Reducing Plant-Available Phosphorus in Agricultural Soils Using Water Treatment Residuals:

Current Field Trials

By

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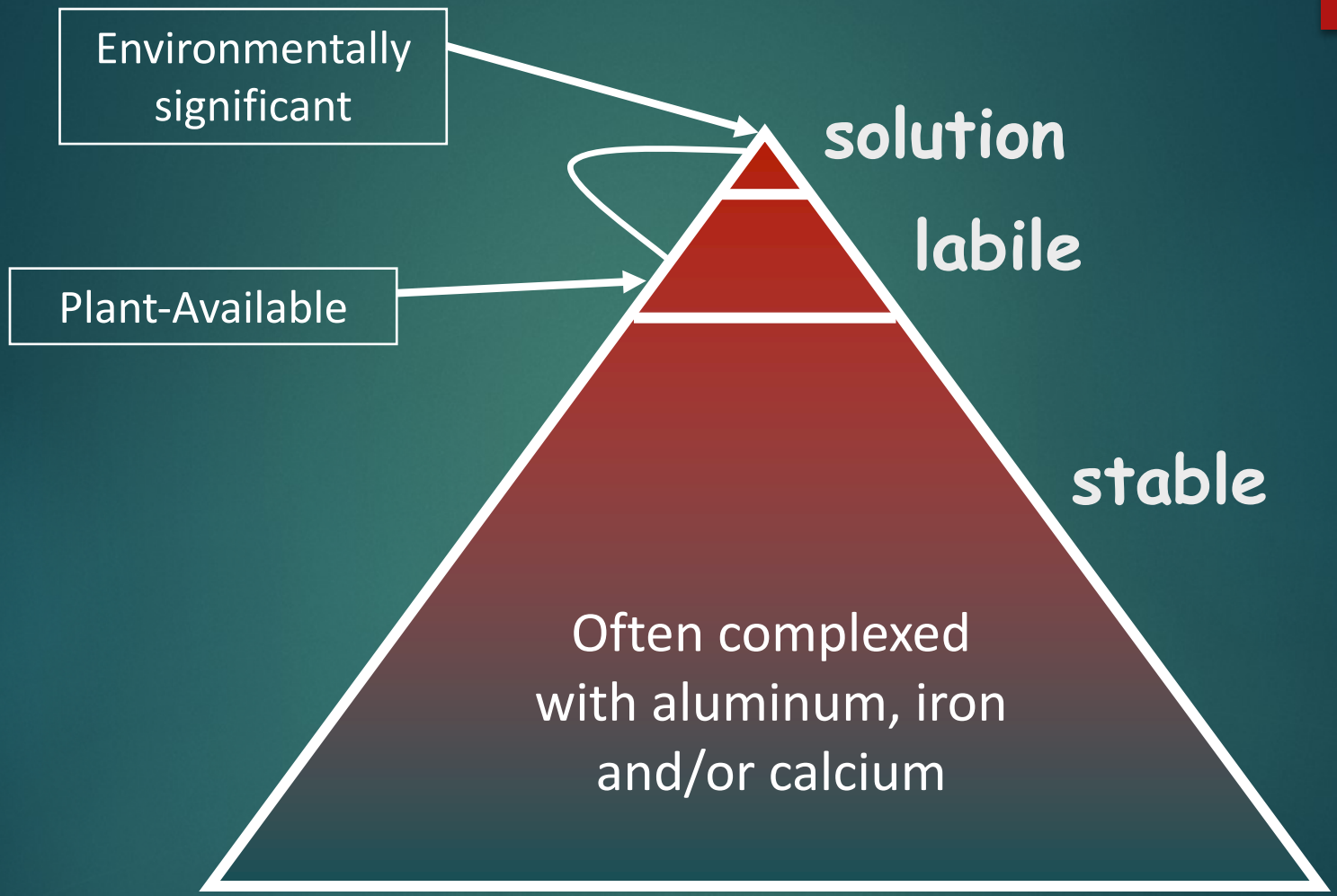
2018 NEWEA Annual Conference

