Final Report – 2022 (for Wyoming Bean Commission)

The Effect of In-Furrow and Foliar Micronutrient Applications on Dry Bean Performance – PREC 2022

Jim Heitholt, Samual George, Cody Hurford, and Chloe Winkler

Document was prepared in February 2023; Funding Awarded, $8,750

Introduction

Due to high pH calcareous soils in Wyoming, several crops have the potential to show deficiency of micronutrient elements such as Fe, Mn, Zn, Cu, and B. Due to solubility and other chemical properties, soils with a high pH have reduced availability of several micronutrients. For all of our dry bean studies, not to mention commercial dry bean producers, our research group routinely pays careful attention to soil test levels of micronutrients such as Fe, Zn, and Mn. We rarely see deficiency symptoms but we are routinely asked if marginal micronutrient levels in the soil are causing yield reductions. In 2020, we conducted a preliminary test of in-furrow and foliar application of one micronutrient products and found a trend for improved yield with the in-furrow application. A producer in the Bighorn Basin suggested that we try other products. In 2021, we conducted the first year of this study and found minimal effects. We decided to repeat this study in 2022 to see if there were any possible yield responses in a different year.

Objectives

The objective of this project is to see if in-furrow and/or foliar applications of micronutrients from three different products marketed locally can improve the yield of dry bean on the high pH soils of the Bighorn Basin.

Methods

A one-acre block of land under furrow irrigation was set aside for this trial. A soil sample was collected in March and Stukenholtz lab recommended applying 95-145-70-60-8 (N-P-K-S-Zn). In contrast to 2021 when we applied the recommended fertilizer and found no effects from any of the in-furrow or foliar treatments, we decided to ignore the recommendation in 2022. Thus, in the past two years, we tried both alternatives (applying all supposedly lacking minerals vs. applying none) to see what might happen.

On Thursday 10 June 2022, seed from eight pinto cultivars were sown in 16 six-row strips using a Kincaid research plot planter. Each strip was 200-feet long and was assigned one of the eight fertility treatments. Each strip contained all eight cultivars at least once. Each cultivar was allocated 15-feet row length within each strip with a five-foot buffer/alleyway in-between. Cultivar names can be found in the results section of this report but included early/late and short/tall cultivars. Individual plots were six-rows wide with a 22-inch spacing and we used a target seeding rate of 90K per acre. Each of the 8 distinct fertility strips (i.e., the in-furrow and foliar treatments) were replicated twice. The treatments are described in Table 1. Chemical composition of the three products applied can be found in Table 2.

For in-furrow treatments, solutions were applied with our Kincaid planter as seed was sown (Fig. 1). Gainer®, a solid granular product, was applied at 4.7# per acre by dissolving in aqueous (water) solution. Our intent was to apply Gainer at a higher rate (7.5 pounds per acre) but product solubility limited the rate and we did not want to risk altering the already-calibrated 10-gallons-per-acre in-furrow volume settings on the Kincaid planter. For in-furrow Sysstem Advance®, a liquid product, we applied

4 pints of product per acre also using the 10-gallons-per-acre delivery volume. Conventional weed control practices were employed and the plots were kept free of weed infestations throughout the year.

For the first foliar applications of Max-In®, Sysstem Advance, and Gainer, applications were made on 22 July 2022 with a backpack sprayer with flat fan nozzles and spray volume of 17 gallons per acre set at 40 psi. At this time, cvs. Max, Othello, and Poncho had just begun flowering; the other five cultivars had not. The second foliar application was made on 17 August 2022. Growth stage for the second foliar application varied among cultivars with Max and Othello approaching late podfill, Poncho approaching mid podfill and the other five cultivars approaching early podfill.

Normalized difference vegetation index (NDVI) was recorded on 18 July (early-season) and on 3 August (late-season). Ten leaf blades (third uppermost trifoliolate) were collected on 19 August for leaf mineral analysis (N, P, K, Ca, S, Mg, Fe, Zn, B, Cu, Mn). Samples were immediately dried at 60°C overnight and ground with a mortar and pestle at a later time. Photos associated with NDVI and leaf mineral analysis are shown in Figure 3.

Harvest began around mid-September for the early-maturing cultivars and was ultimately completed by 29 September. 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.

Table 1. In-furrow and micronutrient treatments used in Powell in 2022. Max-In was not applied in-furrow, it was only applied foliar.

