Nutrient supply from compost, manure, and other waste materials

Dorivar Ruiz Diaz
Soil Fertility and Nutrient Management

Overview

- Compost, manure and other waste materials as fertilizer
- Effect of composting on the availability of plant nutrients
- Nutrients and trace metals uptake from biosolids and dredged river sediment
- Secondary and micronutrients supply from compost and manures

Manure, Compost and Fertilizer

- All 3 materials provide crops with N, P, and K, so why choose one over the other?
  - Differences in nutrient content
  - Effects on plant yield, vigor and health
  - Effects on soil tilth
  - Transportation, application and cost differences

- Commercial fertilizers : AA, AN, UAN, UR (Urea) MAP, DAP etc.
- Compost: Decomposed/stabilized organic matter
- Manure: No explanation needed!

Compost examples include:

- **Food Processing Residuals** —compostable material remaining after fruit, vegetables, grains, nuts, and meat are processed for consumption.
- **Manure and Agricultural By-Products** —originate at feed lots, on the farm, and in greenhouses. Large quantities of manures and/or plant residues are generated and can pose a severe disposal problem.
- **Forestry and Forest Product Residuals** —includes bark and sawdust, and fiber fines, residue and biosolids generated by the papermaking process.
- **Biosolids, or Sewage Sludge** —the solid material generated by the biological treatment of sewage at a wastewater treatment plant. In addition to being composted, sewage sludge can be recycled for beneficial use by direct application to land as a fertilizer.
- **Leaves, Brush and Yard Trimmings** (Yard Waste) —typically consists of leaves, brush, and grass clippings common to urban areas.

Source: The Composting Council Research and Education Foundation (CCREF)

Commercial Fertilizers

- Advantages
  - Precise amount of N, P, K
  - Available in a range of nutrient levels (especially when blended) to provide the producer what is needed for the crop
  - Uniform material for ease of transport and application
  - Known properties of the material with predictable effect on crops
  - Widely available

Commercial Fertilizers

- Disadvantages
  - Costs vary and change during the year, and are currently at record highs
  - Often have higher chance for nutrient runoff or leaching, because of high solubility

Manures

- Advantages
  - Often free (except for ransport/application)
  - Adds organic matter (OM) to the soil which improves structure, increases water holding capacity, increases CEC and reduces erosion
  - Provides both available and ‘slow-release’ N, P, K and micro-nutrients to crops

Manures

- Disadvantages
  - Nutrients can be easily leached through the soil profile or volatilized if left on the surface
  - Nutrient content is highly variable
  - May introduce human pathogenic bacteria such as fecal coliform or E.coli
  - May introduce weed seeds
  - Weight and bulk of transporting and applying wet manures to fields

Compost

- Advantages
  - Lower water content: greater total concentration of nutrients than manure on wet basis
  - Adds OM that releases nutrients slowly
  - High OM content improves soil structure, increases
  - CEC and water holding capacity
    - Greater water holding capacity may decrease irrigation needs and reduce pumping costs
  - Beneficial microbes in compost increase nutrient cycling and can suppress soil and foliar pathogens

Compost

- Advantages to Compost, Cont'd
  - Few to no pathogens & weed seeds due to the heat generated during decomposition
  - Drier than manures with a reduced volume of 50-75%, making it easier to transport and apply
  - Possible source of income for various markets and applications

Compost

- Disadvantages
  - Making compost involves costly equipment, planning, monitoring and time to produce
  - Nutrient enriched leachate must be controlled to prevent runoff or ground water contamination
  - May require special permits depending on quantity produced and if selling compost
  - Will likely be more costly per lb of available nutrient than either fertilizer or manure

Composting and nutrients

- Nitrogen
  - Significant N loses by immobilization amonia volatilization.
- Phosphorus
  - P not lost by volatilization or lixiviation during the composting process, but P form may change as composting proceeds.
- Sulfur
  - Under well-aerated conditions, S sources are oxidized to sulfates, but under anaerobic conditions, they are converted to volatile organic sulfides or to H2S.
- Potassium: All inorganic

Nutrient content in compost

Nutrient	Dry Weight (%)
Nitrogen (N)	<1 – 4.5
Potassium (K2O)	0.5 – 1
Phosphorus (P2O5)	0.8 – 1
Calcium (Ca)	2 – 3
Magnesium (Mg)	2 – 3

B.C. Agricultural Composting Handbook. 1998.

Average animal manure micronutrient content

Manure source	Iron	Manganese	Boron	Zinc	Copper
	----------lb/wet ton----------				
Dairy solid	0.5	0.06	0.01	0.03	0.01
Swine solid	19.0	1.09	0.04	0.79	0.50
Poultry	3.0	0.61	0.08	0.48	0.66
	----------lb/1000 gal----------				
Dairy liquid	0.9	0.11	0.03	0.11	0.12
Swine liquid	2.5	0.23	0.06	1.03	0.62

Average biosolids micronutrient content

Nutrient	Range	Median	Mean
	----------mg/kg----------		
Iron	1,000-153,000	11,000	13,000
Manganese	18-7,100	260	380
Boron	4-760	33	77
Zinc	101-27,800	1740	2790
Copper	84-10,400	850	1210
Molybdenum	5-39	30	28

Sommers (1997) – Journal of Environmental Quality 6:225-232.

Co-composting Green Waste with Animal Manure

Report of Analysis	Green Waste Pre-Compost	Dairy Manure Pre-Compost	Finished Co-Compost	Typical Finished Green Waste Compost
		% Concentration		
Nitrogen	1.69	2.02	1.46	1.29
Phosphorus	0.23	0.46	0.52	0.27
Potassium	1.21	2.21	2.12	1.05
Sulfur	0.2	0.35	0.54	0.20
Magnesium	0.7	0.45	0.89	0.64
Calcium	1.5	1.75	3.21	2.05
Sodium	0.1	0.57	0.45	0.09
Organic Matter	62.55	55.57	34.02	27.08
Moisture	32.18	61.17	29.17	?
		ppm		
Iron	7061	5,267	7,412	15,345
Aluminum	6,993	6,011	4,368	16,915
Manganese	239	139	359	388
Copper	23	86	83	42
Zinc	104	175	219	131
Boron	60	67	92	71
C:N ratio	21:01	16:01	14:01	13:01

