Influence of Phosphorus and Potassium in a Multi-year Spring Wheat-Soybean Crop Rotation

On-Farm Summit

January 20th, 2021

UNIVERSITY OF MINNESOTA

Presentation Overview

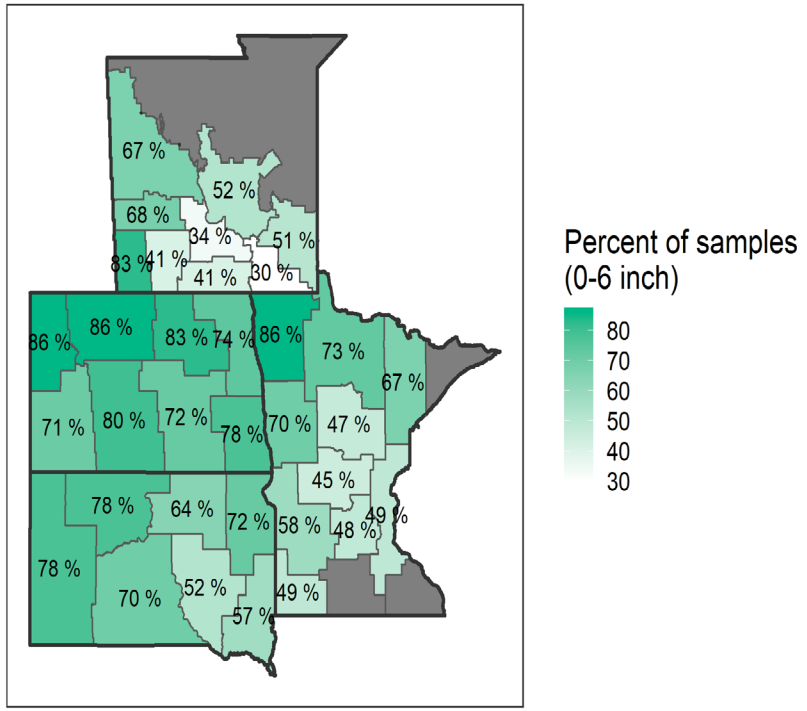
- What know about soils in NW MN
- Liebig's law of the minimum
- Interactions of nutrients - Mulder
- Project scope
- Project objectives
- On-Farm results in 2020
- Small plot results in 2020
- Summary of 2020 results

NW MN Soils: What we Know?

- Glacial Lake Agassiz is the origin of area soils
- Cold soils reduce nutrient uptake
- High pH soils can limit nutrient uptake
- A 50 bu bean crop removes: 40# P205 & 70# K20
- An 80 bu wheat removes: 50# P and 30# K
- A 7-30-30 will not supply needed P&K, so plants will have to ‘mine’ soil to obtain P&K for high yield goals

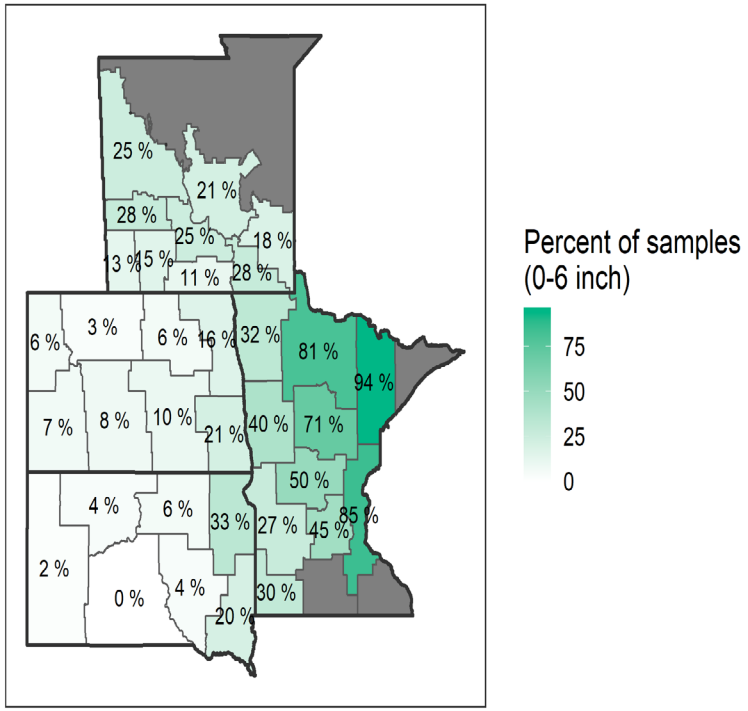
Phosphorus and Potassium Levels in Soils
AGVISE Survey - 2019

