# Manure, Crops and Soil Health

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# Manure:

*A resource:*

Fertilizer: N, P, K, S, Micronutrients:

Soil Builder: Organic Matter,
especially solid manures

# Manure:

*A challenge:*

- **Dilute** e.g. Liquid hog effluent 0.1% N to 0.5% N
  Feedlot manure 0.5% N to 1.5% N
  Liquid N fertilizer 28% N
- **Variable** Must test to know what is in it.
- **Restrictive** May not have the balance of nutrients needed. May need to supplement with commercial fertilizer.

# How to Manage Manure?

- ✓ **As a Fertilizer**
  - ✓Know What's In It
  - ✓Know How It Behaves

***Liquid Effluents:*** High availability of nutrient in year of application, not much organic matter.

***Solid Manures:*** Slow availability of nutrients, lots of organic matter, long-term soil builder.

# Nature of Manure Nutrients

## Liquid Swine Effluent

~ 98% $H_2O$: low in O.M. per unit of wet weight.

15 - 50 lbs Total Nitrogen / 1000 gallons.

30% to 90% of the total N is ammonium.

*Availability of liquid effluent N in year of application*

Ammonium N + Organic N

(100% available) (20% - 30% available)

**~ 50% to 70% availability of N** in swine effluent compared to commercial urea fertilizer.

Good source of readily available nitrogen!

# Phosphorus in Liquid Effluent:

- closely related to solids content: solids ↑, P ↑
- 1 to 20 lbs total P / 1000 gallons.
  10% to 50% of P is readily soluble

*Availability of effluent P in year of application*

~ 50% compared to commercial P fertilizer.

P in manure *initially* quite strongly fixed in many Western Canadian soils.

– Repeated application can result in saturation of fixation sites.

## Potassium, Sulfur, Micronutrients in Effluent:

- 8 to 20 lbs K / 1000 gallons
  - K is readily available to crops.

  *Manures are a good source of potassium*

- 0.1 to 3 lbs S / 1000 gallons
  - S content of effluents is low:

  *high S demanding crops may benefit from additional fertilizer S.*

- 0.05 to 0.5 lbs Cu, Mn, Zn / 1000 gallons
  - Micros strongly fixed in our soils.

  *Manures increase micronutrient metal availability.*

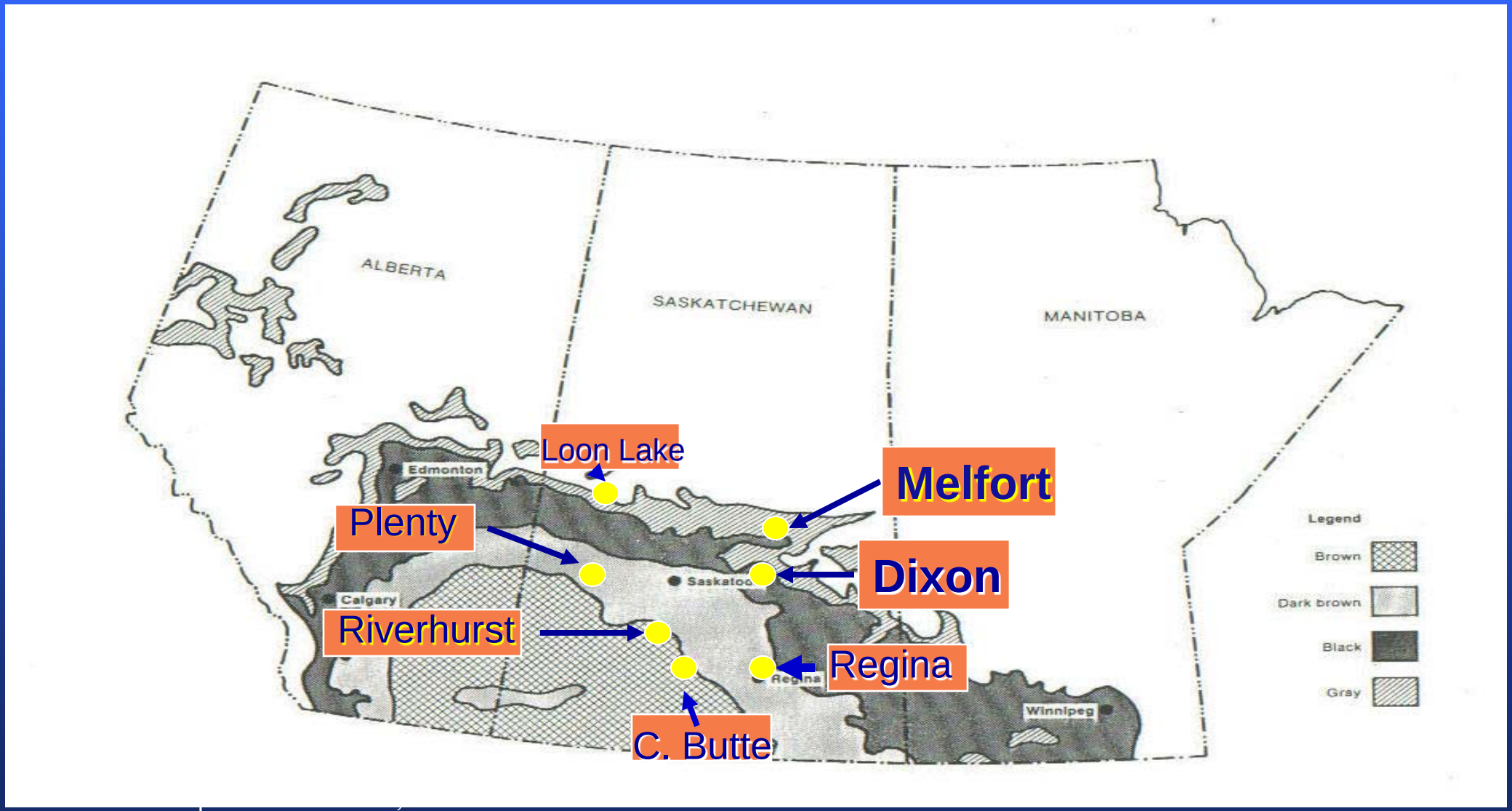
- Sodium content 3- 8 lbs Na / 1000 gallons
  - Effects of repeated applications on soil sodicity and salinity should be monitored.

# Solid Manures

- ~ 50 % water (varies!).
- Compared to effluents, much more organic matter: improves soil tilth, slowly increases nutrient supply power.

Long-term soil builders  soil organic matter 

# Manure Field Research Site Locations




(Dept. of Soil Science, University of Saskatchewan)

# NUTRIENTS

***AGRONOMIC RATE:***

*Rate of manure nutrient that balances crop requirement/removal over time*

**IS SUSTAINABLE, BENEFICIAL IN SHORT AND LONG-TERM: To crops, soils and environment**

RE: ~40,000 litres/ha (3000-4000 gpa) of liquid hog every year

~80,000 litres/ha of liquid hog every 2nd year

~7 tonnes/ha of dry cattle manure every year

~14 tonnes/ha of dry cattle manure every 2nd year

# Manure applied at appropriate rate and method of application is sustainable and economical

## Nutrient Management Planning: *A Balancing Act*

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# Goal: Maximize Crop Utilization

| Rates: | Cumulative Recovery of N by Crop |
|---|---|
| Swine ~ 100 lbs N/ac/yr for 4 yrs | 43% |
| Urea ~ 100 lbs N/ac/yr for 4 yrs | 50% |
| Swine ~ 400 lbs N/ac/yr for 4 yrs | 29% |