K. Hughes, 2003

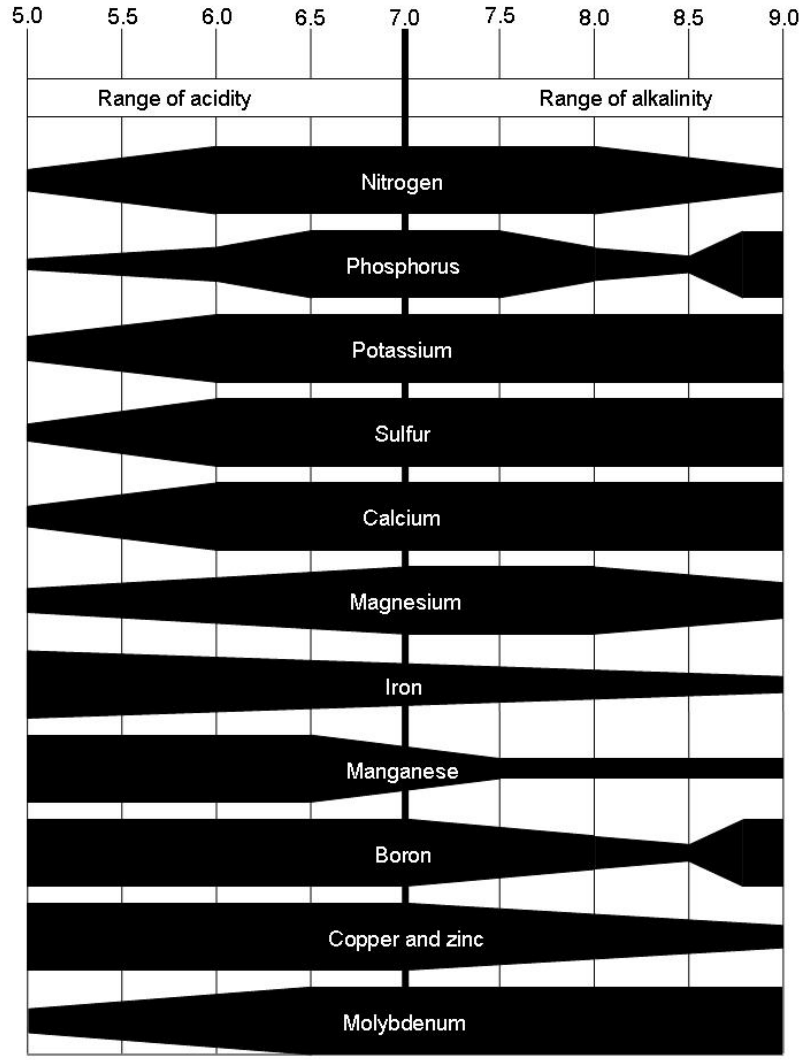
Nutrient availability

Source	Relative nutrient availability
Commercial Fertilizer	High
Manure	High-Medium, depending on source and composition
Compost	Low, Slow release of nutrients

Micronutrient Soil Availability

- Even though we may be supplementing micronutrient nutrition through biosolid/manure application their availability is dictated by soil pH
  - More of a concern as it relates to toxicity from long-term application of biosolids/manures

Micronutrient Availability



Dredged sediment and biosolids for plant growth

K-STATE Kansas State University. Research and Extension

Objectives

- Evaluate dredged sediment and biosolid mixtures used for plant growth
- Determine the effect of the mixtures on plant trace metal uptake.
- Evaluate physical and chemical characteristics of the mixtures.
- Determine best rates to enhance plant growth

Materials

Dredged Sediment

Marlin, John C. 2002

Biosolids

Materials

Compost

Materials Characteristics

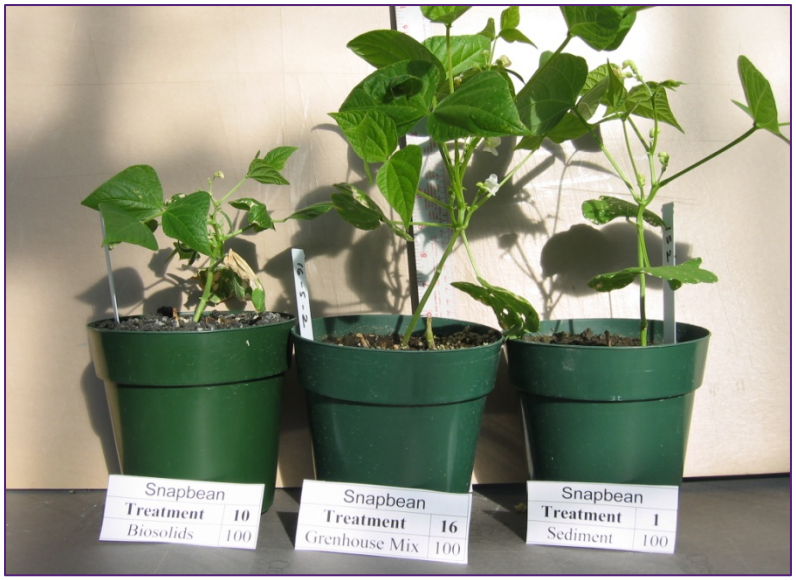
Material	pH Water	O.M. %	Salts mmhos/cm	Soluble Sulfur	P	K	Zn	Ca	Al
					---------- ppm ----------				
Sediment	7.6	4.5	0.6	167	144	226	55	5678	235
Biosolids	6.3	30.0	6.3	2826	2247	714	203	5083	978
Compost	8.2	17.0	0.9	122	352	1416	15	67	70
Control*	6.9	5.3	0.9	646	318	93	3	3196	394

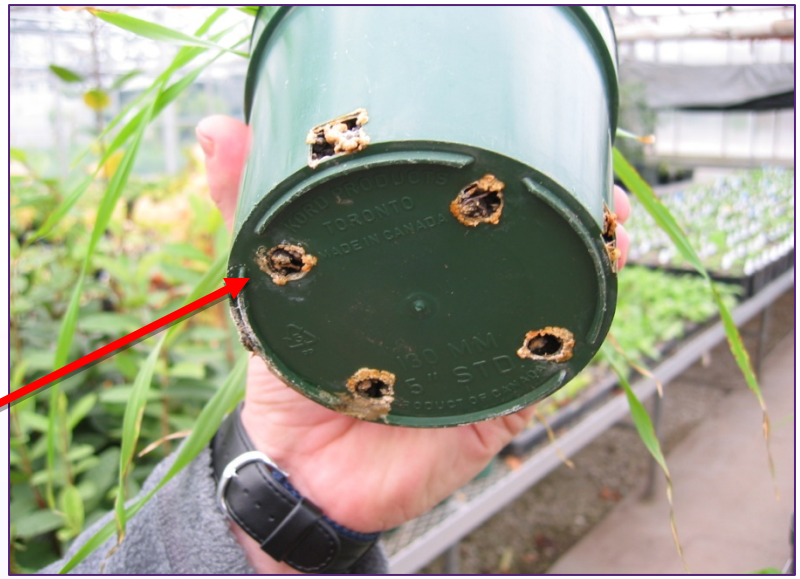
*Standard Greenhouse Mixture= 1:1:1 Soil:Peat:Perlite

