Final Report – 2022 (for Wyoming Bean Commission)

Effect of Nitrogen Rates on Yield of Dry Bean with and without Fertilizer K – Powell REC, 2022

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Introduction

Since dry bean is an N_2-fixing legume, it stands to reason that fertilizer N applications are going to vary in effectiveness. Across the US Dry Bean Belt, and across the world, dry bean producers and researchers routinely question the need for fertilizer N and what rates are truly needed. After conducting several field studies in Lingle (2016 and 2017) with varying N rates and conducting three studies in Powell (2019, 2020, 2021), we have gathered pretty good evidence that it rarely pays to apply more than 60 pounds N per acre regardless of initial soil N concentration. In late 2020, we hypothesized that the lack of response to N may have been due to insufficient available soil K. Nevertheless, our 2021 results also showed no yield response to N or K. Since extractable soil K levels did not respond appreciably to the 100 and 200 unit K_2O applications, we decided that higher K rates needed to be tested in conjunction with our 2022 N rate tests.

Objectives

The primary objective of this test was to compare soil-applied N rates combined with different soil-applied K rates in the Bighorn Basin on dry bean. Recent evidence with N_2-fixing alfalfa suggested that K may be limiting on our Wyoming soils. Thus, combining N and K rates will give us some important data on whether K is deficient on dry bean and/or whether the lack of N effects are really caused by low soil K.

Methods

In order to conduct this test, we identified a one-acre field at PREC with a relatively low soil-N concentration. Within that field, we established 18 strips (11-feet wide) and applied 0, 40, or 80 pounds N per acre and/or 0, 250, and/or 500 pounds K_2O per acre. This created nine unique treatments with each treatment/strip replicated twice. The results of the pre-season soil sample are provided in Table 1. Fertilizers that were applied to the plot test area included: 145 units of P_2O_5, 40 units S, and 4 units Zn. Obviously, N and K were withheld.

Plots were sown on 27 May 2022. Plots were six-rows wide with a 22-inch row spacing, and 15-foot length. Seeding rate was approximately 100K per acre. Seven pinto cultivars and three of our own experimental lines (LPID-series) were tested within each of the 18 strips (please see Results section for the cultivar entries). The study consisted of 180 plots. Flowering dates were recorded twice weekly throughout July. For maturity, buckskin pod date was recorded for each plot by also scouting twice weekly.

Normalized difference vegetation index (NDVI) was recorded on 13/14 July, 1 Aug, and 12 August. Ten leaf blades (third uppermost trifoliolate) were collected in late July for leaf mineral analysis (N, P, K, Ca, S, Mg, Fe, Zn, B, Cu, Mn). Devices used for NDVI and leaf blade analysis are shown in Figure 1.

Harvest began on 29 September for the early-maturing cultivars and was ultimately completed by 6 October with plots being harvested as they matured. A Zurn research plot combine was used to collect grain from the two-center rows of each plot. Seed was cleaned free of trash and dirt prior to collecting yield weights. Ultimately, yield and seed size (a.k.a., number of seed per pound) were recorded. Additionally, soil samples were collected from each strip immediately after harvest.

Table 1. Pre-season soil analysis in 2022 for the NK genotype study.

Soil Trait	**Concentration or Value**
Nitrate-N	12 ppm
Ammonium-N	6.1 ppm
Phosphorus (P)	12 ppm
Potassium (K)	220 ppm
Magnesium (Mg)	4.5 ppm
Sulfate-S	22 ppm
Zinc (Zn)	1.0 ppm
Iron (Fe)	9.6 ppm
Manganese (Mn)	4.5 ppm
Copper (Cu)	0.7 ppm
Boron (B)	0.66 ppm
pH	8.1
Organic Matter	1.53%
CEC (meq/100g)	20.5
K Base Saturation	3.4%
Ca Base Saturation	73.2%
Mg Base Saturation	22.0%

Figure 1. RapidScan CS-45 used for NDVI (left) and example of a ground leaf sample (right).