In-Furrow	**Foliar**
Untreated	Untreated
	Gainer
	Max-In
	Sysstem Advance
Gainer	No
	Gainer
Sysstem Advance	No
	Sysstem Advance

Table 2. Composition of the three products used in the micronutrient research.

Product	**NPK**	**Additional Components**
Gainer (solid)	10-16-38	0.02% B, 0.05% Cu, 0.15% Fe, 0.05% Mn, 0.0005% Mo, 0.15% Zn
Max-In	none	3.6% S, 0.1% B, 3.0% Mn, 4.0% Zn
Sysstem Advance	5-0-0	1.25% S, 0.10% B, 2.0% Mn, 0.01% M, 4.0% Zn

Table 3. Application rates of selected minerals from the seven treatments that received either in-furrow or foliar micronutrients.

Product	How Applied	lbs N per acre	lbs K_2O per acre	lbs Zn per acre	lbs S per acre
Gainer	In-Furrow †	0.47	1.78	0.007	0
	Foliar ‡	1.50	5.70	0.022	0
	Both	1.97	7.48	0.029	0
Max-In	Foliar §	0	0	0.32	0.29
Sysstem Advance	In-Furrow	0.28	0	0.23	0
	Foliar	0.28	0	0.23	0
	Both	0.56	0	0.46	0

† The target for Gainer in-furrow was 7.5 lbs of material per acre but that rate was reduced due to 4.7 lbs due to solubility issues.

‡ The values for Gainer foliar represent the sum of both foliar applications.

§ The values for Max-In were calculated using the density of the solution. For example, 6 pints of Max-In were applied across the two foliar applications. This was 8.07 pounds of product and with the product at 4% Zn, this calculates to 0.32 pounds of Zn per acre. An analogous approach was used for Sysstem Advance.

Figure 1. Kincaid planter unit used to sow dry bean trial and to apply in-furrow micronutrient solutions.

Figure 2. Example of spraying three-rows of a six-row plot. The other three rows of the six-row plot were sprayed in the reverse direction.

Figure 3. RapidScan CS-45 unit used for NDVI (left) and ground leaf blades used for leaf mineral analysis (right).

Results - 2022

Vegetative indexes (NDVI) and were unaffected by the micronutrient treatments, either in-furrow or foliar (Table 4). However, cultivars did differ significantly for NDVI (Table 5). The cultivar 'Max' had higher NDVI in early July than the other eight cultivars. During mid-August, the later-maturing cultivars Poncho had higher NDVI than Croissant. We did not detect any micronutrient treatment-by-cultivar interactions affecting NDVI.

For leaf minerals on 19 August, the micronutrient treatments affected leaf blade concentrations of P, Mn, and Cu (Table 6). We cannot explain the increase in leaf P associated with the foliar sprays. However, we can explain the increases in leaf Mn with foliar Max-In and Sysstem Advance because those products contain a healthy amount of Mn. Likewise, the increase in leaf Cu associated with Max-In was associated with that product containing substantial Cu. The in-furrow or foliar treatments did not affect leaf blade concentrations of N, K, Mg, Ca, S, Fe, or B.

For Zn, there was a treatment-by-cultivar interaction so an additional table is provided for those results (Table 7). Although not completely clear, the interaction appeared to be due to the leaf Zn concentration in cultivar PT9-5-6 responding more favorably to Max-In foliar application whereas the leaf Zn concentration of PT9-5-6 was relatively low in the several of the other treatments. Regardless of the interaction, as was shown for Mn and Cu, the two products that contained the highest amounts of Zn (Max-In and Sysstem Advance) increased leaf Zn more than the product that had lower amounts of Zn (Gainer) or the untreated check.

When the eight cultivars are compared individually, the concentration of all minerals elements differed significantly except Na (Table 8). Rattler had the highest leaf Zn concentrations whereas Windbreaker had the lowest. As was found in 2021, the cultivar 'Max' had the highest leaf Mn concentration. Leaf blades of Windbreaker had the lowest Mn concentration.

Flowering times did not differ among the fertilizer treatments (data not shown). Flowering dates did differ among the cultivars with 'Max', 'Othello', and 'Poncho' flowering earlier. Flowering dates (dap) were as follows: Poncho (42), Max (40), Othello (40), Croissant (49). Windbreaker (50), PT9-5-6 (51), Monterrey (53), and Rattler (52). Yield, seed size, and maturity were unaffected by the treatments (Table 9). However, as expected, significant differences occurred among cultivars with Monterrey, Poncho, and Rattler outyielding the other five entries (Table 10). Regarding maturity, Max, Othello, and Poncho matured earlier than Monterrey, PT9-5-6 and Rattler as expected.

