Minnesota Soybean Research and Promotion Council
and
Minnesota Wheat Research and Promotion Council
Minnesota Agricultural Fertilizer Research and Education Council

Project Title:
Influence of Phosphorus and Potassium Applications in a Multi-year Spring Wheat-Soybean Crop Rotation

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Project Goal: To determine optimum levels of Phosphorus (P) and Potassium (K) in a high yield, long term (4 year) cropping sequence of spring wheat and soybeans in northwest Minnesota.

Project objectives:

1) Establish long term crop rotation trials (4 year minimum) in wheat and soybeans using a combination of small plot replicated and on-farm research trials.
2) Conduct small plot replicated research to determine the influence of elevated levels of P and K on wheat and soybean growth, development, and yield.
3) Partner with the MN Wheat On-Farm Research Network (OFRN) to evaluate enhanced P and K fertility utilizing large on-farm research trial methodologies to determine if current P and K recommendations provide adequate fertility in a high yield wheat-soybean crop rotation.

Background

In the last decade, soybeans have become a popular crop choice for farmers in northwest MN. The USDA National Agricultural Statistics Service (NASS) details an 11-county area of northwest MN as District 10. District 10 includes the following MN counties: Becker, Clearwater, Clay, Kittson, Mahnomen, Marshall, Norman, Polk, Pennington, Red Lake, and Roseau. According to the USDA, soybean acres in District 10 were 1,106,000 in 2007 and had risen to 1,813,000 in 2017. This is an increase of 707,000 acres of soybean during this ten-year period. In this same time frame, spring wheat acres have ranged from a high of 1,284,000 in 2008 to a low of 944, 000 in 2017. This data would indicate a spring wheat-soybean crop rotation is now a common cropping sequence for farmers in District 10 of northwest MN.

In the last ten years (2007-2017), USDA NASS data indicates spring wheat yields have ranged from a low of 47.8 in 2011 to a high of 68.5 bu/acre in 2017. That's a wheat yield increase of 20.7 bu/acre from low-to-high during the last decade. However, reported soybean yields have been relatively flat during this same ten-year time frame. As an example, soybean yields were 35.7 in 2007 and 34.1 bu/acre in 2017.

AGVISE Laboratories in Northwood, ND conducts a soil survey each year in their trade area. In 2017, the area that roughly corresponds to USDA District 10 had 67% of soil samples with a Phosphorus (Olsen Test) level of less than 10 ppm. Further, 39% of the submitted soil samples had Potassium levels less than 150 ppm. This soil survey data suggests that over 2/3 of the fields sampled for P and over 1/3 sampled for K, may not have adequate nutrients to produce high yield soybean and wheat. With the recent increase in wheat yield and the potential increase in soybean yield, the soil levels of P and K may be a limiting factor for plant growth, development, and yield.

The objective of this project was to utilize a combination of small plot replicated research and large on-farm trials to determine if P and K levels are limiting soybean and wheat yields. Field trials will be conducted over four consecutive years in a wheat-soybean cropping sequence in northwest MN.

Methods and Timetables:

The overall objective of this research is to establish two small plot replicated research sites and five on-farm locations each year from 2019- 2022. These sites will serve as in-field laboratories to determine if P and K levels are limiting crop production in a spring wheat-soybean rotation. A complete soil and tissue analysis will be conducted on the collected soil and tissue samples to determine potential nutrient interaction with elevated applied levels of P & K. Previous research suggests elevated levels of P can interact with zinc. Further, high levels of K can have a negative impact on the uptake of calcium, nitrogen, and magnesium. All sites will include an alternating spring wheat-soybean rotation for at least four years. The on-farm cooperators will be selected with input from the MN Wheat OFRN. Farmer cooperators will agree to have this site in a wheat-soybean rotation for at least four years and will follow best management practices (BMP's). Wheat and soybean varieties will be selected from varieties in the upper 25% of yield trials for the geography near the small plot or on-farm research location.

Objective 1

Conduct small plot replicated research to determine the influence of elevated levels of P and K on wheat and soybean growth, development, and yield. The nutrient sources will be 0-46-0 and 0-0-60 and will be applied broadcast and incorporated prior to seeding. Experimental design will be a RCB with a factorial arrangement of treatments. Broadcast fertility treatments will be blended and applied by hand. Individual plot size will be 6 x 15 feet. This small plot fertility trial will have 5 fertility rates for P, 5 for K and the combination of each plus a no treatment (no added P &K). Total number of treatments will be 15 plus a control = 16 treatments replicated 4 times for a total of 64 individual plots. The applied treatments included:

- 0-46-0 @ 20 units; 0-0-60 @ 20 units; 0-46-0 + 0-0-60 @ 20 units of each
- 0-46-0 @ 40 units; 0-0-60 @ 40 units; 0-46-0 + 0-0-60 @ 40 units of each
- 0-46-0 @ 60 units; 0-0-60 @ 60 units; 0-46-0 + 0-0-60 @ 60 units of each
- 0-46-0 @ 80 units; 0-0-60 @ 80 units; 0-46-0 + 0-0-60 @ 80 units of each
- 0-46-0 @ 100 units; 0-0-60 @ 100 units; 0-46-0 + 0-0-60 @ 100 units of each
- Untreated control

These small plots will be managed for a yield goal of 80 bu/acre for spring wheat and 50 bu/acre for soybeans. Individual plots will be harvested with a small plot combine for yield with a sub-sample collected from each plot for seed quality assessments. Soil samples were taken prior to seeding in the

spring of 2019 and after harvest in each year of this project to determine the residual levels of P & K. In-season tissue samples will be collected at early tillering and again at early heading in wheat and at the second to third trifoliate stage and at early bloom in soybeans. Crop vigor 30 days after planting, a relative chlorophyll index (RCI), and plant height will be collected for each plot.