# How to make efficient use of manure nutrients?

Apply at recommended rates which balance crop removal over time

**If apply too much, end up with excess nutrient, crop injury.**
**Greater losses of nutrient to water and air.**

# Deep leaching from excessive rates

## Liquid swine manure applied every year for thirteen years in Black soil zone: Soil nitrate levels in fall of 2009

| | 0-60cm | 60-90cm | 90-120cm |
|---|---|---|---|
| | ---------- lb/acre soil nitrate ---------- | | |
| ~80 lbN/ac/yr (3000 gpa LSM) | 35 | 40 | 31 |
| ~320 lbN/ac/yr (12000 gpa LSM) | 396 | 70 | 85 |
| Urea @ 200 lb N/ac/yr | 224 | 117 | 63 |
| Cattle Manure @300 lbN/ac (15 dry tons/ac/yr) | 32 | 10 | 23 |

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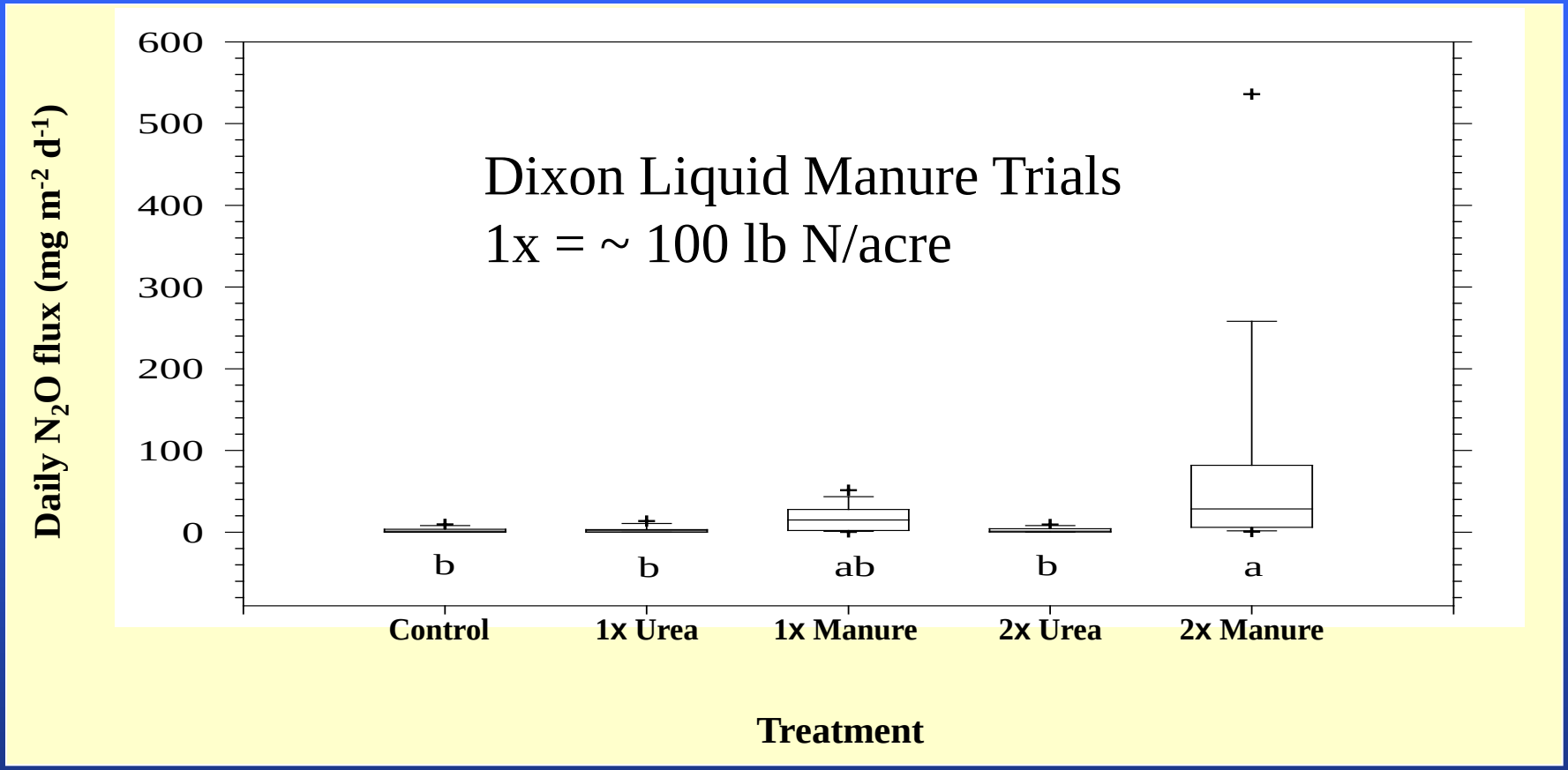
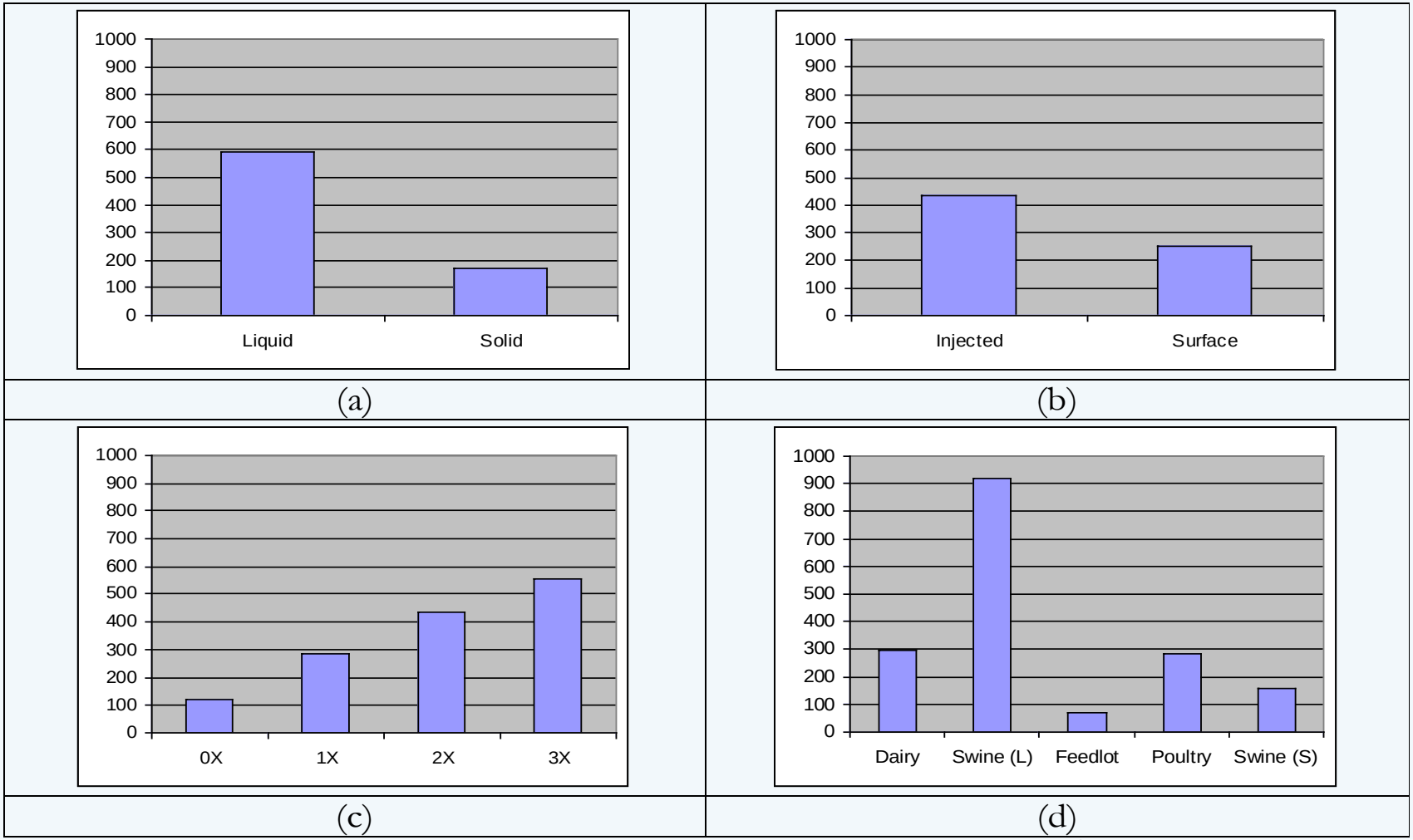
# Greenhouse Gas Production




Rates above agronomic rate significantly increase nitrous oxide production (Dauk et al. 2002)

Agnew, Lague and Schoenau, 2007




Mean greenhouse gas emissions **(carbon dioxide equivalents: ug $CO_2$ equivalent/$m^2$/s)** one day after application of manure as affected by manure type, placement and rate in a field study in Saskatchewan.