Results

Vegetative indexes (NDVI) were unaffected by N or K fertility on three sampling dates (Tables 2, 3, and 4). However, cultivars (only commercially available cultivars are shown) did differ significantly for NDVI (Fig. 1). The cultivar 'Max' had higher NDVI in early July than the other five commercial cultivars but Monterrey had the highest on the final sampling (Fig. 2). In general, there were no N-K fertility-by-cultivar interactions for NDVI. Soil-applied K did not appear to increase leaf blade K concentration (Figs. 3 & 4). Soil-applied N did have a tendency to increase leaf blade N concentration when the zero N rate was compare to the 40 unit N rate for the early-maturing cultivars (Fig. 5). The late-maturing cultivars tended to be higher in leaf N but were unaffected by soil N fertility (Fig. 6).

Flowering and maturity dates did not differ among the N-K fertilizer treatments (Tables 6 & 7). Likewise, upright stature did not differ among the N-K fertility treatments (Table 8). For yield, no differences were observed among the nine different N-K fertility treatments (Table 9). Seed size and the number of seed per pound were also similar across the N-K fertility treatments (Tables 10 and 11).

In contrast to the yield similarity among the N and K treatments, cultivars/genotypes differed significantly for most yield-related traits. Yield, yield components, and maturity for each is provided in Table 12. An experimental line, PT9-5-6, which we've grown frequently here in Powell, ranked first but PT9-5-6 and Rattler were only significantly greater in yield than Max and Croissant. Poncho, Othello, and Max were clearly the earliest to mature.

Mid-season soil NO_3^- and NH_4^+ were not different among the N-K fertility treatments (Tables 13 & 14). Mid-season soil K was increased by K application (Table 15, Fig. 7). Mid-season soil Mg was increased by soil K application when data from the two low N rates was plotted (Fig. 8).

Table 2. Effect of the nine soil N-K treatments on NDVI on 13/14 July 2022 at Powell. Data are averaged across the ten genotypes.

N Rate		**K Rate**	
	0	250	500
0	0.46	0.50	0.45
40	0.47	0.47	0.49
80	0.49	0.47	0.47

P-values for the three sources of variation were:
N Rate, 0.887; K Rate, 0.853; N Rate-by-K Rate, 0.508.

Table 3. Effect of the nine soil N-K treatments on NDVI on 1/2 August 2022 at Powell. Data are averaged across the ten genotypes.

N Rate		**K Rate**	
	0	250	500
0	0.72	0.75	0.73
40	0.74	0.74	0.75
80	0.74	0.74	0.74

P-values for the three sources of variation were: N Rate, 0.951; K Rate, 0.913; N Rate-by-K Rate, 0.238.

Table 4. Effect of N rate and K rate on NDVI on 2/4 August at Powell. Data are averaged across the ten genotypes.

N Rate		**K Rate**	
	0	250	500
0	0.84	0.84	0.83
40	0.83	0.83	0.84
80	0.84	0.83	0.83

P-values for the three sources of variation were: N Rate, 0.109;
K Rate, 0.294; N Rate-by-K Rate, 0.165.

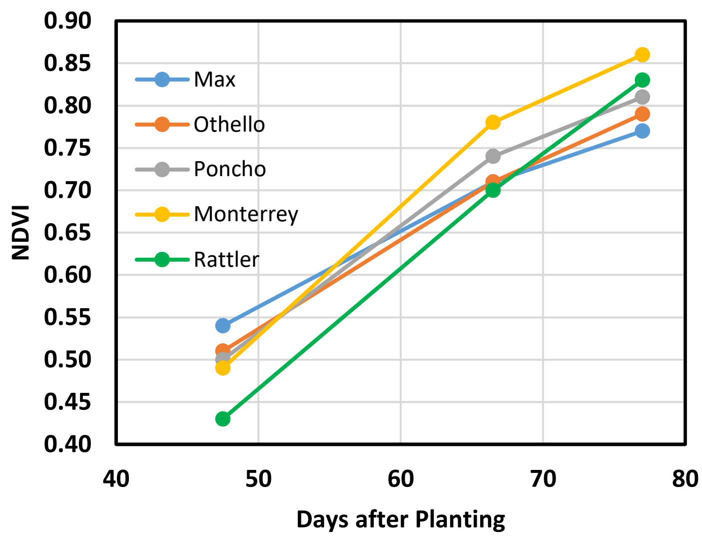

Figure 2. NDVI ratings of the five commercial cultivars across time in 2022.