Boston, MA

RMI

BUILDING HEALTHY SOILS

Soil Phosphorus



From Craig Cogger, WSU, then haphazardly adulterated by Northern Tilth

Matching Crop Needs with Biosolids N & P

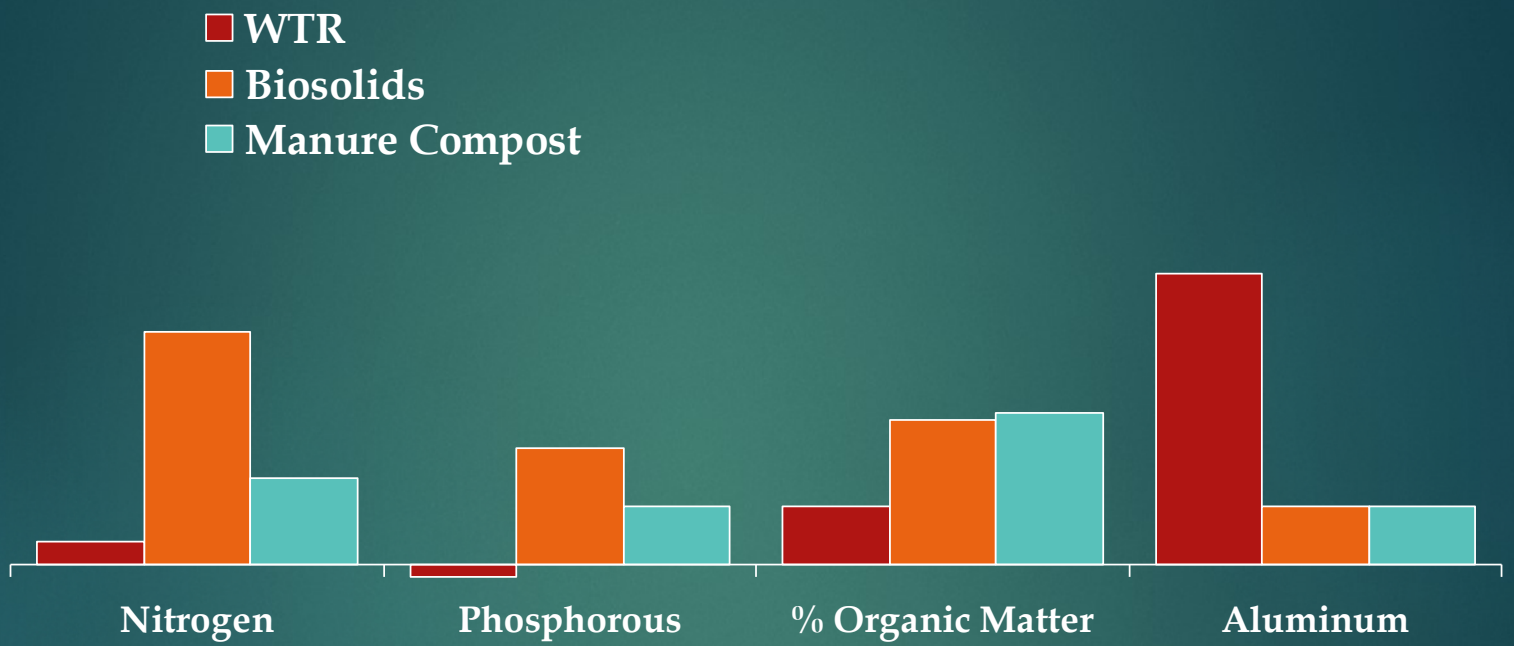
- Anaerobically digested biosolids with 5.4% N, 1% NH_4-N, 2.1% total P, and 24% solids content
- N →**18# plant-available N/ wet ton** (steady state for repeated use with 30%/10%/10%/5% Org N mineralization in Years 1,2,3 and 4, respectively)
- P →2.1% x 2.291 x 24% solids → **23# P_2O_5 /wet ton**
- Using a yield goal of 18 tons of silage corn per acre
  - 162#/acre of nitrogen
  - 90#/acre of P_2O_5
  - crop needs a P_2O_5:N: ratio of 0.55:1
  - These biosolids provide a P_2O_5:N: ratio 1.3:1
  - At a steady state, if biosolids is primary sour
    180#/acre of P_2O_5 each year (if the P in the b
  - Applying at agronomic rates for P would cut