Dredged River Sediment

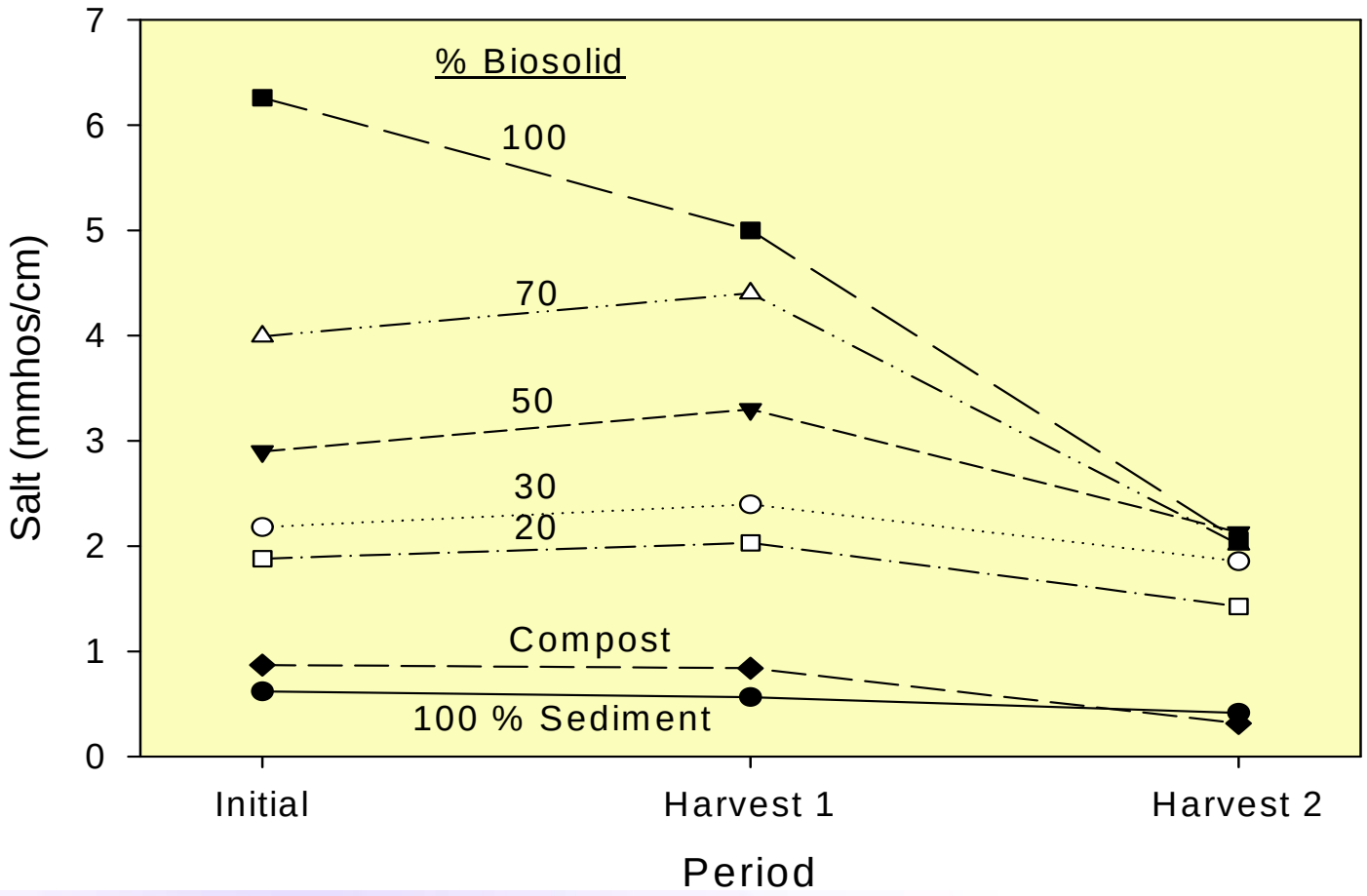
Plant growth after 4 weeks

Salt in mixtures





Salt concentration

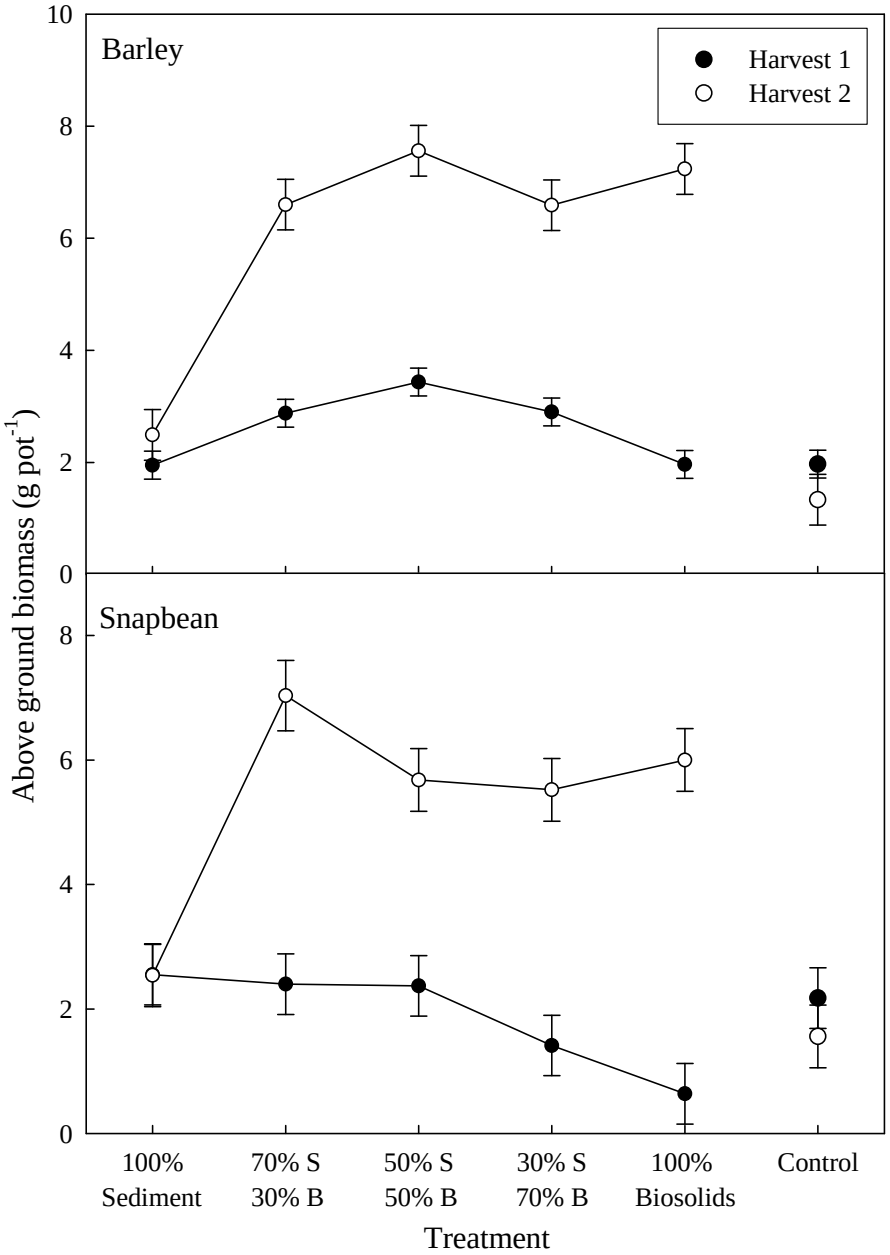


Salt in Biosolids

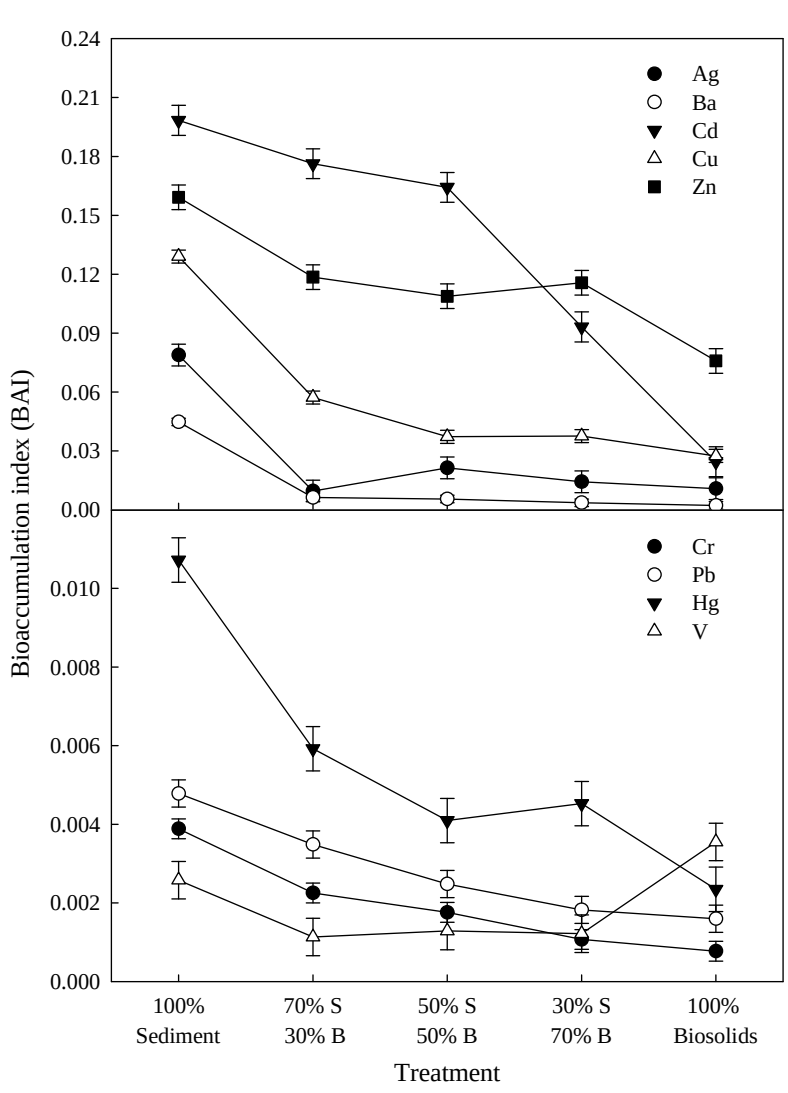
Stage of Processing	pH	Saturation paste extract concentration					
		Total Anions	SO_4	HCO_3	Cl	P	NO_3-N
