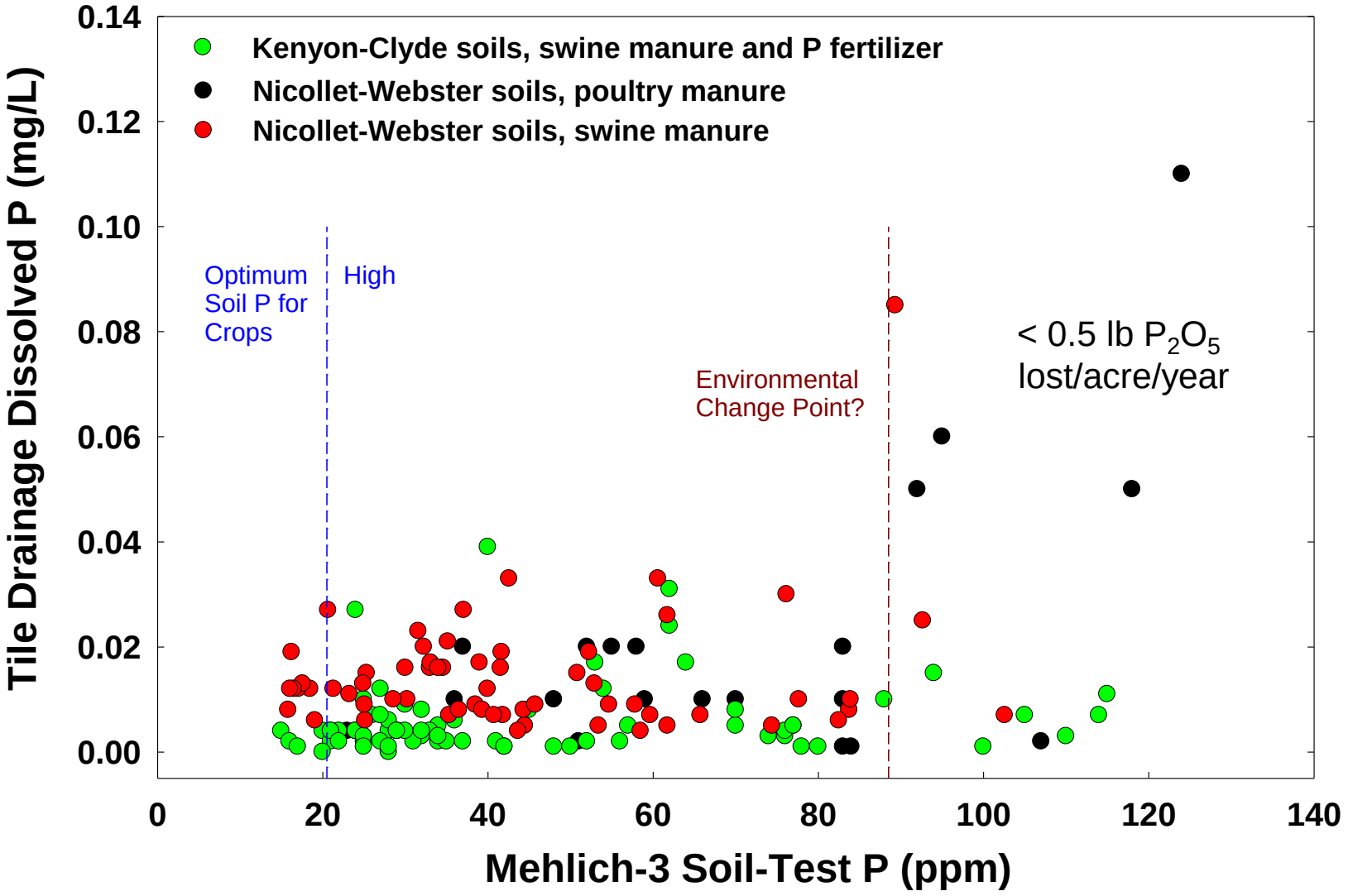
Soil-Test P and Surface Runoff P



Project supported by Iowa DNR, EPA, and USDA/NRCS

Mallarino, Allen, Haq, and Klatt. ISU