Soil samples with soil test phosphorus below 15 ppm (Olsen P) in 2019



Data not shown where n< 100
AGVISE Laboratories, Northwood, ND

Soil samples with soil test potassium below 150 ppm in 2019



Data not shown where n< 100
AGVISE Laboratories, Northwood, ND

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Soil Test Calibration Levels

Soil Test Calibrations

Nutrient	Test	Very Low	Low	Medium	High	Very High
		----------ppm----------				
P	Olsen	0-3	4-7	8-11	12-15	>16
K	NCR-13	0-40	41-80	81-129	121-160	>161

Source: North Dakota Fertilizer Handbook

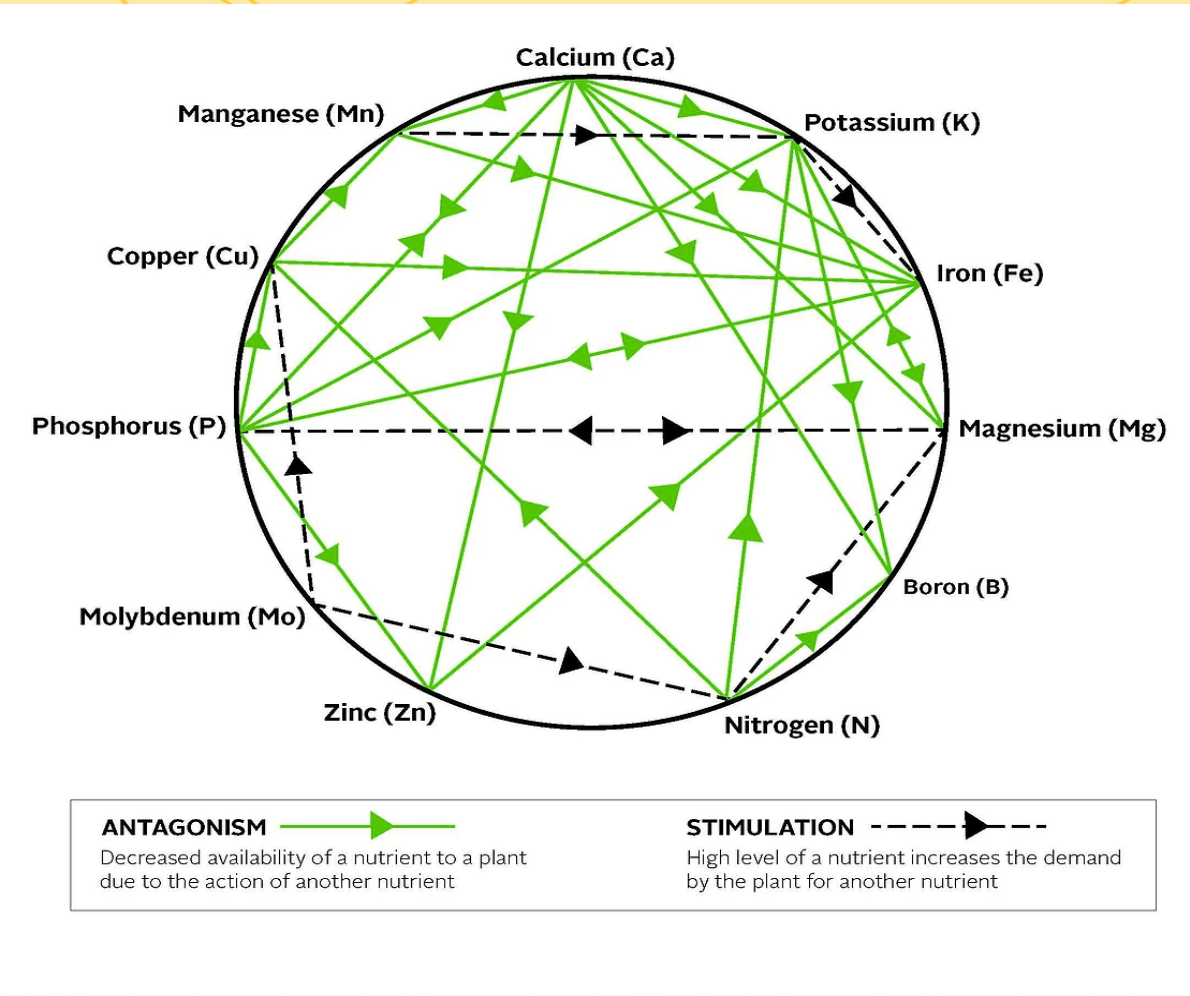
Probability of a Response

- Very Low > 80%
- Low: 60 - 80%
- Medium: 40 - 60%
- High: 20 - 40%
- Very High < 20%