Objective 2

Large on-farm trials will be conducted at various locations in USDA District 10. A goal is to have five field locations for this long-term wheat-soybean rotation project. The trial design will be a randomized complete block with four replications. The farmer cooperators selected to participate in these research trials will strive for high yield wheat 80 and soybeans 50 bu/acre. Farmer cooperators will agree to utilize BMPs in each year of this project. Each site will have two treatments replicated four times (eight strips). All sites will have a standard farmer practice (FP) P & K rate (treatment 1) and an enhanced P & K strip (treatment 2).

- Treatment 1: FP - The current P & K fertility program
- Treatment 2: Enhanced P & K fertility program = FP P & K rate + an additional 50 units of P and K

Plot size will be one or two passes of the application equipment (70 or 140 feet) wide by the length of the field to accommodate the cooperator's production practices and equipment. Commercial equipment will be used in all facets of the on-farm trials with a weigh wagon and/or combine yield map to determine wheat and soybean yield. Other data to be collected will include: Crop vigor and color 30 days after planting, plant tissue samples at the same timing as small plot trials, plant height at physiological maturity, and soil samples from each strip after harvest.

Project Outreach and Deliverables

The Minnesota Wheat OFRN has an established track record of conducting on-farm research. This project will partner with the MN Wheat OFRN to select farmer cooperators, assist in site selection, coordination, and collection of research results, and will assist with data analysis and summaries.

Minnesota Wheat has a tradition of disseminating research results in various methods of communication. Project results were published in the annual Minnesota Wheat Research Review book (1,200 copies) and in the bi-monthly magazine publication titled: Prairie Grains (18,000 copies printed and mailed). This magazine reaches the spring wheat growing region of MN, MT, ND, and SD. Project presentations were given at the annual Prairie Grains Conference, organized in part by Minnesota Wheat, Minnesota Soybean, and Minnesota Barley. The Prairie Grains conference is a two-day conference held annually in December at the Alerus Center in Grand Forks, ND. Project results were also be presented during the annual half-day OFRN Research Summit. Farmers and interested stakeholders attend this research summit to learn and offer opinions on research priorities to help improve crop production and the "bottom lines" for their operations.

Research results were presented at the Small Grains, Wheat, Soybean and Corn Update Meetings held at 8 locations each January. On average, 50 people/location attend these meetings held in Fergus Falls, Moorhead, Crookston, Ada, Hallock, Argyle, Roseau, and St. Hilaire. Research results were presented at the Minnesota Soybean Growers Association regional and county meetings. Project results will be summarized for on-line publication in Minneline (MN Soybean), and U of MN Crops News Blog, and in the smallgrains.org research database (MN Wheat).

Summary of Weather Conditions in 2019-2022 Growing Seasons

Weather Conditions 2019

Early dry spring with soil moisture conditions below normal, but timely precipitation in May and June was a factor in good early season crop growth and development (NDAWN). Accumulated rainfall for July and August was above average. Daily high temperatures during the first few days of wheat flowering averaged 5 degrees cooler, but the remainder of the flowering period was 5 degrees or more higher than average (Source: NDAWN). The wheat harvest came off in a timely manner. However, due to the wet fall much of the soybean harvest was delayed until the ground froze in late October. Rainfall in September and October of 2019 totaled 9.95 and 4.12 inches compared to the average of 3.33 and 2.22 inches, respectively.

Weather Conditions 2020

The above average rainfall received in the fall of 2019 made fall tillage a challenge. April and May were dryer than average, which allowed the topsoil to dry out. However, the incomplete fall tillage and saturated soil conditions in the fall of 2019 made it difficult to prepare a good seedbed in the spring of 2020. Wheat and soybean seeding was delayed until late May of 2020. Saturated soil conditions returned in June and July which limited root development and plant growth. Rainfall totals in June was 6.29 and in July was 8.23 inches which is double the normal rainfall for June and July. Daily high temperatures during wheat flowering were 5 to 10 degrees warmer than average, but temperatures returned average during grain filling. (Source: NDAWN).

Weather Summary in 2021

Precipitation in the fall of 2020 and winter and early spring of 2021 was below average in most of Northern MN. The National Weather Service had much of NW MN in a moderate drought during the summer of 2020 and into winter of 2021. By the end of June, the moderate drought had changed to severe drought and by the end of July most of the area was in a severe drought. Weather records recorded at the Northwest Research & Outreach Center in Crookston since 1890. These weather records indicate the first half of 2021 was the second driest and the first nine months were the driest ever recorded. The lack of precipitation was compounded by over 21 days of daily high temperatures over 90F.