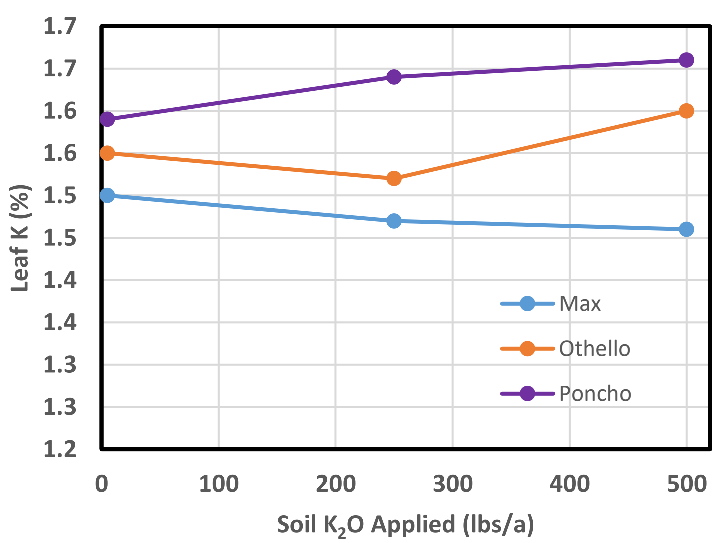

Figure 3. Leaf K concentration as affected by soil applied K rate for three early-maturing cultivars at Powell, late July 2022.

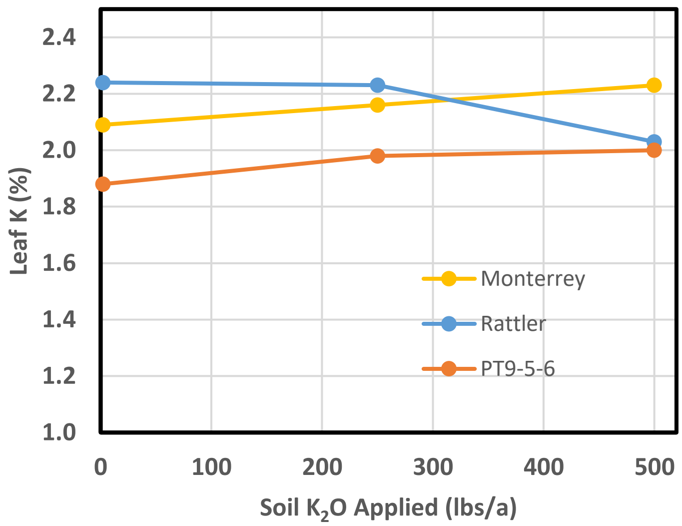

Figure 4. Leaf K concentration as affected by soil applied N rate for three late-maturing dry bean genotypes at Powell, late July 2022.

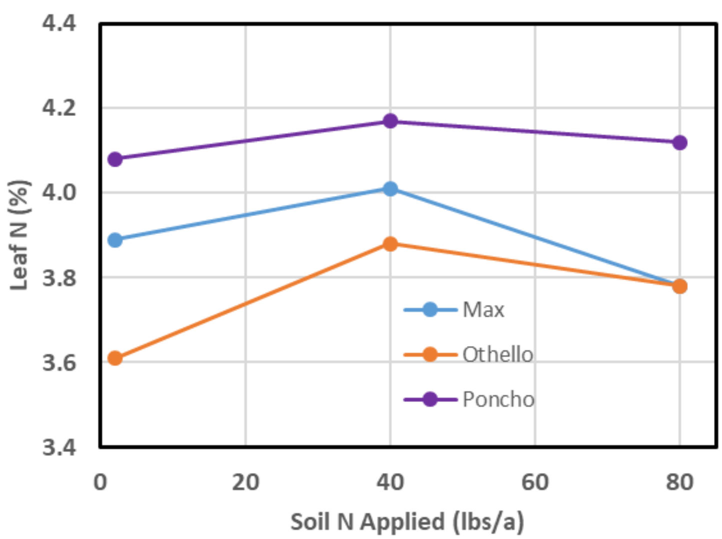

Figure 5. Leaf N concentration as affected by soil applied N rate for three early-maturing genotypes in late July 2022 at Powell.

