HOW DO MANURE AND COMMERCIAL FERTILIZER PHOSPHORUS SOURCES DIFFER?

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Potential Phosphorus Source Differences

- P availability to plants
- Effects on soil test P
- Effects on long-term productivity
- Effects on soil characteristics
- Effects on P losses
  - Runoff
  - Leaching

P Source Application Strategies

- Fertilizers applied to meet crop P need
- Manures applied as a component of manure management plan
- Manures often applied to meet N need
- Excess P may accumulate

Manures as P Sources

All manures are not the same –

- Animal species & management
- Water soluble P content
- Mineralization rates of organic P component
- Constituents that may react with inorganic P

Nutrient Distribution on Wisconsin Farms

- Study was based on:
  - 134 Wisconsin farms
  - Ten counties
  - 41,375 cropland acres
  - 3,208 individual farm fields

Soil Test Phosphorus Averages

Farm Type	Weighted Farm Average (ppm)	Range (ppm)	Relationship to Optimum Range (%)		
			Over	Under	Within
Dairy	60	21-144	77	12	10
Livestock	63	21-145	78	11	12
Vegetable	129	67-174	73	14	13
Cash Grain	41	19-77	78	14	8
All Farms	63	24-139	77	12	10

P Source Differences
(Plant availability of P)

- Goss & Stewart (1979)
  - Compared manure and superphosphate as P sources for alfalfa
  - Alfalfa grown with fertilizer P removed higher % of added P than with manure

P Source Differences
(Plant availability of P)

- Goss & Stewart (1979)
  - Alfalfa grown with manure P had greater yield increase/unit P uptake (efficiency).
  - Greenhouse yields higher with fertilizer, no yield difference in field experiments

P Source Differences
(Plant availability of P)

- Goss & Stewart (1979)
  - Initial microbial immobilization of P with manure addition
  - Inorganic P in manure converted to organic forms with lower initial availability
  - Later release of plant-available microbial P
  - Some mineralization of organic P is also likely

Evidence for enhanced P availability with manure vs. fertilizer P

- During & Weeda (1973)
  - Manure at equiv. rates with P fert. Decreased P sorption and increased recovery in pastures
- Abbott & Tucker (1973)
  - Residual effects of manure or fert. P in calcareous soils showed higher available P with manure
- Laboski & Lamb (2003)
  - Liquid swine manure P more available than fert. in 1 to 9 month incubation

P Source Differences
(Plant availability of P)

- Sharpley & Sisak (1997)
  - P availability greater with KH_2PO_4 than poultry litter leachate
  - Fe-oxide strip P, 7-day incub., vs. P added to 193 soils
  - Slope of relationship provides availability index

P Source Differences
(Plant availability of P)

- Sharpley & Sisak (1997)
  - Lower P availability greater with litter leachate due to P complexation with Ca and organo-Ca, Fe, Al.
  - Ca and organic compounds added in leachate

Comparison of P availability from fertilizer and poultry litter (193 soils)

P source	Calcareous soils n=56	Slightly weathered n=74	Highly weathered n=63
	-------- availability index --------		
KH_2PO_4	0.56	0.57	0.36
Litter leachate	0.34	0.33	0.19

Adapted from Sharpley & Sisak (1997)

Effect of manures and inorganic P on soil test P after 64-wk incubation

P Source	Manure P content (%)		Bray P1 (ppm)
	Total P	Water sol.	
Manure - high P diet	1.31	0.37	59b
Manure - medium P diet	1.09	0.21	55bc
Manure - low P diet	0.66	0.13	46d
Fiber fraction	0.28	0.03	34e
Whole manure	0.85	0.25	58b
Biosolids	3.97	0.22	52c
Fert. - $CaHPO_4$	--	--	70a
Control	--	--	22

Ebeling et al. (2003). Soil test P values are averages from 3 P rates 101, 202, 404 kg/ha

P Source Differences
(Effects on long-term productivity)

- Edmeades (2003)
  - Manure & fertilizer effects on soil productivity & quality
  - 14 trials, 24 paired comparisons, long-term effects (20-120 years)
  - Includes classic experiments: Morrow, Sanborn, Magruder, Breton, Broadbalk (Rothamsted), others