Weather Conditions in 2022

The spring of 2022 was cold and wet in many areas of NW MN. Weather records from the National Weather Service (NWS) in Grand Forks, ND lists April of 2022 as the second coldest on record with an average temperature of 31.8F. Further, May of 2022 was the 5th wettest on record which dates back 140 years. Springs field work finally began in the latter part of May. However, due to the cold wet spring many farmers elected to prevent planting (PP) crop acres instead of planting wheat in June.

Table 1. Soybean yield, test weight, protein and oil content as influenced by various rates of Phosphorus and Potassium in 2019-2022 at Roseau, MN.

Soybeans 2019-22

	Added[1]	Yield Bu./acre[2]				Test Wt./Bu.				Protein[3]				Oil[3]			
TRT#	P & K	2019	2020	2021	2022	2019	2020	2021	2022	2019	2020	2021	2022	2019	2020	2021	2022
1	0-20-0	65.3	64.8	46.0	54.1	57.4	57.7	59.7	59.4	36.7	38.7	37.7	40.0	20.4	20.9	20.6	19.7
2	0-40-0	62.0	69.0	44.3	47.2	57.5	57.7	59.4	59.9	37.1	38.9	37.9	40.2	20.4	20.7	20.9	19.5
3	0-60-0	61.5	65.0	46.3	50.6	57.2	57.8	59.4	59.6	37.4	38.8	37.6	40.2	20.5	20.9	20.8	19.3
4	0-80-0	61.0	65.5	48.3	48.8	57.5	57.8	59.5	59.7	36.9	38.2	36.5	39.9	19.6	21.2	21.3	19.4
5	0-100-0	63.8	69.0	50.9	52.0	57.1	57.8	59.5	59.2	37.8	38.6	38.5	39.9	20.3	20.9	20.6	19.4
6	0-0-20	61.8	61.0	48.3	48.7	57.3	57.7	59.5	59.6	37.0	38.5	37.3	39.7	20.4	20.9	20.2	19.6
7	0-0-40	63.5	69.0	50.7	49.9	57.5	57.7	59.3	59.2	37.0	38.5	36.9	39.3	20.4	20.9	20.9	20.0
8	0-0-60	67.5	63.2	54.1	50.2	57.5	57.8	59.4	59.0	36.9	38.5	35.5	39.3	20.2	21	21.1	20.0
9	0-0-80	61.5	66.3	47.2	47.1	57.5	57.7	59.4	59.3	37.0	38.3	37.4	39.6	20.0	21.0	21.1	19.8
10	0-0-100	68.0	66.5	51.7	51.1	57.4	57.6	59.2	58.9	37.0	38.6	37.9	39.5	20.3	20.9	20.7	20.2
11	0-20-20	67.8	69.8	48.0	57.5	57.3	57.6	59.3	59.2	36.9	38.6	36.4	40.2	20.3	20.9	21.0	19.7
12	0-40-40	64.3	68.3	46.4	55.4	57.5	57.9	59.5	59.4	36.7	38.5	38.6	39.6	20.0	20.9	20.9	19.8
13	0-60-60	64.3	69.3	48.2	53.8	57.4	57.8	59.3	59.3	37.0	38.6	35.8	39.1	20.5	21.0	21.1	19.6
14	0-80-80	62.3	63.5	51.1	53.9	57.5	57.7	59.5	59.5	37.2	38.5	37.6	38.9	20.3	21.0	20.9	19.9
15	0-100-100	68.5	63.8	48.2	57.8	57.3	57.6	59.2	59.6	37.4	39.0	36.9	39.7	20.2	21.0	21.3	19.5
16	0-0-0	61.7	61.0	46.0	52.1	57.3	57.7	59.4	59.0	36.9	39.1	38.0	39.7	19.9	20.7	21.2	20.1
LSD @ 5% Level		NS	8.3	7.5	6.7	0.4	NS	0.4	0.8	NS	0.4	1.4	0.9	NS	0.4	0.8	0.5
LSD @ 10% Level		6.4	**6.5**	6.2	6.1	0.3	0.3	0.3	0.7	0.8	0.4	2.0	0.8	0.8	0.3	0.6	0.4
	CV(%)	8.5	7.8	10.8	9	0.5	0.4	0.5	0.9	1.8	0.8	3.5	1.7	2.3	1.3	2.6	1.9

Experimental Design: RCB with 4 reps

All plots used best management practices(BPM)

Soybean variety - AG005x1 seeded at 1.4 units/ac; 172,000 PLS/ac

Added[1] - 0-46-0 super phosphate and 0-0-60 potash used for P and K sources

Yield[2] - Bushels per acre corrected to 12% moisture for wheat and 13% moisture for soybean

Protein and Oil[3]-on dry matter basis

Plot size= 6' x 15' Harvest area= 5' x 12'

Soil Type-Borup silt loam(2019 wheat) Zippel very fine clay loam(2019 soybeans)

Table 2. Wheat yield, test weight and protein as influenced by various rates and combinations of Phosphorus and Potassium in 2019-2022 at Roseau, MN.