While manure and biosolids are an obvious fit for boosting soil fertility while improving soil health, overuse of any of these materials can increase soil phosphorus levels to above optimum levels. P:N levels in chicken manure can be especially high

Water Treatment Residuals

- Semi-solid residuals generated during the treatment of drinking water from surface water sources
- Alum-based WTRs have been proven effective in sorbing P in a variety of settings, and have to potential to reduce P risks to surface water in agricultural settings
  - High aluminum and iron content of alum-based WTRs help to sorb/bind P

Nutrient Characteristics of WTRs Relative to Other Soil Amendments



- WTRs are low in macro-nutrients and organic matter content when compared with other commonly used soil amendments
- Total aluminum content of alum-based WTRs is very high
- The lack of any obvious nutrient or organic matter benefit is part of the reason that the recycling of WTRs as a soil amendment is slow to catch on

Current Focus on using WTRs in Sensitive Areas

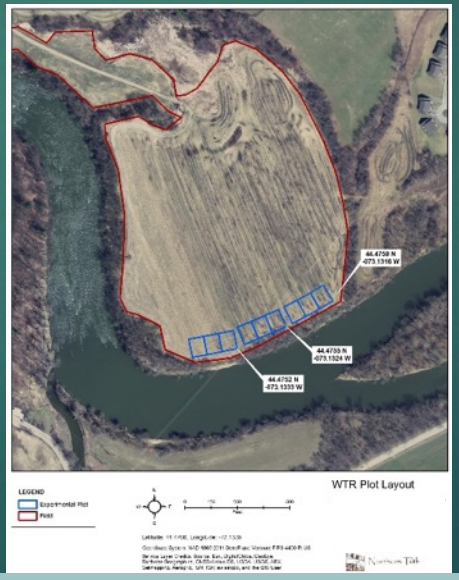
- Completed initial WTR field trials in 2014 that indicated that 120 – 240 tons per acre was effective in reducing plant-available P in high phosphorus agricultural fields.
- These application rates are too high to use as field-wide applications
- Makes more sense to focus on the most sensitive areas
- The focus of the current trials is to use WTRs in sensitive areas where it can have the most benefit to surface water quality.

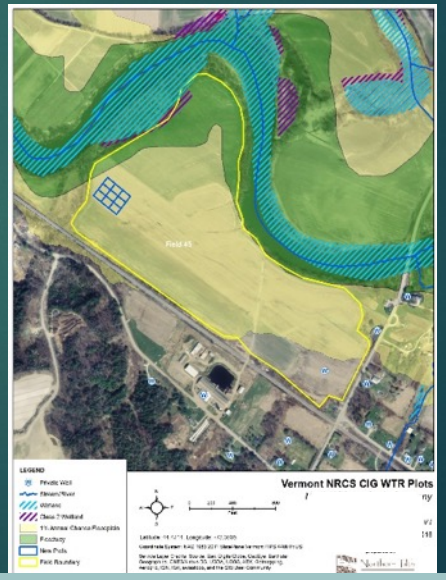
NH and VT Field Trials

- Northern Tilth, in partnership with RMI, received an NRCS – CIG grant to further research the effectiveness of using WTRs to reduce the risk of P run-off
- Four corn silage fields were selected for trials from three farms, two farms in NH and one in VT.
- All fields had a long history of using manure and/or biosolids as primary sources of soil fertility.