Plant Growth & Yield - Law of the Minimum

- Barrel stave concept
- Justus Von Liebig
- Plant growth and yield limited by the nutrient most scarce
- Goal is to provide nutrients (Macro & Micros) in quantity needed to maximize plant growth and yield

Interactions of Plant Nutrients - Mulder

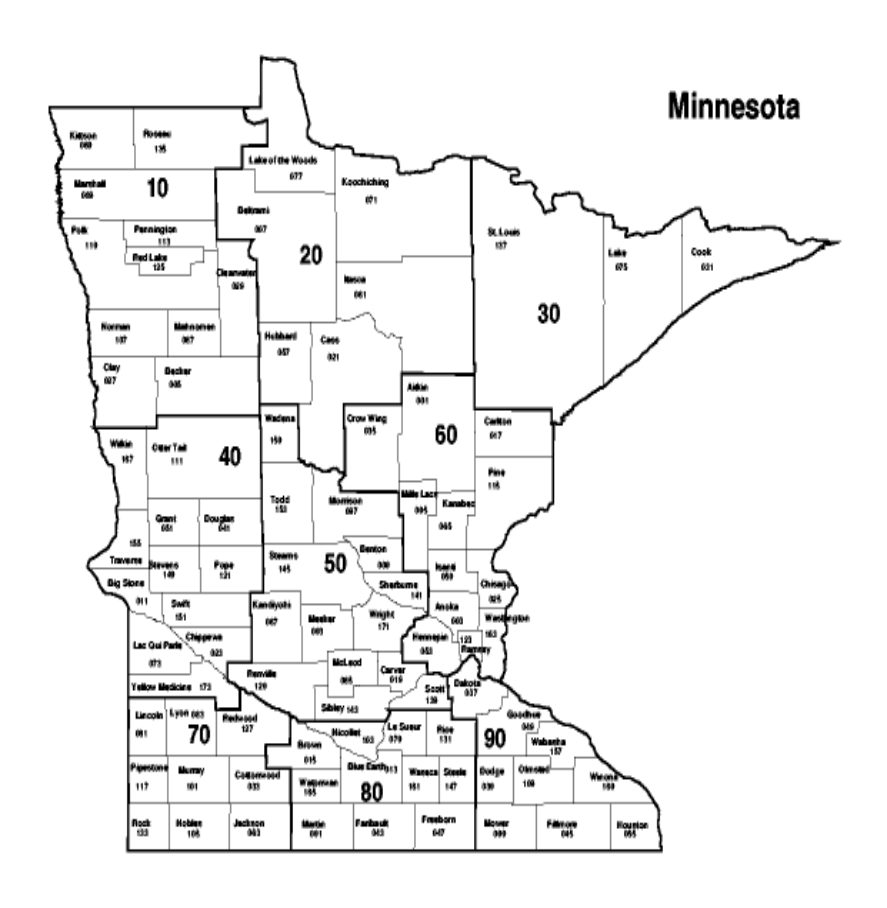


- Too much of one nutrient can either enhance OR decrease availability of another nutrient
- High N can reduce availability of B, Cu, K
- High P can reduce the availability of Fe, Ca, K, Cu, Zn
- High K can reduce the availability of Mg

Nutrient Sufficiency in Soybean Plant Tissue Source: SDSU Aug 25, 2020 - Mueller

Nutrient	Unit	Ideal Range	Likely Response	Small Response
Nitrogen (N)	%	4.5 - 6	< 4	4 - 4.99
Phosphorus (P)	%	0.35 - 0.55	< 0.25	0.25 - 0.34
Potassium (K)	%	2 - 3	< 1.7	1.7 - 1.99
Sulfur(S)	%	0.25 - 0.50	< 0.2	0.2 - 0.24
Calcium (Ca)	%	0.6 - 1.50	< 0.35	0.35 - 0.59
Magnesium (Mg)	%	0.3 - 0.7	< 0.25	0.25 - 0.29
Iron (Fe)	ppm	55 - 300	< 50	50 - 54
Manganese (Mn)	ppm	30 - 100	< 20	20 - 29
Zinc (Zn)	ppm	25 - 60	< 20	20 - 24
Copper (Cu)	ppm	6 - 20	< 4	4 - 5
Boron (B)	ppm	25 - 60	< 20	20 - 24
Molybdenum (Mo)	ppm	1 - 5	< 0.2	0.2 - 0.9