Wheat 2019-22													
	Added[1]	Yield Bu./acre[2]				Test Wt./Bu.				Protein[3]			
TRT#	P & K	2019	2020	2021	2022	2019	2020	2021	2022	2019	2020	2021	2022
1	0-20-0	85.0	73.0	72.6	75.5	60.3	63.0	61.9	60.6	15.3	14.7	16.9	16.6
2	0-40-0	86.3	75.8	79.6	78.1	60.3	62.3	62.0	60.8	15.3	14.6	16.8	16.7
3	0-60-0	87.3	72.8	78.6	76.5	60.2	62.3	62.0	60.5	15.1	14.5	17.0	16.8
4	0-80-0	85.3	69.8	80.0	79.0	60.3	62.7	62.0	60.7	15.1	14.3	16.6	16.8
5	0-100-0	92.8	67.8	79.0	78.2	60.2	62.7	61.4	60.5	15.2	14.0	17.0	16.7
6	0-0-20	81.3	70.5	64.3	74.3	60.0	62.1	62.2	60.7	15.4	14.4	17.0	16.9
7	0-0-40	81.5	69.3	63.2	74.7	60.0	62.9	61.9	60.7	15.4	14.6	17.3	16.8
8	0-0-60	83.3	69.5	60.3	75.0	60.0	63.1	62.1	60.8	15.5	14.5	17.3	16.9
9	0-0-80	81.3	70.3	60.7	77.2	60.3	62.4	62.3	60.7	15.7	14.9	17.4	17.0
10	0-0-100	82.5	71.3	59.0	78.2	60.1	63.1	62.2	61.0	15.7	14.5	17.1	17.1
11	0-20-20	89.0	70.5	75.9	73.7	60.1	63.0	62.2	60.5	15.3	14.5	17.1	16.6
12	0-40-40	86.5	74.8	80.5	78.7	60.1	62.1	61.8	60.7	15.2	14.2	16.8	16.7
13	0-60-60	85.3	73.3	82.4	81.1	60.2	61.7	62.2	60.9	15.1	14.4	17.1	16.7
14	0-80-80	77.5	76.0	82.8	79.3	60.0	62.8	62.3	60.7	15.3	14.6	17.1	16.9
15	0-100-100	87.8	74.0	84.8	77.9	60.3	62.6	62.0	61.1	15.2	14.4	17.1	16.9
16	0-0-0	82.3	67.0	60.0	77.4	60.2	62.6	61.7	60.5	15.3	14.7	17.0	16.7
LSD @ 5% Level		8.6	7.4	7	3.9	0.3	1.3	0.6	0.4	0.2	0.7	0.7	0.3
LSD @ 10% Level		7.2	6.2	5.8	3.2	0.2	1.1	0.5	0.3	0.2	0.5	0.6	0.3
	CV(%)	7.2	7.2	6.7	3.5	0.3	1.5	0.6	0.5	1.1	3.2	3.0	1.2
Linkert wheat seeded @ 120#/acre													
160-0-0 applied and incorporated in final seedbed prep.													

Added[1] -	0-46-0 super phosphate and 0-0-60 potash used for P and K sources
Yield[2] -	Bushels per acre corrected to 12% moisture for wheat and 13% moisture for soybean
Protein on dry matter basis	
Plot size= 6' x 15'	Harvest area= 5' x 12'
Soil Type-Borup silt loam(2019 wheat) Zippel very fine clay loam(2019 soybeans)	

Small Plot Research Results 2019

The trial average for wheat yield was 85 bu/acre, test weight was over 60#/bu and protein over 15%. Wheat yield in the untreated was 82.3 bu/acre. Generally, as the level of P increased wheat yields tended to increase to a top-end yield of 92.8 bu/acre from 0-100-0. However, wheat yield response to K was relatively flat. No treatment differences were detected in wheat test weight which ranged from 60-60.3 lbs/bu. Wheat protein ranged from 15.1 to 15.7. Wheat protein was relatively flat (15.1-15.3%) from the various levels of P and the combinations of P and K. ▪ Wheat protein was highest (15.5-15.7%) from K applied alone, especially with rates over 0-0-60.

Soybean yields ranged from 61- 68.5 bu/acre. ▪ Soybean test weight ranged from 57.1 to 57.5 lbs/bu. No statistical differences were detected between any of the treatments for soybean yield, protein, or oil. This data set pointed to a trend for higher soybean yield as the K rate increased. Soil tests data indicated this site was very high for P and high for K.

Large On-Farm Results in 2019

No differences were observed from the plus 50 compared to the untreated.

Small Plot Research Results 2020

Wheat yields, corrected 12% moisture, ranged from 67 to 76 bu/ac. The lowest yield in the trial was 67 bu/ac from the untreated plots. At the 10% confidence level, the combination of P & K produced more grain yield than the single products alone, especially at 40, 60, 80 and 100 units of each produce. The P alone rates of 20, 40 and 60 produced more grain yield than 80 or 100 units. The wheat yield response was flat from potassium applied alone. Test weight ranged from 61.7 to 63.1 #/bu. Protein ranged from 14 to 14.9%. As a general statement with the single products as P level increased protein level decreased, but as K levels increased protein levels increased. However, with the combination of P & K protein level was relatively flat.