Brief Methodology

- Plots were selected in environmentally sensitive areas (generally close to surface waters)
- 9 plots 70'x90' were set up on each field and referenced by GPS
- Plots were split into sets of 3 (for replication) and WTRs were applied at rates of ranging from 25 to 75 dry tons per acre in the plots (95 to 250 wet tons per acre)
- For the next two cropping years each plot received the same fertilizer treatment from the farmer; no changes in fertilizer regimen from the remainder of the fields
- Soil samples were taken for metals, nutrients, and pre-sideress nitrate annually
- Yield and tissue analyses were conducted in each plot
- Complimentary soil incubations in lab





Spreading WTRs in Field Plots

Corn Growth

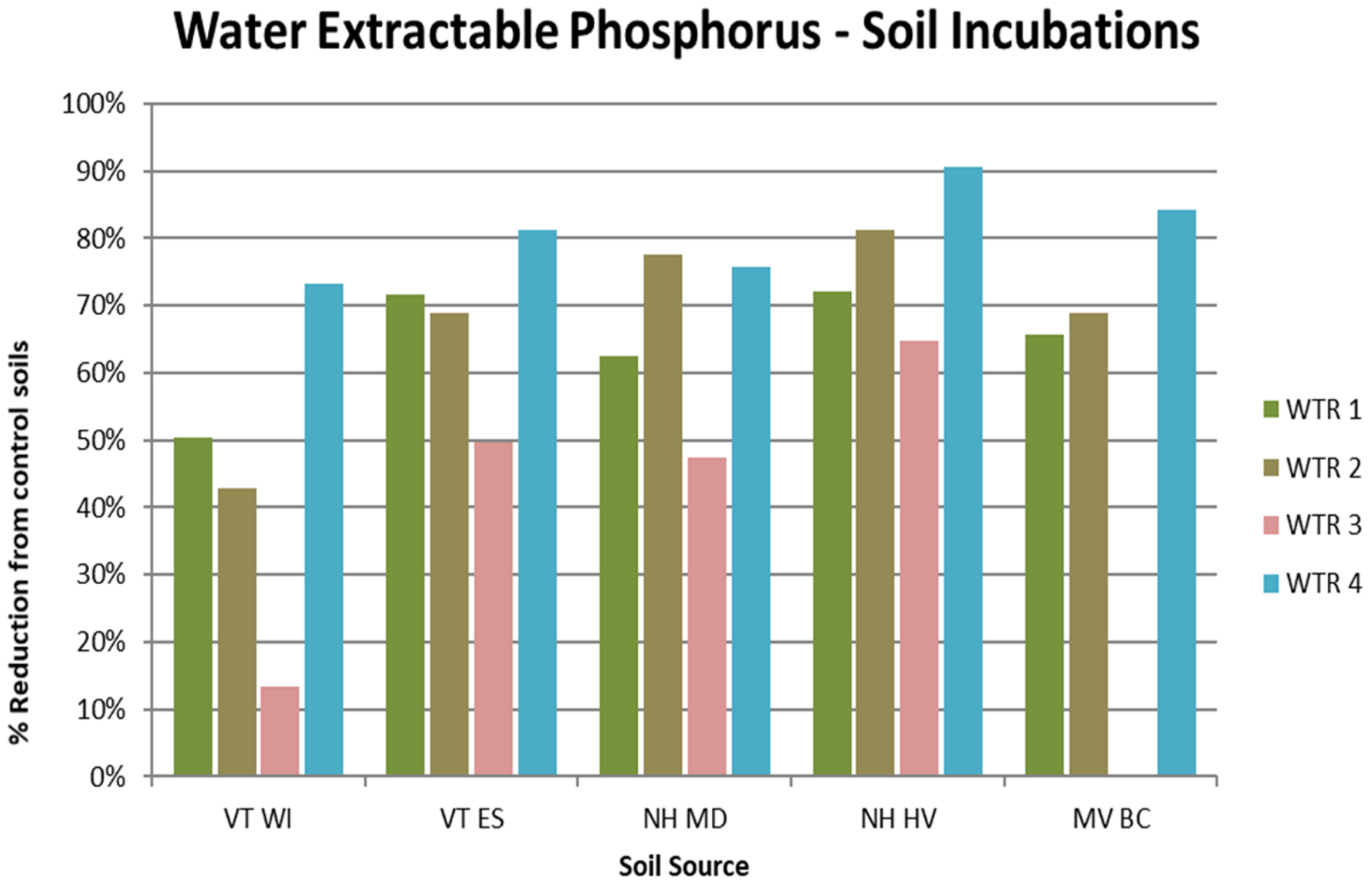
Mid-Season and at Harvest

Harvest – Yield and Tissue Analysis