Project Scope: USDA District 10 - NW MN



- 11 Counties area in NW MN
- Soybean acres
  - 2007 = 1,106,000
  - 2017 = 1,813,000
- Soybean Yields (bu/ac)
  - 2007 = 35.7
  - 2017 = 34.1
- Wheat Yields (bu/ac)
  - 2007 = 50.4
  - 2017 = 65.8

Research Objectives

- To establish long term crop rotation trials (4 year minimum) in wheat and soybeans
- Conduct small plot replicated research and large on-farm trials to determine the influence of elevated levels of P and K on wheat & soybean growth, development, yield and seed quality
- Project partners: AFREC, MN Wheat Growers, MN Soybean Growers, U of MN and farmer cooperators

Project Specifics

- Crop rotation: wheat-soybean-wheat-soybean
- Manage wheat for 80 and soybeans for 50 bu/ac
- Trial design: RCB with 4 replications
- Soil samples collected after harvest in years 2-4
- Tissue samples collected at early tillering in wheat and in the 2nd to 3rd trifoliate stage in soybeans
- Soil and plant tissue analysis will help determine if elevated P&K levels are causing an interaction with other plant nutrients (e.g. P & Zn, K & Ca)

Large Plot On-Farm P&K Trials in 2020

- Five locations in 2020, four soybean and one wheat
- The two treatments:
  - Farmer practice (FP) was the field fertility rate selected by farmer cooperator
  - FP + 50 additional units of P&K

Large Plot On-Farm P&K Trials in 2020

- At harvest, headlands were harvested before individual treatments
- Each strip had a full combine header width taken the entire length of the field
- Each strip was weighted and yield calculated

Large Plot On-Farm P&K Trials in 2020

- **Wheat site**
  - **Elbow Lake**
- **Soybean sites**
  - **Baudette**
  - **Ross**
  - **Roseau**
  - **Roseau**