Soybean yields, corrected to 13% moisture, ranged from 61 to 69.8 bu/ac. The untreated plots gave an average yield of 61 bu/ac. Generally, with the single rate of P & K, soybean yields increased as fertilizer rate increased. However, with the combination of P & K, soybeans yields were better from 20, 40 and 60 compared to 80 or 100 units of each product. The test weight ranged from 57.6 to 57.9 3/bu. Protein ranged from 38.2 to 39.1%. The untreated plots averaged 39.1% which was the highest in the trial, but the yield of 61 bu/ac was the lowest. This relationship between protein and yield has been well documented in previous trials in wheat. Oil content ranged from 20.7 to 21.2%. The untreated plots averaged 20.7% oil which was the lowest in the trial. All fertility treatments tended to increase soybean oil content.

Large On-Farm Results in 2020

There was a significant difference between treatments at the Roseau-1 location. The initial soil P at this location was 10 ppm (medium). In 2020 one of four soybean sites (25%) gave a positive response to additional P&K. However, the combined analysis did not show significant differences between treatments.

Small Plot Research Results 2021

Wheat yields ranged from 60 to 84.8 bu/ac. All P rates applied alone or in combination with K gave higher wheat yields (0.05% confidence level) than the untreated. Wheat yields in bu/ac averaged over all P rates = 78, all K rates = 61.5 and the combination of P&K = 81.2 bu/ac compared to the untreated of 60 bu/ac. Wheat yields from all K treatments applied alone gave similar yields at the untreated. Test weight ranged from 61.1 to 62.3 #/bu with no treatment difference. Wheat protein ranged from 16.6 to 17.1% with no treatment differences. P applied alone or in combination with K increased soil test levels of P. All rates of P increased the levels of P in wheat tissue compared to the untreated. K rates of 60, 80 and 100 #/acre increased K tissue test levels compared to the untreated.

Soybean yields ranged from 46 to 54.1 bu/ac. Yields generally were similar in all treatments compared to the untreated. No treatment differences were observed in test weight, protein, and oil vs untreated. Soil test levels increased with rate. No differences were observed in P tissue test levels compared to the untreated. However, applied K generally increased the K tissue levels in the plant.

Large On-Farm Results 2021

At the (0.05%) confidence level, there was a 5.5 bu/ac yield advantage from the Plus 50 compared to the farmer practice at the Roseau-1 location. The soil P at this location was 6.5 (low). In 2021, one of three wheat sites (33%) gave a positive response to additional P&K.

Small Plot Replicated Research Trial Results in 2022

In 2022, no differences were detected from any of the fertility treatments compared to the untreated in wheat or soybeans. These results were contrary to those obtained in 2021 which suggested that the combination of P and K produced more wheat yield than the single products alone, especially at 40, 60, 80 and 100 units of each product. A possible explanation for the differential response of wheat to the fertility treatments between 2021 and 2022 can be found in the North Dakota Fertilizer Handbook. This publication gives a probability of a response to applied fertilizer based on soil test levels in the field. As an example, with soil P levels of 4-7 ppm (Olsen) applied phosphorus would have a 60-80% chance of a positive yield response. Based on this data, the probability of little or no response to applied P would be 20-40%. The 2022 season probably was one of the times with little to no response to applied fertilizer. Another possible explanation would be the average crop yields in 2022 due to delayed planting of wheat and soybeans. With a higher yield potential, the probability of a positive yield response to applied fertilizer would be higher than in years with average-to-below crop yield production.

Large On-Farm Results in 2022

Due to the cold and wet spring two on-farm sites were harvested in 2022. A wheat site in Elbow Lake experienced good growing conditions with wheat yields in the 80 bu/ac range. At the 95% confidence level the plus 50 treatment of P&K produced 3.8 bu/ac more wheat than the farmer practice. No differences were observed between treatments in the wheat quality analysis. At the soybean site near Baudette, no differences were detected in soybean yield or quality between the plus 50 of P&K and the farmer practice. However, harvested soybean yields were in the mid-30 bu/ac range which indicated that environmental conditions were not favorable for soybean growth and development at this site in 2022.

Small Plot Summary 2019-2022

A positive wheat yield response to P and the combinations of P&K in three (2019, 2020 and 2021) of the four years of this trial (75%). A positive soybean yield response to P and the combinations with K in one (2020) of the four years of this trial (25%). Post harvest soil tests indicate that P levels can be built up or depleted depending upon the rate of applied P and crop removal. Post harvest soil tests indicate K levels were relatively flat regardless of applied K rate. This is most likely due to the clay content of the soil (see attached clay minerology report).

Large On-Farm Summary 2019-2022

In 2019 no differences were detected from the addition of 50 units of P&K applied compared to the farmer practice. In 2020 a positive yield response was detected in 1 of 4 soybean sites (25) and in 2021, 1 of 4 wheat sites (25%). The 2022 season was a challenge with two sites evaluated and the wheat site gave a positive response to the 50 additional units of P&K compared to the untreated. The positive yield responses generally were from sites that had a medium to low level of P and K.

A decade ago, the general thinking was soybeans scavenged well and no additional soil fertility was needed. In northwest MN this thinking has changed and for high yielding soybeans a P&K application rate of 40-60 units of each is quite common. Farmers are seeing a soybean yield response from the supplemental P&K applied prior to a soybean crop.