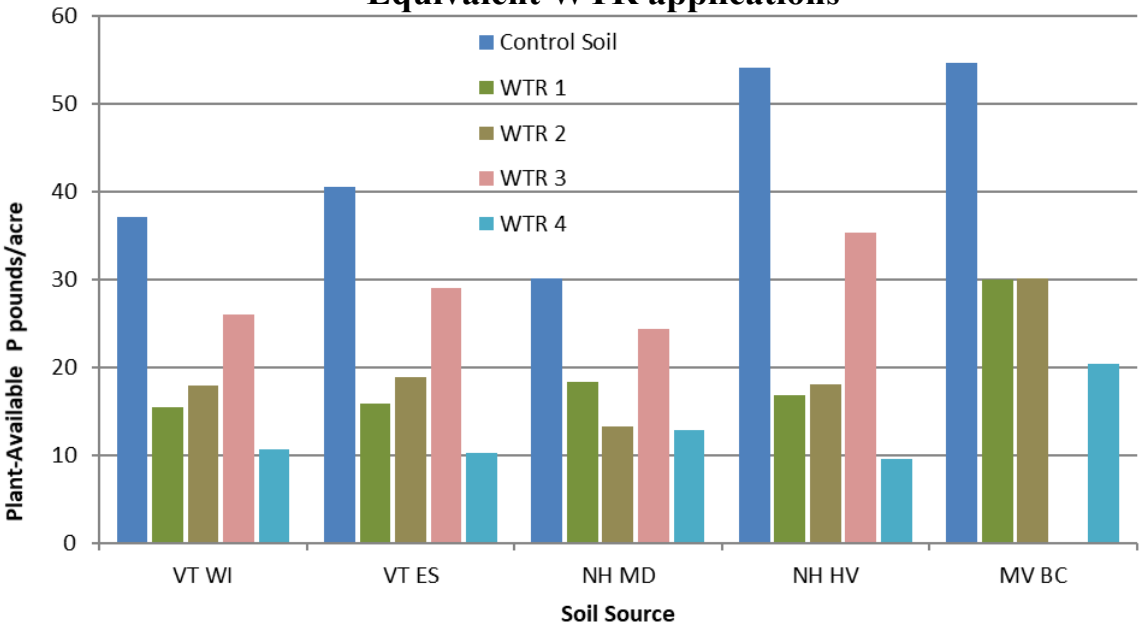
Results

			Total				modified Morgan			Mehlich III					oxalate extractable					WEP
ID	WTR rate	soil pH	Solids	P	Al	Iron	P	Al	Fe	P-ICP	Al	Fe	% DPS	PSR	P	Al	Fe	DPS(%)	PSI	P
	dt/ac		**%**	***mg/kg dry wt.***			***lb/ac***	***mg/kg***		***mg/kg***			**%**	***ratio***	***mg/kg***			**%**	***ratio***	
16	0	6.2	83.07	1,300	6,500	10,000	54.1	13	3.1	457	899	361	74.1	0.37	735	1084	1606	68.8	0.34	13.0
17	50	6.5	80.50	1,200	8,500	9,200	16.8	90	4.4	366	1406	266	41.5	0.21	678	3430	1397	28.8	0.14	3.63
18	50	6.6	79.25	1,100	14,000	10,000	18.1	24	3.4	341	1537	272	35.6	0.18	674	2738	1502	33.9	0.17	2.43
19	50	6.3	82.58	1,200	7,300	10,000	35.3	17	3.4	426	1242	315	53.2	0.27	704	2252	1527	41.0	0.21	4.58
20	50	6.3	78.02	1,300	9,600	10,000	9.6	122	7.9	264	1692	272	25.2	0.13	680	4564	2178	21.1	0.11	1.21