		µeq/g	----------%----------				
Final Drying	7.0	225	71.9*	21.0	9.2	1.7	21.0
		Total Cations	NH_3-N	K	Na	Ca	Mg
		µeq/g	----------%----------				
Final Drying		239	43.5*	3.7	5.9	20.0	26.7

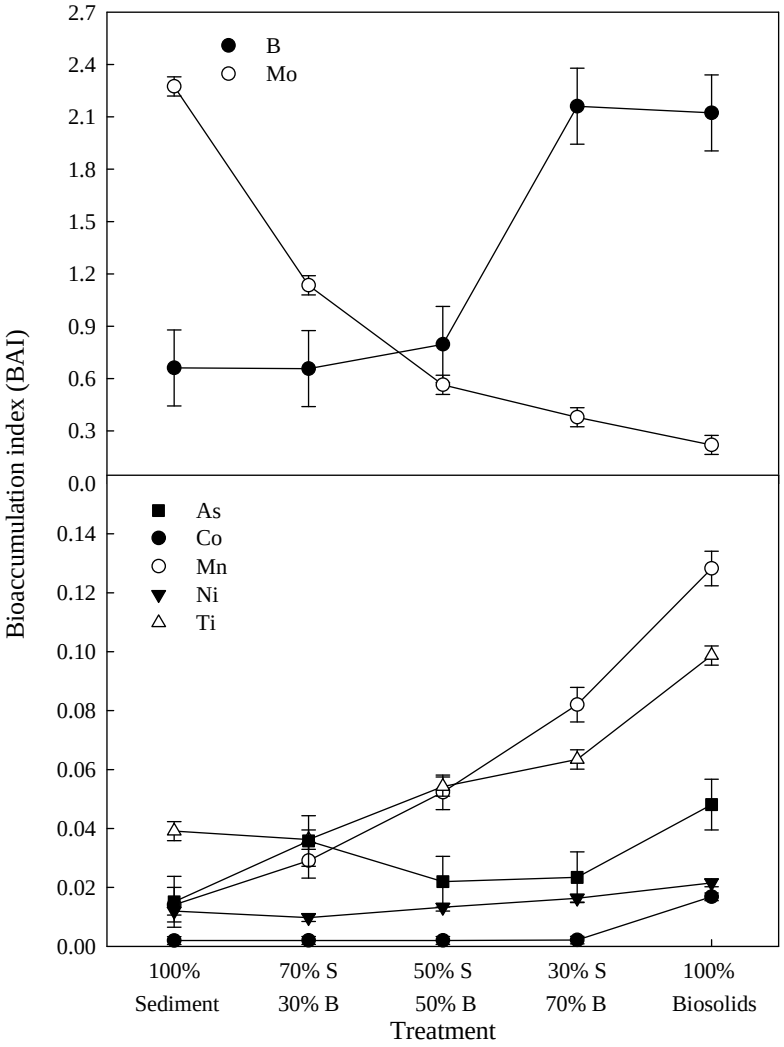
From Granato et al., 2004. Metropolitan Water Reclamation District of Grater Chicago, Research and Development Department.