Figure 1. Potassium Soil Test Levels in a wheat and soybean crop rotation influenced by Potassium application rate in a low P testing soil from 2019 to 2022 near Roseau, MN.

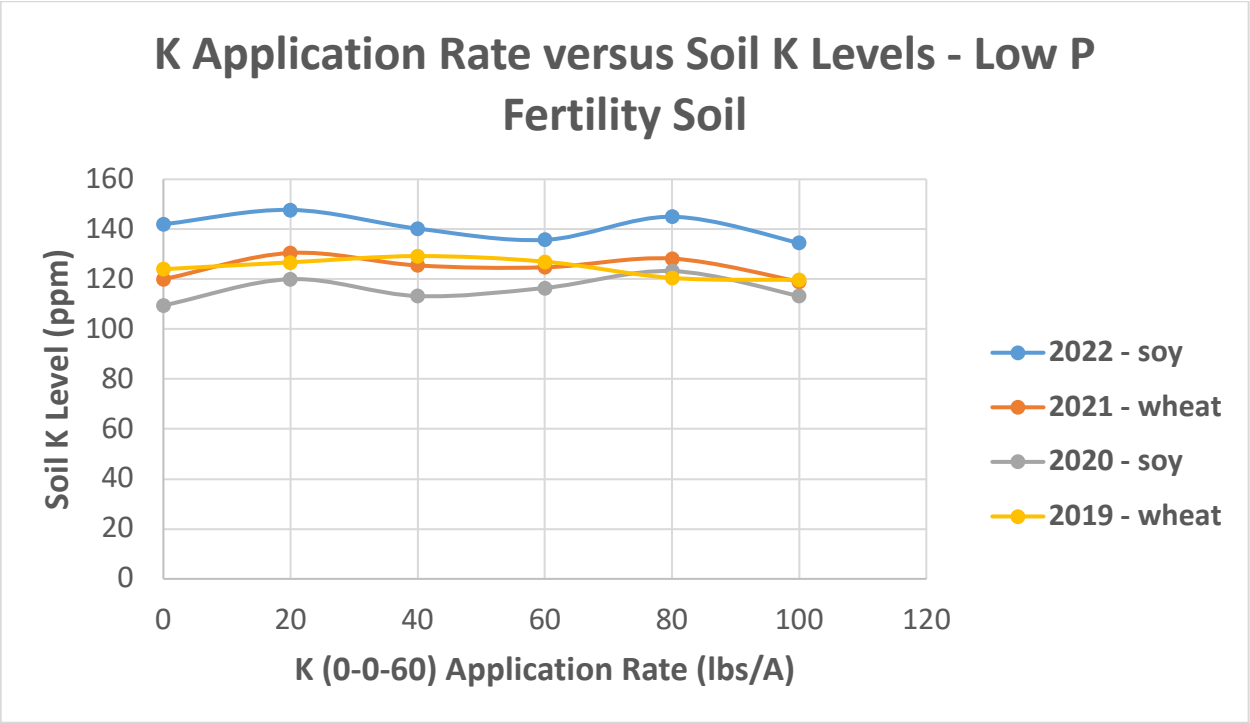

Figure 2. Potassium Soil Test Levels in a wheat and soybean crop rotation influenced by Potassium application rate in a high P testing soil from 2019 to 2022 near Roseau, MN.