Manure and fertilizer effects on soil productivity and quality (Edmeads, 2003)

	Effect	
Characteristic	Manure	Fertilizer
Organic matter	higher	
Soil microfauna	higher	
Topsoil P,K,Ca,Mg	higher	
Subsoil nitrate, Ca, Mg	higher	
Crop production	NS	NS
Soil quality	?	?
Runoff and leaching of P and N	higher	
Bulk density		higher
Hydraulic conductivity	higher	
Aggregate stability	higher	

P Source Differences
(Long-term effects on soil P)

- Motavalli and Myles (2002)
  - Examined long-term (111-yr) effects of manure & fertilizer on soil P fractions in Sanborn Field
  - Continuous corn yields were consistently higher with fertilizer that with manure
  - Functional P pool shown instead of methodology

Long-term P source effects on inorganic P fractions from Sanborn Field continuous corn plots

Treatment	Avail-able	Labile	Slow	Occl-uded	Weather-able
	---------- ppm P ----------				
None	3	18	19	14	1
Fertilizer	54	55	76	39	25
Manure	56	181	149	41	23

Adapted from Motavalli and Myles (2002)

Long-term P source effects on organic P fractions from Sanborn Field continuous corn plots

Treatment	Labile	Slow	Occluded
	---------- ppm P ----------		
None	23	31	8
Fertilizer	37	104	3
Manure	23	149	41

Adapted from Motavalli and Myles (2002)

P Source Differences
(Effects on P runoff losses)

- Kleinman et al. (2002)
  - Compared surface and incorporated DAP and manures, 100 kg P/ha
  - Simulated rainfall, runoff boxes, 3 soils

Runoff P from surface and incorporated P sources on a high P soil

Treatment	Surface-applied		Incorporated
	DRP	Total P	Total P
	---------- ppm ----------		
Control	0.2a	4a	5a
DAP	13b	20b	5a
Dairy manure	2c	3.5a	9b
Poultry manure	11b	21b	7ab
Swine manure	14b	16b	7ab

Adapted from Kleinman et al. (2002). Soil = Hagerstown.

Effect of surface-applied P sources on P in natural runoff

Treatment	Cumulative load		Total P	DRP
	DRP	PP	(TP)	% of TP
	----- mg/plot ----		mg/L	
Control	5	19	0.89	24
TSP	63	19	4.79	74
Cattle manure, lq	62	26	3.99	62
Dw. sludge	8	25	1.19	28

Adapted from Withers et al. (2001)

P Source Differences
(Effects on P leaching losses)

- Eghball et al. (1996)
  - P movement in a sandy soil receiving long-term manure and fertilizer
  - Olsen STP at 1.8 m depth were greater in manure treatment
  - Little movement below 1.1 meters in no-manure plots

P Source Differences
(Effects on P leaching losses)

- Eghball et al. (1996)
  - Suggests movement of P in organic forms
  - Reaction of P with organics in manure to form more stable compounds

Laboratory leaching of P from two sandy soils treated with fertilizer or manure

Source	Rate	Soil P-sorbing capacity	
		Moderate	Very low
	kg P/ha	---- % of P leached ----	
Fertilizer (TSP)	56	1.7	13.6
	224	21.7	20.7
Chicken manure	56	0.12	0.9
	224	0.89	3.0

Adapted from Elliott et al., 2002

Summary

- P availability from manures is equal or less than fertilizer P
- Manure availability is influenced by:
  - Organic P mineralization
  - Initial microbial immobilization
  - Reaction of P with manure constituents
  - Manure soluble P content

Summary

- Recommendations for crediting manure P recognize possibility of lower availability
  - 60-75% of manure total P considered available
- Evidence for higher P availability with manure vs. fertilizer exists
  - Mechanisms may involve prevention of reactions converting available P to slowly soluble inorganic forms

Summary

- Manure vs. fertilizer P effects on long-term productivity indicate no clear advantage to manure
- Long-term manure applications improve many soil characteristic associated with soil quality
- Potential for adverse effects on water quality may be higher with long-term manure additions