Table 4. Effect of micronutrient applications on canopy reflectance values (normalized difference vegetation index, NDVI) on one date in 18 July 2022 and one date in 3 August 2022.

In-Furrow	Foliar	NDVI-July	NDVI-August
Untreated	Untreated	0.49	0.78
	Gainer	0.45	0.78
	Max-In	0.47	0.78
	Sysstem Advance	0.50	0.79
Gainer	No	0.47	0.76
	Yes	0.49	0.79
Sysstem Advance	No	0.49	0.79
	Yes	0.48	0.78
LSD (0.05)		ns	ns
P-value		> 0.10	> 0.10

Table 5. Effect of cultivar on canopy reflectance values (normalized difference vegetation index, NDVI) during early and mid-season and leaf chlorophyll (SPAD).

Cultivar	NDVI – Early July	NDVI – Mid August
Croissant	0.41	0.74
Max	0.51	0.77
Monterrey	0.49	0.80
Othello	0.51	0.80
Poncho	0.53	0.82
PT9-5-6	0.43	0.76
Rattler	0.47	0.81
Windbreaker	0.48	0.77
LSD (0.05)	0.04	0.06
P-value	0.001	0.001

Table 6. Effect of micronutrient applications on leaf blade mineral concentrations on 19 August 2022.

In-Furrow	Foliar	N	P	K	Mg	Ca	S	Fe	Mn	B	Cu
		---------- % ----------						--------- ppm ----------			
Untreated	Untreated	3.81	0.27	1.54	0.34	1.87	0.24	147	104	36	7
	Gainer	3.98	0.32	1.70	0.36	1.90	0.24	157	116	36	11
	Max-In	3.81	0.27	1.43	0.35	1.91	0.25	144	236	40	7
	Sysstem Advance	3.98	0.30	1.52	0.35	1.87	0.24	146	191	38	7
Gainer	No	3.88	0.27	1.46	0.35	1.85	0.23	147	110	35	7
	Yes	4.12	0.33	1.75	0.36	1.91	0.25	164	119	38	11
Sysstem Advance	No	3.74	0.28	1.50	0.35	1.80	0.25	157	110	36	8
	Yes	4.05	0.30	1.52	0.35	1.90	0.26	148	195	39	8
LSD (0.05)		ns	0.04	ns	ns	ns	ns	ns	13	ns	1
P-value		0.108	0.001	0.058	0.959	0.887	0.206	0.623	0.001	0.114	0.001

Table 7. Interaction of micronutrient application and cultivar on leaf zinc (Zn) concentration (ppm) on 19 Aug 2022. The treatment-by-cultivar interaction P=0.007; The LSD (0.05) for the 64 different Zn concentrations was 22.

Cultivar	UNT	GainerIF	GainerFol	GainerBoth	MaxInFol	SysAdvIF	SysAdvFol	SysAdvBoth	Avg
Croissant	21	20	31	33	198	19	134	147	76
Max	17	17	29	33	175	20	162	155	76
Monterrey	22	22	35	38	214	23	143	160	82
Othello	18	15	33	27	168	19	162	133	72
Poncho	22	21	36	32	184	21	141	144	79
PT9-5-6	17	18	34	29	209	20	161	145	79
Rattler	29	23	42	39	174	26	182	193	89
Windbreaker	22	17	28	28	149	17	134	140	67
Average	21	19	33	33	184	21	156	152	77

Table 8. Effect of cultivar on leaf blade mineral concentrations on 19 August 2022. Values are the average across all micronutrient treatments and thus, are averaged across 16 samples for each cultivar.