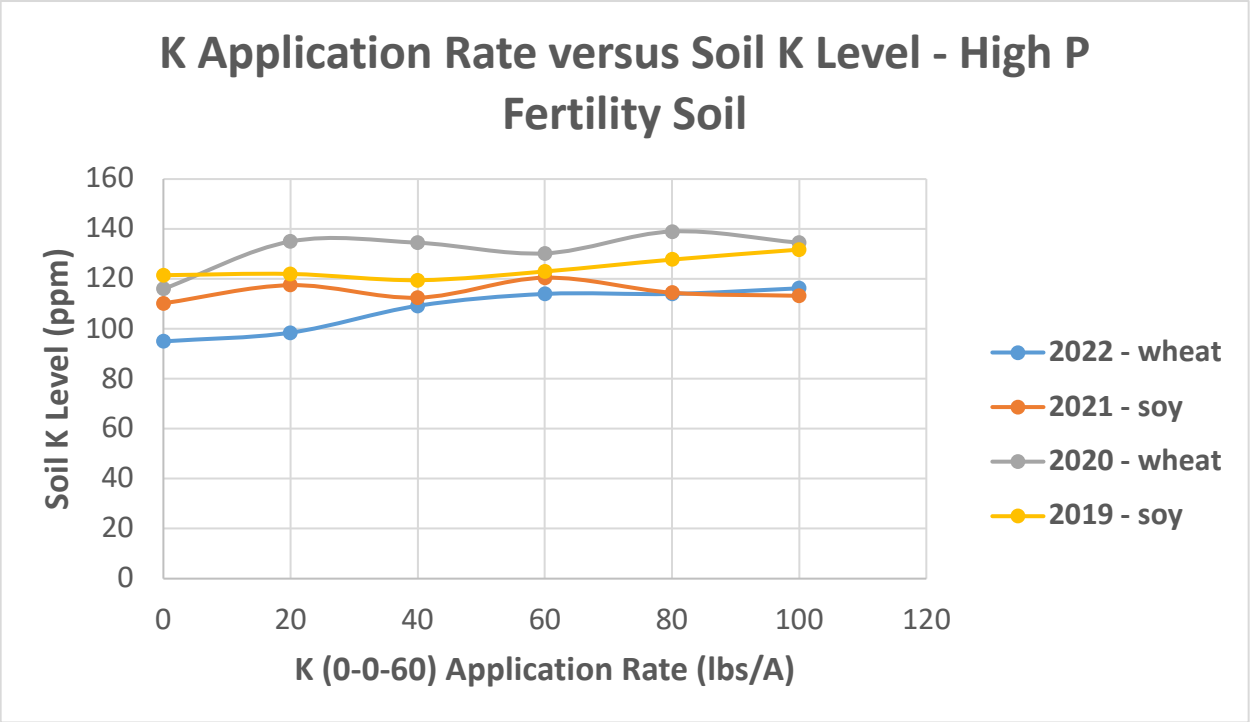

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Figure 3. Phosphorus soil test Levels in a wheat and soybean crop rotation influenced by Phosphorus application rate in a low P testing soil from 2019 to 2022 near Roseau, MN.

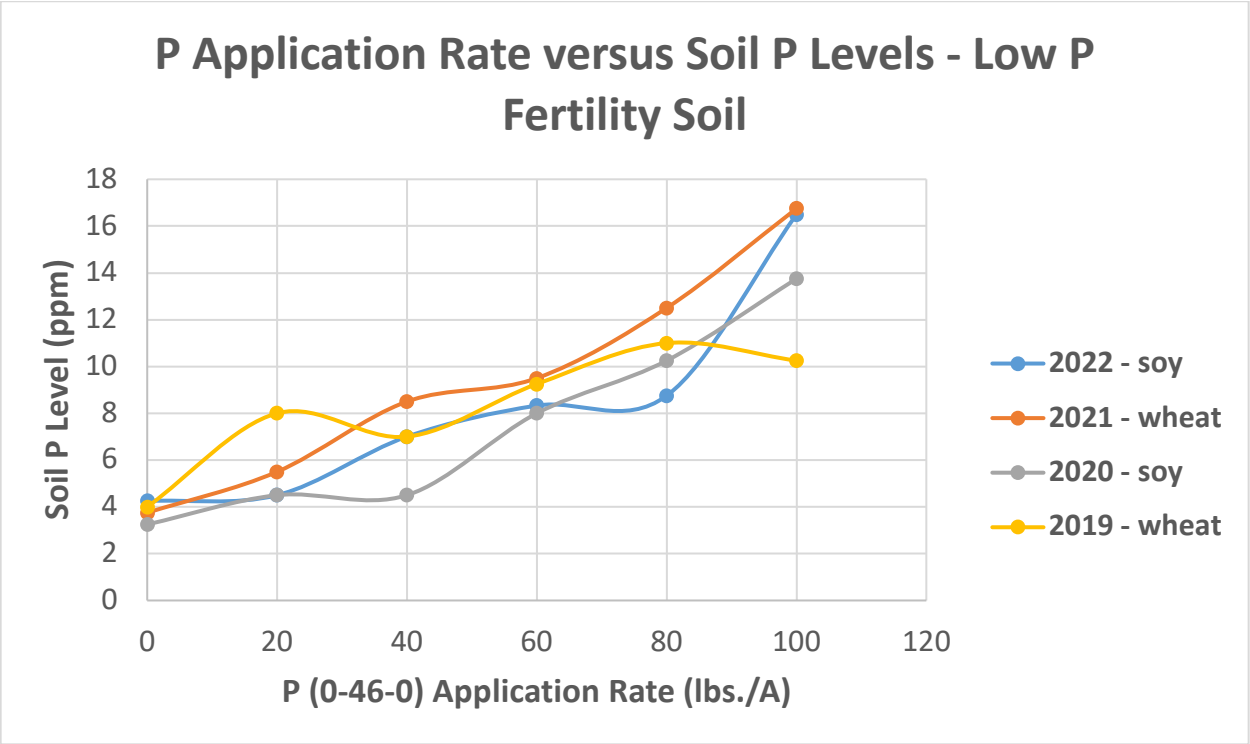
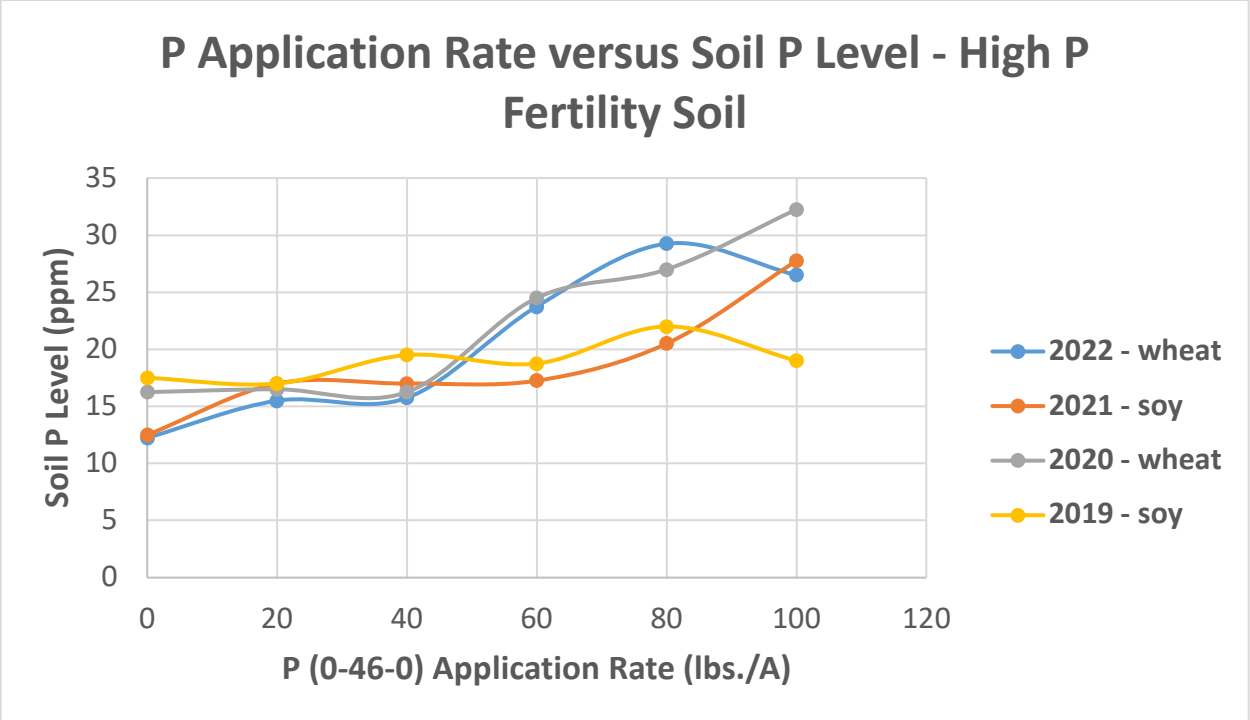


