

Final Report – 2021 (for Wyoming Bean Commission)

Comparison of In-Furrow and Foliar Micronutrient Applications to Dry Bean – Powell REC

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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. Thus, we decided to repeat this study in 2021 to see if there were any consistent yield responses.

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 80-130-80-70S-8Zn; thus, we decided to apply that amount. We realize this trial could have taken the alternative approach of not applying anything and see what happens. Given 20-20 hindsight, we expect to propose the alternative approach for 2022.

On Thursday 10 June 2022, seed from nine pinto cultivars were sown in 24 six-row strips using a Kincaid research plot planter. Each strip was 180-feet long and was assigned one of the eight fertility treatments. Each strip contained all nine cultivars once and only once. Each cultivar was allocated 15-foot row length within each strip with a five-foot buffer in-between. Cultivar names can be found in the results section of this report but included early/late and short/tall cultivars. 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., our treatments) were replicated three times. 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 System 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 application of Max-In, Sysstem Advance, and Gainer, applications were made on 6 July 2022 with a backpack sprayer with flat fan nozzles and spray volume of 17 gallons per acre set at 40 psi. For that application, the crop was at the fourth-leaf stage. For the second foliar application, the three materials were applied again as for the first application date (26 July, 27 July, and 29 July for Blocks One, Two, and Three, respectively). Conditions were too windy on 28 July. Growth stage for the second foliar application varied among cultivars but half the cultivars had reached flowering during late July whereas as the late cultivars were approaching the full flower stage.

Normalized difference vegetation index (NDVI) was recorded on 1 July (early-season) and on 10 to 11 August (late-season, Blocks One/Two on the 10th and Block Three on the 11th). Ten leaf blades (third uppermost trifoliolate) were collected on 5 August Blocks One/Two and 6 August Block Three 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. Leaf chlorophyll was recorded on 10 August 2021 on a third uppermost trifoliolate leaf blade (three leaflets per plot). Photos associated with NDVI, leaf chlorophyll, and leaf mineral analysis are shown in Figure 3.

Harvest began on 14 September for the early-maturing cultivars and was ultimately completed by 30 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 2021. 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
	System 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 ₂ O 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
System 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 System 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), SPAD-502 device used for leaf chlorophyll (center), and ground leaf blades used for leaf mineral analysis (left).

Results

Vegetative indexes (NDVI) and leaf chlorophyll were unaffected by the micronutrient treatments, either in-furrow or foliar (Table 4). However, cultivars did differ significantly for NDVI and for leaf chlorophyll (Table 5). The cultivar 'Max' had higher NDVI in early July than the other eight cultivars. Leaf chlorophyll has highest in Windbreaker in early August. During mid-August, the later-maturing cultivars La Paz, Monterrey, and Nez Perce had higher NDVI than several early-maturing cultivars. We did not detect any micronutrient treatment-by-cultivar interactions among NDVI or leaf chlorophyll.

For leaf minerals on 5/6 August, the micronutrient treatments did not affect concentrations of N, P, K, Mg, Ca, S, Fe, B, or Cu (Table 6). However, the nine cultivars differed for each of these mineral elements (Table 7). Interestingly, the micronutrient treatments did affect the concentrations of Zn and Mn in the leaf blade. However, the treatment-by-cultivar interaction for both of those minerals was significant. For both Zn and Mn, Max-In foliar and System Advance foliar applications increased the concentrations of those minerals above that of the other five treatments and the untreated check (Tables 8 and 9). The cultivar 'Max' had the highest leaf Zn concentration. The four early-maturing cultivars (Blackfoot, Max, Othello, Poncho) had higher leaf Mn concentrations than the four later-maturing cultivars.

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 (40), Max (40), Othello (41), Blackfoot (43), Windbreaker (46), Nez Perce (47), PT9-5-6 (47), Monterrey (50), and La Paz (51). Likewise maturity dates (dap) were: Max (79), Othello (80), Blackfoot (81), Poncho (81), Windbreaker (92), Nez Perce (93), Monterrey (94), PT9-5-6 (94) and La Paz (96).

Yield was unaffected by any of the micronutrient treatments and neither were any of the pairwise comparisons different (Table 10 and table footnote). As was found for the vegetative traits, micronutrient treatment-by-cultivar interaction effects on yield and related traits were also absent. In contrast to the yield similarity among the micronutrient treatments, cultivars differed significantly for most yield-related traits. Yield, yield components, and maturity for each cultivar is provided in Table 11. The later-maturing cultivars La Paz and Monterrey tended to outyield earlier-maturing cultivars.

Table 4. Effect of micronutrient applications on canopy reflectance values (normalized difference vegetation index, NDVI) on two dates and leaf chlorophyll (SPAD) during early August.

In-Furrow	Foliar	NDVI-July	NDVI-August	Leaf Chlorophyll
Untreated	Untreated	0.22	0.81	49.2
	Gainer	0.21	0.82	48.4
	Max-In	0.22	0.82	49.6
	System Advance	0.22	0.83	49.3
Gainer	No	0.22	0.81	48.4
	Yes	0.21	0.81	47.2
System Advance	No	0.21	0.82	49.6
	Yes	0.21	0.82	48.6
LSD (0.05)		ns	ns	ns
P-value		0.246	0.226	0.155

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	Leaf Chlorophyll
La Paz	0.21	0.85	48.8
Monterrey	0.21	0.83	47.1
Max	0.26	0.81	49.3
PT9-5-6	0.19	0.82	47.9
Windbreaker	0.20	0.80	52.8
Othello	0.21	0.80	49.0
Poncho	0.24	0.81	49.3
Nez Perce	0.21	0.84	47.0
Blackfoot	0.21	0.78	48.0
LSD (0.05)	0.01	0.02	1.5
P-value	0.001	0.001	0.001

Table 8. Interaction of micronutrient application and cultivar on leaf zinc concentration (ppm). The treatment-by-cultivar interaction $P=0.001$; The LSD (0.05) for the 72 different Zn concentrations was 7.