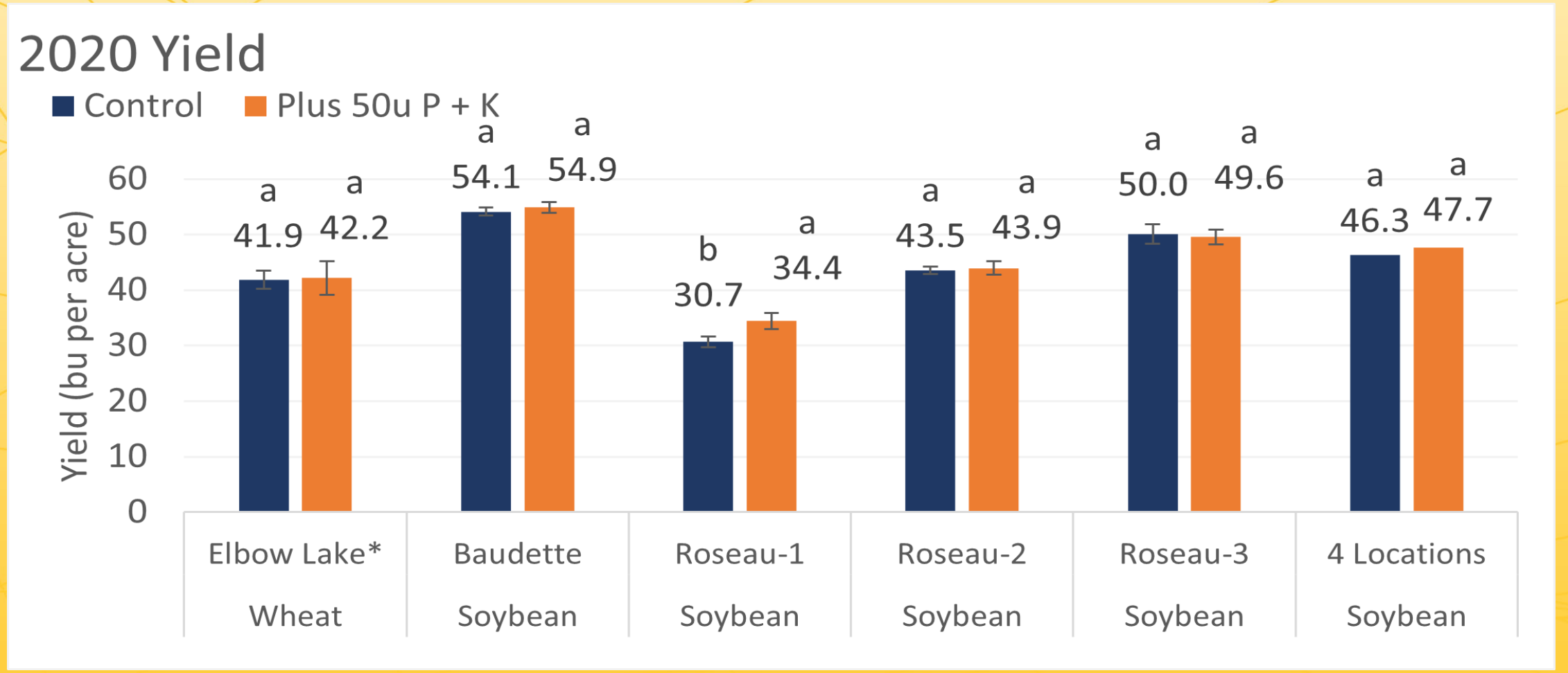
Large Plot On-Farm P&K Trials in 2020

- Soil samples were taken in each strip after harvest
- In heavy soil WD-40 was applied to remove clay from probe
- Soil testing labs indicate applications of WD-40 doesn't have any impact on soil test results

Large Plot On-Farm P&K Trials in 2020

- Soybean yields ranged from 30.7 to 50 bu/acre
- In one of the four sites (25%) gave a higher soybean yield from + 50 compared to FP
- The range in harvested soybean yield difference across the field was 29.7 to 55.2 bu/ac
- Yield monitor 10 to 80+ bu/ac

Large Plot On-Farm Yields in 2020



Large Plot On-Farm P&K Trials in 2020

Soybean tissue test results

- Soybean tissue tests were taken at 50% of the sites
- All nutrient levels were in the normal sufficiency range
- P levels increased in 50% and K 100% in FP+ 50 compared to FP
- Boron levels were less in the FP+50 compared to FP
- Other nutrients non-conclusive

Soil test results after harvest

- Both P and K levels generally higher from FP+50 than FP
- One site P&K levels tested
- Other sites P&K levels tested low to medium for P and med to high for K
- B, Cu, Mn and Zn tested low to medium at all sites

Small Plot Replicated Research

Research Team

- Dr. Nancy Ehlke - PI
- Donn Vellekson - Manager of U of MN Magnusson Research Farm
- Dave Grafstrom - Research agronomist
- Val Laidley - Summer Intern

U of MN Magnusson Research Farm

Small Plot Replicated Wheat Results- 2020

Wheat-2020					Soil Test Results		Tissue Test Results	
	Added[1]	Yield[2]	Test		P	K	P	K
Trt#	P & K	Bu/Acre	Wt./Bu	Protein[3]	ppm	ppm	%	%
1	0-20-0	73.0	63.0	14.7	16.5	123	0.28	1.6
2	0-40-0	75.8	62.3	14.6	16.3	118	0.28	1.6
3	0-60-0	72.8	62.3	14.5	24.5	121	0.28	1.6
4	0-80-0	69.8	62.7	14.3	27.0	123	0.28	1.6
5	0-100-0	67.8	62.7	14.0	32.3	122	0.28	1.5
6	0-0-20	70.5	62.1	14.4	12.8	135	0.28	1.7
7	0-0-40	69.3	62.9	14.6	14.5	135	0.27	1.8
8	0-0-60	69.5	63.1	14.5	12.8	130	0.27	1.8
9	0-0-80	70.3	62.4	14.9	14.0	139	0.28	1.9
10	0-0-100	71.3	63.1	14.5	14.5	135	0.26	1.8
11	0-20-20	70.5	63.0	14.5	17.5	126	0.25	1.6
12	0-40-40	74.8	62.1	14.2	20.5	129	0.27	1.7
13	0-60-60	73.3	61.7	14.4	24.8	135	0.27	1.6
14	0-80-80	76.0	62.8	14.6	25.0	126	0.28	1.7
15	0-100-100	74.0	62.6	14.4	37.0	138	0.29	1.8
16	0-0-0	67.0	62.6	14.7	16.3	116	0.26	1.5
LSD @5%level		7.4	1.3	0.7	8.1	16	0.03	0.2
LSD @10%level		6.2	1.1	0.5	6.7	13	0.02	0.1
CV(%)		7.2	1.5	3.2	28	8	5	4