Figure 4. Phosphorus soil test Levels in a wheat and soybean crop rotation influenced by Phosphorus application rate in a high P testing soil from 2019 to 2022 near Roseau, MN.



Soil samples were taken after harvest each year from 2019 to 2022. Soil analysis for P and K influenced by year and fertilizer rate are listed in Figures 1-4. One site had an initial P test in the low category (4 ppm in the untreated) Figure 3. In the four years of this trial the P levels in the untreated remained in the 4-ppm range. After four years of this trial as the rate of P increased from 40 to 100 pounds/ac the soil test levels increased to a high of over 16 ppm. P applied at 20 pounds/ac resulted in P soil test levels similar to the untreated (4-ppm). Soil P levels were in the range of 7, 8, 8 and 16 ppm from P application rates of 40, 60, 80 and 100 pounds/ac, respectively. These results would suggest that in a soil that tests low in P the rate of P should be 40 pounds/acre or more to build soil P levels.

One site had an initial P test in the high category (17 ppm in the untreated) Figure 4. In the four years of this trial the P levels in the untreated declined to the 12-ppm range. After four years of this trial as the rate of P increased from 60 to 100 pounds/ac the levels of soil test P increased in the range of 25-30 ppm. P applied at 20 and 40 pounds/ac resulted in P soil test levels in the 15-ppm range. Soil P levels were in the range of 25, 30 and 26 ppm from P application rates of 60, 80 and 100 pounds/ac, respectively. These results would suggest that soil test P levels can be built up even in a soil that tests high in P, especially if the applied rate of P is over 60 pounds/ac.

The soil test results for K appear to be influenced more by year than K rate (Figure 1 and 2). The data would suggest that applied K rates from 20 to 100 didn't result in a building of the K level in the soil. These results are difficult to explain as the conventional thinking would be if more K is applied more K should be detected in the soil tests, especially with K rates of 100 pounds/ac applied each year for four years. Recent K research from Kaiser at U of MN and Franzen at NDSU has suggested that clay minerology is important factor in soil test K. The type of clay is important in tie up and release of K from the clay particles. Selected soil samples (untreated) were submitted for a clay minerology analysis (see attached report). The results of this clay mineralogy analysis indicate that over 50% of the clay fraction was smectite. Additional research is needed to determine the fate of K in the soils of NW MN.

Soybean P & K Deficiencies

In 2022, soybean potassium deficiencies were detected in the plots testing low for K. Further, Phosphorus deficiencies were observed in soybean leaves and pods in plots testing low in P. After four years of this trial this was the first year that these deficiencies were observed in the plot testing low in P and K.

Another observation from the 2022 season was that soybean aphids were more prevalent in soybeans from the low K testing soil than soybeans that were growing with higher levels of K. It appeared that, for whatever reason, the soybean aphid was attracted to plots that tested low in K.

Annual reports for this P&K research can be found on-line. The on-farm trials are located at the Mn Wheat growers web site and click On-Farm research: https://mnwheat.org.
Small plot research can be found at the U of MN Turf website:
Seed Production Research - Progress Reports | Turfgrass Science (umn.edu)