Cultivar	UNT	GainerIF	GainerFol	GainerBoth	MaxInFol	SysAdvIF	SysAdvFol	SysAdvBoth	Avg
La Paz	25	21	23	23	43	22	34	31	28
Monterrey	25	21	23	23	52	20	36	32	29
Max	19	15	20	20	70	19	54	55	34
PT9-5-6	22	19	24	20	44	21	52	39	28
Windbreaker	21	20	19	21	39	18	35	42	27
Othello	19	16	18	21	51	16	34	50	30
Poncho	16	15	17	19	62	17	51	46	30
Nez Perce	23	20	21	21	43	21	36	38	28
Blackfoot	18	18	20	19	44	18	36	44	27
Average	21	18	21	21	50	19	41	41	29

Table 9. Interaction of micronutrient application and cultivar on leaf manganese concentration (ppm). The treatment-by-cultivar interaction $P=0.001$; The LSD (0.05) for the 72 different Mn concentrations was 14.

Cultivar	UNT	GainerIF	GainerFol	GainerBoth	MaxInFol	SysAdvIF	SysAdvFol	SysAdvBoth	Avg
La Paz	35	32	35	31	63	35	42	39	40
Monterrey	32	27	32	28	61	36	42	39	38
Max	70	66	65	59	135	52	88	90	78
PT9-5-6	39	33	35	37	62	36	49	49	42
Windbreaker	35	33	30	37	55	33	45	50	40
Othello	68	61	55	62	100	51	90	83	71
Poncho	56	50	57	51	110	52	87	86	69
Nez Perce	34	34	38	36	61	44	50	52	44
Blackfoot	48	54	41	49	76	49	64	65	56
Average	46	43	43	43	81	43	62	61	53

Table 10. 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	2868	356	1286	88
	Gainer	2901	350	1307	88
	Max-In	2813	356	1284	88
	System Advance	3014	359	1274	88
Gainer	No	2802	349	1310	88
	Yes	2812	351	1302	88
System Advance	No	2815	363	1260	87
	Yes	2930	353	1295	87
LSD (0.05)		ns	ns	ns	ns
P-value		0.609	0.084	0.089	0.693

† Pairwise comparisons: In-Furrow vs. No In-Furrow (2853 vs. 2900)
 Foliar vs. No Foliar (2906 vs. 2828)
 Both IF/Foliar vs. NotBoth (2898 vs. 2869)

Table 11. 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
La Paz	3240	312	1458	96	15 Sept
Monterrey	3114	354	1285	94	13 Sept
Max	3058	390	1169	79	28 Aug
PT9-5-6	3011	360	1263	94	13 Sept
Windbreaker	2843	386	1176	92	11 Sept
Othello	2817	350	1302	80	29 Aug
Poncho	2780	377	1207	81	30 Aug
Nez Perce	2696	320	1417	93	12 Sept
Blackfoot	2344	343	1326	81	30 Aug
LSD (0.05)	309	11	41	2	2

Discussion and Summary

The results of this 2021 trial indicated that micronutrient products did not have any positive or negative impact on vegetative indexes or on yield in this particular test. Our approach to fertilize the field before planting by following the recommendation of a commercial soil testing lab could have played a role in why these micronutrient products did not have any effect on yield. Our pre-season fertility program included applying N, P, K, S, and Zn. Our results did not reflect the observations from

2020 when we saw a slight yield increase in yield due to the in-furrow application of System Advance. It might be that we need to test these products in situations where no pre-plant soil fertility applications are made. In a field adjacent to the test described in this report but where zero fertilizer was applied, yields were higher than those reported here (despite a recommendation for adding N, P, K, S, and Zn). It is well known that mineral nutrient deficiencies are complex and it is possible that micronutrient applications might be able to increase yield in situations where N, P, and K are withheld.

Measurements of leaf blade mineral concentrations collected three 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 System Advance, are relatively high in Zn and Mn and both products provided a substantial boost in leaf Zn and Mn compared to the other six treatments. Additionally, the observation that the four early cultivars contained higher leaf Mn concentrations than later-maturing types suggests one of two possibilities. The Mn response could be genetic and it was coincidental that these types retain more Mn. A second possibility is that the late-maturing types developed greater leaf area and aboveground biomass and thus, diluted their Mn across more tissue. However, we really do not have an explanation for this.

Although our test include a wide range of cultivar maturities and statures, we did not observe any micronutrient treatment interactions with cultivar except for the aforementioned leaf Zn and Mn concentrations. As expected however, we did observe significant differences in yield and other traits among the nine cultivars. Late-maturity seemed to be advantageous to yield in this test although the cultivar 'Max' ranked third in yield despite being the earliest-maturing cultivar out of the nine entries.

Overall, the environment for this test was rather favorable with yields being acceptable for a 10 June planting date. 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. 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. Thus, further tests under slightly different conditions may be warranted to see if in-furrow or foliar micronutrient applications can help dry bean yields in the Bighorn Basin.