Watch for crop injury if high rate of liquid swine manure is applied in dry spring and crop seeded into treated layer.

Reduced germination and emergence of flax under drought in 2002 with high (4X) rate of preplant injected swine manure

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# N:P Ratio

| Some Livestock Manure | Crop Uptake |
| --- | --- |
| 3-5:1 | 8-10:1 |

Application of P - rich manure based on crop N requirements

= residual P accumulation in soil

Phosphorus can move with run-off water into streams and lakes

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# P Balance at Dixon Liquid Hog Manure Site 1997-2004

| Treatment | Total P | | |
|---|---|---|---|
| | Inputs† (A) | Outputs‡ (B) | Net (A-B) |
| | kg P $ha^{-1}$ | | |
| Control | 0 | 27 | -27 |
| 37,000 L $ha^{-1}$ Injected | 35 | 70 | -35 |
| 74,000 L $ha^{-1}$ Injected | 70 | 84 | -14 |
| 148,000 L $ha^{-1}$ Injected | 139 | 90 | 49 |
| 37,000 L $ha^{-1}$ B&I§ | 35 | 60 | -25 |
| 112 kg N $ha^{-1}$ Urea | 0 | 64 | -64 |

† Calculated from manure P concentration applied each year

‡ Calculated from grain yield multiplied by %P concentration in grain

§ B&I denotes broadcast and incorporate application

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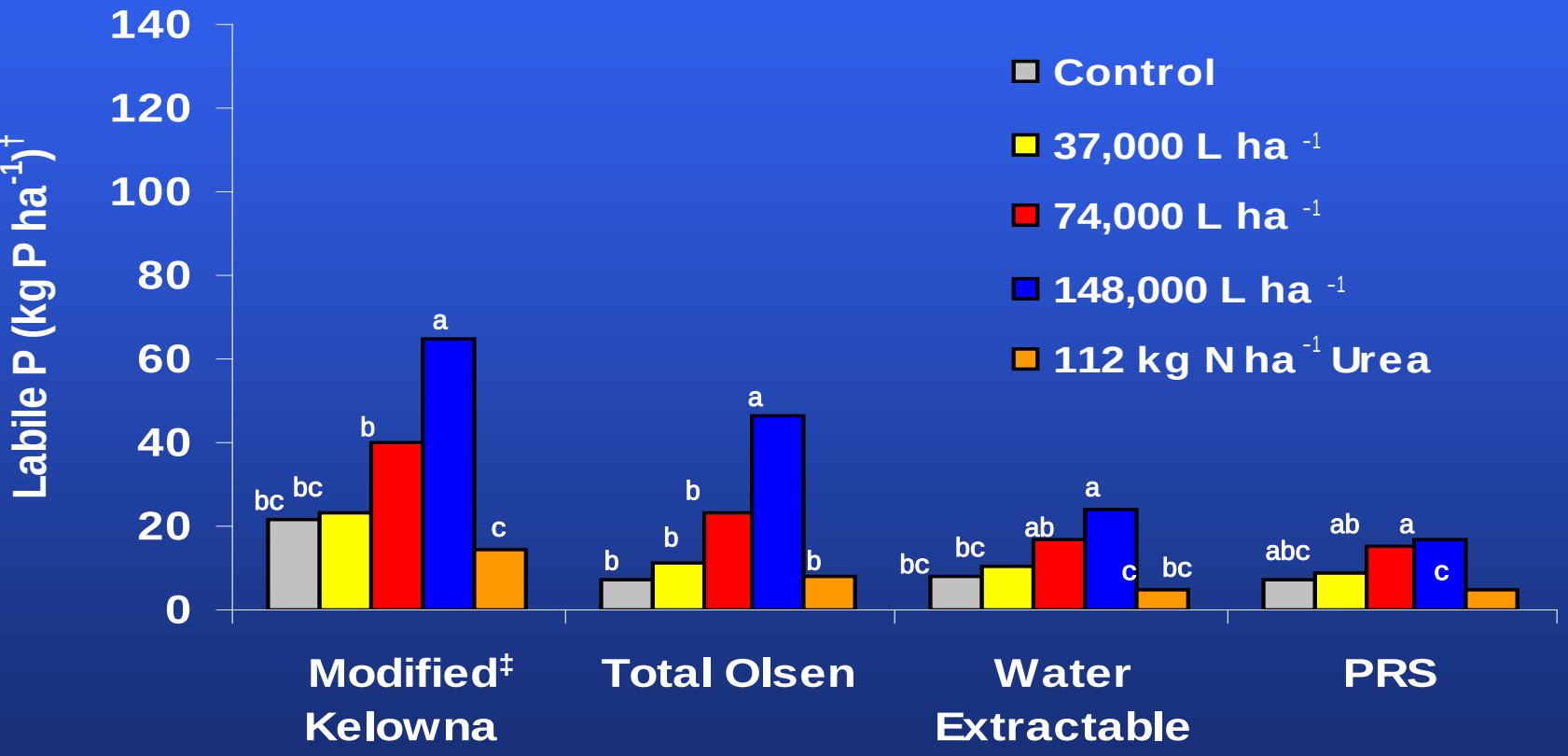
# Comparison of labile P measures with Liquid Swine Manure rate at Dixon, spring 2004 (0- to 15-cm) (Stumborg and Schoenau, 2008)

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# P Balance at Dixon Solid Cattle Manure Site from 1997-2004

| Treatment | Total P | | |
|---|---|---|---|
| | Inputs† (A) | Outputs‡ (B) | Net (A-B) |
| | kg P $ha^{-1}$ | | |
| Control | 0 | 32 | -32 |
| 7.6 T $ha^{-1}$ B&I§ | 265 | 52 | 213 |
| 15.2 T $ha^{-1}$ B&I | 531 | 72 | 459 |
| 30.4 T $ha^{-1}$ B&I | 1062 | 90 | 972 |
| 112 kg N $ha^{-1}$ Urea | 0 | 73 | -73 |