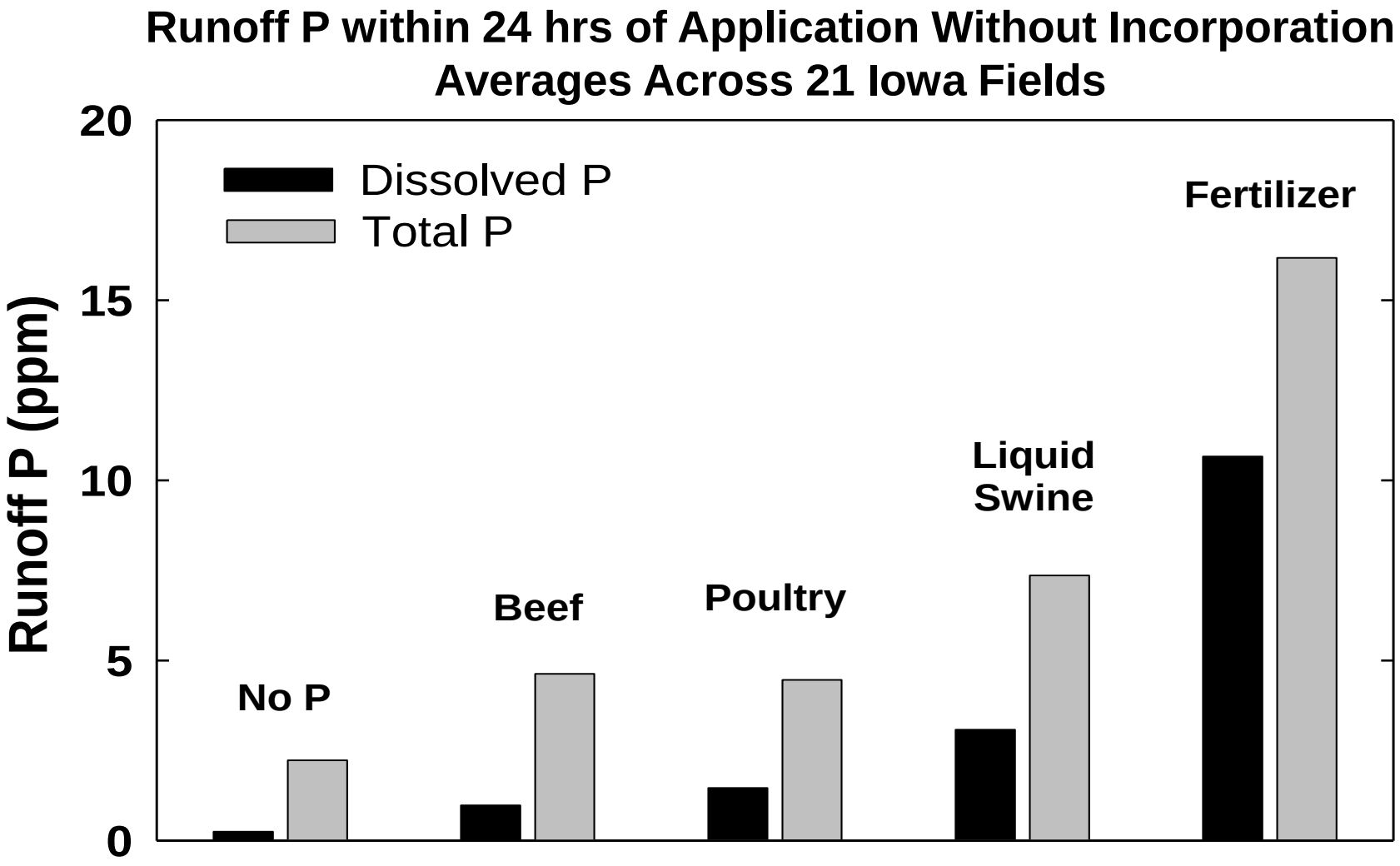
Manure P, Soil P, and Tile Drainage P



Research funded by the Iowa Water Center and the Leopold Center for Sustainable Agriculture