- Yields ranged from 67 to 76 bu/a
- Yields higher from the combination of 40, 60, 80, & 100 of P&K vs untreated
- K alone flat response in wheat yield
- No Trt. difference in test wt. & protein vs untreated
- P applied alone or in combination at 60, 80 & 100 increased soil test P
- K soil test levels tended to or increased with all K rates
- No Trt. effect in P tissue test levels vs untreated
- All K rates tended to or increased K tissue test levels

Small Plot Replicated Soybean Results - 2020

Soybeans-2020		Yield[2]	Test			Soil Test Results		Tissue Test Results	
						P	K	P	K
Trt#		Bu/Acre	Wt./Bu	Protein[3]	Oil[3]	ppm	ppm	%	%
1	0-20-0	64.8	57.7	38.7	20.9	4.5	120	0.54	2.4
2	0-40-0	69.0	57.7	38.9	20.7	4.5	113	0.55	2.2
3	0-60-0	65.0	57.8	38.8	20.9	8.0	117	0.59	2.6
4	0-80-0	65.5	57.8	38.2	21.2	10.3	123	0.58	2.4
5	0-100-0	69.0	57.8	38.6	20.9	13.8	113	0.62	2.5
6	0-0-20	61.0	57.7	38.5	20.9	4.5	111	0.57	2.6
7	0-0-40	69.0	57.7	38.5	20.9	3.3	114	0.53	2.3
8	0-0-60	63.2	57.8	38.5	21	2.5	125	0.59	2.5
9	0-0-80	66.3	57.7	38.3	21.0	3.0	134	0.52	2.3
10	0-0-100	66.5	57.6	38.6	20.9	2.8	131	0.62	2.7
11	0-20-20	69.8	57.6	38.6	20.9	4.0	126	0.57	2.5
12	0-40-40	68.3	57.9	38.5	20.9	6.3	118	0.59	2.5
13	0-60-60	69.3	57.8	38.6	21.0	7.0	123	0.59	2.5
14	0-80-80	63.5	57.7	38.5	21.0	9.5	126	0.60	2.5
15	0-100-100	63.8	57.6	39.0	21.0	9.0	132	0.61	2.5
16	0-0-0	61.0	57.7	39.1	20.7	3.3	109	0.60	2.5
LSD @5%level		8.3	NS	0.4	0.4	3.2	17	0.07	0.32
LSD @10%level		6.5	0.3	0.4	0.3	2.6	14	0.06	0.26
CV(%)		7.8	0.4	0.8	1.3	37	10	6	6

- Yields ranged from 61 to 69.8 bu/a
- Yields higher from the combination of 20, 40, & 60 of P&K vs untreated
- No Trt. difference in test wt. & protein vs untreated
- P applied alone or in combination at 60, 80 & 100 increased soil test P
- P soil test levels increased with rate
- K soil test levels tended to or increased with all K rates
- No Trt. effect in P or K tissue test levels vs untreated

Summary Small Plot Trials - 2020

- Two small plot trials completed in 2020
- Higher wheat yields were detected from the combination of 40, 60, 80 and 100 units of P&K vs untreated
- Higher soybean yields were detected from the combination of 20, 40 and 60 units of P&K vs untreated
- P soil levels tended to or increased as P rate increased in soils (untreated) testing low, 3.3 ppm or high, 16.3 ppm
- K soil levels tended to or increased as K rate increased, especially with 80 and 100 units

Summary Large On-Farm Trials in 2020

- One wheat and four soybean sites harvested in 2020
- Wheat site had herbicide drift that influenced results
- FP+50 increased soybean yields at one site and produced similar yields at three sites compared to FP
- P&K tissue levels generally were higher in FP+50 compared to FP
- Fall soil tests indicate that FP+50 was building P and K levels compared to FP

Questions

MINNESOTA SOYBEAN RESEARCH & PROMOTION COUNCIL

AFREC
Agricultural Fertilizer Research & Education Council

MINNESOTA WHEAT
RESEARCH & PROMOTION COUNCIL

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