† Calculated from manure P concentration applied each year

‡ Calculated from grain yield multiplied by %P concentration in grain

§ B&I denotes broadcast and incorporate application

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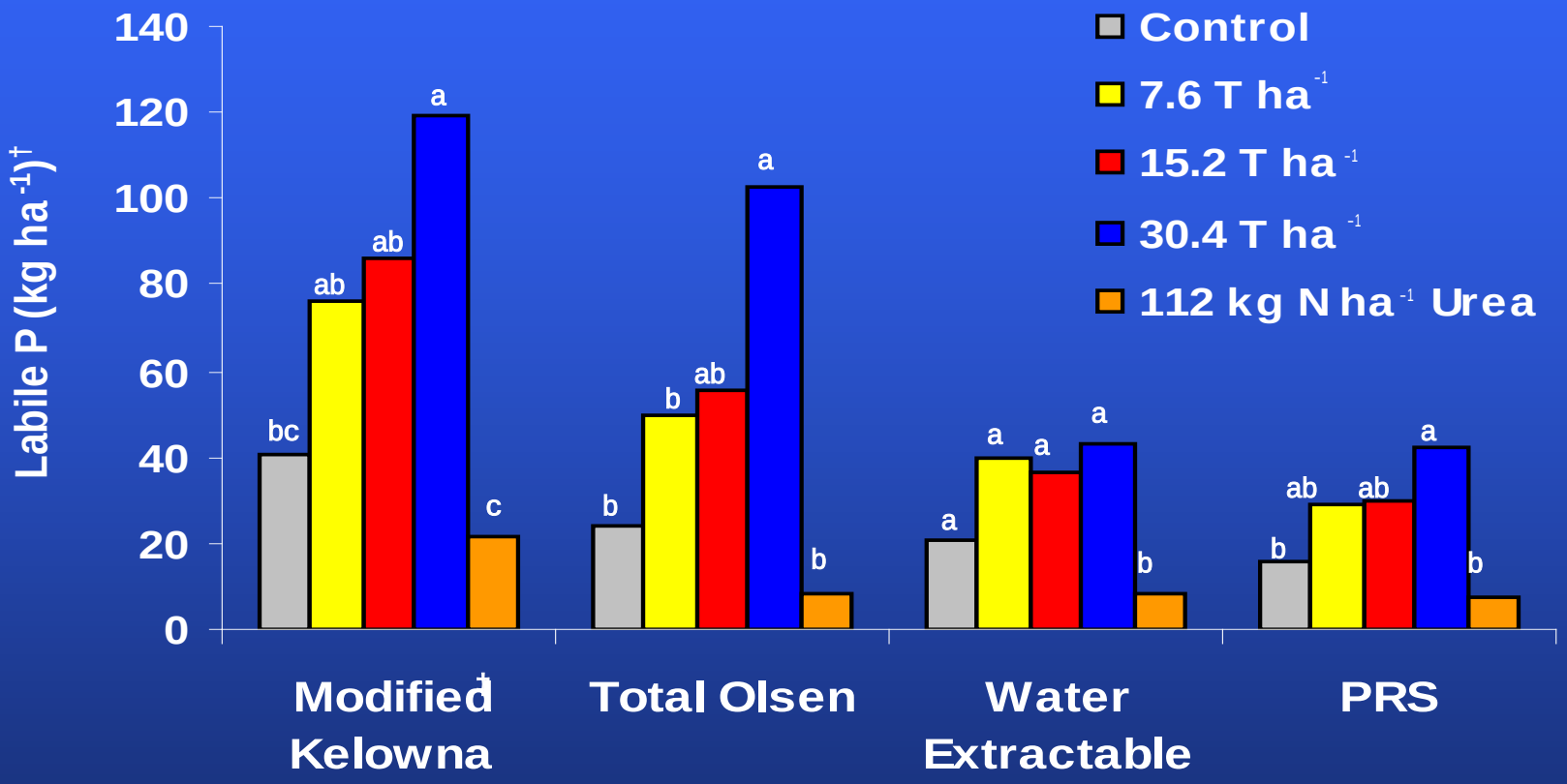
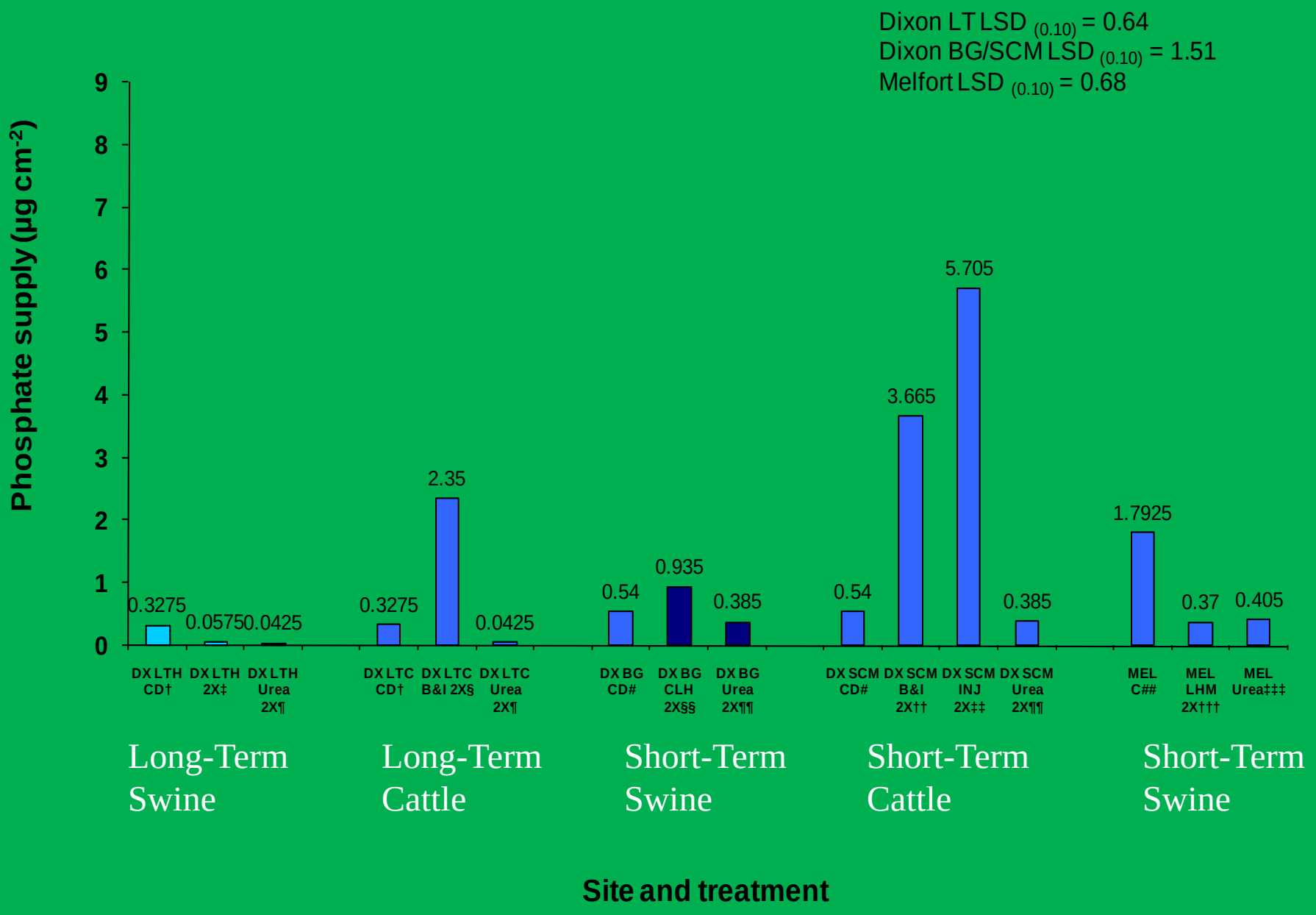



† PRS is measured as µg P 10 $cm^{-2}$, not kg P $ha^{-1}$

‡ LSD is calculated at $p$ = 0.10


Dixon LT LSD (0.10) = 0.64
Dixon BG/SCM LSD (0.10) = 1.51
Melfort LSD (0.10) = 0.68
Phosphate supply (µg cm-2)
9
8
7
6
5
4
3
2
1
0
0.3275
0.05750.0425
0.3275
2.35
0.0425
0.54
0.935
0.385
0.54
3.665
5.705
0.385
1.7925
0.37
0.405
DX LTH CD†
DX LTH 2X‡
DX LTH Urea 2X¶
DX LTC CD†
DX LTC B&I 2X§
DX LTC Urea 2X¶
DX BG CD#
DX BG CLH 2X§§
DX BG Urea 2X¶¶
DX SCM CD#
DX SCM B&I 2X††
DX SCM INJ 2X‡‡
DX SCM Urea 2X¶¶
MEL C##
MEL LHM 2X†††
MEL Urea‡‡‡
Long-Term Swine
Long-Term Cattle
Short-Term Swine
Short-Term Cattle
Short-Term Swine
Site and treatment