Plant growth with combined biosolids and river sediment



Trace metal bioaccumulation





Summary

- Addition of biosolids to sediment increased the levels of salt, organic matter, S, P, K, Zn, and Al and decreased the pH from ~7.6 to ~6.1.

- Both sediments and biosolids supported growth of barley and snap beans in the.

- Highest overall yield for barley was obtained in the treatment composed of 50% sediment and 50% biosolid.

Summary

- For snapbean, the highest yield was the treatment composed of 70% sediment and 30% biosolid.
- Mo uptake needs special attention.
- Trace metals analyzed are within range considered normal.

Summary

- Sediment and biosolids showed no inherent properties that would affect negatively plant growth.
- Mixing of sediment and biosolids increase plant growth and decrease metals uptake.
- Plants grown on compost showed low trace metal uptake

Field study

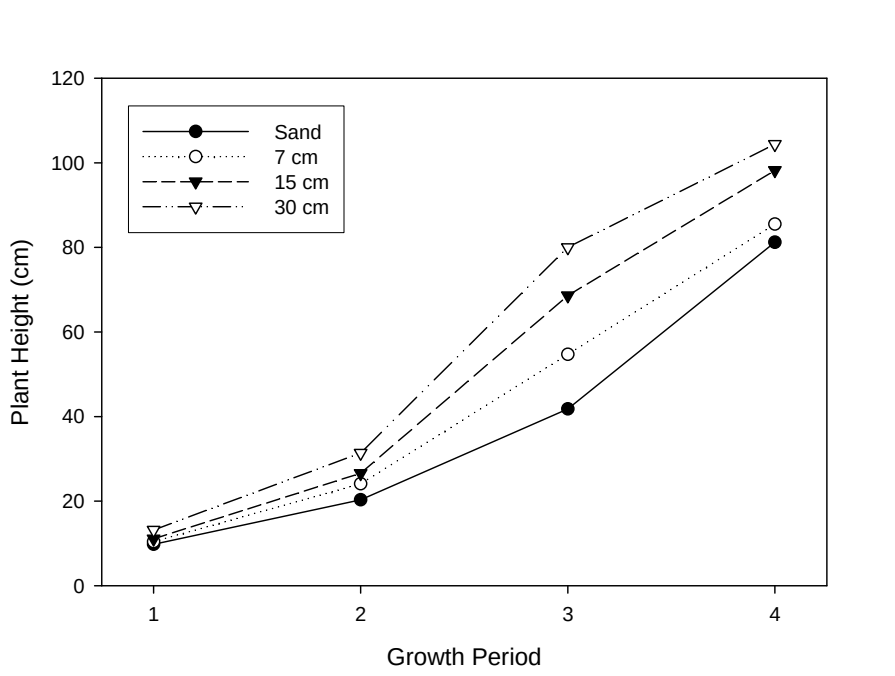
Materials

Plant Growth

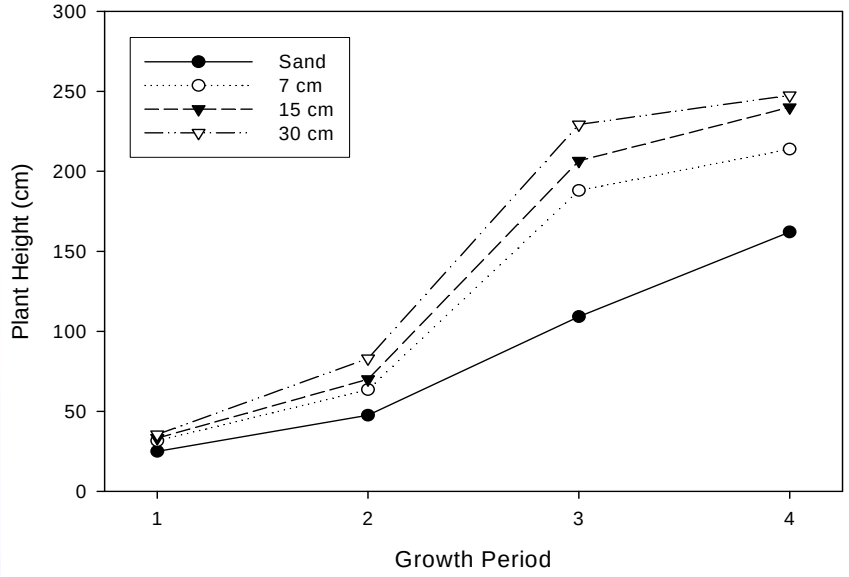
– Marked effect on plant growth, very noticeable in corn.