Mallarino, Haq, Klatt, Baker, Kanwar, Pedersen, & Pecinovsky. ISU

Manure P Source and Short-Term Runoff P

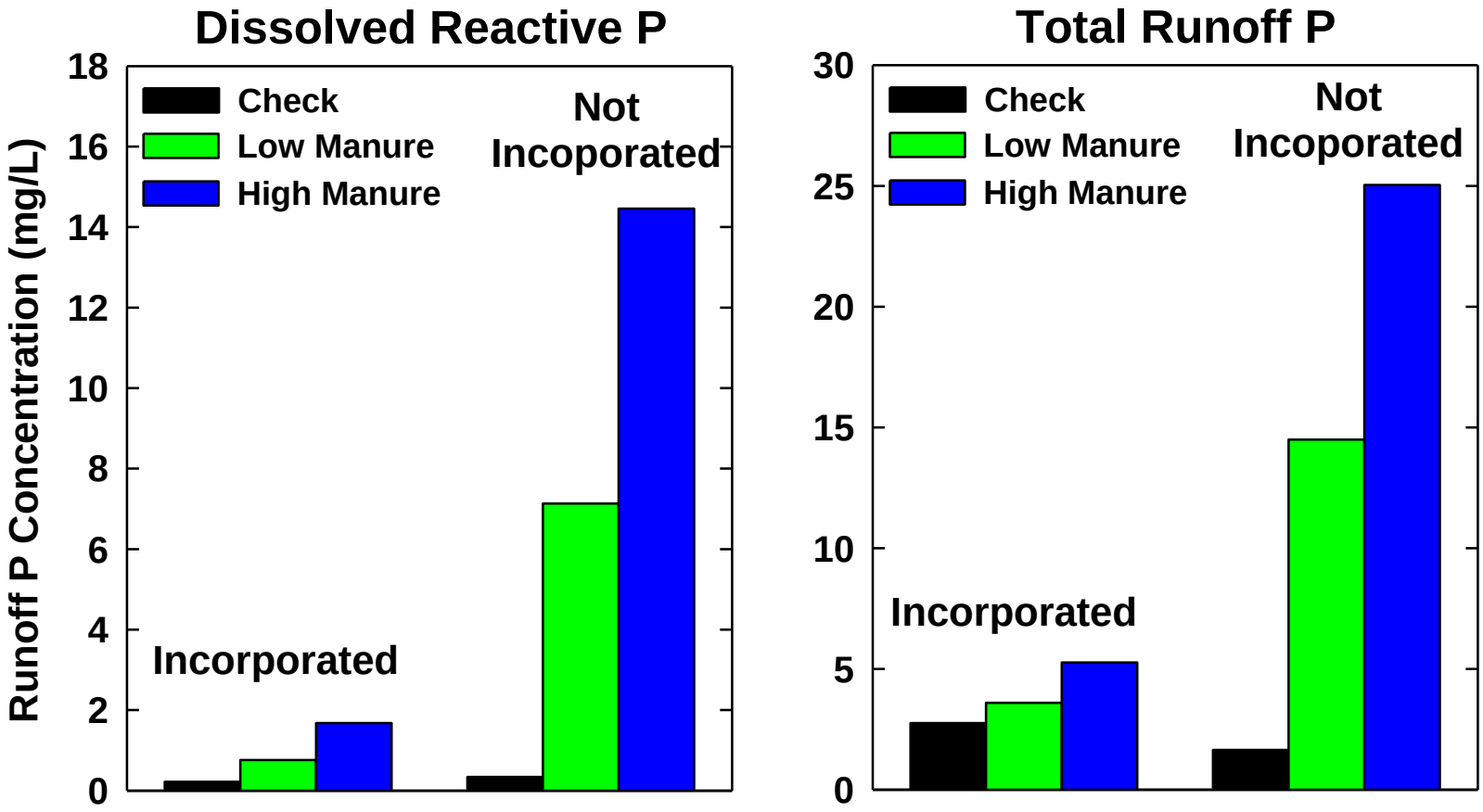


Project supported by Iowa DNR and EPA

Haq, Mallarino, & Allen. ISU

Manure Incorporation and Runoff P Loss

Poultry Manure at 0, 2, or 4 tons/acre, Shortly After Application
Averages Across Eight Fields



Project supported by the IFLM Program
of IDALS and the Iowa Egg Council

Kaiser, Mallarino, Haq, Sawyer, Thompson. ISU

Soil test P

- Need to have an upper limit
- No agronomic reason for applying P when soil test is 30 ppm or above
  - Starter applications – sometimes a response
  - Manure – some justification
- Keeping sediment loss low should be #1 priority to reduce P loss to surface waters
- Incorporation of P sources is also critical!

In Regards to P Movement

- A pound of P may not be a pound of P
  - Total P applied vs. Dissolved P loss
  - A pound of P applied may not be a pound lost
- Soil test P is an important factor for determining P loss
  - Soil erosion is a greater factor to consider
- No reason P cannot be applied beyond agronomic levels if all factors are considered

Thank You
Questions?

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