# Method of Application

- **Liquid manure applications broadcast and left on <u>surface</u> generally result in <u>higher losses</u> compared to <u>injection or incorporation</u>**

  *N: ammonia volatilization losses* *P: run-off*

- Over 13 years at Dixon, <u>every year</u> see <u>higher yield</u>, higher crop N recovery from <u>injected</u> liquid hog vs. broadcast and incorp.

| Treatment | Cumulative Crop N Recovery |
|---|---|
| Liquid Swine ~ 100 lbs N/ac/yr **<u>injected</u>** | **43%** |
| Liquid Swine~ 100 lbs N/ac/yr **<u>broadcast/incorp.</u>** | 31% |

# Solid Manure Injection?

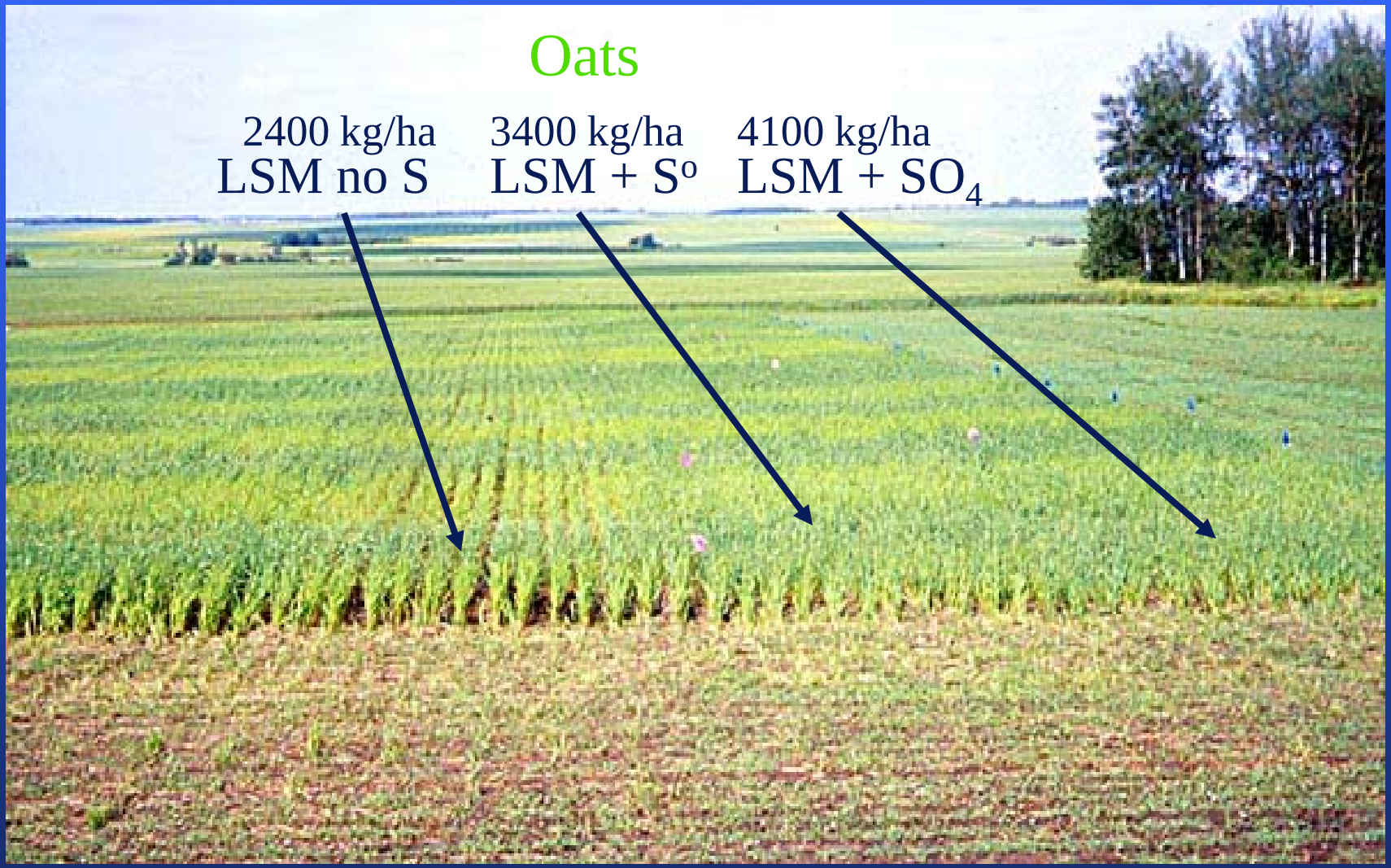

**Three years of data (07-09) from study at Humboldt showed no large differences in yield, N recovery between surface, B&I, and injected SCM.**

**Manure had low content of ammonium, therefore low volatilization potential.**

# Nutrient Source Effects

Liquid Swine Manure:

Readily plant available nutrients, especially N, but may be low in S

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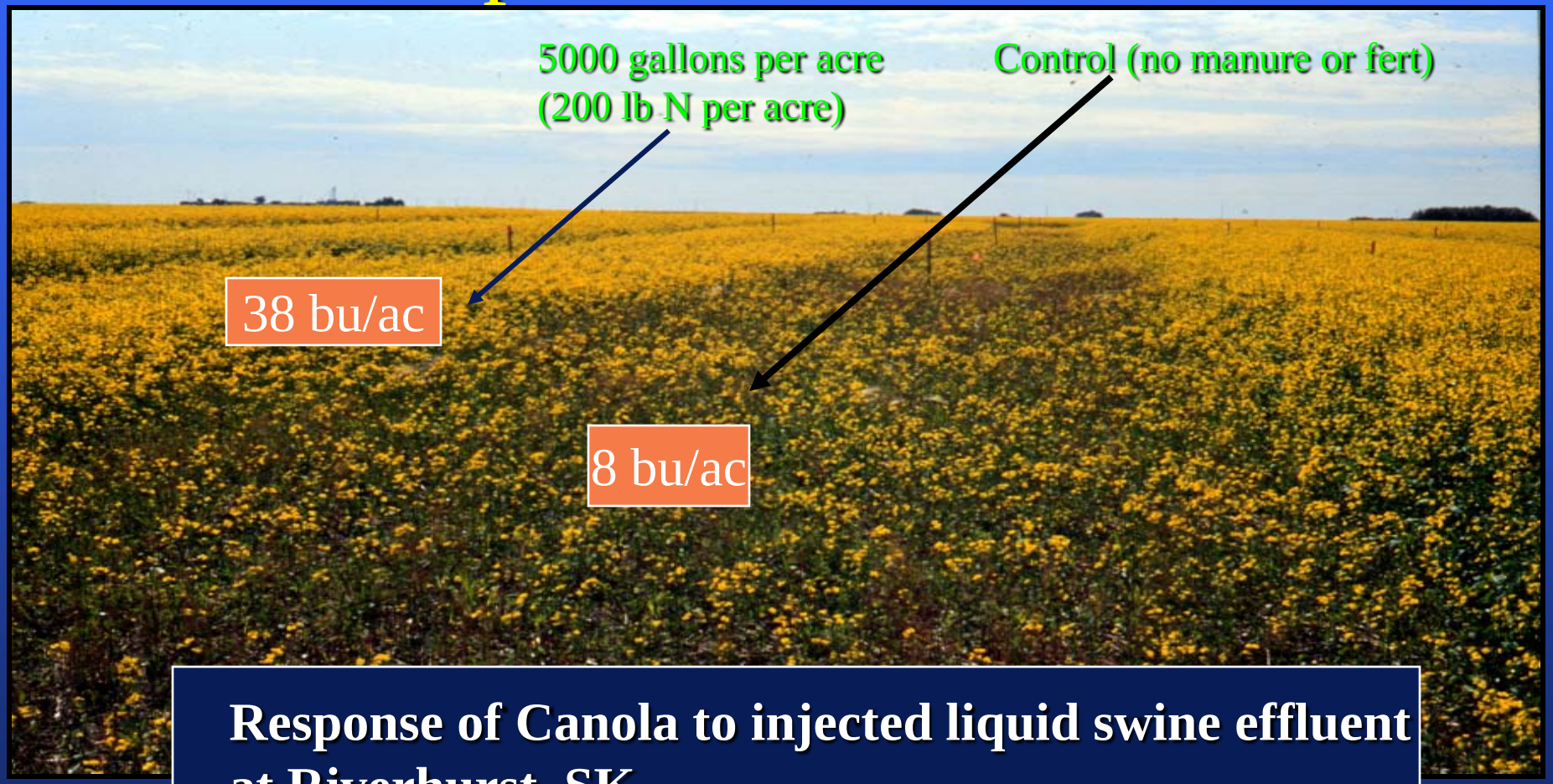
# Consistently see good yield responses to manure