Plant Growth

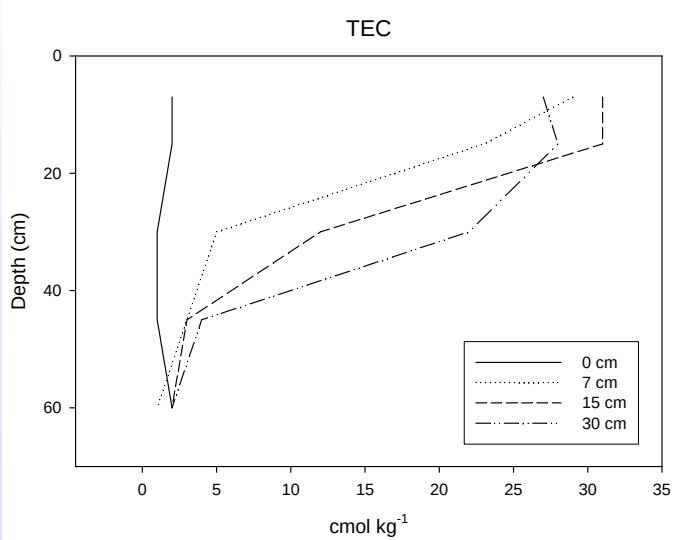
Soybean

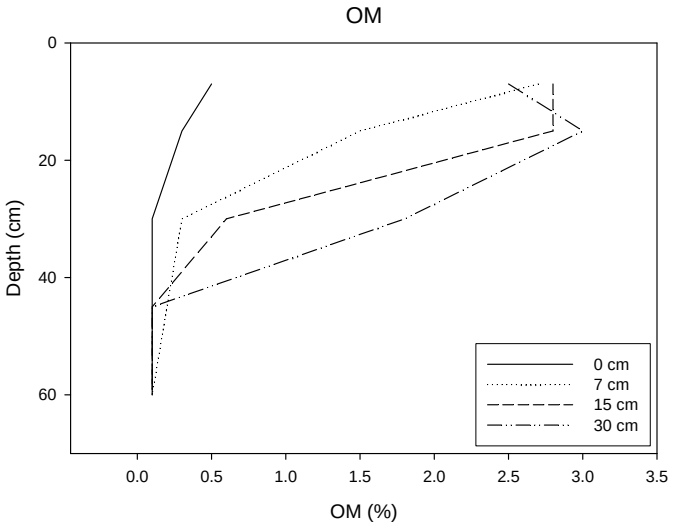


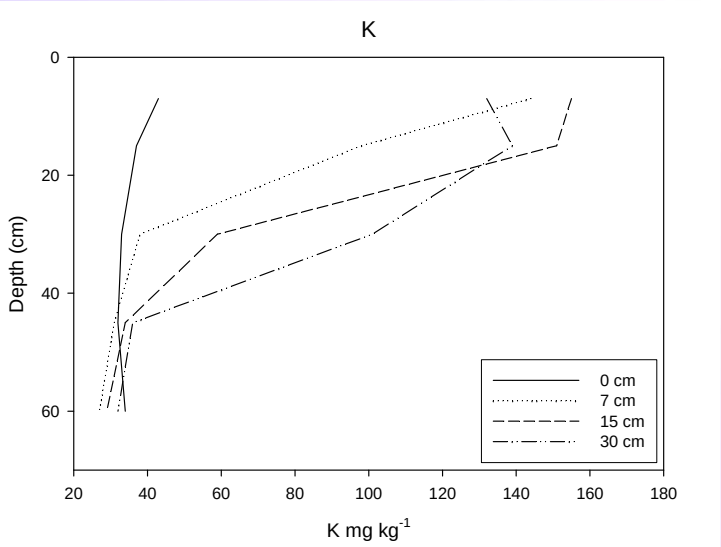
Corn

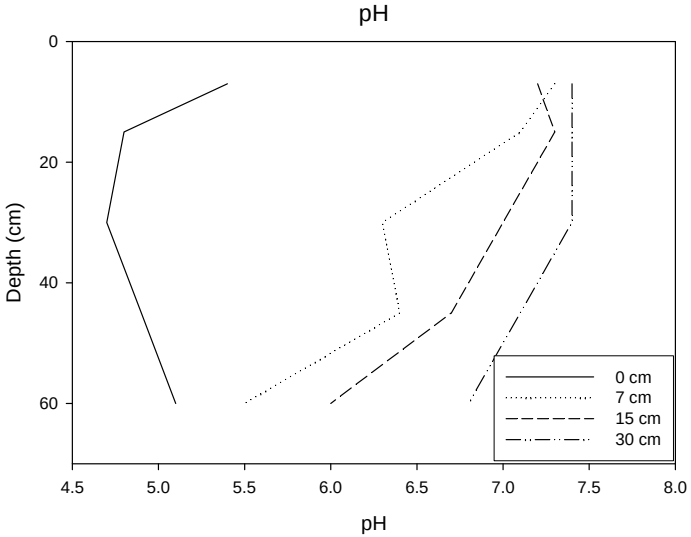


Soil Fertility

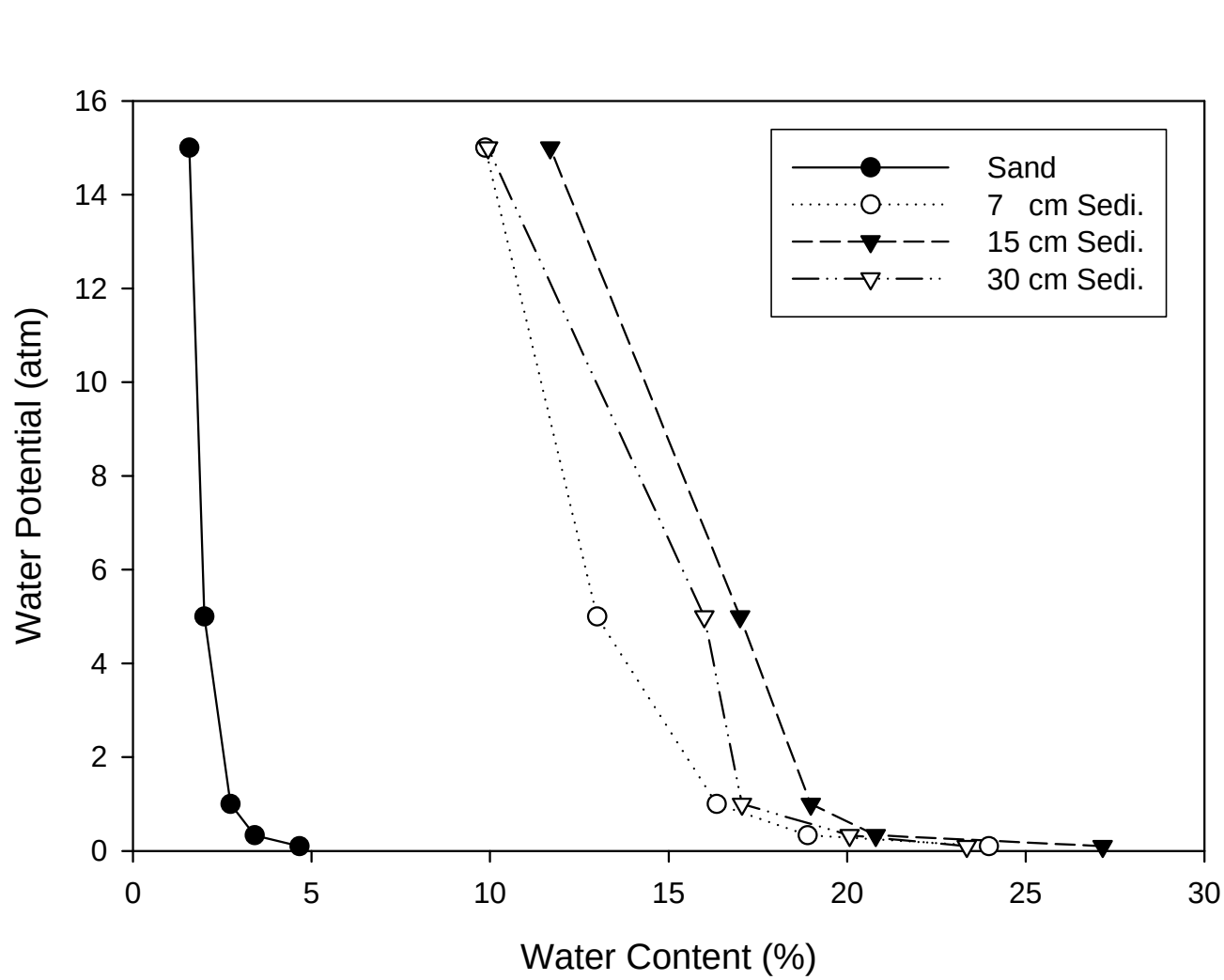








Water holding capacity



0.33 atm – 15 atm (field capacity to pwp)