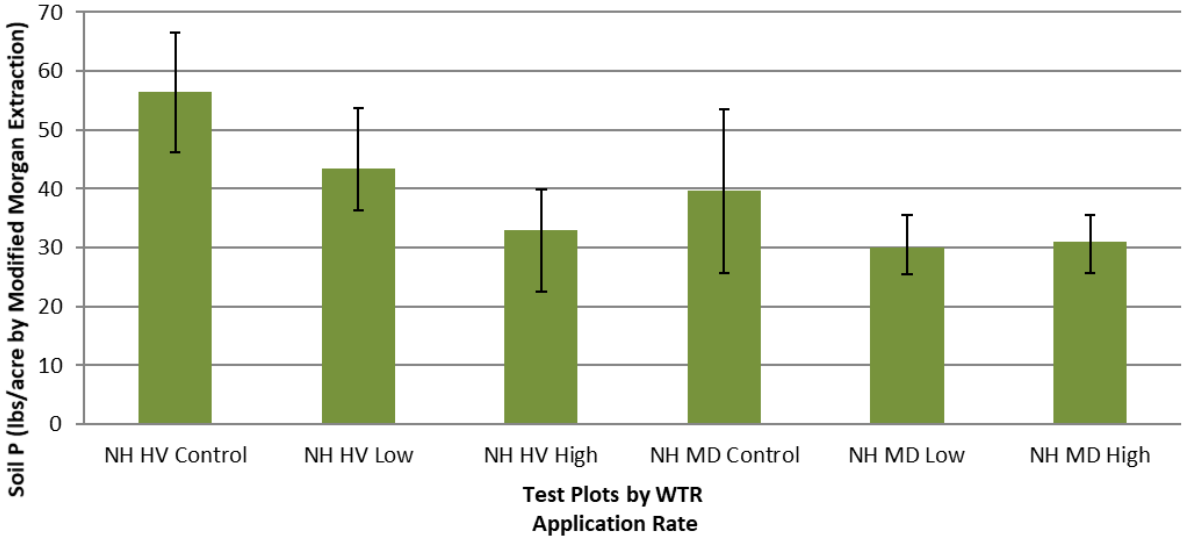
- Lots of data to crunch when completed
- For field plots
  - Total P, Al, Fe (total regulated metals for VT field plots)
  - Modified Morgan, Mehlich III, and Oxalate Extractable P, Al and Fe
    - Which will provide data needed to determine Phosphorus Saturation Index (PSI) and Phosphorus Saturation Ratio (PSR)
  - Standard Soil Fertility testing results (Cornell Soil Health Testing Results for the VT field plots)
  - Crop yields and tissue analysis for two field seasons
- Complimentary Soil incubations will focus on the phosphorus, aluminum and iron by all of these extractions only