**Response of Canola to injected liquid swine effluent at Riverhurst, SK**

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# Manure also contains components that can affect soil quality when land applied over the longer term:

**Organic Matter ->** Biological activity, Tilth, Buffer Agent, Water Dynamics

**Functional and Non-Functional Elements**

plant nutrients  sodium salts, metals

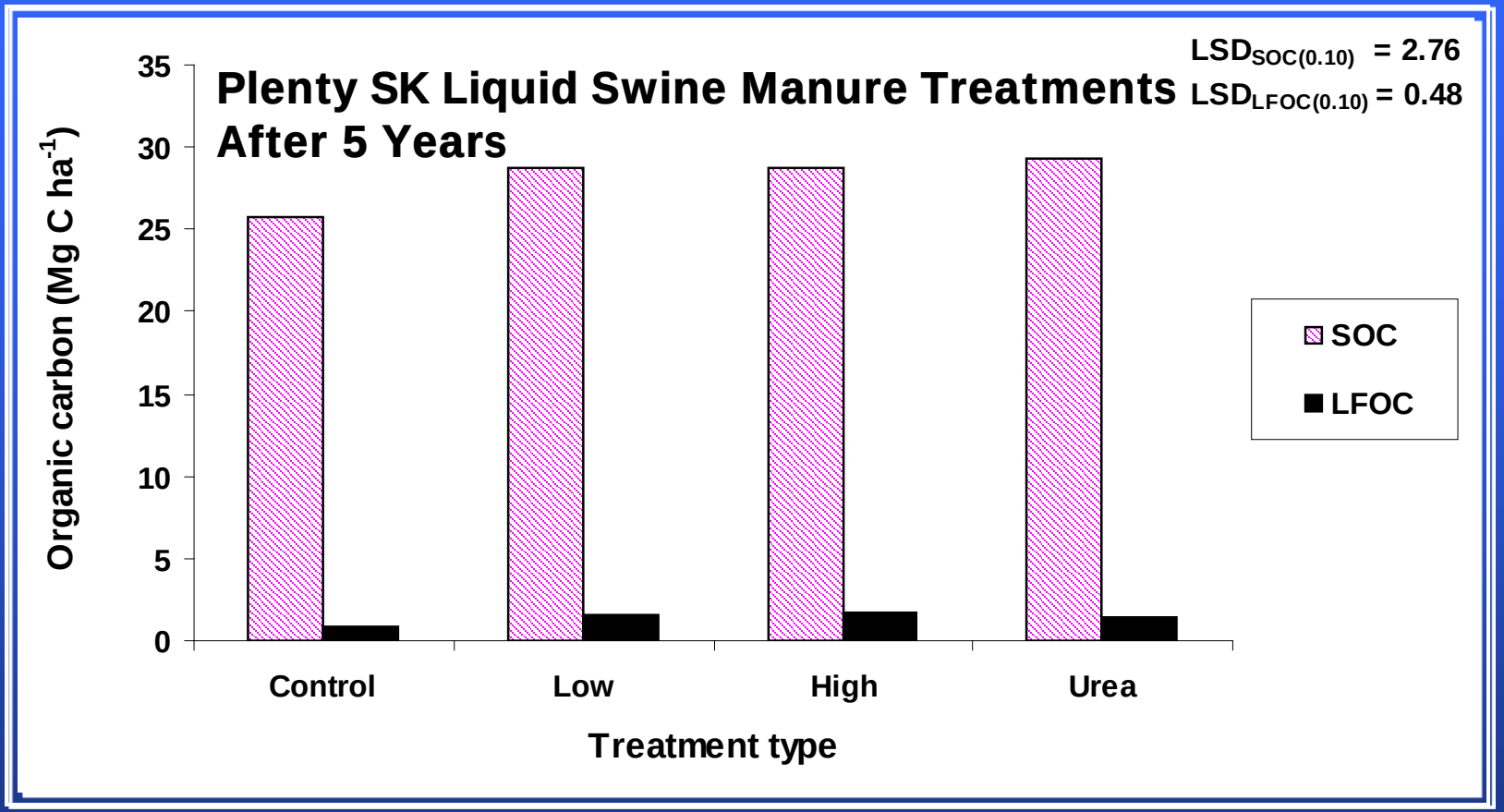
# Organic Matter and Soil Biology

- Repeated application of solid manure most effective at increasing organic matter: large direct addition.

- Liquid manures of low organic matter content increase organic matter more slowly and indirectly by stimulating plant production and residue addition (King et al., 2004).

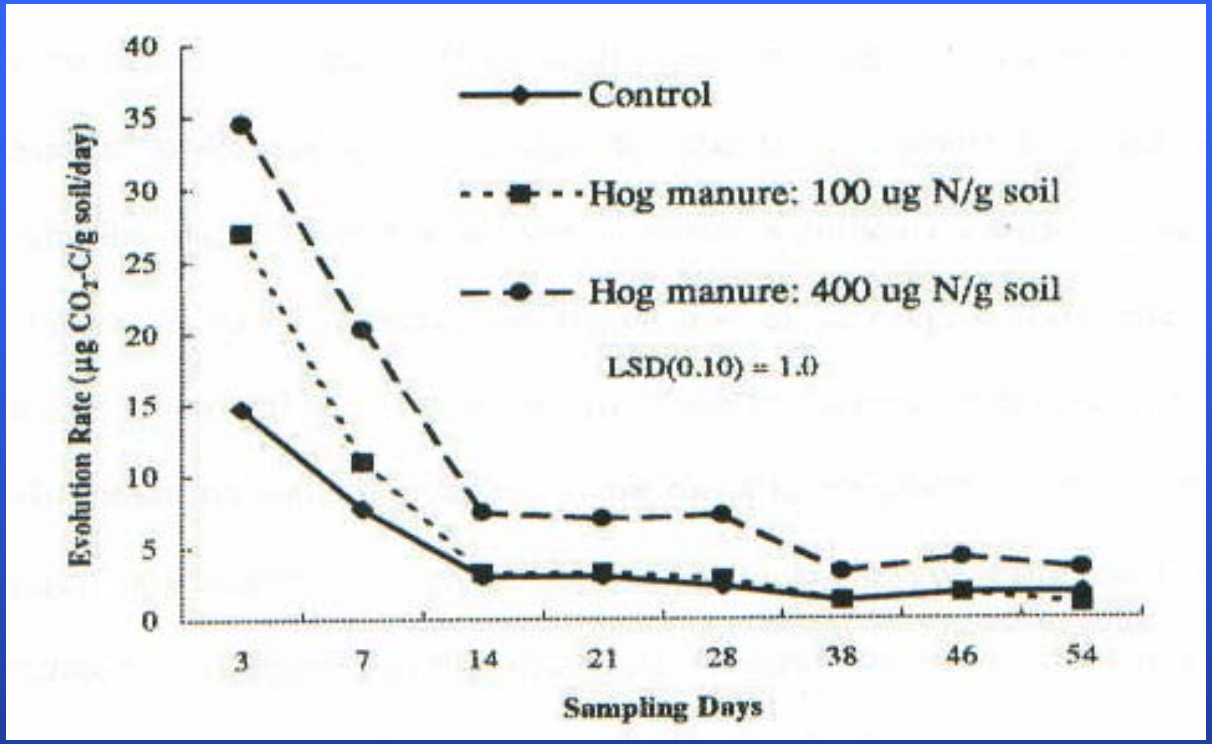
- Manures stimulate microbial activity and respiration.