Crop harvest

Research and Extension

Conclusions

- Dredged river sediment and biosolids increase plant growth yields in sandy soils
- Higher rates of application increase plant growth
- Increase in soil SOM and nutrients
- Better water holding capacity

Waste materials used for park Chicago

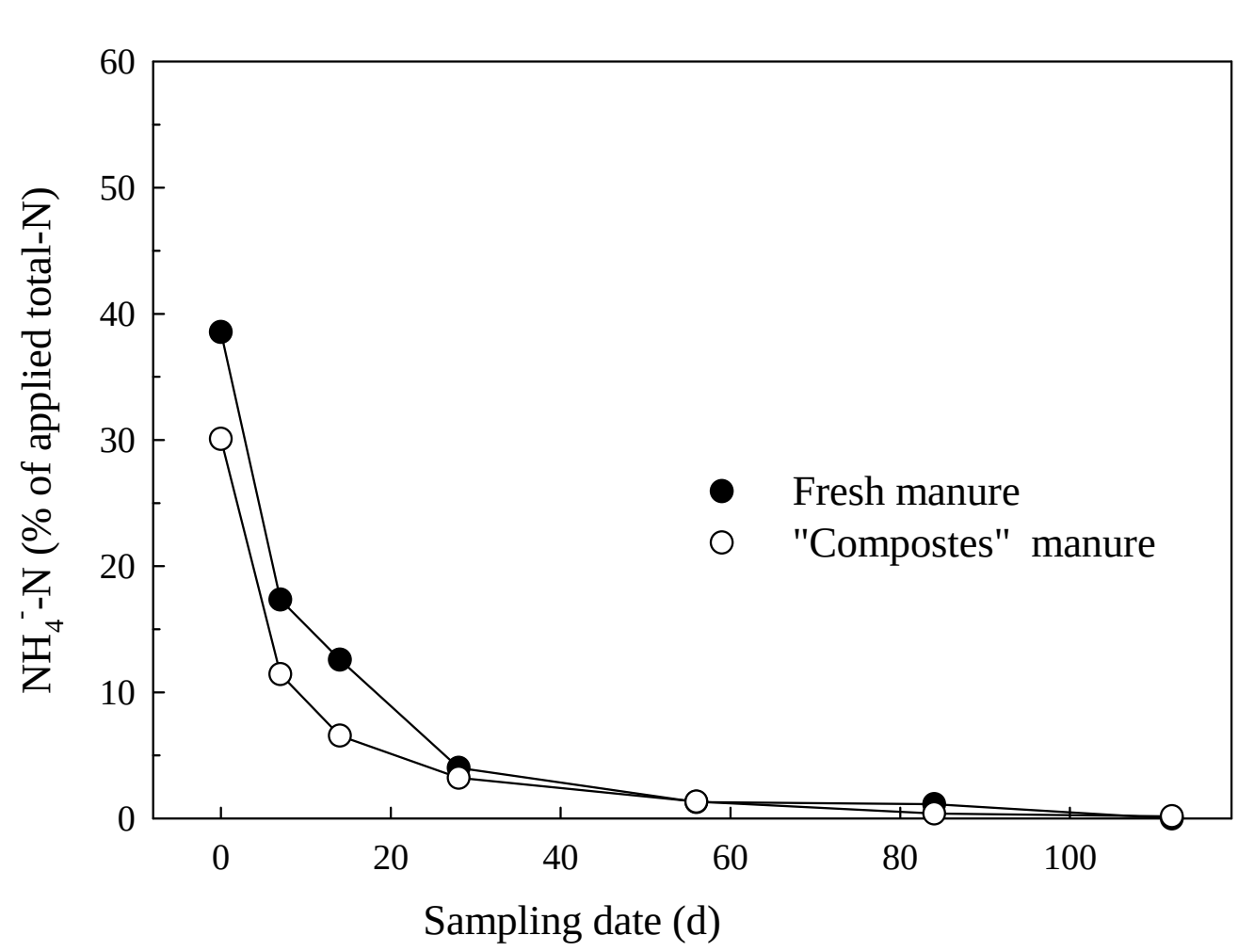
Waste materials used for park Chicago

Comparisons of fresh manure and “composted” manure

Manure and “composted” manure

Manure and “composted” manure

Inorganic N content



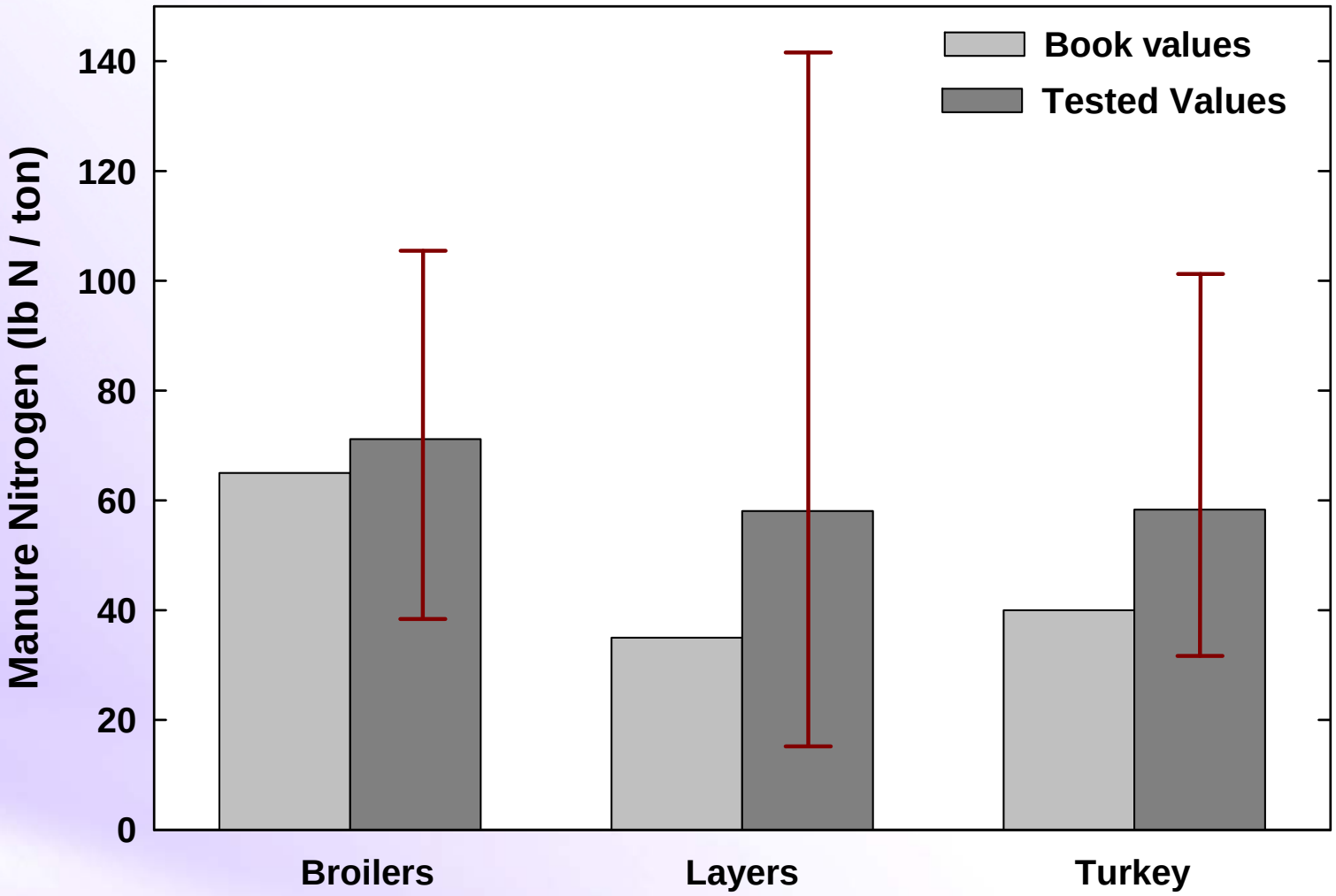
Crop response to manure source

Source of variation	Grain yield	GNU	CM reading	NO_3^-–N
	- - - - - - - - - - - - - -	p > F	- - - - - - - - - - - -	
Manure Source	0.4893	0.0228	0.1415	0.4603
Manure Rate	< 0.001	< 0.001	< 0.001	0.0003
Fertilizer N Rate	< 0.001	< 0.001	< 0.001	< 0.001

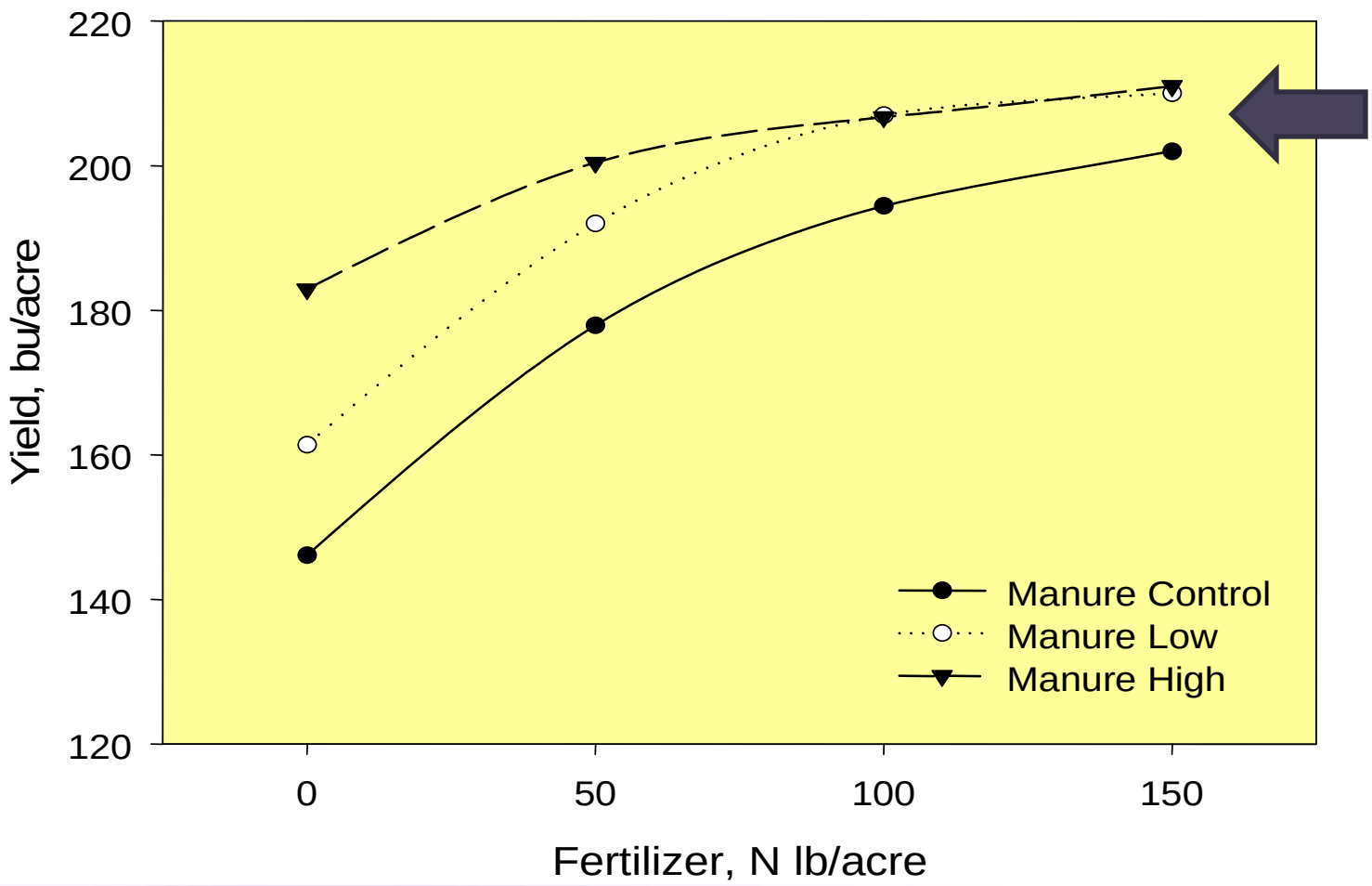
Manure Nitrogen Availability

- Organic N available the first year compared with fertilizer (MF-2562):
  - Liquid manure: 30%
  - Solid manure: 25%
  - Compost: 20%
- As for fertilizers, these numbers indicate potential availability.
- Assumes injection or incorporation and "best management practices".

Manure Nitrogen Concentration



Yields and Manure or Fertilizer N



Summary

- There can be significant N loses with composting process of manure
- Variability in nutrient content of manure is significantly reduced
- Addition of manure can increase nutrient value of compost
- Additional secondary and micronutrients from manures and compost can increase plant response further

Questions?

Dorivar Ruiz Diaz

ruizdiaz@ksu.edu
785-532-6183

www.agronomy.ksu.edu/extension/SoilFertility

K·STATE Research and Extension
Kansas State University.