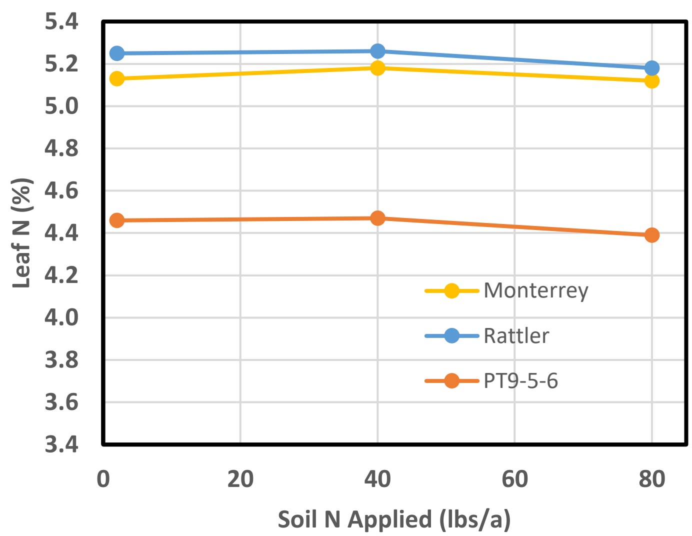

Figure 6. Leaf N concentration as affected by soil applied N rate for three late-maturing genotypes in late July 2022 at Powell.

Table 6. Effect of N rate and K rate on flowering date (days after planting). Values are averaged across 10 genotypes. Each data point represents 20 plots. Powell 2022.

N Rate		**K Rate**	
	0	250	500
0	56	55	56
40	56	56	55
80	56	56	55

Table 7. Effect of N rate and K rate on maturity date (days after planting). Values are averaged across 10 genotypes. Each data point represents 18 plots. Powell 2022.

N Rate		**K Rate**	
	0	250	500
0	101	101	99
40	99	98	100
80	100	99	100

Table 8. Effect of N rate and K rate on upright stature. A value of 0 indicates that the canopy was fully prostrate and a value of 10 indicates the canopy was fully upright. Values are averaged across 10 genotypes. Each data point represents 18 plots. Powell 2022.

N Rate		**K Rate**	
	0	250	500
0	7.9	7.8	8.4
40	7.7	8.1	8.0
80	7.8	7.9	8.1

Table 9. Effect of three N rates combined with three K rates on dry bean yield (lbs/a) at Powell in 2022. Data are averaged across the 10 entries with each data point representing 18 plots. *P*-values were:
N Rate, 0.594; K Rate, 0.751; N Rate-by-K Rate, 0.313.

N Rate		**K Rate**	
	0	250	500
0	3,273	3,411	3,062
40	3,324	3,119	3,300
80	3,322	3,343	3,344

Table 10. Effect of three N rates combined with three K rates on dry seed size (mg) at Powell in 2022. Data are averaged across the 10 entries. Each value represents 18 plots. *P*-values were:
N Rate, 0.523; K Rate, 0.152; N Rate-by-K Rate, 0.028.

N Rate		**K Rate**	
	0	250	500
0	420	420	406
40	423	418	407
80	406	413	419

Table 11. Effect of three N rates combined with three K rates on number of seed per pound at Powell in 2022. Data are averaged across the 10 entries. Each value represents 18 plots. P-values were:
N Rate, 0.432; K Rate, 0.229; N Rate-by-K Rate, 0.028.

N Rate		**K Rate**	
	0	250	500
0	1085	1087	1123
40	1080	1092	1117
80	1125	1107	1088

Table 12. Effect of cultivar/genotype on yield, seed size, seed per pound, and maturity at Powell in 2022. Values are averaged across the nine N-K fertility combinations and 18 plots.

Cultivar/Genotype	**Yield**	**Seed Size**	**Seed per Pound**	**Maturity**	**Upright**
	lbs/a	mg	no.	dap	
Croissant	2,944	386	1,174	104	7.6
LPID-3	3,577	471	966	101	7.4
LPID-7	3,316	385	1,183	104	7.0
LPID-9	3,489	417	1,090	113	6.7
Max	3,029	425	1,068	89	8.0
Monterrey	3,369	405	1,122	100	9.1
Othello	3,002	410	1,109	88	8.1
Poncho	3,075	431	1,156	90	8.0
PT9-5-6	3,497	383	1,185	103	9.1
Rattler	3,479	432	1,050	106	8.9
LSD (0.05)	298	11	30	3	0.5

Table 13. Effect of soil-applied N and K rates on soil NO_3-N (ppm) in the top 18-inches of soil just in July 2022. Values are the average of two plots.