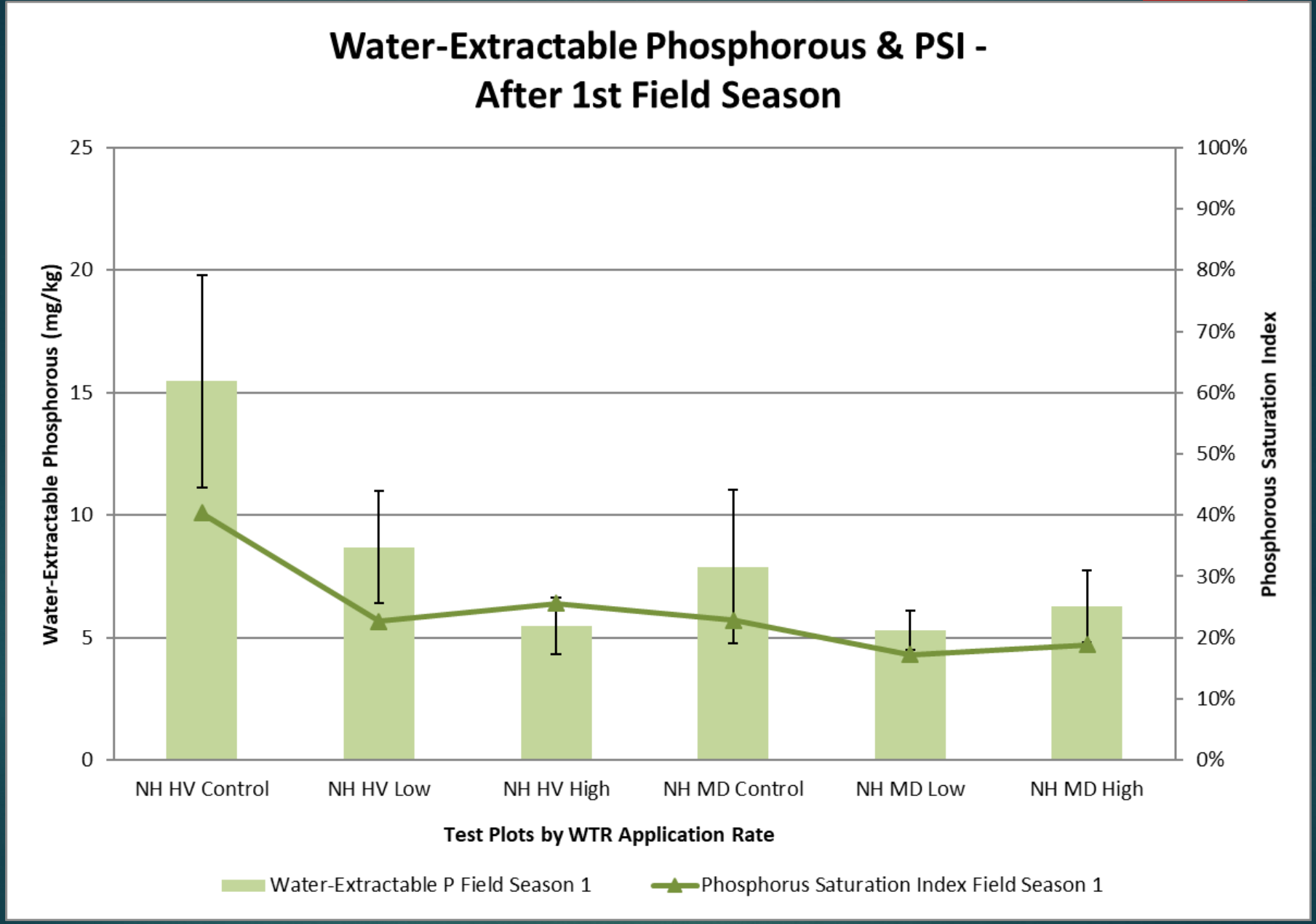

Water Extractable Phosphorus - Soil Incubations
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
% Reduction from control soils
VT WI
VT ES
NH MD
NH HV
MV BC
Soil Source
WTR 1
WTR 2
WTR 3
WTR 4

Modified Morgan Phosphorous – Soil Incubations
Equivalent WTR applications



Modified Morgan Phosphorous – NH Plots
Control, Low, and High WTR Application




Water-Extractable Phosphorous & PSI -
After 1st Field Season
Water-Extractable Phosphorous (mg/kg)
Phosphorous Saturation Index
25
20
15
10
5
0
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
NH HV Control
NH HV Low
NH HV High
NH MD Control
NH MD Low
NH MD High
Test Plots by WTR Application Rate
Water-Extractable P Field Season 1
Phosphorus Saturation Index Field Season 1

Harvest Data

Concluding Remarks

Manure and biosolids are excellent sources of plant nutrients and organic matter, but application rates should take into account the nutrient balance in these soil amendments

In particular, the ratio of phosphorus to plant-available nitrogen is higher in biosolids and manures than the ratio taken up by most crops, leading to a potential excess of phosphorus in soils when applying these materials according to the crops nitrogen needs

Water treatment residuals can play an important role in helping protect water quality in agricultural areas with high soil P levels