# 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

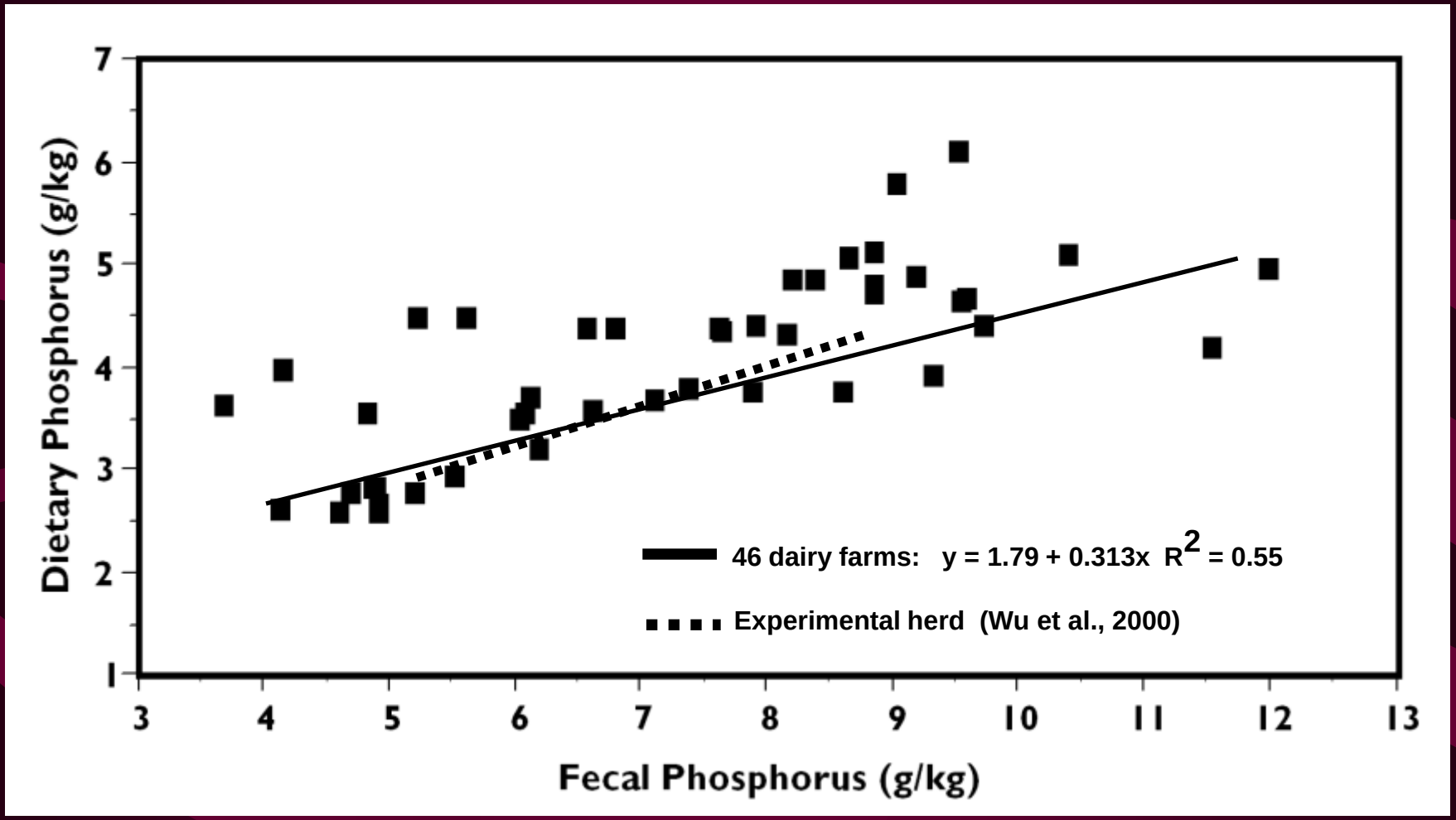
# Summary

- 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