N Rate		**K Rate**		
	0	250	500	Average
0	12	10	11	11
40	13	17	13	14
80	11	13	19	14
Average	12	13	14	13

Table 14. Effect of soil-applied N and K rates on soil NH_4-N (ppm) in the top 18-inches of soil in July 2022. Values are the average of two plots.

N Rate		**K Rate**		
	0	250	500	Average
0	4.5	4.0	5.0	4.5
40	4.5	4.5	4.5	4.5
80	4.5	4.0	5.0	4.5
Average	4.5	4.2	4.8	4.5

Table 15. Effect of soil-applied N and K rates on soil K in the top 18-inches of soil in July 2022. Values are the average of two plots.

N Rate		**K Rate**		
	0	250	500	Average
0	210	225	240	225
40	205	233	238	225
80	215	215	232	221
Average	210	224	237	224

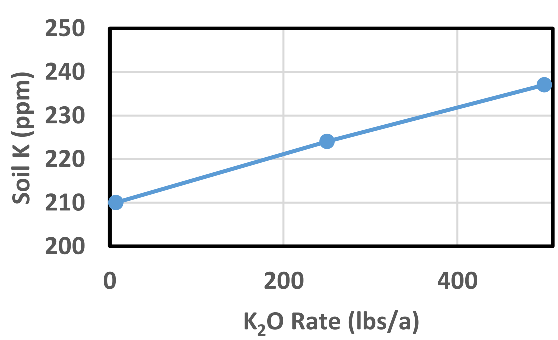

Figure 7. Graphical representation of soil K data. Samples were collected mid-season.

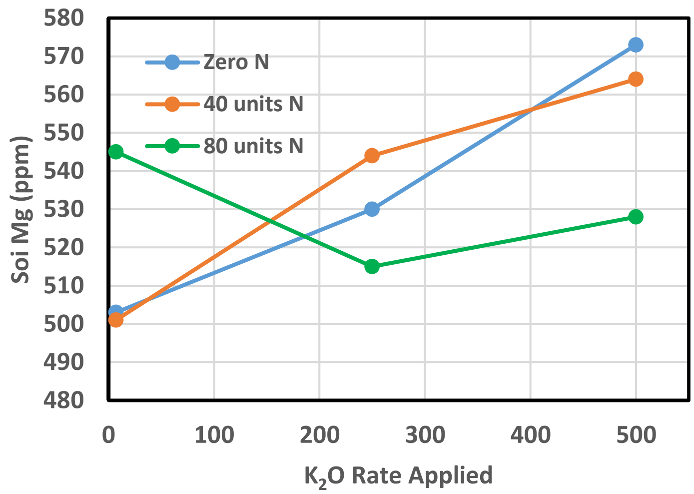

Figure 8. Effect of pre-season soil K application on soil Mg concentration in July 2022.

Discussion and Summary

Current recommendations for N fertilizer to dry bean are often adjusted to account for pre-season soil N and soil organic matter as well as yield goal. However, some dry bean producers still apply 60 to 100 pounds of N at planting to ensure that the dry bean crop will not run out of N. Our limited observations (including those in this report) indicate that there was neither gain nor penalty from applying 40 to 80 units of N. If N is relatively cheap, adding N fertilizer seems to be much like insurance. However, if N is expensive, producers need to be able to predict more accurately whether applying N will be cost effective.

This 2022 research (along with our 2021 report) did not support the idea that adding K would improve yield of the N-fertilized plots. Even in 2022 when we added up to 500 pounds K_2O per acre and increased soil available K, yield was unaffected. Soil scientists often suggest that we strive for a soil K base saturation between 4% and 8% to minimize the possibility of K-deficiency. In contrast to the lack of differences for the soil N and K treatments, our research documented differences in canopy traits (i.e., NDVI) and yield among cultivars.

Results of this research could complement previous research by fine-tuning the yield vs. N response curves that could ultimately give producers confidence that less N applied could increase profit. If these observations of dry bean not responding to N fertilizer can be demonstrated on producer fields and growers become confident that they can reduce their N rates, then there is potential for the added benefit of the bean industry being acknowledged for having less impact on the environment. Our work with N fertilizer on dry bean these past six years was highlighted in UW's College of Agriculture Reflections Magazine so we are letting the public know that dry bean producers are supporting two goals at once, reducing grower fertilizer costs and reducing environmental impact. If reduced N rates are ultimately adopted by Wyoming dry bean producers, we believe we are less than three years away from this industry being nationally recognized for reducing its environmental impact.