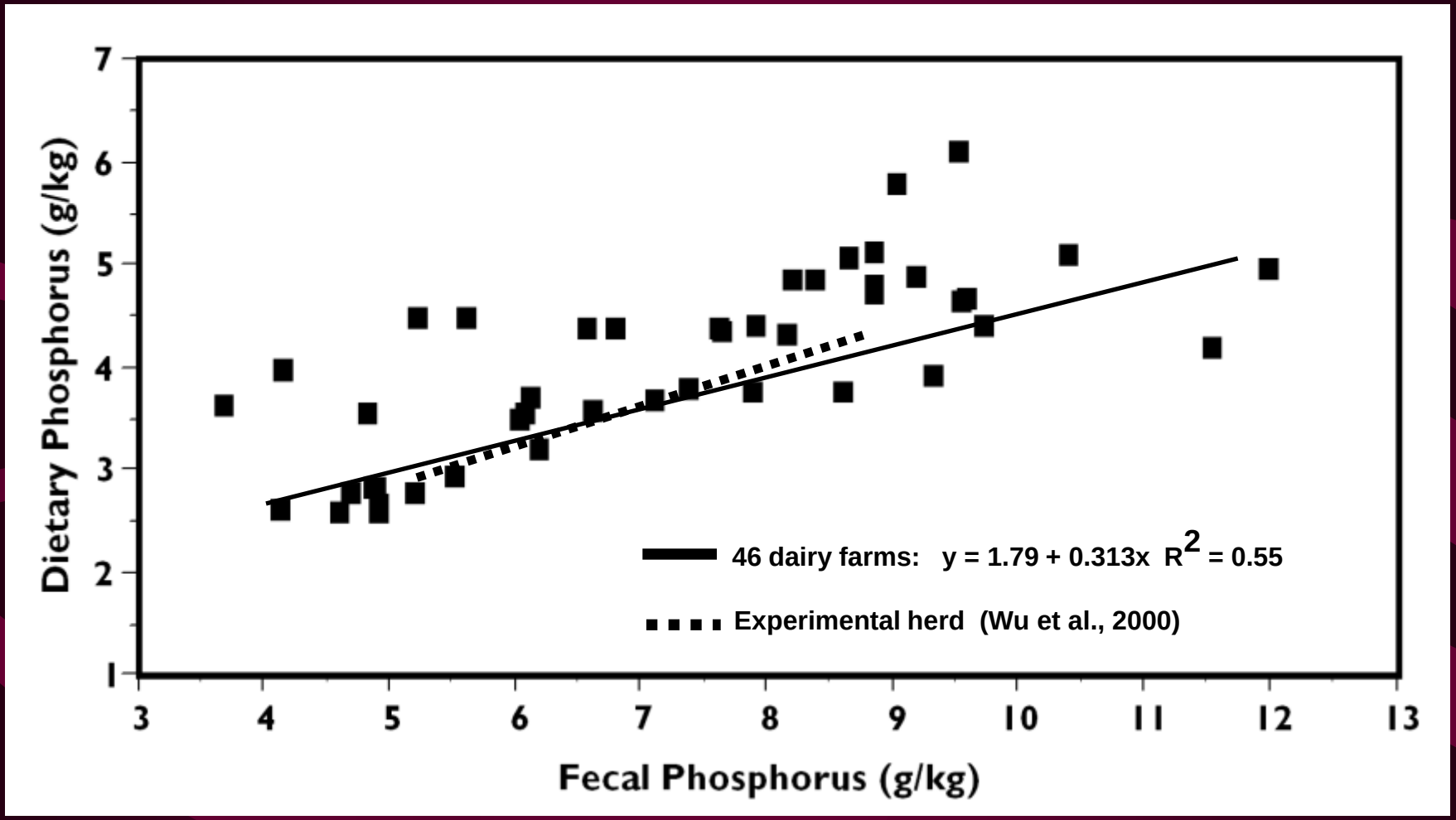
Summary

- Long-term manure and fertilizer applications influence organic and inorganic P fractions
- Differences in runoff losses between manure and fertilizer are often due to placement method and dry matter and soluble P content of manures

Summary

- Manure vs. fertilizer P effects on P leaching are mixed, and may be determined by soil P sorption capacity

Dietary P effects on manure P



Powell et al., 2002

Relative amount of nitrogen and phosphorus in manure and used by crops