# Increase in Soil Organic Carbon




**Liquid swine manure increases soil organic carbon by stimulating increased plant growth and residue addition while solid cattle manure adds OM directly. Takes several years of addition to produce measurable increase (King et al 2007).**

# Microbial Activity




Charles, 1999. Microbial respiration ($CO_2$ evolution) in a Black Chernozem amended with swine manure.

Microbial activity ↑ with manure addition. Similar findings by Loro et al (1997) and others.

# Microbial Populations
(de Freitas et al. 2003)

- Additions of manure affect the soil microbial community structure:
  - microbial populations were more diverse in manured soils than in urea fertilized soils.
- No evidence that addition of swine manure increased soil population of pathogenic microbial isolates.
- No impact of manure on foliar plant diseases.

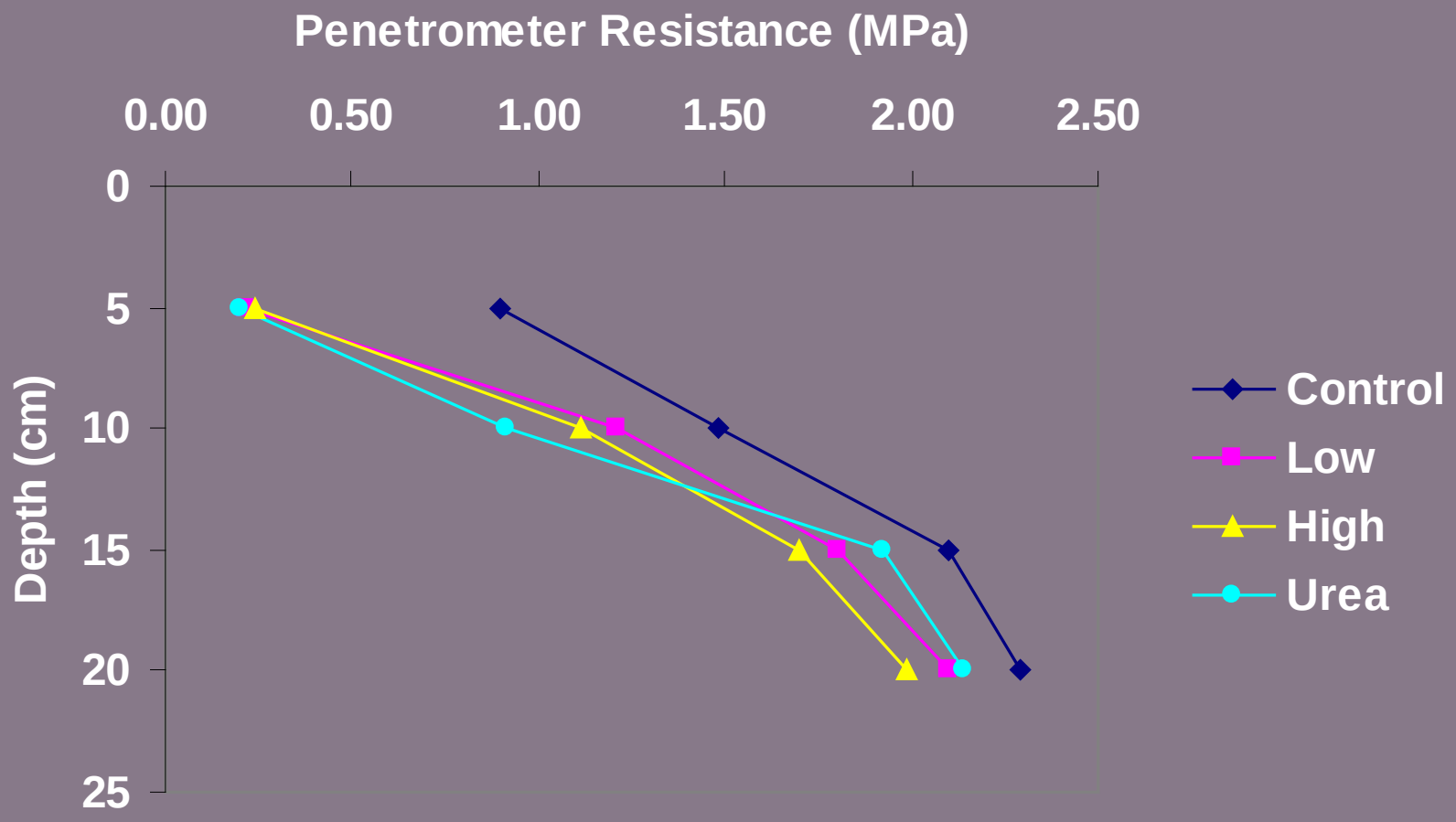
# Salinity and Sodicity

**Salinity**: High concentration of soluble salts, holds back water from the plant; assessed by measuring electrical conductivity (E.C.)

**Sodicity**: High proportion of sodium relative to calcium and magnesium, causes soil particles to disperse, crusting; assessed by measuring sodium adsorption ratio (SAR)

- On well-drained soils, effects of manure application on soil salinity are minimized: flush below root zone.
- Sodicity and surface crusting could be an issue with repeated application, especially with swine manure, **but not evident in soil strength, SAR or emergence measurements to date at agronomic rates**.
- Monitor salinity and sodicity in manured fields using benchmark sites.