Cultivar	N	P	K	Mg	Ca	S	Mn	Fe	Zn	B	Cu
	---------- % ----------						---------- ppm ----------				
Croissant	3.94	0.31	1.65	0.33	1.50	0.24	141	137	76	39	7.5
Max	3.44	0.26	1.28	0.40	2.46	0.22	163	204	76	37	7.7
Monterrey	4.57	0.35	1.71	0.34	1.83	0.26	142	158	82	39	9.4
Othello	3.32	0.23	1.31	0.37	2.23	0.26	149	162	72	31	7.3
Poncho	3.63	0.25	1.38	0.31	2.00	0.21	161	138	79	32	7.9
PT9-5-6	4.11	0.33	1.74	0.32	1.68	0.23	144	135	79	41	8.6
Rattler	4.89	0.36	1.87	0.39	1.69	0.30	157	170	89	44	10.1
Windbreaker	3.44	0.27	1.48	0.33	1.62	0.22	125	108	67	35	8.2
LSD (0.05)	0.15	0.02	0.07	0.02	0.11	0.01	13	22	8	2	0.6
P-value	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001

Table 9. Effect of in-furrow and foliar micronutrient applications on dry bean yield and seed size. Values are averaged across nine cultivars. Pairwise comparisons are provided in a footnote. †

In-Furrow	Foliar	Yield	Seed Size	Seed per Pound	Maturity
		lbs/a	mg	no.	dap
Untreated	Untreated	3340	394	1158	92
	Gainer	3564	393	1159	93
	Max-In	3279	397	1145	93
	Sysstem Advance	3233	386	1182	93
Gainer	No	3313	388	1176	93
	Yes	3597	393	1157	92
Sysstem Advance	No	2978	391	1164	94
	Yes	3526	395	1160	93
LSD (0.05)		ns	ns	ns	ns
P-value		0.432	0.801	0.790	0.890

† Pairwise comparisons:

In-Furrow vs. No In-Furrow	(3353 vs. 3354); ns; *P* = 0.670
Foliar vs. No Foliar	(3457 vs. 3209); ns; *P* = 0.395
Both IF/Foliar vs. Not Both	(3561 vs. 3284): ns; *P* = 0.426

Table 10. Effect of cultivar on yield, yield components, and maturity. Data are averaged across all fertilizer treatments.

Cultivar	Yield	Seed Size	Seed per Pound	Maturity	Maturity
	lbs/a	mg	no.	dap	date
Croissant	2818	359	1266	97	15 Sept
Max	3328	422	1076	80	29 Aug
Monterrey	3507	379	1199	99	17 Sept
Othello	3374	385	1179	81	30 Aug
Poncho	3442	425	1069	85	3 Sept
PT9-5-6	3178	365	1244	101	19 Sept
Rattler	3852	398	1140	102	20 Sept
Windbreaker	3480	403	1128	97	15 Sept
LSD (0.05)	282	12	35	2	

Discussion and Summary

As was found in 2021, the results of this 2022 trial indicated that micronutrient products, whether applied in-furrow or foliar, did not have any positive or negative impact on vegetative indexes or on yield. In 2021, our approach was to fertilize the field before planting with N, P, K, S, and Zn by following the recommendation of a commercial soil testing lab. In 2022, we did the opposite, withholding pre-plant fertilization in the interest of seeing if that might work but that did not seem to matter.

Measurements of leaf blade mineral concentrations collected two days post application indicated that two of the foliar applications were somewhat successful in increasing leaf blade micronutrient concentrations. The two products, Max-In and Sysstem Advance, are relatively high in Zn and Mn and both products, when applied to foliage, provided a substantial boost in leaf Zn and Mn compared to the other five treatments not receiving foliar Max-in or foliar Sysstem Advance.

Although our test included a wide range of cultivar maturities and statures, we did not observe any micronutrient treatment interactions with cultivar except for the aforementioned leaf Zn concentrations. As expected however, we did observe significant differences in yield and other traits among the eight cultivars.

Overall, the environment for this test was rather favorable with yields being acceptable for a 10 June planting date. In fact, this 2022 test was the highest-yielding test across all of our PREC 2022 trials. Circumstances that might be associated with micronutrient deficiencies could be high-yielding environments whereby the crop (and/or soil) may run short of a given micronutrient during that year. That situation did not appear to be the case for this test.

In summary, it is clear that micronutrient applications, either in-furrow or foliar, are not guaranteed to provide a dry bean yield increase in the Bighorn Basin. With that said, there was no penalty from applying any of the products in-furrow or to the foliage. Most of the varieties we tested are considered very reliable and have withstood the test of time. These cultivars may likely have root morphology and/or metabolic activity within their root systems to extract micronutrients quite effectively from our high pH soils. It is not clear whether further tests under slightly different conditions are warranted to see if in-furrow or foliar micronutrient applications can help dry bean yields in the Bighorn Basin.