# Soil strength in May 2003 at Dixon SK as influenced by seven years of swine manure application (Japp et al., 2004)

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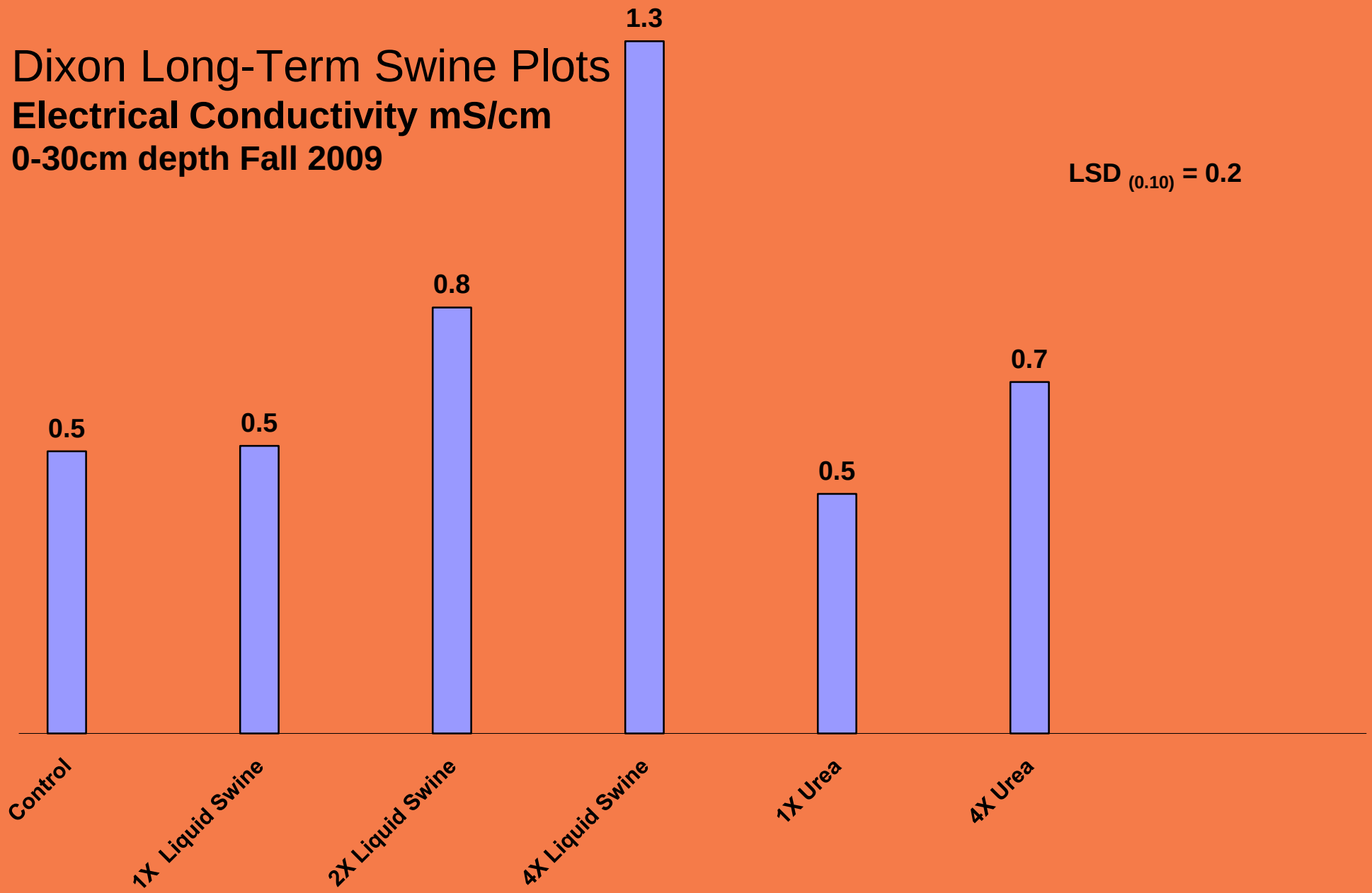
# Dixon Long-Term Swine Plots

**Electrical Conductivity mS/cm**

**0-30cm depth Fall 2009**



## Metals

Some metals are functional plant nutrients: e.g. Cu, Zn

Some are non-functional: e.g. Cd, Pb, Se

Concerns: mobility, accumulation in plants

*Manures can influence soil metal bioavailability:*

Directly (contained in manure e.g. Cu, Zn)

Indirectly (alter pH, microbial activity etc to make more or less soluble, available)

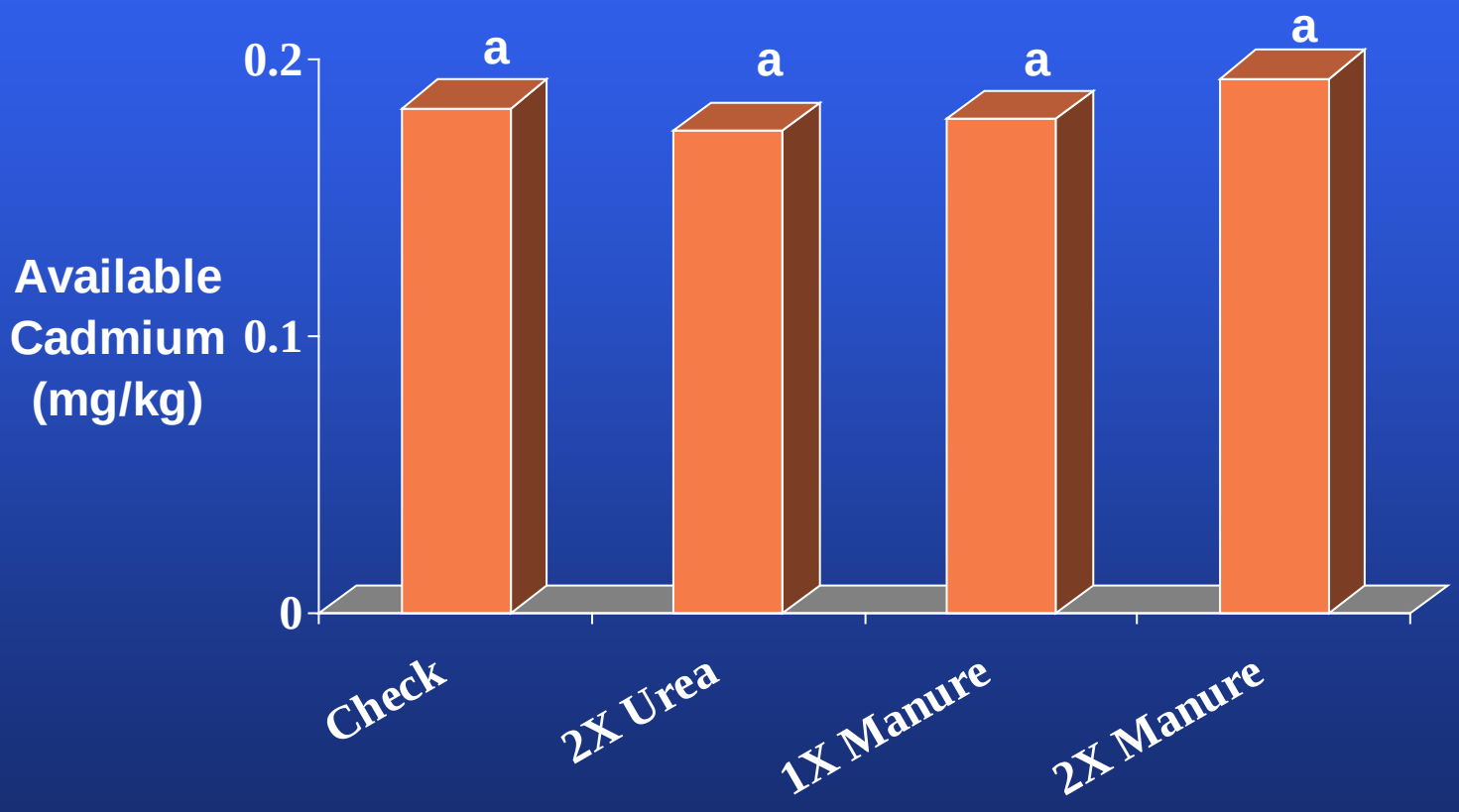
- Repeated (11 yrs) of cattle manure application shown to increase soil Zn in southern Alberta (Chang et al. 1991).

- After three to five years of annual application of cattle or swine manure at four sites in SK, there were only small increases in available soil Cu and Zn fractions (Qian et al., 2003).

- Mercury, arsenic and selenium concentrations in soils and crops were not significantly influenced by repeated manure applications (Lipoth and Schoenau 2004).

# Available Soil Cadmium at Riverhurst SK

Lipoth and Schoenau, 2007




Columns with the same letter are not significantly different at p=0.05

# Soil Structure and Tilth

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By adding organic matter, solid manures are very effective in decreasing soil density and increasing pore spaces for air, water and root exploration.

4 years of cattle manure application at 15 T/ha/yr in SK decreased bulk density from 1.38 g/cm$^3$ to 1.26 g/cm$^3$ .

Manure can increase or decrease aggregation. Organic matter and microbial products of decomposition will help to bind particles together, but sodium added in manure can cause particle dispersion.

# Concluding Points

- By adding nutrients, organic matter and stimulating growth through fertilizing effect, manure addition at agronomic rates has a **positive effect on plant growth and soil quality**. Best results may be obtained through combination of manure and fertilizer to achieve optimum balance: N:P, N:S etc.

- Nutrient and metal loading, salinity, sodicity issues do not appear to be a concern at agronomic rates on normal, well-drained soils, but should be monitored over time.

# Questions?